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Phthalates and Adaptive Immune Response: Role of Social and Biological Factors in Exposure and Vulnerability

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Phthalates and Adaptive Immune Response:

Role of Social and Biological Factors in Exposure and Vulnerability

A dissertation submitted in partial satisfaction of the

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in Public Health

by

Melissa Marie Kelley

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ABSTRACT OF THE DISSERTATION

Phthalates and Adaptive Immune Response:

Role of Social and Biological Factors in Exposure and Vulnerability

by

Melissa Marie Kelley

Doctor of Philosophy in Public Health

University of California, Los Angeles, 2017

Professor Anne R. Pebley, Chair

People are exposed to numerous chemicals daily through the products we use, the food we eat, and the air we breathe. This has been demonstrated by research that indicates virtually all people living in the industrialized world have numerous chemicals in their blood, which has led to growing scientific and public concern over the potential health implications of these exposures. Chemicals, such as phthalates, are a significant public health concern because decades of research have linked them to a wide range of health effects. This dissertation contributes to the literature by assessing how sociodemographic factors influence exposure to phthalate metabolites (Paper 1), and how exposures to phthalates individually (Paper 2) and in combination (Paper 3) affect antibody concentrations (i.e. titers) against organisms that cause infectious diseases.

This dissertation utilized data from five cross-sectional cycles of the National Health and Nutrition Examination Survey, a nationally representative sample of U.S. residents one year and

old, to prepare three dissertation papers. The first paper assessed how sociodemographic characteristics influenced exposure distributions with a focus on birthplace, age, and sex/gender differences. This study found that overall phthalate exposure has decreased for most metabolites examined between 2003 and 2012. While exposure to phthalates was ubiquitous, foreign-born persons generally had greater exposure compared to U.S.-born persons, particularly for low molecular weight (LMW) metabolites; males typically had greater risk of exposure to high molecular weight (HMW) phthalates; and young persons had greater overall exposure compared to adults.

The second paper tested associations between single phthalate metabolite and individual antibody measures against measles virus, mumps virus, rubella virus, poliovirus, Epstein-Bar virus, and *Toxoplasma gondii*. When examining the association between single metabolites and individual antibody measures, exposure to LMW phthalates was generally positively associated with measles, poliovirus, and Epstein-Barr virus antibodies, respectively. Conversely, HMW phthalates were inversely associated with both rubella and poliovirus antibodies. Males typically experienced immune enhancement while suppression was primarily observed in females.

Lastly, the third paper evaluated how co-exposures to phthalate influenced multiple antibody titers simultaneously. This was accomplished with structural equation modeling that showed LMW phthalate metabolites were associated with immune enhancement while HMW phthalates were associated with immune suppression with the exception of mono-ethyl phthalate. If associations are causal, exposure to HMW phthalates could increase a person's risk to infectious diseases while exposure to LMW phthalates could be immunoprotective, or they could increase susceptibility to autoimmunity and/or allergy.

This dissertation of Melissa Marie Kelley is approved.

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2017

DEDICATION

To everyone that has supported me along this journey…

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LIST OF ACRONYMS

Ab	Antibody
BMI	Body Mass Index
BPA	Bisphenol A
BzBP	Benzylbutyl phthalate
CAPI	Computer-assisted personal interview
CDC	Centers for Disease Control and Prevention
CMV	Cytomegalovirus
CRP	C-reactive protein
CRS	Congenital Rubella Syndrome
DBP	Dibutyl phthalates (also DnBP)
DEP	Diethyl phthalate
DEHP	Di(2-ethylhexyl)phthalate
DOP	Di-n-octyl phthalate
EBV	Epstein-Barr Virus
EDC	Endocrine-disrupting chemical/compound
EIA	Enzyme immune assay
ELISA	Enzyme-linked immunosorbent assay
EPA	U.S. Environmental Protection Agency
FIP	Family income-to-poverty ratio
HMW	High molecular weight
Ig	Immunoglobulin
IgG	Immunoglobulin G
IL	Interleukin
IU	International Units
LMW	Low molecular weight
MBzP	Mono-benzyl phthalate
MEC	Mobile Exam Units
MECPP	Mono-2-ethyl-5-carboxypentyl phthalate
MEHP	Mono-(2-ethyl)-hexyl phthalate
MEHHP	Mono-(2-ethyl-5-hydroxyhexyl)
MEOHP	Mono-(2-ethyl-5-oxohexyl)
MEOH	2-(N-Methyl-perfluorooctane sulfonamido) acetic acid
MEP	Mono-ethyl phthalate
MiBP	Mono-isobutyl phthalate
MnBP	Mono-n-butyl phthalate
MMR	Measles, mumps, and rubella vaccine
NCHS	National Center for Health Statistics
PPS	Probability proportionate to size
PSU	Primary sampling unit
NHANES	National Health and Nutrition Examination Survey
SES	Socioeconomic status
SSU	Secondary sampling unit
TNF	Tumor necrosis factor
TSCA	Toxic Substances Control Act

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CHAPTER 1:
INTRODUCTION

Problem Statement

The United States produces or imports 42 billion pounds of chemicals every day (Vogel and Roberts 2011). We are subsequently exposed to many of these chemicals through the products we use, the food we eat, and the air we breathe. Biomonitoring studies have confirmed this with research indicating virtually all people living in the industrialized world have numerous chemicals in their blood serum, which has led to growing scientific and public concern over the potential health implications from exposures (Betts 2007, Centers for Disease Control and Prevention 2017).

Numerous studies have demonstrated an association between chemical exposures and adverse health outcomes. However, our understanding of many outcomes, especially those related to immune function, are limited for political, biological, and scientific reasons. From a political perspective, United States regulations do not require chemical producers to generate or disclose information on health and environmental safety (Wilson, Chia et al. 2006). Thus, there is little to no testing of the health consequences of most chemicals in use today: fewer than 1% of the over 80,000 having been assessed for health risk (Briggs 2003).

Biologically, it can be difficult to assess the immune burden attributable to an individual chemical. For one, immune system components often have different dose-response ranges as well as differentially shaped dose-response curves. Therefore, a single chemical can produce any combination of immune dysregulation (suppression or enhancement), allergy, autoimmunity, and/or chronic inflammation over a range of exposure levels. Of the literature that exists, most has focused on immunosuppression or hypersensitivity with a lack of recognition of broader adverse outcomes (World Health Organization 2012). Further, vulnerable groups may experience differential health outcomes, which could be masked in population-level analysis of laboratory or epidemiology data. Also, structural as well as hormonal changes in immune development can lead to health risks in later-life effects from early-life exposure (Arlt and Hewison 2004, Ponnappan and Ponnappan 2010). Similarly, complex interactions between the endocrine and immune system can create sex-dependent differences (Klein, Jedlicka et al. 2010).

Because of the complexities previous noted, scientific research that exists has concentrated on measuring associations between single chemical congeners (i.e. structure similar compounds from the same family) and single health outcomes. Yet, people are exposed to thousands of chemicals concurrently each day. There is growing evidence that in combination chemicals can produce additive effects even when individual chemicals have no observable impact. Nevertheless, combination effects from co-exposures have not been thoroughly evaluated for most chemical classes (Howdeshell, Wilson et al. 2008, U.S. Consumer Product Safety Commission 2014).

While the exact burden of disease from chemical exposures is unknown, the World Health Organization estimates up to 25% of all diseases are from prolonged exposure to environmental pollutants (United Nations Environment Programme 2006). With over 1,000 new chemicals produced every year (U.S. Environmental Protection Agency 2003), emerging public health threats are omnipresent. Thus, there is a need to better understand exposure distributions; health outcomes associated with exposure (both individually and overall); and the physical as well as social situations that generate, mediate, and/or modify chemical-related diseases.

This dissertation examines exposures to and potential immunological health effects associated with phthalate. Phthalates are important chemicals to study because they are the most widely used plasticizer worldwide for products, such as clothing, food packaging, and toys.

Besides being used as plasticizers, phthalates are utilized as solvents and additives in consumer goods, such as flooring, furniture, construction materials, cosmetics, personal care items, and pharmaceuticals (Serrano, Braun et al. 2014). Due to their chemical properties, phthalates are susceptible to leaching resulting in significant exposure to those that come in contact with them (Heudorf, Mersch-Sundermann et al. 2007, Zota, Calafat et al. 2014).

There is growing concern over exposure to phthalates as numerous experimental and epidemiological studies suggest their association with a range of health effects, such as development toxicity (Mergler 2012), reproductive impacts (Swan 2008), cancer (Kamrin 2009, Lopez-Carrillo, Hernandez-Ramirez et al. 2010), allergies (Kimber and Dearman 2010, Callesen, Bekö et al. 2014), asthma (Bornehag and Nanberg 2010), thyroid dysfunction (Meeker and Ferguson 2011), and endocrine disruption (Huang, Saxena et al. 2014). Experimental studies have found an association between various immune measures in animal and cell models (Dearman, Betts et al. 2009, Kimber and Dearman 2010, Hansen, Bendtzen et al. 2015, Hansen, Nielsen et al. 2015, Robinson and Miller 2015), however, very little is known about the effects of phthalates on immune response in humans. To date, no research exists on the association between phthalate exposure and antibodies for infectious diseases. Understanding how phthalates influence the immune system is important as immune dysregulation can increase risk for infectious diseases and cancer, allergy, autoimmunity, and/or chronic inflammation. These conditions are a public health concern because they can lead to significant levels of morbidity and mortality in the U.S. and around the world.

To explore these potential affects, five cross-sectional waves (2003-2012) of secondary data from the National Health and Nutritional Examination Survey (NHANES), a nationally representative sample of U.S. residents, will be used to address the research aims listed below.

Research and Specific Aims

There is growing evidence from experimental and epidemiological studies that phthalates affect the immune system (Heudorf, Mersch-Sundermann et al. 2007, DeWitt, Shnyra et al. 2009, DeWitt, Peden-Adams et al. 2012, DeWitt, Peden-Adams et al. 2014, Hansen, Nielsen et al. 2015, Robinson and Miller 2015), which is of significant public health concern. Although some studies have been conducted on phthalates, much of this research is limited by small sample sizes and/or is narrowly focused on developmental and reproductive consequences (Hauser and Calafat 2005). Furthermore, immune studies have been primarily limited to cell culture and animal experiments. Thus, there is a gap in the literature concerning human health impacts from low-dose, routine exposures to phthalates, especially as it relates to immune function. Additionally, methodological issues and selection bias from many studies limit generalizability at large or to specific population segments.

This dissertation seeks to address these knowledge gaps by using data from a large, representative population survey to develop three papers. It will contribute to the literature by assessing how social and biological factors influence exposure to phthalate metabolites (Paper 1), and how exposures to phthalates individually (Paper 2) and in combination (Paper 3) affect antibody titers against organisms that cause infectious diseases. Five cross-sectional waves of data (2003-2012) from the continuous NHANES (N=50,019) are utilized to prepare three dissertation papers. Analyses assess nine phthalates metabolites collected in urine samples and eleven antibody titers (i.e. concentrations) collected in blood samples for the infectious agents: measles virus, mumps virus, rubella virus, poliovirus, Epstein-Barr virus, and *Toxoplasma gondii*.

Main Study Research Question and Hypotheses

The overarching research question driving this dissertation is: do phthalates influence the immune system, and if so, in what direction and with what populations? This study hypotheses that: 1) exposure to phthalates, both individually and in combination, is associated with immunomodulation (i.e. modulation of immune response); and 2) some sociodemographic subgroups have increased risk for immunomodulation from these chemicals. These hypotheses are investigated with three research aims:

Research Aims

1) Assess the role of sociodemographic characteristics and social processes on concentrations of phthalate congeners between 2003 and 2012.

Specific Aims

1a. Describe exposure trends to phthalate congeners among birthplace, sex, and age subgroups.

1b. Determine if birthplace, sex, and/or age is associated with concentrations of phthalate congeners.

1c. Among foreign-born persons, examine the role of years lived in the U.S. on concentrations of phthalate congeners.

1d. Among Hispanics in the 2003-2004 data wave, examine the role of parental place of birth on concentrations of phthalate congeners.

2) Evaluate associations between concentrations of individual phthalate congeners and individual antibody titers, and if any of these associations vary by birthplace, sex and/or age.

Specific Aims

2a. Examine associations between concentrations of individual phthalate congeners and individual antibody titers for measles virus, mumps virus, rubella virus, poliovirus, Epstein - Barr virus, and *Toxoplasma gondii*.

2b. Assess if potential dose-response relationships exist for any associations in 2a.

2c. Assess if any of the associations in 2a or 2b vary by birthplace, sex, and/or age subgroups.

3) Investigate how co-exposures of phthalate congeners affect both individual as well as total antibody titers, and whether any of these associations vary by birthplace, sex, and/or age.

Specific Aims

3a. Examine associations between concentrations of individual phthalate congeners and total antibody titers for measles virus, mumps virus, rubella virus, poliovirus, Epstein - Barr virus, and *Toxoplasma gondii*.

3b. Examine associations between concentrations of more than one phthalate congeners and total antibody titers for measles virus, mumps virus, rubella virus, poliovirus, Epstein - Barr virus, and *Toxoplasma gondii*.

3c. Assess if any of the associations in 3a and 3b vary by birthplace, sex, and/or age subgroups.

CHAPTER 2:
BACKGROUND

Chemical Policy and Regulation

The first policy enacted to protect human and environmental health in the United States was the Toxic Substances Control Act (TSCA) in 1976. However, weaknesses in the law led experts and policymakers to agree the TSCA had many shortcomings. For example, it did not require chemical producers to generate or disclose information on health and safety for new or legacy substances (Wilson, Chia et al. 2006). When it was enacted, it grandfathered approximately 62,000 existing chemicals from regulatory scrutiny unless the Environmental Protection Agency (EPA) could demonstrate an "unreasonable risk." Chemicals created or modified after 1976 – an estimated 12,000 – were subject to pre-manufacture authorization by the EPA. But, this process did not obligated manufacturers to generate toxicological data as part of the application process, thus, 85% of applications had missing information on health effects (Hall, Iles et al. 2012). Further, if the EPA suspected potential health risks, it only had 90 days to request additional information before a chemical could go onto the market. But, the EPA could only request this information if it already had sufficient data to justify the request (Silbergeld, Mandrioli et al. 2015). If a manufacturer had no information, to start with, it then had nothing to submit to the EPA, which "must take what is given" (Silbergeld, Mandrioli et al. 2015). Since the EPA cannot deny any approval of a chemical because it lacked information, almost all were approved. Additionally, TSCA's proprietary provisions allowed nearly 20% of all chemicals and their properties to remain trade secrets (Layton 2010).

Even when there was evidence of health and safety concerns, the regulatory process was extensive with a high burden of proof. For instance, it took almost ten years of risk assessments on asbestos before the EPA issued a regulation to ban all uses in 1989. Asbestos producers subsequently sued, and the Fifth Circuit Court of Appeals ruled in 1991 the EPA failed to meet TSCA's burden of proof of "unreasonable risk" and only allowed regulation and banning of some of its uses (Vogel and Roberts 2011). Since its inception, less than 200 chemicals have ever been reviewed for human health risks of which only five – polycholorinated biphenyls (PCBs), chlorofluorocarbons, dioxin, asbestos and hexavalent chromium – have some types of control. Of those, only PCBs and asbestos have been banned to some degree through TSCA (Hall, Iles et al. 2012). Therefore, the EPA primarily has relied on voluntary programs to evaluate health risk and control chemicals suspected or deemed dangerous.

There have been attempts to reform the TSCA since the 1970s, but all failed to gain bipartisan support until recently. In June 2016, the Frank R. Lautenberg Chemical Safety for the 21st Century Act (LCSA) was signed into law to amend the TSCA. The law addresses much needed regulatory improvements, such as:

- Mandatory risk-based evaluation of new and existing chemicals
- Increased transparency of chemical information available to the public
- Protection of vulnerable populations, like pregnant women and children
- Establishment of an independent scientific advisory board
- Timelines for EPA decisions and actions
- Consistent sources of funding to aid the EPA in fulfilling its obligations under the new law (Environmental Protection Agency 2017)

Since most of the new requirements of the LCSA are being phased in over the coming years, it is too soon to know the impact of these new policies on human and environmental health.

Internationally, regulatory practices historically have been weak, like U.S. policy, but improvements have been made abroad. In 2006, a more comprehensive approach to chemical management was passed with the Registration, Evaluation, Authorisation, and Restriction of Chemical (REACH) policy by the European Union (Wilson and Schwarzman 2009). Over the following ten year, REACH provisions are being phased in requiring information gathering from manufacturers and shifting the burden of proof that substances are safe from governments to chemical producers. Similar efforts to overhaul regulation have occurred in other countries, such as Russia, Malaysia, Japan, Australia, Turkey, China, Canada, and South Korea as well as in individual U.S. states, like California, Maine, Wisconsin, and Washington. Not only is there a general perception of the inadequacy of existing regulation to manage public health risks, but an increasing interest in sustainability, or green chemistry, to spur reform (McEldowney 2016).

Since numerous products are imported into the U.S. - from building materials to food - international regulations affects chemical exposure in the U.S. Further, those who immigrate not only bring themselves but their biological histories of exposure and any potential life-long health outcomes associated with these exposures.

Phthalates

Phthalates are synthetic chemicals introduced in the 1920s. Since the introduction of di(2-ethylhexyl)phthalate (DEHP) in 1933, phthalates have been the most widely used plasticizer (i.e. additive that increases a material's fluidity) worldwide. Specifically, phthalates are often used in polyvinyl chloride plastics (PVC) for clothing, bags, food packaging, toys, and hoses/tubing. Besides plasticizers, they are utilized as solvents and additives in many consumer products, such as flooring, furniture, construction materials, cosmetics, personal care items, pharmaceuticals, and pesticides (Frederiksen, Skakkebaek et al. 2007).

Phthalates are generally classified into two groups based on the number of carbons in the their alcohol chain as either low molecular weight (LMW) or high molecular weight (HMW) phthalates. LMW phthalates, such as dibutyl phthalates (DBP) and diethyl phthalate (DEP), are widely used as additives to make varnishes; lacquers; and cosmetic products including perfumes, aftershaves, shampoo, makeup, lotions, and nail products. HMW phthalates, like DEHP, di-n-octyl phthalate (DOP or DnOP) and benzylbutyl phthalate (BzBP), are more commonly utilized as plasticizers for industrial and consumer products, such as flooring, paints, imitation leather, food storage containers, and medical devices (Frederiksen, Skakkebaek et al. 2007, Swan 2008).

Once phthalates are in the body, they are rapidly broken down into metabolites within hours to weeks depending on their molecular size. Phthalate metabolites, also known as phthalate diesters, are typically utilized as biomarkers of exposure instead of the parent chemical because: 1) they are considered the more biologically active molecule, and 2) lab equipment is often made with the parent compound and studying metabolites reduces contamination risks (Hauser and Calafat 2005). Phthalate metabolite biomarkers collected in urine samples are used in this dissertation (Table 1).

Some of the common phthalates in use today are DEHP, BzBP, DOP, DEP, and DBP. DEHP is the most widely used phthalate and is frequently employed in building material, clothing, and medical devices. It is also found in food packaging/storage containers and in some children's toys, but food and medical devices are thought to be the largest sources of exposure. Once in the body, it is transformed into several oxidative metabolites notably MECPP, MEOHP, MEHHP, and MEHP. Another common phthalate is BzBP, which is the parent compound of MBzP. It is a common plasticizer in vinyl flooring, adhesives, car-care products, toys, imitation leather, solvents, and personal care products. DOP is another HMW phthalate, and it is the parent compound of metabolite McPP. It has similar uses as BzBP, but it also used in medical equipment, bags, and tubing like DEHP. DEP is the most commonly used LMW phthalate; it is typically in personal care products and cosmetics, pharmaceuticals as coatings, dyes, and insecticides. MEP is the metabolite of DEP. Lastly, DBP is oxidized into two metabolites:

MnBP and MiBP. Similar to DEP, it is used in cosmetics and pharmaceuticals as coatings as well as in lacquers and varnishes (Hauser and Calafat 2005, Heudorf, Mersch-Sundermann et al. 2007, Ferguson, Loch-Caruso et al. 2011).

Table 1. Phthalates and their general uses.

Phthalate Name	Abbreviation	Urinary Metabolite Name	Metabolite Abbreviation	General Uses
Low Molecular Weight				
Diethyl phthalate	DEP	Mono-ethyl phthalate	MEP	Personal care products and cosmetics; pharmaceuticals coatings, dyes; perfume solvents; medical tubing; car parts; insecticides
Dibutyl phthalates	DBP or DnBP	Mono-n-butyl phthalate	MnBP	Cosmetics and pharmaceuticals coatings; lacquers and varnishes
		Mono-isobutyl phthalate	MiBP	
High Molecular Weight				
Di-n-octyl phthalate	DOP	Mono-(3-carboxypropyl) phthalate	McPP	Medical equipment, bags, and tubing
Benzylbutyl phthalate	BzBP	Mono-benzyl phthalate	MBzP	PVC, vinyl flooring, adhesives, car-care products, toys, imitation leather, solvents, personal care products
Di-2-ethylhexyl phthalate	DEHP	Mono-2-ethylhexyl phthalate	MEHP	PVC, building material, clothing, medical devices, food packaging; toys
		Mono-(2-ethyl-5-hydroxyhexyl) phthalate	MEHHP	
		Mono-(2-ethyl-5-oxohexyl) phthalate	MEOHP	
		Mono-(2-ethyl-5-carboxypentyl) phthalate	MECPP	

Phthalate Exposure

Phthalates have a carbon ring structure that give them high boiling points, low volatility, and lipophilicity (i.e. the ability to dissolve in oils). This structure endows them strength, transparency, flexibility, and durability – all valuable characteristics for many consumer products – leading to their widespread application in various products. Since they are not covalently bound to the matrix, however, this makes them susceptible to leaching, migration, or evaporation (Staples, Peterson et al. 1997, Heudorf, Mersch-Sundermann et al. 2007). This can result in significant exposure directly, indirectly through leaching, or through general environmental contamination (Heudorf, Mersch-Sundermann et al. 2007).

While phthalates can concentrate in human fat, they usually degrade and/or are metabolized within hours to days of exposure and excreted in urine or feces (Meeker, Sathyanarayana et al. 2009). Even though are they eliminated quickly, within-person variability studies have shown both women and men have sufficiently stable levels day-to-day and month-to-month to presume exposure is typically consistent and ever present (Hoppin, Brock et al. 2002, Hauser, Meeker et al. 2004). However, variations in diet, daily activities, and/or use of personal care products can increase or decrease exposure over time.

Exposure to phthalates occurs via ingestion, inhalation, and absorption throughout the life course. While sources of exposure are diverse given the broad utilization of phthalates in consumer and industrial applications, household dust, indoor air, drinking water and food have all been reported as primary sources of exposure (Meeker, Sathyanarayana et al. 2009, Ait Bamai, Shibata et al. 2014, Larsson, Ljung Björklund et al. 2014, Ashley-MJ, Dodds et al. 2015, Cerna, Maly et al. 2015). In particular, food is hypothesized as the leading source of exposure, especially for HMW phthalates; they have been detected in common food products, such as cereals, bread, cakes, nuts, spices, butter, and oils (Main, Mortensen et al. 2006, Frederiksen, Skakkebaek et al. 2007). Phthalate contamination can occur during processing, handling, packaging, and storage. Besides food, other phthalates contribute to LMW exposures (Wittassek, Koch et al. 2011).

Role of the Physical Environment in Exposure

Understanding what drives the fate and transport of chemicals, such as phthalates, in the physical and social environments – how and where, in what form, and in what concentration pollutants are distributed – can help elucidate potential relationships between exposure and health outcomes. Fate and transport of a chemical in the physical environment is influenced by various physical, chemical, and biological mechanisms. Physical mechanisms are defined as processes that transport or disperse chemicals throughout environmental compartments. Chemical influences are defined as transformative reactions that generate new substances. These include oxidation-reaction, acid-base, and free radical reactions. Biological influences are defined as physiological interactions or metabolic changes associated with receptor organisms, which also produce chemical influences. Of concern are biodegradation and bioaccumulation of chemicals, which may reduce or amplify their health impacts, respectively (Suffet 1977). Physical, chemical, and biological processes control the concentration of a chemical in space and time.

Numerous physical processes can influence the transportation and dispersion of phthalates. As noted previously, phthalates are not chemically bond to the products they are in and thus readily mitigated. Once released from their source(s), they can migrate to different environmental compartments. Phthalates can move either within a given compartment or between compartments. For example, dry and/or wet deposition may remove them from the air and deposit them on the land or in water. Infiltration and leaching can bring phthalates in soil into water, and the Wick Effect can bring phthalates from the soil into the air. The degree to which a particular substance favors a given transport pathway depends on the form of the chemical released, its physical state, and the nature of any particulate matter to which it might adsorb upon or be released from.

Wherever they are, phthalates can be subject to chemical transformation, which can change their composition and consequentially their fate. Transformation may include degradation reactions that break a congener down into multiple subspecies. Environmental transformation is critical to consider when addressing exposure to environmental pollutants because it can increase or decrease the toxicity of a compound. Phthalates are susceptible to photodegradation (i.e. altered by light) and biodegradation (i.e. breakdown by organisms) (Liang, Zhang et al. 2008, Barreca, Indelicato et al. 2014), therefore, they do not persist for periods beyond a few days to weeks in outdoor environments (Rudel and Perovich 2009).

Phthalates are ubiquitous in the outdoor environment and have been found in the air, water, sediment, and soil. In particular, DEPH, a HMW phthalate, is most often present and typically most abundant (National Research Council 2008). Urban and suburban areas tend to have higher concentrations compared rural or remote locations (Bergé, Cladière et al. 2013) because of a greater concentration of consumer and industrial products in the built environment. Thus, the built environment – the man-made surroundings where we live and work – plays a role in vulnerability and exposure to phthalates. However, they have found in remote regions of the global without an identifiable source supporting the hypothesis of their atmospheric transport and deposition (Xie, Lakaschus et al. 2006).

Despite their presence outdoors, studies have found phthalate concentrations are typically higher in the indoor environment (Rudel, Camann et al. 2003, Heudorf, Mersch-Sundermann et al. 2007, Wang, Tao et al. 2014). While it has been difficult to definitively link any particular items or processes, research has found higher temperatures increase air concentrations of phthalates (Clausen, Liu et al. 2012, Bergé, Cladière et al. 2013, Bi, Liang et al. 2015) as does vinyl flooring and other plastic consumer products (Bornehag, Sundell et al. 2004, Bornehag, Lundgren et al. 2005, Bornehag and Nanberg 2010, Bi, Liang et al. 2015).

Role of the Social Environment in Exposure

Health consequences from pollution not only depend on the coincidence of both emission and dispersion processes that determine where and when pollutants occur in the physical environment, but also on the social conditions that determine where and when people occupy those same locations. These social conditions include a variety of compositional and contextual factors that involve a person's relationship to others (Link and Phelan 1995). The link between social conditions and health outcomes is widely recognized in the public health literature (Marmot 2005, Marmot, Friel et al. 2008, Ramirez, Baker et al. 2008). Moreover, it is increasingly understood that inequitable distribution of these determinants, such as income, education and access to care, is a significant contributor to persistent and pervasive health disparities (Ramirez, Baker et al. 2008).

Many disparities in social conditions affect groups that have been historical marginalized because of social characteristics, such as socioeconomic status (SES), race/ethnicity, age, gender, geographic location, or some combination of these (Marmot 2005). For example, communities with high unemployment; poor housing; increased environmental exposures; and reduced access to medical, governmental, and transportation services have all been associated with increased incidence or risk for disease (Hillemeier, Lynch et al. 2004). Temporal effects are also apparent as poverty and deprivation in early childhood influences health and development, which can have negative health consequences for the entire life course (Hornberg and Pauli 2007). In spite of the factors already identified, many inequalities in health outcomes remain unexplained.

Proposed processes by which social determinants influence health outcomes are diverse. Relevant theoretical frameworks that specifically address the social aspects of chemical-related health outcomes include social causation and the life course perspective, among others. The social causation perspective suggests that social position determines health through multiple intermediary factors, which are unevenly distributed by socioeconomic class. These factors can be divided into three main groups: material factors (e.g., housing), psychosocial factors (e.g., stress responses), and behavioral factors (e.g., diet, exercise, risk taking)(Whitehead and Dahlgren 2007). A more in-depth discussion of theoretical perspectives is provided in Chapter 3.

Factors Influencing Exposure to Phthalate

Exposure to phthalates is a complex and multi-faceted. Because the mechanism of potential exposure are so numerous, this dissertation only examines important factors from a person's biological, physical, and social background that are included in the NHANES datasets.

Age

While exposure studies have focused on individual characteristics, like age, race/ethnicity and gender (Braun, Sathyanarayana et al. 2013, Zota, Calafat et al. 2014), much of the literature has focused on the role of age in exposure (Göen, Dobler et al. 2011, Larsson, Ljung Björklund et al. 2014, Cerna, Maly et al. 2015). Studies have found exposure risks to vary by age, but children generally have greater exposure compared to adolescents and adults (Wittassek, Koch et al. 2011, Huang, Tsai et al. 2015).

Pathways of exposure have been shown to differ by age (Wormuth, Scheringer et al. 2006). For example, infants are exposed *in utero* and once born through hospital equipment as well as food, such as breast milk, formula, and baby food (Wittassek, Koch et al. 2011). During infancy, baby lotions, powders, and shampoos are likely sources (Braun, Sathyanarayana et al. 2013). Young children and adolescents are often exposed through toys and personal care products, while adults are most likely exposed through food and cosmetics/personal care products (Frederiksen, Skakkebaek et al. 2007). In particular, MEP concentrations in adolescents and adults are consistent with behavioral uses of phthalate-containing consumer goods, like perfumes/colognes, hair products, and cosmetics (Braun, Sathyanarayana et al. 2013). However, the absolute contribution of each source is largely unknown (Wormuth, Scheringer et al. 2006). Besides behaviors that contribute to exposure, the physical environments can drive exposure. Children are more likely to crawl on vinyl flooring and put things, especially plastics, in their mouth. They are also more likely to occupy indoor environments, which can concentration phthalates in the air, dust, and on surfaces (Silva, Barr et al. 2004, Braun, Sathyanarayana et al. 2013).

Due to health concerns over phthalates and generally higher exposure risks in children, some regulation has been in enacted in the U.S. to curb human exposure. Currently, six types of phthalates are regulated in the U.S. according to the Consumer Product Safety Improvement Act of 2008. DEHP, DBP, and BBP have been permanently banned in any amount greater than 0.1% in children's toys and articles that facilitate sleeping or feeding. DINP, DIDP, and DnOP have been banned in any amount greater than 0.1% in the interim in children's toys that can be placed in a child's mouth (U.S. Consumer Product Safety Commission 2015). Protection of children is important because of potential effects on development and because they typically exhibit higher exposure to phthalates compared to adults.

Gender

Studies have shown that men and women may have unique exposure profiles to phthalates (Latini 2005). Both gender and sex influence exposure; the influences of gender are discussed first followed by an examination of the role of sex. Men generally have higher concentrations of phthalates in their bodies, but exposure risks can vary by phthalate congener. For example, women usually have higher levels of MEP compared to men, which is most likely attributable to women's increased use of personal care products, such as hair care products, cosmetics, and perfumes (Silva, Barr et al. 2004, Braun, Sathyanarayana et al. 2013, Huang, Tsai et al. 2015). Women have also been found to have higher DiBP, BBzP,DEHP, and DiNp (Wittassek, Wiesmuller et al. 2007), however, a study from China showed no difference by gender in MEP (Guo, Wu et al. 2011). At present, it is unknown if differences in concentrations are related to gendered exposures and/or sex-differentiated biological reasons.

Exposure differences are linked to social and physical environments as well as behaviors, beginning in childhood. For example, a study of children of farm workers showed boys were in more frequent contact with their environment compared to girls but girls had longer duration with objects in their environment (Beamer, Key et al. 2008). Similarly, a study of children living near dumpsites observed boys roaming contaminated sites more than girls (Steegmann and Hewner 2000). As adults, men and women also have different hobbies, work, household activities, which result in diverse exposures (Mergler 2012).

Sex

Biological difference can influence chemical absorption, metabolism, and excretion (Mergler 2012). While no studies to date have examined sex-differences in exposure, other literature exists on environmental chemicals that demonstrate this to be a plausible pathway. Absorption between males and females could be influenced by differences in condition of the skin, degree of perspiration, number of hair follicles, breathing rates, and respiratory volume can also influence absorption and likely differ between men and women (Arbuckle 2006). For example, dermal absorption of trichloroethylene *in vitro* has been shown to be two-fold greater in female than in male rats with testosterone playing a role in decreasing penetration (McCormick and Abdel-Rahman 1991). Similarly, males and females differ in minute ventilations and tidal volumes and overall lung size (Arbuckle 2006), which could change the amount of phthalates inhaled.

Once chemicals are absorbed, they are transported, metabolized, and either stored or excreted. The rate and duration chemicals are in our bodies can be influenced by sex as women on average have a lower body weight, higher fat composition, smaller plasma volume, and lower average organ blood flow than men (Soldin and Mattison 2009). Sex hormones also impact the binding of chemicals to proteins, thus, leading to variations in pharmacokinetic parameters for certain chemicals (Arbuckle 2006). Sex differences have been observed in disposition and toxicity of lead, arsenic, and methylmercury (Vahter, Åkesson et al. 2007). Depending on how the chemical is metabolized, rates of clearance may vary by sex. Although sex and gender may have different effects, the NHANES only measures the self-reported response to the question on sex, which is more likely to measure gender instead of biological sex.

Birthplace

While no research to data exists on the association between birthplace and phthalate exposure, there is literature on differences in places of residence and exposure. The following brief review will explore this dimension of exposure as a proxy to factors of naivety. When comparing studies from NHANES, German Environmental Survey, Canadian Health Measures Survey, Korean Environmental Health Survey, Consortium to Perform Human Biomonitoring on a European Scale, Taiwan Environmental Surveys for Toxicants and various Danish studies, environmental chemical exposures differ by country, lifestyles, and sources of exposure (Huang, Tsai et al. 2015). Studies on different populations have shown the type and concentration of phthalate exposure differs geographically too. For example, comparing U.S. and German populations found median levels of MBP and MEHP were higher in Germans but MEP concentrations were lower compared to Americans (Silva, Barr et al. 2004). Furthermore, a comparison of general populations from Taiwan, Canada, and the U.S. found MEHP to be higher in the Taiwanese populations compared to the U.S. but MEHP and MnBP to be compared in the U.S. and Canada (Huang, Tsai et al. 2015). In a study of pre-adolescent Egyptian girls, the authors found both urban and rural residents had relatively similar concentrations of some urinary phthalates to U.S. girls, except significant differences in MBzP and MiBP. Differences in daily social and behaviors lifestyle were noted as possible explanations in observed findings, such as use of plastics in food storage and vinyl floor use (Colacino, Soliman et al. 2011).

Besides between country variations, regions within a country have shown to be different. In Spain, region of residence was associated with most concentrations of phthalate metabolites and three phenols (Casas, Fernández et al. 2011). The authors hypothesized different geography, climatology, and even population lifestyle habits, as well as having different social class and education groups, might drive these exposure patterns (Casas, Fernández et al. 2011). Further, studies have found regional variation in China and central Italy possibly due to differences in industrial pollution, lifestyle, and socioeconomic status (Bai, Wittert et al. 2015).

Race/ethnicity

Studies have documented varying urinary phthalate concentrations in different race/ethnicity groups. For instance, Silva et al. found non-Hispanic black children had nearly double MEP concentrations of those for non-Hispanic black adolescents and adults, and non-Hispanic blacks had much higher MEP concentrations than any other race/ethnicity groups studied for all ages (Silva, Barr et al. 2004). Furthermore, phthalate metabolite concentrations varied across major ethnic groups in another study with blacks having the highest levels of MEP, MnBP, MiBP, MBzP, and ∑DEHP and whites having the highest MCPP levels. Mexican-Americans had higher urinary concentrations of MnBP and MiBP than whites (Huang, Saxena et al. 2014). Non-Hispanic blacks also had higher concentrations of all metabolites compared to Mexican Americans and non-Hispanic whites had lower concentrations of LMW metabolites but higher concentrations of HMW metabolites (Trasande, Attina et al. 2013). Race/ethnic differences were also observed in a study of women and feminine hygiene practices. Black women had higher phthalate metabolite levels and reported more feminine hygiene product use compared to white and Mexican American women (Branch, Woodruff et al. 2015). Differences between black and white women in MEP concentrations disappeared when controlling on frequency of douching, but higher concentration between Mexican American and white women remained suggesting that other sources of exposure exist for Mexican American women (Branch, Woodruff et al. 2015).

Authors speculated that differences seen in black populations are primarily due to increased, continuous, or prolonged use of cosmetic and hair care products specifically marketed for this population, which often beginning with young children (Silva, Barr et al. 2004, Trasande, Attina et al. 2013, Branch, Woodruff et al. 2015). A study on endocrine disrupting chemicals supports such claims with evidence of chemical exposure from hair products varied by race/ethnicity, in particular, they found African-American and African-Caribbean women to have the highest proportion of hair product use (James-Todd, Senie et al. 2012). A study by Romero-Franco et al. of Mexican women also found increased number of personal care products was positively associated with MEP concentrations and LMW phthalates (Romero-Franco, Hernandez-Ramirez et al. 2011, Trasande, Attina et al. 2013). Race differences in MEP and MBP levels, where blacks and Hispanics men had higher concentrations than whites men, were associated with specific personal care product use, in particular cologne and aftershave (Duty, Ackerman et al. 2005).

SES

Relatively little is known about the association between socioeconomic factors and phthalate exposure in the general population (Kobrosly, Parlett et al. 2012). In a Spanish study, social class and education were positively related to concentrations of some of the phthalate metabolites and phenols (Casas, Fernández et al. 2011). A study by Kobrosly et al. found higher education levels were associated with higher DEPH concentrations as well as education and income difference in MBzP exposure (Kobrosly, Parlett et al. 2012). Extensive evidence does link socioeconomic variables with personal behaviors, notably diet (Deshmukh-Taskar, Nicklas et al. 2007, Northstone, Emmett et al. 2008, Colacino, Harris et al. 2010, Kobrosly, Parlett et al.

2012). Also, occupational exposure differences could exist by SES. Blue-collar workers have been shown to have higher concentrations of DBP then the general population (Kwapniewski, Kozaczka et al. 2008, Hines, Nilsen Hopf et al. 2009). Financial restrictions could also explain differences in DBP and DEHP sources of exposure from medications, housing, and household products (Schettler 2006). While additional research is still needed to understand the role of SES in phthalate exposure, research has shown SES to be associated in general with the burdens of environmental chemical exposure (Tyrrell, Melzer et al. 2013).

BMI

Because of their lipophilicity, phthalates are able to dissolve and may concentrate in some oils and fats, but they have not been shown accumulate in adipose tissue in humans. Dietary intake is the primary route of exposure, therefore, the general consumption of more food increases risk of exposure. The association between obesity and eating more processed as well as packaged foods has been observed, which results in greater exposure to phthalates (Bai, Wittert et al. 2015). For example, most carbonated soft drink containers are made of or lined with plastics that contain phthalate that can leach into the fluid (Guo, Wei et al. 2010). Studies from NHANES data have shown an association between BMI and phthalate exposure (Stahlhut, van Wijngaarden et al. 2007, Hatch, Nelson et al. 2008, Zhang, Meng et al. 2014).

Smoking

It is not known if smoking is directly related to phthalate exposure. Cigarettes contain thousands of chemicals, and complex chemical interactions can occur in the smoke. DBP is a listed ingredient in the filters of Phillip Morris cigarettes (Duty, Ackerman et al. 2005), but other manufacturers may not include phthalates in their products. One study found an association between current smoking and MBP concentrations but not for other phthalate metabolites examined (Hoppin, Ulmer et al. 2004). Similarly, an association was seen between MEP and current smoking (Duty, Ackerman et al. 2005). Other research found DEP and DEHP in e-cigarette liquids (Oh and Shin 2015) as well as DiBP (Hutzler, Paschke et al. 2014). Additional research is necessary to understand if smoking, whether traditional cigarettes or e-cigarettes, is a risk factors for phthalate exposure.

Health Effects Associated with Phthalates

Research has shown that members of the phthalate group have unique chemical and physical properties; some research suggests they may also produce differential toxicological effects. Despite a significant volume of research however, data at present is not sufficient to explain the range of biological impacts and whether some phthalates are similar enough to have an additive impact (Kamrin 2009).

High-dose animal studies suggest phthalates may induce liver cancer through the peroxisome-proliferator activated receptor (PPARs). Since this pathway is not as prominent in human health as it is in rodents, some scientist do not believe this to be a plausible mechanism of cancer causation (Kamrin 2009). Besides liver cancer, changes in liver enzyme activity, histology, and increased liver weight have been observed in animals exposed to DOP (Poon, Lecavalier et al. 1997) and DEHP (Wormuth, Scheringer et al. 2006).

While focus was initially on hepatic effects of phthalates, much attention has been given to the reproductive and developmental effects of phthalates (Earl Gray, Wilson et al. 2006, Wormuth, Scheringer et al. 2006). Phthalates are suspected of having endocrine disrupting or modulating effects as they interfere with functions of the endocrine system, namely growth, sexual development and essential biological functions (Latini 2005). Reproductive impacts in rodent studies from DEHP, DBP, and BzBP have been found to reduce fetal testosterone production, sperm count, anogenital distance, hypospadias, and fertility (Swan 2008, U.S. Consumer Product Safety Commission 2014). Human studies have found an association between phthalates and anti-androgenic effects, although, their impacts have been understudied to date.

Neurodevelopment has also been a major focus of phthalate research. Animal studies have shown that phthalates might cause hyperactivity similar to symptoms of attention-deficit/hyperactivity disorder (Masuo, Morita et al. 2004) and autism (Ye, Leung et al. 2017). Several studies in humans found phthalate exposure and associations with poorer neurodevelopmental test scores to DEHP, DBP, and DEP metabolites among girls and boys (Engel, Zhu et al. 2009, Kim, Ha et al. 2011, Whyatt, Liu et al. 2012).

Besides linkages to hepatotoxic, teratogenic and carcinogenic affects, epidemiological studies have found associations between phthalates and pulmonary function (Park, Kim et al. 2013, Cakmak, Dales et al. 2014), thyroid function (Huang, Pan et al. 2017, Morgenstern, Whyatt et al. 2017, Park, Choi et al. 2017, Weng, Chen et al. 2017, Wu, Zhou et al. 2017), asthma (Bornehag and Nanberg 2010, Bertelsen, Carlsen et al. 2013, Franken, Lambrechts et al. 2017), and allergies (Bornehag, Sundell et al. 2004, Callesen, Bekö et al. 2014, Bekö, Callesen et al. 2015). Phthalates are also suspected to influence immune system function, which are the focus of this dissertation. Below is a review of research to date on the association between phthalates and immunomodulation.

Phthalates and Immunomodulation

Few studies have examined the effects of phthalates on immune function, most of which are *in vitro* or *in vivo* laboratory experiments. One study found exposure to DnBP and DEP impaired cytokine secretion from monocytes and macrophages interfering with both innate and adaptive immune response (Hansen, Nielsen et al. 2015). Other studies suggested that phthalates influence immunoglobulin production, cytokine secretion from T helper cells, enhance enzyme and histamine release, and increase phagocytic ability in cells from the innate immune system (Bornehag and Nanberg 2010, Hansen, Bendtzen et al. 2015). Similarly, mice exposed to DEHP had increased concentrations of immunoglobulin (Ig) IgE, IgG, and several interleukins (Robinson and Miller 2015).

Of the epidemiological research that exists on phthalates, most concern allergic conditions and hypersensitivity. Several studies have found an association between phthalates in dust and allergic symptoms, such as wheezing, rhinitis, eczema, and asthma (Kolarik, Naydenov et al. 2008, Just, Whyatt et al. 2012). For example, a Swedish study found a positive association between benzyl butyl phthalate (BBzP) dust concentrations and allergies as well as DEHP concentrations and asthmatic symptoms (Bornehag, Sundell et al. 2004). Studies have also seen differences by age groups. In research on allergic symptoms and sensitization in children and adults in the U.S., HMW phthalates were positively associated with allergies in adults but not children (Hoppin, Jaramillo et al. 2013). However, another study with children 3-5 years found no association between phthalate exposure and asthma, rhinoconjunctivitis or atopic dermatitis (Bekö, Callesen et al. 2015). While no clear patterns have emerged, it appears some phthalates congeners may potentially modify immune responses, at least in certain populations under defined conditions.

Multiple Exposures to Chemicals and Immunomodulation

As noted previously, most studies typically focus on a single chemical and single outcome. In reality however, people are exposed to thousands of chemicals simultaneously which can be associated with any number of health effects. Ignoring this complexity can lead to an underestimation of the health effects of a chemical congener and/or chemical class. The scientific community has advocated for assessments that focus on the health risks posed by multiple chemicals over multiple pathways (National Research Council 2008), but the availability of statistical techniques and/or programming to analyze this type of data were limited until recently.

To date, combination effects from exposure to numerous phthalates have not been thoroughly evaluated (Howdeshell, Wilson et al. 2008, U.S. Consumer Product Safety Commission 2014). For epidemiological studies, structural equation modeling (SEM) has become increasing popular to evaluate simultaneous associations from multiple chemicals that could operate through more than one pathway. One study utilized SEM to model the association between phthalate metabolites and general biological indicators in infants in a neonatal intensive care unit (Weuve, Sanchez et al. 2006). Other chemicals, such as polycyclic aromatic hydrocarbons (PAH), cadmium, lead, mercury, polychlorinated biphenyls (PBCs), and perfluoroalkyl substances (PFASs), have been studied with this analytical technique. The use of SEM to study immunomodulation from chemical exposure is also limited. Two studies have examined the association between co-exposures to PFASs and multiple antibody titers. Research by Grandjean et al. found concentrations of PFASs where inversely associated with overall antibody concentrations in children under five (Grandjean, Andersen et al. 2012), and Mogensen et al. reported an association between PFAS co-exposures and decrease anti-diphtheria as well as anti-tetanus titers (Mogensen, Grandjean et al. 2015).

The Immune System: Individual Wellness and Public Health

Until the beginning of the twentieth century, infectious diseases were the leading cause of death for all ages worldwide (Schneider 2000). Poor hygiene, improper food handling, and cramped living conditions, among other factors, led to disease exposures and subsequent outbreaks. This not only led to significant mortality rates, but many infections resulted in complications that led to chronic morbidity, such as blindness from smallpox, paralysis from the poliovirus, and birth defects from rubella (Roitt, Brostoff et al. 2001). Environmental modifications through public health measure, such as disposal of sewage, improved nutrition, and immunizations has helped reduce the burden of infectious diseases significantly. But even with these public health interventions, infectious diseases are still a persistent problem: three of the top ten causes of death, or 16% of all deaths each year, are from infectious diseases globally (The Global Health Policy Center 2014). Infectious disease are also a significant problem in the United States where they are the third leading causes of death after cardiovascular diseases and cancers (Centers for Disease Control and Prevention 2008). Thus, prevention of infectious diseases is of significant public health concern.

A well-functioning immune system is essential to maintaining the integrity of an organism, and chemicals, like phthalates, may act directly on components of the immune system leading to immune stimulation, suppression, and/or dysregulation (World Health Organization 2012). In order to understand this problem and the potential role of phthalates on immune system health, I will briefly review important concepts in immunity.

Immune System

Our immune system is the primary line of defense against harmful agents. It consists of a collection of cells, tissues, and organs tasked with rapid recognition, response, and elimination of microbes, such as bacteria, viruses, and protozoa. Besides microbes, our immune system protects us from other foreign chemical invaders that may lead to disease. It also protects us from internal disrepair by removing our own wounded, dead, and abnormal cells, which can lead to other disease states, such as cancer (Madigan, Martinko et al. 2003). It does this with both specific and not specific components of the immune system.

Non-specific components, or innate immunity, are the first line of defense against invaders. Adaptive or acquired immunity is highly specialized, and it supplements protection provided by innate immunity. It is acquired by contact with a foreign agent, called an antigen, and it is specific only to that invader. Besides antigenic specificity, adaptive immunity is characterized by the diversity of molecules it can recognize, the immunologic memory to react faster and more robustly to subsequent antigen exposure, and the capacity to discriminate between self and non-self (foreign) molecules (Goldsby, Kindt et al. 2003, Madigan, Martinko et al. 2003).

Activation, Response, and Antibody Production

If an antigen evades and supersedes the innate immune response, an adaptive response is mounted usually within the first four to seven days of exposure. Depending on the type of invader, the adaptive immune system could be humeral-mediated (i.e. antibody) or cellular-mediated (i.e. cells). Because this dissertation concerns antibody measures, only humeral-mediated immunity will be discussed in detail. In a humoral response, the production of antibodies is triggered either by direct stimulation of a B cell or through activation of a B cell by a helper T (T_h) cell.

Antibodies (Ab), as known as immunoglobulins (Ig), are protein complexes produced by plasma B cells specific to a type of foreign invader. There are five different types with various functions: IgA, IgD, IgE, IgG, and IgM. At any one time, there are upwards of one to two billion different types of antibodies in a person's blood (Salyers and Whitt 2002). While antibodies are considered one of the most important components of the immune system, they are not capable of directly destroying antigen. Instead, antibodies recognize, bind, and most importantly mark antigen for elimination by other immune cells, such as cytotoxic T cells. They also have the capacity to neutralize antigen and prevent it from entering cells. Lastly, antibodies activate complement proteins, which assist with killing microorganisms and diseased cells. Clonal selection theory and immune network theory help explain the mechanism that generates the specificity of the antibody-antigen interaction (Salyers and Whitt 2002).

The first time the body is exposed to an antigen it can take several weeks to amount an effective immune response capable of destroying the invader. Subsequent exposures should result in much quicker and more robust responses where an individual is often unaware they have been exposed to the disease agent. This antibody production can be stimulated naturally from exposure to an antigen or artificially through vaccination (Figure 1).

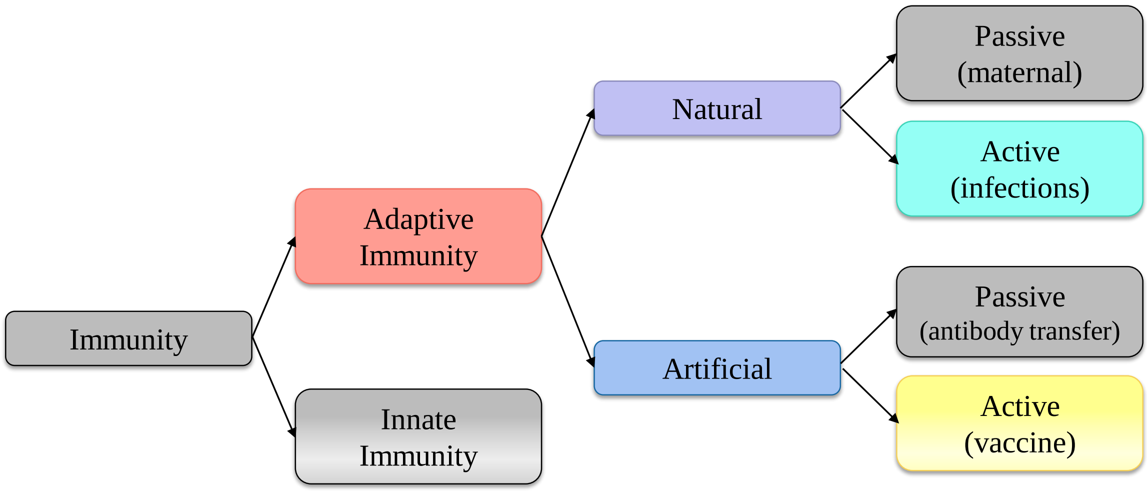

Figure 1. Types of immunity studied in this dissertation are highlighted in colored boxes.

Naturally Acquired Immunity

Naturally acquired immunity occurs as discussed above: a person is exposed to a live infectious disease agent – usually a virus or bacteria – the person develops a disease, and the immune system produces an immune response with antibodies as well as other components to combat the illness. People are naturally exposed to numerous of infectious agents over their life course, which leads to the production of billions of antibodies in their blood at any given time. This dissertation uses antibody titers (i.e. the concentration of antibodies in blood) from two infectious disease agents, EBV and *Toxoplasma gondii*, that are acquired naturally.

Epstein - Barr Virus

EBV, also known as human herpesvirus 4, is a member of the herpes virus family (Centers for Disease Control and Prevention 2012). It is one of the most common viral infections worldwide with seroprevalence (i.e. level of prevalence in a population measured with antibody titers against the disease) estimated between 90-95% (De Paschale and Clerici 2012).

Most people acquire the infection in their lifetime typically in childhood. EBV causes infectious mononucleosis, or mono, and other illnesses. While it is typically asymptomatic in children, adolescents and adults often experience fatigue, fever, and rash. It can also cause more significant morbidity, such as Burkitt's lymphoma, Hodgkin's lymphoma, gastric cancer, and nasopharyngeal carcinoma. It is estimated that 1.8% of all cancer deaths globally associated with EBV infection (Khan and Hashim 2014).

Toxoplasma gondii

Toxoplasma gondii is a single-celled protozoa that causes the disease toxoplasmosis. It is typically acquired by eating undercooked, contaminated food, drinking contaminated water, and ingesting the parasite by contact with contaminated cat feces or soil. The parasite is ubiquitous throughout the world, and 30-50% of people are seropositive (Pappas, Roussos et al. 2009). People with a health immune system are generally asymptomatic, but common symptoms include fatigue, muscle ache, and swollen glands. Infants, pregnant women, and immune-compromised individuals can develop more severe symptoms: eye lesions; brain damage; and fetal death, birth defects, and spontaneous abortion in pregnant women (Centers for Disease Control and Prevention 2013). It is estimated that there are one million new infections each year (Furtado, Smith et al. 2011).

Artificially Acquired Immunity: Vaccination

One of means of preventing infectious disease is through vaccination. Vaccines are biological preparations typically created from microbes or portions of microbes that have been killed (i.e. inactivated vaccines) or weakened (i.e. live attenuated vaccines). When immune cells encounter this modified antigen, the body mounts an adaptive immunological response that results in the production of antibodies from plasma B cells in the same way it would if a person was naturally infected. With naturally acquired immunity, however, a person usually suffers the symptoms of disease and risks potential complications, which can be serious or even deadly. With vaccines, immunity is obtained with little to no risk or symptomatology. Before the advent of vaccines, hundreds of thousands of people died each year from infectious diseases. Vaccines not only help prevent people from becoming sick, but they help reduce the transmission of disease, and thus subsequent infections, through herd immunity. For highly infectious organisms, such as measles, a larger proportion of the population, upwards of 90%, must be maintained for herd immunity.

Vaccines, however, do not guarantee complete protection from the development of disease or adverse symptoms. A multitude of factors can influence vaccine efficacy and effectiveness. For example, some individuals' immune systems do not respond appropriately to vaccines, or individuals with lowered immune response may not have B cells that are capable of producing antibodies or antibodies in sufficient quantity. Vaccine strains may also be damaged in the development process or improperly stored for administration. Further, age is a significant determine of efficiency. If vaccines are given too early in life, maternal antibodies acquired in utero can block immune response in infants, or infants may have not developed the immune cell population to produce an appropriate response. Conversely, as people age, immune function generally decreases and immunologic memory may decline. Multiple booster shots may be given for certain antigens to help combat these particular threats to vaccine efficiency and effectiveness (Male, Brostoff et al. 2013). This dissertation uses antibody measures typically generated from vaccines to measles, mumps, rubella, and polio virus.

Measles, Mumps, and Rubella (MMR) Vaccine

One of the most common vaccines given throughout the world is the MMR vaccine to prevent measles, mumps, and rubella. The MMR vaccine first became available in 1971, and it is typically administered in two doses: the first dose given at age 12-15 months and the second at age 4-6 years (CDC, 2012). Some children receive the MMRV vaccine, which includes the immunization against measles, mumps, rubella, and varicella (chickenpox).

Measles is a respiratory disease characterized by fever, cough, runny nose, conjunctivitis, and a rash of Koplik spots (Arguedas, Deveikis et al. 1991). The virus, one of the most contagious, is spread through respiratory droplets. At present worldwide, an estimated 20 million cases and 164,000 deaths occur annually from the measles virus. Approximately one to two children out of every 1,000 infected with measles die (Centers for Disease Control and Prevention 2013). About 30% of those infected develop one or more complications: about one in 10 children with measles develop ear infections, one in 20 develops pneumonia, and one of 1,000 develops encephalitis. Measles can also cause miscarriage and premature birth in pregnant women (Centers for Disease Control and Prevention 2013). Thus, prevention of measles of international importance.

Like measles, mumps is spread through respiratory secretions. Infection with the virus is characterized by headache, fever, fatigue, muscle ache, and swollen glands. Up to half of all people infected with mumps are asymptomatic. While serious complications and death is rare, up to 50% of all infected males develop inflammation of the testes; inflammation of the ovaries, breasts, pancreas, and brain have also been reported (Centers for Disease Control and Prevention 2013). Most significantly, hearing loss has been reported in about 80% of those infected, and one in 20,000 develops deafness. The case-fatality rates is approximately one in 10,000 (Centers for Disease Control and Prevention 2012)

Rubella is also spread through droplets, like measles and mumps. The disease is sometimes confused with measles initially as it produces similar symptoms of fever, cough, and rash. However, symptoms are often much milder and up to 50% have subclinical expression. Complications are not common, but up to 70% of adult females develop arthritis. Hemorrhagic manifestations (i.e. ruptured vessels and platelets) and encephalitis have also been reported. The case-fatality rate is estimated at 50 in 100,000. Of most concern is congenital rubella syndrome (CRS) in pregnant women infected with the virus; they are at-risk for fetal death, spontaneous abortion, and premature delivery. If their fetus becomes infected, the virus attacks all its organs producing severe birth defects. Deafness is the most prevalent condition, but eye, cardiac, neurologic defects are common. CRS manifestations can appear later in childhood with diabetes frequently observed as well as autism (Centers for Disease Control and Prevention 2012). It is estimated that 110,00 babies are born with CRS each year worldwide (World Health Organization 2012).

The impact of measles, mumps, and rubella vaccination on the natural history of each disease in the United States is significant. With measles, 894,134 cases were reported in 1941 compared to only 288 cases in 1995. With mumps, 152,209 cases were reported in 1968 compared to 840 cases in 1995. Lastly for rubella, 57,686 cases were reported in 1969 compared to 200 cases reported in 1995 (Merck & Co. 2010). Morbidity and mortality has been significantly reduced worldwide but to a lesser degree.

Polio Vaccine

Polio vaccination is also commonly given throughout the world to prevent polymyelitis. The polio vaccine first became available in 1955, and it is typically administered in four doses: age two months, four months, 6-18 months, and 4-6 years (Centers for Disease Control and Prevention 2014). It is usually administered in the U.S. in combination with diphtheria, tetanus, and pertussis vaccines (DTaP) and in a pediatric dose of hepatitis B vaccine.

Polymyelitis is a viral infection that is classified into three serotypes (type 1, type 2, and type 3). The virus primarily effects children and is disseminated by poor sanitary conditions. Namely, it is spread direct person-to-person through fecal-oral route or indirectly via food and water contaminated by feces. They majority of people are asymptomatic, but about 25% develop symptoms such as fever, fatigue, headache, meningitis, and limb stiffness/pain (World Health Organization 1996). Between 25-50% of individuals with symptoms develop post-polio syndrome decades later, which is characterized by chronic muscle weakness and fatigue. One in 200 infections lead to permanent paralysis, 5-10% of which die from paralysis of respiratory measles (World Health Organization 2015).

Polio cases have been decreased over 99% worldwide since 1998 through vaccination programs. As of 2008, only Nigeria, Pakistan and Afghanistan were considered places where polio remains a public health problem. However, since an infected person can shed virus for years, this still creates an ongoing risk (World Health Organization 2015).

Immune Dysfunction

The immune system's role is protective, but it can sometimes function improperly. Chemical pollutants, like phthalates, are capable of producing any combinations of dysregulation.

Immune Stimulation

Up-regulation or immune stimulation can occur via numerous chemical cytokine, cellular, and/or organ-related pathways. Generally, this response is clinically beneficial and even deliberate, such as the use of vaccinations to induce and spur the production of new antibodies against an infectious disease agent. However, adverse effects can occur with the stimulation of the immune system by chemicals, such as inflammation, hypersensitivity, allergy, and autoimmunity, that can cause tissues damage and death (World Health Organization 2012).

Hypersensitivity reactions are one form of inappropriate immune responses. They arise from an over production of antibodies. Common allergic diseases include asthma, rhinitis, conjunctivitis, and eczema. Worldwide, the prevalence of allergic diseases has continued to rise in industrialized nations over the past 50 years. An increase has also been seen in low and middle income countries as well as among children and young adults generally bearing the greatest morbidity burden (Pawankar 2014). In fact, it is estimated the 40-50% of school children are sensitized to one or more common allergens (American Academy of Allergy 2015). It is estimated that more than 50 million people in the U.S. are affected by asthma and hay fever alone (Salo, Calatroni et al. 2011). Besides physical burdens, allergic diseases are have economic and social impacts costing billions of dollars annually to treat and can lead to a reduced quality of life (Salo, Calatroni et al. 2011). The upsurge in allergies has been linked to increases in environmental risk factors, such as indoor and outdoor pollutants (Pawankar 2014). Experimental studies support this as chemicals, like phthalates, have been shown to have an adjuvant effect in allergic sensitization; phthalate-induced enhancement of mast cells can occur in the early inflammation process (Bornehag and Nanberg 2010). Further, lead, arsenic, heavy metals, bisphenol A, triclosan, and parabens have also been shown to influence allergy-reacted immune parameters (Clayton, Todd et al. 2011, Savage, Matsui et al. 2012, Shiue 2013, Wells, Bonfield et al. 2014)

Another condition where there is harm form an over stimulation of the immune system occurs with autoimmunity, the process where one's own body attacks it's on cells. These diseases are a complex collection of disorders that are hypothesized to result from the interaction of genetic and environmental factors, which effect an estimated 7% of the U.S. population (Miller, Alfredsson et al. 2012). Because they are incurable and are on the rise, they constitute a significant public health concern. Our knowledge of autoimmune disorders is limited and scant research exists on their link to environmental exposure. To date, one study found an association between phthalate exposure and lupus in mice (Lim and Ghosh 2005). Silica, heavy metals, industrial solvents, air pollutants, and pesticides have also been associated with autoimmune conditions (Vojdani, Ghoneum et al. 1992, Hess 2002, Miller, Alfredsson et al. 2012).

Immune Suppression

Down regulation or suppression of the immune system is the result of a complex cascade of events that result in increased susceptibility, incidence, and/or severity of infectious and/or neoplastic (i.e. cancer) diseases (Luebke, Parks et al. 2004). While the deliberate down regulation of immune functions is performed to treat certain autoimmune diseases and transplant rejections, immunosuppression is generally viewed as harmful, and it can be deadly.

Numerous components of the immune system could be individually or simultaneously suppressed. Experimental studies suggest phthalates can influence immune cytokine production and can function as adjuvant for antibody production and differentiation (Bornehag and Nanberg 2010, Hansen, Bendtzen et al. 2015). Specifically, tumor necrosis factor (TNF)-α, IL-2 and IL-4 secreted by macrophages as well as TNF-α and interferon-γ secreted by T-cells were impaired by

DEP and DnBP (Hansen, Nielsen et al. 2015), which could potentially lead to a decreased production of antibodies. Other studies have found inhibitory effects in TNF-α and apoptosis of B-cells with MEHP, which could also indicate a down-regulation of antibody production (Schlezinger, Emberley et al. 2007, Bissonnette, Teague et al. 2008). Numerous chemicals have been associated with immune suppression including perfluoroalkyl substances (PFASs), PCBs, polyhalogenated hydrocarbons, dioxin, heavy metals (Gleichmann, Kimber et al. 1989, Mandal 2005, Fairley, Purdy et al. 2007, Huang, Chen et al. 2015, Kielsen, Shamim et al. 2016). Thus, it is possible that phthalates could have a similar effect.

Specific to chemical exposures and antibody titers for infectious diseases, Grandjean et al. found elevated exposure to PFASs was associated with lower antibody titers in children under five (Grandjean, Andersen et al. 2012, Grandjean and Budtz-Jorgensen 2013), and a Norwegian study measured a negative association between rubella antibody production in children under three (Grandjean, Andersen et al. 2012, Grandjean and Budtz-Jorgensen 2013, Granum, Haug et al. 2013). A study using NHANES data found an inverse association between rubella antibody titers and mumps titers with doubling of PFOS concentrations in adolescents (Stein, McGovern et al. 2015). It is possible that similar effects could occur with exposure to phthalates.

Factors Influencing the Immune System

The immune system is governed by a variety of control mechanisms that return it to a resting state when responsiveness is no longer necessary for a given antigen. This is orchestrated by a network of cells and chemicals that facilitate the cell signaling. Besides the components of the immune system, response is influenced by a variety of factors including the form of the antigen, its route of internalization and dose; a person's biological and social background; and any history of previous exposure to the antigen. Individually or in combination, these factors help produce differential vulnerability to an antigenic challenge (Male, Brostoff et al. 2013). Because the factors are so numerous, this dissertation only examines pertinent factors from a person's biological and social background that are included in the NHANES datasets.

Age

From a biological perspective, aging reduces the efficiency of both the innate and adaptive immune systems in a process called immunosenescence. While many of the immune system components are affected, thymus involution and the loss of T cell generation as well as repopulation may play the most significant role (Arlt and Hewison 2004, Ponnappan and Ponnappan 2010). The thymus, which generates antibody-producing T cells, reaches maximal size in adolescence at puberty then continues to atrophy over the life course (Goldsby, Kindt et al. 2003). By age 50, there is a substantial reduction in the ability of the thymus to produce new T cells, and by age 60, an almost complete incapacity to produce new ones (Parham 2005). This not only puts older persons at risk for infection and related complications, but it makes it difficult for older adults to respond to vaccines (Burns and Goodwin, 1997). Thus, older individuals become less able to respond to both novel and previously encountered infectious agents (Graham, Christian et al. 2006). On the other hand, infants do not have a mature complement of immune cells. Therefore, even if they are exposed to an infectious agent, they may not be capable of producing an antibody response. Additionally, maternal antibodies (passed from the mother to the child) can interfere with production of vaccine-induced antibodies right after birth (Niewiesk 2014).

From a social perspective, age can influence when people are exposed to antigens, and thus, mount an immune response as well possess immunological memory. In the U.S. and international, immunization schedules provide recommendations about who should have what vaccinations when with all 50 states having some type of legislation requiring students to have certain vaccinations to attend schools (National Conference of State Legislatures 2017). Further, certain types of professions, like the healthcare industry, require their workers to have vaccines and/or prove they have antibody titers sufficient enough to confer immunity. These social influences tend to increase levels of immunity. Of note, despite being one of the most successful public health initiatives, immunizations have been perceived as unsafe by some resulting in social movements against them. This has led to a decrease in vaccination rates, which has been linked to outbreaks in diseases, like whooping cough and measles. Vaccination decisions have been linked to contextual factors, like past public health crisis, policies, religion, social networks and rumors, as well as individual determinants, such as education, income, and maternal age (Poland, Jacobson et al. 2009, Dubé, Vivion et al. 2015). Age can also impact the physical environments people occupy, thus, influencing exposure to diseases. For example, children are more likely to be indoors, which increases likelihood of exposure due to closer proximities and more surfaces to contaminate (then come into contact with)(La Rosa, Fratini et al. 2013). Furthermore, age can influence health -promotional behavior, such as hand hygiene or a lack there of (Luby, Agboatwalla et al. 2005).

Sex

It is well documented that females are adversely affected by autoimmune disease more than males, and evidence suggests that sex differences also exist in normal immune responses (Shames 2002). Specifically, females tend to produce higher antibody titers than males, and they generally produce an overall more vigorous immune response (Whitacre, Reingold et al. 1999, Goldsby, Kindt et al. 2003). For example, sex-based differences in vaccine efficacy, adverse events, and humoral immune response after immunization have been reported for MMR, influenza, hepatitis A, hepatitis B, yellow fever, smallpox, rabies and human papillomavirus vaccines (Klein, Jedlicka et al. 2010). Both estrogen and testosterone have been shown to modulate an array of immune functions, such cytokine production, lymphocyte production thymocyte mature and selection, and molecular-receptor adhesion (Grossman 1984, Cutolo, Sulli et al. 2004). Research suggests that estrogen enhances B cell-mediated conditions but suppression T cell-dependent diseases, and testosterone suppresses both B cell and T cell-mediated responses (Da Silva 1999). Besides difference from sex-hormones, it is believed that the X chromosome also plays a role genetically in the difference seen in immune response (Angele, Schwacha et al. 2000).

Gender

Likewise, social and cultural aspects of gender roles could be a contributing factor as gender roles can influence infections. Men are also more likely to partake in risky behaviors that could expose them more to antigens. Further, vitamins and micronutrients are essential for immune cell function, therefore, dietary practices and food access could influence disease susceptibility. In some cultures, women are the last to eat after men and children increasing their risk of malnutrition (Whitacre 2001), which increases their susceptibility for infectious diseases. Likewise, knowledge of health promotion practices may vary by gender. Women unaware of water-borne infections and proper handling practices may inadvertently expose the children and male family members increasing their risk of disease (Alexander, Irving et al. 2010). Health promotional behaviors may also differ between men and women; women are less likely to vaccinate compared to men (Klein and Pekosz 2014).

Race/ethnicity

Little research exists on the biological role of race/ethnicity of immune function (Haralambieva, Ovsyannikova et al. 2013). Of the research that exists, studies have found blacks had higher disease burdens compared to whites for Epstein–Barr Virus and Mycobacterium tuberculosis, respectively (Stead, Senner et al. 1990, Dowd, Palermo et al. 2014). Another study found individuals of African descent tended to have significantly higher rubella-specific neutralizing antibody levels compared to individuals of European descent and/or Hispanic ethnicity (Haralambieva, Salk et al. 2014). Another study by Haralambieva found cytokine responses following primary smallpox vaccination was significantly influenced by race and sex (Haralambieva, Ovsyannikova et al. 2013). Furthermore, a study found lower age-specific EBV antibody prevalence in non-Hispanic whites as compared with all other racial/ethnic groups that existed independent of controls on a child's country of birth, sex, adoption status, residential location, household income, day-care attendance, or breastfeeding (Condon, Cederberg et al. 2014). The only socioeconomic variable associated with age-specific antibody prevalence was parental education in non-Hispanic white families. The authors speculated that results were a combination of genetics, family practices, and home environment (Condon, Cederberg et al. 2014). These findings suggest there may be biologically-based racial/ethnic differences in humoral immune response, but no mechanism of action has been hypothesized to date.

From a social perspective, race/ethnicity could also be associated with attitudes about and access to vaccines (Priddy, Cheng et al. 2006, Galarce, Minsky et al. 2011, Soto, Petit et al. 2011, Jeudin, Liveright et al. 2014). For example, in a study on H1N1 vaccine uptake, black participants were more likely to report trying to get the vaccine but not having access to it (Galarce, Minsky et al. 2011). A similar study also reported lower vaccination rates among blacks and Hispanic, but it was attributed not in disparities of care but whites were more likely to initiate appointments for receiving vaccinations (Hebert, Frick et al. 2005). In a study on race and income, low-income and minority adolescents were equal or more likely to start the human papillomavirus (HPV) vaccination series compared to whites and higher income adolescents but less likely to complete all three shots. Furthermore, they reported receiving few recommendations for HPV vaccination (Jeudin, Liveright et al. 2014). Other research has shown disparities in coverage for pneumococcal, tetanus, diphtheria, hepatitis A, hepatitis B, herpes zoster, and HPV vaccines by race/ethnicity (Williams, Lu et al. 2015). Furthermore, Mexican-Americans 20 to 49 years and who were born outside the U.S. were more likely than other races to have protective antibody levels for diphtheria and tetanus (McQuillan, Kruszon-Moran et al. 2002). The authors suggest this probably reflects the absence of childhood immunizations rather than biological differences.

Socioeconomic Status

There is a strong association between socioeconomic status SES and overall health, but less is known about the direct impacts of SES on immune function specifically. Two studies found an association between education and herpes as well as cytomegalovirus antibody levels after controlling for health conditions, smoking, and BMI (Dowd, Haan et al. 2008, Aiello, Diez-Roux et al. 2009). Another study found significant racial and socioeconomic disparities in CMV seroprevalence beginning at early ages and persisting into middle age (Dowd, Aiello et al. 2009). The authors also found a significant association between SES and indirect markers of cell-mediated immunity (Dowd and Aiello 2009). Similarly, research by Zajacova (2009) found seroprevalence of persistent infections to be correlated with education, income, and race/ethnicity. A study of children found an inverse association between SES and innate immune responsiveness (Azad, Lissitsyn et al. 2012), and an a study of adolescents with asthma also found an inverse association between SES and certain immune response cytokines (Chen, Fisher et al. 2003). A study on women found a decrease in phytohemagglutinin activity of lymphocytes and other immune measures in the unemployed group even after receiving a psychosocial program to help counteract the loss of work (Arnetz, Wasserman et al. 1987), suggesting biological influences on the immune system independent of psychosocial impacts.

The social context of socioeconomic disadvantage likely influences the immune system through several pathways, including stress, increased antigen exposure, and barriers in access to care. Psychological stresses can contribute to the physiological production of glucocorticord steroid hormones that play are role in inflammatory responses, which have both stimulatory and suppressive influences on the immune system. Likewise, c-reactive protein, a pro-inflammatory biomarker, has been shown to be inverse related to SES in numerous studies (Cavigelli and Chaudhry 2012). SES can also reduce access to nutritional food; poor food quality is associated with increased inflammation, reduced control of infection, and increased risk for allergic and auto-inflammatory disease (Myles 2014). Individuals with lower SES are also more likely to be uninsured and have less access to healthcare, which includes vaccinations and treatment for infectious diseases (Adler and Newman 2002, Rainey, Watkins et al. 2011, Jeudin, Liveright et al. 2014). Although, access to healthcare does not guarantee people will be offered vaccinations, as individuals who reported sources of care were less likely to have protective antibody levels of tetanus and diphtheria (McQuillan, Kruszon-Moran et al. 2002).

Birthplace

There is a growing body of evidence that suggests early pre-natal and post-natal environments are important determinants of immune function over the life course (McDade 2005). For example, immigrants are typically in better health than their US-born counterparts, but this advantage disappears over time as they immerse, assimilate, and integrate into US culture (Antecol and Bedard 2006). Therefore, place of birth likely has an impact on immune function, however, the extent and magnitude of this impact is largely unknown.

Besides overall health status, birthplace confers differential biological-ecological environments. Early childhood stresses are associated with adverse health outcomes later in life including high inflammation rates (Danese, Moffitt et al. 2009), latent virus reactivation (Fagundes, Glaser et al. 2013), and autoimmune disorders (Dube, Fairweather et al. 2009), among other risks. Some infectious agents are ubiquitously distributed through the world, but lower income countries still suffer more burden of disease owing to diarrhea diseases, pneumonia, HIV/AIDS, tuberculosis, malaria and other pathogens (Dye 2014). Moreover, the most common neglected tropical diseases are a helminthic (worm) infections affecting one-third of the almost three billion people living on less than $2 per day in developing regions of Sub-Saharan Africa, Asia, and the Americas (Bhutta, Sommerfeld et al. 2014). Rapid urbanization and crowding, lack of access to adequate nutrition, and poor healthcare infrastructure further contribute to and sometime amplify risks from infectious diseases in poorer countries. Birthplace can also influence access to the types and quantities of food (Deshmukh-Taskar, Nicklas et al. 2007, Myles 2014). As previously noted in the section of SES and gender, micronutrients are important determines of immune function and response to pathogens. Places with lower quality food and water due to contamination can also increase exposure to infectious agents and thus immune response from antigen challenge (Whitacre 2001). Furthermore, maternal prenatal nutrition could influence fetal immune system development (Marques, O'Connor et al. 2013). Birthplace can also influence legislative requires for immunizations, as discussed in the section on age (Poland, Jacobson et al. 2009, Dubé, Vivion et al. 2015). Likewise, countries have varying access to health infrastructure, including vaccinations and treatment for infectious diseases, as noted previously. For example, a study found Canadian mothers to have greater rubella immunity than mothers from North Africa, the Middle East, China, and the South Pacific (McElroy, Laskin et al. 2009).

BMI

When individuals are obese, they have increased circulating levels of pro-inflammatory proteins. The chronic inflammation is known to impair the immune function by altering leukocyte counts as well as cell-mediated immune responses (Koethe, Jenkins et al. 2011, de Heredia, Gómez-Martínez et al. 2012, Ilavska, Horvathova et al. 2012). Besides pro-inflammatory pathways, obesity often is co-morbid with malnutrition leading to further biological dysregulation of the immune system (de Heredia, Gómez-Martínez et al. 2012), as previously discussed. Additionally, chemicals and toxins that bioaccumulate in adipose tissue can lead to differential risk for those with higher BMIs by conferring greater exposure.

From a psycho-social perspective, people that have higher BMI may experience greater stress from discrimination and social shaming (Moore and Cunningham 2012). Furthermore, people with more stress in their lives tend to have worse eating habits, which can lead to malnutrition and other conditions that exacerbate immune dysfunction (Carroll, Phillips et al. 2008). As noted earlier, hormones associated with stress can both suppress as well as enhance immune system activity. In addition to direct effects, stress can act as an effect modifier to produce differential vulnerability in health outcomes by altering biological systems, thus, affecting the internal dose of environmental toxics. Thus, BMI can influence the immune function through social and biophysical stressors on the system.

Smoking

Cigarettes contain chemicals that cause a pro-inflammatory reaction in the body suppressing the immune system, and nicotine itself is also known to directly suppress immune function (Barbour, Nakashima et al. 1997, Sopori 2002). Cigarettes are also known to have hundreds of chemicals in them leading to multiple toxic exposures that could have immunosuppressive and/or enhancement effects (Rodgman and Green 2003). Therefore, the cigarette smoking could have an array of influences on the immune system.

From a social perspective, smoking rates vary by demographic and geographic characteristics. For example, males are more likely to smoke compared to women as are poorer and less-educated people. American Indians/Alaskan Natives and whites are also more likely to smoke compared to blacks, Hispanics, or Asians. Furthermore, people living in the Midwest and South tend to smoke more than those in West or Northwest (Desilver 2014). As noted in previous sections, demographic factors, like gender, race/ethnicity and SES, influence immune health in various ways. Similar, geography, as noted in the previous section on birthplace, also influences the immune system through multiple pathways.

Contributions of the Proposed Study to Public Health

Limited or inconclusive research has been published on the association between phthalates and immunomodulation. It is important to identify whether phthalates adversely affects immune system health as it protects us against infectious diseases and cancer. This dissertation assesses associations between urinary phthalate concentrations on antibody concentrations, individually and in combinations, that protect against six infectious diseases: measles, mumps, rubella, polio, mononucleosis, and toxoplasmosis. Table 2 summaries characteristics of these infectious agents and the importance of preventing morbidity and mortality associated with them. The infectious agents selected for this dissertation poses a significant public health threat. Vaccines for measles, mumps, rubella, and polio have decreased associated morbidity and mortality considerably, but these infectious agents still have not been eradicated. Furthermore, an increase in people choosing not to vaccinate and factors that influence vaccine efficacy and effectiveness, such as chemical exposures, could increase risks from these infectious diseases now and in the future. Vaccines for mononucleosis and toxoplasmosis are not currently available, however, seroprevalence is high for both conditions, as is associated morbidity and mortality. To my knowledge, no research has been published to date examining the effects of phthalates and infectious disease antibodies titers. This dissertation will help address these literature gaps.

Table 2. Infectious disease agents and their characteristics.

Disease	Measles	Mumps	Rubella	Polio	Mononucleosis	Toxoplasmosis
Agent	Measles virus	Mumps virus	Rubella virus	Poliovirus	Epstein-Barr virus (EBV)	*Toxoplasma gondii*
Agent Type	Virus	Virus	Virus	Virus	Virus	Protozoa
Primary Method of Exposure	Artificially acquired (MMR vaccination)	Artificially acquired (MMR vaccination)	Artificially acquired (MMR vaccination)	Artificially acquired (DTaP vaccination)	Naturally acquired (contact with other people)	Naturally acquired (food, water, cat feces)
Sero-prevalence in the U.S.	90−93% (Lebo, Kruszon-Moran et al. 2015)	85−89% (Lebo, Kruszon-Moran et al. 2015)	94−96% (Lebo, Kruszon-Moran et al. 2015)	>90% types 1 and 2, and >85% to type 3 (Thompson, Wallace et al. 2012)	90-95% (De Paschale and Clerici 2012)	30-50% (Pappas, Roussos et al. 2009)
Symptoms	Fever, cough, runny nose, conjunctivitis, and a rash of Koplik spots	Headache, fever, fatigue, muscle ache, and swollen glands	Fever, cough, and rash	Fever, fatigue, headache, meningitis, and limb stiffness/pain	Fever, fatigue, headache, rash, and swollen glands, liver, and spleen	Usually asymptomatic; fatigue, muscle ache, and swollen glands
Associated Morbidity	30% develop complications, such encephalitis, pneumonia, miscarriage (Centers for Disease Control and Prevention 2013)	50% inflamed testes, ovaries, breasts, pancreas, or brain; 80% report some hearing loss (Centers for Disease Control and Prevention 2013)	70% of adult females develop arthritis; congenital rubella syndrome (CRS) in pregnant women causes fetal death, birth defects, spontaneous abortion	25-50% develop post-polio syndrome (chronic muscle fatigue); one in 200 have permanent paralysis (World Health Organization, 2015)	200,000 cancer cases per year associated with EBV; Burkitt's lymphoma, Hodgkin's lymphoma, gastric cancer, and nasopharyngeal carcinoma; linked with autoimmune diseases	20-80% develop eye lesions in adulthood; damage to brain, eyes, and other organ; pregnant women risk fetal death, birth defects, spontaneous abortion (Centers for Disease Control and Prevention 2013)
Associated Mortality	20 million cases and 164,000 deaths occur annually (Centers for Disease Control and Prevention 2013)	One in 10,000 infected die (Centers for Disease Control and Prevention, 2012)	50 in 100,000 infected die; 110,00 babies born with CRS birth defects yearly (World Health Organization 2012)	5-10% die from paralysis of respiratory measles (World Health Organization, 2015)	1.8% of all cancer deaths globally associated with EBV (Khan and Hashim 2014)	One million new infections each year, 20,000 cases of retinal infection, and 750 deaths (Furtado, Smith et al. 2011)

CHAPTER 3:
THEORETICAL FRAMEWORK AND CONCEPTUAL MODEL

This dissertation is informed by the ecological perspective, life course perspective, and exposure-disease model to provide context for my conceptual model shown in Figure 2.

Ecological Perspective

The ecological perspective, also known as the social ecological model, is concerned with the interaction between and interdependence of factors within and across all levels of a health problem (Glanz and Rimer 1997). It is particularly applicable to the study of chemical-related disease processes, such as those associated with phthalates, because it is concerned with: 1) the interaction between people's physical and social environments through multiple levels of influence, and 2) reciprocal causation, or how people influence and are influenced by factors and situations around them (Glanz and Rimer 1997). While the ecological perspective is credited to Urie Bronfenbrenner, its conceptual roots are in general systems theory and ecological theory, which contributed the ideas of interconnectedness and goodness-of-fit between entities and their environments, respectively (Boulding 1956, Hern 1958, Meyer 1995, Laszlo and Krippner 1998).

Bronfenbrenner's ecological theory is conceived as a set of nested structure, each inside the other, with five levels of influence: microsystems, mesosystems, exosystems, macrosystems, and the chronosystem (Bronfenbrenner 1993). Macrosystems encompass the overarching patterns of micro-, meso-, and exosystem characteristics of a given society, with particular attention to the relationships that are produced and reproduced through social and cultural institutions (Bronfenbrenner 1992). Macrosystems often operate at a state or national level, but due to increased globalization, international influences are powerful determinants too. Aspects such as the natural environment (e.g., climate, topography, water supply), macro-social factors (e.g., historical conditions, legal codes, ideologies), and inequalities between these two (e.g., distribution of opportunity, material wealth, education, and health) drive processes at this level.

Here, political, economic and legal processes, sometimes referred to as fundamental factors, have played leading roles in creating the unequal distribution of material resources, and thus, the spatial concentration of disparities (Schulz and Northridge 2004). The link between the inequitable distributions of these determinants has been well documented as a significant contributor to health disparities by influencing access to multiple resources that are necessary to maintain health (Link and Phelan 1995, Baden, Noonan et al. 2007, Ramirez, Baker et al. 2008). Understanding the relationships that drive health determinants at this level are essential for the study of hazard-related health consequences because most hazards are created (i.e. man-made phenomena) or inherently exist (i.e. natural phenomena) at this level. Thus, structural mitigation strategies and laws can be focused at this specific level to help prevent health effects from chemicals. Understanding the relationships that drive health determinants at this level are essential for the study of chemical-related health consequences because these are created at this level.

Exosystems consist of the linkages and mechanisms taking place between two or more settings that indirectly influence processes within the immediate setting containing the individual or population (Bronfenbrenner 1992). One's neighborhood and community operate at this level as do the built environment (e.g., infrastructure, land use, zoning) and social context (e.g., community capacity, policies, education). The spatial concentration of inequities at this level influences both the built environment and social context, which eventually influence health and well-being. For instance, areas of greater wealth have individuals/groups with the social and economic resources to influence political decisions, which can translate into greater power to sway public, fiscal, and environmental policies regarding infrastructure investments and economic development (i.e., social context). Consequentially, this can influence features of the built environment, including where hazardous waste sites, manufacturing plants, or affordable housing might go. Communities with fewer social, economic, and political resources may consequently experience greater environmental exposure to harmful land uses and chemicals, along with their associated physical and psychosocial stressors (Schulz and Northridge 2004, Schulz, Zenk et al. 2008). At this level, communities may be able to "push up" against fundamental factors of the macrosystem that contribute to health disparities as well as "push down" on proximate factors that lead to negative health outcomes. An example of which was the environmental justice movement in the early 1990's that began with community mobilizations and eventually lead to an Executive Order by President Clinton requiring all agencies to address environmental health disparities (Northridge, Sclar et al. 2003, Schulz and Northridge 2004).

Mesosystems contain of the linkages and processes taking place between two or more setting that directly affect individual and population health, or they can be viewed as systems of microsystems (Bronfenbrenner 1993). These proximate factors are observable at the interpersonal level and include influential determinants, such as stressors (e.g., crime, financial strain, discrimination) and resources (e.g., social support, social networks). Research has shown that neighborhoods with higher concentrations of poverty may experience increased exposure to stressors that are detrimental to health, such as violent crime, at the same time as they experience reduced access to resources that may promote health, for example, public services (Dubow, Edwards et al. 1997, Steptoe and Feldman 2001, Ewart and Suchday 2002). Proximate factors, such as resources that help buffer the stress process, have been shown empirically to be related to health and well-being (Yen and Syme 1999, Israel, Farquhar et al. 2002, Schulz and Northridge 2004, Wright 2011). In addition to direct effects, stress can act as an effect modifier to produce differential vulnerability in health outcomes by altering biological systems, thus, affecting the internal dose of environmental toxics. The stress process may amplify the effects of phthalates and increase people's sensitive to chemical-related health outcomes through disruption of homeostatic mechanisms (Sexton 1997, World Health Organization 2010).

The microsystem is a pattern of activities, social roles, and relations in a given face-to-face setting where proximal processes operate (Bronfenbrenner 1993). Health outcomes are observable here, which resulted from a chain of influences, such as health inequalities (fundamental factors), the built environment and social context (intermediate factors), and stressors and resources (proximate factors). This spatial process also occurs with the passage of time, known as the chronosystem. The life course perspective in many ways is analogous to the chronosystem as it recognizes the importance of time and timing in understanding causal links between determinants and health outcomes (Whitehead and Dahlgren 2007).

Strengths of the ecological perspective include it consideration of the dynamic social and physical processes through which health impacts can be produced, reproduced, and potentially transformed. It also places emphases on the interplay or relationships between social and physical environments when most theoretical frameworks exclusively focus on one or the other (Glanz and Rimer 1997). Similarly, it allows both distal and proximate influences to be addressed while other frameworks usually sacrifice one for the other. This allows for the modeling of complex intrapersonal, interpersonal, intergroup, and human-nature interactions without reducing phenomena to the level of the individual. Importantly, the dynamic nature of the perspective implies systems and processes have the potential to eliminate negative health consequence through social action and environmental stewardship (Schulz, Zenk et al. 2008).

A strong critique of the ecological perspective is that it is so broad and abstract as to be impossible to operationalize reliably, which is problematic since public health is an applied profession. For instance, if theory is too general, then it can lose credibility to deliver concrete services in an intervention. It also implies that the same environment has differential effects depending on the characteristics of the individual or population, which could make it impractical to tailor interventions (Glanz and Rimer 1997). The general framework, however, can still inform practice as a contextual model that is very useful for assessing and planning across a range of domains.

Life Course Perspective

The life course perspective provides a relevant context on the temporal association between social conditions and health outcomes, and as mentioned previously, it is analogous to the chronosystem in the ecological perspective. It explicitly recognizes the importance of time and timing in understanding causal links between exposures and outcomes within an individual life course, across generations, and in population-level diseases trends (Shanahan 2000). Adopting a life course perspective directs attention to how social determinants of health operate at every level of development both to immediately influence health and to provide the basis for health or illness later in life (Whitehead and Dahlgren 2007).

This perspective provides context for how exposures to phthalates at different ages, such as *in utero* and early life, can potentially change development trajectories and thus health outcomes in adulthood. While the theoretical perspective recognizes multiple dimensions of age, biological age and social have some of the greatest influences on phthalate exposure and immune outcomes. For example, the prenatal environment is sensitive time when *in utero* exposure leading to lifelong effects for the fetus. The maternal and fetal immune systems can communicate in a bi-directional manner, and fetal immunity is particularly vulnerable to disruption by environmental factors that impact the mother, such as malnutrition, toxins, and stress (Marques, O'Connor et al. 2013). Once born, children are exposed to phthalates and other chemicals differentially based on numerous factors in their physical (e.g. housing, toys) and social environments (e.g. food and personal care behaviors), which change over time as they age into adulthood. Furthermore, given the immunological memory of the immune system, phthalate exposures at any point in time can influence response for a lifetime.

Strengths of the life course perspective include its attention to the multidimensional processes, such as biological, social and psychological, that influence health and wellbeing. It also highlights the malleability of risk factors and possibility for prevention. Like the ecological perspective, it fails to link micro- and meso-system influences to macro-system because it is broad and abstract (Hutchison 2015).

Exposure-Disease Model

The exposure-disease model is a well-known paradigm that has been used primarily to demonstrate how environmental toxics might cause disease (Lioy 1990). It present a source-to-effect continuum that starts with an environmental hazard, such as a phthalate emission source, and links an exposure to the occurance of a health outcome. The model is sometimes represented with intermediates between exposure and health effect with the concepts of internal dose and biologically effective dose. Some models have built on this perspective, such as the exposure-disease-stress model (Gee and Payne-Sturges 2004) and the environmentl health paradigm (Sexton 1997), to recognize that vulernabilty can intersect this source-effect continuum to amplify or attenuate the effects of the hazard. These perspectives are not explored in this dissertation.

The exposure-disease model is useful because it provides a direct mechanism from which a hazard can generate a health consequence. Since it is built on the ecological perspective, it integrates well with other models that consider factors that affect health on multiple levels. Because it is explicit and direct, it is also conceptually easy to understand. Additionally, its flexibility allows it to be applicable to many hazards beyond pollution by considering the forces a person is exposed to instead of the dose from an agent. There are limitations, however. The mediating variables, such as exposure and dose, can be difficult or impossible to measure accurately, which make it difficult to apply the framework empirically. Many times, there are multiple exposures to multiple hazards, thus, disentangling the effects can also be challenging.(Lioy 1990)

Conceptual Model

There is no single, universally accepted means of formulating the linkages between social and biological systems and processes (Adger 2006). The proposed conceptual model uses constructs from the ecological perspective, life course perspective, and exposure-disease models to explore potential pathways from phthalate exposure to immunotoxicity. For instance, the ecological and life course perspectives help provide an overall structure with the macro-, exo-, meso-, micro-, and chronosystems/time. These perspectives are useful because they provide a context for the dynamic processes across and between levels as well as through time. However, these perspectives are very broad and abstract, which can make it difficult to explain observed outcomes and to apply interventions to reduce negative health consequences.

Because the ecological and life course perspectives are sometimes criticized for being too broad and abstract, the exposure-disease model can be used to shed light on part of the potential causal pathway. The exposure-disease model provides a potential direct process through which pollutants can influence health. Both models integrate well with the other constructs from the ecological perspective. The exposure-disease model does have some notably flaws. It does not account for environmental influences beyond the hazard itself. This is where the social ecological provides these lacking concepts. Second, it does not account for alternative independent variables to help rule out alternative explanations (Aneshensel 2002). Therefore, future research should include additional variables beyond those represented in the conceptual model to better understand how phthalate exposure could be linked to immune system outcomes.

Figure 2 presents the conceptual model that guides this dissertation study. It is limited to the predictor variables of interest (i.e. chemical exposure biomarkers for phthalate concentrations), outcome variables of interest (i.e. immune biomarkers of antibody titers), and controls representing social factors (i.e. sex, age, race/ethnicity, income, birthplace, language), social processes (i.e. time in the U.S. and parental birthplace), health factors (i.e. cotinine concentration, body mass index, c-reactive protein, and creatinine concentration). Below are brief descriptions of the hypothesized associations expected to be observed in this research based on previous experimental and epidemiological studies.

Focal Association: Chemical Biomarkers and Outcome Variables

The few studies on phthalate exposures and immune outcomes have been conducted, almost exclusively in animal models and on cell cultures with both suppressive and stimulatory effects observed (Dearman, Betts et al. 2009, Kimber and Dearman 2010, Hansen, Bendtzen et al. 2015, Hansen, Nielsen et al. 2015, Robinson and Miller 2015). Given that phthalates are suspected endocrine disrupting chemicals (EDCs) and numerous EDCs down regulate the immune system (Diamanti-Kandarakis, Bourguignon et al. 2009, Swedenborg, Rüegg et al. 2009, Nair and Sujatha 2012), I hypothesize that phthalate metabolite concentrations will be inversely associated with the antibody titers for measles virus, mumps virus, rubella virus, poliovirus, EBV, and *Toxoplasma gondii*.

Control Variables – Social Factors

Age: Phthalate concentrations tend to be higher in young people compared to adults (Zota, Calafat et al. 2014), thus, age is expected to be inversely associated metabolite measures. Immune system function tends to decrease with age because of immunosenescence (Arlt and Hewison 2004, Ponnappan and Ponnappan 2010). However, antibody measures in the NHANES samples used for this dissertation are taken from people below the age of 50, therefore, immunosenescence will not likely be a significant driver of titer levels. If an association exists between age and antibody titers, it is expected to be a negative association.

Sex and Gender: Only one measure for males and females exists in the data, which could be operationalized in the context of sex or gender. However for most people, their gender aligns with their biological sex, thus, in most cases the variable in NHANES data represents both. Considering drivers of exposure, gender roles can help explain why I hypothesized that men and women will have different concentration of phthalates depending on the molecular weight of the metabolite. HMW phthalates are common in industrial and commercial products, like flooring, paints and building materials, while LMW phthalates are often in personal care products and perfumes (Kamrin 2009, Johns, Cooper et al. 2015). Socially-influenced roles may explain some of these disparate trends: men are more likely to be in physical environments with industrial or commercial chemicals in use while women are more likely to utilize personal care and cosmetic products (Frederiksen, Skakkebaek et al. 2007, Kwapniewski, Kozaczka et al. 2008, Hines, Nilsen Hopf et al. 2009).

Sex difference can influence chemical absorption, metabolism, and excretion (Mergler 2012), but no studies to date have examined sex-related differences in phthalate exposure. Regarding sex influences on immune function, the sex hormones estrogen and testosterone have been shown to influence immune system function with estrogen typically enhancing but testosterone suppressing responses (Da Silva 1999). Gender differences include health promotion practices of vaccination and dietary factors that may impact disease susceptibility (Klein and Pekosz 2014). Because both gender and sex could be associated with differential exposures as well vulnerabilities, I expect in subgroup analysis for men to have higher exposure to phthalates and to have a negative association with antibody titers. Conversely, I expect women to have lower levels of phthalates and a positive association with titer levels.

Race/Ethnicity: Research suggests that race/ethnic groups have varying exposure to phthalates primarily because of differing uses of personal care products and diets (Romero-

Franco, Hernandez-Ramirez et al. 2011, Trasande, Attina et al. 2013, Huang, Saxena et al. 2014, Branch, Woodruff et al. 2015). I hypothesis a difference may be seen by race/ethnic group with blacks have greater exposure than other subgroups. Little research exists on the role of race/ethnicity of immune function, and findings have not been consistent among subgroups (Haralambieva, Ovsyannikova et al. 2013, Condon, Cederberg et al. 2014). I hypothesize to see a small association between race/ethnicity and antibody titers because social stressors, such as discrimination and lack of access to healthcare, could influence immune system function and thus titer levels in either direction. Variables are not available in the data to test these potential mediating effects.

Socioeconomic Status: Since phthalates are in many consumer products and individuals with higher SES have more buying power, they may be exposed to more phthalates at higher concentrations. Furthermore, extensive evidence does link socioeconomic variables with personal behaviors, notably diet (Deshmukh-Taskar, Nicklas et al. 2007, Northstone, Emmett et al. 2008, Colacino, Harris et al. 2010, Kobrosly, Parlett et al. 2012), and occupations, which could lead to great exposure (Kwapniewski, Kozaczka et al. 2008, Hines, Nilsen Hopf et al. 2009). There is a strong association between socioeconomic status (SES) and overall health, but less is known about the direct impacts of SES on immune function specifically. The social context of socioeconomic disadvantage likely influences the immune system through several pathways, including stress, increased antigen exposure, and barriers in access to care. Research shows poorer individuals typically have a disproportionate burden of infection and lack of access to care among disadvantaged groups (Cavigelli and Chaudhry 2012, Myles 2014). Since phthalates are in many consumer products and individuals with higher SES have more buying power, they may be exposed to more phthalates at higher concentrations. I hypothesize that income is positively associated with phthalate concentrations and antibody titers.

Birthplace: No research to date has examined the association between birthplace and phthalate concentrations, but research on country of residence shows extreme variability between nations in exposure (Göen, Dobler et al. 2011, Cerna, Maly et al. 2015, Den Hond, Govarts et al. 2015). Differences in daily social and behaviors lifestyle are noted as possible explanations in observed findings (Colacino, Soliman et al. 2011). Likewise, the limited research on birthplace and health does not explore immune biomarkers as this study does. However, birthplace confers differential biological-ecological environments that could influence diverse health outcomes later in life (Bhutta, Sommerfeld et al. 2014), such as stress (Danese, Moffitt et al. 2009), more infectious diseases (Dye 2014), malnutrition (Deshmukh-Taskar, Nicklas et al. 2007, Myles 2014), and lack of access to healthcare (Adler and Newman 2002, Rainey, Watkins et al. 2011, Jeudin, Liveright et al. 2014). I expect that there will be an association between birthplace and phthalate exposure, but the direction of the association may vary by type of phthalate. Further, I hypothesize an association between birthplace and antibody titers, but the direction of the association may be different with natural acquired vs. artificially acquired disease antibodies.

Control Variables – Health Factors

BMI: While phthalates do not accumulate in adipose tissue, they are fat-soluble. Furthermore, they are processed foods, and obesity is associated with consumption of more food as well as food that is more likely processed (Bai, Wittert et al. 2015). Studies also from NHANES data have shown an association between BMI and phthalate exposure (Stahlhut, van Wijngaarden et al. 2007, Hatch, Nelson et al. 2008, Zhang, Meng et al. 2014). Thus, I hypothesize a positive association between BMI and phthalate levels.

When individuals are obese, they have increased circulating levels of pro-inflammatory proteins. The chronic inflammation is known to impair the immune function by altering leukocyte counts as well as cell-mediated immune responses (Koethe, Jenkins et al. 2011, de Heredia, Gómez-Martínez et al. 2012, Ilavska, Horvathova et al. 2012). Therefore, I expect that BMI is negatively associated with antibody titers.

Cotinine: Smoking cigarettes increases risk of exposure to hundreds of chemicals, therefore, I expect cotinine levels to be positively associated with phthalate metabolite concentrations. Cigarettes contain chemicals that cause a pro-inflammatory reaction in the body suppressing the immune system, and nicotine itself is also known to directly suppress immune function (Barbour, Nakashima et al. 1997, Sopori 2002). I hypothesize that cotinine levels will be inversely associated with antibody titers.

Moderators – Age and Sex/Gender

Additionally, this research will explore the effects of sex/gender and age as potential modifiers. Statistically, moderation occurs when the relationship of two variables depends on a third variable. In this research, I am examining the effects of sex/gender on antibody titers given increased exposure to phthalates. Because only one measure exists and it is plausible both biological and social factors are at play, I will review pertinent literature on sex and gender, respectively.

Evidence suggests that sex differences exist for exposure and immune responses (Shames 2002). For exposure, absorption, metabolism and excretion can vary between males and females (Arbuckle 2006), but specific research has not been reported for phthalates. Given that males typically have larger lung and body sizes, it possible that males physically ingest higher concentrations of phthalates into their bodies than females. Once inside the body, influences of sex hormones on metabolism and excretion are currently unknown. Studies have shown that men and women may have unique exposure profiles to phthalates with men generally having higher concentrations of phthalates in their urine, but exposure risks can vary by phthalate congener (Latini 2005). For example, women typically have higher levels of MEP compared to men, which is most likely attributable to women's increased use of personal care products, such as hair care products, cosmetics, and perfumes (Silva, Barr et al. 2004, Braun, Sathyanarayana et al. 2013, Huang, Tsai et al. 2015). For both biological and social reasons, there is an expectation that men generally have greater exposure to phthalates.

From an immunological perspective, females are more adversely affected by autoimmune disease compared to males, and evidence suggests that sex differences also exist in normal immune responses. Specifically, females tend to produce higher antibody titers than males, and they generally produce an overall more vigorous immune response (Shames 2002). Research suggests that estrogen enhances B cell-mediated conditions but suppression T cell-dependent diseases, and testosterone suppresses both B cell and T cell-mediated responses (Da Silva 1999). Therefore, it would be expected that testosterone suppresses immune response, but estrogen could enhance or suppress it depending on the pathway.

Likewise, social and cultural aspects of gender roles could be a contributing factor, such as differences in antigen exposure, knowledge of health promotion, and access to care, which could all influence immune response and outcomes (Oertelt-Prigione 2012). For example, men are also more likely to partake in risky behaviors that could expose them more to antigens, and women are less likely to vaccinate compared to men (Klein and Pekosz 2014). Therefore, these factors could increases the antibody titers in men compared to women, which is the opposite direction of some biological factors. It is unknown whether social factors could out weight biological influences, in the directionality that gender and sex play on antibody concentrations. However, given the numerous and diverse social factors, I hypothesize that males will have higher antibody levels compared to females with exposure to higher concentrations of phthalate metabolites.

Age could also be an important modifier. Studies have found exposure risks to vary by age, but children generally have greater exposure compared to adolescents and adults (Wittassek, Koch et al. 2011, Huang, Tsai et al. 2015). Pathways of exposure have been shown to differ by age (Wormuth, Scheringer et al. 2006). For example, infants are exposed *in utero* and once born by hospital equipment as well as food, such as breast milk, formula, and baby food (Wittassek, Koch et al. 2011). During infancy, baby lotions, powders, and shampoos are likely sources (Braun, Sathyanarayana et al. 2013). Young children and adolescents are often exposed through toys and personal care products, while adults are most likely exposed through food and cosmetics/personal care products (Frederiksen, Skakkebaek et al. 2007). Besides behaviors that contribute to exposure, the physical environments can drive exposure. Children are more likely to crawl on vinyl flooring and put things, especially plastics, in their mouth. They are also more likely to occupy indoor environments, which can concentration phthalates in the air, dust, and on surfaces (Silva, Barr et al. 2004, Braun, Sathyanarayana et al. 2013).

From a biological perspective, aging reduces the efficiency of both the innate and adaptive immune systems in a process called immunosenescence. Furthermore, there are numerous differences in pharmacokinetics and metabolism between children and adults where unique enzymes may only exist during certain developmental stages, such as during puberty (Anderson 2002). From a social perspective, age can influence when people are exposed to antigens, and thus, mount an immune response as well possess immunological memory. In the U.S. and international, immunization schedules provide recommendations about who should have what vaccinations when (National Conference of State Legislatures 2017). However, social movements against them have decreased vaccination rates in the general population. Age can also impact the physical environments people occupy, thus, influencing exposure to diseases. For example, children are more likely to be indoors, which increases likelihood of exposure due to closer proximities and more surfaces to contaminate (then come into contact with)(La Rosa, Fratini et al. 2013).   Furthermore, age can influence health -promotional behavior, such as hand hygiene or a lack there of (Luby, Agboatwalla et al. 2005). I hypothesize that young people will have lower antibody levels compared to adults with exposure to higher concentrations of phthalate metabolites.

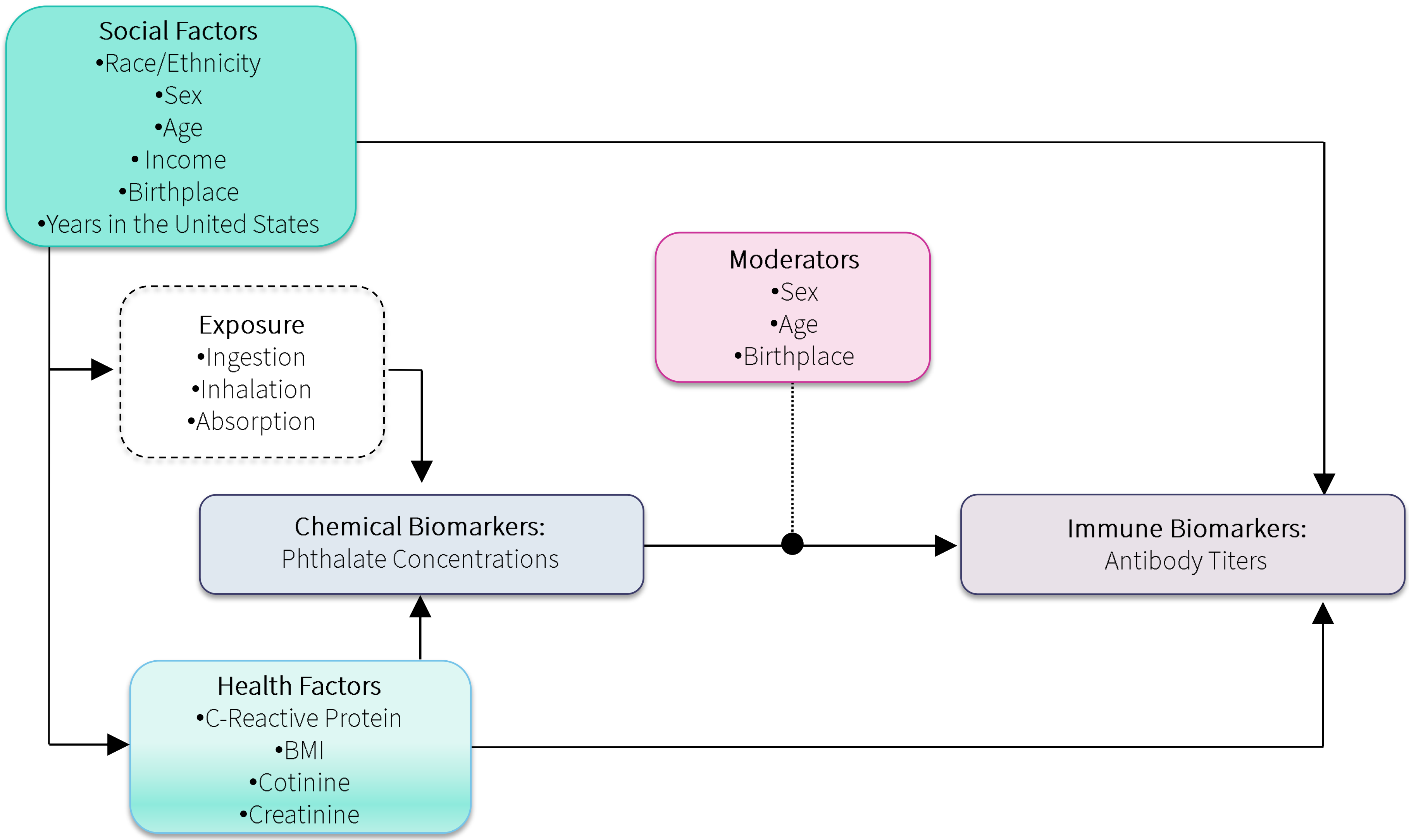

Figure 2. Conceptual model for this dissertation.

CHAPTER 4:
DATASET

Research Approach

This dissertation utilizes data from a five cross-sectional cycles of NHANES data between 2003-2012, which were obtained by surveying a representative sample of the U.S. residents one year and older. An overview of the survey, sample design, data collections processes, datasets used, and missing data are provided in the sections below. Specific details on methodology are described in each of the three papers (Chapters 5, 6, and 7).

National Health and Nutrition Examination Survey

The NHANES is an ongoing study conducted by the National Center for Health Statistics (NCHS). The NHANES program began in the 1960s as a series of surveys designed to measure specific populations or health topics. In 1999, the program became a continuous effort to understand health and nutritional issues nationwide. Since this time, NHANES examines a nationally representative sample of children and adults each year.

Sample Design

The NHANES survey design is a stratified, multistage probability sample of the civilian, non-institutionalized U.S. population age one year and older. Sample selection includes four stages. At the first stage, the primary sampling units (PSU) are single counties or small groups of contiguous counties selected with probability proportionate to size (PPS). At the second stage, segments of households (generally city blocks) within PSUs are selected as secondary sampling units (SSU) with PPS. The third stage involves random selection of households within SSUs. The final stage involves screening everyone in the household and randomly selecting one or more persons per household within designated age-sex-race/ethnicity screening domains. Participants under age 16 are screened via a proxy (usually their parent or guardian). Each year, 15 PSUs are visited and approximately 7,000 people are selected to participate (Centers for Disease Control and Prevention 2006).

To produce more reliable estimates, NHANES over-samples certain segments of the population (Centers for Disease Control and Prevention 2006). In 2007, several modifications were made to these oversampled domains to better reflect characteristics of the changing U.S. population. The primary change was oversampling of the entire Hispanic population instead of just Mexican Americans. It was found that the number of Hispanics in previous samples was generally too small to provide reliable estimates, thus, calculations are not recommended by the NCHS for non-Mexican American Hispanics from data collected prior to 2007 (Mirel, Mohadjer et al. 2013). Sufficient numbers of Mexican American were, however, retained in the sample design to allow trends in Mexican American health to be monitored further (Centers for Disease Control and Prevention 2006).

To allow for oversampling of the Hispanic population starting in 2007, oversampling of pregnant women and adolescents was discontinued. Additionally, for each of the race/ethnicity domains, the 12-15 and 16-19 year age domains were combined and the 40-59 year age minority domains were split into 10-year intervals of 40-49 and 50-59. This has led to an increase in the number of minority participants aged 40 and older, and a decrease in minorities age 12-19 from previous cycles (Centers for Disease Control and Prevention 2006). Beginning in 2011, Asians were included in the oversample for the first time, in addition to the ongoing oversample of Hispanics, non-Hispanic blacks, older adults, and low income persons of all race (Johnson, Dohrmann et al. 2014).

Data Collection

NHANES is a unique survey in that it employs interviews, physical examination, laboratory tests, and household measurements to collect data. Study teams consist of a physician, medical technicians, dietitians, and health interviewers that can administer all survey components in either English or Spanish. The Blaise computer-assisted personal interview (CAPI) system is used to collect survey data, and standardized specimen collection techniques are employed to gather household, exam, and laboratory data. Interviews and household measurements are conducted in respondents' homes while exams and laboratory components are performed in specially designed mobile exam centers (MECs) that travel to locations throughout the country. Laboratory specimens are processed, frozen (–30°C), and shipped from MECs to the National Center for Environmental Health for additional testing. Detailed specimen collection and processing instructions are available from the NHANES Laboratory/Medical Technologists Procedures Manual (Centers for Disease Control and Prevention 2011).

To facilitate participation, local media and governments are notified of the upcoming survey to advertise as well as encourage participation, and selected household receive a letter from the NCHS Director to introduce the survey. As a result, a majority of the household interviews are completed during the initial contact. If the participant is not home or it is an inconvenient time, a follow up is scheduled for a later date. Individuals selected to participate receive compensation for their time,[1] transportation to the mobile examination site, and a report of their medical findings. Data is collected continuously throughout the year with survey sites in northern latitudes visited in summer months and sites in southern latitudes visited in winter months. Data are subsequently released to the public as two-year cross-sectional cycles.

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[1] Nowhere in the NHANES documentation or on the CDC website is there disclosure on how much compensation is provided for participation. A newspaper article from 2010 does, however, mention compensation up to $125 for participating (http://www.nj.com/mercer/index.ssf/2010/08/national_health_survey_targets.html).

Datasets

To produce estimates with greater statistical reliability for demographic sub-domains and rare events, the CDC strongly recommends combining two or more 2-year cycles of the continuous NHANES data (Centers for Disease Control and Prevention 2006). For this reason, this dissertation uses various combinations of data from release cycles 2003-2004, 2005-2006, 2007-2008, 2009-2010, and 2011-2012 to examine the immune health effects associated with phthalates. For some survey components, only random subsamples of participants were tested and only in certain years due to feasibility. These include a variety of lab, nutrition/dietary, environmental, and mental health components.

Table 3 presents the sample characteristics by survey cycle. Across survey cycles, demographic and health factors are fairly consistent. Sex, age, income, BMI, and C-reactive protein were almost unchanged from 2003-2012. Race/ethnicity distributions were mostly stable over the years. Specifically, the majority of U.S.-born respondents were non-Hispanic whites, followed by non-Hispanic blacks and other. Over time, the proportion of non-Hispanic whites has decreased while the proportion of other has increased. The overwhelming majority of people were interviewed in English, but the proportion of Spanish interview increased slightly over the cycles examined (5.2% in 2003-2004 cycle to 8.1% in 2011-2012 cycle). Cotinine concentrations have decreased over time (55.4 ng/mL in 2003-2004 cycle to 42.7 ng/mL in 2011-2012 cycle) as have creatinine concentrations (131.4 ng/mL in 2003-2004 cycle to 114.8 ng/mL in 2011-2012 cycle). The proportion of people foreign-born has increased slightly over the years (12.4% in 2003-2004 cycle to 15.0% in 2011-2012 cycle). Of those born outside the U.S., people in the U.S. for 10 to 30 years as increased over time, however, those in the U.S. less than 10 years or more than 30 years are decreased between 2003 and 2012. For all phthalate metabolites except MiBP and McPP, concentrations have decreased between 2003 and 2012

Missing Data

As with most datasets, respondents may have missing data on key variables. Table 4 presents a summary of the percentage and the number of missing values for key study variables. Missing variables from the demographic questionnaire reflect "don't know" or "refusal" responses where as missing data from the exam (i.e. BMI) and laboratory components (i.e. all other variables) are missing because the respondent did not participate in that particular test. Overall, the percent missing was consist across most study waves, except for an increase in missing income data (from 5% to 8.9%) over time and a doubling of missing data for C-reactive protein for the 2007-2008 waves. There was also a slight increase in missing for "years in the U.S." in the last two data waves. Because missing data can increase biases, imputation was tested on a subset of models analyses. No major differences were observed between the imputed and non-imputed models, thus, non-imputed data were used for all analyses presented in this dissertation.

Weighting

Several weights were provided with each dataset to account for the complex survey design, survey non-response, and post-stratification to independent population controls. An individual was considered a non-responder if s/he was selected to be in the sample, but did not agree to, or did not complete the interview or exam portion of the survey. In addition to accounting for sample non-response, weights were also post-stratified to match the population control totals for each sampling subdomain as derived from the U.S. Census. When combining multiple cycles of data, weights have to be calculated based on the components used in the analysis. For this dissertation, MEC sample weights were adjusted by dividing the total number of combined waves, *n*, by the two-year MEC weights, to rescale the weights to match the population at the midpoint of survey period (Centers for Disease Control and Prevention 2006).

Table 3. Demographic characteristics by survey cycle, NHANES 2003-2012.

	2003-2004 Cycle	**2005-2006 Cycle**	**2007-2008 Cycle**	**2009-2010 Cycle**	**2011-2012 Cycle**
	Weighted percent/mean (SE)	Weighted percent/mean (SE)	Weighted percent/mean (SE)	Weighted percent/mean (SE)	Weighted percent/mean (SE)
CONTROLS					
Sex (%)					
Female	51.1 (.01)	51.0 (.00)	51.0 (.00)	51.0 (.01)	51.1 (.01)
Male	48.9 (.01)	49.0 (.00)	49.0 (.00)	49.0 (.01)	48.9 (.01)
Race/ethnicity (%)					
Non-Hispanic white	68.9 (.04)	68.4 (.03)	66.2 (.04)	64.6 (.03)	62.8 (.04)
Non-Hispanic black	12.2 (.02)	12.3 (.02)	12.2 (.02)	12 (.01)	12.4 (.02)
Mexican American	9.2 (.02)	9.5 (.01)	9.8 (.02)	10.5 (.02)	9.7 (.02)
Other	9.7 (.01)	9.8 (.01)	11.8 (.01)	12.9 (.01)	15.1 (.01)
Age, years (mean)	35.9 (.42)	36.2 (.78)	36.5 (.43)	36.7 (.55)	37.2 (.70)
Age, years (%)					
11 years or younger	16.7 (.01)	16.5 (.01)	16.3 (.01)	16.5 (.01)	15.9 (.01)
12-19 years	11.5 (.01)	11.4 (.00)	11.3 (.00)	11.1 (.00)	11.1 (.00)
20-29 years	13.5 (.01)	13.7 (.01)	13.8 (.01)	13.8 (.01)	13.7 (.01)
30-39 years	14.4 (.01)	13.7 (.01)	13.5 (.01)	13.0 (.00)	12.8 (.01)
40-49 years	15.6 (.01)	15.3 (.01)	14.8 (.01)	14.4 (.01)	13.7 (.01)
50-59 years	12.0 (.01)	12.8 (.01)	13.2 (.01)	13.3 (.01)	13.9 (.01)
60 years or older	16.3 (.01)	16.6 (.01)	17.1 (.01)	17.9 (.01)	18.9 (.01)
Poverty to income ratio (mean)	2.8 (.08)	3.0 (.08)	2.9 (.09)	2.8 (.04)	2.7 (.11)
Language of interview (%)					
English	94.8 (.01)	93.9 (.01)	93.2 (.01)	92.2 (.01)	91.9 (.01)
Spanish	5.2 (.01)	6.1 (.01)	6.8 (.01)	7.7 (.01)	8.1 (.01)
Birthplace (%)					
United States	87.6 (.02)	87.5 (.02)	86.7 (.02)	84.6 (.02)	85.0 (.02)

Foreign-born	12.4 (.02)	12.5 (.02)	13.3 (.02)	15.4 (.02)	15.0 (.02)
Years in the United States (%) [a]					
Less than 1 year	4.7 (.01)	2.6 (.01)	4.8 (.01)	3.2 (.01)	3.4 (.01)
1 year to < 5 years	19.0 (.03)	17.0 (.02)	12.8 (.02)	13.3 (.02)	12.7 (.01)
5 years to < 10 years	17.3 (.03)	20.3 (.01)	19.3 (.02)	20.0 (.02)	15.3 (.02)
10 years to < 15 years	18.9 (.02)	15.7 (.01)	13.9 (.02)	13.3 (.02)	18.5 (.01)
15 years to < 20 years	9.8 (.01)	7.7 (.01)	13.1 (.01)	10.5 (.01)	12.0 (.01)
20 years to < 30 years	12.7 (.01)	18.6 (.02)	16.4 (.01)	19.9 (.02)	19.0 (.01)
30 years to < 40 years	7.8 (.01)	9.3 (.01)	9.1 (.01)	8.6 (.01)	11.3 (.01)
40 years to < 50 years	5.6 (.01)	5.1 (.01)	6.9 (.01)	6.0 (.01)	4.5 (.01)
50 years to more	4.2 (.01)	3.7 (.01)	3.7 (.01)	5.2 (.01)	3.3 (.01)
Parent's country of birth (%) [b]					
Mother's country of birth, US	25.5 (.04)	N/A	N/A	N/A	N/A
Father's country of birth, US	24.4 (.04)	N/A	N/A	N/A	N/A
Body Mass Index (kg/m^2, mean)	26.2 (.15)	26.4 (.22)	26.4 (.15)	26.6 (.11)	26.6 (.17)
Cotinine (ng/mL, mean)	55.4 (4.3)	53.6 (2.7)	53.9 (4.6)	45.6 (3.4)	42.7 (3.1)
C-reactive protein (ng/mL, mean)	.37 (.01)	.38 (.01)	.32 (.01)	.37 (.01)	N/A
Creatinine (ng/mL, mean)	131.4 (3.2)	127.8 (2.2)	124.9 (2.6)	121.0 (1.7)	114.8 (2.2)
DEPENDENT VARIABLES (PAPER 2/3) (OD) [c]					
Antibody Titers					
Measles virus	9.0 (.31)	N/A	N/A	3.0 (.08)	N/A
Mumps virus	2.8 (.07)	N/A	N/A	2.8 (.09)	N/A
Rubella virus	62.2 (1.6)	N/A	N/A	3.4 (.07)	N/A
Polio virus					
Serotype 1	N/A	N/A	N/A	7.1 (.10)	N/A
Serotype 2	N/A	N/A	N/A	7.3 (.13)	N/A
Serotype 3	N/A	N/A	N/A	5.7 (.12)	N/A
Epstein-Barr virus	2.9 (.09)	2.6 (.10)	2.8 (.09)	2.8 (.10)	N/A
Toxoplasma gondii	N/A	N/A	N/A	12.4 (1.8)	N/A
INDEPENDENT VARIABLES (PAPER 2/3) AND DEPENDENT VARIABLES (PAPER 1) (GM) [d]					
Phthalates					
MEP	130 (7.92)	110.4 (6.48)	93.5 (5.09)	66.6 (2.96)	39.3 (2.41)
MnBP	23.3 (0.65)	21.6 (0.71)	20.7 (0.81)	16.5 (0.69)	9.8 (0.49)

MiBP	5.4 (0.21)	7.0 (0.27)	8.9 (0.29)	9.3 (0.38)	7.7 (0.29)
McPP	4.4 (0.07)	3.5 (0.11)	4.3 (0.13)	4.6 (0.23)	4.7 (0.26)
MBzP	12.1 (0.39)	10.5 (0.53)	9.3 (0.35)	8.3 (0.36)	6.3 (0.180
MEHP	3.9 (0.16)	4.6 (0.16)	4.1 (0.22)	3.0 (0.12)	2.7 (0.06)
MEHHP	24.1 (1.29)	27.8 (1.26)	24.1 (1.75)	14.8 (.85)	9.5 (0.23)
MEOHP	16.6 (0.81)	18.4 (0.83)	14.1 (0.99)	9.8 (0.49)	6.6 (0.16)
MECPP	36.7 (1.93)	40.8 (1.98)	35.2 (2.36)	22.5 (1.15)	14.6 (0.43)

Sample sizes vary by cycle and variable measured. **a:** Only foreign-born individuals were asked how many years they have lived in the U.S.; **b:** Only individuals identifying as Hispanic were asked parental birthplace; **c:** Antibody titers are expressed as optical densities (OD) with standard errors (SE). **e.** Phthalates are reported as geometric means (SE).

Table 4. Percentage and number of missing cases on key variables, NHANES 2003-2012.

Variables	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012
CONTROLS					
Demographics					
Sex	0%	0%	0%	0%	0%
Age	0%	0%	0%	0%	0%
Race/ethnicity	0%	0%	0%	0%	0%
Poverty to income ratio	5% (509)	4.7% (487)	8.2% (837)	8.9% (942)	7.9% (775)
Birthplace	0% (1)	0% (3)	0% (4)	0% (7)	0% (5)
Language of interview	0%	0% (2)	0% (1)	0%	0%
Years in the United States [a]	1.3% (19)	2.7% (42)	2.3% (56)	5.2% (103)	3.4% (72)
Mother's birthplace [b]	0% (8)	N/A	N/A	N/A	N/A
Father's birthplace [b]	0.1% (17)	N/A	N/A	N/A	N/A
Health Determinants					
Body Mass Index	9.9% (956)	10% (1001)	9.2% (901)	8.2% (841)	7.8% (736)
Cotinine	8.9% (764)	11% (992)	11% (964)	10% (960)	12%(1057)
C-reactive protein	10% (925)	13% (1268)	22% (1903)	9.9% (912)	N/A
Creatinine	2.8 % (74)	2.8 % (73)	3.8 % (95)	2.7 % (64)	2.7 % (69)
DEPENDENT VARIABLES (PAPER 2/3)					
Antibody Titers					
Measles virus	10% (517)	N/A	N/A	11% (506)	N/A
Mumps virus	0% (5)	N/A	N/A	11% (506)	N/A
Rubella virus	10% (517)	N/A	N/A	11% (506)	N/A
Polio virus	N/A	N/A	N/A	0%	N/A
Epstein-Barr virus	0%	0%	0%	0%	N/A
Toxoplasma gondii	N/A	N/A	N/A	0% (9)	N/A
INDEPENDENT VARIABLES (PAPER 2/3) AND DEPENDENT VARIABLES (PAPER 1)					
Phthalates [c]					
MEP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MnBP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MiBP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
McPP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MBzP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MEHP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MEHHP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MEOHP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)
MECPP	3.4% (92)	3.4% (90)	4.2% (114)	2.5% (70)	4.0% (105)

NOTE: Sample sizes vary depending on the sampling component the variable was derived from as described in detail in subsequent sections. **a:** Only foreign-born individuals were asked how many years they have lived in the U.S.; **b:** Only individuals identifying as Hispanic were asked about parental birthplace; **c:** Chemical biomarkers were only measured in random subsamples. Chemical samples below the limits of detection are not included in the missing data presented here.

CHAPTER 5:
PAPER 1

Role of Immigration, Age, and Sex on Phthalate Exposure in the United States: Findings from the National Health and Examination Survey, 2003-2012

INTRODUCTION

Health consequences from exposure to chemicals not only depend on physical processes that determine where and when pollutants occur in the environment, but also on the social conditions that determine where and when people are exposed to these chemicals. This link between social determinants, physical conditions, and health outcomes is widely recognized (Marmot 2005, Marmot, Friel et al. 2008, Ramirez, Baker et al. 2008, Braveman, Egerter et al. 2011), and it is increasingly understood that the inequitable distribution of such determinants is a significant contributor to numerous persistent and pervasive health disparities (Ramirez, Baker et al. 2008, Braveman and Gottlieb 2014).

There is growing concern over exposure to phthalates as numerous experimental and epidemiological studies suggest their association with a range of health effects, such as cancer (Kamrin 2009, Lopez-Carrillo, Hernandez-Ramirez et al. 2010), allergies (Kimber and Dearman 2010, Callesen, Bekö et al. 2014), asthma (Bornehag and Nanberg 2010), thyroid dysfunction (Meeker and Ferguson 2011), and endocrine disruption (Huang, Saxena et al. 2014). Since their development in the 1920s, phthalates have been the most widely used plasticizer worldwide for products, such as clothing, food packaging, and toys. Besides being used as plasticizers, phthalates are utilized as solvents and additives in consumer goods, such as flooring, furniture, construction materials, cosmetics, personal care items, pharmaceuticals, and pesticides (Serrano, Braun et al. 2014). Due to their chemical properties, phthalates are susceptible to leaching, migration and evaporation resulting in significant exposure to those that come in contact with them (Heudorf, Mersch-Sundermann et al. 2007, Zota, Calafat et al. 2014).

Exposure to phthalates likely occurs through several routes. Food, drinking water, household dust, and consumer products have all been reported as general sources of phthalate exposure (Schettler 2006, Heudorf, Mersch-Sundermann et al. 2007, Meeker, Sathyanarayana et al. 2009, Cerna, Maly et al. 2015, Johns, Cooper et al. 2015). Subgroups of the population may be disproportionally exposed to phthalates due to differences in their environments and behaviors, however, research on exposure in the U.S. has been limited to age, sex, and race/ethnic comparisons (Zota, Calafat et al. 2014).

While immigrants are a growing segment of the U.S. populations, few studies have examined factors associated with their exposure to chemicals in general and how exposure profiles may change over time (Singh and Hiatt 2006, Hernandez, Collins et al. 2015). To date, most research has focused on pesticide exposure, especially in occupation settings (Arcury, Quandt et al. 2001, Quandt, Arcury et al. 2001, Azaroff, Levenstein et al. 2003, Arcury, Laurienti et al. 2016). Birthplace has been shown as a determinant of exposure for other chemical classes. A study exploring polybromo diphenyl ethers (PDBE) exposure found children who had recently immigrated to California from Mexico had lower PDBE concentrations than Mexican-American children born in California (Eskenazi, Fenster et al. 2011). Another study found foreign-born persons to have higher concentrations of metals and organochlorine pesticides but lower levels of perfluoroalkyl substances and dioxins (Muennig, Song et al. 2011). The association between birthplace and phthalate exposure has not been examined in the U.S. population, but research in Europe shows diverse exposure profiles between the different countries (Cerna, Maly et al. 2015).

Because immigrants to the U.S. are highly diverse, it is important to consider other sociodemographic determinants in exposure. Sex differences in exposure to numerous chemicals have been observed with implications for greater disease burdens (Vahter, Åkesson et al. 2007, Berglund, Lindberg et al. 2011, Eng, 't Mannetje et al. 2011, Oiamo and Luginaah 2013). Due to both social and biological factors, women and man can have differences in exposure from work environments, health behaviors, knowledge of health promotion, and access to care, among other factors (Berglund, Lindberg et al. 2011, Eng, 't Mannetje et al. 2011, Oertelt-Prigione 2012). Specific to age, studies have found young persons to have greater levels of phthalates exposure (Ait Bamai, Shibata et al. 2014, Larsson, Ljung Björklund et al. 2014). Greater exposure in children is of particular concern because of potential disruption of growth and development processes (Woodruff, Axelrad et al. 2004). Landrigan et al. estimated that chemical exposures contribute to 100% of lead poisoning, 10% to 35% of asthma, 2% to 10% of cancers, and 5% to 20% of neurobehavioral disorders among children (Landrigan, Kimmel et al. 2003, Wilson, Chia et al. 2006). Further, children carry significant burden of chemically-induced damage to health since they are exposed so early in their life course (Gwinn, Axelrad et al. 2017).

More research is needed on better understand the role of birthplace and migration on phthalate exposure. This study utilizes a representative sample of the U.S. populations from the National Health and Nutrition Examination Survey (NHANES) cycles 2003-2004, 2005-2006, 2007-2008, 2009-2010, and 2011-2012 to assess associations between birthplace and urinary phthalate concentrations. This study also explores how other sociodemographic determinants, such as sex and age, as well a social processes, like length of time in the U.S. and parental birthplace, shape risk for phthalate exposure.

METHODS

Study Population

The NHANES is stratified, multistage probability sample of the civilian, non-institutionalized U.S. population age one year and older. Each year, approximately 7,000 people are selected to participate across the U.S. (Centers for Disease Control and Prevention 2006). The NHANES employs interviews, physical examination, laboratory tests, and household measurements to collect data, which are released in two-year cycles. Interviews and household measurements are conducted in respondents' homes while exams and laboratory components are performed in specially designed mobile exam centers (MECs) that travel to locations throughout the country. Informed consent is obtained from all NHANES participants, and data are de-identified prior to being publically released.

To produce estimates with greater statistical reliability for demographic sub-domains and rare events, the CDC recommends combining two or more 2-year cycles of the continuous NHANES data (Centers for Disease Control and Prevention 2006). For this reason, this study uses a combination of data from release cycles 2003-2004, 2005-2006, 2007-2008, 2009-2010, and 2011-2012. Overall, the response rate was fairly consistent across all five waves. Specifically, the interview response rates was 79%, and exam completion rate was 76% for the 2003-2004 cycle; interview response rate of 80% and exam completion rate of 77% for the 2005-2006 cycle; interview response rate of 78% and exam completion rate of 75% for the 2007-2008 cycle; interview response rate of 79% and exam completion rate of 77% for the 2009-2010 cycle; and interview response rate of 73% and exam completion rate of 70% for the 2011-2012 cycle (Centers for Disease Control and Prevention (CDC) 2011).

The combined interview sample between 2003 and 2012 consisted of 50,912 respondents of which 48,945 completed the physical exam (3.9% missing). Of those with completed exams, 3,866 individuals had missing data on covariates and were dropped from the sample. Phthalates were only measured in a random selection of 1/3 of exam participants six years and older. This yielded an analytic sample of 11,057 individuals. Some of the analyses were restricted only to foreign-born individuals (2,084 subjects) from the combined 2003-2012 analytic sample and others were limited to self-identified Hispanics (both foreign-born and US-born) during the 2003-2004 cycle (550 respondents) (Figure 5.1).

Measures

Phthalate metabolites: Laboratory specimens were collected, processed, frozen (–30°C), and shipped from MECs to the National Center for Environmental Health for additional testing. Phthalate concentrations were assessed using enzymatic deconjuction followed by solid phase extraction coupled with high-performance liquid chromatography/tandem mass spectrometry as described in detail previously (Silva, Barr et al. 2004). Samples with a concentration below the limit of detection (LOD) were assigned an imputed value of the LOD divided by the square root of 2 (Centers for Disease Control and Prevention 2013). Analyses were limited to nine phthalates detected in greater than 50% of all samples from all five waves assessed: mono-ethyl phthalate (MEP), mono-n-butyl phthalate (MnBP), mono-isobutyl phthalate (MiBP), mono-(3-carboxypropyl) phthalate (McPP), mono-benzyl phthalate (MBzP), mono-2-ethylhexyl phthalate (MEHP), mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP), mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP), mono-(2-ethyl-5-carboxypentyl) phthalate (MECPP). Two summary variables were created: one for dibutyl phthalate (∑DBP) by summing MnBP and MiBP, and a second summary variable for di-2-ethylhexyl phthalate (∑ DEHP) created by summing MEHP, MEHHP, MEOHP, and MECPP. For the purposes of this analysis, MEP, ∑DBP, MnBP and MiBP were classified as low molecular weight (LMW) phthalates, and McPP, MBzP, DEHP, MEHP, MEHHP, MEOHP, and MECPP as high molecular weight (HMW) phthalates. Due to skewed distributions, the two summary variables and the individual metabolite concentrations were $\log_{10}$ transformed.

Birthplace: Birthplace was measured with a dichotomous variable. Respondents in every wave were asked, "In what country were you born?" Between 2003 and 2006, survey participants could answer "United States," "Mexico," or "Other." If "Other" was selected, the name of the country was collected, however, publically available data files only released "United States," "Mexico," or "Other" as response categories. While the question remained the same in 2007, the response options changed to "50 United States or Washington, DC," "Mexico," "Other Spanish-speaking country," and "Other non-Spanish speaking country." The response options were once again changed in 2011 to "Born in 50 US States or Washington DC" or "Other." Due to modifications in response categories over time, the birthplace variable was recoded as "US-born" or "foreign-born" for all data waves. During the 2003-2004 cycle only, anyone 12 years or older identifying as Hispanic were asked about parental place of birth. Specifically, participants were asked, "In what country was your father born?" and "In what country was your mother born?" Answers were recoded in the public-use dataset as "US, except Puerto Rico," "Puerto Rico," "Mexico," "El Salvador," and "Other country." The same question was asked regarding participant's mother's birthplace. To maintain consistency with the birthplace variable and due to limited variance in responses, categories were collapsed into an indicator variable as "US-born father" or "foreign-born father" and "US-born mother" or "foreign-born mother," respectively.

To assess the length of time in the U.S., foreign-born subjects were asked, “In what month and year did you come to the United States to stay?” Answers were collected as months and years but publically-available data was recoded into 1 “less than 1 year,” 2 “1 year, less than 5 years,” 3 “5 years, less than 10 years,” 4 “10 years, less than 15 years,” 5 “15 years, less than 20 years,” 6 “20 years, less than 30 years,” 7 “30 years, less than 40 years,” 8 “40 years, less than 50 years,” and 9 “50 years or more.” The length of time in the U.S. variable was left as a continuous measure with response categories ranging from 1 to 9. In sensitivity analysis, category 1 and 2 were combined to create “less than five years” and categories 7, 8, and 9 were combined to create “30 or more years.” Then, indicator variables of length of time were compared to determine if a particular range of years in the U.S. was more influential than simply trending more or less time. This measure was collected in all five waves.

Covariates: Interviewers noted the language the interview was conducted in and recorded this as an indicator variable as “English” or “Spanish.” Sociodemographic variables were derived from standard, self-reported questions on sex, age, race/ethnicity, income, and education. For race/ethnicity, respondents were asked a series of questions including, “Do you consider yourself to be Hispanic or Latino?” with response options of “yes” or “no,” and “What race/ethnicity do you consider yourself to be? Please select one or more of these categories.” While respondents could select among 54 specific categories, the public use data file only made available collapsed categories of “Mexican American,” “other Hispanic,” “non-Hispanic white,” non-Hispanic black,” and “other race including multi-racial.” Due to changes in race/ethnicity categories between waves, race/ethnic categories used were: non-Hispanic white, non-Hispanic black, Mexican-American, or other. Standard questions were used to collect information on sex and age. Sex was coded as female or male; age was collected as a continuous variable from 1 to

85 year old. Anyone over the age of 85 was collapsed into the 85 year category. Because some of the income measures changed throughout the data collection waves, ratio of family income-to-poverty, or FIP, scores were used as a proxy from socioeconomic status. Ratios below 1.00 indicate that a person/family is below the federal threshold defined as poverty, while a ratio of 1.00 or greater indicates income above the poverty level. FIP scores were provided in the public use file with any score above 5.00 collapsed into the 5.00 category, such that, scores ranged from 0.00 to 5.00.

Body mass index (BMI) was measured in the physical exam for survey participants using the standard method of body mass in kilograms divided by the square of the participant's height in meters. The variable was used in analysis as a continuous measure reported in kg/m^2. Exposure to nicotine was measured using the metabolite cotinine in blood serum collected during the exam in participate three years and older. Cotinine was measured with isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (Centers for Disease Control and Prevention 2013).

Statistical Analyses

Analyses were performed with Stata v14.2 (StataCorp LP, 2015). The SVY survey command procedure was used to apply sample weights and adjust standard errors for the complex sample design. Since multiple cycles were combined, sample weights were adjusted by dividing the total number of combined waves, *5*, by the two-year MEC weights, to rescale the weights to match the population at the midpoint of survey period (Centers for Disease Control and Prevention 2006).

Descriptive statistics were assessed to examine the overall distribution of variables of interest among the analytic sample subgroups. Geometric means (GM) were used to examine the concentration of phthalate metabolites by survey cycle among sociodemographic subgroups. Geometric means are less influenced by high values, unlike arithmetic means, thus they provide better estimates of exposure. Next, multivariate ordinary least squares regression was utilized to examine associations between phthalate metabolites and birthplace. Regression covariates were identified from a previous epidemiological studies on phthalate exposure (Richard, Edwin van et al. 2007, Meeker and Ferguson 2011, Shiue 2013, Trasande, Sathyanarayana et al. 2013, Trasande, Sathyanarayana et al. 2014, Zota, Calafat et al. 2014, Smit, Lenters et al. 2015, Sakhi, Sabaredzovic et al. 2017), and only variables that contributed to parsimonious models were retained for additional analyses.

Four models were evaluated on the full analytic sample: model 1 represented the unadjusted model with birthplace and phthalate metabolite concentration; model 2 adjusted for sociodemographics (sex, age, race/ethnicity, and income); model 3 adjusted for model 2 variables plus health factors (BMI and cotinine); and model 4 adjusted for model 3 variables and language of interview. Subgroup analysis was conducted on each of these models stratified by sex (male and female) and age (19 years old or young and 20 years old or older), respectively. All models were run with and without creatinine adjustment; creatinine adjustment models are presented in this paper. Since this is a descriptive study, individual results were not corrected for multiple comparisons.

A subsample of only foreign-born respondents from the combined 2003-2010 wave was used to assess the association between time in the U.S. and urinary phthalate concentrations. Similar analyses were conducted as described for previous models above. Briefly, unadjusted models were fit with the years lived in the U.S. variable predicting each chemical congener concentration. In subsequent steps, control variables were added for sociodemographics, health status, and language, respectively. These models were run on the full sample and then stratified by sex and age, respectively. In sensitivity analysis, the continuous variable measuring time in the U.S. was run as an indicator variable comparing intervals of time to determine if a particular length of time had more influence on exposure. Lastly, the association between parental places of birth and concentrations of phthalate congeners among Hispanics in the 2003-2004 data wave was assessed using the same "core" multivariable regressions described previously. Maternal and paternal place of birth were assessed separately. Significance was assessed at p-value < 0.1, $p < 0.05$, $p < 0.01$, and $p < 0.001$.

RESULTS

Sample Characteristics

Table 5.1 presents the sample characteristics by place of birthplace and sex. The majority of U.S.-born respondents were non-Hispanic whites (73% of females and 74% of males) followed by non-Hispanic blacks (14% of females and 12% and males) and other (8% of females and 7% of males). More racial/ethnic diversity was seen among foreign-born persons where 45% of females and 40% of males identified as other; 27% of females and 32% of males as Mexican American; and 20% of both females and males as non-Hispanic White. When comparing US-born to foreign-born individuals, foreign-born persons were slightly older, had lower incomes, and had lower cotinine levels. Although, both U.S.-born and foreign-born women had higher cotinine levels than their male counterparts. Regardless of birthplace or sex, study participants were slightly overweight with an average BMI 26. The length of time foreign-born study participants have been in the U.S. ranged from less than a year to more than 50 years.

Exposure Distributions by Birthplace, Sex, and Age

The distribution of phthalate metabolites over time among US- and foreign-born persons are shown in Figures 5.2 and in Figure 5.3. For all phthalate metabolites, except MiBP and McPP, concentrations have decreased between 2003 and 2012 in U.S. and foreign-born females and males. Regardless of sex or nativity, MEP had the highest geometric mean concentration and MEHP the lowest concentration between 2003 and 2012. On average, foreign-born persons had higher total concentrations of phthalate metabolites in their urine compared to US-born persons (GM of 192. 6 ng/mL and 179.3 ng/mL, respectively) as did males compared to females (GM of 189.6 ng/mL and 182.3 ng/mL, respectively). Specifically, foreign-born individuals had higher means concentrations of lower molecular weight phthalates MEP, MnBP, and MiBP. Conversely, US-born respondents had higher averages of HMW phthalates McPP, MBzP, MEHHP, and MEOHP. Both foreign and U.S.-born females had higher concentrations, on average, of MEP and MnBP compared to their male counterparts whereas males consistently had higher average concentrations of MiBP, McPP, MBzP, MEHPP, MEOHP, and MECPP. Out of the nine metabolites examined, U.S.-born males had the highest average concentration for five of phthalates (McPP, MBzP, MEHHP, MEOHP, and MECPP) and foreign-born females for two of the phthalates (MEP and MnBP).

When comparing age groups, adolescents age 12 to 19 years had a higher total concentration (GM of 218.3 ng/mL) of phthalate metabolites compared to adults 20 years and old (182.3 ng/mL) and children ages 6 to 11 years (193.8 ng/mL). However, children ages 6 to 11 years had the highest geometric mean concentration in seven of the nine metabolites examined. Specifically, both U.S. and foreign-born children had higher concentrations of MnBP, MiBP, McPP, MBzP, MEHHP, MEOHP, and MECPP compared to U.S. or foreign-born adolescents and adults. Foreign-born children had disproportionately higher exposure to MnBP, MiBP, MEHHP, MEOHP, and MECPP whereas U.S.-born children had higher concentrations of McPP and MBzP. However, adults (95.9 ng/mL) and adolescents (89.8 ng/mL) had almost twice as much MEP in their urine compared to children (46.2 ng/mL) regardless of nativity, which shifted overall geometric mean totals above that of children. MEP concentrations have drastically decreased in adolescents and adults between 2003 and 2010 but have only slowly decreased in children. The exposure gap where children had much higher mean concentrations to MnBP, McPP, MBzP, MEHHP, MEOHP, and MECPP compared to adolescents and adults has decreased between 2003 and 2010. Exposure trends overall were more similar by age group then by birthplace (Figure 5.3).

Association between Birthplace and Phthalate Exposure

In adjusted models, there was a positive association between being foreign-born and exposure to MEP (β=0.192; 95% CI: 0.041, 0.342), MiBP (β=0.125; 95% CI: 0.055, 0.194), and MEHP (β=0.155; 95% CI: 0.070, 0.239), respectively. Conversely, an inverse association was seen among those who were foreign-born and concentrations of ∑ DBP (β=-0.181; 95% CI: -0.264, -0.098) and MBzP (β=-0.229; 95% CI: -0.297, -0.161). Associations were also examined among sex and age subgroups. There was a statistically significant positive association in foreign-born females with MEP (β=0.275; 95% CI: 0.075, 0.475) and MiBP (β=0.196; 95% CI: 0.068, 0.324) exposure compared to U.S.-born females. Negative associations were seen between foreign-born males and U.S.-born males in exposure to ∑ DBP (β=-0.221; 95% CI: -0.352, -0.091), McPP (β=-0.114; 95% CI: -0.238, 0.008), and MBzP (β=-0.253; 95% CI: -0.369,

-0.136), yet, a positive association was seen with MEHP (β=0.186; 95% CI: 0.061, 0.311). Similarly, there was a statistically significant negative association in foreign-born respondents under 19 years old with ∑ DBP, McPP, and MBzP exposure, but a positive association with MEHP exposure compared to U.S.-born young persons under 19 years old. Positive associations were seen in foreign-born adults for MEP (β=0.178; 95% CI: 0.003, 0.354) and MiBP (β=0.180; 95% CI: 0.073, 0.286) compared to U.S.-born adults (Table 5.2A).

Association between Length of Time in the U.S. and Phthalate Exposure

For all phthalates examined in foreign-born persons, there was a negative association between time in the U.S. and metabolite concentration, but only statistically significant associations were only seen for the HMW phthalates MiBP, ∑ DEHP, MEHP, MEHPP, MEOHP, and MECPP. When examining differences by sex, foreign-born females tended to have increased exposure to phthalate metabolites the longer they lived in the U.S. for ∑ DBP, McPP, ∑ DEHP, MEHP, MEHPP, MEOHP, and MECPP. However, foreign-born males tended to have decreased phthalate concentrations for MEP, ∑ DEHP, MEHP, MEHPP, MEOHP, and MECPP. Foreign-born males did have weak associations between increased exposure to ∑ DBP and MBzP and time in the U.S. Likewise, foreign-born person under 19 years of age had decreased concentrations of high molecular weight ∑ DEHP, MEHP, MEHPP, MEOHP, and MECPP. Foreign-born adults also had decreased concentrations of MEHP the longer they lived in the U.S. (Table 5.2B).

Sensitivity analysis was also conducted by examining length of time in the U.S. incrementally by five or ten year intervals to determine if differences existed between people who arrived more recently compared to those in the U.S. for longer time periods. In the full sample, few significant associations were observed and results were mixed. The same was seen in the female subsample. However, foreign-born males in the U.S. 30 or more years compared to males in the U.S. less than five years had statistically significant inverse associations for MnBP, MiBP, MBzP, ∑ DEHP, MEHP, MEHPP, MEOHP, and MECPP concentrations. Further, males in the U.S. between 15 and 30 years also had statistically significant inverse associations for concentrations of ∑ DEHP, MEHP, MEHPP, MEOHP, and MECPP compared to males in the U.S. for less than five years. On average, the longer a foreign-born male was in the U.S. the lower his urine concentration of phthalates, especially for HMW metabolites (Table 5.3). Comparing age subgroups, both foreign-born younger persons and adults had statistically significant inverse associations for HMW phthalates the longer they stayed in the U.S. compared to those who recently arrived.

Parental Birthplace and Phthalate Exposure among Hispanics in 2003-2004 Wave

During the 2003-2004 NHANES cycle, individuals that identified as Hispanic were asked about the birthplace of both parents. In adjusted models, there was a negative association between Hispanics with a foreign-born mother compared to Hispanics with a U.S.-born mother for ∑ DBP (β= -0.517; 95% CI: -0.762, -0.272), MnBP (β= -0.244; 95% CI: -0.382, -0.107), McPP (β= -0.244; 95% CI: -0.382, -0.107), and MBzP (β= -0.543; 95% CI: -0.815, -0.271). Similar inverse associations were seen for Hispanics with a foreign-born father compared to Hispanics with a U.S.-born father for phthalates ∑ DBP (β= -0.385; 95% CI: -0.640, -0.130), McPP (β= -0.184; 95% CI: -0.310, -0.058), and MBzP (β= -0.411; 95% CI: -0.692, -0.129) (Table 5.4).

DISCUSSION

Foreign-born persons generally had overall greater exposure to phthalates compared to U.S.-born persons, particularly for LMW metabolites. For all phthalate metabolites, except MiBP and McPP, urinary concentrations have decreased between 2003 and 2012. MEP had the highest average urinary concentration and MEHP the lowest, regardless nativity, sex, or age. The increase in McPP and MiBP could be a result of increased used of their respective monoesters as substitutes for now banned or regulated phthalate congeners. In particular, DiNP and DiDP are replacing DEHP as plasticizer globally, but this could be driven by replacement with other phthalates. McPP is a non-specific metabolite of several LMW and HMW phthalates and cannot be attributed to a single phthalate monoester; MnBP is a major metabolite of DBP but minor metabolite of BBzP.

Observed decreases in exposures are likely due to several factors, including regulation, chemical substitutions, and public awareness. Overall declining concentrations have been driven in large part by regulation, especially for DEHP metabolites like MEHP. The Consumer Product Safety Improvement Act of 2008 banned DEHP, DBP, and BBP in any amount greater than 0.1% in children's toys and articles that facilitate sleeping or feeding; DINP, DIDP, and DnOP were banned in any amount greater than 0.1% in the interim in children's toys that can be placed in a child's mouth (U.S. Consumer Product Safety Commission 2015). Internationally, the European Union and Canada have also enacted similar or more stringent legislation. Consistent with regulatory changes, this study showed a decline in MEP, ∑ DBP, MnBP, ∑ DEHP, MEHP, MEHHP, MEOHP, and MECPP.

Likewise, public health advocacy has increased awareness of chemical exposures and their potential health impacts. Efforts, such as Campaign for Safe Cosmetics and MADESAFE, have put pressure on companies to remove harmful chemicals from personal care products and cosmetics as well as increase transparency of ingredients (Zota, Calafat et al. 2014). However, it should be noted that limited English proficiency for some immigrants could increase their risk of exposure to hazards, like phthalates. Future awareness campaigns should consider providing materials in multiple languages to increase coverage and depth of understanding.

Because NHANES uses such a board classification for birthplace, and exposure is governed by many factors, it is difficult to generalize the drivers of exposure trends among immigrants. Studies that have compared phthalate exposure within the European Union, where regulations are the same, have found considerable exposure differences by country (Göen, Dobler et al. 2011, Cerna, Maly et al. 2015, Den Hond, Govarts et al. 2015). Food consumption, product usages, and/or lifestyle behaviors have been hypothesized as leading contributors to these differences (Koch, Rüther et al. 2017). Little is known about exposure trends in Central and South American countries, where many immigrants to the U.S. come from. Additionally research is needed to reduce exposure to this population.

Specific to sex, U.S.-born males had the highest average concentration for five of the nine phthalates measured and foreign-born females for two of the phthalates (MEP and MnBP). On average, males had greater exposure to phthalates compared to females, especially to HMW phthalates. HMW phthalates are common in industrial and commercial products, like flooring, paints and building materials, while LMW phthalates are often in personal care products and perfumes. Socially-influenced roles may explain some of these differential trends: men are more likely to be in physical environments with industrial or commercial chemicals in use while women are more likely to utilize personal care and cosmetic products.

When comparing age subgroups, adolescents had the highest average urine concentration of phthalates, yet, children age 6 to 11 years had greater exposure to more types of phthalates. Adults and adolescents had almost twice the exposure to MEP, the most common phthalate metabolite, which shifted their overall geometric mean total above that of children. Similar patterns have been observed worldwide with higher MEP concentrations in adults likely due to greater use of personal care products use compared to children (Cerna, Maly et al. 2015, Sakhi, Sabaredzovic et al. 2017). Both U.S. and foreign-born children had elevated concentrations of HMW metabolites MnBP, MiBP, McPP, MBzP, MEHHP, MEOHP, and MECPP compared to adolescents and adults. In particular, foreign-born children were disproportionately exposed to DBP and DEHP metabolites compared to U.S.-born children. Children are more likely to play with toys; touch surfaces like carpet or vinyl flooring; and stay indoors where pollutants are often concentrated, which may explain some of the observed differences in exposure to HMW phthalates. While exposure, on average, has decreased over the years, more needs to be done to reduce exposure in children. This group is particularly vulnerable to developmental processes that may be altered when in contact with these types of chemicals. Additionally, they bear a greater burden as health consequences from childhood exposures, which could be experienced over the life course.

In adjusted models, there was a positive association between being foreign-born and increased exposure to MEP, MiBP, and MEHP. Conversely, an inverse association was seen among those who were foreign-born and concentrations of $\sum$ DBP and MBzP. Because of heterogeneity of immigrants' birthplace and vast differences in exposure profiles by country of birth, it is difficult to attribute factors contributing to these observed results. Adding to this complexity, exposure levels changed by length of time lived in the U.S. Specifically, foreign-born males that stayed longer in the U.S. had lower urine concentrations of phthalates, but foreign-born females tended to have increased exposure with length of stay in the U.S. Foreign-born younger persons and adults had statistically significant inverse associations for HMW phthalates the longer they stayed in the U.S. compared to those who recently arrived.

Several limitations are present in this study. This research utilizes cross-sectional data, thus, causality nor can temporality be inferred. Another limitation is the broad categorization and/or limited information on key demographic variables. For instance, NHANES collects detailed information on respondent's country of birth. Publically released data, however, only provides a few representative categories, which have also changed over cycles. These confines analyses to U.S.- verses foreign-born, but numerous studies have documented the heterogeneity of immigrants in the U.S. on numerous sociodemographic and health characteristics and outcomes (Chiswick and DebBurman 2004, Singh and Hiatt 2006, Bakhtsiyarava and Nawrotzki 2017). These board categories are used to provide anonymity in the publically-released data, but information is lost that could help explain observed trends and associations as physical, social, and regulatory environments that contribute to phthalate exposure vary substantially globally. Further, although this biomonitoring study is useful for capturing trends in internal dose, it does not identify the sources of exposure, which is key to mitigating contact and reducing associated health risks. Additionally, single spot measurements of phthalate biomarkers may not be the best estimates of average or peak exposure, but several studies using 24 hour urine samples have shown spot samples to be comparable (Aylward, Hays et al. 2016, Koch, Rüther et al. 2017).

Despite several limitations, this research has numerous strengthens. NHANES is a nationally-representative survey providing results that have generalizability to the U.S. population. Even though the data is cross-sectional, population-level trends can be extrapolated over time about environmental chemical exposure. Further, this study's findings are consistent with other studies in the U.S. and aboard (Wittassek, Wiesmuller et al. 2007, Zota, Calafat et al. 2014, Cerna, Maly et al. 2015), thus contributing to a larger body of literature on phthalate exposure. Additionally, this research contributes a unique perspective on the social and physical factors associated with exposure. Sociodemographic subgroups have differential exposure to both amounts and types of phthalates. This has implications to targeting regulation and awareness to decrease exposure as well as potentially for treatments of health conditions associated with these exposures. Of concern are high concentrations of phthalates in children and the diversity of congeners they are exposed to, which could influence their development in the short-term and biological burden of disease long-term. Further, place of birth was associated with different trends in phthalate concentrations overall and among sex as well as age subgroups. This could imply that physical environments as well as social factors associated with geographic locations can influence exposure to phthalates. Additional research is needed to elucidate sources, processes, and outcomes associated with phthalate exposure.

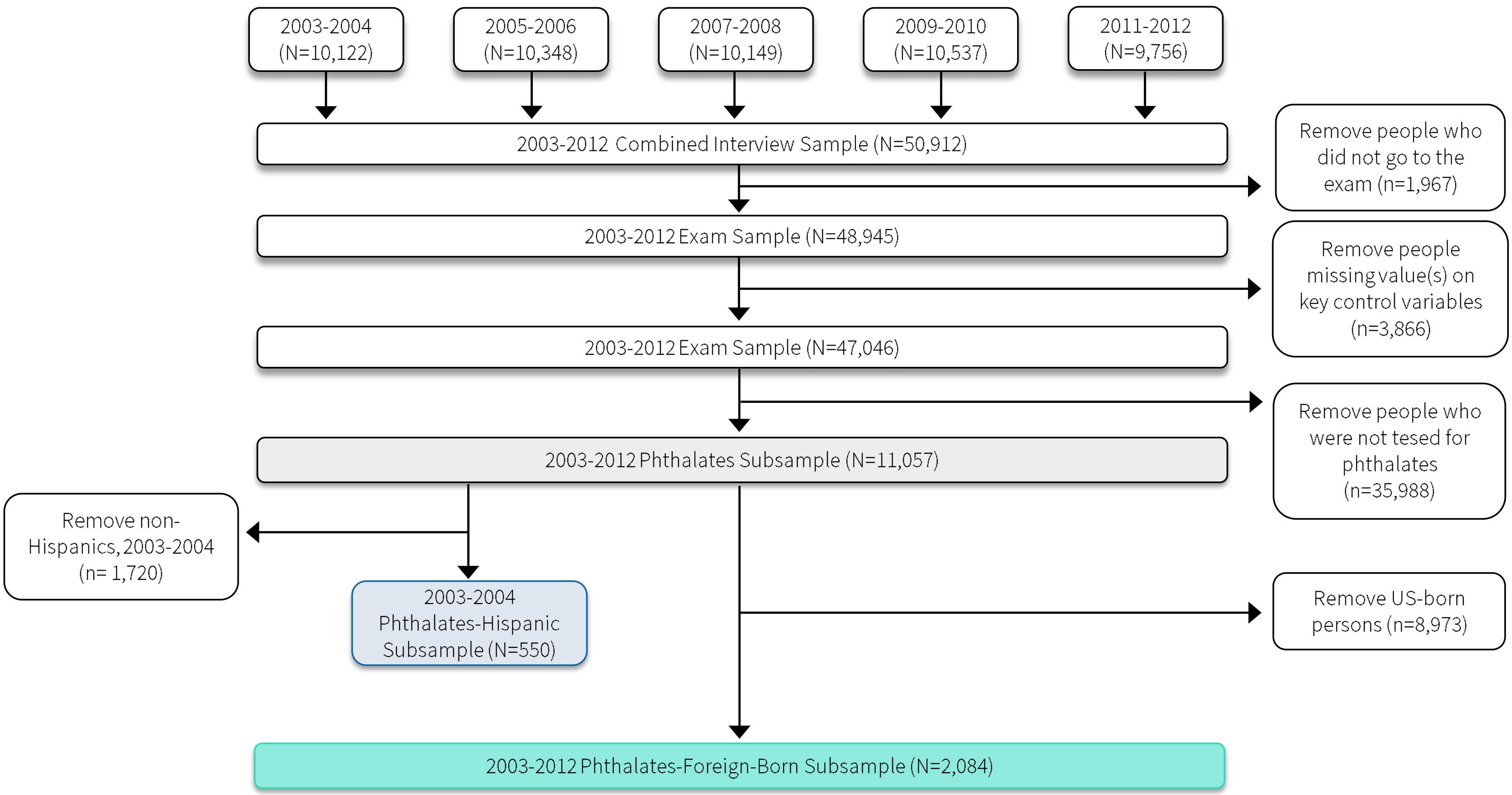


Figure 5.1. Analytic sample construction, NHANES 2003-2012.

Table 5.1. Characteristics of survey sample by sex and place of birth, NHANES 2003-2012 (n=11,057).

	US-Born		**Foreign-Born**	
	Female	**Male**	**Female**	**Male**
Characteristics	Weighted percent/mean (SE)	Weighted percent/mean (SE)	Weighted percent/mean (SE)	Weighted percent/mean (SE)
Race/ethnicity (%)				
Non-Hispanic White	72.9 (.02)	74.0 (.02)	20.5 (.01)	20.8 (.01)
Non-Hispanic Black	13.8 (.01)	12.4 (.01)	6.9 (.07)	6.9 (.01)
Mexican American	6.4 (.01)	6.8 (.01)	27.3 (.02)	32.1 (.02)
Other	7.5 (.04)	6.8 (.01)	45.3 (.02)	40.2 (.02)
Age, years (mean)	36.9 (.32)	34.9 (.34)	40.9 (.43)	38.9 (.41)
Poverty to income ratio (mean)	2.8 (.05)	3.0 (.04)	2.3 (.06)	2.4 (.06)
Language of interview (%)				
English	97.9 (.00)	97.7 (.00)	65.4 (.02)	63.1 (.02)
Spanish	2.1 (.00)	2.3 (.00)	34.6 (.02)	36.9 (.02)
Years in the United States (%) [a]				
Less than 1 year	---	---	3.9 (.00)	3.5 (.00)
1 year to < 5 years	---	---	14.8 (.01)	14.8 (.01)
5 years to < 10 years	---	---	17.8 (.01)	19.0 (.01)
10 years to < 15 years	---	---	15.6 (.01)	16.5 (.01)
15 years to < 20 years	---	---	10.8 (.01)	10.6 (.01)
20 years to < 30 years	---	---	17.8 (.01)	17.2 (.01)
30 years to < 40 years	---	---	9.0 (.01)	9.5 (.01)
40 years to < 50 years	---	---	6.1 (.01)	5.0 (.01)
50 years to more	---	---	4.2 (.01)	3.9 (.01)
Cotinine (ng/mL, mean)	42.4 (1.6)	67.5 (2.5)	13.2 (1.4)	34.4 (1.9)
BMI (mean)	26.6 (.10)	26.6 (.08)	26.7 (.17)	26.6 (.13)
Phthalate (ng/mL, geometric mean)				
Low Molecular Weight				
MEP	78.9 (3.0)	77.2 (2.5)	97.9 (7.3)	93.5 (6.4)
MnBP	17.4 (.45)	17.2 (.42)	18.7 (1.0)	17.7 (.87)
MiBP	7.0 (.14)	7.6 (.18)	8.5 (.35)	9.1 (.39)
High Molecular Weight				
McPP	4.0 (.08)	4.7 (.10)	3.7 (.12)	3.9 (.16)
MBzP	8.9 (.20)	9.9 (.24)	6.7 (.33)	7.4 (.31)
MEHP	3.3 (.07)	3.7 (.09)	3.6 (.13)	4.1 (.20)
MEHHP	17.0 (.54)	20.8 (.68)	15.6 (.78)	18.5 (1.2)
MEOHP	11.4 (.34)	13.3 (.41)	10.7 (.51)	11.6 (.66)
MECPP	25.7 (.79)	30.5 (.96)	25.5 (1.2)	28.4 (1.5)

Abbreviations: standard error (SE); body mass index (BMI)(kg/m^2).

a: Only foreign-born individuals were asked how many years they have lived in the U.S.

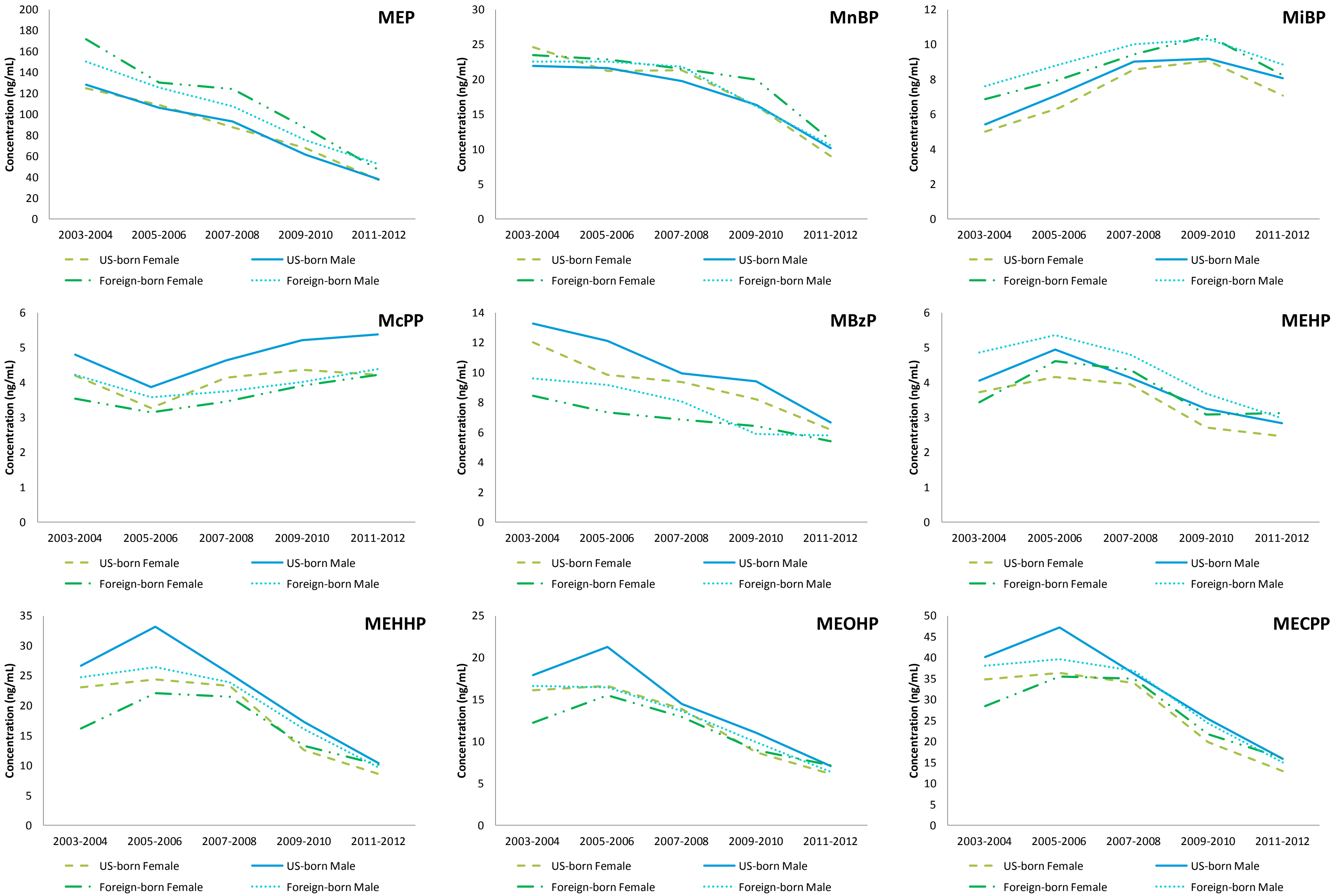


Figure 5.2. Geometric mean of urinary phthalate concentrations by sex and place of birth, NHANES 2003-2012 (n=11,057).

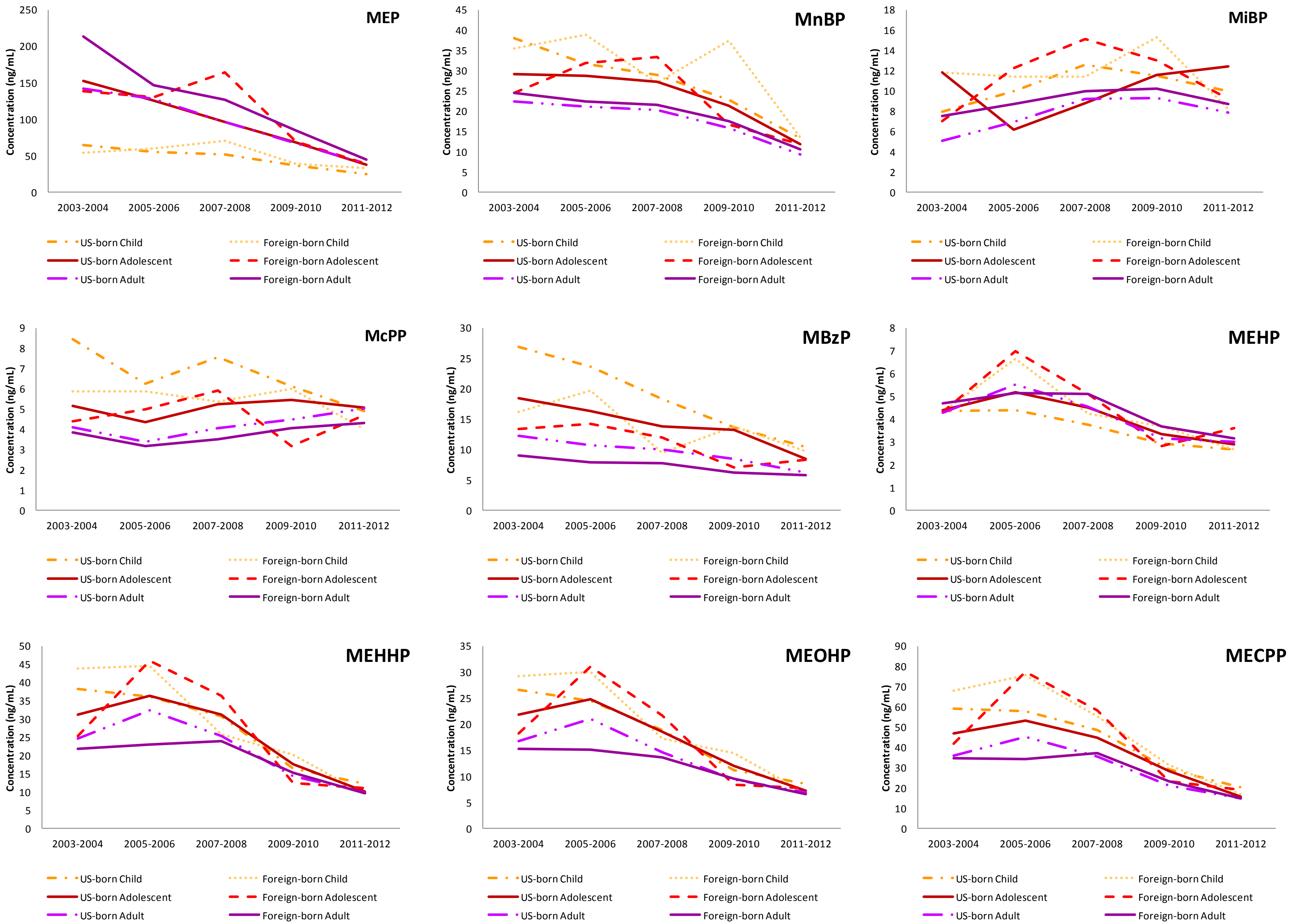


Figure 5.3. Geometric mean of urinary phthalate concentrations by age and place of birth, NHANES 2003-2012 (n=11,057).

Table 5.2A. Comparison of phthalate exposure by place of birth among sex and age subgroups, NHANES 2003-2010.

	Full Sample [c]	Sex [d]		Age [e]	
		Females	Males	< 20 years old	≥ 20 years old
Analyte	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Birthplace: Foreign-Born [a] (n=11,057)					
MEP	.192 (.041, .342)**	.275 (.075, .475)**	.131 (-.053, .317)	.132 (-.056, .320)	.178 (.003, .354)*
∑ DBP	-.181 (-.264, -.098)***	-.170 (-.293, -.048)**	-.221 (-.352, -.091)**	-.209 (-.380, -.038)*	-.150 (-.258, -.042)**
MnBP	.076 (-.013, .165)	.071 (-.083, .226)	.018 (-.114, .151)	.002 (-.158, .163)	.087 (-.033, .208)
MiBP	.125 (.055, .194)***	.196 (.068, .324)**	.106 (-.018, .232)+	.112 (-.022, .248)	.180 (.073, .286)***
McPP	-.063 (-.157, .030)	-.015 (-.108, .078)	-.114 (-.238, .008)+	-.119 (-.247, .007)+	-.007 (-.108, .093)
MBzP	-.229 (-.297, -.161)***	-.232 (-.364, -.100)***	-.253 (-.369, -.136)***	-.225 (-.405, -.045)*	-.209 (-.304, -.114)***
∑ DEHP	-.007 (-.126, .111)	.007 (-.143, .159)	-.021 (-.175, .132)	.092 (-.090, .275)	-.001 (-.150, .148)
MEHP	.155 (.070, .239)***	.121 (.019, .222)*	.186 (.061, .311)**	.166 (.001, .330)*	.102 (-.004, .209)+
MEHHP	-.012 (-.137, .113)	-.021 (-.175, .133)	-.012 (-.170, .145)	.060 (-.133, .254)	-.016 (-.171, .137)
MEOHP	-.019 (-.132, .094)	.004 (-.142, .151)	-.032 (-.175, .111)	.073 (-.108, .255)	-.011 (-.155, .132)
MECPP	-.010 (-.120, .101)	.012 (-.132, .158)	-.024 (-.167, .118)	.107 (-.067, .283)	.009 (-.130, .150)

Table 5.2B. Comparison of phthalate exposure in foreign-born individuals by length of time lived in the U.S., NHANES 2003-2010.

	Full Sample	Sex		Age	
Length of Time in the U.S. [b] (n= 2,084)					
MEP	-.018 (-.064, .028)	.042 (-.040, .125)	-.070 (-.142, .001)+	.125 (-.038, .288)	-.027 (-.076, .020)
∑ DBP	-.009 (-.039, .020)	.061 (.003, .118)*	.044 (-.007, .095)+	.005 (-.142, .153)	.008 (-.022, .038)
MnBP	-.024 (-.053, .057)	.017 (-.042, .077)	-.025 (-.070, .020)	-.049 (-.194, .095)	-.013 (-.044, . .018)
MiBP	-.030 (-.057, -.003)*	.028 (-.020, .076)	-.034 (-.083, .015)	-.009 (-.120, .100)	-.021 (-.050, .007)
McPP	-.000 (-.022, .021)	.058 (.017, .099)**	.003 (-.032, .040)	.030 (-.076, .137)	.010 (-.012, .032)
MBzP	-.021 (-.055, .013)	.038 (-.024, .100)	.048 (-.002, .100)+	-.007 (-.165, .150)	-.003 (-.037, .030)
∑ DEHP	-.040 (-.079, -.001)*	.083 (.027, .139)**	-.085 (-.155, -.016)*	-.139 (-.296, .016)+	-.020 (-.060, .018)
MEHP	-.053 (-.085, -.020)**	.058 (.014, .101)**	-.085 (-.141, -.030)**	-.093 (-.239, .052)	-.047 (-.081, -.013)**
MEHHP	-.040 (-.081, -.001)*	.080 (.023, .138)**	-.091 (-.164, -.018)*	-.156 (-.311, -.001)*	-.023 (-.064, .017)
MEOHP	-.044 (-.081, -.007)*	.063 (.008, .118)*	-.089 (-.155, -.023)**	-.127 (-.280, . .025)+	-.027 (-.065, .010)
MECPP	-.034 (-.071, .003)+	.107 (-.067, .283)	-.076 (-.141, -.011)*	-.076 (-.141, -.011)*	-.014 (-.052, .023)

a: Reference group is U.S.-born persons. b: Sample consists of only foreign-born persons. c: Full sample model shows estimated coefficient (95% confidence interval) adjust for race/ethnicity, sex, age, FIP, BMI, cotinine, language of interview, and creatinine. d: Models stratified by sex adjust for race/ethnicity, age, FIP, BMI, cotinine, language of interview, and creatinine. e: Models stratified by age adjust for race/ethnicity, sex, FIP, BMI, cotinine, language of interview, and creatinine. Significance defined at + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 5.3. Sensitivity analysis of phthalate exposure in foreign-born individuals by length of time lived in the U.S., NHANES 2003-2010.

	MEP	∑ DBP	MnBP	MiBP	McPP	MBzP	∑ DEHP	MEHP	MEHHP	MEOHP	MECPP
Years in U.S.	β	β	β	β	β	β	β	β	β	β	β
Full Sample (n=4,019)											
5 to < 10 yrs.	-0.078	-0.084	-0.161	-0.055	-0.034	-0.119	0.006	0.014	0.022	-0.006	0.015
10 to < 15 yrs.	0.096	0.000	-0.180	-0.147	0.059	-0.054	-0.089	-0.057	-0.045	-0.090	-0.117
15 to < 20 yrs.	-0.130	0.049	-0.187	-0.096	0.075	-0.015	-0.173	-0.008	-0.197+	-0.226*	-0.145
20 to < 30 yrs.	0.083	0.111	-0.089	0.012	0.028	0.115	0.052	0.039	0.073	0.003	0.050
30 or more yrs.	-0.177	0.201+	-0.128	-0.062	0.162+	0.107	-0.019	-0.166+	-0.047	-0.080	0.027
SEX											
Female (n=1,018)											
5 to < 10 yrs.	-0.269	-0.145	-0.113	0.049	-0.102	-0.178	0.218	0.111	0.213	0.178	0.203
10 to < 15 yrs.	-0.293	-0.289	-0.302	-0.189	-0.048	-0.413	-0.125	-0.090	-0.051	-0.118	-0.175
15 to < 20 yrs.	-0.044	-0.113	-0.193	-0.126	-0.075	-0.179	-0.015	0.104	-0.058	-0.081	-0.007
20 to < 30 yrs.	0.052	-0.098	-0.219	-0.148	0.032	-0.191	0.249	0.155	0.291+	0.181	0.235
30 or more yrs.	-0.121	-0.185	-0.151	-0.126	-0.022	-0.314+	0.000	-0.153	0.007	-0.065	0.032
Male (n=1,1070)											
5 to < 10 yrs.	0.117	0.004	-0.214	-0.160	0.042	-0.024	-0.241	-0.127	-0.214	-0.223	-0.203
10 to < 15 yrs.	0.485+	0.171	-0.112	-0.172	0.107	0.189	-0.207	-0.154	-0.191	-0.199	-0.207
15 to < 20 yrs.	-0.172	0.089	-0.226	-0.141	0.140	0.036	-0.451*	-0.217	-0.457*	-0.474**	-0.402*
20 to < 30 yrs.	0.128	0.006	-0.111	-0.041	-0.114	0.082	-0.417*	-0.313*	-0.401*	-0.412*	-0.397**
30 or more yrs.	-0.229	-0.078	-0.363**	-0.371**	0.010	-0.158	-0.579**	-0.635***	-0.604***	-0.565***	-0.503***
AGE											
< 20 years old (n=372)											
5 to < 10 yrs.	0.168	0.165	0.195	0.270	0.154	0.110	0.211	0.136	0.219	0.192	0.199
10 to < 15 yrs.	0.669	0.290	0.275	0.222	0.209	0.236	0.154	0.028	0.157	0.143	0.141
15 to < 20 yrs.	0.180*	-0.210	-0.603**	-0.343	0.140	-0.288	-0.786*	-0.341	-0.891**	-0.772**	-0.710*
20 to < 30 yrs.	---	---	---	---	---	---	---	---	---	---	---
30 or more yrs.	---	---	---	---	---	---	---	---	---	---	---
≥ 20 years old (n=1,753)											
5 to < 10 yrs.	-0.121	-0.157	-0.262	-0.140	-0.072	-0.195+	-0.050	-0.015	-0.034	-0.064	-0.034
10 to < 15 yrs.	0.000	-0.170	-0.332	-0.280	-0.023	-0.233+	-0.217+	-0.135	-0.159	-0.209	-0.247*
15 to < 20 yrs.	-0.178	-0.015	-0.200	-0.128*	0.037	-0.086	-0.149	-0.030	-0.163	-0.206	-0.122
20 to < 30 yrs.	-0.001	-0.017	-0.160	-0.077	-0.033	-0.021	-0.014	-0.058	0.009	-0.056	-0.009
30 or more yrs.	-0.276	-0.106	-0.271*	-0.251*	0.010	-0.212	-0.229*	-0.379***	-0.245*	-0.264*	-0.173+

Sample consists of only foreign-born persons. Full sample model shows estimated coefficient adjusted for race/ethnicity, sex, age, FIP, BMI, cotinine, language of interview, and creatinine. Models stratified by sex adjust for race/ethnicity, age, FIP, BMI, cotinine, language of interview, and creatinine. Models stratified by sex adjust for race/ethnicity, age, FIP, BMI, cotinine, language of interview, and creatinine. Significance defined at + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 5.4. Influence of parental place of birth on chemical exposure in U.S.-born and foreign-born Hispanics, 2003-2004 (N=550).

	Foreign-born Mother		**Foreign-born Father**	
Chemical Analyte	Model 1 β (95% CI)[a]	Model 2 β (95% CI)[a]	Model 1 β (95% CI)[a]	Model 2 β (95% CI)[a]
MEP	.376 (-.000, .752)*	.260 (-.069, .589)	.203 (-.123, .531)	.099 (-.239, .438)
∑ DBP	-.546 (-.775, -.318)***	-.517 (-.762, -.272)***	-.421 (-.652, -.190)***	-.385 (-.640, -.130)**
MnBP	-.229 (-.442, -.015)*	-.232 (-.478, .012)+	-.011 (-.236, .212)	.007 (-.226, .241)
MiBP	.028 (-.256, .314)	.009 (-.324, .343)	.134 (-.129, .397)	.110 (-.180, .400)
McPP	-.233 (-.363, -.103)**	-.244 (-.382, -.107)**	-.191 (-.309, -.073)**	-.184 (-.310, -.058)**
MBzP	-.576 (-.832, -.320)***	-.543 (-.815, -.271)***	-.446 (-.709, -.183)**	-.411 (-.692, -.129)**
∑ DEHP	-.157 (-.451, .136)	-.202 (-.485, .080)	.008 (-.275, .293)	-.028 (-.284, .226)
MEHP	-.058 (-.307, .190)	-.078 (-.308, .151)	.143 (-.103, .389)	.124 (-.062, .312)
MEHHP	-.210 (-.507, .086)	-.234 (-.529, .060)	-.053 (-.335, .227)	-.077 (-.331, .175)
MEOHP	-.165 (-.432, .101)	-.199 (-.463, .064)	-.046 (-.297, .205)	-.080 (-.310, .149)
MECPP	-.117 (-.404, .170)	-.172 (-.446, .101)	.053 (-.236, .343)	.011 (-.248, .270)

a: Reference group is U.S.-born parent (mother or father, respectively). Model 1 shows estimated coefficient (95% confidence interval) adjusted for foreign-born mother or father, sex, race/ethnicity, age, and income. Model 2 adjusts for foreign-born mother or father, sex, race/ethnicity, age, income, BMI, cotinine and creatinine. Significance defined at + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

CHAPTER 6:
PAPER 2

Phthalate Exposure and Antibody Titers:
Implications for Adaptive Immune Response to Measles, Mumps, Rubella, Polio, Mononucleosis, and Toxoplasmosis

INTRODUCTION

Introduced in the 1920s, phthalates are synthetic chemicals widely used as plasticizer, solvents, and additives. They are generally classified into two groups based on the number of carbons in the their alcohol chain as either low molecular weight (LMW) or high molecular weight (HMW) phthalates. LMW phthalates, such as dibutyl phthalates (DBP) and diethyl phthalate (DEP), are widely used as additives to make varnishes; lacquers; and cosmetic products including perfumes, aftershaves, shampoo, makeup, lotions, and nail products. HMW phthalates, like bis(2-ethylhexyl) phthalate (DEHP), di-n-octyl phthalate (DOP or DnOP) and benzylbutyl phthalate (BzBP), are more commonly utilized as plasticizers for industrial and consumer products, such as flooring, paints, imitation leather, food storage containers, and medical devices (Frederiksen, Skakkebaek et al. 2007, Swan 2008). Both LMW and HMW phthalates have relatively high boiling points, low volatility, and lipophilicity endowing them strength, transparency, flexibility, and durability leading to their widespread application in various products. However, since they are not covalently bound to a matrix, this makes phthalates susceptible to leaching, migration and evaporation, which can result in significant exposure (Staples, Peterson et al. 1997, Heudorf, Mersch-Sundermann et al. 2007).

There is growing evidence from experimental and epidemiological studies of a range of health effects associated with phthalate exposure. Nevertheless, few studies have examined the effects of phthalates on immune function, and most of this research has been *in vitro* or *in vivo* laboratory experiments. One such study found exposure to DnBP and DEP impaired cytokine secretion from monocytes and macrophages interfering with both innate and adaptive immune response (Hansen, Nielsen et al. 2015). Other studies suggested that phthalates influence immunoglobulin production, cytokine secretion from T helper cells, histamine release, and phagocytic ability in cells from the innate immune system (Bornehag and Nanberg 2010, Hansen, Bendtzen et al. 2015). Similarly, mice exposed to DEHP had increased concentrations of IgE, IgG, and several interleukins (Robinson and Miller 2015).

Of the epidemiological studies that exist on phthalates, most concern allergic conditions and hypersensitivity. Several studies have found an association between phthalates in dust and allergic symptoms, such as wheezing, rhinitis, eczema, and asthma (Kolarik, Naydenov et al. 2008, Just, Whyatt et al. 2012). In research on allergic symptoms and sensitization in children and adults in the U.S., HMW phthalates were positively associated with allergies in adults but not children (Hoppin, Jaramillo et al. 2013). Another study with children 3-5 years old found no association between phthalate exposure and asthma, rhinoconjunctivitis or atopic dermatitis (Bekö, Callesen et al. 2015). While no clear patterns have emerged, it appears some phthalate congeners may modify immune responses in certain populations.

Since limited or inconclusive research has been published on the association between phthalates and immunomodulation, it is important to identify whether phthalates adversely affects immune system health as it protects us against infectious diseases and cancers. This research utilizes a representative sample of the U.S. populations who participated in the NHANES between 2003 and 2010 to assess associations between phthalate exposure and antibodies that protect against measles, mumps, rubella, polio, mononucleosis, and toxoplasmosis. Vaccines for measles, mumps, rubella, and poliovirus have decreased the prevalence of these diseases considerably, but these infectious agents still have not been eradicated leading to significant morbidity and mortality worldwide. Vaccines for mononucleosis and toxoplasmosis are not currently available, however, seroprevalence is high for both conditions, as can be their consequences. Because these infectious agents are a public health concern and they represent in a mix of naturally as well as artificially acquired immunity, they will be the focus of this study. To assess whether certain sociodemographic subgroups have increased risk for immunomodulation from phthalates, sex-, age-, and birthplace specific associations will also be evaluated.

METHODS

Study Population

The NHANES is an annual, nationally representative sample of the civilian, non-institutionalized U.S. population age one year and older. NHANES is a unique survey in that it employs interviews, physical examination, laboratory tests, and household measurements to collect data. Interviews and household measurements are conducted in respondents' homes while exams and laboratory components are performed in specially designed mobile exam centers (MECs) that travel to locations throughout the country. Laboratory specimens are processed, frozen (–30°C), and shipped from MECs to the National Center for Environmental Health or other locations for additional testing (Centers for Disease Control and Prevention 2011). Informed consent is obtained from all NHANES participants, and data are de-identified prior to being publically released.

Phthalate metabolites were measured in spot urine samples collected in the MECs in a random selection of 1/3 of exam participates six years and older in all cycles. Antibody measures were only collected in blood samples from select NHANES cycles. Specifically, measles, mumps, and rubella (MMR) antibodies were measured in the 2003-2004 and 2009-2010 cycles in individuals six to 49 years; poliovirus antibodies in the 2009-2010 cycle in individuals six to 49 years; *Toxoplasma gondii* antibodies in the 2009-2010 cycle in individuals six and older; and Epstein-Barr virus (EBV) in individuals six to 19 years between 2003 and 2010. Women who were pregnant and participants who tested positive for HIV/AIDS or Hepatitis C were excluded from the analyses because of underlying changes to their immune systems that may influence study results. Participants missing data on key study variables were also excluded from the analytic subsamples. As a result, five analytic subsamples were created: 2,105 participants in the 2003-2004 MMR subsample; 1,813 participants in the 2009-2010 MMR subsample; 1,735 participants in the 2009-2010 polio subsample; 2,368 participants in the 2009-2010 *Toxoplasma gondii* subsample; and 4,162 participants in the 2003-2010 EBV subsample (Figure 6.1).

Measures

Phthalate metabolites: Phthalate concentrations were assessed using enzymatic deconjuction followed by solid phase extraction coupled with high-performance liquid chromatography/tandem mass spectrometry as described in detail previously (Silva, Barr et al. 2004). Samples with a concentration below the limit of detection (LOD) were assigned an imputed value of the LOD divided by the square root of 2 (Centers for Disease Control and Prevention 2013). Analyses were limited to nine phthalates detected in greater than 50% of all samples: mono-ethyl phthalate (MEP), mono-n-butyl phthalate (MnBP), mono-isobutyl phthalate (MiBP), mono-(3-carboxypropyl) phthalate (McPP), mono-benzyl phthalate (MBzP), mono-2-ethylhexyl phthalate (MEHP), mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP), mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP), mono-(2-ethyl-5-carboxypentyl) phthalate (MECPP).

Two summary variables were created: one for dibutyl phthalate (∑DBP) by summing MnBP and MiBP, and a second summary variable for di-2-ethylhexyl phthalate (∑ DEHP) by summing MEHP, MEHHP, MEOHP, and MECPP. Due to skewed distributions, the individual metabolite and the two summary variables concentrations were $\log_{10}$ transformed. Because phthalate metabolites were measured in urine samples, which can vary by age, gender and race/ethnicity, urinary creatinine concentrations were used to adjust for urinary dilution and demographic difference in multiple regression analyses (Barr, Wilder et al. 2005). Analyses were run unadjusted and adjusted for creatinine concentrations; creatinine adjusted results are presented.

Antibody Titers: MMR antibody titers were collected in the 2003-2004 and 2009-2010 cycles. Since there were differences in testing procedures, data from 2003-2004 and 2009-2010 cycles could not be combined for measles, mumps, or rubella. For the 2003-2004 cycle, MMR tests were performed by the Immunoserology Unit, California State Department of Health Services. Measles IgG and rubella IgG antibody tests were conducted with in-house enzyme immune assays (EIA) while mumps IgG was measured with the commercially–available Wampole® enzyme linked immunosorbent assay (ELISA). For the 2009-2010 cycle, measles, mumps and, rubella IgG were measured by the National Center for Immunization and Respiratory Disease Laboratories. Here, commercially-produced Wampole® ELISAs were used to measure antibody concentrations. MMR antibodies were measured as an index value of optical density (OD) ratio for all waves. Assays measured whether an individual had detectable viral antibodies concentrations, defined as seropositivity,. The majority of respondents were seropositive for measles (96% and 92%), mumps (91 and 87%), and rubella (92% and 95%) antibodies in the 2003-2004 and 2009-2010 data cycles, respectively.

Seropositivity, however, does not necessarily indicate whether an individual has sufficient antibody titers to provide protection from disease. Only the protective efficacy of rubella vaccination has been determined to date, which is generally considered IgG antibodies ≥10 International Units (IU) per mL, although, some regard a higher cut point of ≥15 IU/mL as protective (World Health Organization 2008). Rubella antibody data for 2003-2004 and 2009-2010 were converted into IU/mL to examine seroprotection as well as serpositivity. Sensitivity analysis was conducted with a dichotomous variable of protected (≥10 IU/mL) and unprotected (<10 IU/mL) against rubella (World Health Organization 2008).

Poliovirus antibody titers for serotype 1, serotype 2, and serotype 3 were collected in the 2009-2010 cycle and tested at the CDC's Global Polio Specialized Laboratory according to standard WHO protocols (Centers for Disease Control and Prevention 2014). If an individual develops antibodies to a particular strain of poliovirus, they are presumed to be protected against disease, however, protective serum neutralizing antibody levels has not been determined (World Health Organization 1996). Thus, poliovirus antibody titers will only be analyzed as a continuous OD value. The majority of the study populations were seropositive for polio serotype 1 (96%), serotype 2 (98%), and serotype 3 (88%) antibodies.

EBV antibody titers were collected in four cycles between 2003 and 2010. EBV IgG antibodies were measured with commercially-available Diamedix EIA kits and reported as a: 1) continuous OD index and 2) categorical indicators of positive (EIA ≥ 1.10), negative (EIA ≤ 0.90), or equivocal (0.9 < EIA ≥ 1.09) according to testing kits instructions (Centers for Disease Control and Prevention 2012). Individuals with equivocal results were not included in the data analysis as there was no means of determining whether they had a primary EBV infection and were in the process of seroconverting, or whether they had nonspecific reactivity in the antibody

EIA (Balfour, Sifakis et al. 2013). Of young persons tested for EBV, 76% were positive for antibodies between 2003 and 2010.

Toxoplasma gondii antibodies were measured in the 2009-2010 cycle for individuals six years and older. Antibodies were measured with Bio-Rad EIA kits (Redmond, VA) as a continuous OD index and reported as IU/mL. Titers ≥ 33 IU/mL were considered seropositive (Centers for Disease Control and Prevention 2013). In the 2009-2010 cycle, only 15% of participants were seropositive for *Toxoplasma gondii* antibodies.

Covariates: Sociodemographic variables were derived from standard, self-reported questions on sex, age, race/ethnicity, and income. Sex was coded as female or male; age was collected as a continuous variable from 1 to 85 year old. Anyone over the age of 85 was collapsed into the 85 year category. For race/ethnicity, respondents were asked a series of questions including, "Do you consider yourself to be Hispanic or Latino?" with response options of "yes" or "no," and "What race/ethnicity do you consider yourself to be? Please select one or more of these categories." While respondents could select among 54 specific categories, the public use data file only made available collapsed categories of "Mexican American," "Other Hispanic," "Non-Hispanic White," Non-Hispanic Black," and "Other race including multi-racial" for the data waves examined. Due to changes in the categorization of race/ethnicity between cycles, indicators were collapsed into non-Hispanic white, non-Hispanic black, Mexican-American, and other. Because some of the income measures changed throughout the data collection cyce, ratio of family income-to-poverty, or FIP, scores were used as a proxy from socioeconomic status. Ratios below 1.00 indicate that a person/family is below the federal threshold defined as poverty, while a ratio of 1.00 or greater indicates income above the poverty level. FIP scores were provided in the public use file with any score above 5.00 collapsed into the 5.00 category, such that, scores ranged from 0.00 to 5.00.

Birthplace was measured with a dichotomous variable.   Respondents in every data cycle were asked, "In what country were you born?" Between 2003 and 2006, survey participants could answer "United States," "Mexico," or "Other." If "Other" was selected, the name of the country was collected, however, publically available data files only released "United States," "Mexico," or "Other" as response categories. While the question remained the same in 2007, the response options changed to "50 United States or Washington, DC," "Mexico," "Other Spanish-speaking country," and "Other non-Spanish speaking country." The response options were once again changed in 2011 to "Born in 50 US States or Washington DC" or "Other." Due to modifications in response categories over time, the birthplace variable was recoded as 0 "US-born" or 1 "foreign-born" for all data waves.

Body mass index (BMI) was measured in the physical exam for survey participants using the standard method of body mass in kilograms divided by the square of the participant's height. The variable was used in analysis as a continuous measure reported in kg/m^2. Exposure to nicotine was measured using the metabolite cotinine in blood serum collected during the exam in participate three years and older. Cotinine was measured with isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (Centers for Disease Control and Prevention 2013). Concentrations were reported as a continuous measure in ng/mL. Additionally, analyses were adjusted for C-reactive protein (CRP) as it is involved in innate immunity and activation of adaptive immunity (Du Clos 2000). CRP was measured in blood serum collected at physical exams, which was reported in ng/mL.

Statistical Analyses

Stata v14.2 (StataCorp LP, 2015) was used to perform the analyses for this study. The survey command SVY procedure was used to apply sample weights and adjust standard errors for the complex sample design. When combining multiple cycles of data between 2003 and 2010, sample weights were adjusted by dividing the total number of combined waves, *n*, by the two-year MEC weights, to rescale the weights to match the population at the midpoint of survey period (Centers for Disease Control and Prevention 2006). This weighting scheme was necessary for analyses with EBV as it was measured in multiple waves.

Descriptive statistics were assessed to examine the overall distribution of variables of interest. Multivariate ordinary least squares regression was utilized to examine associations between phthalate metabolites and antibody titers. Regression covariates were identified from a literature review, and only variables that contribute to parsimonious models were retained for additional analyses. Four models were evaluated: model 1 represented the unadjusted model with the phthalate metabolite and antibody titer; model 2 adjusted for sociodemographics (sex, age, race/ethnicity, and income); model 3 adjusted for model 2 variables plus health factors (BMI and cotinine); and model 4 adjusted for model 3 variables and inflammation (CRP). All models were adjusted for creatinine. Percent difference was calculated as:

$$[10(\beta) - 1] \times 100\%,$$

with 95% confidence intervals (CIs) as

$$[10[(\beta \pm 1.96 \times SE)] - 1] \times 100\%,$$

where β and SE are the effect estimate and its standard error

To assess potential dose-response relationships, phthalate metabolite concentrations were divided into quartiles with the lowest quartile as the reference group. Additionally, associations were evaluated for effect modification by sex (female and male), age (children 6 to 19 years and adults 20 to 49 years), birthplace (U.S. and foreign-born), and/or sex-age (female children, male children, female adults, and male adults) subgroups. Additionally, all aforementioned models were run twice to account for difference in biological range of antibody titers: once for the full sample and once restricted to seropositive individuals only (Stein, McGovern et al. 2016). Data on vaccination history was not measured, however, analyses comparing the full sample to seropositive individuals helps elucidate its potential influence. Logistic regression was used in sensitivity analysis to compare seropositivity and seroprotection for rubella antibodies.

RESULTS

Sample Characteristics

Sample characteristics are summarized in Table 6.1. The average respondent was a Non-Hispanic White, born in the United States, in his/her mid-30’s, and with an income above the poverty threshold. Of the phthalate metabolites examined in the study, MEP had the highest concentration across all waves while McPP had the lowest. Between the 2003-2004 and 2009-2010 cycles, all phthalate metabolites decreased in concentration, except for an increase in MiBP and a slight increase in McPP. Even with decreasing concentrations between cycles, metabolites were detected in almost all urine samples in each cycle.

Association between Phthalates Concentrations and Antibodies Titers

Tables 6.2 and 6.3 present estimated associations between phthalates metabolites and specific antibody titers. Measles antibody titers were positively associated with lower molecular weight phthalates MnBP, MiBP, and McPP in both the 2003-2004 and 2009-2010 cycles. While MiBP and McPP had non-monotonically increasing associations, there was evidence of a threshold effect for MnBP in the third quartiles in 2003-2004 (β for Q2 =1.30; 95% CI: -0.45, 3.06) (β for Q3 =2.00; 95% CI: -0.57, 3.42) (β for Q4 =1.78; 95% CI: -0.12, 3.68). A positive dose-response effect was seen for McPP in the 2009-2010 cycle (β for Q2 =0.22; 95% CI: 0.03, 0.48) (β for Q3 =0.44; 95% CI: 0.17, 0.71) (β for Q4 =0.39; 95% CI: 0.06, 0.73). While none of the LMW metabolites had statistically significant associations with rubella antibodies, HMW ∑ DEHP and its individual metabolites MEHP, MEHHP, MEOHP, and MECPP were negatively associated with rubella titers in the 2009-2010 cycle. There was evidence of a negative dose-response association for ∑ DEHP and MEHP and a negative, non-monotonic association for MEOHP and MECPP across Q3 and Q4 in 2009-2010 (Table 6.2).

Associations between poliovirus serotypes and antibody titers also varied by phthalate metabolite molecular weight. Similar to rubella, HMW ∑ DEHP and its individual metabolites MEHP, MEHHP, MEOHP, and MECPP were inversely associated with poliovirus serotype 1 antibodies at higher concentrations, especially the third (Q3) and fourth (Q4) quartiles. Q3 of HMW MEHP was also negatively associated with serotype 3 antibody titers. Conversely, LMW phthalates ∑ DBP (β for Q2 =0.19; 95% CI: 0.06, 0.32) and MnBP (β for Q2 =0.13; 95% CI: 0.13, 0.26) were positively associated with serotype 2 and serotype 3 antibody titers. MBzP, a lower molecular HMW phthalate was positively associated with poliovirus serotype 2 (β for Q2 =0.23; 95% CI: 0.10, 0.37) and serotype 3 titers (β for Q2 =0.26; 95% CI: 0.01, 0.51). Likewise, lower molecular weight phthalates were positively associated with EBV titers for ∑ DBP, MnBP, MiBP, McPP, and MBzP (Table 6.3).

Associations between phthalate concentrations and mumps titers were mixed and typically in the opposite patterns seen with the other antibodies. For example, LMW phthalates MEP in the 2003-2004 cycle and MnBP in the 2009-2010 cycls exhibited negative associations while HMW phthalates McPP (2003-2004) and the third quartile of ∑ DEHP, MEHHP, and MEOHP (all 2009-2010) were positively associated. No statistically significant association were seen between phthalate concentrations and *Toxoplasma gondii* antibodies, however, only 15% of the sample population was seropositive for antibodies. Analyses were also restricted only to seropositive individuals for all antibody titers, and similar association patterns were observed.

Seropositivity versus Seroprotection for Rubella

Since seroprotective levels have been established for rubella antibody levels, sensitivity analysis assessed whether phthalate metabolite concentrations were associated with seroprotection. Approximately 8.1% of the 2003-2004 cycle and 2.1% of the 2009-2010 cycle had antibodies < 10 IU/mL, thus lacking seroprotection from the rubella virus. As with seropositivity, LMW phthalates were generally associated with immune enhancement while HMW phthalates with immune suppression. In the 2003-2004 wave, MnBP (OR=1.4; 95% CI: 1.1, 1.7) and MiBP (OR=1.5; 95% CI: 1.1, 1.9) were associated with increased odds for immune protection against rubella. McPP (OR=0.55; 95% CI: 0.35, 0.88) in the 2009-2010 wave as well as HMW ∑ DEHP and its individual metabolites MEHP, MEHHP, MEOHP, and MECPP were associated with lack of protection against rubella in the 2003-2004 and 2009-2010 cycles (Figure 6.2). Given that most individuals had seroprotection against rubella, it is not surprisingly that few associations were detected.

Effect Modification by Sex, Age, and/or Birthplace

Associations were also examined by sex, age, birthplace, and sex-age subgroups (Figure 6.3). As a whole, there was evidence males generally experienced immune enhancement with exposure to phthalates, except with rubella and polio serotype 1, while females exhibit immune suppression, especially with exposure to MEP. Among males, there was a statistically significant positive association between most phthalates metabolites and measles titers in the 2003-2004 cycle. Associations in the 2009-2010 cycle, however, were typically weaker when present. Since concentrations of phthalates have decreased over the years for most metabolites, this may be a reason for weaker associations as evidence exists for some dose-response relationships. Only MnBP had a weak positive association with measles antibodies in females (%Δ=16.2%; 95% CI: -0.6, 35.9) but not in males.

With mumps antibodies, Q2 and Q3 for several HMW metabolites were positively associated in males. LMW MEP in 2003-2004 (%Δ=-9.5%; 95% CI: -18.0, -0.2) and two quartiles of MEP and ∑ DBP were negatively associated in the 2009-2010 cycle for females. Results were mixed for rubella titers. MEP was inversely associated with rubella titers in the 2009-2010 cycle in females (%Δ=-6.8%; 95% CI: -12.1, -1.1), but positively associated with rubella titers in males (%Δ=15.0%; 95% CI: 6.3, 24.4). Similar associations were seen in the 2003-2004 wave but weaker. MEP was also negatively associated with polio serotype 1 (%Δ=-17.3%; 95% CI: -26.4, -7.0) and serotype 3 (%Δ=-18.1%; 95% CI: -28.6, -6.1) titers in females but not male.

Generally, male exhibited a positive, dose-response association between LMW phthalate metabolites and poliovirus serotype 2 as well as serotype 3 antibodies. However, a non-monotonic negative association was seen with the HMW phthalates and polio serotype 1 antibodies in males. For EBV antibodies, data suggests a non-monotonic positive association with ∑ DBP, MnBP, MiBP, McPP and MBzP metabolites in males. Unlike most of the other antibody measures, *Toxoplasma gondii* titers were inversely associated with ∑ DBP, MnBP, ∑DEHP, MEHHP, MEOHP, and MECPP in males. In particular, the effect was strongest at higher concentrations of HMW phthalates. The opposite associations were seen in females where HMW phthalates were associated with immune enhancement. Having associations in the opposite direction for males and females may have masked population level results where no associations were seen for *Toxoplasma gondii* titers.

Results were mixed when examining associations by age group. MEP was positively associated with mumps antibodies in 2003-2004 in children but negatively associated in adults. However, neither association was seen in the 2009-2010 cycle. HMW phthalates were inversely associated with mumps antibodies in 2003-2004 in children but positively associated in the 2009-2010 cycle in children. Results were more consistent with rubella antibodies. In adults in both cycles, there was a negative, non-monotonic association between HMW metabolites and rubella antibody titers. As a whole, LMW phthalates were negatively associated with poliovirus serotypes 1, serotypes 2, and serotypes 3 titers in children. ∑ DBP and MBzP were positively associated with poliovirus serotype 2 in adults. Many of the metabolites were negatively associated with *Toxoplasma gondii* antibodies in children but not adults (Supplemental Table S6.1).

In sex-age stratified models (Supplemental Table S6.2), there was evidence of effect modification. Among adult males, there were statistically significant positive associations between several HMW phthalates and measles titers. However, statistically significant negative associations were seen among both adult males and females for rubella, polio serotype 1, and polio serotype 3 antibodies. Inverse associations were also observed between phthalates and polio serotype 1, serotypes 2, serotypes 3 antibodies in female children. Due to a small sample sizes and inconsistent results, however, interpretations are limited. Effect modification was not observed by place of birth.

DISCUSSION

Of the phthalates examined, MnBP, MiBP, McPP, and DEHP metabolites were most consistency associated with changes in antibody titers across the data cycles examined. Exposure to lower molecular weight phthalates was generally positively associated with measles, polio, and EBV antibodies, respectively. Conversely, HMW phthalates were inversely associated with both rubella and poliovirus antibody titers, specifically, ∑ DEHP and its individual metabolites. Furthermore, males typically experienced immune enhancement while immune suppression was observed in females, except the converse associations were seen for *Toxoplasma gondii*. Patterns were more inconsistent by age, but adults were more likely to exhibit immune suppression with HMW metabolites compared to younger people for rubella titers, whereas children were more likely to have suppression of poliovirus antibodies with LMW metabolites. Many congeners were also negatively associated with *Toxoplasma gondii* antibodies in children but not adults.

This is the first study to examine the association between urinary phthalate concentrations and antibody titers for infectious disease antibodies. While the mechanism of action through which phthalates impact the immune system is poorly understood, it is suspected that they acts as endocrine disrupting chemicals (EDCs) (Hansen, Nielsen et al. 2015, Robinson and Miller 2015). EDCs can interfere with hormones, their production, transport, and/or binding of a target receptor, thus, directly or indirectly impacting immune response. Experimental studies suggest phthalates can influence immune cytokine production and can function as adjuvant for antibody production and differentiation (Bornehag and Nanberg 2010, Hansen, Bendtzen et al. 2015). In experiments with human mononuclear cells exposed to DEP and DnBP monoesters and diesters, Hansen et. al (2015) found that cytokine secretion by innate immune cells and T cells was influence by these phthalates. Specifically, the diester metabolites MEP and MnBP enhanced the secretion of interleukin (IL)-6, IL-10 and the chemokine CXCL8 by macrophages. Yet, tumor necrosis factor (TNF)-α, IL-2 and IL-4 secreted by macrophages as well as TNF-α and interferon-γ secreted by T-cells was impaired by DEP and DnBP (Hansen, Nielsen et al. 2015). Experiments in mice have also shown DEP to induce production of IL-4 and TNF-α (Ochiai, Roediger et al. 2014). IL-2 and IL-4 are particularly important in the proliferation of activated B-cells and IL-2, IL-4, IL-6, IL-10, and interferon-γ in the differentiation of B-cells to produce antibodies against specific infectious agents (Male, Brostoff et al. 2013). While *in vitro* and *in vivo* experiments showed various phthalates can influence the immune system signaling, it is unclear to what degree these phthalates directly influence antibody production.

The majority of research on the immune effects of phthalates concerns allergic response. From epidemiological studies, occupational exposures to high concentrations of phthalates have been linked to asthma and other respiratory symptoms (Norback, Wieslander et al. 2000, Jaakkola, Ieromnimon et al. 2006, Jaakkola and Knight 2008) as have low-dose household exposures in children, especially with HMW metabolites (Bornehag and Nanberg 2010, Bertelsen, Carlsen et al. 2013). Numerous experiments have tested a range of exposure routes, dosing, and allergic responses to better understand these observed allergic airway problems. It is clear that under certain circumstances, phthalates are associated with both immunosuppressant and enhancement in *in vivo* and *in vitro* models (Lee, Park et al. 2004, Larsen, Hansen et al. 2007, Dearman, Betts et al. 2009). For example, Larson et al. (2001) found an adjuvant effect with MEHP and MiNP that had both suppressed and enhanced IgE antibody production, while MBzP and MiBP were without effect for IgE or IgG antibody response in mice. Lee et al. (2004) found DEHP to enhance IL-4 expression in cell cultures as did Glue et al. (2002) in mononuclear cells with MnBP (Glue, Millner et al. 2002). However, other studies have found inhibitory effects in TNF-α and apoptosis of B-cells with MEHP, which would indicate a down-regulation of antibody production (Schlezinger, Emberley et al. 2007, Bissonnette, Teague et al. 2008).

Dose-response effects were seen in this study as were both immunosuppressive and stimulatory difference by sex and age group. Of particular interest, *Toxoplasma gondii* titers were inversely associated with ∑ DBP, MnBP, ∑DEHP, MEHHP, MEOHP, and MECPP in males but positively associated in females. In particular, the effect was strongest at higher concentrations of HMW phthalates in males but at lower concentrations in females. While the process for dose-response effects is not well understood, Kimber et. al. notes that these findings could be evidence of phthalates selectively interaction on cellular processes, or that these observations may be an artifact of natural fluctuations in immune response (Kimber and Dearman 2010). Given the cross-sectional natural of this study, it is not possible to rule out either as from this our findings. Alternatively, another reason why there may be differences in effect could be related to metabolism of monoesters, molecular size, and half-life. Short-branched or LMW phthalates are primarily excreted while long-branch, HMW phthalates undergo oxidation before excretion (Silva, Barr et al. 2003, Frederiksen, Skakkebaek et al. 2007, Hansen, Bendtzen et al. 2015). Not only does this mean that HMW phthalates have the opportunity to stay in the body longer, they have increased opportunity to interact with cells and their processes. As these monoesters are altered in oxidation, chemical intermediates may be able to produce differing effects on the immune system.

Sex differences have been noted in male rats exposed to phthalates (Gray, Ostby et al. 2000, Parks, Ostby et al. 2000, Moore, Rudy et al. 2001, Swan, Liu et al. 2010) and in epidemiological studies with children (Richard, Edwin van et al. 2007, Buser, Murray et al. 2014). Research has shown that phthalates can inhibit testosterone, however, testosterone has anti-inflammatory properties and immunosuppressive effects (Shames 2002). This is the opposite of results found in this study where males generally had antibody titer enhancement. Sex difference may result from the influence of phthalates on peroxisome proliferator-activated receptors (PPARs), a group of nuclear receptor proteins that regulate gene expression and therefore play vital roles in cell development, differentiation, metabolism, and apoptosis (Grun and Blumberg 2006, Larsen and Nielsen 2007). PPARs have been hypothesized to be the primary mechanism through which perfluoroalkyl substances (PFASs) impact immune function (DeWitt, Shnyra et al. 2009, DeWitt, Peden-Adams et al. 2012, Grandjean and Budtz-Jorgensen 2013). For age differences seen, it may be related of an immature immune system in young persons and immunosenescence, the decrease in both the innate and adaptive immune systems as people age, for older study participants. While many of the immune system components are affected, thymus involution and the loss of T cell generation as well as repopulation may play the most significant role (Arlt and Hewison 2004, Ponnappan and Ponnappan 2010). Further research is needed to better understand the differential effects seen by phthalate molecular weights and difference in population subgroups.

Since many of the HMW metabolites were associated with decreased antibody production for specific infectious disease agents, there are clinical implications that phthalates could change or weaken the immune response to pathogens.   In a study by Gascon et. al, higher levels of DEHP metabolites were associated with development of chest infections, bronchitis, and wheezing (Gascon, Casas et al. 2015). When comparing seropositivity and seroprotection in this study, LMW phthalate metabolites were associated with increased odds for immune protection against rubella while HMW phthalate metabolites were associated with a lack of protection against rubella in both the 2003-2004 and 2009-2010 cycles. Additionally, MEP was negatively associated with rubella titers in females as were certain concentrations of MEHP and MEOHP. From a public health standpoint, this is concerning as rubella can adversely affect women. Complications from rubella are not common, but up to 70% of adult females develop arthritis after infection (Centers for Disease Control and Prevention 2016). Of most concern is congenital rubella syndrome (CRS) in pregnant women infected with the virus; they are at-risk for fetal death, spontaneous abortion, and premature delivery. If their fetus becomes infected, the virus attacks all its organs producing severe birth defects. Deafness is the most prevalent condition, but eye, cardiac, neurologic defects are common. CRS manifestations can appear later in childhood with diabetes frequently observed as well as autism (Centers for Disease Control and Prevention 2012). It is estimated that 110,00 babies are born with CRS each year worldwide (World Health Organization 2012). Seroprotective antibody levels have either not been established for the other infectious disease agents studied here, or the types of measures needed to assess seroprotection were not included in the NHANES.

Strengthens and Limitations

Several limitations are present in this study. First, this research utilizes cross-sectional data. Therefore, causality cannot be inferred nor can reverse causation from these findings. However, several antibodies were measured over multiple waves with generally similar results providing evidence of the findings reported. Additionally, single spot measurements of phthalate biomarkers may not be reliable estimates of average or peak exposure (Sobus, DeWoskin et al. 2015). However, studies on phthalates have shown that even though are they eliminated quickly, within-person variability is sufficiently stable day-to-day and month-to-month to presume exposure is typically consistent and ever present (Hoppin, Brock et al. 2002, Hauser, Meeker et al. 2004). Another potential methodological issue is small sample sizes in subgroup analyses. Due to the sampling design where only random subsamples of people are tested for certain biomarkers, small sizes can develop after controlling for all variables. As a consequence, it is possible that type II error could occur where associations that truly exist are failed to be detected.

Despite several limitations, this research has several strengthens. First, the NHANES survey is a nationally-representative survey of the U.S. population. Therefore, this study has external validity, and thus generalizability to the population as a whole. Even though the data is cross-sectional, it still allows for extrapolation of population-level changes to environmental chemical exposure and associated health impacts. Second, besides self-reported demographic measures, all other study variables are biomarker data, which are inherently objective lending to greater validity and reliability of findings compared to self-reported measured. Lastly, this is the first study to assess the health effects of phthalates on antibody titers in a large population and among subpopulations, thus, contributing to the literature on the immunomodulatory impact of this class of chemicals.

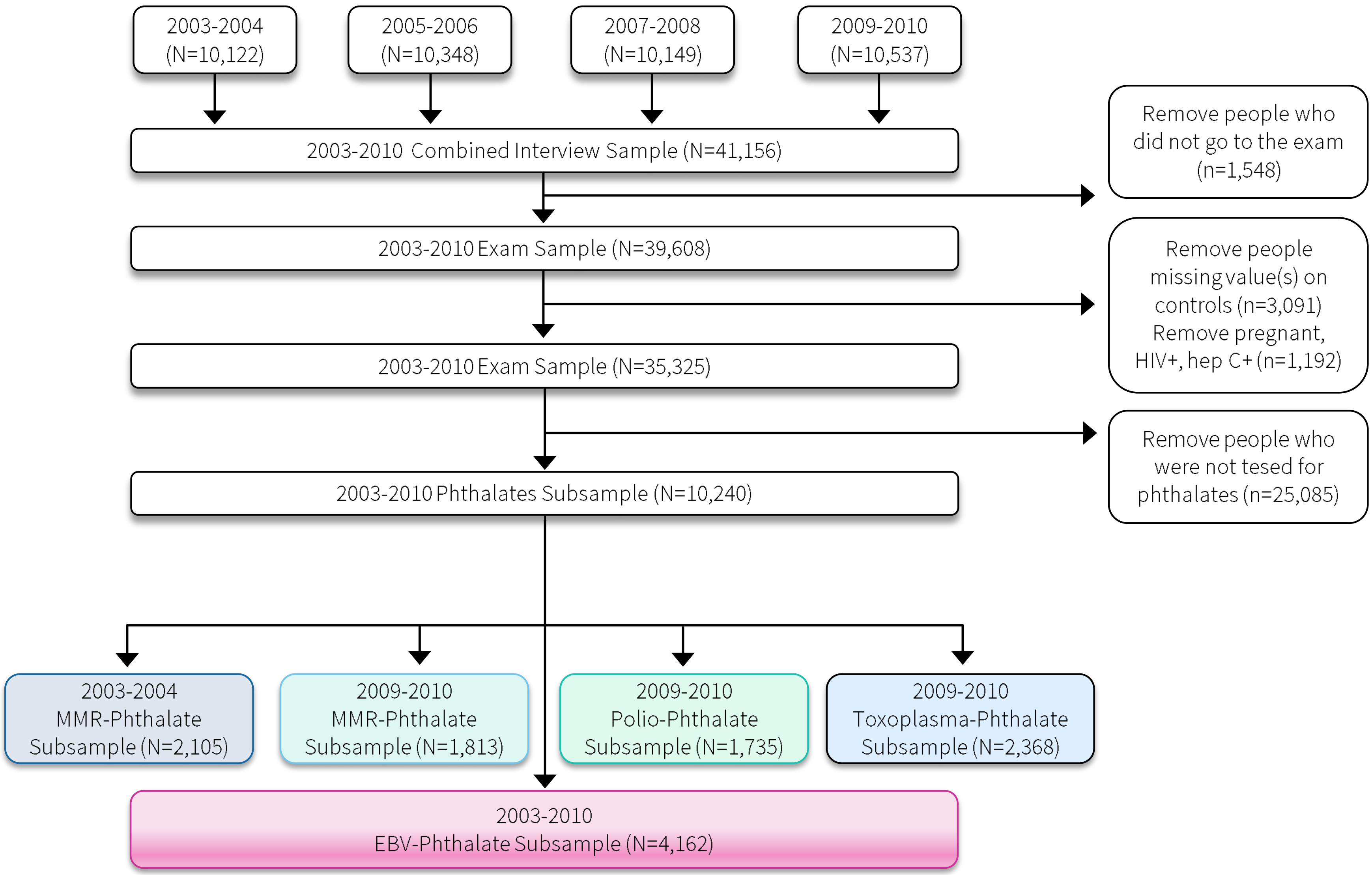


Figure 6.1 Flow chart of construction of analytic samples, NHANES 2003-2004, 2009-2010 and 2003-2010.

Table 6.1 Study characteristics by NHANES survey cycle (2003-2004, 2009-2010, 2003-2010).

Variable	2003-2004 Cycle n=2,105 Weighted percent/mean (SE)	2009-2010 Cycle n=2,368 Weighted percent/mean (SE)	2003-2010 Cycle n=4,162 [c] Weighted percent/mean (SE)
Demographic/Biometric			
Race/ethnicity (%)			
Non-Hispanic White	65.7 (.04)	61.6 (.03)	60.2 (.02)
Non-Hispanic Black	12.7 (.02)	12.2 (.01)	14.4 (.01)
Mexican American	11.5 (.02)	11.1 (.02)	13.5 (.01)
Other	11.1 (.01)	15.1 (.01)	11.9 (.00)
Age, years (mean)	28.3 (.53)	28.1 (.39)	12.7 (.11)
Sex (%)			
Female	51.2 (.01)	51.0 (.01)	51.4 (.01)
Male	48.8 (.01)	49.0 (.01)	48.6 (.01)
FIP (mean)	2.8 (.11)	2.7 (.06)	2.5 (.06)
Place of birth (%)			
United States	85.9 (.02)	85.4 (.02)	93.5 (.01)
Mexico	14.1 (.02)	14.6 (.02)	6.5 (.01)
BMI (mean)	26.1 (.33)	26.4 (.09)	21.5 (.13)
Cotinine (mean)	58.8 (4.9)	47.7 (6.0)	13.3 (1.3)
CRP (mean)	.37 (.02)	.30 (.02)	.18 (.01)
Creatinine (mean)	129 (2.5)	127 (2.5)	131 (2.6)
Phthalates (GM)[a]			
MEP	130.6 (7.92)	66.6 (2.96)	97.1 (2.80)
∑ DBP	16.0 (0.43)	13.0 (0.52)	13.9 (0.27)
MnBP	23.3 (0.65)	16.5 (0.69)	20.4 (0.38)
MiBP	5.4 (0.21)	9.3 (0.38)	7.5 (0.15)
McPP	4.4 (0.07)	4.6 (0.23)	4.2 (0.07)
MBzP	12.1 (0.39)	8.3 (0.36)	9.9 (0.21)
∑ DEHP	78.0 (4.10)	46.6 (2.54)	69.8 (2.17)
MEHP	3.9 (0.16)	3.0 (0.12)	3.9 (0.09)
MEHHP	24.1 (1.29)	14.8 (0.85)	22.1 (0.70)
MEOHP	16.6 (0.81)	9.8 (0.49)	14.3 (0.42)
MECPP	36.7 (1.93)	22.5 (1.15)	33.0 (0.99)
Antibody Titers (OD)[b]			
Measles virus	9.0 (.31)	3.0 (.08)	---
Mumps virus	2.8 (.07)	2.8 (.09)	---
Rubella virus	62.2 (1.6)	3.4 (.07)	---
Poliovirus			
Type 1	---	7.1 (.10)	---
Type 2	---	7.3 (.13)	---
Type 3	---	5.7 (.12)	---
Toxoplasma gondii	---	12.4 (1.8)	---
EBV	---	---	2.7 (.07)

Abbreviations: standard error (SE); family income-poverty ratio (FIP); body mass index (kg/m^2)(BMI); C-reactive protein (CRP); and Epstein-Barr virus. [a] Phthalates are reported as geometric means (SE). [b] Antibody titers are expressed as optical densities (SE). [c] The 2003-2010 wave only consists of young people 6-19 years as EBV was only measured in this age group.

Table 6.2. Associations between phthalate metabolites and antibodies titers, NHANES.

	Measles Antibodies [a]		Mumps Antibodies [a]		Rubella Antibodies [a]	
	2003-2004	2009-2010	2003-2004	2009-2010	2003-2004	2009-2010
	n=2,105	n=1,813	n=2,105	n=1,813	n=2,105	n=1,813
MEP	0.11 (-0.31,0.54)	0.04 (-0.06,0.13)	-0.04 (-0.11,0.04)	-0.06 (-0.15,0.04)	0.68 (-2.33,3.69)	0.03 (-0.03,0.09)
Q2	-0.25 (-1.90,1.41)	0.24 (-0.12,0.61)	**-0.37 -(.75,.02)+**	0.03 (-0.14,0.20)	-2.75 (-16.02,10.52)	0.10 (-0.21,0.41)
Q3	-0.35 (-1.63,0.94)	0.04 (-0.31,0.39)	**-0.48 (-.83,-.13)***	-0.14 (-0.37,0.10)	-10.36 (-23.70,2.98)	0.04 (-0.24,0.33)
Q4	-0.37 (-1.90,1.17)	0.16 (-0.17,0.49)	**-0.35 (-.76,.07)+**	-0.17 (-0.56,0.21)	-3.94 (-16.25,8.38)	0.15 (-0.08,0.38)
∑ DBP	0.12 (-0.30,0.53)	0.05 (-0.10,0.20)	0.03 (-0.07,0.14)	0.05 (-0.13,0.22)	-0.09 (-4.47,4.28)	-0.03 (-0.12,0.07)
Q2	0.42 (-1.44,2.27)	0.05 (-0.25,0.35)	-0.07 (-0.44,0.30)	-0.09 (-0.37,0.20)	1.11 (-12.38,14.60)	-0.01 (-0.30,0.28)
Q3	0.56 (-1.03,2.14)	0.11 (-0.32,0.54)	0.00 (-0.40,0.410	0.11 (-0.18,0.41)	0.25 (-14.57,15.08)	-0.09 (-0.41,0.23)
Q4	0.20 (-1.43,1.82)	0.05 (-0.44,0.54)	0.03 (-0.34,0.41)	0.30 (-0.13,0.72)	1.25 (-13.25,15.76)	-0.04 (-0.35,0.26)
MnBP	**0.68 (-.05,1.42)+**	**0.15 (0.01,0.29)***	0.02 (-0.12,0.16)	0.13 (-0.04,0.31)	0.97 (-2.73,4.66)	-0.01 (-0.07,0.05)
Q2	1.30 (-0.45,3.06)	0.20 (-0.08,0.48)	0.28 (-0.13,0.70)	**-.38 (-.59,-.17)****	6.88 (-3.64,17.39)	-0.23 (-0.57,0.12)
Q3	**2.00 (.57,3.42)****	0.29 (-0.13,0.70)	-0.05 (-0.44,0.34)	-0.19 (-0.45,0.08)	2.61 (-8.47,13.68)	0.14 (-0.09,0.37)
Q4	**1.78 (-.12,3.68) +**	0.37 (-0.09,0.83)	0.09 (-0.35,0.54)	0.13 (-0.24,0.50)	3.22 (-8.13,14.57)	0.09 (-0.09,0.27)
MiBP	**1.09 (0.22,1.96)***	0.14 (-0.06,0.35)	-0.01 (-0.18,0.15)	-0.03 (-0.13,0.06)	1.96 (-1.85,5.77)	-0.02 (-0.11,0.07)
Q2	0.53 (-0.43,1.49)	**0.27 (0.11,0.42)****	-0.03 (-0.35,0.29)	-0.15 (-0.45,0.15)	-3.07 (-10.58,4.43)	-0.22 (-0.54,0.10)
Q3	1.69 (-0.68,4.06)	**0.33 (-0.05,0.71)+**	-0.05 (-0.45,0.34)	-0.12 (-0.49,0.25)	-5.58 (-14.64,3.47)	**-0.26 (-.54,.01)+**
Q4	**2.04 (.58,3.51)****	0.37 (-0.13,0.87)	-0.01 (-0.35,0.34)	-0.05 (-0.37,0.27)	5.53 (-7.72,18.78)	-0.18 (-0.45,0.08)
McP	**0.50 (-.07,1.07)+**	0.07 (-0.04,0.19)	**0.16 (0.00,0.31)***	-0.03 (-0.11,0.05)	0.76 (-5.70,7.22)	-0.01 (-0.13,0.10)
Q2	1.11 (-0.26,2.48)	**0.22 (-0.03,0.48)+**	0.16 (-0.12,0.43)	0.10 (-0.12,0.33)	5.25 (-7.99,18.50)	-0.11 (-0.36,0.15)
Q3	**1.34 (-.27,2.96)+**	**0.44 (0.17,0.71)****	**0.35 (0.01,0.70)***	0.10 (-0.24,0.43)	-5.91 (-17.15,5.33)	0.08 (-0.20,0.35)
Q4	**1.39 (-.27,3.04)+**	**0.39 (0.06,0.73)***	**0.43 (0.05,0.81)***	0.01 (-0.18,0.19)	3.67 (-10.86,18.21)	0.07 (-0.24,0.38)
MBzP	0.05 (-0.37,0.47)	0.06 (-0.08,0.20)	-0.00 -0.09,0.09)	-0.02 (-0.13,0.08)	-0.43 (-4.16,3.30)	-0.00 (-0.13,0.12)
Q2	0.27 (-1.85,2.39)	0.10 (-0.23,0.44)	0.17 -0.27,0.60)	-0.06 (-0.30,0.18)	1.07 (-15.33,17.47)	-0.14 (-.40,.12)
Q3	1.11 (-0.79,3.01)	0.18 (-0.16,0.53)	-0.09 -0.50,0.32)	-0.13 (-0.43,0.16)	4.93 (-8.37,18.23)	-0.08 (-0.31,0.16)
Q4	0.63 (-0.99,2.25)	0.20 (-0.18,0.58)	0.17 -0.22,0.56)	0.08 (-0.23,0.40)	1.60 (-12.44,15.64)	0.06 (-0.28,0.40)
∑ DEHP	0.15 (-0.22,0.53)	-0.01 (-0.15,0.13)	0.01 (-0.09,0.11)	0.03 (-0.07,0.13)	-1.48 (-3.81,0.85)	-0.07 (-0.20,0.06)
Q2	0.41 (-1.00,1.82)	0.15 (-0.11,0.41)	0.02 (-0.24,0.28)	0.10 (-0.15,0.34)	3.29 (-8.40,14.98)	-0.10 (-0.26,0.06)
Q3	0.44 (-1.68,2.57)	0.03 (-0.35,0.41)	-0.03 (-0.31,0.25)	**0.29 (0.06,0.52)***	-3.42 (-11.86,5.03)	**-0.20 (-.42,.02)+**
Q4	0.80 (-0.82,2.41)	-0.10 (-0.47,0.28)	-0.04 (-0.41,0.32)	0.23 (-0.11,0.56)	-1.00 (-11.10,9.09)	**-0.34 (-.67,-.00)***
MEHP	0.11 (-0.28,0.51)	-0.04 (-0.18,0.10)	0.01 (-0.12,0.14)	0.00 (-0.12,0.13)	-0.73 (-3.42,1.97)	-0.07 (-0.16,0.02)
Q2	0.66 (-0.73,2.05)	0.16 (-0.25,0.57)	0.05 (-0.23,0.33)	-0.06 (-0.23,0.11)	-3.87 (-14.04,6.29)	0.05 (-0.13,0.22)
Q3	**1.41 (-.07,2.88)+**	0.17 (-0.18,0.53)	-0.05 (-0.32,0.21)	0.08 (-0.13,0.30)	3.38 (-4.56,11.32)	-0.15 (-0.33,0.04)
Q4	0.57 (-0.61,1.75)	-0.14 (-0.46,0.19)	-0.04 (-0.33,0.24)	-0.08 (-0.33,0.18)	2.01 (-4.72,8.74)	**-.24 (-.39,-.08)****
MEHHP	0.11 (-0.27,0.49)	-0.01 (-0.16,0.13)	-0.00 (-0.10,0.09)	0.03 (-0.07,0.13)	-1.37 (-3.57,0.83)	-0.08 (-0.21,0.04)
Q2	0.82 (-0.22,1.85)	**0.26 (0.09,0.42)****	0.12 (-0.26,0.49)	0.12 (-0.13,0.38)	4.91 (-8.35,18.17)	-0.12 (-0.28,0.05)
Q3	0.17 (-1.97,2.31)	0.03 (-0.31,0.38)	-0.03 (-0.38,0.33)	**.32 (0.15,0.48)*****	-1.26 (-12.51,9.98)	-0.13 (-0.37,0.11)
Q4	0.40 (-1.04,1.83)	-0.06 (-0.38,0.26)	-0.04 (-0.47,0.38)	0.08 (-0.20,0.37)	-1.37 (-10.73,7.99)	**-0.37 (-.68,-.05)***
MEOHP	0.19 (-0.18,0.56)	-0.02 (-0.17,0.12)	0.02 (-0.09,0.12)	0.04 (-0.07,0.15)	-1.42 (-3.75,0.92)	-0.08 (-0.22,0.05)
Q2	**1.26 (-.17,2.68)+**	0.12 (-0.11,0.34)	0.17 (-0.10,0.44)	0.02 (-0.15,0.20)	8.21 (-4.75,21.18)	-0.13 (-0.33,0.07)
Q3	0.98 (-0.86,2.82)	-0.06 (-0.43,0.30)	0.05 (-0.32,0.43)	**0.25 (0.02,0.49)***	2.29 (-6.34,10.91)	**-.26 (-.41,-.10)****
Q4	1.02 (-0.92,2.97)	-0.15 (-0.51,0.21)	0.01 (-0.38,0.40)	0.20 (-0.06,0.46)	0.51 (-8.80,9.81)	**-.31 (-.59,-.03)***
MECPP	0.17 (-0.22,0.55)	-0.02 (-0.16,0.12)	0.01 (-0.09,0.11)	0.04 (-0.07,0.15)	-1.85 (-4.43,0.73)	-0.06 (-0.20,0.08)
Q2	0.05 (-0.93,1.03)	0.04 (-0.22,0.31)	-0.11 (-0.47,0.26)	-0.02 (-0.29,0.25)	3.84 (-5.62,13.30)	-0.07 (-0.25,0.10)
Q3	0.68 (-1.42,2.78)	-0.02 (-0.36,0.31)	-0.04 (-0.38,0.30)	0.22 (-0.05,0.49)	-3.13 (-10.72,4.45)	**-0.25 (-.45,-.05)***
Q4	0.61 (-0.82,2.04)	-0.17 (-0.53,0.20)	-0.06 (-0.45,0.32)	0.20 (-0.06,0.47)	-0.25 (-10.10,9.60)	**-0.28 (-.60,.05)+**

[a] Models show estimated coefficient (95% CI) adjusted for race/ethnicity, sex, age, FIP, BMI, cotinine, CRP, and creatinine. Log_{10} transformed continuous variable. Quartile 1 is reference category for quartiles 2, 3, and 4. Significance levels: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 6.3. Associations between phthalate metabolites and antibodies titers, NHANES.

	Poliovirus Antibodies [a]			EBV Antibodies [a]	Toxoplasma Antibodies [a]
	Serotype 1	Serotype 2	Serotype 3	2003-2010	2009-2010
	n=1,404	n=1,404	n=1,404	n=3,270	n=2,169
MEP	-0.06 (-0.22,0.09)	-0.03 (-0.13,0.07)	-0.10 (-0.24,0.03)	0.07 (-0.04,0.17)	-1.05 (-2.92,0.81)
Q2	-0.09 (-0.60,0.42)	-0.26 (-0.72,0.19)	-0.04 (-0.50,0.42)	0.23 (-0.11,0.56)	0.80 (-6.96,8.55)
Q3	-0.17 (-0.78,0.43)	-0.25 (-0.72,0.23)	-0.40 (-1.02,0.23)	0.19 (-0.18,0.56)	-5.92 (-13.48,1.63)
Q4	-0.28 (-1.04,0.49)	-0.25 (-0.73,0.23)	-0.29 (-0.80,0.22)	0.31 (-0.10,0.72)	-2.27 (-8.80,4.25)
∑ DBP	-0.01 (-0.29,0.27)	**0.19 (.06,.32)****	**0.29** (.11,.47)**	**0.13 (0.03,0.24)***	-1.65 (-3.87,0.56)
Q2	-0.06 (-0.41,0.29)	0.07 (-0.36,0.50)	0.15 (-0.34,0.65)	0.02 (-0.32,0.35)	1.21 (-4.85,7.28)
Q3	-0.02 (-0.57,0.53)	0.27 (-0.16,0.69)	0.44 (-0.18,1.05)	0.25 (-0.11,0.61)	0.59 (-6.29,7.47)
Q4	0.11 (-0.64,0.85)	**0.48 (.04,.93)***	**0.76 (.25,1.27)****	0.28 (-0.08,0.64)	-2.73 (-8.67,3.20)
MnBP	-0.12 (-0.38,0.15)	**0.13 (-.01,.26)+**	**0.24 (-.00,.47)+**	**0.17 (0.03,0.31)***	-1.49 (-3.67,0.68)
Q2	-0.19 (-0.59,0.22)	**0.27 (-.01,.54)+**	0.40 (-0.10,0.89)	-0.09 (-0.44,0.27)	2.39 (-6.50,11.27)
Q3	-0.24 (-0.80,0.31)	0.27 (-0.17,0.71)	**0.77 (.24,1.30)****	**0.36 (-0.00,0.72)+**	-2.01 (-9.49,5.47)
Q4	-0.15 (-0.96,0.66)	**0.45 (-.03,.93)+**	**0.84 (.12,1.57)***	0.30 (-0.10,0.70)	-5.92 (-16.44,4.61)
MiBP	-0.20 (-0.49,0.09)	0.00 (-0.19,0.20)	0.01 (-0.28,0.29)	0.09 (-0.05,0.22)	1.50 (-2.81,5.81)
Q2	-0.23 (-0.74,0.28)	0.09 (-0.46,0.63)	-0.16 (-0.61,0.30)	-0.00 (-0.36,0.36)	-0.16 (-5.64,5.33)
Q3	**-.64 (-1.37,.08)+**	0.19 (-0.31,0.68)	-0.09 (-0.64,0.47)	0.24 (-0.09,0.57)	4.00 (-4.35,12.35)
Q4	-0.52 (-1.30,0.25)	-0.01 (-0.60,0.57)	-0.06 (-0.87,0.74)	**0.33 (-0.04,0.69)+**	-0.40 (-8.77,7.97)
McP	-0.08 (-0.30,0.15)	0.01 (-0.14,0.15)	0.16 (-0.07,0.39)	0.10 (-0.05,0.25)	-0.87 (-2.99,1.24)
Q2	-0.05 (-0.71,0.60)	-0.16 (-0.65,0.33)	0.23 (-0.30,0.75)	**0.47 (0.14,0.79)****	3.45 (-3.83,10.73)
Q3	-0.22 (-0.97,0.52)	-0.27 (-0.80,0.26)	0.14 (-0.53,0.80)	**0.32 (0.04,0.59)***	3.85 (-4.27,11.97)
Q4	-0.17 (-0.77,0.44)	-0.08 (-0.57,0.40)	0.34 (-0.27,0.95)	**0.41 (0.06,0.77)***	0.53 (-6.19,7.24)
MBzP	-0.01 (-0.28,0.26)	**0.23 (.10,.37)****	**0.26 (.01,.51)***	**0.12 (0.02,0.21)***	-0.86 (-3.56,1.85)
Q2	-0.03 (-0.49,0.43)	**0.38 (-.06,.82)+**	0.23 (-0.43,0.90)	0.24 (-0.15,0.64)	-2.79 (-9.32,3.73)
Q3	-0.18 (-0.66,0.29)	**0.39 (-.07,.85+**	0.37 (-0.37,1.10)	0.25 (-0.15,0.65)	3.41 (-4.67,11.50)
Q4	0.16 (-0.63,0.95)	**0.87 (.35,1.40)****	**0.81 (-.01,1.64)+**	0.30 (-0.10,0.69)	**-6.22 (-13.43,.98)+**
∑ DEHP	-0.12 (-0.33,0.08)	0.01 (-0.10,0.12)	0.10 (-0.14,0.33)	0.03 (-0.06,0.12)	-0.13 (-2.40,2.15)
Q2	-0.27 (-0.67,0.13)	-0.07 (-0.46,0.32)	-0.07 (-0.67,0.52)	0.07 (-0.29,0.42)	5.39 (-1.27,12.04)
Q3	**-.56 (-1.04,-.07)***	-0.11 (-0.59,0.38)	-0.04 (-0.69,0.61)	0.08 (-0.21,0.38)	-1.70 (-8.51,5.10)
Q4	**-.46 (-1.00,.09)+**	-0.13 (-0.56,0.30)	0.07 (-0.63,0.77)	0.16 (-0.14,0.46)	-0.47 (-8.95,8.00)
MEHP	-0.12 (-0.33,0.10)	-0.05 (-0.22,0.13)	-0.08 (-0.34,0.18)	0.01 (-0.10,0.11)	0.27 (-2.19,2.72)
Q2	-0.27 (-0.79,0.24)	0.08 (-0.26,0.42)	-0.15 (-0.53,0.22)	-0.06 (–0.40,0.27)	**5.42 (-0.62,11.46)+**
Q3	**-.35 (-0.78,0.07)+**	0.02 (-0.39,0.43)	**-0.53 (-1.08,.02)+**	-0.18 (-0.52,0.16)	5.88 (-4.24,16.01)
Q4	**-.58 (-1.04,-.12)***	-0.21 (-0.66,0.25)	-0.36 (-0.89,0.17)	0.06 (-0.27,0.39)	1.26 (-4.67,7.18)
MEHHP	-0.12 (-0.30,0.07)	-0.01 (-0.11,0.10)	0.08 (-0.14,0.30)	0.03 (-0.07,0.12)	-0.27 (-2.70,2.15)
Q2	-0.15 (-0.58,0.28)	0.03 (-0.34,0.41)	-0.12 (-0.58,0.34)	0.19 (-0.14,0.52)	3.05 (-3.39,9.49)
Q3	-0.25 (-0.67,0.17)	0.03 (-0.37,0.43)	0.17 (-0.42,0.76)	0.18 (-0.16,0.51)	-1.64 (-8.20,4.93)
Q4	**-.59 (-1.09,-.09)***	-0.11 (-0.48,0.26)	0.04 (-0.50,0.58)	0.17 (-0.13,0.47)	-2.46 (-11.04,6.11)
MEOHP	-0.15 (-0.36,0.06)	-0.03 (-0.13,0.08)	0.08 (-0.16,0.32)	0.03 (-0.06,0.13)	-0.40 (-2.95,2.15)
Q2	-0.25 (-0.61,0.11)	0.14 (-0.26,0.54)	-0.16 (-0.55,0.22)	**0.36 (-0.02,0.73)+**	2.81 (-4.44,10.06)
Q3	**-.46 (-.88,-.05)***	0.08 (-0.26,0.42)	0.25 (-0.22,0.72)	0.20 (-0.10,0.50)	-3.77 (-10.98,3.43)
Q4	**-.53 (-1.08,.02)+**	-0.01 (-0.41,0.39)	0.05 (-0.53,0.64)	**0.28 (-0.02,0.58)+**	-1.79 (-11.00,7.43)
MECPP	-0.11 (-0.33,0.11)	0.03 (-0.09,0.16)	0.13 (-0.13,0.40)	0.03 (-0.07,0.12)	-0.05 (-2.24,2.14)
Q2	**-.40 (-.77,-.04)***	-0.01 (-0.37,0.35)	0.12 (-0.49,0.74)	0.11 (-0.19,0.40)	4.86 (-3.33,13.04)
Q3	-0.37 (-0.95,0.22)	0.02 (-0.44,0.47)	0.06 (-0.44,0.55)	0.17 (-0.14,0.47)	-2.99 (-9.11,3.14)
Q4	**-.54 (-1.16,.09)+**	-0.01 (-0.41,0.40)	0.35 (-0.49,1.20)	0.23 (-0.08,0.53)	-0.72 (-8.08,6.64)

[a] Models show estimated coefficient (95% CI) adjusted for race/ethnicity, sex, age, FIP, BMI, cotinine, CRP, and creatinine. Log_{10} transformed continuous variable. Quartile 1 is reference category for quartiles 2, 3, and 4. Significance levels: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

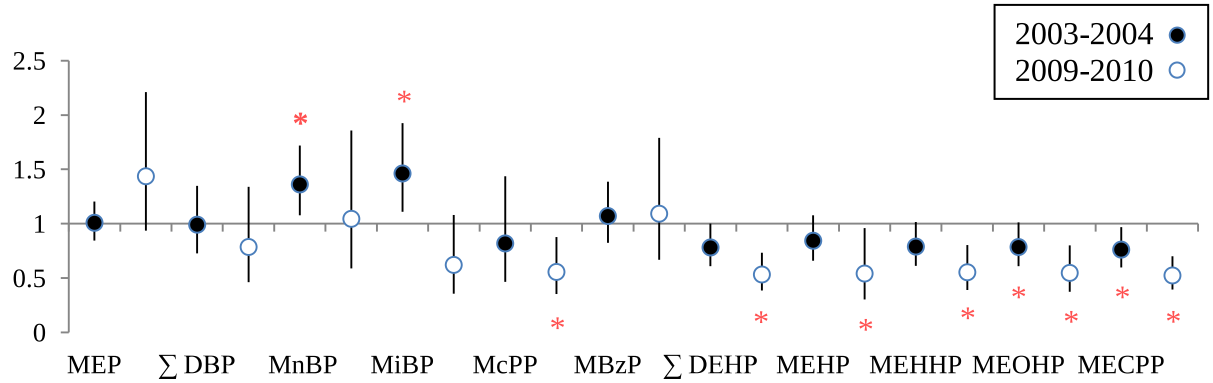
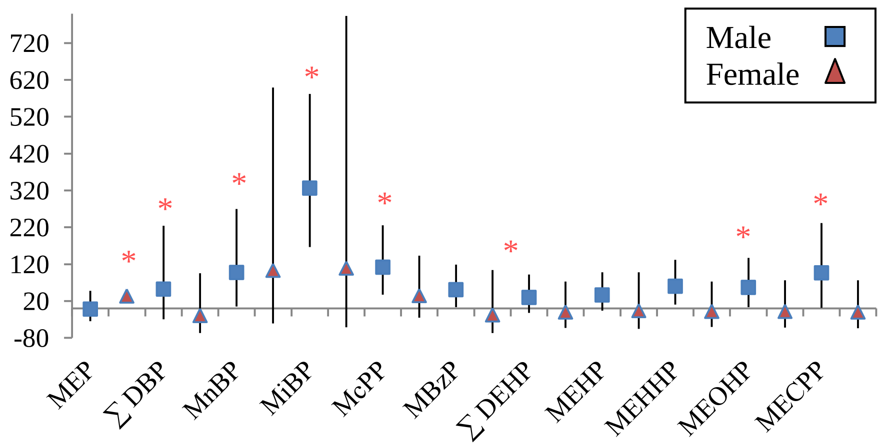
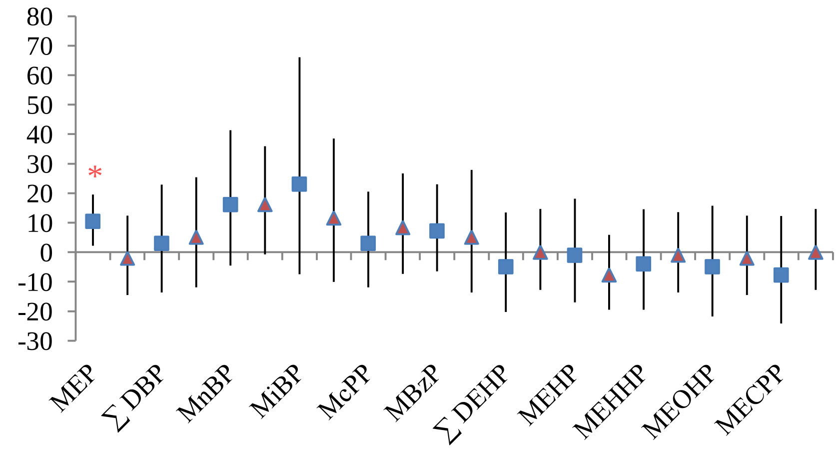


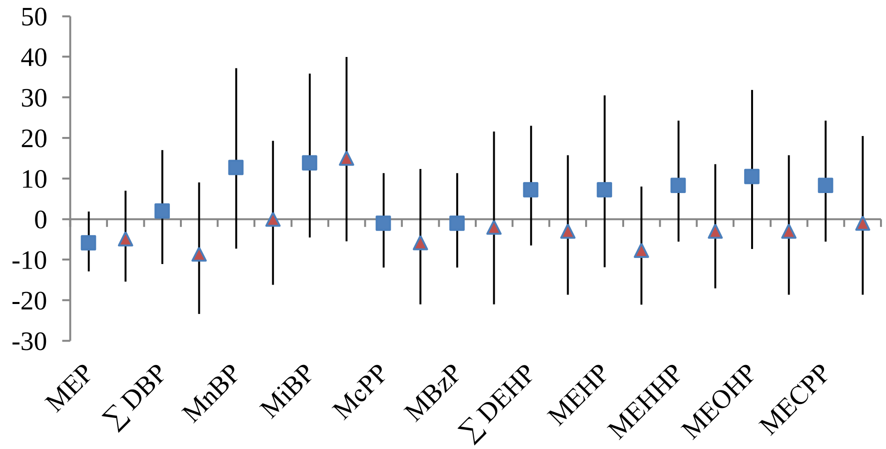
Figure 6.2 Adjusted odds ratio (95% CIs) for seroprotection from rubella antibodies per increase in urinary phthalate metabolite (µg/L) comparing NHANES waves 2003-2004 and 2009-2010. Models adjusted for race/ethnicity, sex, age, FIP, BMI, cotinine, CRP, and creatinine. *Denotes statistical significance $p < 0.10$.



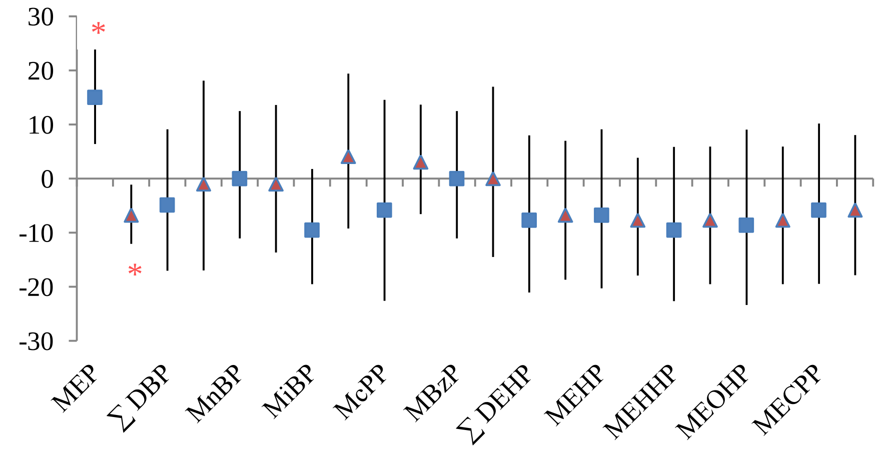
A. Measles Antibodies, 2003-2004 Wave



B. Measles Antibodies, 2009-2010 Wave



C. Mumps Antibodies, 2009-2010 Wave



D. Rubella Antibodies, 2009-2010 Wave

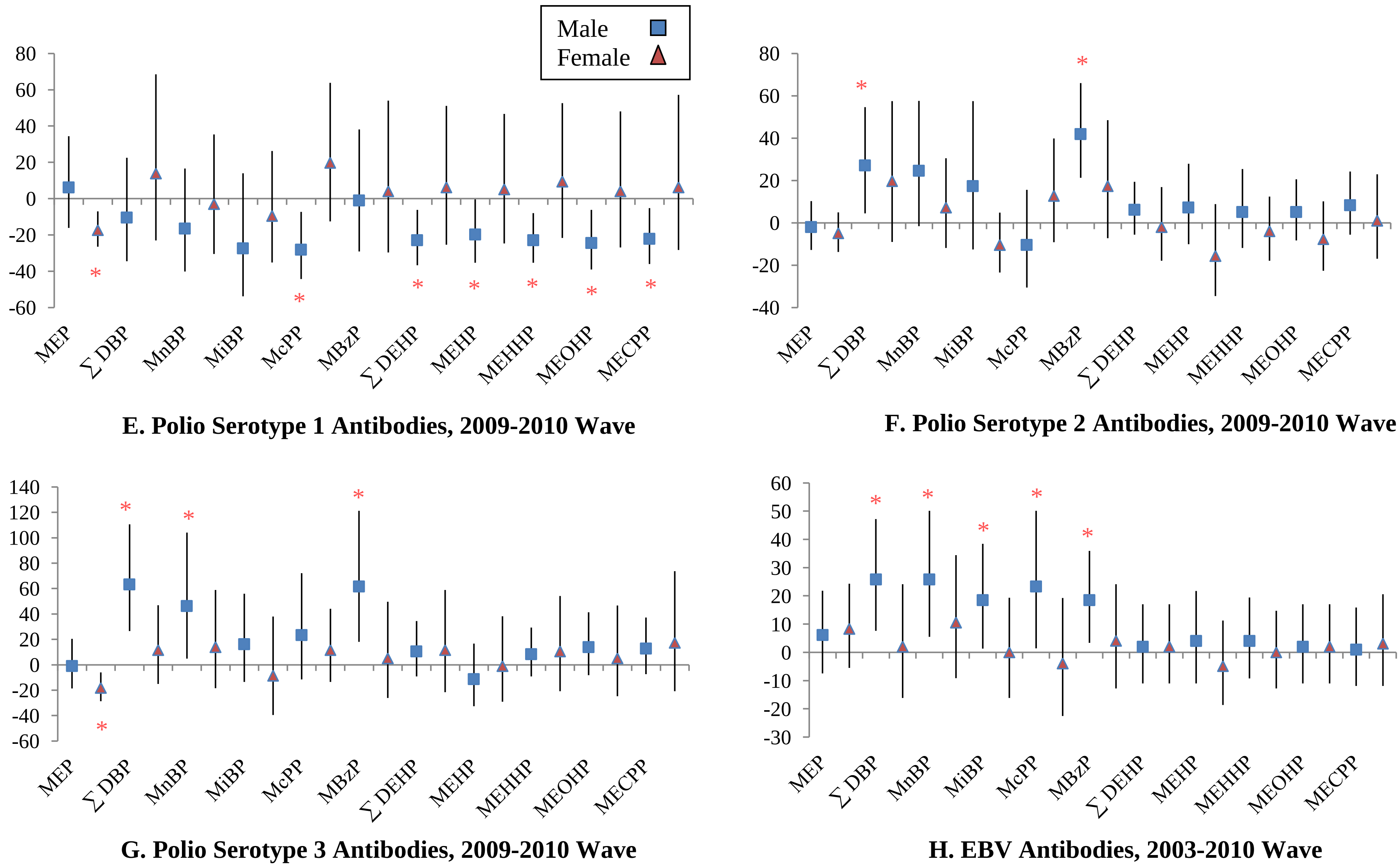


Figure 6.3. Percent change in serum antibodies per increase in urinary phthalate metabolite (µg/L) among males and females. Error bars present 95% CIs. Models adjusted for race/ethnicity, age, FIP, BMI, cotinine, CRP, and creatinine. *Denotes statistical significance $p<0.10$.

CHAPTER 7:
PAPER 3

Immune System Enhancement and Suppression from Co-exposures to Phthalates

INTRODUCTION

Phthalates are a large class of synthetic chemicals widely used as plasticizer, solvents, and additives. While they share some basic structural characteristics, data suggests individual members have unique physical and biological properties (Kamrin 2009). Phthalates are typically classified by the number of carbons in their alcohol chain as either low molecular weight (LMW) or high molecular weight (HMW). LMW phthalates, such as dibutyl phthalates (DBP) and diethyl phthalate (DEP), are widely used as additives to make varnishes; lacquers; and cosmetic products including perfumes, aftershaves, shampoo, makeup, lotions, and nail products. HMW phthalates, like bis(2-ethylhexyl) phthalate (DEHP), di-n-octyl phthalate (DOP or DnOP) and benzylbutyl phthalate (BzBP), are more commonly utilized as plasticizers for industrial and consumer products, such as flooring, paints, imitation leather, food storage containers, and medical devices (Frederiksen, Skakkebaek et al. 2007, Swan 2008). Due to their strength, transparency, flexibility, and durability, phthalates have widespread application in various products globally. Because they are not covalently bound to a matrix however, phthalates are susceptible to leaching, migration and evaporation leading to significant exposure (Staples, Peterson et al. 1997, Heudorf, Mersch-Sundermann et al. 2007).

Most research typically focuses on elucidating a single health outcome from a single chemical exposure. But in reality, people are exposed to thousands of chemicals simultaneously, which can be associated with any number of health effects. It is important to study co-exposures as there is growing evidence that in combination chemicals can produce addictive effects even when individual chemicals have no observable impact (Howdeshell, Wilson et al. 2008, U.S. Consumer Product Safety Commission 2014). Further, using separate regression analysis increases the probability of chance findings from multiple testing, and it does not account for high correlations between certain congeners (Weuve, Sanchez et al. 2006). Ignoring these complexities can lead to an underestimation of the health effects associated with a chemical congener and/or chemical class. To date, joint effects from exposure to numerous phthalates have not been thoroughly evaluated (Howdeshell, Wilson et al. 2008, U.S. Consumer Product Safety Commission 2014), and to the author's knowledge, no studies exist that have assessed the combined immunological effects on antibody titers from co-exposure to phthalate congeners using SEM.

Some research has examined the effects of phthalates on immune function in general. Laboratory experiments have found phthalates to impair cytokine secretion from monocytes and macrophages; influence immunoglobulin production; enhance enzyme and histamine release; and increase phagocytic ability in cells from the innate immune system (Bornehag and Nanberg 2010, Hansen, Bendtzen et al. 2015, Robinson and Miller 2015). Several epidemiological studies have found an association between phthalates in dust and allergic symptoms, such as wheezing, rhinitis, eczema, and asthma (Kolarik, Naydenov et al. 2008, Just, Whyatt et al. 2012). This research has also shown different types of phthalates can have differential effects in subpopulations. For example, research on allergic symptoms and sensitization in children and adults in the U.S. showed HMW phthalates were positively associated with allergies in adults but not children (Hoppin, Jaramillo et al. 2013). Another study with children 3-5 years found no association between phthalate exposure and asthma, rhinoconjunctivitis or atopic dermatitis (Bekö, Callesen et al. 2015).

Limited or inconclusive research has been published on the association between phthalates and immunomodulation. It is important to identify whether phthalates adversely affect immune system health as it protects us against infectious diseases. This study assessed whether combined exposures from phthalates are associated with antibodies for several infectious diseases. SEM was employed because it has the flexibility to simultaneously estimate multiple outcome variables, and these models have greater statistical power while avoiding the need to adjust for multiple comparisons (Weston and Gore 2006). Antibody titers against measles virus, mumps virus, rubella virus, poliovirus, and EBV were used to measure immunomodulation in a representative sample of the U.S. populations who participated in the NHANES between 2003 and 2010. To assess whether certain sociodemographic subgroups have increased risk for immunomodulation from phthalates, sex- and age-specific associations were evaluated.

METHODS

Study Population

The NHANES is a nationally representative sample of U.S. civilians age one year and older. Interviews and household measurements are conducted in respondents' homes while exams and laboratory components are performed in specially designed mobile exam centers (MECs) that travel to locations throughout the country. Laboratory specimens are processed, frozen (–30°C), and shipped from MECs to the National Center for Environmental Health or other locations for additional testing (Centers for Disease Control and Prevention 2011). Informed consent is obtained from all NHANES participants, and data are de-identified prior to being publically released.

Data for this study are from various NHANES cycles depending on the antibody of interest. Specifically, measles, mumps, and rubella (MMR) antibodies were measured in the 2003-2004 and 2009-2010 cycles in individuals 6 to 49 years; polio antibodies in the 2009-2010 cycle in individuals 6 to 49 years; and Epstein-Barr virus in participants between the ages of 6 and 19 years between 2003 and 2010. Phthalate metabolites were measured in spot urine samples collected in the MECs in a random selection of 1/3 of exam participates six years and older in all waves. Women who were pregnant and individuals who tested positive for HIV/AIDS or Hepatitis C were excluded from the analyses because of underlying changes to their immune systems that may influence study results. Participants missing data on key study variables were also excluded. As a result, three analytic subsamples were created: 2,104 participants in the 2003-2004 MMR subsample; 1,735 participants in the 2009-2010 MMR and polio subsample; and 4,162 participants in the 2003-2010 EBV subsample.

Measures

Phthalate metabolites: Phthalate concentrations were assessed using enzymatic deconjuction followed by solid phase extraction coupled with high-performance liquid chromatography/tandem mass spectrometry as described in detail previously (Silva, Barr et al. 2004). Samples with a concentration below the limit of detection (LOD) were assigned an imputed value of the LOD divided by the square root of 2 (Centers for Disease Control and Prevention 2013). Analyses were limited to nine phthalates detected in greater than 50% of all samples: mono-ethyl phthalate (MEP), mono-n-butyl phthalate (MnBP), mono-isobutyl phthalate (MiBP), mono-(3-carboxypropyl) phthalate (McPP), mono-benzyl phthalate (MBzP), mono-2-ethylhexyl phthalate (MEHP), mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP), mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP), mono-(2-ethyl-5-carboxypentyl) phthalate (MECPP).

Due to skewed distributions, individual metabolite concentrations were $\log_{10}$ transformed. Because phthalate metabolites were measured in urine samples, which can vary by age, gender and race/ethnicity, urinary creatinine concentrations are typically used to adjust for urinary dilution and demographic difference in multiple regression analyses (Barr, Wilder et al. 2005). Analyses were adjusted for creatinine concentrations.

Antibody Titers: MMR antibody titers were collected in the 2003-2004 and 2009-2010 cycles. For the 2003-2004 cycle, MMR tests were performed by the Immunoserology Unit, California State Department of Health Services. Measles IgG and rubella IgG antibody tests were conducted with in-house enzyme immune assays (EIA) while mumps IgG was measured with the commercially–available Wampole® enzyme linked immunosorbent assay (ELISA). For the 2009-2010 cycle, measles, mumps and, rubella IgG were measured by the National Center for Immunization and Respiratory Disease Laboratories. Here, commercially-produced Wampole® ELISAs were used to measure antibody concentrations. MMR antibodies were measured as an index value of optical density (OD) ratio for all waves. Assays measured whether an individual had detectable viral antibodies concentrations, defined as seropositivity, which was greater than 90% for all antibody titers. The majority of respondents were seropositive for measles (96% and 92%), mumps (91 and 87%), and rubella (92% and 95%) antibodies in the 2003-2004 and 2009-2010 data waves, respectively.

Poliovirus antibody titers for serotype 1, serotype 2, and serotype 3 were collected in the 2009-2010 cycle and tested at the CDC's Global Polio Specialized Laboratory according to standard WHO protocols (Centers for Disease Control and Prevention 2014). Poliovirus antibody titers were analyzed as a continuous OD value. The majority of the study populations were seropositive for polio serotype 1 (96%), serotype 2 (98%), and serotype 3 (88%) antibodies.

EBV antibody titers were collected in four waves between 2003 and 2010. EBV IgG antibodies were measured with commercially-available Diamedix enzyme immunoassay (EIA) kits and reported as 1) a continuous OD index, and 2) categorical indicators of positive (EIA $\geq$ 1.10), negative (EIA $\leq$ 0.90), or equivocal (0.9 < EIA $\geq$ 1.09) according to testing kits instructions (Centers for Disease Control and Prevention 2012). Individuals with equivocal results were not included in the data analysis as there was no means of determining whether they had a primary EBV infection and were in the process of seroconverting, or whether they had nonspecific reactivity in the antibody EIA (Balfour, Sifakis et al. 2013). Of young persons ages 6-19 years, 76% were positive for EBV antibodies between 2003 and 2010.

Covariates: Sociodemographic variables were derived from standard, self-reported questions on gender, age, race/ethnicity, income, and education. For race/ethnicity, respondents could select among 54 specific categories, but the public use data file only made available collapsed categories of "Mexican American," "Other Hispanic," "Non-Hispanic White," Non-Hispanic Black," and "Other race including multi-racial" for the data cycles analyzed. Because some of the income measures changed throughout the data collection waves, ratio of family income-to-poverty, or FIP, scores were used as a proxy from socioeconomic status. Ratios below 1.00 indicate that a person/family is below the federal threshold defined as poverty, while a ratio of 1.00 or greater indicates income above the poverty level. FIP scores were provided in the public use file with any score above 5.00 collapsed into the 5.00 category, such that, scores ranged from 0.00 to 5.00. Standard questions were used to collect information on gender and age. Gender was coded as female or male; age was collected as a continuous variable from 1 to 85 year old. Anyone over the age of 85 was collapsed into the 85 year category.

Body mass index (BMI) was measured in the physical exam for survey participants using the standard method of body mass in kilograms divided by the square of the participant's height. The variable was used in analysis as a continuous measure reported in kg/m^2. Exposure to nicotine was measured using the metabolite cotinine in blood serum collected during the exam in participate three years and older. Cotinine was measured with isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (Centers for Disease Control and Prevention 2013). Concentrations were reported as a continuous measure in ng/mL. Additionally, analysis were adjusted for C-reactive protein (CRP) in ng/mL as it is involved in innate immunity and activation of adaptive immunity (Du Clos 2000).

Statistical Analyses

First, descriptive statistics were assessed to examine the overall distribution and central tendency of study variables. Spearman correlations were run to determine the strength and distribution of bivariate associations among phthalate and antibody measures. Then, predictive models for individual phthalate congeners and single antibody measures were estimated using multivariate ordinary least squares regression to help inform subsequent model building. As previously noted however, people are exposed to numerous chemicals at any one time, and experimental as well as epidemiological studies have shown individual chemicals can have multiple health effects. Additionally, there is growing evidence that in combination chemicals can produce addictive effects even when individual chemicals have no observable impact.

While conventional multivariate regression analyses provide useful information, their limitations prompt alterative techniques. For example, using separate regression models for each congener increases the probability of confounding due to multiple comparison; increases the problem of multicollinearity as environmental chemicals are often highly correlated; yields relatively large numbers of coefficients to interpret; and can create situations where a score variable is used to represent data leading to a loss of information (Weuve, Sanchez et al. 2006, Stokes-Riner 2009).

Structural equation modeling (SEM) has become increasingly popular in environmental epidemiology to evaluate simultaneous associations from multiple chemicals that could operate through more than one pathway. It allows for incorporation of multiple outcomes while correcting for measurement error and incomplete cases (Budtz-Jørgensen, Keiding et al. 2002). Additionally, it can handle highly correlated and non-normally distributed data as well as categorical variables in the same model. SEM can also handle both multiple exposure and multiple outcome data (numerous dependent variables) that are continuous, categorical, or a combination of types. This is particularly useful with data on environmental exposures as it more closely models realist exposure profiles in people. Therefore, SEM was employed to simultaneously relate co-exposure to phthalates and multiple antibody titers.

SEMs typically consist of two components: a measurement and a structural model. Measurement models depict the links between observed (measured) variables and latent (hypothesized unobserved) constructs. Structural models show the hypothesized associations among latent variables. Several measurement models were initially hypothesized due some variations in classification cut points between LMW and HMW phthalates as well as behavior in empirical findings (Figure 7.1, Supplemental Figure S7.1 and S7.2). These were tested and only the best fitting, most parsimonious models were retained for subsequent analyses. MnBP, MiBP, and MBzP were identified as indicators of the LMW phthalate construct while McPP, MEHP, MEHHP, MEOHP, and MECPP as indicators of the HMW phthalate construct. MEP, a LMW phthalate metabolite, was retained as a measured variable due to behavioral differences apart from other LMW in multiple linear regression models with single exposure – single antibody outcome models. Only one measurement model was identified among the outcome variables. Poliovirus serotype 1, 2, and 3 were selected as indicators of the polio latent construct. While measures for measles, mumps, and rubella were initially considered for a latent construct, these measures only had moderate correlations, and they behaved divergently in single exposure – single antibody outcome models. Therefore, they were left as measured variables as was the EBV variable in structural models.

Multiple structural models were estimated using the maximum likelihood (ML) estimator in Stata 14.2 (StataCorp LP, 2015). Since Stata does not allow for robust estimates with complex survey data, issues of non-normality were corrected in continuous variables with log-transformation prior to analysis. Phthalates were conceptualized identically in all three analytical datasets with two latent constructs (LMW and HMW), and MEP being estimated independently as a measured variable. For the 2003-2004 cycle, outcome variables consisted for the MMR antibody titers. For the 2009-2010 cycle, outcomes variables were the MMR titers and the poliovirus latent construct. For the 2003-2010 cycle, EBV titer was the only outcome measure. All structural models were adjusted for demographic (sex, age, race/ethnicity, and income) and biometric characteristics (creatinine concentration, cotinine concentration, BMI, and -reactive protein). Additionally, models were evaluated for effect modification by sex (female and male) and age (children 6 to 19 years and adults 20 to 49 years) subgroups. A reduced structural model was also explored for the 2009-2010 cycle where only statistically significant associations were retained to generate the most parsimonious model. Covariance was accounted for between phthalates congeners and outcome measures, respectively, as determined by correlation analysis.

Standardized regression coefficients were reported and represent the standard deviation change in outcome per standard deviation change in exposure. They allow for comparisons of effective sizes across independent variables with different units/scaling. The standardized root mean square residual (SRMR) was reported for model fit with an acceptable fitting model < 0.08 (Hu and Bentler 1999). Associations with *p*-value <0.05 were considered statistically significant and *p*-values <0.10 marginally significant. Stata v14.2 (StataCorp LP, 2015) was utilized to conduct all analyses, and the SVY survey command procedures were used to apply sample weights as well as adjust standard errors for the complex sample design. When combining multiple data between 2003 and 2010 for the EBV analysis, sample weights were adjusted by dividing the total number of combined cycles (4) by the two-year MEC weights (Centers for Disease Control and Prevention 2006).

RESULTS

Sample Characteristics

Sample characteristics are summarized in Table 7.1. The average respondent was non-Hispanic White, born in the United States, in his/her mid-30's, and with an income above the poverty threshold. Of the phthalate metabolites examined in the study, MEP had the highest concentration across all waves while McPP had the lowest. Between the 2003-2004 and 2009-2010 waves, all phthalate metabolites decreased in concentration, except MiBP and a slight increase in McPP. Even with decreasing concentrations between waves, metabolites were detected in almost all urine samples in each wave.

Bivariate and Multivariate Models

Spearman correlations were examined for phthalate metabolites and antibody titers (Table 7.2a, 7.2b, and 7.2c). Most phthalate congeners had moderate to very high correlations that were consistent across all cycles. In particular, DEHP metabolites MEHP, MEHHP, MEOHP, and MECPP ranged from correlations greater than 0.75 to 0.98. LMW phthalates MnBP, MiBP, and McPP also had higher correlations between 0.50 and 0.80. MEP had the lowest correlation with any of the phthalate metabolites ranging from 0.22 with McPP in the 2003-2004 cycle to 0.46 with MiBP in the 2009-2010. Polio serotype antibodies were moderately correlated around 0.50, but MMR antibodies had weaker correlations amongst themselves and other viral titers.

Multiple linear regression models for single phthalate metabolites and single antibody titers were conducted, which showed exposure to phthalates was generally positively associated with measles and EBV antibodies regardless of molecular weight after adjusting for age, sex, race/ethnicity, income, BMI, cotinine concentration, C-protein concentration, and creatinine concentration. However, LMW phthalates tended to be positively associated and HMW phthalates negatively associated with rubella and polio antibodies, respectively, after adjusting for covariates. Furthermore, males typically experienced immune system enhancement for most phthalate metabolites while females saw immune suppression, but only for LMW phthalates. Patterns were more inconsistent among age subgroups.

Structural Equation Modeling: Combined Effects

Since co-exposures to multiple chemicals occur every day and numerous biological processes occur simultaneously, SEM was used to jointly evaluate associations between various phthalate concentrations and antibody titers after adjusting for covariates. The MMR and polio antibody model from the 2009-2010 cycle had the best model fit with a SRMR = 0.038. The MMR model for the 2003-2004 cycle was just outside the 0.08 cut point of acceptable fit with a SRMR = 0.082 as was the 2003-2010 EBV antibody model with a SRMR = 0.089 (Table 7.3).

Figures 7.1-7.3 graphically depict the structural equation models with statistically significant associations bolded in black while Table 7.3 presents the standardized coefficients for these models. In the 2003-2004 cycle, LMW phthalates were positively associated with measles (β=3.11; 95% CI: 1.68, 4.54), mumps (β=1.79; 95% CI: 0.73, 2.82), and rubella (β=1.82; 95% CI: 0.75, 2.88) antibody titers while HMW phthalates were negatively associated with mumps titers (β= -.07; 95% CI: -0.13, -0.12). MEP was not associated with any of the antibody titers (Table 7.3, Figure 7.1). Similarly, LMW phthalates were positively associated with measles, mumps, rubella, and polio antibodies while HMW phthalates were negatively associated with measles, mumps, rubella, and polio antibodies in the 2009-2010 cycle. MEP was negatively associated with both mumps (β= -.08; 95% CI: -0.17, -0.01) and polio (β= -.08; 95% CI: -0.18, -0.01) antibodies in the 2009-2010 cycle (Table 7.3, Figure 7.2). Regarding EBV titers from the combined 2003-2010 data cycles, LMW phthalates (β=0.02; 95% CI: 0.01, 0.03) were positively associated with EBV titers as was MEP (β=0.08; 95% CI: 0.01, 0.15). While there was no statistically significant association between HMW phthalates and EBV titers, the association trended in a negative direction, like other antibody models from the 2003-2004 and 2009-2010 cycles (Table 7.3, Figure 7.3).

Structural Equation Modeling: Effect Modification by Sex

Each model was examined to determine if there were sex and/or age differences. Models examined by age did not converge for any of the three data cycles, therefore, the results were unreliable and are not presented. For the 2003-2004 data cycle, LMW phthalates were positively associated with measles (β=1.82; 95% CI: 0.38, 3.26), mumps (β=0.96; 95% CI: 0.51, 1.41), and rubella (β=1.04; 95% CI: 0.46, 1.62) antibody titers in males; only MEP was inversely associated with mumps antibodies in females (β= -.11; 95% CI: -0.22, -0.01). Males also saw immune enhancement in the 2009-2010 data wave where MEP was positively associated with measles (β=0.10; 95% CI: 0.02, 0.18) and rubella (β=0.14; 95% CI: 0.05, 0.22). LMW phthalates were also positively associated with measles (β=3.56; 95% CI: 1.23, 5.88) and polio (β=2.45; 95% CI: 0.45, 7.07) titers in males as was HMW with mumps antibodies (β=0.06; 95% CI: -0.07, 0.19). However, MEP was negatively associated with mumps antibodies in males (β= -.09; 95% CI: -0.18, -0.01). Females experienced both immune suppression and enhancement in the 2009-2010 cycle. Specifically, MEP was negatively associated with measles, rubella, and polio antibodies; LMW phthalates were positively associated with mumps, rubella, and polio antibodies. LMW phthalates were both positively associated with EBV antibodies in females (β= 0.29; 95% CI: 0.22, 0.36) and males (β= 0.05; 95% CI: 0.02, 0.07); MEP was positively associated with EBV antibodies in females only (β= 0.09; 95% CI: 0.05, 0.15). For almost all associations, females had a stronger immune response compared to males (Table 7.3).

Structural Equation Modeling: Restricted Model

The largest numbers of antibody measures were available during the 2009-2010 cycle. To determine the most parsimonious model, only measured variables and latent constructs that were statistically significant were retained in this wave. For measles, mumps, rubella and polio antibody titers, LMW phthalates were positively associated while HMW phthalates were negatively associated. For all antibody titers, being male was positively associated, and creatinine was negatively associated. Age was positively associated with mumps (β= 0.12; 95%

CI: 0.04, 0.12) and rubella (β= 0.15; 95% CI: 0.10, 0.20) antibodies but negatively associated with polio antibodies (β= -0.20; 95% CI: -0.29, -0.11). Cotinine concentrations were negatively associated with both LMW and HMW phthalates while creatinine concentrations were positively associated. Both BMI and being male was negatively associated with LMW phthalates. Overall, the reduced model had an acceptable model fit of SRMR = 0.045 (Table 7.4, Figure 7.4).

DISCUSSION

Besides MEP, LMW phthalate metabolites were associated with immune enhancement while HMW phthalates were associated with immune suppression in SEM analyses. Specifically, LMW phthalates were positively associated with measles, mumps, and rubella antibody titers in the 2003-2004 cycle and measles, mumps, rubella, and polio titers in the 2009-2010 cycle. HMW phthalates were inversely associated with rubella antibodies in the 2003-2004 cycle, and inversely associated with measles, mumps, rubella, and poliovirus antibodies in 2009-2010. Similarly in the 2003-2010 combined sample, LMW phthalates were positively associated with EBV antibodies; there was no statistically significant association for HMW and EBV titers. MEP was estimated separate from the LWM construct due to inconsistent behavior in multivariate analyses. In SEM models, MEP was negatively associated with mumps and polio antibodies in the 2009-2010, but positively associated with EBV antibodies in the 2003-2010 combined sample.

When comparing joint associations by sex subgroups, the direction of associations were mostly similar to the SEMs run on the full samples. However, males experienced immune enhancement of measles and rubella titers with MEP exposure as well as an increase in mumps titers with exposure to HMW phthalates in the 2009-2010 cycle while females had immune suppression of titers for these chemical exposures. Where directionality of associations was comparable, on average, females had stronger immune response to phthalate exposures compared to males. Previous research has shown women tend to produce higher antibody titers compared to men, and they generally produce an overall more vigorous immune response (Whitacre, Reingold et al. 1999, Goldsby, Kindt et al. 2003). For example, sex-based differences in vaccine efficacy, adverse events, and humoral immune response after immunization have been reported for MMR, influenza, hepatitis A, yellow fever, smallpox, rabies and human papillomavirus vaccines (Klein, Jedlicka et al. 2010).

This is the first study to simultaneous estimate co-exposures to phthalates and multiple antibody measures for infectious agents. Importantly, there is growing scientific awareness of the synergistic influence of multiple-chemical exposure acting together, as known as the "cocktail effect." While most studies typically focus on a single chemical and single outcome, the reality is people are exposed to thousands of chemicals simultaneously, which can be associated with any number of health effects. Ignoring this complexity can lead to an underestimation these health effects. SEM has become increasingly popular in environmental epidemiology to evaluate simultaneous associations from multiple chemicals that could operate through more than one pathway. It allows for incorporation of multiple outcomes while correcting for measurement error and incomplete cases (Budtz-Jørgensen, Keiding et al. 2002). Additionally, it can handle highly correlated and non-normally distributed data as well as categorical variables in the same model. To date, SEM has been used to study infant exposure to phthalates (Weuve, Sanchez et al. 2006) and the health impacts of exposure to polycyclic aromatic hydrocarbons (PAH), cadmium, lead, mercury, polychlorinated biphenyls (PBCs), and perfluoroalkyl substances (PFASs) (Grandjean, Andersen et al. 2012, Peters, Patricia Fabian et al. 2014, Trzeciakowski, Gardiner et al. 2014, Mogensen, Grandjean et al. 2015, Alshaarawy, Elbaz et al. 2016).

Scant research exists on the association between phthalate exposures and antibodies for infectious agents with most studies focusing on PFASs; SEM has been only used assess the joint immunotoxic impacts of PFASs for diphtheria and tetanus antibodies in two studies (Grandjean and Budtz-Jorgensen 2013, Mogensen, Grandjean et al. 2015). Research on a birth cohort from the Faroe Islands found elevated exposure to PFASs was associated with lower antibody titers in children under five (Grandjean, Andersen et al. 2012, Grandjean and Budtz-Jorgensen 2013, Mogensen, Grandjean et al. 2015). A Norwegian study measured a negative association between rubella antibody production in children under three (Granum, Haug et al. 2013) as did a study using NHANES data found an inverse association between rubella antibody titers and mumps titers with doubling of perfluorooctanesulfonic acid (PFOS) concentrations in adolescents (Stein, McGovern et al. 2015). Research by Looker et al. (2014) found perfluorooctanoic acid (PFOA) was associated with reduced A/H3N2 influenza virus antibodies and an increased risk of not attaining antibody threshold considered necessary for long-term production. A study found serum concentrations of PFAS concentrations, especially long-chain PFASs, were negatively associated with antibody responses to diphtheria and tetanus booster vaccinations supporting previous findings of immunosuppression of PFASs (Kielsen, Shamim et al. 2016).

As a whole, research on PFASs shows an association between chemical exposures and immunosuppression of antibodies to infectious diseases. However, this research demonstrates that different types of congeners within the same chemical class can have variable effects. This has important regulatory and scientific implications. First, LMW phthalates have a much stronger impact on antibody titers than HMW phthalates. While it is concerning that immune suppression from HMW phthalates could increase a person's susceptibility to disease, exposure to LMW phthalates may have a protective effect from infectious disease agents, in particular viruses. Nevertheless, if LMW phthalates enhance antibody production in general, this could have implications for exacerbating autoimmunity and hypersensitivity (i.e. allergies) in people. The World Health Organization estimates that 20% of the world's population suffers from allergic conditions (Robinson and Miller 2015), and the rapid increase in the prevalence of allergies as been far too rapid to be driven by the gene pool, therefore, changes in environmental conditions, diet, and/or lifestyle are suspected (Kimber and Dearman 2010). Both experimental (Hillemeier, Lynch et al. 2004, Larsen, Hansen et al. 2007, Schlezinger, Emberley et al. 2007, Bissonnette, Teague et al. 2008, Dearman, Betts et al. 2009) and epidemiological studies have shown phthalate to be immunomodulatory and to be associated with increases in allergic symptoms (Norback, Wieslander et al. 2000, Jaakkola, Ieromnimon et al. 2006, Jaakkola and Knight 2008, Bornehag and Nanberg 2010, Bertelsen, Carlsen et al. 2013, Hoppin, Jaramillo et al. 2013). Ubiquitous exposure to LMW phthalates in consumer products could help drive the rise in allergic diseases. Continued research is necessary to help determine if there is a casual link been phthalate exposure and immunomodulation.

Several limitations are present in this study. First, this research utilizes cross-sectional data. Therefore, causality cannot be inferred nor can reverse causation from these findings. However, multiple waves of data were used with generally comparable results providing evidence to support reported findings. Additionally, single spot urinary measurements of phthalate biomarkers may not be reliable estimates of average or peak exposure (Sobus, DeWoskin et al. 2015). However, studies on phthalates have shown that even though are they eliminated quickly, within-person variability is sufficiently stable day-to-day and month-to-month to presume exposure is typically consistent and ever present (Hoppin, Brock et al. 2002, Hauser, Meeker et al. 2004). Despite several limitations, this research has several strengthens. First, the NHANES survey is a nationally-representative survey of the U.S. population. Therefore, this study has generalizability to the population as a whole and population subgroups. Even though the data is cross-sectional, it still allows for extrapolation of population-level changes to environmental chemical exposures. Second, besides self-reported demographic measures, all other study variables are biomarker data, which are inherently objective tending to greater validity and reliability of findings than self-reported measured.

In conclusion, this study contributes to growing evidence that environmental chemicals, in general and specific to phthalates, may have immunomodulatory effects. If associations are causal, exposure to HMW phthalates could increase a person's risk to infectious diseases, like measles, mumps, rubella and polio, despite vaccination for these diseases. Further, exposure to LMW phthalates could be immunoprotective against infectious diseases, or they could increase susceptibility to autoimmunity and/or allergy. These models help contribute to our understanding of the public health risks of exposure to phthalates, but additional research is needed to confirm study findings and to better understand the cumulative health impact of phthalates.

Table 7.1. Study characteristics by NHANES wave, 2003-2004, 2009-2010, and 2003-2010.

Variables	2003-2004 Cycle n=2,104 Weighted percent/mean (SE)	2009-2010 Cycle n=1,735 Weighted percent/mean (SE)	2003-2010 Cycle n=4,162 [c] Weighted percent/mean (SE)
Demographic/Biometric			
Race/ethnicity (%)			
Non-Hispanic White	65.7 (.04)	61.6 (.03)	60.2 (.02)
Non-Hispanic Black	12.7 (.02)	12.2 (.01)	14.4 (.01)
Mexican American	11.5 (.02)	11.1 (.02)	13.5 (.01)
Other	11.1 (.01)	15.1 (.01)	11.9 (.00)
Age, years (mean)	28.3 (.53)	28.1 (.39)	12.7 (.11)
Sex (%)			
Female	51.2 (.01)	51.0 (.01)	51.4 (.01)
Male	48.8 (.01)	49.0 (.01)	48.6 (.01)
FIP (mean)	2.8 (.11)	2.7 (.06)	2.5 (.06)
BMI (mean)	26.1 (.33)	26.4 (.09)	21.5 (.13)
Cotinine (mean)	58.8 (4.9)	47.7 (6.0)	13.3 (1.3)
CRP (mean)	.37 (.02)	.30 (.02)	.18 (.01)
Creatinine (mean)	129 (2.5)	127 (2.5)	131 (2.6)
Phthalates (GM)[a]			
MEP	130.6 (7.92)	66.6 (2.96)	97.1 (2.80)
∑ DBP	16.0 (0.43)	13.0 (0.52)	13.9 (0.27)
MnBP	23.3 (0.65)	16.5 (0.69)	20.4 (0.38)
MiBP	5.4 (0.21)	9.3 (0.38)	7.5 (0.15)
McPP	4.4 (0.07)	4.6 (0.23)	4.2 (0.07)
MBzP	12.1 (0.39)	8.3 (0.36)	9.9 (0.21)
∑ DEHP	78.0 (4.10)	46.6 (2.54)	69.8 (2.17)
MEHP	3.9 (0.16)	3.0 (0.12)	3.9 (0.09)
MEHHP	24.1 (1.29)	14.8 (0.85)	22.1 (0.70)
MEOHP	16.6 (0.81)	9.8 (0.49)	14.3 (0.42)
MECPP	36.7 (1.93)	22.5 (1.15)	33.0 (0.99)
Antibody Titers (OD)[b]			
Measles virus	9.0 (.31)	3.0 (.08)	---
Mumps virus	2.8 (.07)	2.8 (.09)	---
Rubella virus	62.2 (1.6)	3.4 (.07)	---
Poliovirus			
Type 1	---	7.1 (.10)	---
Type 2	---	7.3 (.13)	---
Type 3	---	5.7 (.12)	---
EBV	---	---	2.7 (.07)

Abbreviations: standard error (SE); family income-poverty ratio (FIP); body mass index (kg/m^2)(BMI); C-reactive protein (CRP); and Epstein-Barr virus. [a] Antibody titers are expressed as optical densities (SE). [b] Phthalates are reported as geometric means (SE). [c] The 2003-2010 wave only consists of young people 6-19 years as EBV was only measured in this age group.

Table 7.2a. Spearman correlations for phthalate metabolites and antibody titers, 2003-2004 NHANES (n=2,104).

	MEP	MnBP	MiBP	McPP	MBzP	MEHP	MEHHP	MEOHP	MECPP	Measles	Mump	Rubella
2003-2004 Wave												
MEP	1.000											
MnBP	0.353	1.000										
MiBP	0.340	0.742	1.000									
McPP	0.224	0.674	0.556	1.000								
MBzP	0.273	0.710	0.584	0.657	1.000							
MEHP	0.235	0.440	0.448	0.413	0.353	1.000						
MEHHP	0.229	0.542	0.521	0.575	0.508	0.792	1.000					
MEOHP	0.232	0.558	0.531	0.588	0.518	0.789	0.982	1.000				
MECPP	0.233	0.513	0.494	0.583	0.474	0.752	0.949	0.952	1.000			
Measles	0.025	0.054	0.096	0.072	0.030	0.042	0.054	0.056	0.064	1.000		
Mumps	0.042	0.021	0.031	0.014	-0.018	0.014	-0.006	-0.002	0.001	0.329	1.000	
Rubella	-0.023	-0.025	0.028	-0.025	-0.053	-0.004	-0.046	-0.050	-0.046	0.361	0.285	1.000

Table 7.2b. Spearman correlations for phthalate metabolites and antibody titers, 2009-2010 NHANES (n=1,735).

	MEP	MnBP	MiBP	McPP	MBzP	MEHP	MEHHP	MEOHP	MECPP	Measles	Mump	Rubella	Polio 1	Polio 2	Polio 3
2009-2010 Wave															
MEP	1.000														
MnBP	0.450	1.000													
MiBP	0.464	0.801	1.000												
McPP	0.270	0.562	0.500	1.000											
MBzP	0.341	0.733	0.664	0.510	1.000										
MEHP	0.320	0.477	0.480	0.491	0.403	1.000									
MEHHP	0.322	0.570	0.569	0.589	0.517	0.821	1.000								
MEOHP	0.332	0.594	0.593	0.609	0.548	0.814	0.983	1.000							
MECPP	0.310	0.538	0.536	0.617	0.483	0.764	0.938	0.945	1.000						
Measles	0.030	0.085	0.056	0.063	0.050	-0.005	0.000	0.001	-0.007	1.000					
Mumps	-0.018	0.050	0.049	-0.005	-0.013	0.000	0.011	0.011	0.018	0.300	1.000				
Rubella	0.026	0.046	0.007	0.012	-0.021	-0.021	-0.053	-0.052	-0.050	0.362	0.370	1.000			
Polio v1	-0.064	-0.017	-0.023	-0.024	0.009	-0.060	-0.051	-0.054	-0.060	0.144	0.147	0.180	1.000		
Polio v2	-0.053	0.032	0.010	0.002	0.043	-0.043	-0.016	-0.015	-0.012	0.205	0.153	0.196	0.5209	1.000	
Polio v3	-0.100	0.048	-0.003	0.041	0.058	-0.048	0.022	0.031	0.051	0.210	0.163	0.213	0.4076	0.507	1.000

Table 7.2c. Spearman correlations for phthalate metabolites and antibody titers, 2003-2010 NHANES (n=4,162).

	MEP	MnBP	MiBP	McPP	MBzP	MEHP	MEHHP	MEOHP	MECPP	Measle
2003-2004 Wave										
MEP	1.000									
MnBP	0.428	1.000								
MiBP	0.320	0.715	1.000							
McPP	0.221	0.621	0.500	1.000						
MBzP	0.333	0.741	0.569	0.607	1.000					
MEHP	0.297	0.468	0.414	0.436	0.391	1.000				
MEHHP	0.316	0.583	0.492	0.575	0.534	0.788	1.000			
MEOHP	0.329	0.606	0.495	0.584	0.556	0.785	0.986	1.000		
MECPP	0.302	0.534	0.453	0.587	0.486	0.745	0.947	0.949	1.000	
EBV	0.129	0.063	0.073	-0.033	0.026	0.042	0.020	0.023	0.022	1.000

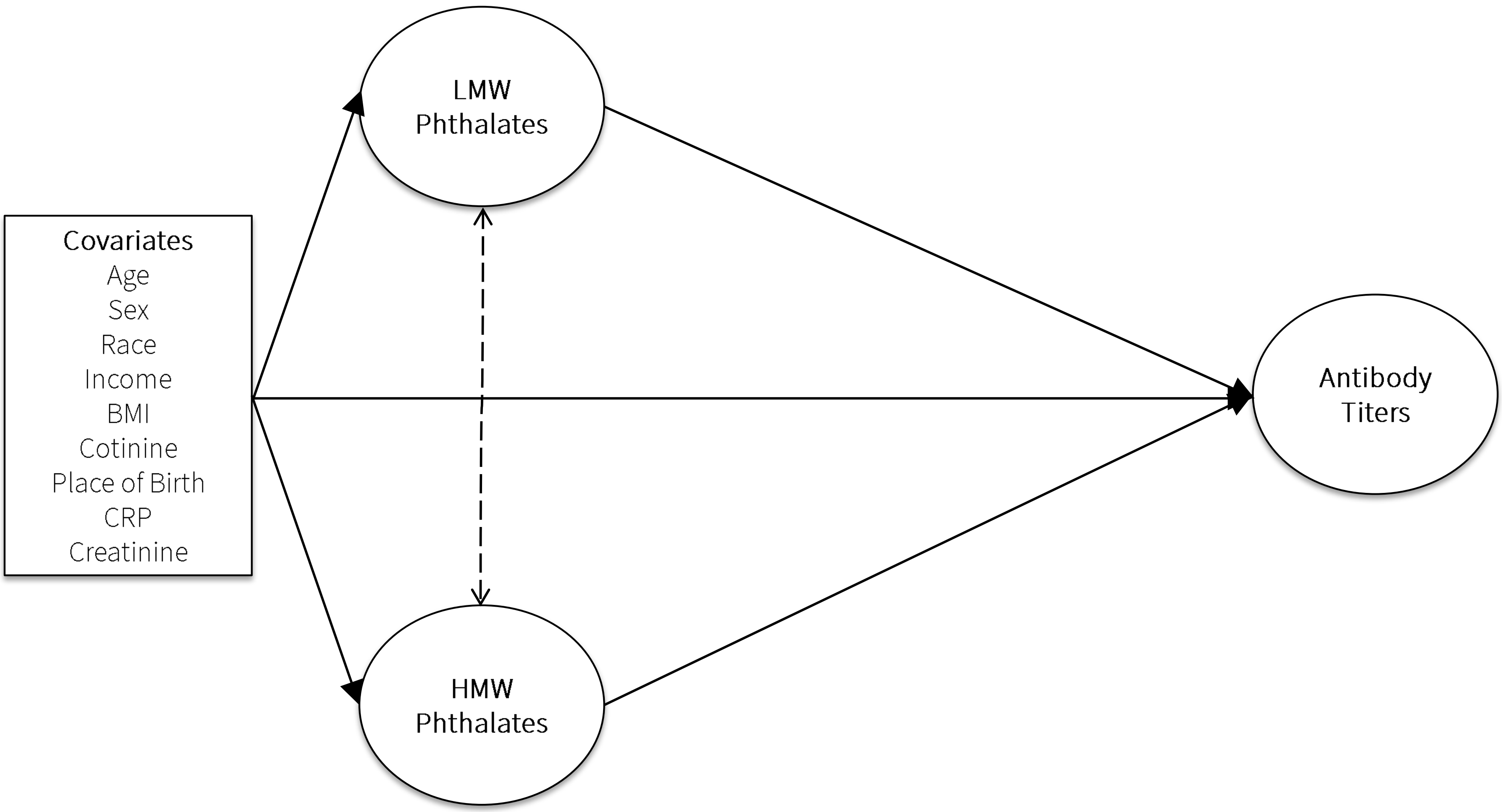


Figure 7.1. Hypothesized associations between antibody titers by phthalate metabolites, NHANES 2003-2010.

Table 7.3. Adjusted SEMs of phthalate metabolites on various antibody titers.

2003-2004: MMR antibody titers by phthalate metabolites			
	Full Sample (n=2,104)	Females (n=833)	Males (n=792)
Variable	B (95% CI)	B (95% CI)	B (95% CI)
Measles Antibodies			
MEP	0.001 (-0.092, 0.094)	0.051 (-0.071, 0.174)	-0.029 (-0.131, 0.073)
LMW	3.108 (1.680, 4.536)***	7.748 (-9.607, 25.102)	1.819 (0.382, 3.257)*
HMW	-0.020 (-0.085, 0.044)	-0.045 (-0.178, 0.088)	0.022 (-0.075, 0.120)
Mumps Antibodies			
MEP	-.052 (-0.129, 0.025)	-0.105 (-0.217, 0.008)+	-0.001 (-0.122, 0.121)
LMW	1.793 (0.763, 2.824)***	5.343 (-7.264, 17.951)	0.962 (0.513, 1.411)***
HMW	-0.016 (-0.095, 0.062)	-0.013 (-0.182, 0.155)	-0.019 (-0.087, 0.050)
Rubella Antibodies			
MEP	0.010 (-0.082, 0.103)	-0.024 (-0.130, 0.082)	0.060 (-0.066, 0.186)
LMW	1.817 (0.753, 2.880)**	5.173 (-7.302, 17.648)	1.036 (0.456, 1.616)**
HMW	-0.068 (-0.125, -0.012)*	-0.055 (-0.161, 0.051)	-0.070 (-0.164, 0.024)
Fit Statistics	SRMR = .082, CD=.98	SRMR =.082, CD=.99	SRMR = .088, CD=.95
2009-2010: MMR and polio antibody titers by phthalate metabolites			
	Full Sample (n=1,735)	Females (n=731)	Males (n=720)
Variable	B (95% CI)	B (95% CI)	B (95% CI)
Measles Antibodies			
MEP	0.027 (-0.066, 0.120)	-0.034 (-0.184, 0.115)	0.100 (0.023, 0.177)*
LMW	3.421 (1.744, 5.098)***	3.805 (0.198, 7.412)*	3.555 (1.230, 5.880)**
HMW	-1.265 (-2.102, -0.427)**	-0.029 (-0.120, 0.062)	-0.061 (-0.212, 0.089)
Mumps Antibodies			
MEP	-0.077 (-0.168, 0.014)+	-0.057 (-0.191, 0.077)	-0.088 (-0.183, 0.007)+
LMW	1.036 (.809, 1.264)***	3.934 (0.530, 7.338)*	3.158 (0.885, 5.431)
HMW	-3.690 (-6.164, -1.214)**	-0.041 (-0.151, 0.068)	0.060 (-0.073, 0.194)**
Rubella Antibodies			
MEP	0.013 (-0.051, 0.077)	-0.118 (-0.207, -0.030)*	0.135 (0.046, 0.224)**
LMW	4.453 (1.976, 6.930)**	6.057 (0.230, 11.884)+	3.759 (0.446, 7.071)
HMW	-1.755 (-2.942, -0.569)**	-0.101 (-0.224, 0.022)*	-0.100 (-0.228, 0.027)*
Polio Antibodies			
MEP	-0.083 (-0.177, 0.011)+	-0.162 (-0.261, -.062)**	-0.034 (-0.139, 0.070)
LMW	2.613 (0.998, 4.229)**	3.047 (0.530, 5.564)*	2.491 (-.062, 4.361)*
HMW	-0.951 (-1.671, -0.231)*	0.015 (-0.164, 0.193)	0.069 (-0.038, 0.175)
Fit Statistics	SRMR = .038, CD=.99	SRMR =.055, CD=.99	SRMR = .056, CD=.99
2003-2010: EBV antibody titer by phthalate metabolites			
	Full Sample (n=4,162)	Females (n=1,269)	Males (n=1,345)
Variable	B (95% CI)	B (95% CI)	B (95% CI)
EBV Antibodies			
MEP	0.077 (0.005, 0.149)*	0.093 (0.005, 0.149)*	0.068 (0.021, 0.157)
LMW	0.020 (0.009, 0.031)***	0.286 (0.215, .357)***	0.047 (0.024, 0.071)***
HMW	-0.038 (-.010, 0.026)	-0.042 (-0.137., 0.054)	-0.058 (-0.146., 0.029)
Fit Statistics	SRMR = .089, CD=.61	SRMR = .087, CD=1.0	SRMR = .097, CD=.57

Models show standardized coefficients (95% CI) adjusted for race/ethnicity, age, sex, income, BMI, cotinine concentration, CRP concentration, and creatinine concentration. Significance defined as + $p < .1$, * $p < .05$, ** $p < .01$, and *** $p < .001$

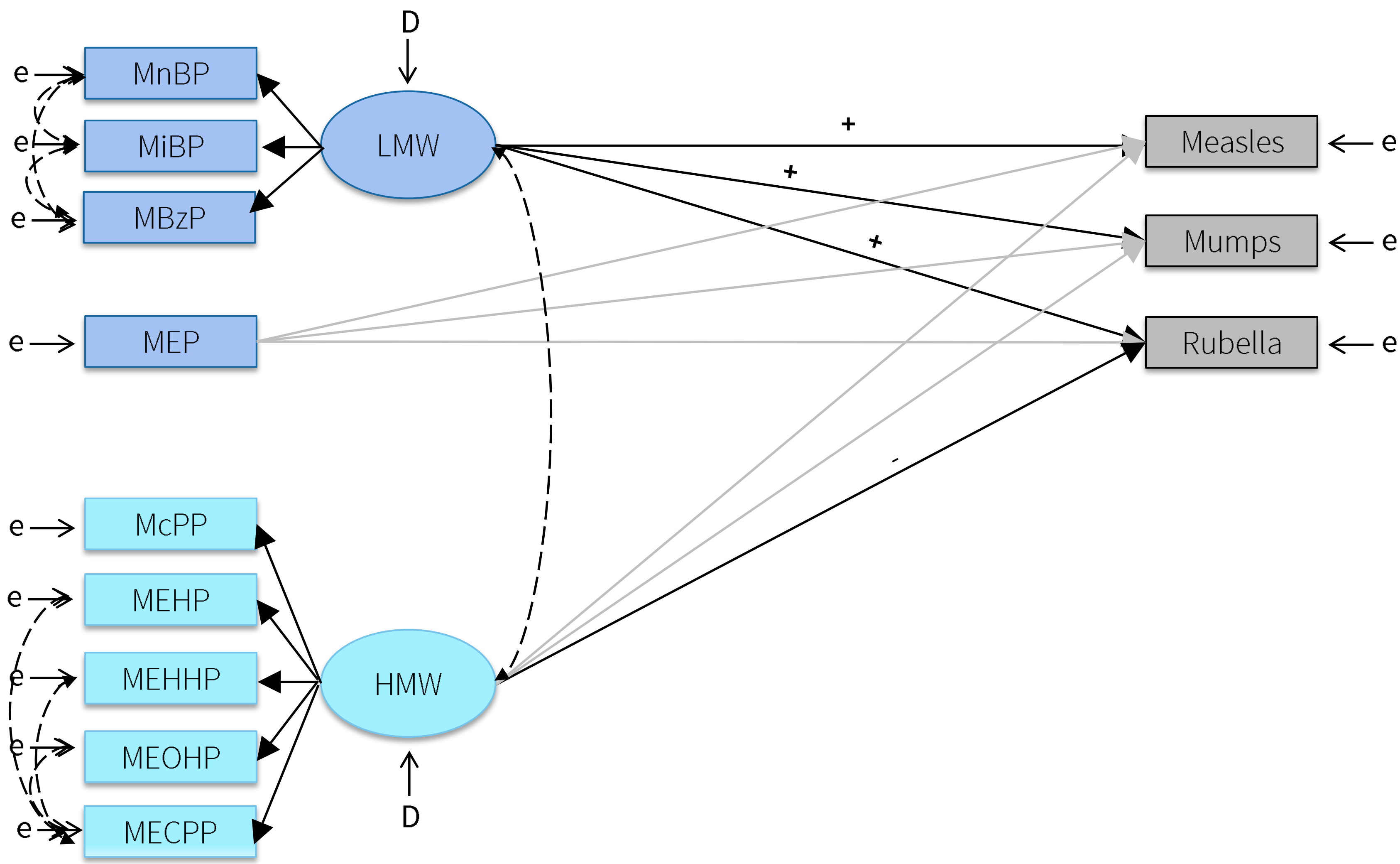


Figure 7.2. Adjusted SEM for MMR antibody titers by phthalate metabolites, NHANES 2003-2004 (full sample). Model adjusted by race/ethnicity, age, sex, income, BMI, cotinine concentration, C-reactive protein concentration, and creatinine concentration.

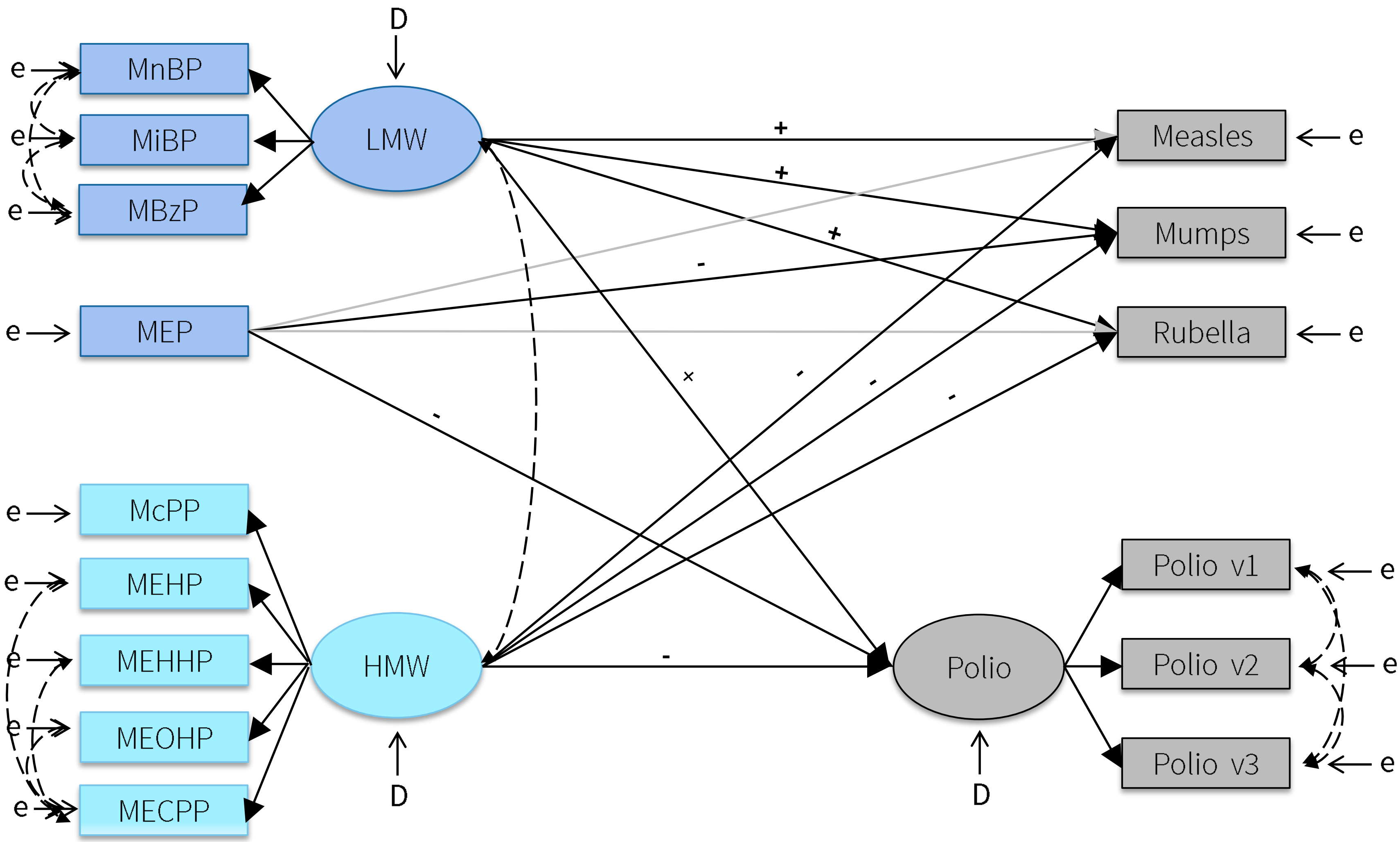


Figure 7.3. Adjusted SEM for MMR and polio antibody titers by phthalate metabolites, NHANES 2009-2010 (full sample). Model adjusted by race/ethnicity, age, sex, income, BMI, cotinine concentration, C-reactive protein concentration, and creatinine concentration.

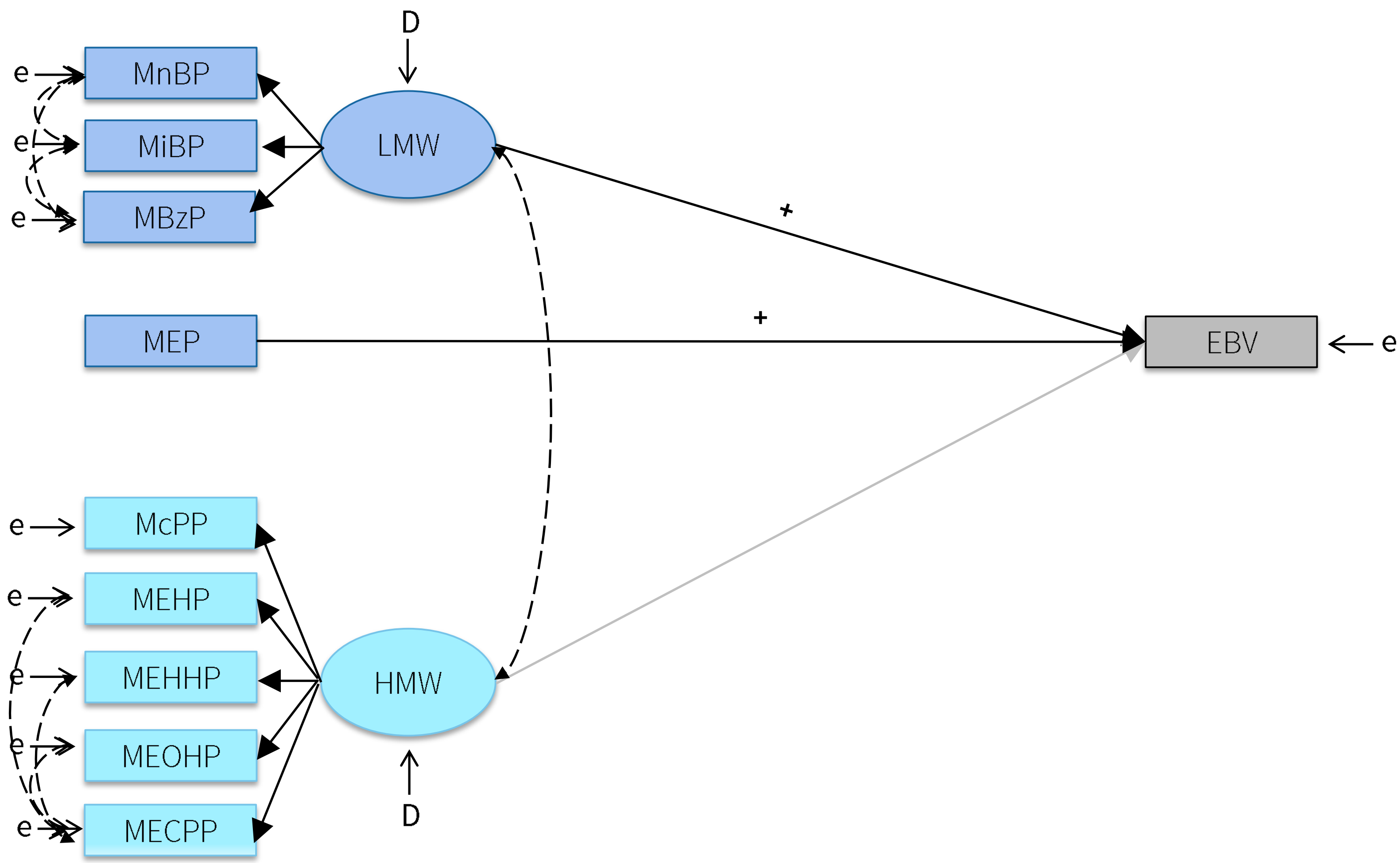


Figure 7.4. Adjusted SEM for EBV antibody titers by phthalate metabolites, NHANES 2003-2010 (full sample). Model adjusted by race/ethnicity, age, sex, income, BMI, cotinine concentration, C-reactive protein concentration, and creatinine concentration.

Table 7.4. Reduced structural equation model of phthalate metabolite concentrations on antibody titers, NHANES 2009-2010.

	Full Sample (n=1,735)
Variable	Standardized B (95% CI)
Measles Antibodies	
LMW	3.935 (1.897, 5.973)***
HMW	-1.587 (-2.582, -0.591)**
Male	0.656 (0.206, 1.106)**
Creatinine	-2.906 (-4.359, -1.453)***
Mumps Antibodies	
LMW	3.876 (1.949, 5.802)**
HMW	-1.513 (-2.519, -0.508)***
Male	0.591 (0.174, 1.008)***
Age	0.119 (0.043, 0.195)**
Creatinine	-2.949 (-4.307, -1.591)***
Rubella Antibodies	
LMW	5.007 (2.264, 7.749)**
HMW	-2.031 (-3.405, -0.657)***
Male	0.858 (0.227, 1.489)***
Age	0.147 (0.096, 0.198)***
Creatinine	-3.729 (-5.638, -1.820)***
Polio Antibodies	
LMW	2.979 (1.077, 4.881)+
HMW	-1.146 (-2.078, -0.213)***
Male	0.521 (0.115, 0.928)+
Age	-0.200 (-0.290, -0.110)***
Creatinine	-2.335 (-3.683, -0.986)*
LMW	
Male	-1.996 (-3.282, -0.709)**
BMI	-0.022 (-0.033, -0.012)***
Cotinine	-0.001 (-0.003, 0.000)*
Creatinine	0.068 (0.034, 0.101)***
HMW	
Cotinine	-0.051 (-0.105, 0.002)+
Creatinine	0.498 (0.475, 0.520)*
Fit Statistics	SRMR = .045, CD=.99

Models show standardized coefficients (95% CI) adjusted for age, sex, BMI, and creatinine concentration. Significance defined as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

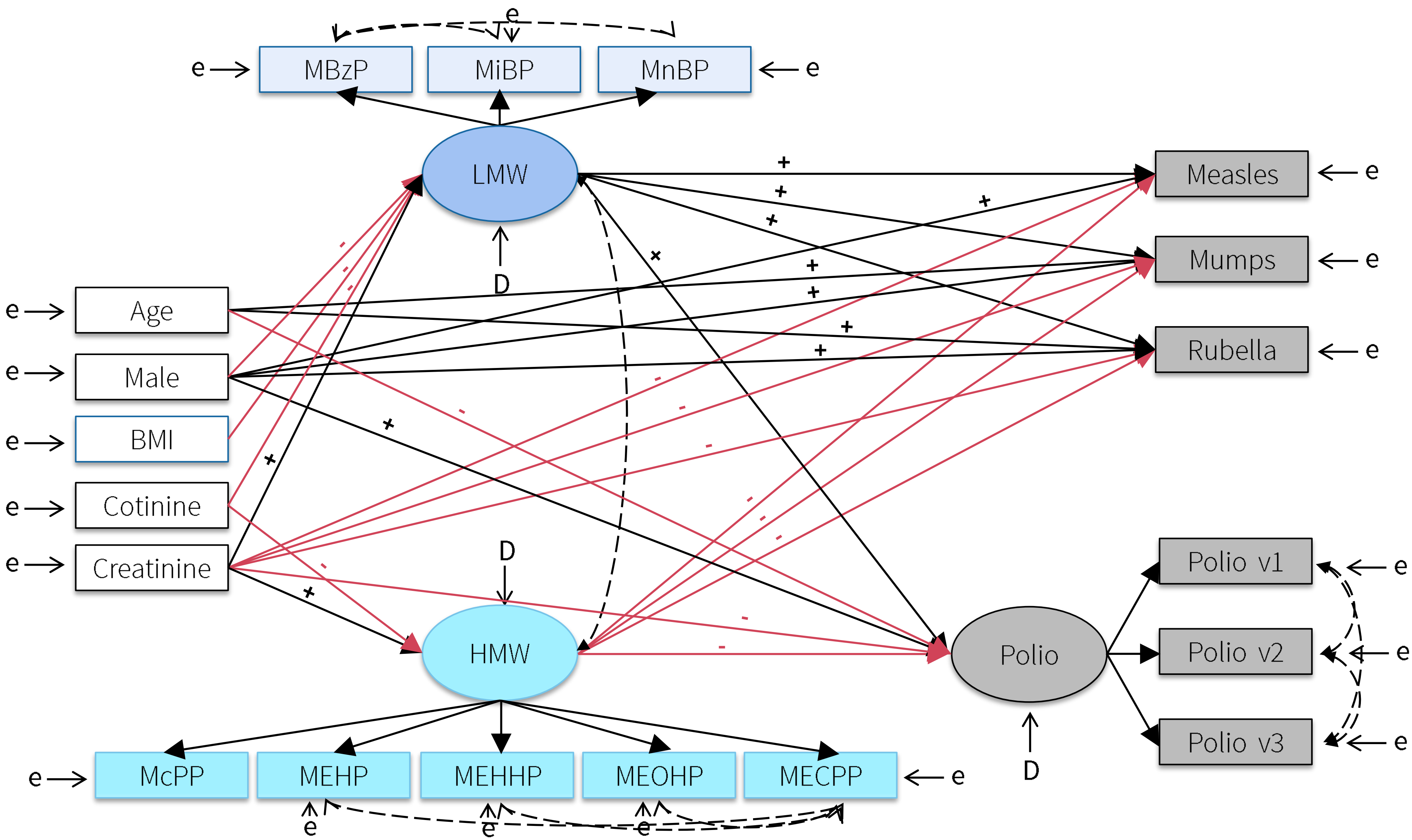
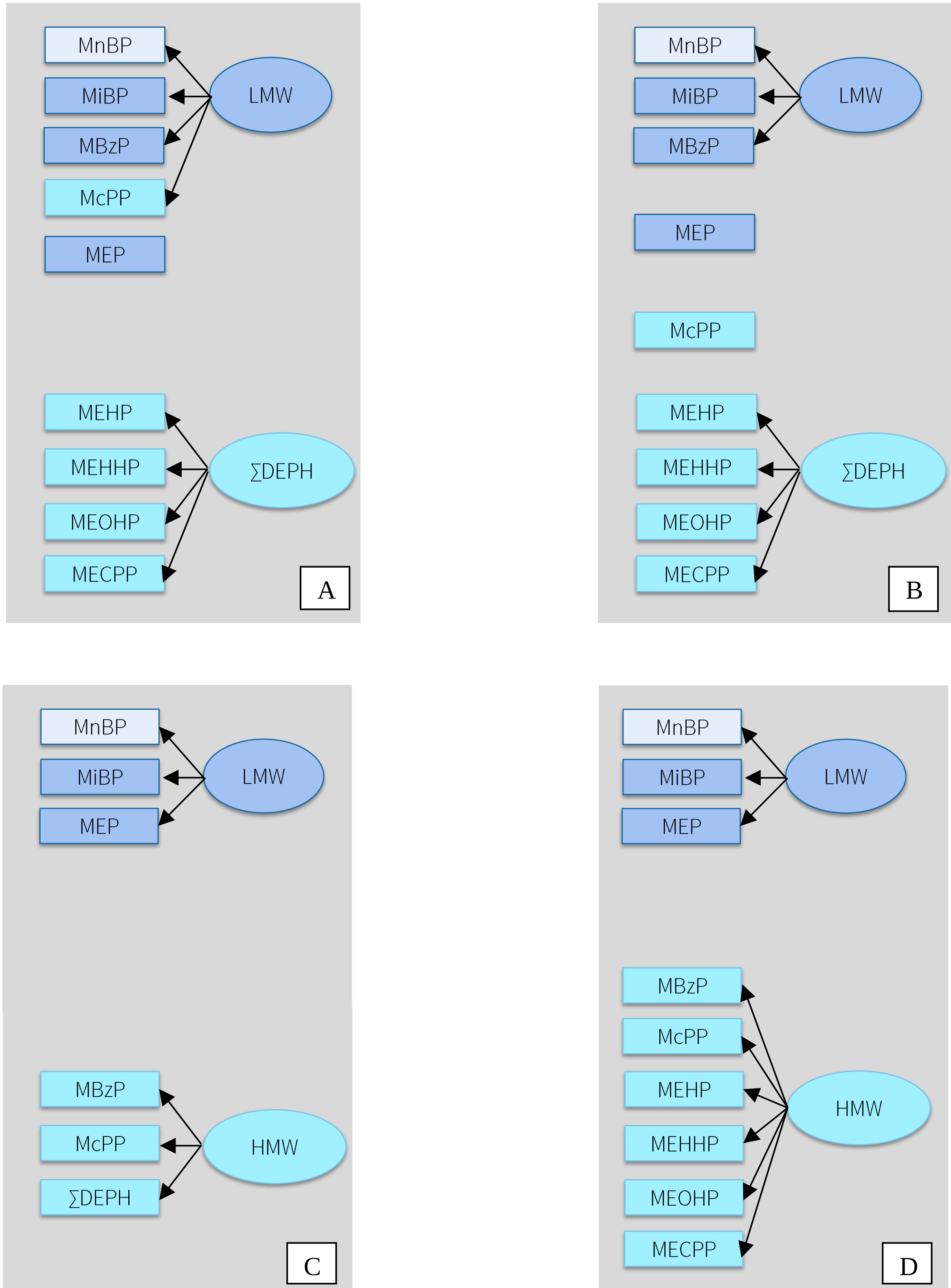
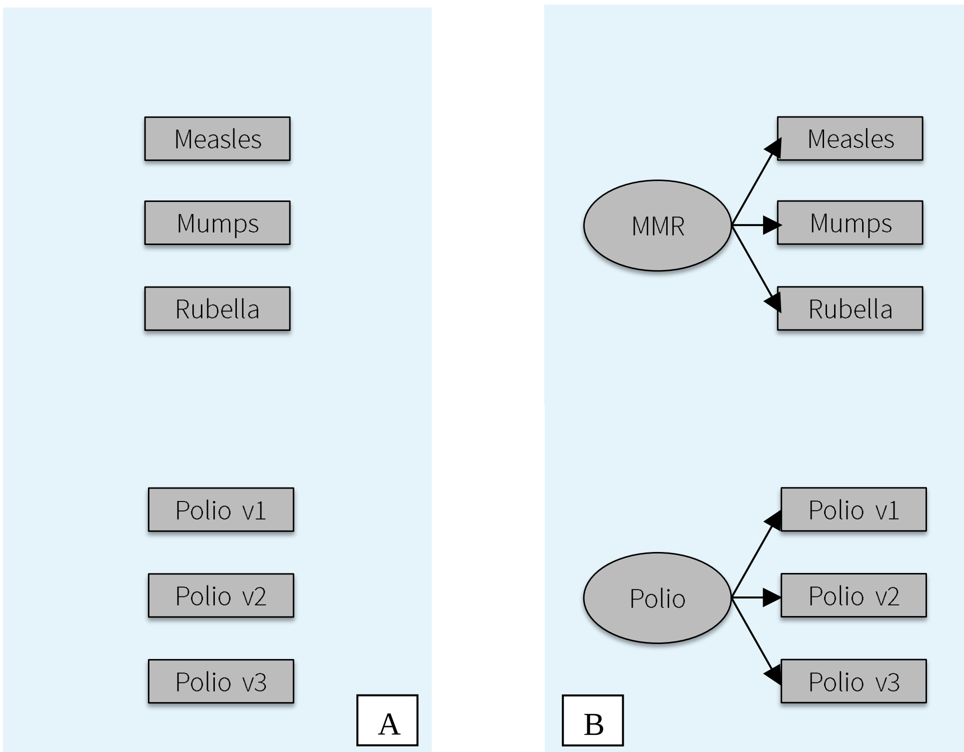


Figure 7.5. Reduced SEM for MMR and polio antibody titers by phthalate metabolites, NHANES 2009-2010 (full sample).



Supplemental Figure S7.1. Conceptualization of phthalate measures and latent variables.



Supplemental Figure S7.2. Conceptualization of antibody measures and latent variables.

CHAPTER 8:
Summary and Discussion

Chemicals, such as phthalates, are a significant public health concern because they are used in innumerable processes and products, and at some point in their lifecycle, people are exposed to many of them (Etzel and French 1997, Porter 1999, U.S. Environmental Protection Agency 2012). There is mounting scientific evidence over of the biological implications of exposure to phthalates as decades of research have linked them to a wide range of direct health effects (Parks, Ostby et al. 2000, Moore, Rudy et al. 2001, Larsen, Hansen et al. 2007, Richard, Edwin van et al. 2007, Lopez-Carrillo, Hernandez-Ramirez et al. 2010, Ferguson, Loch-Caruso et al. 2011, Upson, Sathyanarayana et al. 2013, Buser, Murray et al. 2014, Huang, Saxena et al. 2014, Min and Min 2014, Bekö, Callesen et al. 2015). This study contributes to the literature by assessing how sociodemographic factors influence exposure distributions of phthalate metabolites (Paper 1), and how exposures to phthalate metabolites individually (Paper 2) and in combination (Paper 3) affect antibody titers for infectious disease agents.

Public Health Implications

Key Finding 1: Association between Phthalate Exposure and Immunomodulation

A significant public health contribution of this research is providing evidence of the immunomodulatory effects of phthalates. This is the first study to examine the association between urinary phthalate concentrations and antibody titers for infectious organisms. When examining the association between single metabolites and individual antibody titer measures, exposure to lower molecular weight phthalates was generally positively associated with measles, poliovirus, and EBV antibodies, respectively. Conversely, HMW phthalates were inversely associated with both rubella and poliovirus antibody titers. Assessment of co-exposures to multiple phthalates with SEM showed similar results with LMW phthalate metabolites associated with immune enhancement while HMW phthalates were associated with immune suppression, except for MEP, a LWM phthalate, was negatively associated with mumps and polio antibodies but positively associated with EBV antibodies.

If associations found in this study are causal, exposure to HMW phthalates could increase a person's risk to infectious diseases, like measles, mumps, rubella and polio, despite vaccination for these diseases. Infectious diseases are still a persistent problem today: they are the leading cause of death among children and adolescents, and one of the leading causes of death in adults worldwide. In fact, three of the top ten causes of death, or 16% of all deaths each year, are from infectious diseases globally (The Global Health Policy Center, 2014). Infectious diseases are also a significant problem in the United States where they are the third leading causes of death after cardiovascular diseases and cancers (Centers for Disease Control and Prevention, 2008). Thus, prevention of infectious diseases, especially in children and adolescents, is of significant public health concern. If exposure to chemicals, in general or particular to phthalates, reduces the robustness of the immune system, they could have implications for increasing morbidity and mortality associated with infectious diseases.

Furthermore, if associations are causal for LMW phthalates, they may be protective against infectious disease. This could be a significant public health benefit if they result in increases antibody levels that were seroprotective against infectious diseases. It would be particular important for diseases where no vaccines are available, such for EBV. However, over simulation of the immune system can also lead to or exacerbate autoimmunity and hypersensitivity. One study found an association between phthalate exposure and lupus in mice

(Lim and Ghosh 2005), thus, it is plausible that phthalates could be linked to autoimmunity. Much more research has shown an association between phthalates and allergic conditions. Both experimental (Hillemeier, Lynch et al. 2004, Larsen, Hansen et al. 2007, Schlezinger, Emberley et al. 2007, Bissonnette, Teague et al. 2008, Dearman, Betts et al. 2009) and epidemiological studies have shown phthalate to be immunomodulatory and to be associated with increases in allergic symptoms (Norback, Wieslander et al. 2000, Jaakkola, Ieromnimon et al. 2006, Jaakkola and Knight 2008, Bornehag and Nanberg 2010, Bertelsen, Carlsen et al. 2013, Hoppin, Jaramillo et al. 2013). In particular, they seem to have an adjuvant effect in allergic sensitization; phthalate-induced enhancement of mast cells can occur in the early inflammation process (Bornehag and Nanberg 2010).

The World Health Organization estimates that 20% of the world's population suffers from allergic conditions (Robinson and Miller 2015), and 7% of the U.S. suffers from autoimmune conditions (Miller, Alfredsson et al. 2012). Besides physical burdens, allergic diseases are have economic and social impacts costing billions of dollars annually to treat and can lead to a reduced quality of life (Salo, Calatroni et al. 2011). The rapid increase in the prevalence of these conditions as been far too rapid to be driven by the gene pool, therefore, changes in environmental conditions, diet, and/or lifestyle are suspected (Kimber and Dearman 2010). Thus, it is concern that exposure to LMW phthalates could help contribute to the rise in allergic and autoimmune diseases. Given the exploratory nature of this research, cautious should be taken with making any causal assumptions, but findings are intriguing and worth additional research to confirm as well as extend our understanding of the role of phthalate exposure on immune system function.

Key Finding 2: Differences in Immune Effect by Sex/Gender

In subgroup analysis of the association between phthalate concentrations and antibody titers, males typically experienced immune enhancement while immune suppression was observed in females, especially for LMW metabolites. When comparing joint associations by sex subgroups, males experienced immune enhancement of measles and rubella titers with MEP exposure as well as an increase in mumps titers with exposure to HMW phthalates in the 2009-2010 cycle while females had immune suppression of titers for these chemical exposures. Where directionality of associations was comparable, on average, females had stronger immune response to phthalate exposures compared to males.

In experiments with rats, phthalates have an anti-androgenic effect and were found to reduce testosterone levels (Hoyer 2001, Latini 2005). Since testosterone is immune suppressive (Da Silva 1999), a reduction in this sex hormone could lead to normal or enhanced immune function. This is consistent with the immune enhancement seen for several antibody measures in this study. Regarding effects in females, research suggests that estrogen enhances B cell-mediated conditions but suppression T cell-dependent diseases (Da Silva 1999). Since suppression was observed, it is possible that phthalates influence the immune system via T cell-dependent pathways. Given that no molecular mechanism of action has been identified or proposed, additional experiments and epidemiological research is needed to confirm if these hypotheses are valid.

Additionally, social roles relating to role both influence exposure to phthalates and immune system response. For example, women typically have higher levels of MEP compared to men, which is most likely attributable to women's increased use of personal care products, such as hair care products, cosmetics, and perfumes (Silva, Barr et al. 2004, Braun, Sathyanarayana et al. 2013, Huang, Tsai et al. 2015). Since MEP was associated with antibody titers suppression for the measured studied, increasing awareness at the consumer level to avoid products with this substance could have an impact. Furthermore, if associations are casual, regulatory action may needed to ban or limit utilization of MEP, or may require a warning label on consumer products it is. Identifying subpopulations that may be at increased risk for negative health impacts is important for targeting awareness campaigns and policy initiatives. If phthalates reduce antibody titers enough to increase diseases susceptibility, it may be necessary to provide vaccine boosters, when available, to subpopulations at risk for immune suppression.

Key Finding 3: Phthalates May Compromise Seroprotection

This research has shown that phthalates may influence seropositivity, but it is important to understand if the magnitude of the effect is clinically significant and could potentially influence seroprotection, thus leading to disease and even death. To inform whether exposure to phthalates could affect antibody levels in a clinically significant way, models were tested using rubella antibody titers. Seroprotective standards have not been established for the other infectious agents studied, and if they existed, the exact type of antibody measures were not collected in the NHANES, except for rubella. In this study, LMW phthalate metabolites were associated with increased odds for immune protection against rubella while HMW phthalate metabolites were associated with a lack of protection against rubella in both the 2003-2004 and 2009-2010 cycles. Additionally, MEP was negatively associated with rubella titers in females as were certain concentrations of MEHP and MEOHP.

These findings are concerning, especially for women. Congenital rubella syndrome can occur when a pregnant women is infected with the virus leading to fetal death, spontaneous abortion, and premature delivery (Centers for Disease Control and Prevention 2016). If their fetus becomes infected, the virus attacks all its organs producing severe birth defects (Centers for Disease Control and Prevention 2012). It is estimated that 110,00 babies are born with congenital rubella syndrome each year worldwide (World Health Organization 2012). In counties where access to vaccines may be limited, phthalate exposure could increase risk for pregnancy complications or even fetal abortion. Even in countries where access to vaccines is relatively accessible, those choosing not to vaccinate could be at increased risk for pregnancy complications.

Key Finding 4: Differential Exposure Risk to Phthalate Exposure

Another public health contribution of this research is to document exposure risk to phthalates in the U.S. population. Two previous studies on the U.S. population has examined exposure trends to phthalates (Silva, Barr et al. 2004, Zota, Calafat et al. 2014); this study confirms and extends research on exposure distributions. This study found that overall phthalate exposure has decreased for most congeners assessed between 2003 and 2012, except for MiBP and McPP. Increases in MiBP and McPP could be a result of substitution of their respective monoesters for now banned or regulated phthalate congeners, but more research is necessary to understand these trends. Continuous development of new phthalate congeners and substitution of existing ones will challenge the scientific and regulatory communities in decades to come. While exposure to phthalates was ubiquitous, certain subpopulations had greater risk of exposure to different types of phthalates. Specifically, foreign-born persons generally had greater exposure compared to U.S.-born persons, particularly for LMW metabolites; males had greater exposure to phthalates compared to females, especially to HMW phthalates; and young persons had greater exposure compared to adults for most of the phthalates examined.

Having a greater understanding of differential exposures is important for targeting regulation and awareness campaigns to decrease exposure now and in the future. For instance, Campaign for Safe Cosmetics and MADESAFE have pressured companies to remove harmful chemicals from personal care products and cosmetics (Zota, Calafat et al. 2014). The audiences for many of these campaigns are women as they are generally greater uses of personal care products. While women did have higher concentrations of MEP, which is in many cosmetics, on average, males had a greater overall concentrations of all phthalates combined. More research is needed to pinpoint what helps contribute to greater exposure in males, and awareness efforts need to be directed to this subpopulation to reduce risks as well. Furthermore, it should be noted that limited English proficiency for some immigrants could increase their risk of exposure to hazards, like phthalates (Add, 2017). Future awareness campaigns should consider providing materials in multiple languages to increase coverage and depth of understanding (Gobber et al, 2017).

Likewise, young persons had a greater exposure risk to phthalates compared to adults. Since 2008, policy in the U.S. limits and/or bans the use of DEHP, DBP, BBP, DINP, DIDP, and DnOP in consumer goods for children. While a decrease was seen in their respective diesters measured in this study between 2003 and 2010, additional cycles of NHANES data will need to be analyzed to help determine if regulatory efforts have curbed exposure levels in young persons. Since adults typically have the purchasing power to buy goods for young persons, awareness campaigns targeted toward educating them about phthalates in their children's products is needed, such as labeling on products to show ingredients. This approach has been successfully applied to items containing bisphenol A (BPA) (Stahlhut, Welshons et al. 2009, Rudel, Gray et al. 2011).

Lastly, foreign-born persons were found to have generally greater exposure to phthalates compared to U.S.-born persons, but concentrations generally decreased with length of stay in the U.S. Because NHANES uses such a board classification for birthplace, and exposure is governed by many factors, it is difficult to generalize the drivers of these trends. Importantly however, this study shows that place of birth can have an impact of exposure levels even after an individual has immigrated. This is important for informing the global conversation about chemical regulation as immigrants may take their exposure histories with them when they move aboard. Further, if food consumption and/or lifestyle behaviors increase their risk of exposure, they may carry a greater disease burden then their U.S. counterparts.

Limitations and Strengths

Several limitations are present in this study. First, the proposed research utilizes cross-sectional data. Therefore, causality cannot be inferred nor can reverse causation from these findings. Testing multiple measures over several waves while controlling for key covariates, however, still provides insight into possible associations between phthalates and immune effects as well as the factors that influence these possible associations. Additionally, single spot measurements of chemical biomarkers may not be reliable estimates of average or peak exposure (Sobus, DeWoskin et al. 2015). However, studies on phthalates have shown that even though are they eliminated quickly, within-person variability is sufficiently stable day-to-day and month-to-month to presume exposure is typically consistent and ever present (Hoppin, Brock et al. 2002, Hauser, Meeker et al. 2004). Thus, phthalate exposure is persistent and ever present.

Another potential methodological issue is small sample sizes for some analyses due to the sampling design where only random subsamples of people were tested for certain biomarker. This was a particular problem when conducting subgroup analysis. Likewise, most individuals in the study were seropositive for the antibodies examined, thus, there was a lack of variability with tests for seropositivity and seroprotection. As a consequence, it is possible that type II errors could occur where I fail to detect associations that truly exist. Lastly, the broad categorization and/or lack of information on key demographic variables is limiting. For instance, NHANES collects detailed information on respondent's country of birth. Publically released data, however, only provides a few representative categories, which have also changed over cycles. This confines analyses to U.S. verses foreign-born. Similarly, racial/ethnic subgroups lack specificity and have changed over time. In particular, non-Mexican Hispanics are under sampled in waves before 2007, and Asian individuals are grouped into the "other" category with groups that may be dissimilar until 2011. This limits ability to generalize findings to these race/ethnic groups. These board categories are used to protect anonymity in the publically-released data, but information is lost that could help explain observed trends and associations as physical, social, and regulatory environments that contribute to phthalate exposure vary substantially globally.

Despite several limitations, this research has numerous strengthens. First, the NHANES survey is a nationally-representative survey conducted over time. Therefore, study has external validity, and thus generalizability to the population as a whole. Even though the data is cross-sectional, health impacts cannot be characterized at the individual level or causality determined, it still allows for extrapolation of population-level changes to environmental chemical exposure and associated health impacts. Further, this study's findings are consistent with other studies in the U.S. and aboard (Wittassek, Wiesmuller et al. 2007, Zota, Calafat et al. 2014, Cerna, Maly et al. 2015), where available. Second, besides self-reported demographic measures, all other study variables are biomarker data. Besides random error due to instrumentation or processing, biomarker data is inherently objective tending to greater validity and reliability of findings. Lastly, gaps in the literature are being addressed regarding the health effects of phthalates on immunological health. This research contributes a unique perspective of exploring both the social and biological processes involved in exposure and disease processes.

Future Research Opportunities

While the three papers developed for this dissertation contribute to the literature, additional research is necessary. Greater information is needed on how social and physical environments influence exposure. This dissertation only focused on three sociodemographic characteristics in Paper 1: birthplace, sex, and age. Data will need to be examined from cycles after 2012 to determine if exposure trends remain consistent with these findings. NHANES has also added new phthalate congeners to the panel of chemicals tested, which could be included in subsequent analyses. Data from other countries could be examined and/or collected to determine if trends are consistent with those seen in the U.S. Additionally, other sociodemographic characteristics should be explored. Research has shown certain ethnic minorities and people with low income are more likely to live close to pollution sources, such as high-volume roadways, airports, industry, and power stations (Ringquist 2005), which confer greater exposure to toxics (Rios, Poje et al. 1993, Morgan, Reger et al. 1997, Sydbom, Blomberg et al. 2001, California Office of Environmental Health Hazard Assessment 2007). They may also have differing access to food and consumer products that result in different exposure risks to phthalates. Examining data from longitudinal studies would help determine if certain sociodemographic characteristics are casually linked to exposure. This is important for better targeting awareness efforts and regulation.

Beyond social factors that drive exposure to phthalates, physical environmental characteristics should be explored. To date, a few studies have explored the household environment (Norback, Wieslander et al. 2000, Jaakkola, Ieromnimon et al. 2006) and occupational setting (Petrovicova, Kolena et al. 2016) for exposure trends. Neighborhood or community-level data is lacking on exposure trends, and spatial analysis with geographic information system (GIS) or hierarchical modeling could be applied to provide more insight into the how one's ecosystem contributes to exposure. At a larger scale, obtaining access to restricted data on country of birth in the NHANES could provide greater detail into spatial exposure trends. Conversely, micro-environments could be explored for factors that drive exposure. Studying food environments or social networks may provide perspective on behaviors and lifestyles that influence exposure. Since this is the first study to examine the association between phthalate exposure and infectious disease antibody titers, much research is needed to confirm these findings. First, additional measures would be helpful to control for potential confounding. For example, knowing the vaccine and infectious diseases history of study participants would be useful or having detailed information on changes in the composition of lymphocyte subsets and cytokine levels in serum (Claus, Dychus et al. 2016). Furthermore, testing the association between phthalate concentrations and other antibody measures could provide evidence of the immunomodulation. Determining whether antibody titers developed against other infectious agents, such as influenza, hepatitis or HIV/AIDS, are associated with phthalate concentrations, and if so, whether these associations are similar in direction and magnitude.

This dissertation primarily focused on viral antibodies developed from acquired immunity (i.e. vaccination) with only one measure for viral antibodies developed from natural immunity (i.e. EBV) and one measure for antibodies developed from natural immunity from a protozoa (i.e. *Toxoplasma gondii*). Research that further explicates if differences occur because of natural or acquired immunity and/or because of different types of organisms is needed (e.g. bacteria vs. viral vs. protozoa). Besides different antibody measures, research should study existing phthalate congeners not included in this dissertation as well as emerging phthalates. Since this exploratory research found differences among sex and age subgroups, it would be important to also conduct subgroup analyses on any of proposed research. Lastly, longitudinal studies with a more robust panel of immune measures, infectious diseases antibodies, and more detailed sociodemographic profiles would help establish if phthalates cause immunomodulation and in which direction(s), to what magnitude, and under what circumstances.

Conclusion

In summary, this dissertation found that overall phthalate exposure has decreased for most congeners in the United States during the study years 2003-2012. Exposure distributions varied by certain subgroups, such as birthplace, sex, and age. When examining the association between single metabolites and individual antibody titer measures, exposure to lower molecular weight phthalates was generally positively associated with viral antibody titers. Conversely, HMW phthalates were inversely associated with several antibody titers. Results did not depend on whether antibody titers were for infectious diseases naturally or artificially acquired. Males typically experienced immune enhancement eight, while immune suppression was observed in females. Assessment of co-exposures to multiple phthalates with SEM showed that LMW phthalate metabolites were associated with immune enhancement while HMW phthalates were associated with immune suppression. Having a better understanding of the physical and social mechanisms that generate and modify phthalate-related diseases, the effectiveness of regulatory and/or awareness strategies can be increased.

CHAPTER 9:
APPENDIX A – ADDITIONAL ANALYSES FOR CHAPTER 6

The Table S6.1 through S6.21 present the point estimates (95% CI) for the full model (Table 6.1 and Table 6.2) as well as the full model stratified by sex and age, respectively for each phthalate metabolite and antibody pair in Paper 2. Percent change calculations for models stratified by sex are shown in Figure 6.3. Columns contain β (95% CI) of each phthalate-antibody analysis. The full models are adjusted for race/ethnicity, sex, age, FIP, BMI, cotinine, CRP, and creatinine. Models stratified by sex are adjusted for race/ethnicity, age, FIP, BMI, cotinine, CRP, and creatinine. Models stratified by age are adjusted for race/ethnicity, sex, FIP, BMI, cotinine, CRP, and creatinine. The first row with chemical name is continuous estimate with the subsequent rows with Q2, Q3, and Q4 are dose-response analysis where Q1 is reference category. Bolding indicates statistically significant association defined as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table S6.1. Association between urinary phthalate metabolites and measles antibodies (full model) and stratified models by gender and age, NHANES 2003-2004.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	0.11 (-0.31,0.54)	0.29 (-0.36,0.94)	-0.02 (-0.48,0.43)	0.35* (0.00,0.70)	0.24 (-0.35,0.82)
Q2	-0.25 (-1.90,1.41)	1.13 (-1.07,3.32)	-1.53 (-3.89,0.83)	0.10 (-2.14,2.33)	0.41 (-1.35,2.16)
Q3	-0.35 (-1.63,0.94)	0.22 (-1.56,1.99)	-0.67 (-2.56,1.21)	0.90 (-0.87,2.68)	-0.21 (-1.79,1.38)
Q4	-0.37 (-1.90,1.17)	0.94 (-1.20,3.08)	-1.55 (-3.57,0.47)	1.23 (-0.50,2.96)	0.22 (-1.69,2.12)
∑ DBP	0.12 (-0.30,0.53)	-0.21 (-1.17,0.76)	0.42+ (-0.05,.89)	-0.51 (-1.16,0.14)	-.71*(-1.40,-.03)
Q2	0.42 (-1.44,2.27)	-0.59 (-3.60,2.41)	1.99*** (1.03,2.96)	-0.13 (-3.53,3.27)	-0.19 (-2.47,2.08)
Q3	0.56 (-1.03,2.14)	-0.42 (-3.12,2.28)	2.39* (0.17,4.62)	-0.59 (-3.84,2.66)	-0.40 (-2.29,1.49)
Q4	0.20 (-1.43,1.82)	-0.83 (-4.20,2.53)	2.92*** (1.96,3.88)	-1.43 (-4.49,1.63)	-2.17* (-4.10,-.23)
MnBP	0.68+ (-.05,1.42)	0.71 (-0.64,2.06)	0.68+ (-.00,1.37)	-0.15 (-0.84,0.54)	0.43 (-0.60,1.46)
Q2	1.30 (-0.45,3.06)	-0.02 (-2.70,2.66)	2.53** (.75,4.30)	-0.40 (-2.08,1.27)	1.04 (-1.16,3.24)
Q3	2.00** (.57,3.42)	0.82 (-1.83,3.46)	3.28** (1.41,5.15)	-0.57 (-2.88,1.75)	1.67+ (-.31,3.66)
Q4	1.78+ (-.12,3.68)	1.35 (-2.47,5.17)	2.19* (0.42,3.97)	-0.67 (-2.98,1.65)	0.74 (-1.67,3.15)
MiBP	1.09* (0.22,1.96)	0.74 (-1.05,2.54)	1.45*** (.93,1.98)	-0.42 (-1.43,0.58)	1.00 (-0.31,2.32)
Q2	0.53 (-0.43,1.49)	-0.98 (-3.47,1.50)	1.67+ (-0.06,3.40)	-0.32 (-2.08,1.43)	0.31 (-0.87,1.50)
Q3	1.69 (-0.68,4.06)	0.96 (-2.90,4.82)	1.65+ (-0.15,3.45)	-0.44 (-2.38,1.51)	1.85 (-1.49,5.18)
Q4	2.04** (.58,3.51)	1.20 (-2.02,4.43)	1.18+ (-0.10,2.45)	-0.74 (-2.99,1.50)	1.90+ (-.39,4.19)
McPP	0.50+ (-.07,1.07)	0.30 (-0.44,1.05)	0.75+ (-.07,1.58)	-0.33 (-1.62,0.97)	-0.49 (-1.55,0.57)
Q2	1.11 (-0.26,2.48)	0.12 (-2.00,2.23)	2.26* (0.33,4.19)	-0.76 (-2.51,1.00)	0.81 (-0.91,2.52)
Q3	1.34+ (-.27,2.96)	1.09 (-2.16,4.34)	1.79+ (-.22,3.80)	-0.17 (-2.53,2.18)	0.50 (-1.37,2.38)
Q4	1.39+ (-.27,3.04)	0.56 (-2.36,3.47)	2.44** (.68,4.19)	-0.53 (-3.39,2.32)	-0.55 (-2.57,1.47)
MBzP	0.05 (-0.37,0.47)	-0.19 (-1.17,0.78)	0.24 –(0.25,0.73)	-.53+ (-1.10,0.04)	-.69* (-1.34,-.04)
Q2	0.27 (-1.85,2.39)	-0.98 (-4.03,2.06)	1.80 (-0.39,3.99)	-0.49 (-2.60,1.62)	-0.19 (-2.69,2.31)
Q3	1.11 (-0.79,3.01)	0.04 (-3.78,3.85)	2.29* (0.51,4.08)	-0.74 (-3.61,2.13)	0.46 (-1.85,2.76)
Q4	0.63 (-0.99,2.25)	-0.46 (-3.81,2.89)	1.76* (0.36,3.15)	-1.63 (-4.02,0.76)	-1.26 (-3.11,0.60)
∑ DEHP	0.15 (-0.22,0.53)	-0.10 (-0.81,0.62)	0.41+ (-.00,0.82)	-0.08 (-1.02,0.86)	-0.28 (-0.85,0.29)
Q2	0.41 (-1.00,1.82)	-0.58 (-2.86,1.70)	1.53 (-0.70,3.76)	-0.37 (-2.01,1.27)	-0.11 (-1.80,1.57)
Q3	0.44 (-1.68,2.57)	0.39 (-3.03,3.81)	0.55 (-1.22,2.32)	0.23 (-1.75,2.22)	-0.63 (-3.52,2.26)
Q4	0.80 (-0.82,2.41)	0.15 (-2.43,2.73)	1.47 (-0.61,3.56)	-1.01 (-3.08,1.06)	-0.50 (-2.68,1.67)
MEHP	0.11 (-0.28,0.51)	-0.06 (-0.87,0.75)	0.26 (-0.16,0.68)	0.10 (-1.04,1.23)	-0.14 (-0.76,0.49)
Q2	0.66 (-0.73,2.05)	-0.04 (-2.10,2.02)	1.62+ (-.22,3.47)	0.56 (-1.33,2.46)	0.47 (-1.42,2.37)
Q3	1.41+ (-.07,2.88)	1.51 (-0.79,3.82)	1.12 (-0.43,2.68)	1.03 (-0.74,2.810)	1.30 (-0.62,3.21)
Q4	0.57 (-0.61,1.75)	-0.19 (-2.16,1.78)	1.25* (0.04,2.46)	0.07 (-2.74,2.88)	-0.17 (-1.93,1.59)
MEHHP	0.11 (-0.27,0.49)	-0.08 (-0.77,0.61)	0.31 (-0.09,0.72)	-0.15 (-1.07,0.77)	-0.29 (-0.88,0.30)
Q2	0.82 (-0.22,1.85)	-0.42 (-2.74,1.89)	2.21+ (-.34,4.75)	-0.55 (-2.77,1.66)	0.71 (-0.57,2.00)
Q3	0.17 (-1.97,2.31)	0.33 (-3.01,3.68)	-0.03 (-1.80,1.73)	-0.01 (-2.48,2.46)	-0.89 (-3.87,2.08)
Q4	0.40 (-1.04,1.83)	-0.18 (-2.91,2.54)	0.98 (-0.85,2.82)	-1.52 (-3.79,0.74)	-0.67 (-2.57,1.23)
MEOHP	0.19 (-0.18,0.56)	-0.08 (-0.77,0.61)	0.47* (0.06,0.87)	-0.09 (-1.06,0.87)	-0.24 (-0.84,0.36)
Q2	1.26+ (-.17,2.68)	-0.38 (-3.09,2.34)	3.12** (.88,5.35)	-0.26 (-2.16,1.63)	1.06 (-0.61,2.74)
Q3	0.98 (-0.86,2.82)	0.70 (-2.14,3.54)	1.38+ (-.26,3.01)	0.25 (-1.97,2.48)	0.25 (-2.37,2.88)
Q4	1.02 (-0.92,2.97)	0.08 (-3.30,3.47)	2.11* (0.27,3.96)	-0.68 (-3.00,1.64)	-0.40 (-3.00,2.21)
MECPP	0.17 (-0.22,0.55)	-0.10 (-0.84,0.63)	0.45* (0.01,0.80)	-0.04 (-1.00,0.92)	-0.31 (-0.88,0.26)

Q2	0.05 (-0.93,1.03)	-0.72 (-2.76,1.32)	0.89 (-0.86,2.64)	-0.92 (-2.78,0.95)	-0.31 (-1.79,1.16)
Q3	0.68 (-1.42,2.78)	1.07 (-2.48,4.62)	0.35 (-1.43,2.14)	-0.24 (-2.05,1.57)	-0.27 (-2.99,2.44)
Q4	0.61 (-0.82,2.04)	0.19 (-2.24,2.62)	1.05 (-1.00,3.10)	-1.27 (-3.58,1.04)	-0.84 (-2.73,1.05)

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.2. Association between urinary phthalate metabolites and measles antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	0.04 -0.06,0.13	-0.02 -0.17,0.13	**0.10* 0.02,0.18**	-0.05 -0.16,0.07	0.04 -0.06,0.15
Q2	0.24 -0.12,0.61	0.17 -0.29,0.63	0.29 -0.12,0.70	0.03 -0.32,0.38	0.27 -0.17,0.72
Q3	0.04 -0.31,0.39	-0.19 -0.65,0.26	0.24 -0.15,0.63	**-0.50* -0.87,-0.12**	0.11 -0.29,0.51
Q4	0.16 -0.17,0.49	0.04 -0.51,0.59	**0.26+ -0.04,0.56**	0.16 -0.26,0.58	0.13 -0.24,0.50
∑ DBP	0.05 -0.10,0.20	0.05 -0.15,0.24	0.03 -0.15,0.22	0.05 -0.16,0.25	0.00 -0.19,0.19
Q2	0.05 -0.25,0.35	0.11 -0.30,0.53	-0.00 -0.54,0.53	0.15 -0.42,0.72	0.02 -0.37,0.41
Q3	0.11 -0.32,0.54	0.02 -0.51,0.56	0.21 -0.28,0.70	0.23 -0.33,0.78	0.05 -0.49,0.59
Q4	0.05 -0.44,0.54	0.15 -0.53,0.82	-0.04 -0.58,0.51	0.13 -0.56,0.81	-0.14 -0.76,0.48
MnBP	**0.15* 0.01,0.29**	**0.15+ -0.02,0.33**	0.15 -0.06,0.36	-0.03 -0.27,0.21	0.12 -0.06,0.29
Q2	0.20 -0.08,0.48	0.28 -0.21,0.76	0.13 -0.32,0.59	0.14 -0.52,0.80	0.22 -0.13,0.56
Q3	0.29 -0.13,0.70	0.36 -0.32,1.04	0.27 -0.16,0.69	-0.15 -0.91,0.60	0.29 -0.25,0.83
Q4	0.37 -0.09,0.83	0.50 -0.13,1.13	0.25 -0.37,0.87	-0.14 -0.80,0.52	0.24 -0.37,0.85
MiBP	0.14 -0.06,0.35	0.11 -0.12,0.35	0.16 -0.06,0.39	-0.05 -0.33,0.23	0.13 -0.11,0.36
Q2	**0.27** 0.11,0.42**	0.23 -0.09,0.55	**0.33** 0.11,0.55**	-0.10 -0.51,0.30	**0.36** 0.14,0.58**
Q3	**0.33+ -0.05,0.71**	0.20 -0.29,0.69	**0.50+ -0.08,1.07**	0.06 -0.62,0.74	**0.38+ -0.08,0.83**
Q4	0.37 -0.13,0.87	0.28 -0.36,0.92	**0.46+ -0.02,0.94**	-0.27 -1.01,0.47	0.45 -0.17,1.07
McPP	0.07 -0.04,0.19	0.08 -0.09,0.25	0.03 -0.14,0.21	0.06 -0.16,0.29	0.04 -0.12,0.19
Q2	**0.22+ -0.03,0.48**	0.01 -0.37,0.40	**0.41+ -0.00,0.83**	0.22 -0.26,0.70	0.21 -0.10,0.52
Q3	**0.44** 0.17,0.71**	0.15 -0.16,0.45	**0.65** 0.19,1.10**	0.23 -0.32,0.78	**0.51* 0.12,0.89**
Q4	**0.39* 0.06,0.73**	0.17 -0.27,0.61	**0.55+ -0.00,1.11**	0.31 -0.30,0.92	0.30 -0.12,0.72
MBzP	0.06 -0.08,0.20	0.05 -0.17,0.27	0.07 -0.09,0.24	0.05 -0.17,0.27	0.01 -0.13,0.14
Q2	0.10 -0.23,0.44	0.22 -0.18,0.62	0.04 -0.47,0.54	0.07 -0.41,0.56	0.06 -0.32,0.44
Q3	0.18 -0.16,0.53	0.04 -0.39,0.47	**0.33+ -0.03,0.70**	0.32 -0.32,0.96	0.13 -0.24,0.50
Q4	0.20 -0.18,0.58	0.25 -0.33,0.84	0.15 -0.25,0.56	0.18 -0.45,0.81	0.07 -0.27,0.41
∑ DEHP	-0.01 -0.15,0.13	-0.00 -0.15,0.15	-0.05 -0.24,0.14	0.06 -0.13,0.24	-0.04 -0.18,0.10
Q2	0.15 -0.11,0.41	-0.09 -0.50,0.32	**0.39* 0.09,0.68**	-0.06 -0.69,0.56	0.21 -0.10,0.53
Q3	0.03 -0.35,0.41	0.02 -0.48,0.52	0.08 -0.37,0.53	-0.04 -0.80,0.73	0.01 -0.40,0.42
Q4	-0.10 -0.47,0.28	-0.07 -0.56,0.42	-0.15 -0.67,0.37	0.10 -0.52,0.73	-0.19 -0.59,0.21
MEHP	-0.04 -0.18,0.10	-0.08 -0.24,0.08	-0.01 -0.20,0.18	0.10 -0.12,0.32	-0.09 -0.23,0.06
Q2	0.16 -0.25,0.57	0.03 -0.43,0.50	0.28 -0.27,0.83	-0.20 -0.61,0.22	0.24 -0.19,0.67
Q3	0.17 -0.18,0.53	-0.16 -0.48,0.16	**0.50* 0.05,0.96**	0.08 -0.31,0.47	0.22 -0.21,0.66
Q4	-0.14 -0.46,0.19	-0.25 -0.68,0.18	-0.01 -0.40,0.38	0.04 -0.46,0.54	-0.19 -0.60,0.21
MEHHP	-0.01 -0.16,0.13	-0.01 -0.16,0.14	-0.04 -0.23,0.15	0.07 -0.11,0.25	-0.05 -0.20,0.10
Q2	**0.26** 0.09,0.42**	0.13 -0.31,0.56	**0.37** 0.13,0.61**	0.12 -0.59,0.84	**0.25* 0.04,0.45**
Q3	0.03 -0.31,0.38	-0.02 -0.45,0.41	0.10 -0.36,0.57	0.05 -0.61,0.72	-0.04 -0.41,0.33
Q4	-0.06 -0.38,0.26	-0.16 -0.62,0.30	-0.02 -0.52,0.49	0.17 -0.44,0.78	-0.24 -0.64,0.16
MEOHP	-0.02 -0.17,0.12	-0.02 -0.17,0.13	-0.05 -0.26,0.15	0.09 -0.10,0.28	-0.07 -0.23,0.08
Q2	0.12 -0.11,0.34	-0.07 -0.49,0.35	**0.30* 0.05,0.56**	0.03 -0.64,0.71	0.09 -0.24,0.42
Q3	-0.06 -0.43,0.30	-0.03 -0.54,0.48	-0.08 -0.50,0.33	-0.00 -0.76,0.75	-0.21 -0.57,0.15
Q4	-0.15 -0.51,0.21	-0.17 -0.70,0.37	-0.19 -0.71,0.32	0.14 -0.50,0.77	**-0.37+ -0.80,0.06**
MECPP	-0.02 -0.16,0.12	0.00 -0.15,0.16	-0.08 -0.27,0.12	0.03 -0.16,0.23	-0.05 -0.18,0.09
Q2	0.04 -0.22,0.31	-0.18 -0.60,0.24	**0.27+ -0.03,0.56**	-0.18 -0.84,0.49	0.06 -0.25,0.36

Q3	-0.02 -0.36,0.31	-0.09 -0.51,0.33	0.04 -0.37,0.45	-0.26 -1.01,0.50	0.00 -0.36,0.36
Q4	-0.17 -0.53,0.20	-0.10 -0.55,0.36	-0.27 -0.82,0.28	-0.25 -0.96,0.45	-0.22 -0.62,0.19

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.3. Association between urinary phthalate metabolites and mumps antibodies (full model) and stratified models by gender and age, NHANES 2003-2004.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	-0.04 -0.11,0.04	**-0.10+ -0.21,0.02**	0.01 -0.10,0.13	**0.10* 0.01,0.19**	-0.06 -0.15,0.03
Q2	**-0.37+ -0.75,0.02**	**-0.41+ -0.89,0.07**	-0.39 -0.98,0.20	0.16 -0.42,0.74	**-0.36+ -0.79,0.07**
Q3	**-0.48* -0.83,-0.13**	**-0.70* -1.22,-0.18**	-0.29 -0.90,0.31	0.24 -0.19,0.68	**-0.56* -0.98,-0.14**
Q4	**-0.35+ -0.76,0.07**	**-0.62* -1.22,-0.02**	-0.13 -0.78,0.51	**0.44* 0.01,0.86**	**-0.46+ -0.96,0.04**
∑ DBP	0.03 -0.07,0.14	0.05 -0.17,0.27	-0.02 -0.12,0.08	**0.11+ -0.01,0.23**	-0.00 -0.14,0.14
Q2	-0.07 -0.44,0.30	-0.22 -0.78,0.35	0.09 -0.28,0.45	0.19 -0.44,0.82	-0.12 -0.46,0.23
Q3	0.00 -0.40,0.41	-0.20 -0.97,0.57	0.00 -0.40,0.41	0.09 -0.48,0.65	-0.08 -0.55,0.39
Q4	0.03 -0.34,0.41	-0.09 -0.81,0.63	-0.19 -0.64,0.25	0.40 -0.12,0.92	-0.14 -0.54,0.25
MnBP	0.02 -0.12,0.16	0.06 -0.19,0.31	-0.05 -0.20,0.10	0.07 -0.09,0.22	-0.00 -0.19,0.18
Q2	0.28 -0.13,0.70	0.33 -0.26,0.93	0.22 -0.46,0.91	-0.00 -0.41,0.40	0.28 -0.19,0.76
Q3	-0.05 -0.44,0.34	-0.08 -0.73,0.58	-0.10 -0.64,0.45	-0.16 -0.65,0.34	-0.12 -0.55,0.31
Q4	0.09 -0.35,0.54	0.22 -0.48,0.92	-0.11 -0.79,0.58	0.04 -0.36,0.44	-0.01 -0.56,0.54
MiBP	-0.01 -0.18,0.15	0.00 -0.34,0.35	-0.06 -0.25,0.12	-0.03 -0.26,0.19	-0.06 -0.30,0.18
Q2	-0.03 -0.35,0.29	-0.22 -0.68,0.25	0.08 -0.31,0.47	0.13 -0.24,0.50	-0.14 -0.56,0.28
Q3	-0.05 -0.45,0.34	-0.17 -0.85,0.50	0.17 -0.29,0.63	0.17 -0.28,0.62	-0.18 -0.73,0.38
Q4	-0.01 -0.35,0.34	0.09 -0.62,0.80	0.10 -0.22,0.42	-0.10 -0.65,0.45	0.01 -0.46,0.49
McPP	**0.16* 0.00,0.31**	0.23 -0.09,0.55	0.05 -0.18,0.28	-0.02 -0.27,0.24	**0.21+ -0.00,0.41**
Q2	0.16 -0.12,0.43	0.08 -0.32,0.48	0.24 -0.14,0.61	-0.21 -0.94,0.52	**0.25+ -0.04,0.54**
Q3	**0.35* 0.01,0.70**	0.20 -0.42,0.81	**0.51** 0.20,0.82**	0.06 -0.64,0.76	**0.40* 0.01,0.79**
Q4	**0.43* 0.05,0.81**	0.53 -0.33,1.40	0.30 -0.15,0.74	-0.09 -0.80,0.62	**0.60* 0.10,1.09**
MBzP	-0.00 -0.09,0.09	0.01 -0.18,0.19	-0.04 -0.14,0.06	**0.11+ -0.02,0.23**	-0.05 -0.19,0.08
Q2	0.17 -0.27,0.60	-0.04 -0.78,0.70	**0.38+ -0.06,0.81**	-0.00 -0.78,0.78	0.22 -0.19,0.63
Q3	-0.09 -0.50,0.32	-0.34 -1.08,0.40	0.12 -0.34,0.58	-0.14 -0.87,0.59	-0.14 -0.58,0.30
Q4	0.17 -0.22,0.56	-0.03 -0.81,0.74	**0.33* 0.03,0.63**	0.22 -0.45,0.89	0.10 -0.32,0.53
∑ DEHP	0.01 -0.09,0.11	-0.01 -0.23,0.21	0.02 -0.05,0.09	**-0.12* -0.23,-0.02**	-0.02 -0.14,0.10
Q2	0.02 -0.24,0.28	-0.13 -0.61,0.35	0.14 -0.28,0.56	-0.21 -0.65,0.23	-0.03 -0.40,0.33
Q3	-0.03 -0.31,0.25	-0.23 -0.81,0.35	0.13 -0.24,0.50	0.09 -0.35,0.53	-0.19 -0.57,0.19
Q4	-0.04 -0.41,0.32	-0.11 -0.83,0.60	-0.03 -0.32,0.26	**-0.35+ -0.70,0.01**	-0.20 -0.61,0.22
MEHP	0.01 -0.12,0.14	0.05 -0.18,0.28	-0.03 -0.11,0.05	-0.07 -0.21,0.08	-0.03 -0.21,0.14
Q2	0.05 -0.23,0.33	-0.03 -0.51,0.45	0.09 -0.30,0.48	0.03 -0.35,0.42	0.03 -0.37,0.44
Q3	-0.05 -0.32,0.21	-0.10 -0.50,0.30	-0.05 -0.36,0.26	0.11 -0.29,0.52	-0.21 -0.59,0.17
Q4	-0.04 -0.33,0.24	0.03 -0.47,0.53	-0.14 -0.35,0.06	-0.11 -0.46,0.25	-0.22 -0.61,0.18
MEHHP	-0.00 -0.10,0.09	-0.02 -0.23,0.18	0.01 -0.06,0.09	**-0.13* -0.24,-0.02**	-0.03 -0.15,0.09
Q2	0.12 -0.26,0.49	0.07 -0.58,0.71	0.16 -0.18,0.50	**-0.44+ -0.90,0.02**	0.21 -0.29,0.70
Q3	-0.03 -0.38,0.33	-0.08 -0.68,0.52	-0.02 -0.43,0.39	-0.06 -0.57,0.45	-0.13 -0.61,0.34
Q4	-0.04 -0.47,0.38	-0.06 -0.82,0.69	-0.05 -0.39,0.29	**-0.51* -0.92,-0.09**	-0.15 -0.67,0.37
MEOHP	0.02 -0.09,0.12	0.00 -0.22,0.23	0.02 -0.06,0.10	**-0.13* -0.24,-0.02**	-0.01 -0.13,0.12
Q2	0.17 -0.10,0.44	0.15 -0.31,0.62	0.20 -0.19,0.59	-0.32 -0.94,0.30	0.20 -0.18,0.58
Q3	0.05 -0.32,0.43	0.01 -0.62,0.64	0.06 -0.42,0.54	0.05 -0.56,0.65	-0.06 -0.53,0.40
Q4	0.01 -0.38,0.40	0.01 -0.80,0.81	-0.03 -0.36,0.30	-0.39 -0.87,0.09	-0.14 -0.58,0.30
MECPP	0.01 -0.09,0.11	-0.02 -0.23,0.20	0.03 -0.05,0.10	**-0.12* -0.22,-0.01**	-0.03 -0.15,0.10

Q2	-0.11 -0.47,0.26	-0.34 -1.01,0.33	0.12 -0.24,0.48	-0.18 -0.76,0.40	-0.21 -0.73,0.30
Q3	-0.04 -0.38,0.30	-0.29 -1.01,0.42	0.19 -0.22,0.61	0.00 -0.36,0.36	-0.19 -0.61,0.23
Q4	-0.06 -0.45,0.32	-0.19 -0.98,0.59	0.03 -0.23,0.28	**-0.33+ -0.74,0.07**	-0.23 -0.66,0.20

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.4. Association between urinary phthalate metabolites and mumps antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	-0.06 -0.15,0.04	-0.05 -0.17,0.08	-0.06 -0.16,0.03	-0.03 -0.15,0.10	-0.05 -0.17,0.07
Q2	0.03 -0.14,0.20	0.06 -0.17,0.30	-0.01 -0.33,0.32	0.31 -0.18,0.80	0.00 -0.31,0.31
Q3	-0.14 -0.37,0.10	**-0.25+ -0.54,0.05**	-0.03 -0.35,0.29	0.09 -0.58,0.76	-0.19 -0.46,0.08
Q4	-0.17 -0.56,0.21	-0.11 -0.61,0.39	-0.26 -0.63,0.11	0.02 -0.49,0.53	-0.17 -0.69,0.36
∑ DBP	0.05 -0.13,0.22	-0.09 -0.28,0.11	0.02 -0.13,0.16	0.05 -0.14,0.25	**-0.17+ -0.35,0.01**
Q2	-0.09 -0.37,0.20	**-0.55** -0.90,-.21**	-0.11 -0.50,0.27	-0.39 -0.88,0.10	-0.19 -0.60,0.21
Q3	0.11 -0.18,0.41	**-0.28* -0.56,-0.01**	0.03 -0.43,0.50	-0.01 -0.50,0.48	-0.21 -0.71,0.30
Q4	0.30 -0.13,0.72	0.11 -0.26,0.47	0.05 -0.42,0.51	-0.15 -0.61,0.31	-0.26 -0.85,0.34
MnBP	0.13 -0.04,0.31	-0.00 -0.20,0.20	0.12 -0.10,0.33	-0.09 -0.28,0.09	0.02 -0.20,0.23
Q2	**-0.38** -0.59,-.17**	-0.20 -0.63,0.22	0.05 -0.22,0.33	-0.29 -0.87,0.28	-0.10 -0.44,0.25
Q3	-0.19 -0.45,0.08	-0.02 -0.33,0.30	0.31 -0.16,0.77	-0.24 -0.87,0.39	0.09 -0.34,0.51
Q4	0.13 -0.24,0.50	0.13 -0.38,0.64	**0.53+ -0.06,1.13**	-0.29 -0.81,0.24	0.36 -0.17,0.89
MiBP	-0.03 -0.13,0.06	0.14 -0.07,0.34	0.13 -0.07,0.33	-0.08 -0.23,0.08	0.13 -0.13,0.40
Q2	-0.15 -0.45,0.15	-0.18 -0.65,0.29	-0.17 -0.63,0.29	-0.41 -1.28,0.45	**-0.44* -0.79,-0.09**
Q3	-0.12 -0.49,0.25	-0.26 -0.77,0.25	-0.05 -0.52,0.42	**-0.51+ -1.06,0.05**	-0.14 -0.56,0.28
Q4	-0.05 -0.37,0.27	-0.15 -0.74,0.45	0.18 -0.43,0.78	**-0.54* -1.05,-0.04**	0.22 -0.34,0.78
McPP	-0.03 -0.11,0.05	-0.06 -0.24,0.13	-0.01 -0.14,0.12	0.10 -0.12,0.32	-0.11 -0.25,0.03
Q2	0.10 -0.12,0.33	0.01 -0.26,0.28	0.20 -0.34,0.73	-0.15 -0.79,0.48	0.13 -0.16,0.42
Q3	0.10 -0.24,0.43	0.04 -0.43,0.51	0.11 -0.30,0.51	-0.03 -0.59,0.52	0.08 -0.39,0.54
Q4	0.01 -0.18,0.19	-0.05 -0.46,0.36	0.04 -0.27,0.35	0.15 -0.30,0.59	-0.16 -0.52,0.20
MBzP	-0.02 -0.13,0.08	-0.02 -0.25,0.20	-0.01 -0.13,0.11	-0.00 -0.17,0.16	**-0.14+ -0.30,0.02**
Q2	-0.06 -0.30,0.18	-0.03 -0.48,0.42	-0.07 -0.29,0.15	-0.00 -0.56,0.56	-0.14 -0.44,0.16
Q3	-0.13 -0.43,0.16	-0.34 -0.92,0.24	0.09 -0.27,0.44	-0.21 -0.62,0.19	-0.20 -0.59,0.19
Q4	0.08 -0.23,0.40	0.01 -0.68,0.71	0.14 -0.31,0.60	-0.08 -0.62,0.45	-0.08 -0.54,0.39
∑ DEHP	0.03 -0.07,0.13	-0.03 -0.22,0.16	0.07 -0.08,0.23	**0.18+ -0.00,0.36**	-0.03 -0.20,0.13
Q2	0.10 -0.15,0.34	-0.05 -0.46,0.35	**0.28+ -0.06,0.62**	-0.20 -0.83,0.43	0.10 -0.19,0.40
Q3	**0.29* 0.06,0.52**	0.21 -0.26,0.69	**0.42* 0.07,0.77**	0.24 -0.23,0.70	0.25 -0.18,0.68
Q4	0.23 -0.11,0.56	0.15 -0.41,0.71	0.32 -0.20,0.84	0.36 -0.16,0.89	0.15 -0.40,0.70
MEHP	0.00 -0.12,0.13	-0.08 -0.24,0.09	0.07 -0.15,0.29	0.15 -0.11,0.41	-0.03 -0.23,0.16
Q2	-0.06 -0.23,0.11	**-0.28* -0.54,-0.03**	0.20 -0.08,0.47	-0.30 -0.68,0.08	-0.07 -0.24,0.10
Q3	0.08 -0.13,0.30	-0.12 -0.53,0.30	**0.31* 0.02,0.61**	0.08 -0.29,0.45	0.09 -0.28,0.45
Q4	-0.08 -0.33,0.18	-0.29 -0.66,0.08	0.16 -0.33,0.66	0.11 -0.39,0.62	-0.16 -0.50,0.18
MEHHP	0.03 -0.07,0.13	-0.03 -0.20,0.15	0.08 -0.08,0.24	**0.19* 0.02,0.36**	-0.02 -0.18,0.14
Q2	0.12 -0.13,0.38	-0.07 -0.47,0.33	**0.35* 0.05,0.65**	-0.04 -0.57,0.50	0.09 -0.23,0.41
Q3	**0.32*** 0.15,0.48**	0.17 -0.24,0.59	**0.52* 0.13,0.90**	0.25 -0.14,0.65	**0.32+ -0.05,0.70**
Q4	0.08 -0.20,0.37	-0.07 -0.56,0.42	0.25 -0.23,0.73	**0.43+ -0.07,0.92**	-0.07 -0.60,0.45
MEOHP	0.04 -0.07,0.15	-0.03 -0.22,0.16	0.10 -0.09,0.28	**0.18+ -0.01,0.38**	-0.02 -0.20,0.17
Q2	0.02 -0.15,0.20	-0.19 -0.54,0.16	**0.26+ -0.03,0.56**	-0.14 -0.75,0.47	-0.03 -0.27,0.21
Q3	**0.25* 0.02,0.49**	0.18 -0.35,0.72	**0.36+ -0.05,0.77**	0.20 -0.12,0.53	0.21 -0.26,0.68
Q4	0.20 -0.06,0.46	0.02 -0.45,0.49	0.39 -0.14,0.92	0.31 -0.16,0.77	0.09 -0.38,0.56
MECPP	0.04 -0.07,0.15	-0.01 -0.21,0.2	0.08 -0.07,0.23	**0.19+ -0.00,0.38**	-0.03 -0.20,0.14

Q2	-0.02 -0.29,0.25	-0.18 -0.52,0.16	0.16 -0.27,0.58	-0.19 -0.84,0.46	-0.04 -0.40,0.32
Q3	0.22 -0.05,0.49	0.20 -0.26,0.65	0.28 -0.12,0.67	0.20 -0.23,0.63	0.12 -0.29,0.54
Q4	0.20 -0.06,0.47	0.06 -0.46,0.58	**0.34+ -0.06,0.74**	0.35 -0.15,0.86	0.08 -0.40,0.56

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.5. Association between urinary phthalate metabolites and rubella antibodies (full model) and stratified models by gender and age, NHANES 2003-2004.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	0.68 -2.33,3.69	-0.55 -4.15,3.05	2.39 -2.16,6.94	1.83 -2.28,5.94	1.31 -2.76,5.37
Q2	-2.75 -16.02,10.52	-3.28 -16.15,9.59	-8.50 -21.49,4.50	-2.68 -16.20,10.83	2.90 -16.86,22.67
Q3	-10.36 -23.70,2.98	**-11.20+ -23.82,1.43**	-8.12 -27.81,11.58	-0.66 -12.73,11.41	-11.81 -28.86,5.24
Q4	-3.94 -16.25,8.38	-5.09 -17.45,7.27	-2.41 -17.47,12.66	3.37 -11.93,18.66	-0.99 -17.24,15.27
∑ DBP	-0.09 -4.47,4.28	-0.69 -5.60,4.23	1.44 -5.13,8.02	-1.51 -7.19,4.16	-4.22 -11.97,3.54
Q2	1.11 -12.38,14.60	-0.15 -14.08,13.79	0.64 -7.49,8.78	-8.23 -28.84,12.38	-0.23 -15.37,14.92
Q3	0.25 -14.57,15.08	-1.94 -17.11,13.23	-6.10 -18.89,6.69	-12.31 -32.09,7.47	-6.02 -23.91,11.86
Q4	1.25 -13.25,15.76	-1.80 -14.73,11.12	11.70 -9.20,32.61	-9.39 -31.65,12.87	-10.41 -31.58,10.76
MnBP	0.97 -2.73,4.66	-1.44 -6.74,3.85	**4.45+ -0.31,9.21**	0.55 -4.42,5.52	-0.57 -5.86,4.72
Q2	6.88 -3.64,17.39	5.79 -4.39,15.98	**18.51* 1.25,35.77**	-4.97 -22.47,12.53	6.20 -7.89,20.29
Q3	2.61 -8.47,13.68	0.47 -11.23,12.16	**17.17+ -1.06,35.40**	-1.13 -18.72,16.46	-3.78 -17.06,9.50
Q4	3.22 -8.13,14.57	0.22 -9.51,9.95	12.41 -4.78,29.60	-0.52 -20.54,19.49	-3.95 -18.96,11.05
MiBP	1.96 -1.85,5.77	0.53 -6.38,7.43	**4.13+ -0.74,8.99**	-0.07 -5.13,4.98	0.63 -6.00,7.26
Q2	-3.07 -10.58,4.43	-4.08 -12.20,4.04	7.96 -13.07,29.00	6.97 -2.64,16.58	**-8.31+ -16.77,0.16**
Q3	-5.58 -14.64,3.47	-7.17 -16.89,2.54	7.33 -13.80,28.47	-1.64 -11.56,8.28	**-11.83+ -26.17,2.51**
Q4	5.53 -7.72,18.78	3.45 -10.54,17.44	3.27 -18.55,25.10	-1.23 -11.86,9.40	7.08 -13.10,27.25
McPP	0.76 -5.70,7.22	-0.25 -9.35,8.86	3.69 -5.15,12.53	-3.41 -13.84,7.01	-4.11 -14.52,6.31
Q2	5.25 -7.99,18.50	4.14 -9.15,17.43	1.99 -11.00,14.98	4.42 -9.03,17.86	2.65 -12.89,18.19
Q3	-5.91 -17.15,5.33	-7.76 -17.82,2.29	-5.38 -26.57,15.81	-4.05 -16.79,8.70	**-12.83+ -28.11,2.45**
Q4	3.67 -10.86,18.21	1.11 -11.89,14.10	8.36 -10.89,27.61	0.96 -18.63,20.55	-4.58 -27.93,18.77
MBzP	-0.43 -4.16,3.30	-1.17 -5.15,2.82	0.86 -5.27,6.99	-1.19 -6.03,3.66	-4.15 -10.68,2.38
Q2	1.07 -15.33,17.47	-0.05 -16.47,16.37	15.57 -4.97,36.11	-4.73 -24.86,15.40	0.75 -18.09,19.58
Q3	4.93 -8.37,18.23	2.62 -11.48,16.73	**16.71* .41,33.01**	-12.96 -31.77,5.84	1.45 -14.06,16.95
Q4	1.60 -12.44,15.64	-1.54 -13.98,10.91	12.12 -9.04,33.27	-10.32 -33.23,12.58	-7.99 -26.61,10.63
∑ DEHP	-1.48 -3.81,0.85	-1.56 -5.30,2.18	-1.06 -5.15,3.03	-0.38 -4.75,3.98	**-4.79*** -7.28,-2.31**
Q2	3.29 -8.40,14.98	2.42 -9.54,14.38	14.90 -4.18,33.97	-6.47 -24.59,11.65	2.02 -12.62,16.66
Q3	-3.42 -11.86,5.03	-4.84 -13.81,4.14	4.19 -10.67,19.05	-1.45 -18.77,15.87	-9.23 -21.70,3.24
Q4	-1.00 -11.10,9.09	-2.68 -12.11,6.75	2.02 -14.87,18.91	-2.98 -24.07,18.11	**-11.36+ -24.27,1.55**
MEHP	-0.73 -3.42,1.97	-0.38 -5.76,5.01	-1.17 -6.58,4.2	2.46 -1.68,6.60	**-3.86* -7.54,-0.19**
Q2	-3.87 -14.04,6.29	-4.71 -15.41,5.98	-3.13 -20.41,14.16	0.20 -9.46,9.85	-6.19 -21.46,9.07
Q3	3.38 -4.56,11.32	1.90 -7.20,11.00	7.25 -4.55,19.06	8.52 -4.05,21.09	0.58 -10.69,11.86
Q4	2.01 -4.72,8.74	-0.03 -6.22,6.15	1.04 -10.82,12.89	3.61 -8.39,15.60	-5.25 -12.87,2.37
MEHHP	-1.37 -3.57,0.83	-1.06 -4.67,2.55	-1.34 -5.35,2.66	-0.65 -4.90,3.59	**-4.49** -6.89,-2.08**
Q2	4.91 -8.35,18.17	4.08 -9.28,17.43	11.39 -6.12,28.90	-4.34 -25.01,16.32	4.05 -12.31,20.42
Q3	-1.26 -12.51,9.98	-2.66 -13.75,8.43	6.65 -9.53,22.83	1.10 -17.09,19.30	-6.40 -21.48,8.69
Q4	-1.37 -10.73,7.99	-3.03 -10.22,4.17	-2.07 -17.07,12.94	-4.47 -25.34,16.40	**-10.88+ -21.83,0.07**
MEOHP	-1.42 -3.75,0.92	-1.26 -5.10,2.57	-1.18 -5.41,3.05	-0.55 -5.07,3.98	**-4.72*** -7.10,-2.34**
Q2	8.21 -4.75,21.18	7.01 -5.24,19.27	13.40 -5.00,31.80	-10.70 -29.09,7.69	8.07 -7.32,23.46
Q3	2.29 -6.34,10.91	0.40 -8.29,9.09	10.31 -5.60,26.22	-2.52 -21.66,16.61	-2.03 -13.49,9.44
Q4	0.51 -8.80,9.81	-1.71 -8.59,5.17	2.28 -12.22,16.77	-7.15 -28.07,13.77	**-9.25+ -20.10,1.61**
MECPP	-1.85 -4.43,0.73	-2.19 -6.04,1.66	-1.14 -5.41,3.12	-0.32 -4.79,4.15	**-5.48** -8.36,-2.60**

Q2	3.84 -5.62,13.30	2.90 -6.64,12.44	**18.34+ -3.84,40.51**	5.43 -10.90,21.76	1.25 -11.51,14.01
Q3	-3.13 -10.72,4.45	-4.64 -12.64,3.36	3.23 -11.79,18.24	-0.71 -14.64,13.23	-8.03 -20.10,4.04
Q4	-0.25 -10.10,9.60	-2.09 -11.12,6.94	5.02 -13.24,23.29	2.54 -14.27,19.35	**-11.68+ -23.39,0.02**

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.6. Association between urinary phthalate metabolites and rubella antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex: Females	Stratified by Sex: Males	Stratified by Age: Children	Stratified by Age: Adults
MEP	0.03 -0.03,0.09	**-0.07* -0.14,-0.01**	**0.14** 0.05,0.23**	0.09 -0.06,0.23	0.04 -0.04,0.11
Q2	0.10 -0.21,0.41	-0.07 -0.49,0.34	0.23 -0.10,0.56	0.20 -0.23,0.62	0.12 -0.30,0.54
Q3	0.04 -0.24,0.33	**-0.29* -0.58,-0.01**	0.33 -0.12,0.78	-0.05 -0.46,0.36	0.09 -0.26,0.45
Q4	0.15 -0.08,0.38	**-0.25+ -0.54,0.03**	**0.53** 0.20,0.85**	**0.41+ -0.01,0.82**	0.18 -0.13,0.50
∑ DBP	-0.03 -0.12,0.07	-0.01 -0.17,0.14	-0.05 -0.20,0.11	-0.09 -0.34,0.16	-0.10 -0.24,0.03
Q2	-0.01 -0.30,0.28	-0.00 -0.37,0.37	0.00 -0.32,0.33	-0.27 -0.81,0.27	-0.02 -0.37,0.33
Q3	-0.09 -0.41,0.23	0.02 -0.42,0.47	-0.18 -0.64,0.29	-0.26 -0.87,0.35	-0.15 -0.57,0.26
Q4	-0.04 -0.35,0.26	0.02 -0.35,0.39	-0.08 -0.59,0.44	-0.41 -1.11,0.29	-0.21 -0.58,0.16
MnBP	-0.01 -0.07,0.05	-0.01 -0.11,0.09	0.00 -0.13,0.13	-0.13 -0.39,0.12	-0.06 -0.15,0.03
Q2	-0.23 -0.57,0.12	-0.13 -0.61,0.34	-0.30 -0.72,0.13	-0.10 -0.62,0.42	-0.31 -0.76,0.15
Q3	0.14 -0.09,0.37	0.05 -0.25,0.34	0.29 -0.11,0.69	-0.21 -0.67,0.25	0.16 -0.21,0.53
Q4	0.09 -0.09,0.27	0.04 -0.33,0.41	0.22 -0.15,0.58	-0.31 -0.93,0.31	0.01 -0.28,0.29
MiBP	-0.02 -0.11,0.07	0.04 -0.10,0.18	-0.10 -0.22,0.02	-0.03 -0.30,0.24	-0.10 -0.24,0.03
Q2	-0.22 -0.54,0.10	-0.07 -0.44,0.30	**-0.41+ -0.84,0.01**	-0.37 -1.04,0.31	-0.21 -0.60,0.18
Q3	**-0.26+ -0.54,0.01**	-0.09 -0.37,0.18	**-0.46* -0.87,-0.05**	-0.30 -1.18,0.58	**-0.33* -0.62,-0.04**
Q4	-0.18 -0.45,0.08	0.03 -0.34,0.40	**-0.40+ -0.88,0.07**	-0.17 -0.98,0.64	-0.29 -0.71,0.13
McPP	-0.01 -0.13,0.10	0.03 -0.08,0.13	-0.06 -0.28,0.16	-0.03 -0.20,0.13	-0.08 -0.20,0.05
Q2	-0.11 -0.36,0.15	-0.24 -0.54,0.07	0.05 -0.38,0.48	-0.27 -0.78,0.24	-0.12 -0.42,0.17
Q3	0.08 -0.20,0.35	0.05 -0.26,0.37	0.12 -0.33,0.57	-0.21 -0.92,0.49	0.06 -0.26,0.39
Q4	0.07 -0.24,0.38	0.03 -0.26,0.33	0.14 -0.40,0.67	-0.00 -0.58,0.58	-0.13 -0.52,0.26
MBzP	-0.00 -0.13,0.12	-0.00 -0.18,0.18	-0.00 -0.13,0.13	-0.08 -0.34,0.17	-0.06 -0.24,0.11
Q2	-0.14 -0.40,0.12	-0.10 -0.37,0.17	-0.16 -0.52,0.20	-0.03 -0.51,0.46	-0.18 -0.49,0.13
Q3	-0.08 -0.31,0.16	-0.07 -0.45,0.30	-0.08 -0.37,0.21	-0.18 -0.70,0.34	-0.08 -0.40,0.24
Q4	0.06 -0.28,0.40	0.11 -0.35,0.57	0.04 -0.38,0.47	-0.28 -0.98,0.42	0.01 -0.47,0.49
∑ DEHP	-0.07 -0.20,0.06	-0.07 -0.23,0.08	-0.08 -0.25,0.09	-0.05 -0.22,0.12	-0.11 -0.25,0.03
Q2	-0.10 -0.26,0.06	-0.21 -0.48,0.06	-0.02 -0.33,0.29	-0.11 -0.79,0.56	**-0.19* -0.33,-0.05**
Q3	**-0.20+ -0.42,0.02**	-0.17 -0.52,0.18	-0.19 -0.57,0.19	-0.08 -0.44,0.29	**-0.37* -0.65,-0.08**
Q4	**-0.34* -0.67,-0.00**	-0.28 -0.73,0.17	-0.39 -0.90,0.13	-0.18 -0.68,0.31	**-0.51* -0.90,-0.13**
MEHP	-0.07 -0.16,0.02	-0.08 -0.21,0.05	-0.07 -0.23,0.09	-0.00 -0.15,0.14	-0.08 -0.19,0.02
Q2	0.05 -0.13,0.22	**-0.22** -0.37,-.07**	0.29 -0.07,0.66	-0.17 -0.56,0.23	0.09 -0.14,0.32
Q3	-0.15 -0.33,0.04	-0.24 -0.62,0.13	-0.02 -0.34,0.30	0.03 -0.30,0.35	-0.21 -0.46,0.05
Q4	**-0.24** -0.39,-.08**	**-0.27+ -0.54,0.00**	-0.18 -0.55,0.18	-0.09 -0.40,0.22	**-0.25* -0.49,-0.02**
MEHHP	-0.08 -0.21,0.04	-0.08 -0.23,0.07	-0.10 -0.26,0.06	-0.06 -0.21,0.10	-0.11 -0.25,0.03
Q2	-0.12 -0.28,0.05	-0.12 -0.42,0.17	-0.17 -0.38,0.05	0.08 -0.41,0.58	**-0.23* -0.44,-0.02**
Q3	-0.13 -0.37,0.11	-0.14 -0.44,0.16	-0.09 -0.49,0.30	0.09 -0.29,0.46	**-0.27+ -0.60,0.06**
Q4	**-0.37* -0.68,-0.05**	-0.32 -0.76,0.11	**-0.43+ -0.94,0.08**	-0.01 -0.36,0.33	**-0.58** -1.00,-0.17**
MEOHP	-0.08 -0.22,0.05	-0.08 -0.24,0.08	-0.09 -0.27,0.09	-0.06 -0.23,0.11	-0.12 -0.27,0.03
Q2	-0.13 -0.33,0.07	**-0.21+ -0.45,0.04**	-0.09 -0.41,0.22	-0.00 -0.70,0.70	**-0.26* -0.51,-0.01**
Q3	**-0.26** -0.41,-.10**	-0.21 -0.61,0.19	**-0.28+ -0.62,0.05**	-0.11 -0.55,0.33	**-0.45** -0.69,-0.21**
Q4	**-0.31* -0.59,-0.03**	-0.29 -0.73,0.14	-0.33 -0.78,0.11	-0.14 -0.55,0.27	**-0.26* -0.51,-0.01**
MECPP	-0.06 -0.20,0.08	-0.06 -0.22,0.09	-0.06 -0.25,0.12	-0.05 -0.23,0.13	-0.10 -0.25,0.05
Q2	-0.07 -0.25,0.10	-0.13 -0.43,0.17	-0.03 -0.30,0.24	0.06 -0.70,0.82	**-0.20+ -0.43,0.03**

Q3	**-0.25* -0.45,-0.05**	-0.19 -0.52,0.14	**-0.29+ -0.63,0.05**	-0.11 -0.58,0.36	**-0.42** -0.70,-0.15**
Q4	**-0.28+ -0.60,0.05**	-0.24 -0.64,0.16	-0.31 -0.81,0.19	-0.04 -0.58,0.49	**-0.49* -0.88,-0.10**

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.7. Association between urinary phthalate metabolites and polio serotype 1 antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	-0.06 -0.22,0.09	-0.19** -0.31,-.07	0.06 -0.21,0.33	-0.15 -0.42,0.13	-0.03 -0.19,0.14
Q2	-0.09 -0.60,0.42	-0.08 -0.73,0.56	-0.15 -0.86,0.55	-0.50 -1.78,0.78	0.07 -0.47,0.62
Q3	-0.17 -0.78,0.43	-0.52 -1.18,0.15	0.02 -0.69,0.74	-0.85+ -1.80,0.11	0.10 -0.56,0.75
Q4	-0.28 -1.04,0.49	-0.90* -1.66,-0.15	0.26 -0.88,1.40	-0.54 -1.60,0.52	-0.17 -1.03,0.69
∑ DBP	-0.01 -0.29,0.27	0.13 -0.29,0.55	-0.11 -0.45,0.23	-0.14 -0.48,0.20	0.02 -0.39,0.43
Q2	-0.06 -0.41,0.29	-0.16 -1.01,0.70	0.10 -0.53,0.74	-0.63 -1.54,0.28	0.06 -0.48,0.61
Q3	-0.02 -0.57,0.53	-0.03 -0.89,0.83	0.08 -0.69,0.85	-0.57 -1.72,0.58	0.11 -0.70,0.92
Q4	0.11 -0.64,0.85	0.17 -0.91,1.25	0.13 -0.77,1.02	-0.57 -1.64,0.50	0.28 -0.74,1.29
MnBP	-0.12 -0.38,0.15	-0.03 -0.38,0.33	-0.18 -0.54,0.18	-0.13 -0.56,0.30	-0.18 -0.50,0.15
Q2	-0.19 -0.59,0.22	-0.14 -0.64,0.37	-0.12 -0.78,0.54	-0.75* -1.34,-0.17	-0.06 -0.62,0.51
Q3	-0.24 -0.80,0.31	-0.39 -1.26,0.49	0.02 -0.66,0.70	-0.46+ -1.01,0.09	-0.34 -1.14,0.46
Q4	-0.15 -0.96,0.66	-0.24 -1.12,0.64	0.05 -1.02,1.11	-0.69 -1.96,0.57	-0.12 -1.10,0.85
MiBP	-0.20 -0.49,0.09	-0.10 -0.47,0.26	-0.32 -0.81,0.18	-0.31 -0.78,0.17	-0.19 -0.62,0.25
Q2	-0.23 -0.74,0.28	-0.06 -1.00,0.88	-0.23 -0.84,0.38	-0.77* -1.37,-0.18	-0.19 -0.85,0.46
Q3	-0.64+ -1.37,0.08	-0.51 -1.58,0.56	-0.64 -1.76,0.49	-1.56*** -2.33,-.79	-0.46 -1.38,0.45
Q4	-0.52 -1.30,0.25	-0.45 -1.60,0.70	-0.49 -1.73,0.74	-1.05* -2.00,-0.09	-0.40 -1.55,0.76
McPP	-0.08 -0.30,0.15	0.18 -0.15,0.51	-0.33* -0.60,-0.06	-0.03 -0.34,0.28	-0.08 -0.35,0.19
Q2	-0.05 -0.71,0.60	0.29 -0.48,1.06	-0.43 -1.10,0.24	-0.75 -1.71,0.21	0.12 -0.61,0.85
Q3	-0.22 -0.97,0.52	0.13 -0.96,1.22	-0.69* -1.25,-0.12	-0.93 -2.10,0.25	-0.15 -1.08,0.77
Q4	-0.17 -0.77,0.44	0.46 -0.50,1.43	-0.82* -1.47,-0.17	-0.32 -1.32,0.69	-0.17 -0.87,0.53
MBzP	-0.01 -0.28,0.26	0.04 -0.38,0.45	-0.01 -0.36,0.34	-0.19 -0.62,0.24	0.04 -0.33,0.40
Q2	-0.03 -0.49,0.43	-0.06 -0.67,0.54	0.02 -0.64,0.67	-0.43 -1.28,0.43	0.07 -0.49,0.63
Q3	-0.18 -0.66,0.29	-0.23 -0.94,0.48	-0.05 -0.72,0.61	-0.67 -1.61,0.28	-0.06 -0.61,0.49
Q4	0.16 -0.63,0.95	0.19 -1.00,1.38	0.18 -0.89,1.25	-0.76 -2.29,0.78	0.47 -0.55,1.49
∑ DEHP	-0.12 -0.33,0.08	0.06 -0.32,0.45	-0.26* -0.47,-0.05	-0.18 -0.47,0.10	-0.11 -0.34,0.12
Q2	-0.27 -0.67,0.13	-0.39 -1.10,0.32	-0.07 -0.59,0.45	-0.01 -0.79,0.78	-0.34 -0.86,0.18
Q3	-0.56* -1.04,-0.07	-0.25 -1.07,0.56	-0.82+ -1.71,0.07	0.00 -0.71,0.71	-0.85* -1.57,-0.12
Q4	-0.46+ -1.00,0.09	0.29 -0.72,1.31	-1.05* -1.82,-0.28	-0.29 -1.11,0.53	-0.42 -1.04,0.19
MEHP	-0.12 -0.33,0.10	0.05 -0.30,0.40	-0.22+ -0.46,0.01	-0.24 -0.59,0.11	-0.06 -0.27,0.15
Q2	-0.27 -0.79,0.24	-0.30 -1.02,0.42	-0.14 -0.64,0.36	-0.29 -0.91,0.33	-0.25 -0.92,0.42
Q3	-0.35+ -0.78,0.07	-0.25 -1.03,0.53	-0.38 -1.00,0.23	-0.51 -1.42,0.40	-0.28 -0.82,0.25
Q4	-0.58* -1.04,-0.12	-0.13 -0.99,0.72	-0.89** -1.53,-.25	-0.82* -1.59,-0.05	-0.43+ -0.94,0.09
MEHHP	-0.12 -0.30,0.07	0.09 -0.26,0.43	-0.26* -0.46,-0.06	-0.18 -0.45,0.09	-0.10 -0.31,0.12
Q2	-0.15 -0.58,0.28	-0.49 -1.28,0.30	0.29 -0.19,0.77	0.27 -0.49,1.02	-0.22 -0.78,0.33
Q3	-0.25 -0.67,0.17	0.02 -0.67,0.71	-0.49 -1.29,0.32	0.39 -0.35,1.12	-0.58 -1.32,0.16
Q4	-0.59* -1.09,-0.09	0.01 -1.05,1.08	-0.91* -1.63,-0.20	-0.32 -0.96,0.32	-0.54 -1.29,0.21
MEOHP	-0.15 -0.36,0.06	0.04 -0.35,0.43	-0.28* -0.52,-0.04	-0.25 -0.57,0.07	-0.13 -0.37,0.11
Q2	-0.25 -0.61,0.11	-0.45 -1.07,0.18	0.03 -0.50,0.56	-0.03 -0.79,0.73	-0.31 -0.77,0.15
Q3	-0.46* -0.88,-0.05	-0.20 -0.94,0.54	-0.69 -1.57,0.18	-0.07 -0.68,0.54	-0.69* -1.36,-0.03
Q4	-0.53+ -1.08,0.02	0.14 -0.89,1.17	-1.00* -1.88,-0.12	-0.40 -1.23,0.43	-0.48 -1.12,0.16
MECPP	-0.11 -0.33,0.11	0.06 -0.35,0.48	-0.25* -0.46,-0.05	-0.18 -0.48,0.12	-0.11 -0.36,0.15

Q2	**-0.40* -0.77,-0.04**	-0.39 -0.93,0.15	-0.39 -0.93,0.16	0.06 -0.87,0.99	**-0.48+ -1.02,0.06**
Q3	-0.37 -0.95,0.22	0.01 -0.88,0.90	**-0.73+ -1.62,0.15**	0.44 -0.35,1.23	-0.63 -1.48,0.22
Q4	**-0.54+ -1.16,0.09**	0.15 -0.92,1.21	**-1.15** -1.97,-.34**	0.02 -0.69,0.73	**-0.66+ -1.37,0.05**

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.8. Association between urinary phthalate metabolites and polio serotype 2 antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	-0.03 -0.13,0.07	-0.05 -0.16,0.05	-0.02 -0.13,0.10	**-0.19* -0.36,-0.03**	-0.01 -0.14,0.12
Q2	-0.26 -0.72,0.19	-0.21 -0.92,0.49	-0.32 -0.77,0.12	-0.35 -1.38,0.68	-0.34 -0.87,0.19
Q3	-0.25 -0.72,0.23	-0.33 -0.90,0.24	-0.26 -0.80,0.27	-0.55 -1.57,0.47	-0.16 -0.71,0.39
Q4	-0.25 -0.73,0.23	-0.31 -0.92,0.30	-0.23 -0.69,0.22	-0.53 -1.44,0.38	-0.25 -0.91,0.41
∑ DBP	**0.19** 0.06,0.32**	0.18 -0.11,0.47	**0.24* 0.03,0.45**	0.08 -0.33,0.48	**0.21* 0.03,0.38**
Q2	0.07 -0.36,0.50	0.36 -0.28,1.00	-0.21 -0.88,0.46	-0.27 -1.43,0.90	0.17 -0.34,0.68
Q3	0.27 -0.16,0.69	0.32 -0.38,1.01	0.26 -0.43,0.95	-0.20 -1.56,1.16	**0.41+ -0.07,0.88**
Q4	**0.48* 0.04,0.93**	0.51 -0.25,1.27	0.51 -0.20,1.22	-0.02 -1.33,1.28	**0.63* 0.10,1.16**
MnBP	**0.13+ -0.01,0.26**	0.07 -0.14,0.28	0.22 -0.05,0.48	-0.08 -0.46,0.30	0.09 -0.08,0.25
Q2	**0.27+ -0.01,0.54**	0.32 -0.20,0.83	**0.35* 0.01,0.70**	-0.25 -0.96,0.47	**0.32+ -0.06,0.71**
Q3	0.27 -0.17,0.71	0.05 -0.65,0.76	**0.63+ -0.01,1.28**	-0.51 -1.69,0.67	0.33 -0.26,0.91
Q4	**0.45+ -0.03,0.93**	0.18 -0.45,0.80	**0.86* 0.04,1.68**	-0.15 -1.38,1.09	0.38 -0.29,1.06
MiBP	0.00 -0.19,0.20	-0.11 -0.28,0.07	0.16 -0.15,0.47	-0.31 -0.78,0.15	0.05 -0.24,0.35
Q2	0.09 -0.46,0.63	0.33 -0.44,1.10	0.03 -0.89,0.94	**-1.07** -1.79,-0.35**	0.17 -0.40,0.75
Q3	0.19 -0.31,0.68	0.13 -0.47,0.72	0.38 -0.74,1.49	**-1.15* -2.20,-0.09**	**0.38+ -0.06,0.83**
Q4	-0.01 -0.60,0.57	-0.12 -0.81,0.57	0.24 -0.83,1.31	**-1.19* -2.33,-0.05**	0.15 -0.64,0.95
McPP	0.01 -0.14,0.15	0.12 -0.11,0.36	-0.11 -0.39,0.17	-0.07 -0.43,0.30	0.00 -0.21,0.21
Q2	-0.16 -0.65,0.33	0.23 -0.51,0.97	**-0.60+ -1.32,0.11**	**-0.66+ -1.47,0.14**	-0.10 -0.76,0.55
Q3	-0.27 -0.80,0.26	0.00 -0.69,0.69	-0.61 -1.38,0.15	**-1.28** -2.11,-0.44**	-0.18 -0.85,0.48
Q4	-0.08 -0.57,0.40	0.31 -0.30,0.93	-0.51 -1.34,0.32	-0.51 -1.50,0.47	-0.07 -0.65,0.51
MBzP	**0.23** 0.10,0.37**	0.16 -0.09,0.41	**0.35*** .17,0.53**	0.13 -0.37,0.63	**0.27** 0.07,0.46**
Q2	**0.38+ -0.06,0.82**	**0.49+ -0.02,1.01**	0.32 -0.47,1.11	-0.23 -1.32,0.86	**0.46+ -0.05,0.96**
Q3	**0.39+ -0.07,0.85**	0.39 -0.27,1.06	0.49 -0.12,1.09	-0.09 -1.56,1.39	0.46 -0.10,1.01
Q4	**0.87** 0.35,1.40**	**0.71* 0.01,1.41**	**1.12** 0.42,1.82**	0.01 -1.71,1.73	**1.11** 0.45,1.78**
∑ DEHP	0.01 -0.10,0.12	-0.02 -0.20,0.17	0.06 -0.07,0.20	-0.06 -0.41,0.28	0.00 -0.16,0.17
Q2	-0.07 -0.46,0.32	-0.00 -0.54,0.54	-0.06 -0.53,0.40	-0.07 -0.98,0.84	-0.06 -0.68,0.56
Q3	-0.11 -0.59,0.38	-0.25 -0.81,0.30	0.04 -0.73,0.82	-0.03 -1.46,1.39	-0.24 -0.87,0.39
Q4	-0.13 -0.56,0.30	-0.39 -1.00,0.22	0.14 -0.44,0.71	-0.20 -1.11,0.71	-0.19 -0.86,0.47
MEHP	-0.05 -0.22,0.13	-0.17 -0.44,0.09	0.07 -0.12,0.26	-0.23 -0.60,0.14	-0.00 -0.21,0.20
Q2	0.08 -0.26,0.42	0.29 -0.13,0.71	-0.05 -0.54,0.45	-0.33 -1.11,0.45	0.15 -0.28,0.58
Q3	0.02 -0.39,0.43	-0.10 -0.69,0.50	0.13 -0.47,0.73	**-0.93+ -2.02,0.15**	0.13 -0.30,0.55
Q4	-0.21 -0.66,0.25	**-0.51+ -1.11,0.09**	0.08 -0.40,0.56	**-0.85* -1.65,-0.04**	-0.04 -0.53,0.45
MEHHP	-0.01 -0.11,0.10	-0.04 -0.21,0.13	0.05 -0.10,0.20	-0.07 -0.41,0.28	-0.02 -0.18,0.13
Q2	0.03 -0.34,0.41	-0.08 -0.53,0.37	0.25 -0.25,0.75	-0.00 -0.87,0.87	0.05 -0.51,0.60
Q3	0.03 -0.37,0.43	-0.21 -0.70,0.28	0.29 -0.42,1.01	0.33 -0.86,1.53	-0.21 -0.78,0.37
Q4	-0.11 -0.48,0.26	-0.44 -1.01,0.13	0.26 -0.26,0.78	-0.26 -1.33,0.81	-0.08 -0.70,0.54
MEOHP	-0.03 -0.13,0.08	-0.08 -0.26,0.11	0.05 -0.11,0.21	-0.10 -0.46,0.26	-0.05 -0.22,0.12
Q2	0.14 -0.26,0.54	0.16 -0.41,0.72	0.21 -0.33,0.74	0.18 -0.72,1.07	0.13 -0.48,0.75
Q3	0.08 -0.26,0.42	-0.27 -0.77,0.23	**0.43+ -0.09,0.95**	0.24 -0.92,1.41	-0.13 -0.67,0.41
Q4	-0.01 -0.41,0.39	-0.29 -0.97,0.39	0.33 -0.22,0.89	-0.14 -1.35,1.07	-0.01 -0.68,0.65
MECPP	0.03 -0.09,0.16	0.01 -0.20,0.23	0.08 -0.07,0.22	-0.05 -0.40,0.2	0.03 -0.15,0.21

Q2	-0.01 -0.37,0.35	-0.05 -0.42,0.31	0.13 -0.44,0.71	-0.17 -1.24,0.90	-0.01 -0.52,0.51
Q3	0.02 -0.44,0.47	-0.09 -0.71,0.52	0.19 -0.49,0.86	0.06 -1.21,1.32	-0.09 -0.69,0.51
Q4	-0.01 -0.41,0.40	-0.24 -0.87,0.40	0.28 -0.29,0.84	-0.03 -1.30,1.24	-0.13 -0.74,0.49

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.9. Association between urinary phthalate metabolites and polio serotype 3 antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	-0.10 -0.24,0.03	**-0.20** -0.34,-.06**	-0.01 -0.22,0.20	-0.07 -0.31,0.18	-0.09 -0.23,0.04
Q2	-0.04 -0.50,0.42	-0.19 -0.85,0.48	0.03 -0.54,0.61	-0.21 -1.22,0.80	0.00 -0.69,0.69
Q3	-0.40 -1.02,0.23	**-0.80* -1.57,-0.03**	-0.13 -1.03,0.76	-0.13 -1.05,0.78	-0.33 -1.00,0.35
Q4	-0.29 -0.80,0.22	**-0.76* -1.34,-0.19**	0.08 -0.66,0.83	-0.20 -1.06,0.67	-0.22 -0.84,0.39
∑ DBP	**0.29** 0.11,0.47**	0.11 -0.24,0.47	**0.49** 0.21,0.76**	-0.03 -0.44,0.38	0.04 -0.22,0.30
Q2	0.15 -0.34,0.65	-0.08 -1.21,1.06	**0.48+ -0.03,1.00**	-0.77 -1.83,0.29	0.00 -0.65,0.66
Q3	0.44 -0.18,1.05	-0.45 -1.51,0.61	**0.99* 0.27,1.71**	-0.59 -2.10,0.93	0.09 -0.48,0.66
Q4	**0.76** 0.25,1.27**	-0.37 -1.89,1.16	**1.27** 0.53,2.00**	-0.62 -1.85,0.61	0.34 -0.32,1.01
MnBP	**0.24+ -0.00,0.47**	0.13 -0.21,0.48	**0.38* 0.01,0.75**	-0.06 -0.55,0.42	-0.03 -0.26,0.19
Q2	0.40 -0.10,0.89	0.19 -0.59,0.96	**0.72** 0.22,1.21**	-0.15 -1.05,0.74	0.15 -0.55,0.85
Q3	**0.77** 0.24,1.30**	0.23 -0.73,1.20	**1.45*** .78,2.13**	-0.40 -1.45,0.64	0.47 -0.31,1.26
Q4	**0.84* 0.12,1.57**	0.45 -0.52,1.42	**1.38** 0.42,2.34**	-0.18 -1.27,0.92	0.18 -0.56,0.92
MiBP	0.01 -0.28,0.29	-0.09 -0.53,0.36	0.15 -0.16,0.47	**-0.49* -0.96,-0.02**	-0.16 -0.51,0.19
Q2	-0.16 -0.61,0.30	-0.10 -1.01,0.81	-0.07 -0.91,0.76	**-0.91+ -1.82,0.01**	-0.15 -0.86,0.57
Q3	-0.09 -0.64,0.47	-0.03 -1.17,1.10	0.42 -0.19,1.04	**-1.53* -2.91,-0.15**	-0.24 -1.14,0.65
Q4	-0.06 -0.87,0.74	0.26 -0.61,1.13	0.39 -0.56,1.34	**-1.18+ -2.57,0.21**	-0.45 -1.59,0.69
McPP	0.16 -0.07,0.39	0.11 -0.16,0.39	0.21 -0.15,0.57	-0.04 -0.56,0.48	-0.05 -0.35,0.25
Q2	0.23 -0.30,0.75	0.35 -0.09,0.79	0.10 -0.78,0.97	-0.16 -1.09,0.76	-0.01 -0.71,0.68
Q3	0.14 -0.53,0.80	-0.08 -0.75,0.59	0.29 -0.64,1.22	**-1.00+ -2.03,0.04**	-0.12 -0.86,0.62
Q4	0.34 -0.27,0.95	0.17 -0.49,0.82	0.49 -0.44,1.42	-0.27 -1.51,0.97	-0.17 -0.86,0.52
MBzP	**0.26* 0.01,0.51**	0.05 -0.33,0.43	**0.48** 0.15,0.82**	0.03 -0.49,0.56	0.02 -0.26,0.30
Q2	0.23 -0.43,0.90	-0.03 -0.91,0.85	0.55 -0.33,1.43	-0.96 -2.18,0.26	0.12 -0.70,0.94
Q3	0.37 -0.37,1.10	-0.09 -1.05,0.87	**0.90+ -0.15,1.94**	-0.26 -1.70,1.18	0.03 -0.73,0.79
Q4	**0.81+ -0.01,1.64**	0.10 -0.87,1.06	**1.52** 0.45,2.58**	-0.43 -1.99,1.12	0.42 -0.53,1.37
∑ DEHP	0.10 -0.14,0.33	0.11 -0.26,0.49	0.10 -0.11,0.31	-0.08 -0.47,0.30	-0.03 -0.30,0.25
Q2	-0.07 -0.67,0.52	-0.21 -1.09,0.67	0.15 -0.40,0.69	-0.11 -1.37,1.15	-0.40 -1.13,0.33
Q3	-0.04 -0.69,0.61	0.08 -0.69,0.85	-0.09 -0.89,0.70	0.19 -0.94,1.32	-0.69 -1.56,0.17
Q4	0.07 -0.63,0.77	0.29 -0.99,1.56	-0.06 -0.80,0.67	-0.29 -1.20,0.61	-0.26 -1.01,0.49
MEHP	-0.08 -0.34,0.18	-0.01 -0.37,0.35	-0.12 -0.42,0.18	-0.21 -0.77,0.36	-0.08 -0.34,0.17
Q2	-0.15 -0.53,0.22	**-0.47+ -1.02,0.08**	0.30 -0.12,0.72	-0.19 -1.15,0.77	-0.18 -0.65,0.30
Q3	**-0.53+ -1.08,0.02**	-0.46 -1.12,0.21	-0.46 -1.17,0.25	-0.74 -2.30,0.82	**-0.73* -1.32,-0.15**
Q4	-0.36 -0.89,0.17	-0.12 -0.92,0.69	-0.43 -0.97,0.10	-0.71 -2.12,0.69	-0.35 -0.91,0.20
MEHHP	0.08 -0.14,0.30	0.10 -0.26,0.45	0.08 -0.12,0.28	-0.12 -0.48,0.25	-0.02 -0.28,0.25
Q2	-0.12 -0.58,0.34	-0.36 -1.00,0.29	0.24 -0.45,0.92	0.31 -0.55,1.17	-0.46 -1.04,0.12
Q3	0.17 -0.42,0.76	0.14 -0.57,0.86	0.26 -0.58,1.11	0.58 -0.44,1.61	-0.48 -1.29,0.32
Q4	0.04 -0.50,0.58	0.18 -0.96,1.31	0.06 -0.60,0.73	-0.31 -1.25,0.63	-0.22 -0.90,0.46
MEOHP	0.08 -0.16,0.32	0.05 -0.31,0.41	0.13 -0.11,0.36	-0.16 -0.56,0.24	-0.04 -0.32,0.25
Q2	-0.16 -0.55,0.22	-0.33 -0.90,0.25	0.11 -0.48,0.70	-0.14 -1.14,0.85	-0.40 -1.01,0.21
Q3	0.25 -0.22,0.72	0.08 -0.41,0.58	0.49 -0.21,1.19	0.32 -0.61,1.25	-0.29 -0.90,0.33
Q4	0.05 -0.53,0.64	0.14 -0.87,1.15	0.10 -0.66,0.87	-0.15 -1.29,1.00	-0.28 -0.86,0.31
MECPP	0.13 -0.13,0.40	0.16 -0.25,0.58	0.12 -0.11,0.35	-0.06 -0.49,0.36	-0.00 -0.29,0.28

Q2	0.12 -0.49,0.74	-0.28 -1.23,0.67	**0.60+ -0.11,1.32**	0.01 -0.95,0.97	-0.14 -0.86,0.57
Q3	0.06 -0.44,0.55	0.17 -0.46,0.80	0.03 -0.64,0.69	0.29 -0.66,1.23	-0.50 -1.19,0.19
Q4	0.35 -0.49,1.20	0.27 -1.01,1.55	0.49 -0.42,1.40	0.15 -1.03,1.34	-0.14 -0.92,0.64

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.10. Association between urinary phthalate metabolites and Epstein-Barr virus antibodies (full model) and stratified models by gender and age, NHANES 2003-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	0.07 -0.04,0.17	0.08 -0.07,0.22	0.06 -0.08,0.19	---	---
Q2	0.23 -0.11,0.56	0.26 -0.19,0.71	0.19 -0.23,0.60	---	---
Q3	0.19 -0.18,0.56	0.21 -0.27,0.69	0.14 -0.38,0.66	---	---
Q4	0.31 -0.10,0.72	0.38 -0.16,0.92	0.23 -0.28,0.73	---	---
∑ DBP	**0.13* 0.03,0.24**	0.02 -0.18,0.22	**0.23** 0.07,0.38**	---	---
Q2	0.02 -0.32,0.35	-0.15 -0.70,0.39	0.19 -0.31,0.69	---	---
Q3	0.25 -0.11,0.61	0.14 -0.39,0.67	0.37 -0.13,0.87	---	---
Q4	0.28 -0.08,0.64	-0.00 -0.61,0.60	**0.52+ -0.00,1.05**	---	---
MnBP	**0.17* 0.03,0.31**	0.10 -0.10,0.30	**0.23* 0.05,0.42**	---	---
Q2	-0.09 -0.44,0.27	-0.32 -0.80,0.16	0.09 -0.38,0.56	---	---
Q3	**0.36+ -0.00,0.72**	**0.45+ -0.08,0.98**	0.27 -0.21,0.75	---	---
Q4	0.30 -0.10,0.70	0.26 -0.31,0.83	0.28 -0.23,0.80	---	---
MiBP	0.09 -0.05,0.22	-0.00 -0.19,0.18	**0.17* 0.01,0.32**	---	---
Q2	-0.00 -0.36,0.36	-0.04 -0.52,0.44	0.04 -0.43,0.52	---	---
Q3	0.24 -0.09,0.57	-0.02 -0.51,0.47	**0.48* 0.06,0.90**	---	---
Q4	**0.33+ -0.04,0.69**	0.15 -0.37,0.68	**0.49* 0.03,0.94**	---	---
McPP	0.10 -0.05,0.25	-0.04 -0.27,0.19	**0.21* 0.00,0.42**	---	---
Q2	**0.47** 0.14,0.79**	0.15 -0.40,0.70	**.81*** 0.38,1.25**	---	---
Q3	**0.32* 0.04,0.59**	0.09 -0.40,0.58	**0.54* 0.09,0.99**	---	---
Q4	**0.41* 0.06,0.77**	0.05 -0.49,0.60	**0.73** 0.20,1.26**	---	---
MBzP	**0.12* 0.02,0.21**	0.04 -0.13,0.21	**0.17* 0.04,0.31**	---	---
Q2	0.24 -0.15,0.64	0.13 -0.43,0.69	0.34 -0.27,0.96	---	---
Q3	0.25 -0.15,0.65	0.16 -0.36,0.67	0.31 -0.26,0.88	---	---
Q4	0.30 -0.10,0.69	0.06 -0.51,0.63	0.48 -0.10,1.05	---	---
∑ DEHP	0.03 -0.06,0.12	0.02 -0.13,0.16	0.02 -0.11,0.16	---	---
Q2	0.07 -0.29,0.42	0.26 -0.27,0.79	-0.13 -0.72,0.46	---	---
Q3	0.08 -0.21,0.38	0.06 -0.43,0.55	0.07 -0.38,0.53	---	---
Q4	0.16 -0.14,0.46	0.19 -0.35,0.72	0.07 -0.42,0.56	---	---
MEHP	0.01 -0.10,0.11	-0.05 -0.20,0.11	0.04 -0.12,0.20	---	---
Q2	-0.06 -0.40,0.27	-0.03 -0.55,0.49	-0.11 -0.53,0.31	---	---
Q3	-0.18 -0.52,0.16	-0.15 -0.66,0.36	-0.24 -0.70,0.22	---	---
Q4	0.06 -0.27,0.39	-0.06 -0.57,0.44	0.12 -0.36,0.59	---	---
MEHHP	0.03 -0.07,0.12	0.00 -0.14,0.14	0.04 -0.10,0.17	---	---
Q2	0.19 -0.14,0.52	0.18 -0.31,0.66	0.20 -0.40,0.81	---	---
Q3	0.18 -0.16,0.51	-0.05 -0.58,0.47	**0.39+ -0.05,0.83**	---	---
Q4	0.17 -0.13,0.47	0.13 -0.38,0.64	0.18 -0.29,0.65	---	---
MEOHP	0.03 -0.06,0.13	0.02 -0.12,0.17	0.02 -0.12,0.16	---	---
Q2	**0.36+ -0.02,0.73**	0.35 -0.19,0.90	0.36 -0.29,1.00	---	---
Q3	0.20 -0.10,0.50	0.13 -0.36,0.63	0.24 -0.20,0.69	---	---
Q4	**0.28+ -0.02,0.58**	0.34 -0.20,0.88	0.19 -0.29,0.67	---	---
MECPP	0.03 -0.07,0.12	0.03 -0.12,0.18	0.01 -0.13,0.15	---	---

Q2	0.11 -0.19,0.40	0.10 -0.53,0.73	0.12 -0.41,0.65	---	---
Q3	0.17 -0.14,0.47	0.02 -0.47,0.51	0.31 -0.12,0.73	---	---
Q4	0.23 -0.08,0.53	0.23 -0.36,0.82	0.20 -0.22,0.62	---	---

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.11. Association between urinary phthalate metabolites and *Toxoplasma gondii* antibodies (full model) and stratified models by gender and age, NHANES 2009-2010.

Variables	Full Model	Stratified by Sex		Stratified by Age	
		Females	Males	Children	Adults
MEP	-1.05 -2.92,0.81	-0.87 -3.30,1.56	-1.21 -3.00,0.57	-0.81 -3.33,1.71	-1.86+ -3.91,0.18
Q2	0.80 -6.96,8.55	1.84 -7.69,11.36	-0.32 -9.26,8.63	-0.75 -9.45,7.95	3.66 -5.15,12.46
Q3	-5.92 -13.48,1.63	-4.44 -15.19,6.30	-7.08 -16.97,2.81	-8.04* -16.02,-0.06	-6.02 -15.39,3.35
Q4	-2.27 -8.80,4.25	-2.44 -12.69,7.80	-1.95 -9.95,6.06	-3.14 -13.38,7.10	-3.87 -11.34,3.60
∑ DBP	-1.65 -3.87,0.56	0.88 -3.34,5.10	-4.38* -7.76,-1.01	-3.19+ -6.43,0.06	-2.55 -5.70,0.61
Q2	1.21 -4.85,7.28	2.86 -3.69,9.41	-1.00 -11.90,9.90	11.94 -6.86,30.73	-1.24 -11.30,8.82
Q3	0.59 -6.29,7.47	1.67 -3.44,6.77	-0.87 -11.59,9.86	-1.47 -10.96,8.01	1.24 -8.98,11.47
Q4	-2.73 -8.67,3.20	1.29 -13.28,15.87	-7.02 -15.65,1.62	-6.23 -15.39,2.93	-5.61 -12.96,1.73
MnBP	-1.49 -3.67,0.68	0.18 -2.73,3.09	-3.94* -7.55,-0.34	-0.33 -4.06,3.40	-1.32 -4.80,2.16
Q2	2.39 -6.50,11.27	6.54 -3.58,16.66	-2.37 -14.03,9.29	13.69 -4.39,31.78	-1.05 -10.88,8.77
Q3	-2.01 -9.49,5.47	2.74 -4.76,10.24	-7.46 -19.85,4.93	0.07 -5.73,5.87	-0.99 -12.29,10.30
Q4	-5.92 -16.44,4.61	-1.45 -13.37,10.46	-11.14+ -23.66,1.39	-2.55 -10.28,5.17	-5.40 -16.24,5.44
MiBP	1.50 -2.81,5.81	0.84 -5.48,7.15	1.92 -3.00,6.83	-0.82 -3.47,1.82	2.11 -6.12,10.34
Q2	-0.16 -5.64,5.33	-0.33 -10.20,9.54	-0.06 -6.91,6.79	3.92 -9.39,17.24	0.42 -6.75,7.60
Q3	4.00 -4.35,12.35	4.00 -5.45,13.46	3.76 -9.49,17.00	9.98 -8.11,28.08	4.72 -7.91,17.35
Q4	-0.40 -8.77,7.97	0.23 -13.55,14.01	-1.55 -10.87,7.76	4.94 -6.59,16.47	4.14 -11.51,19.79
McPP	-0.87 -2.99,1.24	0.13 -2.81,3.08	-1.85 -4.56,0.86	-3.73* -7.04,-0.43	-1.56 -4.75,1.62
Q2	3.45 -3.83,10.73	9.09+ -0.53,18.72	-3.58 -13.45,6.28	5.71 -10.55,21.98	5.57 -4.88,16.02
Q3	3.85 -4.27,11.97	3.14 -1.99,8.27	3.89 -9.24,17.01	-3.11 -11.74,5.51	5.75 -5.27,16.77
Q4	0.53 -6.19,7.24	6.51 -1.78,14.79	-5.24 -15.02,4.53	-7.84 -17.51,1.83	-0.27 -10.93,10.38
MBzP	-0.86 -3.56,1.85	1.29 -3.38,5.95	-3.21 -7.27,0.84	-2.01 -6.02,2.01	-1.26 -5.60,3.08
Q2	-2.79 -9.32,3.73	0.41 -5.17,5.99	-6.10 -14.76,2.57	4.01 -6.51,14.52	-7.23+ -15.63,1.17
Q3	3.41 -4.67,11.50	6.16 -4.33,16.66	0.71 -10.59,12.01	6.41 -11.10,23.92	3.01 -7.57,13.59
Q4	-6.22+ -13.43,.98	-3.15 -13.70,7.39	-9.76+ -20.53,1.0	-2.87 -16.07,10.32	-8.83 -20.58,2.91
∑ DEHP	-0.13 -2.40,2.15	1.97 -1.46,5.40	-2.08 -4.80,0.65	-3.49+ -7.09,0.11	0.73 -3.01,4.47
Q2	5.39 -1.27,12.04	12.7* 2.80,22.60	-4.32 -14.92,6.27	-8.10 -23.64,7.44	6.26 -1.67,14.18
Q3	-1.70 -8.51,5.10	5.41+ -0.54,11.37	-10.69* -21.15,-.23	-13.14+ -26.42,0.13	0.65 -7.53,8.83
Q4	-0.47 -8.95,8.00	9.01 -5.01,23.03	-11.45* -21.71,-1.19	-14.25+ -31.39,2.89	2.46 -11.33,16.24
MEHP	0.27 -2.19,2.72	2.19 -2.52,6.89	-1.38 -4.22,1.45	-3.10 -7.15,0.94	-0.13 -4.85,4.58
Q2	5.42+ -0.62,11.46	4.23 -5.90,14.36	6.09+ -1.12,13.31	-5.44 -19.14,8.26	7.07 -1.94,16.09
Q3	5.88 -4.24,16.01	9.40+ -0.90,19.71	1.95 -10.18,14.09	-5.26 -15.02,4.50	7.38 -5.05,19.81
Q4	1.26 -4.67,7.18	4.47 -6.17,15.10	-2.20 -10.46,6.07	-8.35 -20.77,4.08	3.14 -11.14,17.41
MEHHP	-0.27 -2.70,2.15	2.14 -1.70,5.98	-2.37+ -5.06,0.31	-3.39* -6.72,-0.06	0.82 -3.18,4.82
Q2	3.05 -3.39,9.49	8.47 -2.26,19.20	-4.28 -12.59,4.02	-6.65 -22.96,9.66	3.31 -4.85,11.48
Q3	-1.64 -8.20,4.93	6.56+ -0.63,13.75	-11.50* -20.60,-2.4	-11.00+ -23.45,1.45	3.63 -7.04,14.30
Q4	-2.46 -11.04,6.11	5.89 -10.17,21.94	-11.98* -21.17,-2.79	-12.36 -28.72,4.00	-0.08 -16.20,16.04
MEOHP	-0.40 -2.95,2.15	2.19 -1.97,6.35	-2.66+ -5.68,0.37	-3.60* -7.15,-0.06	0.46 -3.60,4.52
Q2	2.81 -4.44,10.06	9.33+ -0.77,19.44	-5.26 -19.04,8.52	-1.55 -15.93,12.83	2.50 -5.84,10.85
Q3	-3.77 -10.98,3.43	6.76* 0.52,13.00	-14.80* -26.72,-2.87	-8.62 -19.97,2.74	-0.87 -8.38,6.63
Q4	-1.79 -11.00,7.43	7.57 -7.78,22.92	-12.06* -23.69,-0.43	-9.84 -25.19,5.52	-0.19 -15.29,14.92
MECPP	-0.05 -2.24,2.14	1.62 -1.45,4.69	-1.65 -4.42,1.12	-3.66+ -7.67,0.36	0.79 -2.69,4.27

Q2	4.86 -3.33,13.04	**10.01* .87,19.16**	-1.23 -13.20,10.75	-6.09 -24.19,12.02	4.20 -5.20,13.60
Q3	-2.99 -9.11,3.14	3.64 -3.05,10.33	**-10.13+ -21.23,0.96**	-8.65 -22.48,5.18	-0.61 -8.71,7.48
Q4	-0.72 -8.08,6.64	6.55 -4.34,17.44	**-8.74* -17.24,-0.25**	-12.52 -30.98,5.94	3.43 -6.24,13.10

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.12. Association between urinary phthalate metabolites and measles antibodies among female children and adults, NHANES 2003-2004 and 2009-2010.

Variables	2003-2004		2009-2010	
	Children	Adults	Children	Adults
MEP	**0.69+ -0.02,1.39**	0.49 -0.44,1.42	**-0.18+ -0.37,0.02**	0.00 -0.17,0.18
Q2	1.53 -0.85,3.91	1.74 -1.13,4.61	-0.18 -1.06,0.70	0.32 -0.23,0.88
Q3	2.00 -1.22,5.22	0.64 -1.76,3.03	**-0.83* -1.62,-0.04**	-0.05 -0.64,0.53
Q4	**3.38* 0.66,6.11**	1.76 -1.49,5.01	-0.08 -1.00,0.84	0.09 -0.55,0.73
∑ DBP	-0.31 -1.15,0.52	**-1.45+ -3.03,0.12**	0.08 -0.39,0.55	0.02 -0.18,0.21
Q2	0.95 -2.11,4.00	-2.50 -6.33,1.34	-0.00 -0.74,0.74	0.20 -0.28,0.68
Q3	0.94 -2.54,4.43	**-2.56+ -5.66,0.54**	-0.05 -1.02,0.92	-0.10 -0.67,0.47
Q4	-0.02 -2.84,2.80	**-4.43* -8.65,-0.22**	0.20 -1.02,1.42	-0.05 -0.68,0.58
MnBP	0.22 -0.92,1.35	0.24 -1.65,2.12	-0.04 -0.56,0.49	0.13 -0.07,0.33
Q2	-0.84 -4.21,2.54	-0.88 -4.33,2.57	-0.14 -1.49,1.20	0.31 -0.21,0.83
Q3	0.21 -3.31,3.74	-0.24 -3.64,3.15	-0.55 -2.00,0.90	0.50 -0.31,1.30
Q4	-0.44 -4.13,3.25	-0.31 -5.28,4.66	-0.35 -1.77,1.07	0.47 -0.29,1.22
MiBP	-0.78 -2.02,0.45	0.31 -2.26,2.87	-0.07 -0.59,0.44	0.11 -0.15,0.38
Q2	-0.12 -2.66,2.41	-1.90 -4.92,1.12	-0.22 -1.32,0.87	**0.35* 0.03,0.66**
Q3	-0.15 -3.18,2.88	0.69 -4.60,5.98	-0.12 -1.57,1.33	0.31 -0.24,0.87
Q4	-1.09 -4.11,1.92	0.49 -4.10,5.08	-0.44 -1.93,1.05	0.48 -0.30,1.26
McPP	-0.13 -2.07,1.81	**-1.03+ -2.16,0.10**	0.01 -0.42,0.44	0.05 -0.14,0.24
Q2	-1.99 -4.65,0.66	-0.21 -2.96,2.55	0.08 -0.91,1.08	-0.03 -0.51,0.46
Q3	-0.62 -3.71,2.47	-0.23 -4.22,3.76	0.12 -1.11,1.35	0.22 -0.16,0.59
Q4	-1.54 -5.61,2.53	-1.77 -4.73,1.20	0.13 -1.09,1.35	0.08 -0.38,0.54
MBzP	-0.33 -1.14,0.48	-1.29 -2.85,0.28	0.18 -0.21,0.57	-0.02 -0.23,0.20
Q2	0.61 -2.39,3.60	-1.95 -5.51,1.62	0.10 -0.48,0.67	0.14 -0.34,0.61
Q3	1.15 -2.61,4.91	-1.70 -5.59,2.19	0.31 -0.52,1.14	-0.11 -0.55,0.34
Q4	-0.32 -2.99,2.34	-3.16 -7.27,0.95	0.67 -0.46,1.81	0.03 -0.50,0.56
∑ DEHP	-0.39 -1.55,0.77	-0.71 -1.73,0.31	-0.03 -0.26,0.21	-0.01 -0.18,0.15
Q2	-0.40 -2.92,2.12	-1.86 -4.53,0.80	-0.22 -1.04,0.60	-0.02 -0.54,0.49
Q3	0.97 -1.45,3.40	-1.28 -5.50,2.94	-0.11 -1.01,0.80	0.01 -0.59,0.61
Q4	-1.61 -5.27,2.04	-1.66 -4.88,1.57	0.03 -0.81,0.87	-0.17 -0.74,0.39
MEHP	-0.48 -1.85,0.88	-0.36 -1.41,0.70	-0.03 -0.37,0.30	-0.11 -0.29,0.06
Q2	**2.18+ -0.24,4.60**	-1.08 -3.81,1.66	-0.53 -1.28,0.22	0.22 -0.25,0.69
Q3	1.04 -1.23,3.31	1.66 -1.08,4.39	-0.08 -0.79,0.64	-0.22 -0.58,0.14
Q4	-0.39 -4.05,3.26	-1.31 -3.83,1.20	-0.51 -1.27,0.25	-0.19 -0.76,0.37
MEHHP	-0.43 -1.58,0.72	-0.67 -1.68,0.34	-0.00 -0.23,0.22	-0.03 -0.19,0.12
Q2	0.12 -2.42,2.66	-1.22 -4.11,1.68	-0.10 -0.96,0.75	0.09 -0.35,0.54
Q3	1.01 -1.56,3.58	-1.17 -5.48,3.14	-0.15 -0.96,0.66	-0.09 -0.54,0.36
Q4	-1.52 -4.58,1.55	-1.86 -5.22,1.49	-0.06 -0.88,0.75	-0.35 -0.88,0.18
MEOHP	-0.43 -1.68,0.82	-0.70 -1.70,0.31	0.03 -0.21,0.27	-0.06 -0.21,0.09
Q2	-0.56 -3.59,2.48	-1.19 -4.36,1.97	-0.23 -1.03,0.57	-0.10 -0.59,0.39
Q3	0.66 -2.08,3.41	-0.48 -3.89,2.92	-0.17 -1.11,0.77	-0.16 -0.71,0.38
Q4	-1.27 -4.86,2.33	-1.91 -6.03,2.22	-0.05 -0.93,0.83	-0.40 -1.04,0.24
MECPP	-0.38 -1.57,0.80	-0.75 -1.80,0.30	-0.04 -0.29,0.20	0.01 -0.17,0.19

Q2	-1.52 -4.98,1.93	-1.53 -4.21,1.14	-0.71 -1.75,0.34	-0.07 -0.68,0.54
Q3	0.34 -2.24,2.92	-0.61 -4.86,3.64	-0.73 -1.75,0.28	0.03 -0.55,0.62
Q4	-2.45 -6.32,1.43	-1.62 -4.58,1.35	-0.66 -1.81,0.49	-0.05 -0.66,0.56

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.13. Association between urinary phthalate metabolites and measles antibodies among male children and adults, NHANES 2003-2004 and 2009-2010.

Variables	2003-2004 Children	2003-2004 Adults	2009-2010 Children	2009-2010 Adults
MEP	0.08 -0.63,0.80	0.05 -0.42,0.52	0.07 -0.14,0.27	**0.08+ -0.01,0.17**
Q2	-1.49 -4.84,1.87	-0.94 -3.25,1.38	0.25 -0.21,0.70	0.19 -0.40,0.79
Q3	-0.16 -3.27,2.95	-0.77 -2.96,1.42	-0.13 -0.65,0.38	0.23 -0.17,0.64
Q4	-0.96 -3.97,2.05	-1.09 -3.14,0.95	0.34 -0.29,0.97	0.13 -0.17,0.44
∑ DBP	**-0.72+ -1.46,0.02**	0.11 -0.71,0.92	0.07 -0.15,0.28	-0.03 -0.29,0.23
Q2	-1.24 -4.94,2.46	1.23 -1.00,3.47	0.39 -0.27,1.04	0.02 -0.69,0.73
Q3	-1.61 -5.23,2.01	1.31 -1.38,3.99	**0.44+ -0.03,0.91**	0.24 -0.39,0.88
Q4	-1.74 -5.39,1.91	-0.89 -2.82,1.03	0.15 -0.24,0.55	-0.32 -1.02,0.39
MnBP	-0.48 -1.18,0.22	0.73 -0.36,1.83	0.01 -0.17,0.20	0.09 -0.19,0.36
Q2	-0.34 -3.13,2.46	**2.89* 0.56,5.23**	0.49 -0.20,1.18	0.11 -0.44,0.67
Q3	-1.26 -3.71,1.18	**4.06** 1.65,6.46**	0.35 -0.10,0.79	0.09 -0.53,0.71
Q4	-1.12 -3.48,1.24	1.90 -0.44,4.24	0.17 -0.39,0.73	-0.09 -0.93,0.75
MiBP	-0.15 -1.28,0.99	**1.78*** .92,2.65**	-0.00 -0.24,0.23	0.12 -0.14,0.39
Q2	-0.49 -2.65,1.67	**2.56** 0.84,4.27**	-0.04 -0.80,0.73	**0.40* 0.09,0.72**
Q3	-0.95 -3.83,1.93	**3.01* 0.12,5.89**	0.25 -0.36,0.86	0.50 -0.18,1.18
Q4	-0.38 -2.71,1.95	**3.35** 1.05,5.65**	-0.02 -0.55,0.51	0.38 -0.30,1.06
McPP	-0.45 -1.67,0.77	0.28 -1.27,1.83	0.17 -0.11,0.45	-0.02 -0.26,0.21
Q2	0.77 -2.10,3.65	**2.05+ -0.19,4.30**	0.37 -0.32,1.06	**0.42+ -0.06,0.91**
Q3	0.12 -2.89,3.13	1.57 -0.96,4.09	**0.39+ -0.01,0.79**	**0.71* 0.13,1.29**
Q4	0.39 -2.80,3.57	1.22 -1.68,4.12	**0.60* 0.03,1.16**	0.45 -0.26,1.16
MBzP	**-0.72* -1.45,-0.00**	-0.08 -0.86,0.71	-0.00 -0.20,0.19	0.04 -0.13,0.20
Q2	-1.68 -5.87,2.52	2.07 -0.48,4.62	0.12 -0.48,0.72	0.03 -0.60,0.67
Q3	-3.04 -7.27,1.18	**2.88* 0.44,5.32**	**0.47+ -0.07,1.01**	**0.37+ -0.07,0.82**
Q4	-3.10 -7.21,1.02	0.87 -1.15,2.89	-0.04 -0.43,0.34	0.11 -0.29,0.51
∑ DEHP	0.40 -0.60,1.41	0.14 -0.51,0.80	0.16 -0.07,0.40	-0.11 -0.31,0.10
Q2	-0.67 -3.56,2.22	1.93 -0.78,4.64	0.19 -0.53,0.92	**0.46* 0.02,0.89**
Q3	-0.72 -2.83,1.38	0.23 -2.37,2.82	0.14 -0.57,0.84	0.00 -0.55,0.56
Q4	-0.57 -2.92,1.77	0.97 -1.96,3.89	0.28 -0.28,0.83	-0.28 -0.98,0.42
MEHP	0.85 -0.30,2.01	0.03 -0.63,0.69	**0.28* 0.03,0.53**	-0.09 -0.29,0.11
Q2	-0.44 -3.16,2.28	**2.92* 0.45,5.39**	0.10 -0.57,0.77	0.28 -0.41,0.98
Q3	1.26 -0.80,3.33	0.55 -1.71,2.81	0.27 -0.15,0.68	**0.64* 0.03,1.24**
Q4	0.88 -1.78,3.54	0.92 -0.93,2.78	**0.61* 0.10,1.13**	-0.20 -0.76,0.35
MEHHP	0.25 -0.73,1.23	0.08 -0.56,0.73	0.16 -0.05,0.37	-0.09 -0.31,0.13
Q2	-1.50 -4.24,1.23	**2.97+ -0.25,6.19**	0.46 -0.31,1.22	**0.39+ -0.04,0.83**
Q3	-1.15 -3.64,1.35	-0.53 -3.04,1.98	0.35 -0.20,0.90	-0.00 -0.59,0.58
Q4	-1.53 -4.10,1.04	0.79 -2.00,3.58	**0.48+ -0.05,1.01**	-0.22 -0.95,0.51
MEOHP	0.38 -0.62,1.38	0.21 -0.47,0.89	0.18 -0.05,0.41	-0.12 -0.35,0.11
Q2	-0.10 -2.56,2.36	**3.76** 1.15,6.38**	0.36 -0.29,1.01	0.31 -0.11,0.72
Q3	-0.41 -2.85,2.03	1.33 -1.11,3.76	0.25 -0.40,0.89	-0.31 -0.78,0.17
Q4	-0.13 -2.47,2.20	1.74 -0.69,4.16	0.38 -0.12,0.88	-0.45 -1.16,0.26
MECPP	0.51 -0.54,1.56	0.14 -0.55,0.83	0.15 -0.12,0.41	-0.14 -0.34,0.07

Q2	-0.64 -3.32,2.04	1.07 -1.11,3.25	**0.53+ -0.07,1.12**	0.17 -0.20,0.55
Q3	-1.15 -3.30,1.00	0.25 -2.29,2.79	0.40 -0.18,0.97	-0.09 -0.51,0.33
Q4	-0.24 -2.57,2.08	0.09 -2.81,2.99	0.31 -0.38,1.00	-0.45 -1.14,0.23

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.14. Association between urinary phthalate metabolites and mumps antibodies among female children and adults, NHANES 2003-2004 and 2009-2010.

Variables	2003-2004		2009-2010	
	Children	Adults	Children	Adults
MEP	**0.19** 0.06,0.32**	**-0.14* -0.27,-0.01**	-0.06 -0.35,0.24	-0.04 -0.19,0.11
Q2	0.20 -0.48,0.88	-0.43 -1.16,0.30	0.07 -0.93,1.07	0.09 -0.47,0.66
Q3	0.36 -0.27,0.99	**-0.91* -1.59,-0.22**	-0.03 -1.04,0.98	-0.26 -0.78,0.26
Q4	**0.65* 0.11,1.20**	**-0.86* -1.60,-0.12**	0.10 -1.18,1.39	-0.10 -0.79,0.59
∑ DBP	**0.22* 0.06,0.38**	-0.01 -0.33,0.31	-0.10 -0.47,0.26	**-0.24+ -0.53,0.04**
Q2	0.17 -0.65,0.99	-0.33 -0.98,0.33	-0.18 -1.12,0.75	-0.31 -0.93,0.30
Q3	0.43 -0.37,1.24	-0.44 -1.39,0.51	-0.35 -1.38,0.69	-0.39 -1.02,0.24
Q4	**0.77* 0.11,1.42**	-0.39 -1.25,0.47	-0.32 -1.25,0.62	-0.43 -1.28,0.43
MnBP	**0.14+ -0.02,0.29**	0.05 -0.29,0.40	-0.17 -0.60,0.26	-0.02 -0.23,0.18
Q2	0.29 -0.39,0.96	0.34 -0.35,1.04	-0.63 -1.42,0.15	-0.20 -0.66,0.27
Q3	0.37 -0.23,0.97	-0.19 -0.97,0.59	-0.48 -1.44,0.47	0.10 -0.28,0.48
Q4	0.39 -0.14,0.91	0.10 -0.81,1.01	-0.43 -1.36,0.50	0.13 -0.51,0.77
MiBP	0.09 -0.11,0.30	-0.08 -0.58,0.42	-0.01 -0.32,0.30	0.14 -0.12,0.40
Q2	0.32 -0.15,0.80	-0.39 -0.99,0.20	-0.59 -1.93,0.75	**-0.58* -1.05,-0.10**
Q3	**0.39+ -0.02,0.80**	-0.34 -1.34,0.66	**-0.68+ -1.38,0.02**	-0.14 -0.44,0.17
Q4	0.07 -0.69,0.84	0.09 -0.84,1.03	-0.64 -1.63,0.36	0.26 -0.20,0.72
McPP	0.31 -0.10,0.72	0.24 -0.17,0.65	-0.01 -0.37,0.34	-0.15 -0.41,0.11
Q2	0.00 -0.55,0.56	0.17 -0.32,0.65	-0.33 -1.40,0.74	0.01 -0.46,0.48
Q3	0.39 -0.29,1.07	0.16 -0.56,0.88	0.10 -0.74,0.94	0.02 -0.58,0.62
Q4	0.43 -0.35,1.20	0.64 -0.42,1.70	-0.04 -0.69,0.62	-0.25 -0.85,0.34
MBzP	**0.20* 0.05,0.35**	-0.07 -0.34,0.19	-0.11 -0.44,0.21	-0.14 -0.39,0.12
Q2	0.26 -0.59,1.11	-0.06 -0.84,0.71	0.17 -0.79,1.13	-0.11 -0.59,0.37
Q3	0.42 -0.40,1.24	-0.54 -1.34,0.27	-0.41 -1.16,0.34	-0.38 -1.13,0.36
Q4	**0.77* 0.17,1.38**	-0.24 -1.15,0.66	-0.11 -1.14,0.93	-0.14 -0.79,0.51
∑ DEHP	-0.09 -0.22,0.03	-0.09 -0.37,0.20	0.19 -0.10,0.47	-0.15 -0.41,0.11
Q2	-0.16 -0.77,0.44	-0.27 -0.98,0.43	-0.02 -0.81,0.78	-0.04 -0.56,0.48
Q3	0.35 -0.27,0.97	-0.52 -1.41,0.37	0.26 -0.32,0.84	0.17 -0.59,0.93
Q4	-0.11 -0.57,0.34	-0.39 -1.32,0.54	0.44 -0.59,1.48	-0.03 -0.83,0.77
MEHP	-0.08 -0.22,0.06	-0.02 -0.37,0.32	0.19 -0.17,0.54	**-0.20+ -0.42,0.02**
Q2	0.28 -0.26,0.82	-0.23 -0.88,0.42	-0.35 -0.95,0.25	**-0.33* -0.62,-0.03**
Q3	0.17 -0.36,0.69	-0.24 -0.76,0.29	0.37 -0.49,1.22	-0.26 -0.86,0.34
Q4	-0.09 -0.48,0.31	-0.25 -0.94,0.43	0.15 -0.60,0.90	**-0.49+ -1.03,0.05**
MEHHP	-0.09 -0.22,0.03	-0.10 -0.38,0.17	0.21 -0.07,0.48	-0.14 -0.38,0.09
Q2	-0.24 -0.81,0.34	0.10 -0.80,1.00	-0.20 -1.00,0.59	-0.06 -0.61,0.48
Q3	0.28 -0.26,0.82	-0.25 -1.07,0.58	0.25 -0.37,0.87	0.14 -0.52,0.79
Q4	-0.06 -0.52,0.40	-0.34 -1.33,0.64	0.30 -0.69,1.29	-0.40 -1.10,0.30
MEOHP	-0.09 -0.22,0.03	-0.06 -0.36,0.24	0.18 -0.12,0.49	-0.16 -0.42,0.11
Q2	0.01 -0.67,0.70	0.12 -0.53,0.77	-0.13 -1.01,0.76	-0.25 -0.71,0.21
Q3	0.51 -0.12,1.14	-0.22 -1.07,0.64	0.02 -0.46,0.51	0.21 -0.60,1.02
Q4	-0.02 -0.55,0.51	-0.25 -1.25,0.75	0.25 -0.75,1.25	-0.23 -0.89,0.43
MECPP	-0.10 -0.24,0.05	-0.10 -0.39,0.18	0.17 -0.12,0.47	-0.13 -0.42,0.17

Q2	-0.26 -1.28,0.77	-0.52 -1.41,0.38	-0.43 -1.21,0.35	-0.12 -0.66,0.41
Q3	0.18 -0.46,0.82	-0.59 -1.61,0.42	0.36 -0.37,1.09	0.02 -0.70,0.74
Q4	-0.17 -0.79,0.44	-0.48 -1.44,0.49	0.00 -0.90,0.91	-0.14 -0.96,0.67

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.15. Association between urinary phthalate metabolites and mumps antibodies among male children and adults, NHANES 2003-2004 and 2009-2010.

Variables	2003-2004 Children	2003-2004 Adults	2009-2010 Children	2009-2010 Adults
MEP	0.04 -0.12,0.20	0.02 -0.12,0.16	0.03 -0.19,0.24	-0.07 -0.21,0.07
Q2	0.09 -0.54,0.72	-0.37 -1.10,0.36	**0.62+ -0.05,1.29**	-0.10 -0.50,0.30
Q3	0.14 -0.34,0.61	-0.25 -1.06,0.56	0.32 -0.38,1.01	-0.12 -0.55,0.30
Q4	0.22 -0.43,0.88	-0.10 -0.88,0.68	0.14 -0.58,0.86	-0.25 -0.74,0.25
∑ DBP	0.03 -0.20,0.26	-0.03 -0.19,0.14	0.16 -0.05,0.37	-0.10 -0.38,0.19
Q2	0.00 -0.45,0.45	0.04 -0.41,0.50	-0.32 -1.07,0.42	-0.10 -0.59,0.39
Q3	-0.06 -0.63,0.50	0.15 -0.35,0.66	0.15 -0.63,0.94	0.09 -0.66,0.84
Q4	-0.23 -0.82,0.36	-0.02 -0.52,0.47	0.12 -0.55,0.79	-0.13 -0.93,0.67
MnBP	0.01 -0.19,0.20	-0.08 -0.30,0.14	0.00 -0.24,0.25	0.07 -0.24,0.39
Q2	-0.23 -0.69,0.22	0.24 -0.63,1.10	0.19 -0.59,0.96	0.01 -0.41,0.42
Q3	**-0.53+ -1.12,0.06**	-0.07 -0.80,0.67	0.20 -0.45,0.85	0.12 -0.61,0.85
Q4	-0.24 -0.75,0.26	-0.20 -1.14,0.75	0.11 -0.63,0.84	**0.68+ -0.12,1.47**
MiBP	-0.15 -0.39,0.09	-0.07 -0.34,0.2	-0.04 -0.41,0.33	0.13 -0.21,0.47
Q2	-0.03 -0.85,0.79	0.06 -0.47,0.59	-0.14 -0.76,0.48	-0.27 -0.92,0.37
Q3	-0.28 -1.07,0.51	-0.08 -0.61,0.44	-0.14 -0.93,0.65	-0.09 -0.82,0.64
Q4	-0.08 -0.88,0.73	-0.16 -0.81,0.49	-0.24 -1.16,0.69	0.18 -0.74,1.11
McPP	**-0.22+ -0.47,0.02**	0.14 -0.20,0.49	**0.25* 0.05,0.45**	-0.10 -0.30,0.11
Q2	-0.49 -1.53,0.55	**0.35+ -0.06,0.76**	-0.02 -0.75,0.71	0.25 -0.45,0.94
Q3	-0.32 -1.12,0.48	**0.64* 0.17,1.11**	-0.08 -0.85,0.68	0.08 -0.45,0.60
Q4	-0.58 -1.37,0.22	0.51 -0.13,1.15	0.39 -0.30,1.09	-0.12 -0.63,0.38
MBzP	0.04 -0.20,0.28	-0.06 -0.24,0.11	0.06 -0.16,0.28	-0.13 -0.35,0.09
Q2	-0.19 -1.13,0.75	**0.51* 0.01,1.00**	-0.16 -0.81,0.49	-0.15 -0.48,0.18
Q3	-0.54 -1.54,0.47	0.22 -0.26,0.70	0.01 -0.72,0.75	0.01 -0.40,0.42
Q4	-0.20 -1.32,0.93	**0.39* 0.03,0.75**	-0.07 -0.86,0.71	-0.02 -0.83,0.80
∑ DEHP	-0.16 -0.36,0.04	0.03 -0.06,0.12	**0.17+ -0.02,0.35**	0.04 -0.18,0.27
Q2	-0.15 -0.68,0.39	0.18 -0.38,0.73	-0.45 -1.18,0.28	0.27 -0.10,0.64
Q3	-0.11 -0.65,0.42	0.12 -0.34,0.59	0.13 -0.64,0.90	0.35 -0.10,0.79
Q4	**-0.52* -1.00,-0.03**	-0.04 -0.36,0.28	0.30 -0.44,1.05	0.29 -0.51,1.09
MEHP	-0.07 -0.30,0.16	-0.05 -0.17,0.07	0.10 -0.14,0.34	0.07 -0.23,0.38
Q2	-0.15 -0.62,0.32	0.30 -0.32,0.91	-0.21 -0.65,0.23	0.27 -0.12,0.66
Q3	0.13 -0.35,0.62	-0.22 -0.62,0.19	-0.08 -0.51,0.35	**0.48+ -0.02,0.98**
Q4	-0.16 -0.69,0.37	-0.22 -0.53,0.09	0.06 -0.44,0.56	0.19 -0.45,0.84
MEHHP	**-0.18+ -0.37,0.01**	0.03 -0.05,0.12	**0.17+ -0.01,0.34**	0.06 -0.17,0.29
Q2	-0.52 -1.16,0.12	0.34 -0.12,0.80	0.08 -0.52,0.68	0.27 -0.14,0.68
Q3	-0.35 -1.05,0.36	-0.06 -0.59,0.48	0.18 -0.43,0.78	**0.54* 0.07,1.02**
Q4	**-0.86** -1.45,-.27**	0.04 -0.37,0.46	0.56 -0.29,1.41	0.18 -0.58,0.94
MEOHP	**-0.18* -0.36,-0.01**	0.03 -0.07,0.13	**0.18+ -0.02,0.38**	0.07 -0.19,0.33
Q2	-0.56 -1.46,0.34	0.30 -0.21,0.80	-0.24 -0.85,0.38	0.23 -0.15,0.61
Q3	-0.38 -1.17,0.41	0.09 -0.52,0.69	0.31 -0.33,0.95	0.20 -0.28,0.68
Q4	**-0.68* -1.28,-0.08**	-0.06 -0.47,0.35	0.39 -0.48,1.27	0.34 -0.48,1.16
MECPP	-0.15 -0.37,0.06	0.04 -0.07,0.14	**0.20* 0.01,0.39**	0.03 -0.18,0.24

Q2	-0.18 -0.64,0.27	0.10 -0.38,0.58	0.10 -0.62,0.81	0.05 -0.45,0.56
Q3	-0.20 -0.68,0.27	0.21 -0.33,0.74	0.21 -0.37,0.80	0.20 -0.20,0.60
Q4	**-0.52+ -1.11,0.07**	-0.01 -0.37,0.35	**0.72* 0.13,1.31**	0.24 -0.41,0.89

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.16. Association between urinary phthalate metabolites and rubella antibodies among female children and adults, NHANES 2003-2004 and 2009-2010.

Variables	2003-2004		2009-2010	
	Children	Adults	Children	Adults
MEP	-1.66 -5.37,2.04	0.30 -4.47,5.07	0.05 -0.12,0.21	**-0.08+ -0.17,0.01**
Q2	4.63 -17.61,26.87	10.46 -19.05,39.98	0.04 -0.66,0.74	-0.06 -0.59,0.48
Q3	1.86 -17.79,21.50	-13.69 -30.55,3.18	-0.04 -0.70,0.62	-0.31 -0.70,0.08
Q4	-3.89 -20.02,12.23	1.00 -23.92,25.92	0.44 -0.28,1.16	-0.31 -0.72,0.10
∑ DBP	0.49 -5.79,6.77	-5.15 -12.49,2.20	-0.14 -0.41,0.13	-0.03 -0.29,0.23
Q2	1.11 -16.56,18.78	**-13.88+ -29.72,1.97**	-0.10 -0.46,0.25	-0.08 -0.61,0.45
Q3	7.65 -13.44,28.75	-9.85 -32.58,12.87	-0.34 -0.77,0.10	-0.08 -0.73,0.57
Q4	4.92 -18.00,27.84	-1.72 -34.50,31.05	-0.19 -0.76,0.39	-0.19 -0.91,0.53
MnBP	0.12 -6.66,6.91	-3.72 -11.36,3.92	-0.05 -0.28,0.18	-0.05 -0.17,0.07
Q2	-6.41 -24.02,11.20	-10.77 -30.73,9.19	-0.33 -0.85,0.19	-0.18 -0.81,0.46
Q3	13.50 -7.10,34.11	**-21.49* -39.74,-3.24**	-0.28 -0.92,0.36	0.11 -0.31,0.52
Q4	-3.83 -23.31,15.66	-13.70 -33.53,6.14	-0.31 -1.24,0.62	-0.10 -0.59,0.40
MiBP	0.72 -4.99,6.43	-2.64 -14.19,8.90	0.17 -0.08,0.42	-0.03 -0.18,0.13
Q2	**14.69+ -0.89,30.27**	-9.28 -29.62,11.06	-0.18 -0.58,0.23	0.02 -0.45,0.49
Q3	1.47 -10.76,13.70	-13.14 -34.58,8.31	-0.10 -0.61,0.41	-0.07 -0.30,0.16
Q4	1.13 -11.02,13.28	-10.88 -28.45,6.69	0.13 -0.39,0.64	0.01 -0.48,0.49
McPP	-.05 -11.41,11.31	-6.12 -17.39,5.14	-0.13 -0.41,0.16	0.03 -0.11,0.16
Q2	3.75 -13.40,20.91	7.37 -13.97,28.70	**-0.37+ -0.79,0.05**	-0.24 -0.62,0.15
Q3	6.17 -10.95,23.29	**-17.69* -33.99,-1.38**	0.06 -0.60,0.72	0.02 -0.43,0.47
Q4	4.11 -17.69,25.92	-10.60 -33.70,12.50	-0.12 -0.77,0.53	-0.05 -0.42,0.32
MBzP	0.74 -4.98,6.46	**-5.23+ -11.17,.72**	-0.04 -0.25,0.16	-0.06 -0.32,0.20
Q2	-0.27 -19.63,19.09	-13.34 -37.80,11.13	0.03 -0.22,0.28	-0.16 -0.50,0.19
Q3	6.45 -14.14,27.05	-13.00 -33.71,7.70	-0.22 -0.54,0.11	-0.09 -0.61,0.43
Q4	2.01 -20.32,24.34	**-17.54* -33.42,-1.66**	0.08 -0.47,0.64	0.01 -0.65,0.67
∑ DEHP	0.13 -4.91,5.17	**-5.11+ -10.55,.33**	-0.08 -0.27,0.10	-0.10 -0.31,0.10
Q2	-0.18 -23.86,23.50	-13.05 -36.72,10.62	0.07 -0.38,0.52	-0.29 -0.68,0.09
Q3	7.71 -10.59,26.00	-17.86 -39.72,4.01	0.06 -0.24,0.36	-0.31 -0.81,0.19
Q4	3.84 -22.67,30.34	-11.33 -29.06,6.40	-0.07 -0.63,0.49	-0.43 -1.00,0.15
MEHP	2.32 -2.25,6.89	-3.58 -10.74,3.59	-0.12 -0.40,0.15	-0.06 -0.23,0.11
Q2	4.09 -9.82,17.99	-5.67 -24.78,13.43	**-0.37* -0.67,-0.08**	**-0.19+ -0.41,0.04**
Q3	9.03 -6.21,24.27	-0.56 -19.79,18.68	-0.01 -0.53,0.51	-0.32 -0.78,0.13
Q4	3.92 -9.65,17.50	-3.67 -22.37,15.04	-0.35 -0.88,0.18	-0.17 -0.57,0.23
MEHHP	0.45 -4.38,5.27	-4.41 -9.94,1.12	-0.08 -0.26,0.10	-0.10 -0.30,0.09
Q2	1.23 -21.97,24.44	-5.81 -31.67,20.05	0.08 -0.45,0.60	-0.22 -0.60,0.16
Q3	7.33 -12.08,26.73	-15.30 -39.09,8.49	0.18 -0.17,0.52	-0.28 -0.70,0.15
Q4	4.98 -20.30,30.25	-8.96 -29.52,11.60	-0.09 -0.52,0.34	**-0.50+ -1.09,0.09**
MEOHP	0.21 -4.84,5.25	-4.56 -10.24,1.12	-0.09 -0.28,0.11	-0.11 -0.32,0.09
Q2	-2.80 -28.33,22.73	-0.22 -23.94,23.50	0.07 -0.49,0.62	**-0.33* -0.65,-0.01**
Q3	9.10 -12.92,31.12	-13.08 -33.72,7.56	-0.01 -0.37,0.34	-0.37 -0.88,0.14
Q4	1.78 -25.29,28.84	-8.62 -29.65,12.41	-0.16 -0.65,0.33	**-0.48+ -1.02,0.06**
MECPP	-0.27 -5.56,5.03	**-6.09* -11.48,-.69**	-0.08 -0.27,0.12	-0.10 -0.32,0.11

Q2	6.78 -11.80,25.37	-16.40 -42.45,9.65	-0.14 -0.62,0.34	-0.18 -0.63,0.27
Q3	1.84 -13.53,17.22	-15.51 -37.87,6.86	-0.19 -0.80,0.41	-0.31 -0.83,0.21
Q4	2.75 -18.72,24.22	**-14.90+ -32.60,2.79**	-0.29 -0.82,0.25	-0.38 -0.94,0.17

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.17 Association between urinary phthalate metabolites and rubella antibodies among male children and adults, NHANES 2003-2004 and 2009-2010.

Variables	2003-2004 Children	2003-2004 Adults	2009-2010 Children	2009-2010 Adults
MEP	4.24 -1.85,10.34	3.13 -2.93,9.19	0.09 -0.15,0.32	**0.16** 0.06,0.26**
Q2	-11.00 -33.29,11.29	-1.96 -25.06,21.14	0.34 -0.28,0.96	0.21 -0.28,0.71
Q3	-4.69 -26.83,17.44	-6.75 -35.51,22.00	-0.14 -0.80,0.53	0.42 -0.16,1.00
Q4	7.13 -19.31,33.57	-0.10 -21.59,21.39	0.33 -0.47,1.14	**0.62** 0.24,1.01**
∑ DBP	-3.37 -11.42,4.67	-1.92 -13.99,10.15	-0.07 -0.41,0.26	**-0.18+ -0.38,0.02**
Q2	0.77 -12.10,13.64	7.02 -18.59,32.64	-0.61 -1.58,0.36	-0.10 -0.48,0.28
Q3	-5.61 -20.68,9.46	5.19 -19.52,29.91	-0.42 -1.32,0.49	-0.22 -0.80,0.36
Q4	-3.84 -21.29,13.61	-13.31 -48.01,21.39	-0.59 -1.59,0.40	-0.41 -1.09,0.26
MnBP	0.27 -5.49,6.04	4.18 -3.34,11.70	-0.19 -0.58,0.20	-0.08 -0.26,0.10
Q2	-2.92 -25.45,19.61	**23.32+ -2.26,48.90**	0.07 -0.85,0.98	-0.40 -1.01,0.21
Q3	-12.24 -34.29,9.81	19.49 -7.84,46.83	-0.15 -1.11,0.81	0.25 -0.39,0.88
Q4	4.05 -22.01,30.11	7.90 -16.64,32.45	-0.28 -1.29,0.72	0.17 -0.47,0.81
MiBP	-0.79 -8.89,7.32	5.20 -2.36,12.76	-0.25 -0.74,0.23	**-0.20* -0.38,-0.01**
Q2	-14.28 -43.79,15.23	-1.08 -10.32,8.16	-0.46 -1.50,0.59	**-0.46+ -0.98,0.05**
Q3	**-25.73* -50.91,-.55**	-12.20 -29.47,5.07	-0.45 -1.70,0.80	**-0.63* -1.15,-0.12**
Q4	-15.81 -44.58,12.96	18.86 -12.57,50.30	-0.50 -1.87,0.87	**-0.61+ -1.31,0.08**
McPP	-6.27 -18.33,5.79	1.24 -14.23,16.70	0.06 -0.24,0.35	-0.21 -0.47,0.06
Q2	4.78 -23.58,33.13	-0.57 -16.57,15.44	-0.12 -0.93,0.70	-0.00 -0.51,0.51
Q3	-16.29 -37.79,5.21	-6.18 -35.34,22.98	-0.48 -1.38,0.42	0.12 -0.34,0.59
Q4	-5.62 -30.22,18.97	4.52 -24.81,33.85	0.15 -0.76,1.07	-0.20 -0.83,0.43
MBzP	-2.73 -9.80,4.34	-2.34 -13.07,8.39	-0.13 -0.48,0.22	-0.07 -0.24,0.09
Q2	-6.67 -39.20,25.86	**20.62+ -1.90,43.13**	-0.24 -1.20,0.73	-0.17 -0.57,0.23
Q3	**-27.42+ -57.06,2.21**	**20.66* 2.06,39.27**	-0.21 -1.19,0.77	-0.06 -0.41,0.29
Q4	-18.59 -54.16,16.99	5.15 -26.25,36.55	-0.59 -1.77,0.60	0.04 -0.60,0.68
∑ DEHP	-1.98 -8.07,4.11	**-3.97+ -8.56,0.62**	-0.01 -0.26,0.24	-0.14 -0.32,0.04
Q2	-11.19 -35.54,13.16	19.50 -7.03,46.03	-0.24 -1.14,0.65	-0.12 -0.44,0.20
Q3	-10.89 -36.32,14.54	3.16 -18.98,25.30	-0.09 -0.81,0.62	**-0.43+ -0.92,0.07**
Q4	-10.69 -33.12,11.75	-8.15 -32.04,15.74	-0.15 -0.81,0.50	**-0.64* -1.27,-0.01**
MEHP	1.23 -4.55,7.01	-4.07 -11.00,2.87	0.11 -0.03,0.26	-0.12 -0.29,0.05
Q2	-5.56 -28.25,17.13	-1.41 -24.68,21.87	0.10 -0.58,0.78	0.38 -0.14,0.89
Q3	7.52 -12.39,27.44	3.92 -15.73,23.57	0.04 -0.32,0.40	-0.05 -0.57,0.47
Q4	-0.62 -15.62,14.39	-4.92 -20.57,10.74	0.21 -0.25,0.68	-0.29 -0.73,0.15
MEHHP	-2.65 -8.33,3.02	**-4.09+ -8.42,0.25**	-0.02 -0.23,0.19	-0.15 -0.32,0.03
Q2	-6.96 -36.30,22.39	14.38 -10.43,39.19	0.08 -0.52,0.69	**-0.30+ -0.62,0.01**
Q3	-4.98 -31.11,21.15	6.62 -17.76,30.99	0.12 -0.50,0.75	-0.30 -0.86,0.27
Q4	-13.86 -36.80,9.09	-10.62 -30.44,9.21	0.12 -0.32,0.56	**-0.72* -1.40,-0.04**
MEOHP	-2.15 -8.19,3.90	**-4.29+ -8.92,0.35**	-0.01 -0.26,0.24	-0.15 -0.35,0.04
Q2	-16.12 -42.54,10.30	16.98 -8.16,42.12	-0.08 -1.02,0.86	-0.20 -0.56,0.17
Q3	-13.76 -39.44,11.91	12.36 -11.21,35.93	-0.12 -0.92,0.68	**-0.56* -1.11,-0.02**
Q4	-15.98 -38.26,6.29	-6.90 -25.54,11.73	-0.02 -0.62,0.58	**-0.60+ -1.21,0.01**
MECPP	-1.58 -8.06,4.90	**-4.30+ -9.19,0.59**	-0.00 -0.27,0.27	-0.13 -0.31,0.06

Q2	1.04 -26.74,28.82	21.28 -8.05,50.61	0.13 -0.99,1.25	-0.22 -0.54,0.09
Q3	-7.14 -31.62,17.35	2.47 -18.88,23.83	-0.05 -0.91,0.82	**-0.55* -0.98,-0.12**
Q4	-2.62 -24.61,19.38	-5.66 -29.10,17.77	0.24 -0.63,1.11	**-0.62* -1.19,-0.06**

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.18. Association between urinary phthalate metabolites and polio serotype 1 antibodies by sex and age, NHANES 2009-2010.

Variables	Female		Male	
	Children	Adults	Children	Adults
MEP	-0.20 -0.45,0.05	**-0.16+ -0.32,0.01**	-0.14 -0.14,-0.14	0.11 -0.20,0.41
Q2	-0.78 -2.08,0.52	0.29 -0.56,1.13	-0.19 -0.19,-0.19	-0.20 -1.00,0.59
Q3	**-1.06+ -2.24,0.12**	-0.17 -1.01,0.68	-0.87 -0.87,-0.87	0.23 -0.46,0.92
Q4	-0.77 -1.75,0.21	-0.84 -1.88,0.20	-0.47 -0.47,-0.47	0.43 -0.91,1.76
∑ DBP	-0.25 -0.65,0.16	0.14 -0.54,0.82	-0.06 -0.06,-0.06	-0.07 -0.52,0.37
Q2	-0.87 -2.08,0.34	0.20 -1.01,1.40	-1.45 -1.45,-1.45	0.26 -0.44,0.97
Q3	**-1.00+ -2.13,0.12**	0.27 -1.02,1.55	-0.37 -0.37,-0.37	0.19 -0.90,1.27
Q4	-0.91 -2.32,0.50	0.53 -1.19,2.26	-0.71 -0.71,-0.71	0.22 -1.01,1.46
MnBP	-0.42 -1.00,0.16	-0.11 -0.50,0.28	0.08 0.08,0.08	-0.23 -0.67,0.20
Q2	**-1.18* -2.15,-0.20**	0.05 -0.74,0.84	-0.28 -0.28,-0.28	-0.07 -0.94,0.80
Q3	**-1.22+ -2.44,0.01**	-0.42 -1.42,0.58	0.22 0.22,0.22	-0.08 -1.13,0.98
Q4	**-1.76+ -3.57,0.04**	-0.23 -1.18,0.72	0.27 0.27,0.27	0.12 -1.34,1.58
MiBP	-0.25 -0.73,0.22	-0.10 -0.66,0.46	-0.40 -0.40,-0.40	-0.28 -1.03,0.46
Q2	-0.92 -2.07,0.23	0.08 -1.16,1.32	-0.55 -0.55,-0.55	-0.32 -1.10,0.47
Q3	**-2.14* -3.83,-0.45**	-0.19 -1.59,1.21	-0.89 -0.89,-0.89	-0.61 -2.15,0.94
Q4	**-1.49* -2.73,-0.25**	-0.36 -2.16,1.44	-0.59 -0.59,-0.59	-0.34 -2.06,1.38
McPP	-0.15 -0.63,0.33	0.18 -0.33,0.69	0.06 0.06,0.06	**-0.37+ -0.76,0.02**
Q2	-0.50 -1.94,0.93	0.48 -0.34,1.30	-0.89 -0.89,-0.89	-0.31 -1.17,0.55
Q3	-0.56 -1.45,0.34	0.11 -1.33,1.55	-1.04 -1.04,-1.04	**-0.61* -1.19,-0.04**
Q4	-0.52 -1.49,0.44	0.56 -0.73,1.85	-0.05 -0.05,-0.05	**-0.98* -1.91,-0.06**
MBzP	-0.26 -0.71,0.18	0.07 -0.52,0.65	-0.11 -0.11,-0.11	0.06 -0.39,0.51
Q2	-0.42 -1.51,0.66	0.02 -0.86,0.91	-0.36 -0.36,-0.36	0.16 -0.58,0.89
Q3	**-1.35+ -2.83,0.14**	-0.02 -0.88,0.84	0.24 0.24,0.24	-0.02 -0.82,0.78
Q4	-0.62 -1.99,0.75	0.33 -1.32,1.99	-0.70 -0.70,-0.70	0.71 -0.73,2.15
∑ DEHP	-0.20 -0.67,0.26	0.12 -0.40,0.64	-0.19 -0.19,-0.19	**-0.28** -0.49,-0.08**
Q2	0.44 -0.54,1.42	-0.56 -1.51,0.40	-0.82 -0.82,-0.82	-0.05 -0.93,0.82
Q3	0.27 -0.74,1.28	-0.57 -1.85,0.71	-0.33 -0.33,-0.33	**-1.04+ -2.22,0.14**
Q4	0.16 -1.35,1.68	0.52 -0.87,1.91	-1.01 -1.01,-1.01	**-1.20* -2.19,-0.21**
MEHP	-0.22 -0.73,0.29	0.16 -0.28,0.60	-0.27 -0.27,-0.27	**-0.20+ -0.40,0.01**
Q2	-0.10 -0.55,0.35	-0.34 -1.24,0.56	-0.38 -0.38,-0.38	-0.09 -0.76,0.58
Q3	-0.07 -0.91,0.77	-0.36 -1.43,0.70	-0.72 -0.72,-0.72	-0.18 -0.97,0.62
Q4	-0.84 -2.03,0.35	0.28 -0.72,1.29	-0.72 -0.72,-0.72	**-0.93* -1.80,-0.07**
MEHHP	-0.16 -0.64,0.32	0.18 -0.29,0.65	-0.22 -0.22,-0.22	**-0.28* -0.49,-0.08**
Q2	0.55 -0.16,1.25	-0.61 -1.68,0.46	-0.13 -0.13,-0.13	0.24 -0.55,1.03
Q3	0.76 -0.41,1.94	-0.24 -1.41,0.92	0.09 0.09,0.09	-0.86 -1.94,0.22
Q4	0.06 -1.23,1.35	0.31 -1.25,1.87	-0.81 -0.81,-0.81	**-1.00* -1.99,-0.01**
MEOHP	-0.25 -0.79,0.29	0.13 -0.41,0.66	-0.26 -0.26,-0.26	**-0.30* -0.54,-0.05**
Q2	0.38 -0.69,1.45	-0.53 -1.48,0.42	-0.50 -0.50,-0.50	-0.02 -0.87,0.83
Q3	-0.08 -1.02,0.87	-0.35 -1.44,0.74	0.04 0.04,0.04	**-1.01+ -2.20,0.19**
Q4	-0.03 -1.48,1.42	0.42 -1.18,2.02	-0.82 -0.82,-0.82	**-1.17* -2.18,-0.16**
MECPP	-0.24 -0.72,0.25	0.10 -0.47,0.67	-0.18 -0.18,-0.18	**-0.27* -0.47,-0.06**
Q2	**0.77+ -0.12,1.65**	**-0.65+ -1.43,0.13**	-0.93 -0.93,-0.93	-0.29 -1.19,0.61

Q3	**1.00+ -0.00,2.00**	-0.42 -1.85,1.00	-0.35 -0.35,-0.35	-0.81 -2.02,0.40
Q4	0.12 -0.94,1.18	0.25 -1.21,1.71	-0.44 -0.44,-0.44	**-1.47* -2.54,-0.39**

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.19. Association between urinary phthalate metabolites and polio serotype 2 antibodies by sex and age, NHANES 2009-2010.

Variables	Female		Male	
	Children	Adults	Children	Adults
MEP	**-0.22* -0.42,-0.02**	-0.05 -0.19,0.10	-0.18 -0.18,-0.18	0.02 -0.13,0.17
Q2	-0.32 -1.40,0.76	-0.18 -1.12,0.76	-0.29 -0.29,-0.29	-0.49 -1.13,0.16
Q3	-0.65 -2.01,0.72	-0.22 -0.90,0.46	-0.50 -0.50,-0.50	-0.18 -0.87,0.50
Q4	-0.58 -1.48,0.33	-0.40 -1.21,0.41	-0.52 -0.52,-0.52	-0.12 -0.75,0.50
∑ DBP	-0.06 -0.75,0.63	0.25 -0.13,0.63	0.20 0.20,0.20	0.25 -0.09,0.59
Q2	-0.37 -1.69,0.95	**0.69+ -0.11,1.49**	-0.88 -0.88,-0.88	-0.04 -0.96,0.87
Q3	-0.04 -1.83,1.76	0.72 -0.24,1.69	0.02 0.02,0.02	0.28 -0.86,1.42
Q4	-0.48 -2.62,1.65	**0.99* 0.02,1.96**	0.20 0.20,0.20	0.16 -1.14,1.47
MnBP	**-0.51+ -1.10,0.09**	0.08 -0.16,0.32	0.26 0.26,0.26	0.14 -0.19,0.47
Q2	-0.56 -1.84,0.72	0.54 -0.28,1.36	0.30 0.30,0.30	0.23 -0.20,0.66
Q3	**-1.73* -3.31,-0.16**	0.36 -0.46,1.17	0.80 0.80,0.80	0.47 -0.50,1.44
Q4	-1.05 -2.64,0.53	0.17 -0.53,0.88	0.83 0.83,0.83	0.82 -0.44,2.07
MiBP	**-0.67* -1.25,-0.10**	0.01 -0.30,0.31	0.07 0.07,0.07	0.16 -0.31,0.63
Q2	**-1.40** -2.34,-0.46**	0.60 -0.41,1.60	-0.68 -0.68,-0.68	-0.03 -0.80,0.74
Q3	**-2.08** -3.48,-0.68**	0.61 -0.25,1.47	-0.05 -0.05,-0.05	0.39 -0.48,1.26
Q4	**-2.40*** -3.54,-1.26**	0.33 -0.76,1.42	0.12 0.12,0.12	0.54 -0.74,1.83
McPP	-0.21 -0.79,0.38	0.17 -0.14,0.48	0.07 0.07,0.07	-0.17 -0.58,0.25
Q2	-0.28 -1.83,1.27	0.33 -0.54,1.20	-1.07 -1.07,-1.07	-0.57 -1.44,0.29
Q3	**-1.25+ -2.63,0.13**	0.23 -0.73,1.19	-1.22 -1.22,-1.22	-0.65 -1.54,0.24
Q4	-0.83 -2.41,0.74	0.51 -0.31,1.33	-0.10 -0.10,-0.10	-0.67 -1.80,0.46
MBzP	0.06 -0.66,0.77	0.24 -0.11,0.59	0.23 0.23,0.23	**0.39** 0.15,0.64**
Q2	-0.25 -1.51,1.02	0.58 -0.16,1.32	-0.08 -0.08,-0.08	0.36 -0.41,1.13
Q3	-0.20 -2.03,1.62	0.54 -0.38,1.46	0.21 0.21,0.21	0.52 -0.13,1.18
Q4	-0.04 -2.14,2.07	**0.98+ -0.03,2.00**	0.20 0.20,0.20	**1.43*** 0.68,2.18**
∑ DEHP	-0.10 -0.50,0.31	-0.01 -0.28,0.25	-0.04 -0.04,-0.04	0.07 -0.09,0.22
Q2	0.27 -1.17,1.70	0.08 -0.77,0.93	-0.58 -0.58,-0.58	-0.08 -0.72,0.56
Q3	0.02 -1.64,1.68	-0.49 -1.39,0.40	-0.12 -0.12,-0.12	0.04 -0.80,0.87
Q4	-0.03 -1.42,1.37	-0.46 -1.32,0.40	-0.52 -0.52,-0.52	0.13 -0.57,0.83
MEHP	-0.23 -0.80,0.34	-0.17 -0.44,0.10	-0.24 -0.24,-0.24	0.15 -0.07,0.38
Q2	0.17 -1.19,1.54	0.35 -0.09,0.80	-0.82 -0.82,-0.82	0.07 -0.62,0.75
Q3	-0.69 -1.94,0.56	-0.10 -0.80,0.60	-1.05 -1.05,-1.05	0.36 -0.22,0.94
Q4	-0.74 -2.28,0.80	-0.44 -1.04,0.16	-0.89 -0.89,-0.89	0.34 -0.24,0.91
MEHHP	-0.08 -0.50,0.33	-0.05 -0.28,0.19	-0.05 -0.05,-0.05	0.04 -0.11,0.20
Q2	0.42 -0.96,1.79	-0.04 -0.74,0.67	-0.44 -0.44,-0.44	0.28 -0.37,0.92
Q3	0.35 -1.35,2.04	-0.48 -1.30,0.35	0.42 0.42,0.42	0.12 -0.72,0.96
Q4	0.12 -1.26,1.50	-0.54 -1.29,0.22	-0.64 -0.64,-0.64	0.42 -0.20,1.03
MEOHP	-0.14 -0.55,0.28	-0.09 -0.36,0.19	-0.06 -0.06,-0.06	0.03 -0.14,0.20
Q2	0.55 -0.95,2.05	0.22 -0.66,1.11	-0.21 -0.21,-0.21	0.13 -0.57,0.82
Q3	0.10 -1.55,1.74	-0.50 -1.38,0.38	0.46 0.46,0.46	0.26 -0.31,0.82
Q4	-0.14 -1.54,1.27	-0.27 -1.26,0.71	-0.20 -0.20,-0.20	0.34 -0.33,1.00
MECPP	-0.09 -0.50,0.32	0.02 -0.28,0.32	-0.04 -0.04,-0.04	0.08 -0.09,0.26

Q2	0.20 -1.37,1.78	-0.09 -0.70,0.52	-0.62 -0.62,-0.62	0.18 -0.54,0.89
Q3	0.47 -0.95,1.89	-0.37 -1.38,0.63	-0.32 -0.32,-0.32	0.29 -0.51,1.08
Q4	-0.34 -1.92,1.24	-0.25 -1.18,0.67	0.13 0.13,0.13	0.11 -0.60,0.83

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.20. Association between urinary phthalate metabolites and polio serotype 3 antibodies by sex and age, NHANES 2009-2010.

Variables	Female		Male	
	Children	Adults	Children	AdultsM
MEP	-0.26 -0.65,0.14	**-0.18* -0.33,-0.03**	0.08 0.08,0.08	0.01 -0.18,0.21
Q2	-0.64 -1.79,0.51	0.18 -0.70,1.05	0.32 0.32,0.32	-0.21 -1.04,0.62
Q3	-0.94 -2.34,0.46	-0.45 -1.43,0.52	0.61 0.61,0.61	-0.29 -0.97,0.40
Q4	-0.60 -1.74,0.55	**-0.71+ -1.48,0.07**	0.16 0.16,0.16	0.25 -0.60,1.09
∑ DBP	-0.45 -1.21,0.31	-0.06 -0.55,0.43	0.31 0.31,0.31	0.18 -0.18,0.53
Q2	-0.64 -1.78,0.51	-0.42 -1.67,0.84	-1.83 -1.83,-1.83	**0.74** 0.22,1.26**
Q3	-0.60 -2.64,1.44	-0.15 -1.38,1.07	-0.07 -0.07,-0.07	0.53 -0.18,1.23
Q4	-1.25 -3.31,0.80	-0.04 -1.19,1.11	-0.03 -0.03,-0.03	0.58 -0.40,1.55
MnBP	-0.52 -1.21,0.16	-0.08 -0.40,0.24	0.30 0.30,0.30	0.06 -0.41,0.54
Q2	-0.54 -1.70,0.63	-0.01 -1.18,1.17	0.51 0.51,0.51	0.40 -0.12,0.92
Q3	**-1.61* -3.15,-0.06**	0.09 -1.03,1.20	0.84 0.84,0.84	**1.05* 0.12,1.97**
Q4	**-1.32+ -2.73,0.09**	-0.00 -0.99,0.98	1.01 1.01,1.01	0.55 -0.72,1.81
MiBP	**-0.80* -1.39,-0.21**	-0.20 -0.76,0.36	-0.17 -0.17,-0.17	-0.05 -0.45,0.34
Q2	-1.43 -3.29,0.44	-0.17 -1.83,1.48	-0.29 -0.29,-0.29	0.10 -0.81,1.00
Q3	**-2.20* -3.90,-0.51**	-0.60 -2.15,0.95	-0.65 -0.65,-0.65	0.31 -0.43,1.04
Q4	**-2.38* -4.21,-0.56**	-0.64 -2.72,1.43	0.11 0.11,0.11	-0.04 -0.90,0.82
McPP	-0.48 -1.37,0.40	-0.04 -0.42,0.34	0.39 0.39,0.39	-0.06 -0.49,0.38
Q2	-0.11 -1.72,1.49	0.07 -0.58,0.72	-0.08 -0.08,-0.08	-0.05 -0.92,0.82
Q3	**-1.71* -3.31,-0.11**	-0.41 -1.25,0.42	-0.19 -0.19,-0.19	0.12 -0.78,1.02
Q4	-1.63 -3.81,0.55	-0.13 -0.97,0.71	1.19 1.19,1.19	-0.18 -1.07,0.72
MBzP	-0.26 -1.00,0.47	-0.10 -0.59,0.38	0.32 0.32,0.32	0.19 -0.30,0.67
Q2	-0.74 -2.32,0.84	-0.35 -1.61,0.91	-1.10 -1.10,-1.10	0.65 -0.29,1.58
Q3	-0.60 -2.33,1.12	-0.31 -1.43,0.81	0.28 0.28,0.28	0.49 -0.56,1.55
Q4	-0.92 -2.72,0.89	-0.31 -1.50,0.89	0.12 0.12,0.12	**1.17+ -0.25,2.58**
∑ DEHP	-0.42 -0.97,0.14	0.04 -0.42,0.51	0.25 0.25,0.25	-0.06 -0.29,0.17
Q2	0.31 -1.37,1.99	-0.65 -1.77,0.47	-0.71 -0.71,-0.71	-0.08 -0.81,0.65
Q3	-0.35 -1.64,0.94	-0.39 -1.65,0.86	0.72 0.72,0.72	**-0.86+ -1.76,0.04**
Q4	-0.47 -2.36,1.43	0.18 -1.33,1.70	-0.26 -0.26,-0.26	-0.56 -1.29,0.18
MEHP	-0.28 -1.06,0.50	-0.01 -0.37,0.35	-0.13 -0.13,-0.13	-0.12 -0.40,0.15
Q2	0.28 -0.91,1.47	**-0.55+ -1.13,0.03**	-0.54 -0.54,-0.54	0.30 -0.35,0.95
Q3	-0.56 -1.58,0.46	**-0.75+ -1.63,0.13**	-0.70 -0.70,-0.70	**-0.54+ -1.09,0.01**
Q4	-0.93 -2.74,0.88	0.16 -0.67,0.98	-0.33 -0.33,-0.33	**-0.60* -1.18,-0.02**
MEHHP	-0.39 -0.96,0.17	0.04 -0.42,0.51	0.16 0.16,0.16	-0.04 -0.25,0.18
Q2	0.81 -0.63,2.25	-0.77 -1.73,0.18	-0.21 -0.21,-0.21	-0.05 -0.82,0.72
Q3	0.10 -1.22,1.42	-0.23 -1.40,0.94	1.28 1.28,1.28	-0.66 -1.64,0.33
Q4	-0.52 -2.15,1.11	0.06 -1.41,1.53	-0.18 -0.18,-0.18	-0.29 -0.86,0.28
MEOHP	**-0.51+ -1.08,0.06**	-0.01 -0.48,0.46	0.22 0.22,0.22	-0.03 -0.28,0.22
Q2	0.31 -1.03,1.66	-0.57 -1.50,0.35	-0.62 -0.62,-0.62	-0.12 -0.88,0.64
Q3	-0.33 -1.72,1.05	-0.24 -1.15,0.66	1.06 1.06,1.06	-0.23 -1.03,0.57
Q4	-0.65 -2.49,1.20	0.07 -1.19,1.33	0.25 0.25,0.25	-0.42 -1.12,0.28
MECPP	-0.44 -1.02,0.14	0.09 -0.40,0.59	0.33 0.33,0.33	-0.07 -0.33,0.20

Q2	0.66 -0.66,1.99	-0.77 -1.92,0.37	-0.76 -0.76,-0.76	0.59 -0.15,1.34
Q3	-0.13 -1.38,1.12	-0.38 -1.50,0.73	0.62 0.62,0.62	-0.47 -1.22,0.28
Q4	-0.61 -2.35,1.12	0.09 -1.36,1.55	0.85 0.85,0.85	-0.23 -0.99,0.54

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association.

Table S6.21. Association between urinary phthalate metabolites and Toxoplasma antibodies by sex and age, NHANES 2009-2010.

Variables	Female		Male	
	Children	Adults	Children	Adults
MEP	1.37 -2.89,5.62	-0.33 -2.57,1.90	-2.00 -2.00,-2.00	**-3.21* -6.22,-0.20**
Q2	5.55 -7.63,18.74	3.53 -3.39,10.46	-6.73 -6.73,-6.73	4.09 -9.78,17.96
Q3	-4.46 -13.92,4.99	-6.62 -17.19,3.95	-9.84 -9.84,-9.84	-2.52 -18.92,13.88
Q4	1.67 -19.69,23.03	-0.79 -9.68,8.09	-6.70 -6.70,-6.70	-7.35 -19.79,5.08
∑ DBP	-0.88 -6.20,4.44	-1.65 -5.84,2.54	-3.51 -3.51,-3.51	-3.69 -8.81,1.43
Q2	**22.75+ -.74,46.25**	0.00 -9.53,9.54	0.20 0.20,0.20	-4.47 -25.67,16.72
Q3	1.34 -10.97,13.64	4.24 -3.59,12.08	-0.77 -0.77,-0.77	0.81 -15.20,16.81
Q4	-2.32 -13.13,8.48	-4.42 -13.88,5.03	-7.97 -7.97,-7.97	-6.23 -22.32,9.86
MnBP	3.06 -2.89,9.01	0.03 -3.83,3.90	-2.59 -2.59,-2.59	-4.12 -9.83,1.59
Q2	19.26 -4.45,42.97	4.00 -4.58,12.58	5.39 5.39,5.39	-8.13 -25.27,9.01
Q3	2.61 -7.29,12.51	1.41 -9.39,12.21	-2.70 -2.70,-2.70	-3.63 -23.65,16.39
Q4	1.34 -8.56,11.24	0.61 -11.81,13.04	-5.89 -5.89,-5.89	-13.33 -31.54,4.87
MiBP	-0.69 -5.81,4.42	1.28 -8.45,11.01	-0.48 -0.48,-0.48	1.67 -7.96,11.30
Q2	9.22 -15.54,33.99	-0.94 -8.05,6.16	-5.26 -5.26,-5.26	2.08 -7.60,11.76
Q3	16.24 -4.53,37.01	2.99 -12.49,18.47	1.38 1.38,1.38	4.32 -11.44,20.09
Q4	11.36 -7.60,30.31	6.93 -15.64,29.51	0.23 0.23,0.23	-1.97 -19.90,15.95
McPP	-4.68 -10.75,1.40	**-2.55* -4.70,-0.39**	-2.88 -2.88,-2.88	-0.64 -6.36,5.09
Q2	**18.42+ -1.84,38.68**	7.23 -4.24,18.70	-11.22 -11.22,-11.22	2.62 -9.40,14.63
Q3	3.39 -8.54,15.32	-0.38 -6.24,5.47	-6.11 -6.11,-6.11	9.52 -6.74,25.77
Q4	-3.09 -16.08,9.90	-2.56 -11.82,6.71	-13.45 -13.45,-13.45	1.66 -13.49,16.80
MBzP	1.61 -5.36,8.58	0.04 -4.86,4.94	-3.20 -3.20,-3.20	-2.70 -8.82,3.42
Q2	9.95 -5.25,25.16	-1.04 -8.58,6.49	-1.40 -1.40,-1.40	**-15.05* -26.33,-3.77**
Q3	16.00 -8.06,40.06	3.95 -4.33,12.22	-2.29 -2.29,-2.29	4.24 -11.39,19.87
Q4	6.65 -14.26,27.56	-5.43 -18.39,7.53	-9.26 -9.26,-9.26	**-15.83* -29.74,-1.92**
∑ DEHP	-4.85 -11.90,2.19	3.51 -4.98,12.00	-2.64 -2.64,-2.64	-1.27 -5.67,3.13
Q2	-13.66 -31.67,4.35	**12.27** 4.38,20.15**	0.80 0.80,0.80	-1.37 -16.78,14.04
Q3	**-15.83* -31.28,-.38**	8.78 -5.48,23.04	-6.04 -6.04,-6.04	-8.12 -22.12,5.89
Q4	-24.38 -54.95,6.19	12.88 -17.44,43.19	-7.20 -7.20,-7.20	-8.08 -24.07,7.91
MEHP	-3.55 -9.93,2.82	3.54 -5.45,12.53	-2.51 -2.51,-2.51	-3.11 -8.00,1.77
Q2	**-16.44+ -34.68,1.79**	5.38 -5.42,16.18	5.31 5.31,5.31	7.91 -2.12,17.95
Q3	-5.76 -23.57,12.05	**9.17+ -1.05,19.39**	-2.75 -2.75,-2.75	4.28 -14.96,23.52
Q4	-15.61 -36.10,4.88	11.86 -12.49,36.21	-2.84 -2.84,-2.84	-4.35 -16.38,7.69
MEHHP	-4.76 -11.25,1.74	4.18 -5.24,13.61	-2.52 -2.52,-2.52	-1.46 -5.84,2.91
Q2	-11.22 -28.57,6.13	**9.32+ -1.19,19.84**	2.83 2.83,2.83	-3.78 -17.73,10.17
Q3	**-13.14+ -27.98,1.70**	11.15 -4.86,27.16	-4.85 -4.85,-4.85	-5.13 -21.46,11.20
Q4	-21.48 -48.57,5.61	9.36 -28.11,46.83	-4.99 -4.99,-4.99	-8.99 -25.93,7.95
MEOHP	-4.61 -11.37,2.15	3.87 -6.15,13.88	-3.00 -3.00,-3.00	-1.87 -6.63,2.89
Q2	-0.41 -21.63,20.82	**8.94+ -0.12,18.01**	2.54 2.54,2.54	-4.58 -20.57,11.41
Q3	-7.32 -22.88,8.24	10.14 -4.05,24.33	-4.95 -4.95,-4.95	**-11.91* -23.56,-0.27**
Q4	-15.89 -45.37,13.58	10.60 -24.30,45.51	-5.94 -5.94,-5.94	-10.13 -27.79,7.53
MECPP	-5.14 -12.97,2.69	2.76 -5.09,10.61	-2.65 -2.65,-2.65	-0.63 -5.14,3.88

Q2	-10.79 -37.52,15.94	**5.74* 0.17,11.31**	1.17 1.17,1.17	1.53 -14.63,17.69
Q3	-6.40 -26.33,13.53	4.46 -6.53,15.45	-6.70 -6.70,-6.70	-6.03 -22.97,10.91
Q4	-19.05 -50.39,12.28	9.43 -12.66,31.52	-7.72 -7.72,-7.72	-2.95 -16.63,10.73

Columns contain β and 95% CI. First row with chemical name is continuous estimate. Rows with Q2, Q3, and Q4 are dose-response analysis of quartile with Q1 as reference category. Bolding indicates statistically significant association

APPENDIX B. CHAPTER 6 ADDITIONAL ANALYSES

Supplement Table S6.22 is a comparison of models tested for a single phthalate metabolite and single antibody pair to inform Paper 2. First, unadjusted models were fit with the congener concentration predicting each antibody titer separately in Model 1. In subsequent models, control variables were added for sociodemographics (Model 2), health behaviors (Model 3), and immune health status (Model 4), respectively. These models were run with the entire sample first then stratified by sex, age, and birthplace subgroups, respectively. Models were run on the full sample and were not adjusted for creatinine. In these models, chemical concentrations are continuous measures. Because different concentrations of chemicals could potentially generate a range of biological effects, sensitivity analysis was conducted with the phthalate concentrations using quartiles with the lowest quartile as the reference group.

Model 1: $Y_{[antibody]} = a + b_f chemical + e$

Model 2: $Y_{[antibody]} = a + b_f chemical + b_b demographics + e$

Model 3: $Y_{[antibody]} = a + b_f chemical + b_b demographics + b_b healthbehavior + e$

Model 4: $Y_{[antibody]} = a + b_f chemical + b_b demographics + b_b healthbehavior + b_c healthstatus + e$

Supplemental Table 6.22. Estimated association (95% CI) between phthalate metabolites and antibody titers without creatinine adjustment. NHANES 2003-2004, 2009-2010, and 2003-2010.

	Measles 2003-2004				Measles 2009-2010			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.17 -2.98,3.33	0.08 -0.32,0.48	0.11 -0.30,0.52	0.12 -0.29,0.52	0.04 -0.03,0.11	0.01 -0.06,0.09	0.03 -0.05,0.10	0.03 -0.05,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.33 -1.91,1.26	-0.32 -2.05,1.42	-0.20 -1.91,1.50	-0.20 -1.90,1.51	0.25+ -0.02,0.53	0.22 -0.13,0.58	0.22 -0.12,0.56	0.23 -0.12,0.57
Q3	-0.11 -1.43,1.21	-0.48 -1.73,0.77	-0.29 -1.53,0.95	-0.27 -1.55,1.01	0.04 -0.24,0.33	-0.01 -0.33,0.32	0.01 -0.31,0.34	0.01 -0.31,0.33
Q4	-0.00 -1.38,1.38	-0.42 -1.84,0.99	-0.27 -1.79,1.24	-0.26 -1.79,1.28	0.17 -0.06,0.40	0.08 -0.18,0.34	0.13 -0.16,0.41	0.12 -0.16,0.40
MnBP								
Continuous	0.40 -0.13,0.93	0.44 -0.14,1.03	0.51+ -0.09,1.11	0.52+ -0.08,1.12	0.10** 0.04,0.17	0.08+ -0.01,0.17	0.09* 0.00,0.17	0.09* 0.00,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.80 -1.07,2.66	1.03 -0.67,2.74	1.16 -0.54,2.85	1.15 -0.54,2.85	0.14 -0.10,0.38	0.11 -0.17,0.40	0.13 -0.13,0.39	0.13 -0.13,0.39
Q3	1.42* 0.10,2.74	1.57* 0.25,2.89	1.68* 0.38,2.98	1.70* 0.38,3.02	0.19 -0.06,0.45	0.14 -0.16,0.44	0.17 -0.13,0.46	0.17 -0.13,0.46
Q4	0.98 -0.33,2.30	1.09 -0.35,2.53	1.33+ -0.17,2.82	1.37+ -0.15,2.89	0.25* 0.05,0.45	0.18 -0.11,0.47	0.19 -0.09,0.47	0.19 -0.10,0.47
MiBP								
Continuous	0.80* 0.22,1.39	0.87* 0.18,1.57	0.83* 0.12,1.55	0.84* 0.12,1.55	0.08 -0.04,0.20	0.07 -0.06,0.19	0.08 -0.05,0.21	0.08 -0.05,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.19 -0.73,1.11	0.26 -0.58,1.10	0.31 -0.58,1.20	0.34 -0.55,1.22	0.21* 0.05,0.36	0.19* 0.02,0.36	0.22* 0.04,0.40	0.22* 0.05,0.39
Q3	1.41 -0.56,3.39	1.50 -0.70,3.71	1.38 -0.75,3.51	1.39 -0.74,3.52	0.17 -0.06,0.39	0.17 -0.06,0.41	0.22+ -0.01,0.45	0.23+ -0.01,0.46
Q4	1.77** 0.50,3.03	1.91* 0.45,3.37	1.63* 0.29,2.96	1.65* 0.32,2.97	0.23+ -0.03,0.50	0.18 -0.11,0.46	0.22 -0.07,0.52	0.22 -0.08,0.51
∑ DBP								
Continuous	-0.01 -0.42,0.39	0.04 -0.37,0.44	0.11 -0.32,0.54	0.11 -0.32,0.54	0.02 -0.08,0.12	0.01 -0.10,0.13	0.02 -0.09,0.13	0.02 -0.09,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.13 -1.61,1.87	0.21 -1.62,2.04	0.43 -1.41,2.27	0.43 -1.39,2.26	-0.01 -0.26,0.23	0.01 -0.23,0.25	0.03 -0.21,0.26	0.03 -0.22,0.28
Q3	0.02 -1.48,1.52	0.35 -1.28,1.97	0.57 -1.12,2.26	0.59 -1.10,2.28	0.03 -0.29,0.35	0.04 -0.29,0.37	0.07 -0.24,0.38	0.07 -0.24,0.38
Q4	-0.13 -1.46,1.20	-0.06 -1.49,1.37	0.22 -1.23,1.67	0.24 -1.19,1.67	-0.02 -0.35,0.31	-0.03 -0.38,0.33	-0.00 -0.34,0.33	0.00 -0.34,0.34
McPP								
Continuous	0.31 -0.27,0.89	0.39 -0.24,1.02	0.41 -0.24,1.05	0.41 -0.23,1.06	0.05 -0.04,0.15	0.04 -0.07,0.15	0.05 -0.06,0.16	0.05 -0.06,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.64 -0.50,1.78	0.61 -0.71,1.93	0.99 -0.30,2.27	0.99 -0.29,2.27	0.18 -0.09,0.44	0.17 -0.08,0.42	0.17 -0.09,0.42	0.17 -0.09,0.42
Q3	0.77 -0.38,1.92	0.79 -0.61,2.18	1.11 -0.40,2.61	1.14 -0.34,2.62	0.38** 0.16,0.60	0.35* 0.09,0.61	0.36** 0.11,0.60	0.35** 0.11,0.59
Q4	0.74 -0.56,2.05	0.87 -0.68,2.41	1.09 -0.43,2.62	1.11 -0.41,2.62	0.25+ -0.00,0.51	0.26+ -0.04,0.56	0.27+ -0.03,0.57	0.27+ -0.03,0.58
MBzP								
Continuous	-0.07 -0.48,0.33	-0.01 -0.42,0.39	0.06 -0.35,0.47	0.07 -0.34,0.48	0.03 -0.07,0.13	0.02 -0.08,0.13	0.03 -0.07,0.13	0.03 -0.07,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.12 -1.91,2.16	0.15 -2.02,2.32	0.22 -1.92,2.36	0.23 -1.89,2.35	0.01 -0.30,0.32	0.05 -0.26,0.37	0.07 -0.24,0.38	0.07 -0.24,0.38
Q3	0.41 -1.45,2.27	0.81 -1.17,2.80	1.01 -1.02,3.05	1.04 -1.01,3.08	0.04 -0.23,0.32	0.08 -0.19,0.34	0.12 -0.15,0.38	0.12 -0.16,0.39
Q4	0.10 -1.45,1.64	0.25 -1.30,1.81	0.51 -1.11,2.12	0.53 -1.07,2.12	0.11 -0.18,0.39	0.10 -0.19,0.38	0.11 -0.16,0.38	0.11 -0.17,0.39
∑ DEHP								
Continuous	0.11 -0.30,0.51	0.11 -0.29,0.51	0.14 -0.24,0.53	0.15 -0.24,0.53	-0.02 -0.11,0.07	-0.03 -0.13,0.07	-0.02 -0.12,.09	-0.02 -0.13,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.19 -1.53,1.16	0.13 -1.33,1.60	0.36 -1.09,1.81	0.37 -1.08,1.82	0.11 -0.10,0.32	0.11 -0.11,0.32	0.13 -0.08,0.34	0.14 -0.08,0.36

Q3	0.03 -1.84,1.91	0.11 -1.86,2.08	0.36 -1.68,2.40	0.38 -1.66,2.41	0.01 -0.26,0.28	-0.01 -0.31,0.29	0.01 -0.29,0.32	0.02 -0.30,0.33
Q4	0.46 -1.11,2.03	0.50 -1.10,2.11	0.70 -0.88,2.28	0.72 -0.86,2.29	-0.12 -0.40,0.17	-0.15 -0.46,0.16	-0.13 -0.44,0.18	-0.12 -0.45,0.22
MEHP								
Continuous	0.19 -0.21,0.58	0.12 -0.29,0.53	0.12 -0.24,0.48	0.12 -0.24,0.49	-0.02 -0.14,0.09	-0.05 -0.17,0.07	-0.04 -0.16,.08	-0.04 -0.16,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.37 -1.02,1.76	0.60 -0.88,2.08	0.62 -0.82,2.07	0.64 -0.79,2.07	0.14 -0.23,0.50	0.12 -0.25,0.49	0.15 -0.22,0.51	0.16 -0.22,0.54
Q3	1.23+ -0.16,2.62	1.38+ -0.14,2.91	1.35+ -0.12,2.82	1.37+ -0.08,2.81	0.16 -0.16,0.48	0.13 -0.20,0.47	0.16 -0.16,0.49	0.16 -0.17,0.50
Q4	0.51 -0.63,1.65	0.38 -0.80,1.57	0.51 -0.57,1.59	0.52 -0.55,1.59	-0.08 -0.34,0.18	-0.18 -0.44,0.09	-0.16 -0.42,0.11	-0.15 -0.43,0.13
MEHHP								
Continuous	0.08 -0.32,0.47	0.06 -0.34,0.47	0.11 -0.28,0.51	0.11 -0.28,0.51	-0.02 -0.12,0.08	-0.03 -0.14,0.08	-0.02 -0.13,0.09	-0.02 -0.13,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.57 -0.53,1.67	0.77 -0.40,1.93	0.85 -0.28,1.98	0.84 -0.28,1.96	0.25*** 0.12,0.38	0.22** 0.09,0.34	0.23** 0.09,0.37	0.24** 0.10,0.38
Q3	-0.00 -1.92,1.92	0.06 -1.96,2.08	0.20 -1.84,2.24	0.20 -1.83,2.24	0.02 -0.22,0.26	-0.03 -0.31,0.26	0.00 -0.29,0.30	0.01 -0.31,0.32
Q4	0.27 -1.04,1.58	0.23 -1.14,1.60	0.44 -0.95,1.83	0.44 -0.95,1.83	-0.08 -0.35,0.18	-0.11 -0.39,0.16	-0.09 -0.36,0.18	-0.08 -0.37,0.21
MEOHP								
Continuous	0.13 -0.27,0.52	0.13 -0.27,0.52	0.17 -0.21,0.56	0.18 -0.21,0.56	-0.03 -0.13,0.08	-0.04 -0.15,0.07	-0.03 -0.14,0.09	-0.02 -0.14,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.70 -0.59,1.98	1.06 -0.31,2.43	1.19+ -0.15,2.52	1.19+ -0.15,2.53	0.08 -0.10,0.26	0.09 -0.08,0.25	0.11 -0.05,0.28	0.12 -0.07,0.31
Q3	0.56 -0.98,2.10	0.70 -0.90,2.30	0.86 -0.71,2.44	0.88 -0.67,2.43	-0.03 -0.28,0.22	-0.07 -0.37,0.23	-0.05 -0.35,0.24	-0.05 -0.36,0.25
Q4	0.54 -1.11,2.18	0.64 -1.05,2.34	0.89 -0.85,2.63	0.90 -0.83,2.64	-0.16 -0.44,0.13	-0.18 -0.47,0.11	-0.15 -0.44,0.13	-0.14 -0.45,0.16
MECPP								
Continuous	-0.06 -0.18,0.06	0.13 -0.29,0.56	0.15 -0.26,0.56	0.16 -0.25,0.57	-0.02 -0.11,0.06	-0.03 -0.14,0.07	-0.02 -0.13,0.08	-0.02 -0.13,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.39 -1.28,0.49	-0.20 -1.24,0.84	-0.00 -1.02,1.01	0.00 -1.01,1.02	0.05 -0.14,0.24	0.03 -0.20,0.25	0.04 -0.18,0.26	0.05 -0.17,0.26
Q3	0.24 -1.66,2.14	0.45 -1.50,2.41	0.59 -1.42,2.60	0.61 -1.39,2.61	-0.03 -0.27,0.20	-0.04 -0.31,0.24	-0.02 -0.29,0.25	-0.02 -0.30,0.26
Q4	0.25 -1.20,1.70	0.29 -1.18,1.76	0.51 -0.95,1.96	0.52 -0.94,1.98	-0.16 -0.41,0.10	-0.19 -0.50,0.11	-0.17 -0.48,0.13	-0.16 -0.49,0.17
	Mumps 2003-2004				Mumps 2009-2010			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.01 -0.06,0.08	-0.03 -0.11,0.04	-0.02 -0.10,0.05	-0.02 -0.09,0.05	-0.05 -0.12,0.03	-0.09* -0.15,-0.02	-0.08* -0.14,-0.01	-0.08* -0.14,-.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.33+ -0.72,0.07	-0.35+ -0.73,0.03	-0.33+ -0.72,0.05	-0.33+ -0.71,0.05	0.05 -0.12,0.23	-0.00 -0.17,0.16	-0.02 -0.17,0.13	-0.01 -0.16,0.14
Q3	-0.32+ -0.67,0.03	-0.46* -0.81,-0.10	-0.43* -0.78,-0.07	-0.42* -0.78,-0.07	-0.14 -0.35,0.07	-0.22+ -0.44,0.00	-0.21* -0.41,-0.00	-0.21* -0.41,-.02
Q4	-0.15 -0.55,0.25	-0.32 -0.71,0.07	-0.27 -0.67,0.13	-0.27 -0.66,0.13	-0.12 -0.44,0.20	-0.30* -0.58,-0.02	-0.26+ -0.56,0.03	-0.27+ -0.56,0.02
MnBP								
Continuous	0.02 -0.10,0.14	0.02 -0.11,0.15	0.03 -0.10,0.16	0.03 -0.10,0.16	-0.04 -0.15,0.07	-0.05 -0.17,0.08	-0.03 -0.16,0.09	-0.04 -0.16,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.12,0.63	0.28 -0.10,0.66	0.31 -0.08,0.70	0.31 -0.08,0.69	-0.20 -0.48,0.09	-0.23 -0.54,0.07	-0.21 -0.51,0.08	-0.21 -0.50,0.07
Q3	-0.07 -0.37,0.24	-0.04 -0.39,0.31	-0.00 -0.36,0.36	0.00 -0.36,0.36	-0.14 -0.35,0.06	-0.15 -0.35,0.05	-0.10 -0.31,0.11	-0.10 -0.30,0.10
Q4	0.15 -0.22,0.52	0.13 -0.26,0.52	0.16 -0.24,0.55	0.17 -0.24,0.57	-0.01 -0.35,0.32	-0.04 -0.43,0.36	-0.02 -0.40,0.36	-0.02 -0.40,0.35
MiBP								
Continuous	0.01 -0.13,0.15	0.01 -0.12,0.13	0.01 -0.11,0.14	0.02 -0.11,0.14	-0.00 -0.14,0.14	-0.02 -0.18,0.14	0.01 -0.15,0.16	0.00 -0.15,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.38,0.22	-0.04 -0.35,0.28	-0.01 -0.33,0.31	0.00 -0.33,0.33	-0.49*** -.72,-.26	-0.52*** -.74,-.31	-0.47*** -.66,-.28	-.47*** -.65,-.28
Q3	-0.01 -0.39,0.37	-0.02 -0.35,0.32	-0.01 -0.34,0.33	-0.00 -0.34,0.33	-0.49** -0.75,-.22	-0.48** -0.75,-.21	-0.39** -0.61,-.17	-.39** -.61,-.16
Q4	0.07 -0.20,0.34	0.05 -0.20,0.31	0.05 -0.19,0.30	0.06 -0.19,0.30	-.21 -.51,.09	-0.24 -.56,.08	-0.16 -0.49,0.16	-.17 -0.48,0.15
∑ DBP								

Continuous	-0.02 -0.12,0.09	0.04 -0.07,0.14	0.04 -0.06,0.15	0.04 -0.06,0.15	-0.13** -.21,-.04	-0.10+ -0.20,0.00	-0.09+ -0.19,0.01	-0.09+ -0.19,0.01
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.09 -0.46,0.29	-0.09 -0.48,0.29	-0.05 -0.45,0.34	-0.05 -0.45,0.34	-0.24 -0.55,0.07	-0.25+ -0.56,0.05	-0.21 -0.50,0.07	-0.21 -0.50,0.09
Q3	-0.05 -0.41,0.31	0.00 -0.39,0.40	0.03 -0.37,0.43	0.04 -0.37,0.44	-0.31* -0.57,-0.04	-0.28+ -0.58,0.03	-0.24 -0.54,0.06	-0.24 -0.54,0.06
Q4	-0.12 -0.49,0.26	0.04 -0.35,0.43	0.07 -0.32,0.46	0.08 -0.31,0.47	-0.33* -0.59,-0.07	-0.26+ -0.56,0.05	-0.21 -0.52,0.10	-0.21 -0.51,0.10
McPP								
Continuous	0.06 -0.09,0.22	0.14* 0.01,0.27	0.14* 0.00,0.28	0.14* 0.01,0.28	-0.11** -0.18,-.03	-0.09* -0.18,-0.01	-0.08+ -0.16,0.00	-0.08+ -0.16,0.00
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.06 -0.16,0.28	0.09 -0.17,0.35	0.13 -0.13,0.38	0.13 -0.13,0.39	0.02 -0.21,0.26	0.03 -0.23,0.29	0.04 -0.22,0.29	0.03 -0.22,0.28
Q3	0.23 -0.07,0.52	0.26 -0.06,0.58	0.30+ -0.04,0.63	0.31+ -0.03,0.65	-0.03 -0.33,0.28	-0.00 -0.29,0.29	-0.00 -0.29,0.28	-0.01 -0.30,0.28
Q4	0.16 -0.18,0.49	0.34* 0.02,0.67	0.36* 0.02,0.70	0.36* 0.02,0.71	-0.23* -0.40,-0.06	-0.17+ -0.35,0.02	-0.14+ -0.31,.03	-0.14+ -0.31,0.03
MBzP								
Continuous	-0.04 -0.14,0.06	0.01 -0.09,0.11	0.02 -0.08,0.12	0.02 -0.08,0.12	-0.12* -0.21,-0.02	-0.09 -0.19,0.02	-0.08 -0.18,0.02	-0.08 -0.18,0.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.14 -0.26,0.55	0.16 -0.28,0.60	0.18 -0.27,0.63	0.18 -0.26,0.63	-0.18 -0.46,0.10	-0.17 -0.46,0.13	-0.13 -0.39,0.13	-0.13 -0.39,0.14
Q3	-0.14 -0.53,0.24	-0.09 -0.51,0.33	-0.07 -0.49,0.36	-0.06 -0.49,0.37	-0.36** -0.60,-.13	-0.32* -0.60,-0.03	-0.27* -0.53,-.00	-0.26+ -0.54,0.01
Q4	0.03 -0.38,0.44	0.17 -0.25,0.59	0.21 -0.21,0.63	0.21 -0.20,0.63	-0.20 -0.52,0.12	-0.11 -0.48,0.26	-0.10 -0.43,0.24	-0.10 -0.43,0.23
∑ DEHP								
Continuous	-0.00 -0.11,0.10	0.01 -0.09,0.10	0.02 -0.08,0.13	0.02 -0.08,0.13	-0.05 -0.13,0.02	-0.05 -0.14,0.05	-0.03 -0.12,0.06	-0.03 -0.12,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.07 -0.40,0.26	0.01 -0.31,0.33	0.05 -0.25,0.35	0.05 -0.24,0.35	-0.11 -0.41,0.19	-0.06 -0.35,0.24	-0.05 -0.33,0.23	-0.04 -0.32,0.24
Q3	-0.05 -0.33,0.23	-0.00 -0.30,0.29	0.02 -0.27,0.31	0.03 -0.27,0.32	-0.02 -0.21,0.17	0.05 -0.16,0.25	0.08 -0.10,0.27	0.09 -0.10,0.27
Q4	-0.11 -0.50,0.29	-0.04 -0.42,0.34	0.02 -0.38,0.42	0.02 -0.38,0.42	-0.08 -0.38,0.22	-0.03 -0.38,0.32	-0.00 -0.35,0.35	0.01 -0.34,0.36
MEHP								
Continuous	0.02 -0.10,0.14	0.01 -0.11,0.12	0.02 -0.11,0.15	0.02 -0.11,0.15	-0.05 -0.16,0.07	-0.06 -0.19,0.07	-0.05 -0.18,0.08	-0.05 -0.18,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.05 -0.24,0.34	0.06 -0.21,0.34	0.07 -0.21,0.35	0.07 -0.21,0.35	-0.20* -0.37,-.03	-0.18+ -0.37,0.02	-0.14 -0.33,0.05	-0.13 -0.32,0.06
Q3	-0.01 -0.25,0.24	-0.03 -0.29,0.24	-0.03 -0.30,0.24	-0.02 -0.29,0.25	-0.07 -0.29,0.15	-0.03 -0.25,0.20	-0.01 -0.22,0.20	-0.01 -0.23,0.21
Q4	-0.01 -0.31,0.29	-0.04 -0.33,0.24	-0.00 -0.30,0.29	0.00 -0.29,0.30	-0.18 -0.43,0.07	-0.24+ -0.50,0.03	-0.21 -0.48,0.06	-0.20 -0.47,0.06
MEHHP								
Continuous	-0.01 -0.12,0.09	-0.01 -0.10,0.09	0.01 -0.09,0.11	0.01 -0.09,0.12	-0.05 -0.13,0.03	-0.04 -0.14,0.05	-0.03 -0.12,0.07	-0.02 -0.12,0.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.29,0.44	0.13 -0.25,0.51	0.15 -0.24,0.55	0.15 -0.24,0.54	-0.05 -0.32,0.22	-0.02 -0.32,0.28	-0.01 -0.30,0.28	-0.00 -0.29,0.29
Q3	-0.02 -0.36,0.31	0.01 -0.35,0.37	0.03 -0.34,0.39	0.03 -0.34,0.40	0.06 -0.12,0.25	0.09 -0.11,0.29	0.12 -0.04,0.29	0.13 -0.04,0.30
Q4	-0.07 -0.49,0.35	-0.03 -0.45,0.39	0.02 -0.41,0.46	0.02 -0.41,0.46	-0.18 -0.43,0.06	-0.15 -0.45,0.15	-0.12 -0.42,0.18	-0.11 -0.41,0.19
MEOHP								
Continuous	-0.00 -0.11,0.11	0.01 -0.09,0.11	0.03 -0.08,0.13	0.03 -0.08,0.14	-0.05 -0.13,0.04	-0.04 -0.15,0.06	-0.03 -0.13,0.07	-0.02 -0.13,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.10 -0.22,0.42	0.18 -0.12,0.48	0.20 -0.11,0.51	0.20 -0.10,0.50	-0.18 -0.43,0.08	-0.13 -0.37,0.12	-0.11 -0.33,0.10	-0.10 -0.32,0.12
Q3	0.02 -0.33,0.36	0.08 -0.30,0.45	0.09 -0.29,0.48	0.10 -0.29,0.49	-0.04 -0.24,0.16	0.01 -0.22,0.23	0.04 -0.18,0.25	0.04 -0.17,0.25
Q4	-0.05 -0.45,0.34	0.01 -0.38,0.41	0.06 -0.35,0.47	0.07 -0.34,0.48	-0.11 -0.36,0.13	-0.06 -0.36,0.24	-0.03 -0.33,0.27	-0.02 -0.31,0.27
MECPP								
Continuous	-0.01 -0.11,0.10	0.01 -0.09,0.11	0.02 -0.08,0.13	0.02 -0.08,0.13	-0.05 -0.13,0.03	-0.04 -0.14,0.06	-0.02 -0.12,0.08	-0.02 -0.12,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18 -0.56,0.19	-0.11 -0.51,0.29	-0.08 -0.47,0.32	-0.07 -0.47,0.32	-0.20 -0.46,0.06	-0.17 -0.46,0.12	-0.15 -0.43,0.12	-0.14 -0.42,0.13
Q3	-0.09 -0.40,0.22	-0.02 -0.34,0.30	0.01 -0.32,0.34	0.01 -0.32,0.34	-0.07 -0.25,0.11	0.01 -0.20,0.22	0.05 -0.16,0.25	0.05 -0.15,0.25
Q4	-0.12 -0.52,0.28	-0.05 -0.44,0.34	-0.00 -0.41,0.40	0.00 -0.41,0.41	-0.11 -0.32,0.11	-0.05 -0.32,0.22	-0.01 -0.28,0.25	-0.00 -0.27,0.27

	Rubella 2003-2004				Rubella 2009-2010			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.75 -2.38,3.88	-0.12 -3.17,2.92	0.05 -3.10,3.21	0.17 -2.98,3.33	0.02 -0.03,0.07	-0.00 -0.06,0.05	0.01 -0.04,0.06	0.01 -0.04,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-5.04 -18.40,8.31	-3.99 -16.67,8.69	-3.57 -16.59,9.45	-3.28 -16.15,9.59	0.09 -0.25,0.42	0.06 -0.23,0.36	0.07 -0.21,0.34	0.07 -0.20,0.34
Q3	-10.44 -24.01,3.14	-12.49* -24.39,-.6	-11.91+ -24.55,0.72	-11.20+ -23.82,1.43	0.03 -0.23,0.28	-0.02 -0.29,0.24	-0.01 -0.26,0.24	-0.01 -0.25,0.23
Q4	-3.58 -16.51,9.35	-6.29 -17.92,5.34	-5.60 -17.83,6.63	-5.09 -17.45,7.27	0.13 -0.06,0.31	0.03 -0.16,0.22	0.08 -0.09,0.26	0.08 -0.10,0.26
MnBP								
Continuous	-1.70 -5.04,1.64	-0.76 -4.18,2.66	-0.55 -4.04,2.94	-0.23 -3.75,3.29	-0.02 -0.08,0.04	-0.04 -0.10,0.02	-0.03 -0.09,0.03	-0.03 -0.09,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.78 -5.79,15.35	5.16 -5.00,15.31	5.84 -4.42,16.10	5.79 -4.39,15.98	-0.25 -0.55,0.06	-0.30+ -0.62,0.02	-0.28+ -0.60,0.03	-0.28+ -.60,0.03
Q3	-1.54 -12.27,9.19	-0.55 -12.05,10.95	-0.06 -12.00,11.88	0.47 -11.23,12.16	-0.00 -0.21,0.21	-0.00 -0.21,0.21	0.05 -0.17,0.27	0.05 -0.18,0.27
Q4	-3.38 -11.80,5.03	-1.63 -11.12,7.86	-0.85 -10.47,8.78	0.22 -9.51,9.95	-0.03 -0.18,0.13	-0.06 -0.24,0.11	-0.05 -0.23,0.13	-0.05 -0.23,0.13
MiBP								
Continuous	-0.95 -5.14,3.24	0.17 -3.96,4.30	0.16 -4.07,4.39	0.29 -3.90,4.47	-0.06 -0.13,0.02	-0.06 -0.14,0.02	-0.04 -0.13,0.04	-0.04 -0.13,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-6.62 -15.38,2.13	-5.22 -13.49,3.05	-5.02 -13.22,3.19	-4.08 -12.20,4.04	-0.26 -0.60,0.08	-0.26 -0.59,0.08	-0.23 -0.55,0.10	-0.23 -0.55,0.10
Q3	-8.28 -19.00,2.44	-6.69 -16.61,3.24	-7.38 -17.10,2.35	-7.17 -16.89,2.54	-0.32* -0.63,-0.02	-0.34* -0.63,-0.05	-0.28+ -0.56,0.01	-0.28+ -0.57,0.01
Q4	-0.25 -12.16,11.66	2.97 -10.17,16.11	2.74 -11.28,16.76	3.45 -10.54,17.44	-0.25* -0.49,-0.00	-0.26+ -0.53,0.01	-0.20 -0.47,0.07	-0.20 -0.47,0.07
∑ DBP								
Continuous	-3.34+ -6.96,0.27	-1.65 -5.20,1.91	-1.25 -4.83,2.33	-1.03 -4.60,2.54	-0.08* -0.15,-0.01	-0.05 -0.14,0.03	-0.04 -0.13,0.04	-0.04 -0.13,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.51 -12.94,13.96	-1.03 -14.81,12.75	-0.31 -14.39,13.78	-0.15 -14.08,13.79	-0.07 -0.33,0.19	-0.07 -0.35,0.22	-0.03 -0.33,0.27	-0.03 -0.32,0.27
Q3	-5.45 -19.11,8.21	-3.12 -17.72,11.48	-2.45 -17.71,12.82	-1.94 -17.11,13.23	-0.18 -0.42,0.05	-0.16 -0.41,0.09	-0.12 -0.40,0.15	-0.12 -0.40,0.15
Q4	-7.48 -18.97,4.01	-3.67 -16.20,8.86	-2.50 -15.36,10.36	-1.80 -14.73,11.12	-0.20 -0.44,0.04	-0.13 -0.40,0.15	-0.09 -0.37,0.19	-0.09 -0.37,0.20
McPP								
Continuous	-3.11 -7.80,1.57	-1.01 -6.32,4.30	-0.86 -6.23,4.51	-0.62 -6.01,4.76	-0.06 -0.16,0.04	-0.05 -0.16,0.06	-0.03 -0.15,0.08	-0.03 -0.15,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	3.11 -9.60,15.82	3.31 -9.70,16.32	4.07 -9.25,17.39	4.14 -9.15,17.43	-0.15 -0.41,0.10	-0.15 -0.42,0.11	-0.14 -0.42,0.13	-0.14 -0.42,0.13
Q3	-8.71 -19.82,2.39	-9.10+ -18.53,0.33	-8.63+ -18.51,1.25	-7.76 -17.82,2.29	0.04 -0.25,0.33	0.01 -0.27,0.29	0.02 -0.26,0.30	0.02 -0.27,0.30
Q4	-4.04 -15.67,7.59	0.12 -12.52,12.76	0.78 -12.39,13.95	1.11 -11.89,14.10	-0.09 -0.37,0.19	-0.04 -0.35,0.27	-0.01 -0.32,0.30	-0.01 -0.32,0.30
MBzP								
Continuous	-3.45* -6.81,-0.09	-1.80 -4.97,1.37	-1.37 -4.53,1.78	-1.19 -4.30,1.93	-0.06 -0.14,0.02	-0.03 -0.12,0.05	-0.03 -0.12,0.06	-0.03 -0.12,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.58 -16.17,15.00	-0.45 -16.77,15.88	-0.25 -16.79,16.29	-0.05 -16.47,16.37	-0.20+ -0.43,0.03	-0.20 -0.45,0.04	-0.17 -0.42,0.08	-0.17 -0.42,0.08
Q3	-1.28 -13.92,11.35	1.26 -12.49,15.00	1.90 -12.43,16.24	2.62 -11.48,16.73	-0.20* -0.39,-0.02	-0.17+ -0.37,0.02	-0.14 -0.33,0.06	-0.13 -0.33,0.07
Q4	-7.69 -18.49,3.10	-3.20 -15.48,9.09	-2.05 -14.53,10.42	-1.54 -13.98,10.91	-0.13 -0.36,0.10	-0.04 -0.30,0.22	-0.02 -0.28,0.25	-0.02 -0.28,0.25
∑ DEHP								
Continuous	-3.13** -4.85,-1.42	-2.26* -3.92,-0.60	-1.93* -3.82,-0.04	-1.82+ -3.79,0.16	-0.08 -0.19,0.03	-0.09 -0.20,0.02	-0.07 -0.18,0.04	-0.07 -0.18,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.60 -15.07,11.88	1.05 -11.42,13.52	2.13 -10.05,14.31	2.42 -9.54,14.38	-0.12 -0.30,0.07	-0.11 -0.29,0.07	-0.09 -0.26,0.07	-0.09 -0.26,0.08
Q3	-8.09+ -17.57,1.38	-6.49 -15.00,2.02	-5.28 -14.26,3.69	-4.84 -13.81,4.14	-0.21+ -0.46,0.03	-0.22+ -0.46,0.01	-0.19+ -0.41,0.03	-0.19+ -0.41,0.04
Q4	-7.77+ -16.84,1.30	-4.39 -12.86,4.08	-3.09 -12.10,5.93	-2.68 -12.11,6.75	-0.33+ -0.66,0.00	-0.36* -0.69,-0.02	-0.33* -0.65,-0.00	-0.32+ -0.65,0.01
MEHP								
Continuous	-1.66 -3.79,0.48	-1.51 -3.60,0.58	-1.30 -3.68,1.08	-1.19 -3.59,1.20	-0.06 -0.17,0.04	-0.09+ -0.18,0.00	-0.08+ -0.18,0.01	-0.08 -0.18,0.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-8.22 -20.06,3.63	-5.02 -16.09,6.06	-5.14 -15.99,5.72	-4.71 -15.41,5.98	-0.02 -0.21,0.17	0.01 -0.19,0.20	0.04 -0.17,0.24	0.04 -0.16,0.24
Q3	-1.14 -9.27,6.99	1.15 -8.00,10.31	1.26 -8.19,10.71	1.90 -7.20,11.00	-0.16 -0.37,0.05	-0.17 -0.38,0.05	-0.15 -0.37,0.06	-0.15 -0.37,0.06
Q4	-2.85 -8.22,2.51	-1.12 -6.93,4.68	-0.27 -6.43,5.89	-0.03 -6.22,6.15	-0.19+ -0.41,0.02	-0.27** -0.45,-.09	-0.25** -0.43,-.07	-0.25* -0.43,-.06
MEHHP								
Continuous	-2.93** -4.53,-1.34	-2.16** -3.69,-.62	-1.80* -3.57,-0.04	-1.72+ -3.58,0.13	-0.08 -0.20,0.03	-0.10+ -0.21,0.01	-0.08 -0.19,0.03	-0.08 -0.20,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	2.96 -11.97,17.88	4.24 -9.44,17.93	4.39 -8.95,17.73	4.08 -9.28,17.43	-0.13 -0.31,0.05	-0.13 -0.31,0.06	-0.12 -0.30,0.06	-0.11 -0.30,0.07
Q3	-5.48 -16.20,5.25	-3.56 -14.25,7.14	-2.89 -13.98,8.20	-2.66 -13.75,8.43	-0.13 -0.38,0.12	-0.16 -0.41,0.09	-0.13 -0.36,0.11	-0.12 -0.36,0.11
Q4	-6.84+ -14.34,0.67	-4.14 -10.48,2.19	-3.08 -9.65,3.49	-3.03 -10.22,4.17	-0.37* -0.72,-0.02	-0.40* -0.72,-0.07	-0.37* -0.69,-0.04	-0.36* -0.69,-.03
MEOHP								
Continuous	-3.21*** -4.87,-1.56	-2.25** -3.85,-.65	-1.92* -3.76,-0.08	-1.79+ -3.71,0.13	-0.09 -0.20,0.03	-0.10+ -0.21,0.02	-0.08 -0.20,0.04	-0.08 -0.20,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.33 -9.15,17.81	6.65 -6.20,19.50	6.86 -5.48,19.20	7.01 -5.24,19.27	-0.12 -0.36,0.12	-0.13 -0.37,0.11	-0.12 -0.35,0.11	-0.11 -0.35,0.12
Q3	-3.45 -12.50,5.60	-0.78 -9.30,7.75	-0.13 -9.01,8.75	0.40 -8.29,9.09	-0.23* -0.42,-0.04	-0.26* -0.44,-0.07	-0.23* -0.40,-0.05	-0.23* -0.41,-.05
Q4	-6.90+ -14.68,0.87	-3.32 -10.08,3.44	-2.20 -8.98,4.58	-1.71 -8.59,5.17	-0.29+ -0.60,0.01	-0.31* -0.61,-0.02	-0.28+ -0.57,0.01	-0.28+ -0.57,0.02
MECPP								
Continuous	-3.55** -5.57,-1.54	-2.58* -4.57,-0.58	-2.26* -4.46,-0.05	-2.14+ -4.40,0.12	-0.08 -0.19,0.03	-0.08 -0.20,0.04	-0.06 -0.18,0.05	-0.06 -0.18,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.04 -10.13,10.04	1.78 -8.07,11.64	2.71 -6.91,12.33	2.90 -6.64,12.44	-0.08 -0.24,0.08	-0.09 -0.28,0.09	-0.07 -0.25,0.11	-0.06 -0.24,0.11
Q3	-8.77* -17.31,-0.23	-5.91 -13.46,1.64	-5.17 -13.26,2.93	-4.64 -12.64,3.36	-0.27** -0.47,-.08	-0.28** -0.47,-.08	-0.24* -0.44,-0.05	-0.24* -0.44,-.04
Q4	-7.39+ -15.36,0.59	-4.01 -11.67,3.66	-2.52 -10.97,5.93	-2.09 -11.12,6.94	-0.29+ -0.61,0.03	-0.30+ -0.63,0.02	-0.26+ -0.58,0.05	-0.26 -0.58,0.06

	Polio virus 1 2009-2010				Polio virus 2 2009-2010			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.11 -0.27,0.05	-0.11 -0.26,0.04	-0.08 -0.23,0.06	-0.09 -0.23,0.06	-0.06+ -0.13,0.01	-0.05 -0.12,0.02	-0.04 -0.12,0.04	-0.04 -0.12,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.15 -0.59,0.28	-0.13 -0.59,0.32	-0.13 -0.63,0.37	-0.13 -0.62,0.37	-0.25 -0.64,0.15	-0.26 -0.66,0.14	-0.28 -0.69,0.13	-0.27 -0.68,0.14
Q3	-0.25 -0.83,0.33	-0.25 -0.78,0.27	-0.23 -0.76,0.30	-0.24 -0.75,0.28	-0.27 -0.70,0.16	-0.27 -0.67,0.13	-0.25 -0.66,0.15	-0.26 -0.64,0.12
Q4	-0.47 -1.21,0.27	-0.47 -1.23,0.30	-0.35 -1.08,0.38	-0.35 -1.08,0.38	-0.33+ -0.67,0.01	-0.29 -0.65,0.07	-0.26 -0.66,0.13	-0.27 -0.65,0.12
MnBP								
Continuous	-0.16+ -0.35,0.03	-0.15 -0.34,0.04	-0.14 -0.35,0.07	-0.14 -0.35,0.07	0.04 -0.05,0.14	0.03 -0.05,0.12	0.04 -0.04,0.12	0.04 -0.04,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.23 -0.66,0.19	-0.23 -0.67,0.21	-0.24 -0.64,0.17	-0.23 -0.64,0.18	0.13 -0.22,0.49	0.14 -0.18,0.46	0.15 -0.16,0.46	0.16 -0.15,0.47
Q3	-0.32 -0.75,0.12	-0.35+ -0.77,0.07	-0.32 -0.78,0.13	-0.32 -0.79,0.14	0.12 -0.26,0.49	0.06 -0.28,0.39	0.08 -0.29,0.44	0.07 -0.30,0.45
Q4	-0.34 -0.92,0.24	-0.28 -0.86,0.31	-0.27 -0.90,0.37	-0.27 -0.92,0.38	0.20 -0.17,0.56	0.15 -0.19,0.49	0.17 -0.15,0.49	0.16 -0.16,0.48
MiBP								
Continuous	-0.21+ -0.45,0.02	-0.22* -0.44,-0.00	-0.20+ -0.43,0.03	-0.20+ -0.44,0.04	-0.02 -0.18,0.13	-0.05 -0.20,0.09	-0.04 -0.18,0.11	-0.04 -0.18,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.24 -0.77,0.28	-0.24 -0.71,0.24	-0.23 -0.71,0.26	-0.22 -0.72,0.28	-0.04 -0.64,0.55	-0.02 -0.57,0.54	0.05 -0.50,0.59	0.06 -0.48,0.59
Q3	-0.69* -1.32,-0.06	-0.67* -1.27,-0.07	-0.63+ -1.27,0.01	-0.62+ -1.27,0.03	0.05 -0.35,0.44	0.03 -0.36,0.42	0.10 -0.32,0.53	0.11 -0.30,0.53
Q4	-0.53+ -1.15,0.10	-0.54+ -1.10,0.02	-0.48+ -1.07,0.10	-0.49 -1.08,0.11	-0.09 -0.62,0.45	-0.18 -0.66,0.29	-0.12 -0.59,0.36	-0.12 -0.58,0.35
∑ DBP								
Continuous	-0.10 -0.29,0.10	-0.09 -0.28,0.11	-0.07 -0.28,0.14	-0.07 -0.29,0.14	0.08 -0.03,0.20	0.08 -0.04,0.19	0.08 -0.03,0.19	0.08 -0.03,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.22 -0.60,0.17	-0.16 -0.50,0.18	-0.14 -0.48,0.21	-0.13 -0.48,0.22	-0.09 -0.51,0.33	-0.06 -0.48,0.36	-0.04 -0.45,0.38	-0.03 -0.45,0.39
Q3	-0.19 -0.57,0.18	-0.18 -0.53,0.17	-0.17 -0.57,0.23	-0.17 -0.58,0.24	0.01 -0.42,0.43	0.05 -0.33,0.43	0.07 -0.30,0.43	0.07 -0.31,0.44
Q4	-0.22 -0.67,0.24	-0.15 -0.64,0.34	-0.10 -0.67,0.46	-0.10 -0.67,0.47	0.20 -0.10,0.50	0.18 -0.14,0.49	0.21 -0.09,0.51	0.22 -0.08,0.51

McPP								
Continuous	-0.14 -0.34,0.06	-0.14 -0.34,0.07	-0.12 -0.32,0.09	-0.12 -0.33,0.10	0.01 -0.10,0.12	-0.04 -0.15,0.08	-0.03 -0.14,0.08	-0.03 -0.14,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.10 -0.82,0.62	-0.11 -0.82,0.59	-0.10 -0.78,0.58	-0.10 -0.78,0.58	-0.10 -0.59,0.39	-0.17 -0.67,0.33	-0.18 -0.67,0.32	-0.18 -0.68,0.32
Q3	-0.30 -1.00,0.40	-0.32 -1.07,0.43	-0.28 -1.04,0.47	-0.29 -1.04,0.45	-0.11 -0.53,0.31	-0.27 -0.71,0.17	-0.30 -0.77,0.18	-0.31 -0.78,0.17
Q4	-0.32 -0.92,0.29	-0.31 -0.91,0.29	-0.26 -0.85,0.32	-0.26 -0.86,0.33	-0.03 -0.37,0.31	-0.14 -0.50,0.21	-0.14 -0.51,0.24	-0.13 -0.52,0.25
MBzP								
Continuous	-0.08 -0.26,0.09	-0.07 -0.26,0.11	-0.07 -0.27,0.14	-0.07 -0.27,0.13	0.11+ -0.01,0.23	0.11+ -0.02,0.24	0.12+ -0.00,0.24	0.11+ -0.01,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -0.61,0.26	-0.12 -0.57,0.32	-0.11 -0.50,0.29	-0.10 -0.51,0.30	0.17 -0.24,0.59	0.22 -0.18,0.63	0.25 -0.16,0.66	0.25 -0.16,0.67
Q3	-0.34* -0.67,-0.01	-0.33+ -0.67,0.01	-0.32+ -0.69,0.05	-.32+ -0.70,0.06	0.05 -0.37,0.47	0.11 -0.30,0.53	0.14 -0.29,0.57	0.14 -0.29,0.58
Q4	-0.10 -0.58,0.38	-0.04 -0.55,0.48	-0.04 -0.60,0.53	-0.04 -0.61,0.54	0.49* 0.10,0.87	0.52* 0.10,0.93	0.52* 0.13,0.90	0.52* 0.13,0.91
∑ DEHP								
Continuous	-0.18* -0.33,-0.04	-0.17+ -0.34,0.01	-0.14 -0.32,0.04	-0.14 -0.33,0.04	-0.03 -0.14,0.08	-0.03 -0.14,0.07	-0.02 -0.12,0.08	-0.02 -0.12,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.33* -0.62,-0.03	-0.31* -0.61,-0.01	-0.28+ -0.61,0.05	-0.27 -0.61,0.07	-0.10 -0.49,0.28	-0.10 -0.50,0.30	-0.11 -0.51,0.28	-0.10 -0.50,0.30
Q3	-0.58** -1.00,-0.17	-0.61* -1.07,-0.15	-0.56* -0.99,-0.13	-0.56* -1.00,-.11	-0.17 -0.59,0.26	-0.18 -0.64,0.28	-0.16 -0.60,0.29	-0.15 -0.60,0.30
Q4	-0.59** -1.02,-0.17	-0.51* -0.95,-0.07	-0.47* -0.91,-0.02	-0.45+ -0.92,0.01	-0.19 -0.58,0.19	-0.21 -0.58,0.15	-0.20 -0.56,0.16	-0.18 -0.55,0.19
MEHP								
Continuous	-0.20* -0.37,-0.03	-0.17+ -0.37,0.04	-0.15 -0.35,0.05	-0.15 -0.36,0.06	-0.12 -0.29,0.05	-0.09 -0.25,0.08	-0.07 -0.25,0.10	-0.07 -0.24,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.35 -0.82,0.12	-0.32 -0.82,0.19	-0.30 -0.78,0.19	-0.29 -0.79,0.21	0.03 -0.30,0.36	0.02 -0.30,0.35	0.04 -0.28,0.36	0.06 -0.28,0.39
Q3	-0.42+ -0.85,0.01	-0.41+ -0.87,0.04	-0.37+ -0.80,0.06	-0.37+ -0.82,0.07	-0.07 -0.45,0.32	-0.04 -0.44,0.36	-0.02 -0.43,0.40	-0.02 -0.44,0.41
Q4	-0.67** -1.02,-0.31	-0.64** -1.02,-.26	-0.61** -.99,-0.23	-0.61** -1.00,-.21	-0.33 -0.74,0.08	-0.29 -0.69,0.11	-0.26 -0.69,0.16	-0.25 -0.68,0.17
MEHHP								
Continuous	-0.18* -0.31,-0.04	-0.16+ -0.33,0.01	-0.14 -0.31,0.03	-0.14 -0.31,0.04	-0.05 -0.15,0.06	-0.04 -0.14,0.05	-0.04 -0.13,0.06	-0.03 -0.13,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.20 -0.57,0.17	-0.19 -0.57,0.19	-0.19 -0.59,0.22	-0.17 -0.59,0.24	-0.01 -0.39,0.36	-0.02 -0.42,0.38	-0.03 -0.43,0.37	-0.01 -0.41,0.39
Q3	-0.33+ -0.71,0.04	-0.36+ -0.79,0.06	-0.29 -0.70,0.11	-0.29 -0.70,0.13	-0.03 -0.37,0.30	-0.05 -0.45,0.34	-0.04 -0.44,0.35	-0.04 -0.42,0.35
Q4	-0.72** -1.15,-0.30	-0.68** -1.09,-.26	-0.64** -1.06,-.22	-0.63** -1.07,-.19	-0.19 -0.57,0.18	-0.21 -0.56,0.14	-0.20 -0.55,0.15	-0.18 -0.54,0.18
MEOHP								
Continuous	-0.21* -0.36,-0.05	-0.19* -0.38,-0.00	-0.17+ -0.36,0.03	-0.17+ -0.36,0.03	-0.05 -0.16,0.06	-0.06 -0.17,0.04	-0.05 -0.15,0.05	-0.05 -0.15,0.05
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.32* -0.59,-0.05	-0.29* -0.56,-0.01	-0.26+ -0.56,0.04	-0.25 -0.56,0.06	0.04 -0.36,0.44	0.08 -0.33,0.49	0.07 -0.34,0.47	0.08 -0.33,0.50
Q3	-0.49** -0.83,-0.15	-0.50* -0.87,-0.14	-0.46* -0.83,-0.10	-0.46* -0.84,-0.08	-0.03 -0.35,0.30	-0.04 -0.38,0.30	-0.02 -0.35,0.31	-0.02 -0.34,0.31
Q4	-0.66** -1.12,-0.19	-0.58* -1.06,-0.10	-0.54* -1.03,-0.05	-0.53* -1.03,-0.02	-0.12 -0.51,0.28	-0.14 -0.52,0.24	-0.12 -0.50,0.25	-0.10 -0.49,0.28
MECPP								
Continuous	-0.19* -0.35,-0.02	-0.16+ -0.36,0.03	-0.14 -0.33,0.06	-0.14 -0.33,0.06	-0.01 -0.14,0.11	-0.02 -0.13,0.10	-0.01 -0.12,0.10	-0.00 -0.12,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.48** -0.75,-0.21	-0.46** -0.74,-.17	-0.42** -0.70,-.13	-0.41** -0.71,-.12	-0.03 -0.39,0.33	-0.05 -0.45,0.36	-0.07 -0.45,0.32	-0.06 -0.43,0.32
Q3	-0.49+ -0.98,0.01	-0.43 -0.96,0.09	-0.38 -0.87,0.11	-0.38 -0.88,0.12	-0.07 -0.50,0.35	-0.08 -0.54,0.38	-0.06 -0.50,0.38	-0.06 -0.49,0.38
Q4	-0.70** -1.15,-0.25	-0.62* -1.11,-0.13	-0.56* -1.06,-0.06	-0.55* -1.06,-0.04	-0.08 -0.46,0.31	-0.13 -0.51,0.25	-0.11 -0.49,0.27	-0.09 -0.47,0.29

	Polio virus 3 2003-2004				Toxoplasma 2009-2010			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.18** -0.28,-0.08	-0.17* -0.29,-0.04	-0.14* -0.26,-0.01	-0.14* -0.26,-0.01	0.65 -1.41,2.71	-0.79 -2.42,0.84	-0.84 -2.48,0.79	-0.84 -2.47,0.80
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-0.11 -0.60,0.38	-0.09 -0.62,0.44	-0.10 -0.57,0.37	-0.09 -0.57,0.38	1.41 -5.13,7.95	1.18 -5.37,7.72	1.21 -5.66,8.07	1.21 -5.58,7.99
Q3	-0.51* -0.94,-0.07	-0.52+ -1.04,0.01	-0.49+ -1.08,0.10	-0.49+ -1.08,0.10	-2.09 -9.82,5.64	-5.23 -12.55,2.08	-5.41 -12.63,1.81	-5.35 -12.52,1.82
Q4	-0.61** -1.02,-0.21	-0.54* -1.05,-0.03	-0.41+ -0.89,0.08	-0.41+ -0.89,0.08	4.36 -3.47,12.18	-1.45 -7.47,4.57	-1.55 -7.45,4.36	-1.54 -7.44,4.36
MnBP								
Continuous	0.08 -0.11,0.27	0.02 -0.16,0.20	0.04 -0.14,0.22	0.04 -0.14,0.22	-0.05 -1.64,1.54	-0.67 -2.53,1.18	-0.85 -2.68,0.98	-0.80 -2.66,1.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.06 -0.48,0.60	0.13 -0.43,0.68	0.13 -0.33,0.60	0.13 -0.33,0.60	4.02 -3.93,11.96	3.33 -4.38,11.04	3.33 -4.36,11.01	3.39 -4.26,11.05
Q3	0.35 -0.11,0.82	0.25 -0.21,0.71	0.31 -0.11,0.73	0.31 -0.11,0.73	0.51 -6.07,7.10	-0.09 -5.39,5.21	-0.27 -5.33,4.80	-0.20 -5.19,4.78
Q4	0.27 -0.29,0.83	0.12 -0.44,0.68	0.16 -0.41,0.74	0.16 -0.41,0.74	-1.65 -7.99,4.69	-3.08 -10.77,4.60	-3.41 -11.08,4.26	-3.27 -11.05,4.52
MiBP								
Continuous	-0.08 -0.29,0.13	-0.15 -0.35,0.05	-0.11 -0.30,0.08	-0.11 -0.30,0.08	0.88 -2.20,3.95	0.93 -2.17,4.04	0.96 -1.92,3.84	1.01 -1.90,3.93
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.36 -0.91,0.20	-0.30 -0.75,0.15	-0.24 -0.70,0.22	-0.24 -0.70,0.22	-0.22 -6.77,6.33	-0.05 -5.85,5.76	-0.15 -6.17,5.88	-0.19 -6.38,6.01
Q3	-0.37+ -0.75,0.02	-0.40* -0.79,-0.00	-0.28 -0.65,0.09	-0.28 -0.64,0.09	3.10 -4.87,11.07	4.41 -2.97,11.78	4.01 -3.06,11.08	3.93 -3.21,11.08
Q4	-0.28 -0.89,0.34	-0.47 -1.06,0.11	-0.35 -0.91,0.21	-0.35 -0.91,0.21	-0.97 -7.79,5.85	-0.68 -6.81,5.46	-0.59 -6.21,5.03	-0.49 -6.15,5.16
∑ DBP								
Continuous	0.13 -0.04,0.31	0.06 -0.08,0.20	0.08 -0.05,0.22	0.08 -0.05,0.22	-0.90 -2.15,0.36	-0.71 -2.39,0.98	-0.96 -2.62,0.69	-0.92 -2.57,0.73
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.09 -0.67,0.49	-0.09 -0.61,0.43	-0.04 -0.49,0.41	-0.04 -0.49,0.41	1.96 -3.80,7.72	1.69 -4.77,8.14	1.64 -4.77,8.05	1.60 -4.85,8.06
Q3	0.05 -0.61,0.70	0.01 -0.53,0.55	0.05 -0.45,0.54	0.05 -0.45,0.54	0.68 -5.12,6.49	1.52 -4.63,7.68	1.29 -5.06,7.63	1.33 -4.89,7.55
Q4	0.34 -0.08,0.75	0.15 -0.20,0.51	0.23 -0.11,0.57	0.23 -0.11,0.58	-2.22 -5.70,1.27	-0.94 -5.73,3.86	-1.73 -6.63,3.16	-1.71 -6.63,3.21
McPP								
Continuous	0.09 -0.10,0.28	0.01 -0.17,0.19	0.04 -0.14,0.23	0.04 -0.14,0.23	-1.28 -3.32,0.76	-0.52 -2.43,1.38	-0.59 -2.47,1.29	-0.60 -2.50,1.29
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.18 -0.33,0.69	0.08 -0.45,0.60	0.10 -0.40,0.60	0.10 -0.41,0.60	2.28 -4.47,9.02	2.87 -4.25,9.98	3.34 -3.51,10.18	3.42 -3.39,10.23
Q3	0.18 -0.38,0.74	-0.10 -0.64,0.44	-0.07 -0.64,0.51	-0.07 -0.64,0.51	1.84 -5.63,9.31	3.75 -4.09,11.59	3.65 -4.43,11.73	3.81 -4.27,11.89
Q4	0.18 -0.33,0.70	-0.02 -0.53,0.50	0.05 -0.45,0.56	0.06 -0.45,0.56	-1.57 -7.32,4.18	0.26 -5.50,6.02	0.42 -5.30,6.13	0.47 -5.25,6.19
MBzP								
Continuous	0.13 -0.07,0.33	0.06 -0.13,0.26	0.07 -0.12,0.26	0.07 -0.12,0.26	-0.21 -1.55,1.13	-0.21 -2.21,1.79	-0.50 -2.45,1.45	-0.44 -2.37,1.49
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.03 -0.62,0.67	-0.00 -0.68,0.67	0.04 -0.56,0.65	0.04 -0.56,0.65	-1.68 -8.12,4.76	-2.23 -7.91,3.45	-2.33 -7.86,3.21	-2.31 -7.81,3.18
Q3	0.02 -0.58,0.62	-0.03 -0.59,0.53	0.01 -0.54,0.56	0.01 -0.54,0.56	4.09 -3.48,11.67	4.61 -2.69,11.91	4.27 -2.88,11.41	4.24 -2.87,11.36
Q4	0.46 -0.18,1.11	0.28 -0.37,0.93	0.30 -0.32,0.91	0.30 -0.32,0.91	-4.10* -7.84,-0.36	-4.32 -9.68,1.04	-5.14* -10.18,-.09	-5.01+ -10.02,.00
∑ DEHP								
Continuous	0.02 -0.15,0.19	-0.04 -0.22,0.15	0.00 -0.17,0.18	0.00 -0.18,0.18	-0.51 -2.48,1.46	-0.11 -2.23,2.00	-0.02 -2.27,2.23	-0.02 -2.29,2.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -0.71,0.36	-0.21 -0.71,0.29	-0.21 -0.70,0.28	-0.21 -0.70,0.29	5.54 -1.61,12.68	5.32 -1.58,12.22	5.64+ -0.88,12.17	5.63+ -1.02,12.28
Q3	-0.16 -0.72,0.41	-0.32 -0.92,0.29	-0.24 -0.77,0.28	-0.24 -0.77,0.29	-1.66 -8.27,4.94	-1.61 -8.36,5.14	-1.37 -8.24,5.51	-1.33 -8.20,5.55
Q4	-0.02 -0.69,0.65	-0.20 -0.78,0.38	-0.13 -0.72,0.45	-0.13 -0.72,0.46	-1.95 -8.97,5.06	-0.47 -8.48,7.54	-0.01 -8.43,8.41	-0.08 -8.55,8.39
MEHP								
Continuous	-0.14 -0.34,0.05	-0.17 -0.40,0.06	-0.14 -0.37,0.08	-0.14 -0.37,0.09	-0.46 -2.68,1.76	0.29 -2.16,2.74	0.35 -2.15,2.85	0.31 -2.21,2.83
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -0.51,0.18	-0.24 -0.60,0.12	-0.21 -0.56,0.14	-0.21 -0.55,0.14	2.31 -3.52,8.15	4.62 -1.23,10.46	5.43+ -0.22,11.07	5.24+ -0.56,11.04
Q3	-0.56* -1.09,-0.02	-0.64* -1.19,-0.09	-0.61* -1.12,-0.10	-0.61* -1.12,-0.09	2.65 -5.66,10.95	5.18 -4.77,15.12	5.61 -4.28,15.50	5.59 -4.39,15.58
Q4	-0.41* -0.81,-0.01	-0.53* -0.99,-0.06	-0.47* -0.93,-0.01	-0.47* -0.93,-0.00	-0.00 -4.48,4.47	0.73 -4.62,6.09	0.99 -4.46,6.45	0.86 -4.74,6.46
MEHHP								
Continuous	0.00 -0.16,0.16	-0.04 -0.22,0.14	-0.01 -0.18,0.16	-0.01 -0.18,0.16	-0.45 -2.49,1.60	-0.19 -2.42,2.05	-0.12 -2.51,2.26	-0.14 -2.54,2.27

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.16 -0.58,0.25	-0.25 -0.62,0.13	-0.26 -0.65,0.13	-0.26 -0.66,0.14	3.93 -2.35,10.21	3.29 -3.10,9.68	3.57 -2.73,9.87	3.44 -2.99,9.88
Q3	-0.02 -0.50,0.46	-0.13 -0.66,0.40	-0.05 -0.53,0.43	-0.05 -0.53,0.43	-0.74 -7.32,5.84	-1.28 -7.48,4.91	-0.97 -7.45,5.52	-1.01 -7.49,5.47
Q4	-0.04 -0.54,0.47	-0.24 -0.70,0.23	-0.18 -0.62,0.25	-0.18 -0.63,0.26	-2.73 -9.89,4.44	-2.05 -10.03,5.92	-1.70 -10.17,6.77	-1.82 -10.38,6.74
MEOHP								
Continuous	0.01 -0.17,0.19	-0.05 -0.24,0.14	-0.02 -0.20,0.17	-0.02 -0.20,0.17	-0.80 -2.88,1.27	-0.30 -2.64,2.05	-0.23 -2.72,2.27	-0.22 -2.73,2.29
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.26 -0.63,0.11	-0.32+ -0.64,0.01	-0.32+ -0.65,0.01	-0.32+ -0.65,0.01	4.10 -2.80,11.01	3.58 -3.46,10.62	3.59 -3.43,10.61	3.46 -3.71,10.62
Q3	0.04 -0.41,0.50	-0.07 -0.55,0.41	-0.02 -0.45,0.41	-0.02 -0.45,0.41	-2.73 -9.30,3.83	-2.90 -9.54,3.74	-2.67 -9.44,4.09	-2.62 -9.37,4.13
Q4	-0.05 -0.65,0.55	-0.28 -0.80,0.25	-0.21 -0.73,0.30	-0.21 -0.73,0.30	-2.21 -9.46,5.03	-0.86 -9.27,7.54	-0.55 -9.42,8.32	-0.62 -9.55,8.30
MECPP								
Continuous	0.05 -0.14,0.25	-0.02 -0.21,0.18	0.03 -0.17,0.22	0.03 -0.17,0.22	-0.61 -2.59,1.37	-0.08 -2.15,1.99	0.04 -2.17,2.25	0.04 -2.19,2.27
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.03 -0.63,0.57	-0.09 -0.64,0.46	-0.05 -0.57,0.47	-0.05 -0.57,0.48	5.72 -3.47,14.91	5.13 -3.64,13.91	5.26 -3.12,13.63	5.23 -3.17,13.64
Q3	-0.09 -0.63,0.45	-0.27 -0.79,0.25	-0.18 -0.60,0.24	-0.18 -0.60,0.24	-2.60 -9.41,4.21	-2.78 -9.26,3.70	-2.45 -8.92,4.01	-2.39 -8.88,4.10
Q4	0.19 -0.59,0.97	-0.02 -0.72,0.68	0.07 -0.63,0.78	0.08 -0.64,0.79	-2.29 -8.49,3.92	-0.23 -7.13,6.68	-0.02 -7.45,7.42	-0.09 -7.50,7.32
	Epstein Barr Virus 2003-2004							
	Model 1	Model 2	Model 3	Model 4				
MEP								
Continuous	0.24*** 0.17,0.32	0.08+ -0.01,0.16	0.07 -0.02,0.16	0.08 -0.02,0.17				
Q1	reference	reference	reference	reference				
Q2	0.44** 0.14,0.74	0.23 -0.07,0.52	0.21 -0.10,0.52	0.24 -0.09,0.56				
Q3	0.64*** 0.34,0.94	0.23 -0.08,0.54	0.21 -0.12,0.53	0.21 -0.15,0.57				
Q4	0.96*** 0.65,1.26	0.37* 0.02,0.72	0.35+ -0.01,0.70	0.34+ -0.03,0.72				
MnBP								
Continuous	0.14** 0.05,0.23	0.13* 0.03,0.23	0.12* 0.03,0.22	0.14** 0.04,0.25				
Q1	reference	reference	reference	reference				
Q2	0.01 -0.34,0.36	-0.07 -0.42,0.28	-0.08 -0.42,0.26	-0.10 -0.45,0.25				
Q3	0.36* 0.05,0.66	0.33* 0.01,0.64	0.32* 0.01,0.64	0.33* 0.00,0.67				
Q4	0.34* 0.05,0.64	0.24 -0.07,0.56	0.23 -0.08,0.55	0.26 -0.06,0.58				
MiBP								
Continuous	0.17** 0.06,0.28	0.09+ -0.01,0.19	0.09+ -0.01,0.19	0.10+ -0.01,0.21				
Q1	reference	reference	reference	reference				
Q2	0.04 -0.26,0.35	0.03 -0.29,0.35	0.01 -0.32,0.34	-0.01 -0.35,0.33				
Q3	0.38* 0.08,0.67	0.24 -0.06,0.54	0.23 -0.07,0.53	0.24 -0.07,0.54				
Q4	0.48** 0.18,0.78	0.29* 0.01,0.57	0.29* 0.01,0.57	0.31* 0.01,0.61				
∑ DBP								
Continuous	0.06 -0.02,0.14	0.11** 0.03,0.19	0.11** 0.03,0.19	0.12** 0.03,0.21				
Q1	reference	reference	reference	reference				
Q2	0.13 -0.18,0.45	0.05 -0.25,0.34	0.03 -0.26,0.33	0.02 -0.30,0.33				
Q3	0.20 -0.16,0.55	0.22 -0.12,0.56	0.22 -0.11,0.55	0.25 -0.09,0.60				
Q4	0.23+ -0.04,0.50	0.28* 0.01,0.55	0.27+ -0.00,0.54	0.28+ -0.02,0.57				
McPP								
Continuous	-0.07 -0.18,0.05	0.09 -0.03,0.21	0.10+ -0.01,0.21	0.11+ -0.01,0.24				
Q1	reference	reference	reference	reference				
Q2	0.38* 0.09,0.67	0.44** 0.15,0.74	0.43** 0.13,0.73	0.47** 0.16,0.78				
Q3	0.21 -0.05,0.46	0.36** 0.12,0.60	0.34** 0.11,0.58	0.33** 0.09,0.57				

Q4	0.03 -0.24,0.29	0.37** 0.12,0.63	0.38** 0.12,0.63	0.43** 0.16,0.70				
MBzP								
Continuous	0.08* 0.01,0.15	0.10** 0.03,0.18	0.10** 0.03,0.17	0.11** 0.03,0.19				
Q1	reference	reference	reference	reference				
Q2	0.28 -0.07,0.63	0.24 -0.12,0.59	0.26 -0.11,0.62	0.26 -0.13,0.64				
Q3	0.28 -0.10,0.66	0.23 -0.16,0.61	0.23 -0.15,0.60	0.26 -0.13,0.65				
Q4	0.32* 0.01,0.63	0.33* 0.00,0.65	0.32+ -0.01,0.64	0.33+ -0.03,0.69				
∑ DEHP								
Continuous	0.05 -0.02,0.12	0.04 -0.04,0.12	0.04 -0.04,0.12	0.05 -0.03,0.12				
Q1	reference	reference	reference	reference				
Q2	0.06 -0.31,0.43	0.08 -0.28,0.43	0.05 -0.29,0.40	0.09 -0.23,0.42				
Q3	0.18 -0.10,0.47	0.19 -0.10,0.48	0.16 -0.13,0.45	0.13 -0.16,0.41				
Q4	0.16 -0.09,0.40	0.17 -0.09,0.43	0.15 -0.11,0.41	0.21+ -0.04,0.47				
MEHP								
Continuous	0.10* 0.01,0.19	0.01 -0.08,0.10	0.02 -0.07,0.11	0.03 -0.07,0.12				
Q1	reference	reference	reference	reference				
Q2	-0.07 -0.41,0.28	-0.09 -0.43,0.24	-0.11 -0.43,0.21	-0.05 -0.38,0.29				
Q3	-0.11 -0.41,0.18	-0.14 -0.45,0.16	-0.15 -0.46,0.15	-0.14 -0.47,0.20				
Q4	0.24 -0.06,0.54	0.04 -0.26,0.35	0.05 -0.26,0.36	0.12 -0.20,0.43				
MEHHP								
Continuous	0.05 -0.01,0.11	0.03 -0.04,0.11	0.04 -0.04,0.11	0.04 -0.03,0.12				
Q1	reference	reference	reference	reference				
Q2	0.20 -0.16,0.55	0.20 -0.13,0.53	0.17 -0.16,0.50	0.21 -0.10,0.53				
Q3	0.32* 0.01,0.63	0.29+ -0.04,0.61	0.27 -0.06,0.60	0.22 -0.10,0.54				
Q4	0.21+ -0.03,0.45	0.18 -0.07,0.43	0.16 -0.09,0.42	0.22+ -0.03,0.47				
MEOHP								
Continuous	0.05 -0.01,0.12	0.04 -0.04,0.12	0.04 -0.04,0.12	0.05 -0.03,0.13				
Q1	reference	reference	reference	reference				
Q2	0.32 -0.08,0.73	0.35+ -0.01,0.72	0.32+ -0.04,0.68	0.37* 0.01,0.73				
Q3	0.32* 0.04,0.60	0.30* 0.01,0.59	0.28+ -0.01,0.57	0.24 -0.07,0.54				
Q4	0.26* 0.01,0.52	0.27* 0.00,0.53	0.25+ -0.01,0.52	0.32* 0.06,0.58				
MECPP								
Continuous	0.05 -0.03,0.12	0.04 -0.04,0.12	0.04 -0.05,0.12	0.05 -0.03,0.13				
Q1	reference	reference	reference	reference				
Q2	0.14 -0.14,0.42	0.15 -0.13,0.43	0.13 -0.15,0.41	0.12 -0.15,0.40				
Q3	0.21 -0.06,0.49	0.22 -0.07,0.51	0.20 -0.08,0.49	0.20 -0.10,0.49				
Q4	0.25* 0.02,0.49	0.26+ -0.01,0.52	0.23+ -0.03,0.50	0.26* 0.00,0.53				
	Measles 2003-2004, Female				**Measles 2003-2004, Male**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.32 -0.20,0.83	0.21 -0.41,0.83	0.25 -0.35,0.85	0.27 -0.33,0.87	0.04 -0.49,0.57	-0.05 -0.53,0.43	-0.02 -0.47,0.43	-0.02 -0.47,0.43
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.73 -1.33,2.78	0.66 -1.53,2.86	1.04 -1.47,3.55	1.14 -1.31,3.59	-1.32 -3.67,1.04	-1.25 -3.63,1.13	-1.46 -3.81,0.90	-1.46 -3.79,0.88
Q3	0.46 -1.36,2.29	-0.02 -1.89,1.84	0.13 -1.91,2.17	0.24 -1.76,2.25	-0.68 -2.75,1.38	-0.81 -2.77,1.15	-0.57 -2.34,1.20	-0.57 -2.34,1.21
Q4	0.93 -0.76,2.62	0.60 -1.55,2.75	0.86 -1.46,3.18	0.97 -1.32,3.27	-0.99 -3.24,1.25	-1.46 -3.58,0.65	-1.41 -3.36,0.54	-1.41 -3.36,0.54
MnBP								
Continuous	0.39 -0.40,1.18	0.43 -0.48,1.34	0.49 -0.42,1.40	0.52 -0.40,1.43	0.38 -0.21,0.97	0.44 -0.22,1.10	0.51 -0.15,1.17	0.51 -0.17,1.19

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.52 -2.89,1.85	-0.36 -2.61,1.90	-0.16 -2.46,2.14	-0.13 -2.44,2.18	2.11+ -0.02,4.25	2.31* 0.36,4.26	2.31* 0.51,4.11	2.31* 0.51,4.10
Q3	0.14 -1.57,1.85	0.13 -1.80,2.07	0.46 -1.47,2.39	0.56 -1.35,2.48	2.80** 1.06,4.54	3.03** 1.32,4.74	2.85** 1.05,4.66	2.85** 1.04,4.66
Q4	0.63 -1.66,2.92	0.68 -1.88,3.24	0.90 -1.65,3.45	0.98 -1.55,3.52	1.23+ -0.24,2.71	1.42+ -0.13,2.96	1.64* 0.14,3.13	1.62* 0.06,3.19
MiBP								
Continuous	0.44 -0.58,1.46	0.50 -0.76,1.76	0.53 -0.73,1.80	0.56 -0.69,1.81	1.21*** 0.67,1.74	1.27*** 0.69,1.86	1.14** 0.54,1.74	1.14** 0.54,1.74
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.37+ -3.01,0.28	-1.38 -3.15,0.40	-1.14 -2.97,0.70	-1.05 -2.85,0.76	1.84** 0.77,2.92	1.89** 0.80,2.98	1.67** 0.50,2.85	1.67* 0.44,2.91
Q3	0.76 -1.89,3.42	0.80 -2.34,3.93	0.82 -2.26,3.91	0.85 -2.22,3.93	2.14* 0.10,4.18	2.22* 0.05,4.39	1.92+ -0.21,4.05	1.92+ -0.21,4.05
Q4	0.90 -1.19,2.99	1.08 -1.30,3.45	0.99 -1.32,3.29	1.07 -1.18,3.33	2.72** 1.23,4.21	2.76** 0.93,4.59	2.30** 0.99,3.62	2.30** 0.96,3.65
∑ DBP								
Continuous	-0.19 -0.94,0.55	-0.17 -0.90,0.56	-0.09 -0.85,0.68	-0.07 -0.81,0.68	0.22 -0.25,0.69	0.27 -0.28,0.82	0.30 -0.26,0.87	0.30 -0.27,0.88
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.60 -3.59,2.39	-0.71 -3.55,2.14	-0.49 -3.40,2.42	-0.41 -3.28,2.46	1.14 -0.54,2.82	1.38 -0.40,3.16	1.57+ -0.16,3.30	1.57+ -0.16,3.31
Q3	-0.69 -3.28,1.90	-0.47 -3.14,2.21	-0.21 -2.90,2.47	-0.12 -2.76,2.52	1.00 -1.10,3.11	1.31 -0.85,3.47	1.47 -0.69,3.63	1.47 -0.69,3.63
Q4	-0.66 -3.28,1.96	-0.76 -3.46,1.94	-0.45 -3.23,2.33	-0.40 -3.13,2.34	0.67 -0.63,1.98	0.78 -0.56,2.12	0.94 -0.33,2.21	0.94 -0.33,2.20
McPP								
Continuous	0.20 -0.53,0.93	0.22 -0.51,0.96	0.24 -0.52,1.01	0.28 -0.46,1.01	0.47 -0.31,1.26	0.56 -0.30,1.43	0.59 -0.29,1.46	0.58 -0.29,1.46
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -1.97,1.63	-0.34 -2.18,1.50	0.02 -1.83,1.87	0.06 -1.78,1.91	1.71+ -0.35,3.77	1.71 -0.46,3.87	2.03* 0.12,3.93	2.03* 0.12,3.94
Q3	0.56 -1.69,2.81	0.54 -1.90,2.97	0.86 -1.75,3.47	1.00 -1.52,3.51	1.20 -1.31,3.71	1.18 -1.38,3.73	1.45 -0.75,3.64	1.44 -0.77,3.65
Q4	0.26 -1.59,2.10	0.21 -1.70,2.13	0.34 -1.65,2.33	0.42 -1.52,2.36	1.49+ -0.28,3.26	1.66 -0.41,3.73	1.94* 0.03,3.85	1.94* 0.04,3.85
MBzP								
Continuous	-0.22 -0.99,0.54	-0.17 -0.95,0.61	-0.09 -0.88,0.71	-0.07 -0.85,0.71	0.12 -0.33,0.56	0.15 -0.38,0.68	0.18 -0.34,0.71	0.18 -0.35,0.72
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.06 -4.16,2.05	-1.23 -4.32,1.85	-1.00 -4.04,2.05	-0.92 -3.91,2.07	1.64 -0.81,4.08	1.85 -0.57,4.28	1.68 -0.66,4.02	1.68 -0.66,4.03
Q3	-0.58 -3.96,2.80	-0.28 -3.91,3.35	0.04 -3.68,3.76	0.16 -3.51,3.84	1.72 -0.74,4.19	2.07+ -0.28,4.43	2.06+ -0.19,4.30	2.06+ -0.20,4.31
Q4	-0.82 -3.59,1.94	-0.71 -3.62,2.20	-0.34 -3.36,2.67	-0.29 -3.25,2.68	1.32 -0.30,2.94	1.41+ -0.13,2.95	1.43+ -0.20,3.07	1.43+ -0.20,3.07
∑ DEHP								
Continuous	-0.10 -0.68,0.49	-0.14 -0.68,0.40	-0.05 -0.59,0.50	-0.03 -0.58,0.51	0.32 -0.16,0.80	0.36 -0.13,0.85	0.34 -0.15,0.82	0.34 -0.15,0.82
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.36 -3.25,0.54	-1.01 -3.01,0.99	-0.65 -2.81,1.51	-0.56 -2.66,1.54	1.12 -1.28,3.52	1.40 -0.99,3.80	1.41 -0.89,3.71	1.41 -0.88,3.71
Q3	-0.05 -2.75,2.66	0.01 -2.99,3.02	0.32 -2.82,3.46	0.42 -2.67,3.52	0.18 -1.69,2.06	0.21 -1.66,2.07	0.36 -1.37,2.09	0.36 -1.37,2.08
Q4	-0.15 -2.06,1.76	-0.30 -2.17,1.57	0.12 -1.70,1.95	0.18 -1.62,1.99	1.18 -0.99,3.35	1.32 -0.82,3.46	1.25 -0.95,3.46	1.25 -0.96,3.46
MEHP								
Continuous	0.03 -0.65,0.70	-0.12 -0.80,0.55	-0.02 -0.67,0.63	-0.02 -0.69,0.65	0.33 -0.17,0.84	0.33 -0.23,0.88	0.24 -0.20,0.68	0.24 -0.21,0.69
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.50 -2.82,1.81	-0.30 -2.63,2.03	-0.20 -2.41,2.01	-0.02 -2.08,2.04	1.29 -0.72,3.31	1.61 -0.42,3.65	1.54 -0.42,3.50	1.55 -0.39,3.49
Q3	1.46 -0.63,3.55	1.44 -0.85,3.73	1.43 -0.87,3.74	1.55 -0.68,3.77	0.83 -0.87,2.53	1.11 -0.62,2.84	1.02 -0.68,2.71	1.01 -0.69,2.71
Q4	-0.15 -1.80,1.49	-0.48 -2.08,1.11	-0.21 -1.70,1.28	-0.14 -1.64,1.35	1.17 -0.29,2.63	1.14 -0.30,2.59	1.09 -0.28,2.47	1.10 -0.28,2.47
MEHHP								
Continuous	-0.08 -0.64,0.49	-0.14 -0.67,0.40	-0.04 -0.57,0.49	-0.03 -0.56,0.51	0.24 -0.23,0.71	0.27 -0.22,0.75	0.26 -0.23,0.75	0.26 -0.23,0.75
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.59 -2.60,1.42	-0.45 -2.40,1.51	-0.35 -2.42,1.71	-0.37 -2.46,1.73	1.90 -0.63,4.44	2.17 -0.50,4.84	2.19+ -0.39,4.76	2.19+ -0.37,4.75
Q3	0.06 -2.70,2.81	0.15 -2.80,3.10	0.38 -2.68,3.44	0.43 -2.62,3.47	-0.04 -1.98,1.89	-0.09 -2.00,1.82	-0.06 -1.86,1.74	-0.06 -1.86,1.74
Q4	-0.19 -1.97,1.59	-0.42 -2.27,1.44	-0.08 -1.94,1.78	-0.07 -1.97,1.82	0.80 -1.23,2.83	0.89 -1.09,2.87	0.95 -1.07,2.98	0.95 -1.08,2.98
MEOHP								

Continuous	-0.09 -0.66,0.47	-0.14 -0.68,0.40	-0.04 -0.58,0.50	-0.02 -0.56,0.52	0.35 -0.12,0.82	0.39 -0.09,0.87	0.39 -0.09,0.86	0.39 -0.09,0.87
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.99 -3.25,1.27	-0.52 -2.83,1.79	-0.40 -2.79,1.99	-0.36 -2.72,2.00	2.53* 0.18,4.88	2.85* 0.52,5.18	2.93* 0.70,5.16	2.93* 0.69,5.17
Q3	0.25 -1.82,2.31	0.46 -1.85,2.77	0.67 -1.72,3.06	0.74 -1.60,3.08	0.99 -0.83,2.81	1.02 -0.66,2.69	1.09 -0.47,2.66	1.09 -0.47,2.66
Q4	-0.36 -2.58,1.86	-0.34 -2.76,2.08	0.06 -2.48,2.60	0.13 -2.40,2.65	1.59 -0.37,3.54	1.74+ -0.10,3.58	1.78+ -0.11,3.68	1.78+ -0.13,3.69
MECPP								
Continuous	-0.11 -0.73,0.52	-0.13 -0.69,0.44	-0.05 -0.64,0.53	-0.04 -0.61,0.54	0.36 -0.15,0.87	0.40 -0.12,0.93	0.37 -0.14,0.88	0.37 -0.14,0.88
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.24 -2.77,0.30	-1.09 -2.89,0.71	-0.80 -2.67,1.06	-0.74 -2.59,1.10	0.56 -1.29,2.40	0.76 -1.12,2.65	0.80 -1.06,2.65	0.80 -1.05,2.65
Q3	0.46 -2.39,3.31	0.70 -2.44,3.85	0.94 -2.25,4.13	1.03 -2.15,4.21	0.11 -1.69,1.91	0.24 -1.61,2.09	0.21 -1.51,1.94	0.21 -1.52,1.95
Q4	-0.20 -1.84,1.45	-0.32 -1.93,1.28	0.10 -1.54,1.74	0.14 -1.50,1.78	0.81 -1.37,2.99	0.94 -1.25,3.12	0.89 -1.32,3.10	0.88 -1.34,3.11
	Measles 2003-2004, Adolescents				Measles 2003-2004, Adults			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.32* 0.02,0.61	0.17 -0.12,0.45	0.21 -0.12,0.54	0.21 -0.12,0.54	0.29 -0.24,0.82	0.28 -0.27,0.83	0.25 -0.32,0.81	0.25 -0.32,0.82
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.22 -2.27,1.82	-0.34 -2.51,1.82	-0.12 -2.26,2.02	-0.02 -2.25,2.21	0.30 -1.35,1.95	0.45 -1.36,2.26	0.49 -1.32,2.29	0.49 -1.32,2.30
Q3	0.50 -1.03,2.04	0.18 -1.14,1.49	0.48 -0.99,1.94	0.50 -1.00,2.00	0.14 -1.42,1.70	-0.10 -1.59,1.38	-0.12 -1.65,1.42	-0.09 -1.67,1.50
Q4	1.07 -0.35,2.49	0.52 -0.95,1.99	0.72 -0.84,2.27	0.74 -0.88,2.36	0.49 -1.25,2.22	0.46 -1.30,2.22	0.36 -1.48,2.21	0.39 -1.49,2.26
MnBP								
Continuous	-0.06 -0.55,0.43	-0.28 -0.81,0.25	-0.22 -0.72,0.28	-0.21 -0.73,0.31	0.36 -0.32,1.05	0.37 -0.41,1.16	0.39 -0.44,1.21	0.40 -0.43,1.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.58 -2.38,1.22	-0.97 -2.67,0.74	-0.65 -2.35,1.05	-0.44 -2.07,1.19	0.77 -1.49,3.03	1.10 -0.97,3.17	1.04 -1.01,3.09	1.03 -1.02,3.08
Q3	-0.36 -2.57,1.86	-0.98 -3.07,1.11	-0.72 -2.86,1.43	-0.64 -2.79,1.52	1.61* 0.03,3.18	1.78* 0.21,3.36	1.64+ -0.01,3.29	1.65+ -0.02,3.32
Q4	-0.40 -2.26,1.47	-1.20 -3.00,0.59	-0.90 -2.59,0.78	-0.80 -2.53,0.93	0.61 -0.93,2.16	0.60 -1.22,2.43	0.68 -1.24,2.59	0.72 -1.21,2.65
MiBP								
Continuous	-0.01 -0.51,0.50	-0.47 -1.11,0.17	-0.44 -1.05,0.18	-0.42 -1.04,0.20	0.80+ -0.09,1.69	0.91+ -0.18,2.00	0.84 -0.27,1.94	0.84 -0.26,1.94
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.09 -1.84,2.02	-0.29 -2.12,1.54	-0.31 -2.04,1.43	-0.37 -2.06,1.31	0.24 -0.92,1.40	0.26 -0.80,1.31	0.17 -0.94,1.27	0.20 -0.87,1.28
Q3	0.12 -1.28,1.51	-0.48 -1.96,1.00	-0.51 -2.04,1.02	-0.51 -2.04,1.02	1.65 -1.21,4.50	1.76 -1.42,4.94	1.66 -1.49,4.82	1.67 -1.49,4.83
Q4	0.29 -1.03,1.61	-0.85 -2.47,0.77	-0.89 -2.40,0.61	-0.84 -2.34,0.65	1.57+ -0.32,3.47	1.92 -0.46,4.29	1.64 -0.40,3.68	1.67+ -0.34,3.68
∑ DBP								
Continuous	-0.37 -0.92,0.19	-0.49+ -1.04,0.05	-0.43 -0.98,0.12	-0.44 -1.00,0.12	-0.22 -0.72,0.29	-0.29 -0.85,0.27	-0.32 -0.90,0.27	-0.31 -0.89,0.27
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.16 -3.11,3.43	-0.27 -3.76,3.23	-0.12 -3.52,3.28	-0.06 -3.43,3.32	0.05 -2.20,2.30	0.16 -2.20,2.53	0.18 -2.13,2.50	0.19 -2.11,2.49
Q3	-0.34 -3.36,2.68	-0.75 -3.83,2.33	-0.47 -3.47,2.53	-0.47 -3.44,2.49	0.01 -1.78,1.80	0.36 -1.57,2.29	0.32 -1.61,2.25	0.34 -1.58,2.26
Q4	-0.84 -3.55,1.88	-1.51 -4.23,1.22	-1.23 -3.89,1.44	-1.23 -3.92,1.45	-0.79 -2.34,0.76	-1.13 -2.95,0.70	-1.18 -3.00,0.63	-1.16 -2.91,0.59
McPP								
Continuous	-0.24 -1.19,0.71	-0.32 -1.23,0.60	-0.40 -1.35,0.55	-0.38 -1.34,0.57	-0.04 -0.78,0.70	-0.18 -0.98,0.63	-0.17 -1.07,0.72	-0.17 -1.06,0.73
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.72 -2.57,1.13	-0.98 -2.74,0.77	-0.96 -2.69,0.78	-0.85 -2.57,0.86	0.79 -0.67,2.26	0.75 -0.90,2.40	1.00 -0.63,2.64	1.00 -0.63,2.63
Q3	-0.10 -2.29,2.08	-0.36 -2.62,1.89	-0.44 -2.50,1.62	-0.34 -2.41,1.73	0.72 -0.49,1.94	0.68 -0.81,2.17	0.80 -0.94,2.54	0.83 -0.88,2.55
Q4	-0.45 -2.72,1.82	-0.74 -2.87,1.38	-0.87 -2.92,1.18	-0.80 -2.88,1.29	0.12 -1.36,1.60	-0.27 -2.02,1.49	-0.07 -1.84,1.69	-0.07 -1.83,1.69
MBzP								
Continuous	-0.39 -0.89,0.11	-0.52* -1.01,-0.02	-0.44+ -0.95,0.06	-0.46+ -0.97,0.05	-0.26 -0.78,0.25	-0.32 -0.88,0.24	-0.35 -0.91,0.21	-0.34 -0.89,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.80 -2.98,1.37	-0.64 -2.94,1.65	-0.47 -2.69,1.75	-0.43 -2.60,1.75	0.04 -2.41,2.50	-0.01 -2.63,2.61	-0.02 -2.53,2.49	-0.01 -2.50,2.48

Q3	-0.89 -3.52,1.75	-1.00 -3.83,1.83	-0.63 -3.35,2.09	-0.64 -3.32,2.04	0.49 -1.77,2.75	0.89 -1.48,3.26	0.83 -1.48,3.15	0.86 -1.46,3.18
Q4	-1.36 -3.48,0.75	-1.73 -3.97,0.51	-1.41 -3.56,0.74	-1.45 -3.60,0.70	-0.43 -2.10,1.24	-0.66 -2.49,1.17	-0.73 -2.58,1.12	-0.71 -2.53,1.10
∑ DEHP								
Continuous	-0.05 -0.76,0.67	-0.18 -0.95,0.59	-0.16 -0.90,0.58	-0.14 -0.84,0.57	-0.01 -0.51,0.50	-0.07 -0.61,0.48	-0.15 -0.68,0.39	-0.14 -0.68,0.39
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.78 -2.47,0.92	-0.80 -2.50,0.90	-0.46 -2.20,1.29	-0.41 -2.19,1.36	-0.22 -1.71,1.27	0.12 -1.53,1.76	0.10 -1.57,1.77	0.11 -1.55,1.77
Q3	-0.05 -2.17,2.06	-0.06 -2.22,2.10	0.15 -1.93,2.22	0.17 -1.89,2.22	-0.26 -2.59,2.08	-0.31 -2.82,2.20	-0.25 -2.85,2.35	-0.24 -2.82,2.34
Q4	-1.00 -2.87,0.88	-1.38 -3.21,0.46	-1.15 -2.86,0.55	-1.10 -2.79,0.59	0.33 -1.47,2.14	0.10 -1.83,2.03	-0.07 -1.98,1.84	-0.06 -1.97,1.85
MEHP								
Continuous	0.19 -0.72,1.11	-0.05 -1.04,0.94	0.01 -0.98,0.99	0.03 -0.94,0.99	0.12 -0.44,0.69	0.05 -0.56,0.66	-0.06 -0.68,0.55	-0.06 -0.68,0.56
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -1.75,1.77	0.06 -1.69,1.81	0.56 -1.36,2.47	0.52 -1.36,2.41	0.29 -1.50,2.07	0.51 -1.50,2.53	0.51 -1.44,2.46	0.54 -1.36,2.44
Q3	0.63 -0.85,2.11	0.77 -0.84,2.37	0.91 -0.66,2.48	0.96 -0.70,2.62	1.26 -0.60,3.11	1.46 -0.57,3.48	1.38 -0.63,3.40	1.41 -0.56,3.38
Q4	0.32 -2.07,2.71	-0.37 -2.76,2.03	-0.11 -2.49,2.26	-0.09 -2.47,2.29	0.25 -1.20,1.70	0.07 -1.60,1.74	-0.03 -1.62,1.56	-0.02 -1.61,1.57
MEHHP								
Continuous	-0.10 -0.80,0.61	-0.24 -1.00,0.53	-0.21 -0.94,0.52	-0.19 -0.89,0.51	-0.02 -0.51,0.48	-0.09 -0.64,0.46	-0.16 -0.73,0.40	-0.16 -0.73,0.41
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.94 -3.12,1.23	-0.96 -3.24,1.32	-0.58 -2.87,1.71	-0.57 -2.90,1.76	0.79 -0.42,2.00	1.06+ -0.20,2.32	0.99 -0.31,2.29	0.98 -0.30,2.26
Q3	-0.25 -2.82,2.31	-0.24 -2.87,2.39	-0.05 -2.55,2.45	-0.04 -2.53,2.45	-0.35 -2.83,2.13	-0.42 -3.10,2.26	-0.46 -3.16,2.25	-0.45 -3.13,2.24
Q4	-1.41 -3.52,0.70	-1.87+ -3.94,.20	-1.63+ -3.59,0.34	-1.56 -3.52,0.41	0.22 -1.19,1.63	0.02 -1.54,1.57	-0.15 -1.83,1.54	-0.15 -1.84,1.54
MEOHP								
Continuous	-0.05 -0.78,0.69	-0.21 -1.02,0.60	-0.17 -0.94,0.59	-0.15 -0.88,0.58	0.01 -0.50,0.53	-0.05 -0.61,0.51	-0.12 -0.69,0.45	-0.12 -0.69,0.46
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.74 -2.69,1.20	-0.69 -2.79,1.41	-0.27 -2.28,1.74	-0.34 -2.35,1.66	0.88 -0.62,2.38	1.26 -0.29,2.81	1.25 -0.31,2.81	1.26 -0.30,2.82
Q3	-0.14 -2.50,2.21	-0.10 -2.49,2.29	0.10 -2.20,2.39	0.11 -2.16,2.39	0.54 -1.54,2.62	0.53 -1.73,2.79	0.55 -1.71,2.82	0.57 -1.65,2.79
Q4	-0.82 -2.89,1.26	-1.18 -3.35,0.99	-0.89 -2.90,1.13	-0.85 -2.85,1.15	0.25 -1.71,2.20	0.09 -1.98,2.17	-0.03 -2.26,2.19	-0.02 -2.24,2.21
MECPP								
Continuous	-0.02 -0.76,0.73	-0.14 -0.93,0.65	-0.13 -0.89,0.63	-0.11 -0.82,0.61	-0.02 -0.56,0.52	-0.07 -0.64,0.49	-0.16 -0.70,0.38	-0.16 -0.70,0.38
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.03 -3.19,1.13	-1.18 -3.22,0.86	-1.07 -2.91,0.77	-0.94 -2.85,0.96	-0.33 -1.53,0.86	-0.08 -1.48,1.32	-0.08 -1.50,1.34	-0.08 -1.49,1.33
Q3	-0.39 -2.27,1.48	-0.46 -2.34,1.42	-0.36 -2.08,1.37	-0.28 -2.04,1.47	0.04 -2.36,2.43	0.13 -2.38,2.63	0.10 -2.45,2.65	0.12 -2.41,2.64
Q4	-1.21 -3.16,0.73	-1.53 -3.42,0.36	-1.43+ -3.17,0.30	-1.32 -3.03,0.38	-0.02 -1.70,1.65	-0.25 -2.04,1.54	-0.39 -2.13,1.35	-0.38 -2.12,1.36
	Measles 2003-2004, US-Born				Measles 2003-2004, Foreign Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.07 -0.29,0.42	-0.06 -0.36,0.24	-0.00 -0.28,0.28	-0.00 -0.29,0.29	0.52 -0.58,1.62	0.44 -0.41,1.29	0.43 -0.49,1.36	0.42 -0.48,1.33
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -1.49,1.65	0.19 -1.54,1.92	0.25 -1.51,2.01	0.25 -1.51,2.02	-2.65 -7.46,2.15	-3.22 -7.78,1.34	-2.95 -7.88,1.97	-2.90 -7.82,2.02
Q3	0.42 -0.91,1.74	0.11 -1.12,1.35	0.27 -1.02,1.56	0.28 -1.06,1.62	-3.32 -8.00,1.36	-3.04 -6.78,0.69	-3.09 -7.15,0.96	-3.03 -7.09,1.04
Q4	-0.04 -1.54,1.46	-0.48 -1.82,0.86	-0.26 -1.67,1.14	-0.25 -1.70,1.19	-0.91 -5.70,3.88	-1.60 -5.07,1.87	-1.56 -5.36,2.24	-1.58 -5.34,2.17
MnBP								
Continuous	0.48* 0.03,0.94	0.45+ -0.00,0.91	0.50* 0.05,0.96	0.51* 0.05,0.98	-0.06 -1.76,1.63	0.53 -1.06,2.11	0.65 -1.11,2.40	0.65 -1.10,2.39
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.71 -1.43,2.85	0.83 -1.19,2.86	0.87 -1.15,2.89	0.87 -1.15,2.89	1.06 -3.42,5.55	2.56 -1.22,6.33	3.71+ -0.44,7.86	3.80+ -0.28,7.87
Q3	1.08 -0.24,2.39	0.95 -0.31,2.21	1.08 -0.26,2.41	1.09 -0.28,2.45	3.00 -0.88,6.88	3.52+ -0.66,7.70	3.98+ -0.44,8.40	4.13+ -0.24,8.50
Q4	1.26+ -0.09,2.61	1.09+ -0.23,2.42	1.27+ -0.08,2.62	1.30+ -0.08,2.68	-0.77 -4.22,2.68	1.13 -2.39,4.65	1.77 -2.23,5.76	1.73 -2.21,5.67

MiBP								
Continuous	0.78** 0.35,1.21	0.69** 0.23,1.15	0.69* 0.19,1.19	0.69** 0.19,1.19	0.46 -0.97,1.89	0.76 -0.82,2.34	0.82 -0.70,2.35	0.82 -0.67,2.30
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.00 -1.08,1.07	-0.13 -1.04,0.79	-0.09 -1.04,0.86	-0.07 -1.00,0.86	1.39 -2.91,5.69	2.77 -0.74,6.28	3.12+ -0.37,6.61	3.20+ -0.29,6.70
Q3	0.90 -0.59,2.39	0.69 -1.05,2.42	0.59 -1.14,2.32	0.59 -1.14,2.32	3.33 -1.81,8.47	3.07 -1.94,8.09	3.57 -1.88,9.02	3.55 -1.83,8.93
Q4	1.80** 0.63,2.97	1.49* 0.26,2.72	1.45* 0.13,2.76	1.46* 0.13,2.80	1.41 -1.78,4.59	2.16 -1.47,5.80	1.79 -1.05,4.63	1.79 -0.97,4.54
∑ DBP								
Continuous	0.11 -0.28,0.51	0.11 -0.28,0.51	0.14 -0.27,0.55	0.15 -0.26,0.56	-0.24 -1.55,1.08	0.09 -1.30,1.47	0.36 -1.31,2.02	0.34 -1.31,1.99
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.06 -2.02,1.90	0.03 -1.96,2.01	0.16 -1.81,2.12	0.16 -1.81,2.12	1.16 -1.78,4.11	1.68 -0.51,3.88	2.46+ -0.24,5.17	2.59+ -0.06,5.24
Q3	-0.23 -1.64,1.19	0.05 -1.41,1.51	0.20 -1.29,1.69	0.21 -1.28,1.70	1.57 -2.12,5.26	1.85 -1.87,5.57	2.50 -1.92,6.91	2.58 -1.76,6.91
Q4	0.12 -1.40,1.63	0.08 -1.48,1.65	0.25 -1.34,1.84	0.26 -1.29,1.82	-1.38 -4.56,1.81	-0.68 -3.80,2.44	-0.02 -2.90,2.87	-0.10 -2.94,2.73
McPP								
Continuous	0.40 -0.11,0.91	0.46+ -0.09,1.00	0.43 -0.12,0.98	0.43 -0.12,0.99	0.27 -2.17,2.72	-0.53 -2.90,1.84	-0.19 -2.78,2.40	-0.19 -2.78,2.40
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.72 -0.58,2.02	0.58 -0.65,1.80	0.82 -0.38,2.03	0.83 -0.37,2.02	0.35 -2.40,3.11	1.28 -2.17,4.73	2.07 -1.21,5.35	2.00 -1.31,5.31
Q3	0.30 -0.90,1.50	0.28 -0.92,1.48	0.47 -0.81,1.74	0.49 -0.74,1.71	4.16* 0.38,7.94	3.59+ -0.40,7.58	4.37* 0.18,8.57	4.34* 0.15,8.52
Q4	1.02 -0.36,2.40	1.06 -0.28,2.41	1.11 -0.24,2.46	1.11+ -0.23,2.45	-0.74 -5.59,4.11	-1.44 -5.84,2.95	-0.54 -5.37,4.28	-0.54 -5.38,4.30
MBzP								
Continuous	0.07 -0.34,0.48	0.07 -0.34,0.48	0.11 -0.30,0.52	0.11 -0.30,0.53	-0.41 -1.61,0.79	0.21 -1.20,1.61	0.42 -1.29,2.13	0.40 -1.28,2.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.40 -1.74,2.54	0.39 -1.85,2.63	0.40 -1.82,2.61	0.40 -1.81,2.61	-0.45 -3.62,2.72	1.23 -1.50,3.96	1.62 -1.34,4.58	1.76 -1.26,4.77
Q3	0.28 -1.42,1.99	0.60 -1.15,2.34	0.74 -1.09,2.56	0.75 -1.08,2.58	1.90 -1.93,5.73	3.45* 0.13,6.77	3.74+ -0.07,7.55	3.83* 0.07,7.58
Q4	0.45 -1.15,2.05	0.48 -1.05,2.01	0.63 -0.94,2.20	0.64 -0.91,2.19	-0.47 -4.06,3.11	1.06 -2.40,4.52	1.48 -2.65,5.60	1.37 -2.69,5.43
∑ DEHP								
Continuous	0.12 -0.28,0.53	0.07 -0.33,0.47	0.13 -0.27,0.53	0.13 -0.27,0.52	0.13 -0.99,1.26	0.03 -1.52,1.58	0.02 -1.59,1.62	0.01 -1.61,1.62
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.43 -1.73,0.88	-0.20 -1.42,1.02	-0.07 -1.22,1.09	-0.06 -1.22,1.10	1.43 -2.00,4.86	2.17 -1.37,5.72	3.13 -1.07,7.33	3.05 -1.13,7.24
Q3	-0.07 -1.69,1.55	-0.22 -1.74,1.30	-0.02 -1.52,1.49	-0.01 -1.52,1.50	0.45 -3.46,4.35	1.00 -2.36,4.36	1.60 -2.19,5.39	1.59 -2.20,5.37
Q4	0.54 -0.97,2.04	0.35 -1.11,1.82	0.56 -0.86,1.99	0.57 -0.84,1.99	0.48 -3.59,4.56	0.77 -4.07,5.60	0.92 -3.79,5.63	0.88 -3.87,5.63
MEHP								
Continuous	0.24 -0.15,0.62	0.10 -0.31,0.51	0.17 -0.22,0.56	0.17 -0.22,0.56	-0.17 -1.38,1.04	-0.24 -1.89,1.42	-0.61 -2.41,1.18	-0.62 -2.42,1.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.39 -1.75,0.98	-0.34 -1.81,1.12	-0.29 -1.71,1.12	-0.28 -1.68,1.11	3.45+ -0.43,7.33	3.97* 0.32,7.62	4.27* 0.17,8.36	4.36* 0.29,8.43
Q3	1.06+ -0.08,2.20	1.01 -0.31,2.34	0.98 -0.31,2.28	1.00 -0.26,2.26	1.80 -1.68,5.27	2.87+ -0.03,5.77	3.41* 0.05,6.78	3.47* 0.19,6.75
Q4	0.64 -0.48,1.75	0.26 -0.97,1.49	0.42 -0.78,1.61	0.42 -0.77,1.61	-0.45 -3.60,2.70	0.16 -3.58,3.90	0.47 -3.18,4.12	0.54 -3.07,4.15
MEHHP								
Continuous	0.10 -0.30,0.51	0.04 -0.38,0.47	0.11 -0.32,0.53	0.11 -0.31,0.53	0.09 -0.97,1.16	-0.03 -1.52,1.46	-0.04 -1.58,1.51	-0.05 -1.60,1.51
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.42 -0.68,1.52	0.55 -0.45,1.56	0.57 -0.41,1.56	0.57 -0.42,1.55	1.54 -2.16,5.23	2.21 -1.28,5.70	2.72 -1.36,6.80	2.61 -1.51,6.74
Q3	0.04 -1.67,1.75	-0.07 -1.69,1.56	0.03 -1.58,1.64	0.03 -1.58,1.64	-0.12 -4.56,4.32	0.67 -3.37,4.71	1.11 -3.32,5.54	1.11 -3.29,5.52
Q4	0.38 -0.96,1.71	0.16 -1.14,1.46	0.37 -0.95,1.69	0.37 -0.95,1.69	0.19 -3.79,4.17	0.34 -4.48,5.16	0.45 -4.33,5.23	0.38 -4.46,5.23
MEOHP								
Continuous	0.17 -0.23,0.57	0.12 -0.28,0.52	0.18 -0.22,0.59	0.19 -0.22,0.59	0.02 -1.14,1.18	-0.10 -1.73,1.52	-0.11 -1.82,1.60	-0.11 -1.83,1.60
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.23 -1.02,1.49	0.51 -0.60,1.63	0.56 -0.54,1.65	0.56 -0.52,1.65	3.18+ -0.36,6.72	3.50+ -0.00,7.01	4.30* 0.02,8.59	4.20+ -0.05,8.44
Q3	0.52 -0.82,1.87	0.40 -0.81,1.61	0.52 -0.69,1.72	0.53 -0.65,1.70	0.82 -3.40,5.03	2.09 -1.80,5.98	2.43 -1.67,6.54	2.44 -1.64,6.52

Q4	0.55 -1.03,2.14	0.41 -1.03,1.86	0.64 -0.80,2.08	0.65 -0.78,2.08	0.74 -3.07,4.55	0.75 -3.38,4.88	1.17 -3.42,5.77	1.10 -3.55,5.74
MECPP								
Continuous	0.12 -0.30,0.55	0.09 -0.32,0.50	0.13 -0.28,0.54	0.13 -0.28,0.54	0.18 -1.03,1.39	0.04 -1.58,1.66	0.02 -1.61,1.65	0.01 -1.63,1.65
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.59 -1.67,0.50	-0.55 -1.63,0.53	-0.41 -1.41,0.58	-0.41 -1.40,0.58	0.70 -2.88,4.28	1.61 -2.10,5.33	2.23 -1.82,6.29	2.17 -1.90,6.24
Q3	0.06 -1.51,1.63	0.09 -1.29,1.47	0.23 -1.16,1.61	0.24 -1.14,1.61	1.11 -2.94,5.17	1.47 -2.07,5.02	1.76 -2.20,5.72	1.74 -2.23,5.71
Q4	0.38 -1.02,1.78	0.18 -1.12,1.49	0.39 -0.89,1.68	0.40 -0.88,1.68	-0.20 -4.07,3.67	0.20 -4.41,4.80	0.44 -4.14,5.03	0.40 -4.23,5.03

	Mumps 2003-2004, Female				Mumps 2003-2004, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.01 -0.10,0.09	-0.07 -0.17,0.03	-0.06 -0.17,0.04	-0.07 -0.17,0.04	0.02 -0.10,0.14	-0.00 -0.12,0.12	0.02 -0.10,0.14	0.02 -0.10,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.30 -0.80,0.19	-0.37 -0.87,0.13	-0.33 -0.81,0.14	-0.35 -0.81,0.12	-0.32 -0.91,0.26	-0.33 -0.94,0.29	-0.35 -0.95,0.25	-0.36 -0.95,0.23
Q3	-0.44+ -0.89,0.01	-0.60* -1.06,-0.13	-0.58* -1.04,-0.11	-0.59* -1.05,-0.13	-0.22 -0.81,0.37	-0.30 -0.94,0.33	-0.26 -0.89,0.37	-0.25 -0.88,0.38
Q4	-0.24 -0.77,0.29	-0.49+ -1.04,0.07	-0.45+ -1.00,0.10	-0.47+ -1.00,0.07	-0.07 -0.72,0.58	-0.15 -0.82,0.51	-0.08 -0.74,0.57	-0.08 -0.72,0.56
MnBP								
Continuous	0.05 -0.12,0.22	0.07 -0.13,0.26	0.07 -0.12,0.27	0.07 -0.13,0.27	-0.03 -0.19,0.12	-0.03 -0.19,0.12	-0.02 -0.18,0.14	-0.01 -0.17,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.31 -0.19,0.81	0.33 -0.22,0.89	0.36 -0.20,0.92	0.36 -0.21,0.93	0.24 -0.43,0.91	0.24 -0.44,0.92	0.27 -0.38,0.92	0.27 -0.37,0.91
Q3	-0.09 -0.59,0.42	-0.06 -0.67,0.55	-0.02 -0.62,0.59	-0.03 -0.65,0.59	-0.04 -0.56,0.48	-0.02 -0.57,0.53	-0.01 -0.56,0.55	-0.00 -0.56,0.55
Q4	0.26 -0.25,0.77	0.28 -0.31,0.88	0.30 -0.29,0.89	0.29 -0.32,0.91	-0.02 -0.61,0.57	-0.05 -0.66,0.55	-0.01 -0.61,0.59	0.02 -0.60,0.63
MiBP								
Continuous	0.02 -0.19,0.23	0.04 -0.18,0.26	0.05 -0.18,0.27	0.04 -0.19,0.27	0.00 -0.20,0.20	-0.03 -0.23,0.16	-0.02 -0.20,0.16	-0.02 -0.21,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.28+ -0.56,0.01	-0.20 -0.57,0.18	-0.15 -0.55,0.25	-0.16 -0.59,0.27	0.13 -0.25,0.51	0.12 -0.21,0.45	0.11 -0.22,0.44	0.12 -0.22,0.47
Q3	-0.10 -0.52,0.32	-0.09 -0.53,0.35	-0.07 -0.55,0.40	-0.08 -0.56,0.40	0.09 -0.42,0.59	0.05 -0.41,0.51	0.05 -0.39,0.49	0.05 -0.39,0.50
Q4	0.18 -0.24,0.61	0.22 -0.26,0.69	0.22 -0.26,0.69	0.21 -0.29,0.70	-0.05 -0.47,0.37	-0.14 -0.57,0.29	-0.14 -0.54,0.27	-0.13 -0.54,0.28
∑ DBP								
Continuous	-0.00 -0.16,0.16	0.06 -0.12,0.24	0.07 -0.12,0.25	0.06 -0.12,0.25	-0.02 -0.15,0.11	0.00 -0.12,0.13	0.00 -0.12,0.13	0.01 -0.12,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.13 -0.69,0.44	-0.20 -0.74,0.33	-0.16 -0.70,0.38	-0.17 -0.72,0.39	0.03 -0.35,0.40	0.07 -0.34,0.48	0.10 -0.29,0.50	0.10 -0.30,0.49
Q3	-0.17 -0.76,0.42	-0.13 -0.79,0.52	-0.11 -0.77,0.55	-0.12 -0.79,0.56	0.14 -0.34,0.62	0.17 -0.34,0.68	0.20 -0.29,0.68	0.20 -0.29,0.68
Q4	-0.16 -0.69,0.36	0.01 -0.59,0.60	0.03 -0.56,0.63	0.03 -0.58,0.64	-0.00 -0.42,0.41	0.09 -0.30,0.48	0.12 -0.25,0.49	0.14 -0.24,0.51
McPP								
Continuous	0.11 -0.13,0.36	0.19+ -0.03,0.40	0.19+ -0.04,0.42	0.19 -0.05,0.43	0.02 -0.13,0.18	0.07 -0.13,0.26	0.07 -0.12,0.25	0.07 -0.12,0.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.00 -0.38,0.37	0.00 -0.41,0.42	0.05 -0.35,0.44	0.04 -0.36,0.45	0.20 -0.17,0.56	0.22 -0.17,0.60	0.23 -0.16,0.62	0.23 -0.16,0.61
Q3	0.07 -0.34,0.49	0.11 -0.36,0.58	0.14 -0.34,0.62	0.13 -0.38,0.64	0.46** 0.19,0.72	0.45** 0.16,0.73	0.48** 0.19,0.77	0.49** 0.20,0.79
Q4	0.22 -0.34,0.79	0.44 -0.16,1.03	0.44 -0.16,1.04	0.44 -0.18,1.06	0.19 -0.18,0.55	0.28 -0.15,0.70	0.28 -0.14,0.70	0.28 -0.13,0.69
MBzP								
Continuous	-0.03 -0.17,0.11	0.03 -0.14,0.20	0.04 -0.13,0.20	0.03 -0.14,0.21	-0.04 -0.17,0.10	-0.02 -0.15,0.11	-0.01 -0.15,0.12	-0.01 -0.14,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.00 -0.71,0.71	-0.05 -0.74,0.65	0.01 -0.69,0.71	0.00 -0.71,0.71	0.35 -0.08,0.77	0.42+ -0.03,0.87	0.40+ -0.04,0.84	0.39+ -0.05,0.83
Q3	-0.28 -0.82,0.27	-0.27 -0.91,0.37	-0.24 -0.88,0.40	-0.25 -0.91,0.40	0.08 -0.43,0.58	0.13 -0.39,0.64	0.13 -0.38,0.64	0.14 -0.37,0.64
Q4	-0.13 -0.74,0.49	0.05 -0.65,0.74	0.09 -0.60,0.78	0.08 -0.62,0.78	0.26 -0.16,0.67	0.33+ -0.07,0.73	0.34+ -0.04,0.73	0.35+ -0.03,0.74
∑ DEHP								
Continuous	-0.02 -0.20,0.17	-0.00 -0.17,0.17	0.01 -0.16,0.19	0.01 -0.17,0.19	0.01 -0.05,0.08	0.02 -0.06,0.09	0.03 -0.05,0.11	0.03 -0.04,0.11

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.20 -0.72,0.32	-0.10 -0.63,0.43	-0.06 -0.56,0.43	-0.07 -0.59,0.45	0.09 -0.38,0.57	0.15 -0.35,0.65	0.18 -0.32,0.68	0.17 -0.31,0.65
Q3	-0.24 -0.70,0.21	-0.15 -0.64,0.34	-0.12 -0.60,0.36	-0.13 -0.63,0.36	0.18 -0.26,0.62	0.17 -0.30,0.63	0.18 -0.29,0.65	0.18 -0.27,0.63
Q4	-0.14 -0.73,0.46	-0.05 -0.64,0.54	0.01 -0.60,0.62	0.00 -0.62,0.63	-0.04 -0.36,0.28	-0.02 -0.35,0.32	0.03 -0.31,0.36	0.03 -0.29,0.35
MEHP								
Continuous	0.07 -0.14,0.29	0.05 -0.16,0.25	0.06 -0.15,0.28	0.06 -0.15,0.28	-0.01 -0.08,0.05	-0.03 -0.10,0.05	-0.02 -0.11,0.07	-0.01 -0.10,0.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.03 -0.49,0.43	-0.00 -0.45,0.45	0.01 -0.45,0.47	-0.00 -0.49,0.49	0.13 -0.32,0.58	0.14 -0.27,0.56	0.14 -0.27,0.55	0.12 -0.29,0.52
Q3	-0.01 -0.36,0.35	-0.03 -0.42,0.37	-0.04 -0.45,0.36	-0.05 -0.46,0.35	-0.04 -0.31,0.24	-0.04 -0.34,0.26	-0.02 -0.32,0.28	-0.01 -0.31,0.29
Q4	0.07 -0.38,0.52	0.04 -0.40,0.48	0.10 -0.37,0.56	0.09 -0.39,0.56	-0.08 -0.35,0.20	-0.12 -0.38,0.15	-0.09 -0.35,0.18	-0.09 -0.34,0.17
MEHHP								
Continuous	-0.03 -0.20,0.15	0.05 -0.16,0.25	0.00 -0.17,0.17	0.00 -0.17,0.18	0.01 -0.06,0.07	0.01 -0.07,0.08	0.02 -0.06,0.10	0.03 -0.05,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -0.61,0.64	0.10 -0.57,0.78	0.11 -0.56,0.78	0.12 -0.55,0.78	0.15 -0.23,0.52	0.17 -0.23,0.58	0.20 -0.19,0.60	0.20 -0.18,0.58
Q3	-0.08 -0.58,0.43	-0.02 -0.57,0.53	0.00 -0.54,0.55	0.00 -0.55,0.55	0.05 -0.43,0.52	0.04 -0.46,0.54	0.04 -0.45,0.54	0.04 -0.43,0.52
Q4	-0.09 -0.69,0.51	-0.02 -0.64,0.60	0.03 -0.62,0.68	0.03 -0.61,0.68	-0.03 -0.40,0.35	-0.04 -0.43,0.35	0.02 -0.38,0.42	0.02 -0.37,0.42
MEOHP								
Continuous	-0.01 -0.20,0.17	0.01 -0.17,0.18	0.03 -0.16,0.2	0.02 -0.16,0.21	0.01 -0.06,0.08	0.01 -0.07,0.09	0.03 -0.06,0.11	0.03 -0.05,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.07 -0.39,0.52	0.20 -0.25,0.64	0.20 -0.24,0.63	0.19 -0.26,0.64	0.15 -0.30,0.61	0.19 -0.28,0.66	0.23 -0.22,0.68	0.23 -0.21,0.68
Q3	-0.05 -0.52,0.42	0.08 -0.47,0.62	0.09 -0.45,0.63	0.08 -0.47,0.63	0.10 -0.43,0.63	0.09 -0.46,0.63	0.11 -0.45,0.67	0.12 -0.44,0.67
Q4	-0.07 -0.69,0.55	0.05 -0.58,0.68	0.10 -0.55,0.75	0.09 -0.57,0.75	-0.02 -0.36,0.33	-0.02 -0.38,0.34	0.03 -0.34,0.40	0.04 -0.33,0.41
MECPP								
Continuous	-0.02 -0.21,0.17	-0.00 -0.18,0.17	0.01 -0.17,0.19	0.01 -0.17,0.19	0.02 -0.04,0.08	0.02 -0.05,0.10	0.04 -0.04,0.11	0.04 -0.04,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.35 -1.00,0.31	-0.31 -1.02,0.41	-0.27 -0.98,0.43	-0.28 -0.99,0.43	0.04 -0.41,0.48	0.12 -0.32,0.57	0.15 -0.29,0.59	0.15 -0.28,0.57
Q3	-0.35 -0.91,0.22	-0.20 -0.80,0.40	-0.18 -0.78,0.43	-0.19 -0.80,0.43	0.22 -0.25,0.69	0.20 -0.30,0.69	0.23 -0.27,0.72	0.23 -0.25,0.71
Q4	-0.19 -0.84,0.45	-0.13 -0.76,0.51	-0.06 -0.72,0.60	-0.06 -0.73,0.60	0.00 -0.26,0.27	0.04 -0.25,0.32	0.06 -0.20,0.32	0.07 -0.18,0.32
	Mumps 2003-2004, Adolescents				Mumps 2003-2004, Adults			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.10* 0.01,0.19	0.08+ -0.01,0.18	0.09+ -0.00,0.19	0.09+ -0.00,0.19	-0.01 -0.09,0.06	-0.05 -0.14,0.04	-0.05 -0.13,0.04	-0.04 -0.13,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.01 -0.60,0.58	0.07 -0.53,0.66	0.14 -0.43,0.72	0.15 -0.43,0.74	-0.27 -0.71,0.16	-0.32 -0.75,0.12	-0.32 -0.76,0.12	-0.32 -0.75,0.12
Q3	0.15 -0.27,0.56	0.13 -0.31,0.57	0.21 -0.24,0.66	0.21 -0.24,0.67	-0.35+ -0.76,0.05	-0.50* -0.92,-0.09	-0.51* -0.92,-0.10	-0.50* -0.91,-.09
Q4	0.38+ -0.05,0.82	0.36+ -0.07,0.79	0.40+ -0.04,0.84	0.41+ -0.04,0.85	-0.25 -0.71,0.20	-0.39+ -0.87,0.08	-0.38 -0.86,0.11	-0.37 -0.84,0.11
MnBP								
Continuous	0.09 -0.02,0.20	0.05 -0.08,0.17	0.06 -0.07,0.19	0.06 -0.07,0.19	0.04 -0.11,0.20	0.02 -0.16,0.19	0.02 -0.15,0.19	0.02 -0.15,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.06 -0.38,0.27	-0.13 -0.48,0.23	-0.01 -0.40,0.38	0.01 -0.39,0.41	0.30 -0.13,0.73	0.33 -0.11,0.77	0.34 -0.11,0.79	0.34 -0.11,0.78
Q3	-0.17 -0.58,0.24	-0.25 -0.69,0.19	-0.14 -0.62,0.33	-0.14 -0.62,0.34	0.01 -0.32,0.33	-0.03 -0.43,0.37	-0.02 -0.42,0.39	-0.01 -0.41,0.39
Q4	0.14 -0.18,0.47	-0.01 -0.33,0.31	0.07 -0.27,0.40	0.07 -0.28,0.43	0.20 -0.28,0.67	0.10 -0.41,0.60	0.11 -0.41,0.62	0.12 -0.41,0.65
MiBP								
Continuous	0.07 -0.09,0.23	0.00 -0.16,0.16	0.00 -0.17,0.17	0.00 -0.17,0.17	0.01 -0.17,0.19	-0.02 -0.20,0.16	-0.01 -0.19,0.17	-0.01 -0.19,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.19 -0.13,0.51	0.17 -0.18,0.52	0.15 -0.20,0.50	0.15 -0.20,0.50	-0.11 -0.49,0.26	-0.11 -0.50,0.28	-0.10 -0.50,0.30	-0.09 -0.50,0.33
Q3	0.35+ -0.05,0.74	0.25 -0.15,0.64	0.20 -0.21,0.60	0.20 -0.21,0.60	-0.06 -0.53,0.40	-0.12 -0.57,0.33	-0.10 -0.55,0.36	-0.09 -0.56,0.37

Q4	0.11 -0.30,0.51	-0.07 -0.48,0.35	-0.07 -0.50,0.36	-0.07 -0.49,0.36	0.14 -0.18,0.47	0.09 -0.24,0.43	0.11 -0.21,0.43	0.12 -0.20,0.44
∑ DBP								
Continuous	0.10* 0.00,0.20	0.08 -0.02,0.19	0.09+ -0.01,0.19	0.09+ -0.01,0.19	0.02 -0.11,0.16	0.03 -0.12,0.18	0.03 -0.12,0.17	0.03 -0.11,0.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.16 -0.40,0.73	0.10 -0.53,0.73	0.16 -0.46,0.77	0.16 -0.45,0.78	-0.07 -0.49,0.34	-0.09 -0.48,0.30	-0.07 -0.47,0.33	-0.07 -0.46,0.32
Q3	0.06 -0.44,0.56	-0.01 -0.55,0.53	0.05 -0.51,0.60	0.04 -0.51,0.60	0.00 -0.39,0.40	0.00 -0.44,0.45	0.01 -0.43,0.45	0.01 -0.43,0.46
Q4	0.36 -0.09,0.82	0.28 -0.20,0.76	0.33 -0.15,0.80	0.33 -0.15,0.80	-0.08 -0.51,0.36	-0.04 -0.52,0.44	-0.03 -0.49,0.43	-0.02 -0.48,0.44
McPP								
Continuous	0.05 -0.12,0.22	0.05 -0.14,0.24	0.02 -0.19,0.23	0.02 -0.20,0.23	0.16 -0.04,0.35	0.16+ -0.03,0.35	0.17+ -0.02,0.36	0.18+ -0.01,0.36
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.77,0.48	-0.20 -0.87,0.47	-0.20 -0.87,0.48	-0.19 -0.87,0.49	0.17 -0.10,0.43	0.18 -0.10,0.46	0.20 -0.07,0.47	0.20 -0.07,0.47
Q3	0.19 -0.43,0.81	0.15 -0.51,0.80	0.09 -0.54,0.72	0.09 -0.55,0.73	0.32 -0.09,0.73	0.29 -0.13,0.70	0.31 -0.10,0.71	0.32 -0.09,0.73
Q4	0.03 -0.50,0.56	0.01 -0.57,0.60	-0.04 -0.63,0.54	-0.04 -0.63,0.56	0.39+ -0.07,0.85	0.46* 0.01,0.91	0.47* 0.04,0.91	0.47* 0.04,0.91
MBzP								
Continuous	0.10* 0.00,0.20	0.08 -0.03,0.19	0.09+ -0.01,0.19	0.09+ -0.01,0.19	-0.01 -0.14,0.11	-0.01 -0.15,0.14	-0.01 -0.15,0.13	-0.01 -0.15,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.13 -0.85,0.59	-0.06 -0.82,0.70	-0.02 -0.79,0.75	-0.02 -0.79,0.75	0.26 -0.16,0.69	0.23 -0.19,0.66	0.25 -0.18,0.69	0.25 -0.17,0.68
Q3	-0.24 -0.91,0.42	-0.25 -0.96,0.47	-0.16 -0.89,0.56	-0.16 -0.88,0.56	-0.06 -0.46,0.34	-0.07 -0.52,0.37	-0.07 -0.52,0.37	-0.06 -0.51,0.38
Q4	0.14 -0.45,0.73	0.13 -0.52,0.78	0.18 -0.47,0.82	0.18 -0.46,0.82	0.17 -0.27,0.60	0.18 -0.31,0.67	0.20 -0.27,0.66	0.20 -0.27,0.67
∑ DEHP								
Continuous	-0.08 -0.18,0.03	-0.09+ -0.20,0.02	-0.09 -0.19,0.02	-0.08 -0.19,0.03	0.01 -0.11,0.14	-0.00 -0.13,0.12	0.00 -0.13,0.13	0.00 -0.13,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.22 -0.69,0.25	-0.23 -0.69,0.23	-0.16 -0.62,0.30	-0.16 -0.61,0.30	-0.04 -0.43,0.34	0.01 -0.40,0.42	0.03 -0.38,0.44	0.03 -0.37,0.43
Q3	0.09 -0.32,0.50	0.10 -0.34,0.53	0.17 -0.26,0.60	0.17 -0.26,0.60	-0.06 -0.39,0.27	-0.08 -0.46,0.29	-0.08 -0.45,0.29	-0.08 -0.45,0.29
Q4	-0.27 -0.63,0.10	-0.29 -0.65,0.07	-0.25 -0.59,0.10	-0.24 -0.60,0.12	-0.05 -0.50,0.40	-0.10 -0.54,0.34	-0.07 -0.54,0.40	-0.07 -0.53,0.40
MEHP								
Continuous	-0.02 -0.16,0.12	-0.04 -0.18,0.09	-0.05 -0.19,0.09	-0.05 -0.19,0.09	0.01 -0.14,0.15	-0.02 -0.18,0.14	-0.02 -0.19,0.16	-0.01 -0.18,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.09 -0.49,0.30	-0.08 -0.50,0.34	0.05 -0.34,0.44	0.05 -0.34,0.43	0.12 -0.27,0.50	0.07 -0.32,0.47	0.07 -0.33,0.46	0.08 -0.32,0.47
Q3	0.05 -0.38,0.48	0.10 -0.33,0.54	0.13 -0.26,0.52	0.13 -0.25,0.52	-0.07 -0.42,0.27	-0.14 -0.52,0.24	-0.15 -0.53,0.23	-0.14 -0.52,0.24
Q4	-0.05 -0.41,0.32	-0.11 -0.47,0.25	-0.07 -0.41,0.27	-0.06 -0.41,0.28	-0.06 -0.43,0.31	-0.15 -0.52,0.23	-0.13 -0.52,0.26	-0.13 -0.52,0.26
MEHHP								
Continuous	-0.09 -0.20,0.02	-0.10+ -0.21,0.01	-0.09+ -0.20,0.01	-0.09+ -0.21,0.02	0.00 -0.12,0.12	-0.01 -0.14,0.11	-0.01 -0.14,0.12	-0.01 -0.14,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.44+ -0.89,0.02	-0.47* -0.94,-0.00	-0.40+ -0.86,0.06	-0.40+ -0.87,0.06	0.20 -0.25,0.65	0.26 -0.23,0.76	0.28 -0.23,0.78	0.27 -0.24,0.78
Q3	-0.04 -0.53,0.45	-0.02 -0.52,0.48	0.02 -0.49,0.52	0.02 -0.49,0.52	0.01 -0.43,0.45	-0.03 -0.51,0.44	-0.03 -0.51,0.45	-0.03 -0.51,0.45
Q4	-0.43* -0.86,-0.01	-0.48* -0.90,-0.05	-0.42* -0.80,-0.03	-0.41* -0.82,-0.00	-0.00 -0.51,0.51	-0.05 -0.57,0.47	-0.03 -0.57,0.52	-0.03 -0.57,0.52
MEOHP								
Continuous	-0.08 -0.20,0.03	-0.10+ -0.21,0.01	-0.10+ -0.20,0.01	-0.09+ -0.21,0.02	0.02 -0.11,0.15	0.00 -0.12,0.13	0.01 -0.12,0.15	0.01 -0.12,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.34 -0.94,0.25	-0.35 -0.94,0.24	-0.27 -0.88,0.34	-0.28 -0.88,0.33	0.18 -0.19,0.56	0.25 -0.15,0.65	0.26 -0.16,0.67	0.26 -0.15,0.67
Q3	0.04 -0.51,0.59	0.06 -0.52,0.64	0.13 -0.46,0.72	0.13 -0.46,0.72	0.05 -0.37,0.48	0.03 -0.45,0.50	0.03 -0.45,0.51	0.04 -0.44,0.52
Q4	-0.34 -0.79,0.11	-0.38+ -0.82,0.06	-0.30 -0.72,0.12	-0.30 -0.73,0.14	-0.00 -0.46,0.46	-0.05 -0.52,0.43	-0.03 -0.52,0.46	-0.02 -0.52,0.47
MECPP								
Continuous	-0.08 -0.18,0.02	-0.09 -0.19,0.02	-0.08 -0.19,0.02	-0.08 -0.19,0.03	0.01 -0.12,0.14	-0.01 -0.13,0.12	-0.00 -0.14,0.13	0.00 -0.13,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.80,0.51	-0.15 -0.78,0.48	-0.14 -0.72,0.44	-0.13 -0.72,0.46	-0.20 -0.68,0.28	-0.16 -0.70,0.38	-0.15 -0.69,0.40	-0.15 -0.70,0.40

Q3	0.05 -0.32,0.41	0.05 -0.31,0.40	0.08 -0.27,0.42	0.08 -0.27,0.43	-0.09 -0.46,0.27	-0.09 -0.50,0.32	-0.08 -0.50,0.33	-0.08 -0.49,0.33
Q4	-0.26 -0.68,0.15	-0.27 -0.68,0.15	-0.24 -0.64,0.17	-0.23 -0.66,0.20	-0.08 -0.53,0.37	-0.12 -0.57,0.32	-0.10 -0.57,0.36	-0.10 -0.57,0.37

	Mumps 2003-2004, US-Born				Mumps 2003-2004, Foreign Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.01 -0.07,0.09	-0.04 -0.11,0.04	-0.02 -0.10,0.05	-0.02 -0.10,0.05	-0.03 -0.17,0.11	-0.05 -0.22,0.11	-0.06 -0.22,0.10	-0.06 -0.22,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.33 -0.74,0.08	-0.34+ -0.72,0.03	-0.32+ -0.71,0.06	-0.32+ -0.70,0.06	-0.21 -0.68,0.26	-0.14 -0.67,0.38	-0.14 -0.70,0.42	-0.13 -0.70,0.43
Q3	-0.30+ -0.65,0.06	-0.42* -0.78,-0.07	-0.38* -0.74,-0.03	-0.38* -0.73,-0.03	-0.38 -1.32,0.56	-0.54 -1.42,0.33	-0.57 -1.49,0.36	-0.56 -1.48,0.36
Q4	-0.16 -0.58,0.27	-0.31 -0.70,0.08	-0.25 -0.66,0.16	-0.25 -0.65,0.16	-0.26 -0.79,0.26	-0.35 -0.98,0.28	-0.40 -1.06,0.26	-0.40 -1.06,0.26
MnBP								
Continuous	0.03 -0.10,0.17	0.04 -0.11,0.19	0.05 -0.10,0.19	0.05 -0.10,0.20	-0.02 -0.21,0.16	-0.01 -0.23,0.21	-0.01 -0.24,0.21	-0.01 -0.24,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.17 -0.26,0.60	0.20 -0.24,0.64	0.22 -0.23,0.67	0.22 -0.22,0.67	0.71* 0.09,1.34	0.83* 0.19,1.47	0.78* 0.16,1.40	0.78* 0.14,1.43
Q3	-0.12 -0.48,0.23	-0.10 -0.51,0.32	-0.06 -0.50,0.37	-0.06 -0.49,0.38	0.22 -0.39,0.84	0.23 -0.36,0.81	0.21 -0.38,0.81	0.22 -0.39,0.83
Q4	0.14 -0.29,0.56	0.12 -0.33,0.57	0.15 -0.31,0.61	0.16 -0.31,0.63	0.21 -0.47,0.88	0.30 -0.43,1.04	0.30 -0.43,1.03	0.29 -0.43,1.02
MiBP								
Continuous	-0.00 -0.19,0.18	0.00 -0.15,0.16	0.01 -0.15,0.17	0.01 -0.15,0.17	-0.05 -0.23,0.14	-0.06 -0.27,0.15	-0.06 -0.28,0.15	-0.06 -0.28,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.13 -0.48,0.22	-0.07 -0.41,0.27	-0.03 -0.39,0.33	-0.02 -0.39,0.35	0.15 -0.30,0.60	0.18 -0.25,0.62	0.16 -0.28,0.61	0.17 -0.28,0.62
Q3	-0.04 -0.51,0.43	-0.04 -0.45,0.37	-0.04 -0.45,0.36	-0.04 -0.45,0.37	-0.06 -0.60,0.47	-0.04 -0.62,0.54	-0.04 -0.63,0.55	-0.04 -0.63,0.55
Q4	0.05 -0.27,0.36	0.08 -0.23,0.38	0.08 -0.21,0.36	0.09 -0.20,0.37	-0.09 -0.60,0.42	-0.16 -0.73,0.41	-0.16 -0.72,0.40	-0.16 -0.72,0.40
∑ DBP								
Continuous	-0.00 -0.12,0.12	0.05 -0.06,0.17	0.06 -0.06,0.17	0.06 -0.06,0.18	0.05 -0.20,0.29	0.06 -0.20,0.32	0.04 -0.24,0.32	0.04 -0.24,0.33
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.55,0.31	-0.11 -0.55,0.32	-0.08 -0.53,0.38	-0.08 -0.53,0.37	0.09 -0.50,0.69	0.11 -0.53,0.75	0.04 -0.62,0.69	0.04 -0.64,0.72
Q3	-0.05 -0.45,0.35	0.01 -0.43,0.45	0.03 -0.42,0.48	0.04 -0.41,0.49	0.03 -0.42,0.47	0.09 -0.35,0.53	0.02 -0.52,0.56	0.02 -0.50,0.54
Q4	-0.11 -0.51,0.29	0.06 -0.37,0.48	0.08 -0.36,0.52	0.09 -0.36,0.53	0.25 -0.67,1.17	0.29 -0.74,1.32	0.27 -0.81,1.34	0.26 -0.81,1.34
McPP								
Continuous	0.09 -0.09,0.27	0.18* 0.04,0.32	0.18* 0.03,0.34	0.18* 0.03,0.34	-0.01 -0.37,0.35	-0.01 -0.42,0.40	-0.03 -0.47,0.40	-0.03 -0.47,0.40
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.19,0.35	0.09 -0.22,0.41	0.12 -0.18,0.42	0.12 -0.17,0.42	0.02 -0.46,0.49	0.14 -0.32,0.59	0.12 -0.35,0.60	0.12 -0.36,0.59
Q3	0.27 -0.09,0.62	0.31 -0.07,0.69	0.35+ -0.05,0.74	0.36+ -0.04,0.76	0.19 -0.24,0.63	0.22 -0.26,0.70	0.24 -0.33,0.82	0.24 -0.34,0.82
Q4	0.22 -0.17,0.61	0.43* 0.07,0.80	0.44* 0.05,0.83	0.44* 0.05,0.83	0.05 -0.64,0.74	0.12 -0.61,0.85	0.06 -0.71,0.83	0.06 -0.71,0.83
MBzP								
Continuous	-0.03 -0.13,0.07	0.02 -0.09,0.13	0.02 -0.09,0.13	0.02 -0.09,0.13	0.07 -0.16,0.29	0.08 -0.16,0.33	0.07 -0.19,0.33	0.07 -0.19,0.33
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.15 -0.28,0.58	0.16 -0.32,0.64	0.18 -0.32,0.68	0.18 -0.32,0.68	0.23 -0.45,0.91	0.31 -0.44,1.06	0.28 -0.48,1.05	0.29 -0.50,1.08
Q3	-0.16 -0.60,0.28	-0.09 -0.59,0.41	-0.06 -0.57,0.45	-0.06 -0.57,0.46	0.06 -0.38,0.51	0.11 -0.39,0.60	0.07 -0.47,0.61	0.07 -0.47,0.61
Q4	0.04 -0.40,0.47	0.19 -0.27,0.65	0.22 -0.25,0.69	0.22 -0.25,0.69	0.47 -0.26,1.21	0.51 -0.30,1.32	0.51 -0.31,1.34	0.51 -0.32,1.34
∑ DEHP								
Continuous	-0.01 -0.13,0.11	-0.01 -0.12,0.11	0.01 -0.11,0.14	0.01 -0.11,0.14	0.05 -0.06,0.16	0.06 -0.06,0.18	0.05 -0.10,0.19	0.05 -0.10,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.52,0.25	-0.04 -0.39,0.31	-0.00 -0.34,0.34	0.00 -0.34,0.34	0.32 -0.48,1.13	0.40 -0.40,1.19	0.37 -0.32,1.05	0.36 -0.30,1.03
Q3	-0.12 -0.43,0.18	-0.06 -0.38,0.25	-0.04 -0.35,0.28	-0.03 -0.35,0.29	0.29 -0.32,0.90	0.32 -0.26,0.91	0.29 -0.29,0.88	0.29 -0.30,0.88
Q4	-0.13 -0.57,0.31	-0.08 -0.50,0.35	-0.01 -0.46,0.44	-0.00 -0.46,0.45	0.14 -0.24,0.53	0.18 -0.24,0.60	0.17 -0.27,0.61	0.17 -0.26,0.61
MEHP								

Continuous	0.02 -0.12,0.16	-0.01 -0.14,0.13	0.01 -0.13,0.16	0.01 -0.13,0.16	0.00 -0.16,0.17	0.00 -0.17,0.17	-0.04 -0.25,0.18	-0.04 -0.25,0.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.13 -0.37,0.12	-0.11 -0.34,0.12	-0.10 -0.32,0.12	-0.10 -0.31,0.12	0.88* 0.03,1.73	1.02* 0.20,1.85	0.99* 0.14,1.83	0.99* 0.13,1.86
Q3	-0.11 -0.35,0.13	-0.15 -0.41,0.12	-0.16 -0.43,0.12	-0.15 -0.43,0.12	0.54+ -0.01,1.09	0.58* 0.06,1.10	0.54* 0.04,1.04	0.54* 0.03,1.06
Q4	-0.07 -0.41,0.27	-0.13 -0.45,0.19	-0.07 -0.42,0.27	-0.07 -0.42,0.27	0.36 -0.18,0.89	0.39 -0.16,0.93	0.33 -0.26,0.92	0.33 -0.27,0.94
MEHHP								
Continuous	-0.02 -0.14,0.10	-0.02 -0.13,0.10	0.00 -0.12,0.12	0.00 -0.12,0.13	0.05 -0.05,0.15	0.06 -0.05,0.17	0.04 -0.09,0.17	0.04 -0.09,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.43,0.47	0.10 -0.36,0.55	0.12 -0.36,0.59	0.12 -0.36,0.59	0.39 -0.40,1.18	0.45 -0.32,1.23	0.43 -0.28,1.14	0.42 -0.26,1.11
Q3	-0.08 -0.49,0.32	-0.04 -0.46,0.38	-0.02 -0.45,0.42	-0.02 -0.46,0.42	0.31 -0.27,0.88	0.35 -0.23,0.93	0.30 -0.29,0.88	0.30 -0.29,0.89
Q4	-0.09 -0.57,0.40	-0.06 -0.53,0.42	0.00 -0.50,0.51	0.01 -0.50,0.51	0.09 -0.33,0.52	0.14 -0.32,0.60	0.11 -0.36,0.58	0.11 -0.35,0.56
MEOHP								
Continuous	-0.00 -0.13,0.12	-0.00 -0.12,0.12	0.02 -0.11,0.15	0.02 -0.11,0.15	0.05 -0.06,0.17	0.06 -0.08,0.20	0.05 -0.11,0.20	0.04 -0.11,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.04 -0.35,0.43	0.13 -0.23,0.50	0.15 -0.22,0.53	0.16 -0.22,0.53	0.39 -0.49,1.26	0.43 -0.47,1.33	0.38 -0.44,1.20	0.37 -0.41,1.15
Q3	-0.05 -0.45,0.35	0.03 -0.39,0.45	0.05 -0.40,0.49	0.05 -0.40,0.50	0.39 -0.21,1.00	0.41 -0.16,0.97	0.37 -0.21,0.96	0.37 -0.21,0.96
Q4	-0.08 -0.53,0.38	-0.03 -0.48,0.42	0.03 -0.44,0.50	0.04 -0.44,0.51	0.15 -0.40,0.70	0.18 -0.49,0.86	0.12 -0.58,0.82	0.12 -0.56,0.79
MECPP								
Continuous	-0.01 -0.14,0.11	-0.00 -0.12,0.11	0.01 -0.11,0.14	0.01 -0.11,0.14	0.06 -0.06,0.19	0.07 -0.07,0.21	0.05 -0.10,0.21	0.05 -0.10,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18 -0.60,0.23	-0.09 -0.50,0.33	-0.05 -0.46,0.35	-0.05 -0.46,0.36	-0.18 -0.88,0.53	-0.13 -0.83,0.58	-0.16 -0.91,0.60	-0.16 -0.92,0.60
Q3	-0.10 -0.42,0.22	-0.01 -0.33,0.31	0.02 -0.31,0.36	0.03 -0.31,0.37	-0.08 -0.78,0.63	-0.04 -0.75,0.67	-0.04 -0.77,0.69	-0.04 -0.78,0.69
Q4	-0.14 -0.57,0.29	-0.07 -0.49,0.34	-0.01 -0.45,0.43	-0.01 -0.45,0.44	0.12 -0.50,0.73	0.14 -0.47,0.75	0.10 -0.59,0.79	0.10 -0.60,0.80

	Rubella 2003-2004, Female				Rubella 2003-2004, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.54 -4.54,3.46	-1.81 -5.94,2.32	-1.60 -5.66,2.46	-1.27 -5.25,2.72	2.12 -1.92,6.15	1.55 -2.91,6.01	1.78 -2.97,6.54	1.83 -2.86,6.51
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.52 -22.43,19.40	0.03 -18.89,18.95	1.43 -17.74,20.59	2.93 -17.24,23.09	-8.25 -22.66,6.17	-8.49 -23.18,6.20	-8.93 -23.00,5.13	-9.16 -23.05,4.73
Q3	-10.96 -26.34,4.41	-14.96* -27.7,-2.2	-14.21* -27.7,-.75	-12.56+ -26.1,.94	-9.64 -29.41,10.14	-10.17 -29.64,9.30	-9.36 -29.63,10.92	-9.02 29.30,11.26
Q4	-5.61 -26.20,14.97	-8.65 -28.41,11.11	-7.66 -27.78,12.45	-5.87 -26.21,14.5	-1.14 -16.94,14.67	-4.33 -20.43,11.77	-3.65 -20.70,13.40	-3.62 20.19,12.95
MnBP								
Continuous	-3.00 -8.18,2.17	-2.99 -8.22,2.25	-3.00 -8.44,2.44	-2.56 -8.10,2.98	0.11 -4.01,4.23	1.78 -2.67,6.23	2.25 -2.49,6.99	2.54 -2.16,7.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-9.09 -25.99,7.82	-8.10 -26.21,10.0	-7.16 -25.60,11.27	-6.79 -25.06,11.48	17.86+ -0.82,36.53	16.52+ -.32,33.35	16.71+ -.59,34.02	16.63+ .76,34.02
Q3	-12.89 -28.97,3.19	-14.3+ -31.42,2.80	-13.66 -30.40,3.08	-12.10 -29.08,4.89	10.69 -6.69,28.07	13.27 -5.65,32.18	13.40 -6.79,33.60	13.49 -6.81,33.79
Q4	-8.96 -25.55,7.64	-9.63 -26.18,6.91	-9.38 -26.49,7.73	-8.12 -25.15,8.9	2.34 -11.81,16.48	5.45 -10.57,21.46	6.56 -10.43,23.54	7.54 -9.42,24.51
MiBP								
Continuous	-2.92 -9.85,4.01	-2.16 -8.52,4.20	-2.21 -8.61,4.18	-1.79 -8.05,4.46	1.17 -3.32,5.67	2.40 -2.82,7.62	2.31 -2.92,7.54	2.33 -2.89,7.55
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-11.75+ -25.30,1.80	-10.36 -23.15,2.44	-9.58 -22.68,3.52	-7.94 -20.46,4.58	-1.33 -10.68,8.02	-0.60 -9.30,8.10	-1.04 -9.83,7.74	-0.51 -9.83,8.81
Q3	-8.11 -24.18,7.97	-7.03 -22.51,8.45	-7.14 -22.18,7.89	-6.61 -21.70,8.47	-8.43 -23.58,6.72	-6.62 -20.78,7.53	-7.87 -21.80,6.06	-7.81 -22.00,6.38
Q4	-4.81 -24.29,14.67	-2.92 -21.25,15.41	-3.70 -21.79,14.38	-2.1 -19.42,15.24	4.67 -9.76,19.11	8.83 -9.85,27.51	9.11 -11.11,29.33	9.47 -10.57,29.51
∑ DBP								
Continuous	-3.87 -9.16,1.41	-2.87 -8.14,2.40	-2.47 -8.14,3.21	-2.14 -7.66,3.38	-2.77 -8.06,2.51	-0.33 -6.09,5.44	0.04 -5.84,5.92	0.21 -5.65,6.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-4.95 -20.46,10.56	-8.16 -23.80,7.48	-7.45 -22.92,8.01	-6.13 -21.72,9.47	6.66 -13.01,26.32	6.55 -14.62,27.71	7.16 -14.49,28.82	6.85 -14.82,28.53

Q3	-11.31 -27.72,5.10	-10.07 -28.15,8.00	-9.59 -28.39,9.21	-8.02 -26.34,10.3	1.22 -18.22,20.66	4.18 -16.45,24.82	5.14 -16.36,26.64	5.19 -16.54,26.92
Q4	-8.18 -23.45,7.10	-6.18 -21.84,9.49	-4.96 -21.53,11.61	-4.05 20.31,12.21	-6.04 -23.74,11.66	-1.06 -21.26,19.14	-0.12 -20.99,20.76	0.42 -20.45,21.28
McPP								
Continuous	-4.00 -11.99,3.99	-3.08 -11.49,5.34	-2.89 -11.30,5.52	-2.38 -10.70,5.95	-2.31 -8.92,4.30	1.47 -6.60,9.53	1.79 -6.47,10.06	1.87 -6.24,9.98
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	5.40 -12.53,23.32	5.51 -12.63,23.66	6.55 -12.06,25.15	7.13 -11.33,25.59	0.39 -13.34,14.12	0.07 -12.83,12.97	0.41 -12.49,13.31	0.29 -12.72,13.30
Q3	-9.56+ -21.07,1.95	-11.2+ -23.09,0.69	-10.3+ -22.51,1.90	-8.45 -20.16,3.26	-8.15 -28.61,12.30	-8.39 -28.62,11.85	-8.35 -28.47,11.78	-7.95 28.09,12.20
Q4	-5.87 -23.19,11.45	-4.08 -22.16,14.00	-3.74 -22.78,15.29	-2.66 21.37,16.05	-2.90 -18.97,13.16	3.73 -14.39,21.86	4.78 -13.89,23.46	4.71 -13.88,23.30
MBzP								
Continuous	-4.06+ -8.80,0.68	-3.01 -7.65,1.64	-2.62 -7.69,2.45	-2.35 -7.24,2.54	-2.79 -7.75,2.17	-0.60 -5.99,4.78	-0.25 -5.74,5.24	-0.10 -5.57,5.37
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-12.49 -31.54,6.56	-13.99 -34.51,6.54	-13.05 -33.82,7.72	-11.78 32.29,8.73	14.01 -5.10,33.12	15.10 -5.65,35.86	14.46 -5.83,34.75	14.10 -6.23,34.42
Q3	-11.03 -28.28,6.22	-9.64 -28.33,9.05	-8.98 -28.30,10.34	-6.93 25.63,11.77	10.19 -4.14,24.52	13.23 -3.31,29.77	13.58 -3.47,30.63	13.72 -3.50,30.95
Q4	-15.25+ -30.78,0.29	-12.66 -29.05,3.72	-11.02 -28.04,6.00	-10.17 26.58,6.24	2.00 -13.86,17.86	7.34 -11.57,26.25	7.76 -11.56,27.08	8.05 -11.36,27.45
∑ DEHP								
Continuous	-3.34* -6.65,-0.03	-3.04* -6.03,-0.05	-2.58 -5.86,0.71	-2.34 -5.79,1.10	-2.98+ -6.23,0.27	-1.63 -5.46,2.20	-1.46 -5.89,2.97	-1.38 -5.80,3.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-15.04 -37.64,7.57	-12.18 -34.15,9.79	-10.68 -32.79,11.4	-9.27 30.66,12.13	13.00 -6.46,32.47	13.88 -4.28,32.04	14.03 -4.07,32.14	13.84 -4.15,31.83
Q3	-16.47+ -35.29,2.35	-15.22 -34.03,3.59	-13.67 -33.43,6.10	-12.07 31.81,7.67	1.33 -12.53,15.19	1.94 -11.52,15.39	2.51 -10.63,15.64	2.46 -10.72,15.64
Q4	-9.75 -24.47,4.97	-8.81 -22.47,4.84	-6.90 -21.26,7.47	-5.93 -20.56,8.71	-4.99 -17.97,7.99	-0.45 -16.11,15.21	-0.11 -17.03,16.80	0.05 -17.04,17.14
MEHP								
Continuous	-0.78 -4.93,3.37	-1.67 -6.09,2.75	-1.30 -5.72,3.11	-1.31 -5.78,3.17	-2.48 -7.02,2.06	-1.64 -6.71,3.43	-1.65 -7.64,4.34	-1.49 -7.40,4.42
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-9.80 -25.20,5.60	-6.82 -23.05,9.42	-6.42 -22.86,10.01	-3.76 19.15,11.62	-6.38 -23.17,10.40	-2.79 -20.11,14.53	-3.17 -20.14,13.80	-3.88 20.75,12.99
Q3	-2.15 -16.57,12.28	-3.30 -18.98,12.38	-3.53 -18.97,11.90	-1.85 16.40,12.69	0.33 -9.88,10.53	5.52 -6.55,17.59	5.76 -7.07,18.58	6.08 -7.13,19.28
Q4	-2.06 -12.34,8.23	-2.45 -14.88,9.98	-1.00 -13.32,11.32	0.04 -11.91,11.99	-3.66 -13.62,6.30	-0.88 -13.53,11.76	-0.60 -13.81,12.62	-0.62 13.77,12.53
MEHHP								
Continuous	-2.83+ -5.92,0.25	-2.57+ -5.49,0.35	-2.08 -5.15,0.98	-1.92 -5.21,1.36	-3.11+ -6.28,0.06	-1.88 -5.66,1.90	-1.67 -6.08,2.74	-1.61 -6.01,2.78
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-4.00 -27.50,19.49	-2.60 -24.40,19.21	-2.97 -24.87,18.94	-3.25 25.35,18.85	11.00 -7.10,29.10	10.75 -5.41,26.91	10.88 -5.62,27.38	10.64 -5.88,27.17
Q3	-13.85 -31.22,3.52	-11.93 -30.09,6.23	-10.92 -30.10,8.25	-10.23 30.08,9.61	3.73 -9.68,17.13	5.08 -9.16,19.31	5.28 -9.31,19.88	5.32 -9.11,19.76
Q4	-5.37 -19.90,9.17	-4.25 -17.67,9.16	-2.99 -16.43,10.44	-2.86 17.43,11.71	-7.79 -19.03,3.45	-4.22 -17.75,9.31	-3.65 -18.43,11.14	-3.56 18.37,11.25
MEOHP								
Continuous	-3.22+ -6.44,0.01	-2.84+ -5.87,0.19	-2.41 -5.66,0.83	-2.14 -5.56,1.27	-3.24+ -6.60,0.13	-1.80 -5.85,2.24	-1.58 -6.22,3.07	-1.50 -6.14,3.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-2.07 -25.10,20.97	1.35 -20.77,23.48	0.70 -21.28,22.68	1.35 -20.29,22.98	11.15 -6.47,28.77	11.53 -5.34,28.41	11.95 -5.35,29.25	11.98 -5.25,29.20
Q3	-12.10 -29.92,5.72	-9.07 -27.25,9.11	-8.48 -27.38,10.43	-7.39 26.72,11.95	6.12 -8.10,20.34	7.49 -7.30,22.28	7.79 -7.95,23.53	8.11 -7.48,23.71
Q4	-7.84 -22.95,7.28	-5.80 -20.89,9.29	-4.49 -19.81,10.83	-3.47 19.14,12.19	-5.56 -17.43,6.31	-1.22 -15.40,12.96	-0.55 -15.66,14.57	-0.27 15.29,14.75
MECPP								
Continuous	-4.02* -7.67,-0.38	-3.64* -6.82,-0.46	-3.13+ -6.65,0.39	-2.86 -6.47,0.74	-3.13+ -6.50,0.24	-1.68 -5.61,2.24	-1.54 -6.00,2.93	-1.47 -5.96,3.01
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-14.65 -35.08,5.78	-13.43 -35.12,8.27	-12.22 -34.34,9.90	-11.31 33.57,10.9	15.61 -6.17,37.40	16.99 -4.42,38.40	17.25 -4.18,38.68	17.16 -4.01,38.34
Q3	-15.77+ -33.41,1.87	-13.10 -30.55,4.36	-11.86 -30.06,6.34	-10.47 29.14,8.20	-0.52 -13.31,12.26	1.28 -12.16,14.71	1.20 -12.08,14.49	1.38 -11.74,14.50
Q4	-10.64 -24.01,2.72	-9.90 -22.17,2.36	-7.91 -21.18,5.36	-7.18 -21.24,6.89	-3.00 -16.57,10.57	1.86 -14.94,18.66	2.51 -15.73,20.75	2.81 -15.50,21.12
	Rubella 2003-2004, Adolescents				**Rubella 2003-2004, Adults**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								

Continuous	1.71 -1.75,5.17	0.94 -2.47,4.35	0.93 -2.63,4.49	0.93 -2.65,4.50	0.77 -3.24,4.78	0.77 -3.29,4.82	0.69 -3.56,4.94	0.89 -3.43,5.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-4.62 -16.76,7.52	-4.62 -17.37,8.13	-4.05 -17.43,9.32	-3.34 -16.99,10.3	-0.11 -19.92,19.70	2.08 -16.72,20.89	2.18 -17.00,21.36	2.37 -16.66,21.40
Q3	-2.53 -11.84,6.78	-3.67 -13.19,5.86	-3.07 -13.65,7.51	-2.90 -13.57,7.77	-11.37 -29.58,6.84	-13.33+ -29.26,2.6	-13.68+ -30.06,2.7	-12.55 -28.96,3.86
Q4	2.40 -10.77,15.57	0.36 -13.26,13.98	0.47 -13.65,14.59	0.65 -13.40,14.71	-3.27 -20.07,13.54	-2.59 -17.98,12.81	-2.83 -18.86,13.21	-2.03 -18.51,14.45
MnBP								
Continuous	-0.13 -4.00,3.74	-0.70 -4.78,3.39	-0.61 -4.77,3.55	-0.57 -4.90,3.76	-0.96 -5.51,3.58	-1.62 -6.55,3.31	-1.65 -6.70,3.41	-1.21 -6.26,3.85
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-7.27 -24.49,9.95	-8.34 -25.61,8.93	-7.37 -24.87,10.12	-5.99 -23.17,11.2	7.33 -6.36,21.02	6.82 -6.92,20.56	6.60 -7.07,20.26	6.20 -7.41,19.81
Q3	-2.95 -19.55,13.66	-4.34 -20.54,11.86	-3.46 -19.88,12.97	-2.93 -19.47,13.6	-2.03 -14.64,10.58	-3.54 -17.26,10.18	-4.34 -18.12,9.43	-3.78 -17.21,9.66
Q4	-2.79 -19.56,13.97	-4.93 -22.01,12.15	-4.54 -21.93,12.85	-3.87 -21.42,13.7	-2.58 -14.44,9.29	-5.41 -17.89,7.08	-5.39 -18.18,7.40	-3.95 -16.83,8.93
MiBP								
Continuous	0.84 -3.35,5.03	-1.19 -5.71,3.33	-1.25 -5.79,3.30	-1.14 -5.83,3.54	-0.62 -6.91,5.66	-0.63 -7.28,6.01	-0.74 -7.53,6.06	-0.58 -7.27,6.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	7.51+ -1.25,16.28	6.20 -3.23,15.64	6.20 -3.16,15.57	5.78 -3.56,15.12	-8.82+ -19.20,1.57	-9.12+ -18.27,0.03	-9.87* -19.04,-0.7	-8.52+ -17.28,0.25
Q3	-0.21 -9.28,8.85	-2.75 -12.60,7.10	-3.35 -13.44,6.73	-3.38 -13.67,6.91	-11.33 -25.79,3.12	-11.56 -26.26,3.14	-12.36+ -26.93,2.2	-12.18+ -26.82,2.46
Q4	1.98 -7.50,11.46	-3.70 -12.28,4.89	-3.85 -12.93,5.24	-3.54 -12.83,5.76	3.72 -14.30,21.74	4.94 -15.48,25.36	5.68 -15.38,26.73	6.64 -14.27,27.56
∑ DBP								
Continuous	-1.05 -5.44,3.34	-1.78 -6.47,2.91	-1.78 -6.57,3.01	-1.86 -6.71,2.99	-2.98 -7.78,1.82	-3.80 -9.01,1.40	-3.84 -9.29,1.61	-3.50 -8.88,1.88
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-8.58 -28.99,11.82	-9.78 -29.96,10.41	-8.86 -28.97,11.26	-8.41 -28.36,11.5	2.30 -12.78,17.37	0.45 -15.13,16.03	0.13 -15.44,15.70	0.34 -15.17,15.84
Q3	-10.40 -31.02,10.22	-13.13 -32.82,6.56	-12.58 -32.45,7.28	-12.59 -32.17,7.0	-5.19 -21.08,10.71	-5.14 -22.93,12.65	-5.62 -23.75,12.50	-4.94 -23.08,13.21
Q4	-7.80 -26.16,10.56	-10.23 -28.87,8.41	-9.82 -28.96,9.33	-9.87 -29.07,9.33	-5.87 -19.93,8.19	-9.57 -25.73,6.59	-9.90 -26.60,6.81	-8.92 -25.82,7.97
McPP								
Continuous	-2.22 -10.64,6.19	-3.33 -11.87,5.21	-3.69 -12.48,5.11	-3.56 -12.45,5.34	-3.18 -10.24,3.89	-4.18 -11.57,3.21	-4.15 -11.79,3.49	-3.88 -11.50,3.74
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	3.47 -9.57,16.51	2.66 -10.26,15.58	2.89 -9.67,15.44	3.65 -8.98,16.27	3.84 -11.10,18.79	3.20 -11.92,18.32	3.10 -12.24,18.44	3.09 -12.12,18.31
Q3	-3.75 -16.21,8.71	-5.78 -17.53,5.97	-6.13 -17.47,5.22	-5.39 -16.53,5.74	-9.63 -23.08,3.82	-12.4* -23.66,-1.1	-13.18* -24.6,-1.7	-12.08* -23.84,-.33
Q4	0.73 -16.72,18.18	-1.34 -18.25,15.57	-1.69 -18.70,15.31	-1.13 -18.27,16.0	-1.50 -18.25,15.26	-4.01 -22.24,14.22	-3.63 -22.48,15.23	-3.49 -21.95,14.97
MBzP								
Continuous	-0.93 -4.74,2.89	-1.53 -5.64,2.58	-1.49 -5.67,2.69	-1.59 -5.84,2.65	-3.01 -7.38,1.35	-3.84+ -8.50,0.81	-3.88 -8.77,1.01	-3.58 -8.35,1.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-7.29 -27.68,13.10	-5.79 -25.24,13.66	-5.13 -24.74,14.47	-4.83 -24.33,14.7	1.15 -17.32,19.62	0.76 -18.12,19.63	0.46 -18.42,19.34	0.67 -18.22,19.56
Q3	-13.13 -31.64,5.39	-13.94 -32.35,4.47	-13.03 -31.82,5.77	-13.12 -31.69,5.5	0.98 -14.63,16.59	0.76 -16.05,17.57	0.29 -16.69,17.28	1.27 -15.63,18.18
Q4	-10.25 -29.88,9.37	-10.84 -30.50,8.81	-10.32 -30.37,9.73	-10.60 -30.79,9.6	-6.21 -17.95,5.53	-8.50 -23.02,6.02	-8.91 -23.79,5.97	-8.22 -23.07,6.63
∑ DEHP								
Continuous	-0.94 -4.97,3.08	-1.16 -5.43,3.10	-1.03 -5.24,3.17	-0.88 -5.10,3.34	-3.79** -5.86,-1.73	-4.17*** -5.99,-2.34	-4.37*** -6.20,-2.55	-4.24*** -6.28,-2.2
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-8.56 -24.86,7.74	-8.62 -25.37,8.12	-7.69 -24.91,9.53	-7.39 -24.97,10.2	1.01 -14.46,16.49	2.54 -12.73,17.80	2.41 -12.74,17.57	2.79 -11.99,17.56
Q3	-3.36 -19.29,12.58	-3.98 -19.80,11.85	-3.06 -18.93,12.81	-2.90 -18.87,13.1	-7.63 -20.61,5.34	-8.64 -21.21,3.93	-8.40 -21.18,4.38	-7.89 -20.48,4.70
Q4	-5.36 -23.81,13.09	-5.80 -24.66,13.06	-5.26 -24.10,13.58	-4.83 -24.09,14.4	-7.77 -19.20,3.65	-9.81* -19.37,-.24	-10.29* -20.1,-0.5	-9.83+ -20.68,1.01
MEHP								
Continuous	1.86 -1.93,5.65	1.70 -2.33,5.73	1.61 -2.37,5.60	1.77 -2.27,5.82	-3.23* -5.66,-0.80	-3.80** -6.33,-1.27	-4.06* -7.13,-1.00	-3.92* -6.87,-0.97
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-0.56 -10.13,9.01	-1.07 -10.19,8.05	0.00 -10.01,10.02	-0.25 -9.90,9.40	-8.83 -24.82,7.16	-7.12 -23.22,8.97	-7.47 -23.75,8.80	-6.58 -22.63,9.46
Q3	7.13 -4.35,18.60	7.19 -5.06,19.43	7.37 -4.81,19.54	7.70 -4.80,20.20	-2.19 -13.89,9.51	-1.05 -13.76,11.67	-1.01 -14.26,12.23	-0.10 -12.93,12.73
Q4	2.48 -8.50,13.47	1.52 -9.97,13.01	1.70 -9.70,13.11	1.87 -9.92,13.65	-5.78* -11.50,-.06	-6.27* -12.16,-.37	-6.46+ -12.98,0.05	-6.12+ -12.74,0.49
MEHHP								
Continuous	-1.19 -5.10,2.71	-1.38 -5.52,2.77	-1.20 -5.27,2.87	-1.07 -5.18,3.04	-3.50** -5.46,-1.53	-3.93*** -5.69,-2.17	-4.16*** -5.92,-2.40	-4.07*** -6.08,-2.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-6.09 -24.66,12.47	-5.92 -25.15,13.31	-5.08 -24.87,14.70	-4.97 -25.08,15.1	4.53 -12.95,22.01	5.65 -11.63,22.93	4.99 -12.02,22.01	4.55 -12.32,21.42
Q3	-0.33 -16.84,16.18	-0.71 -17.32,15.91	-0.29 -17.25,16.66	-0.18 -17.20,16.8	-5.44 -20.55,9.66	-5.71 -21.01,9.59	-5.90 -21.02,9.23	-5.58 -20.57,9.40
Q4	-6.78 -24.93,11.37	-7.41 -25.85,11.03	-6.54 -25.34,12.26	-6.00 -25.49,13.5	-7.29 -16.32,1.75	-9.02* -16.3,-1.75	-9.80** -16.4,-3.2	-9.92* -17.68,-2.16
MEOHP								
Continuous	-1.18 -5.32,2.96	-1.33 -5.72,3.05	-1.18 -5.50,3.15	-1.02 -5.37,3.33	-3.80** -5.85,-1.76	-4.18*** -6.04,-2.32	-4.40*** -6.25,-2.56	-4.25*** -6.30,-2.2
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-11.67 -27.37,4.03	-11.75 -28.00,4.51	-10.84 -27.97,6.29	-11.41 -29.17,6.4	7.52 -7.61,22.66	8.48 -7.01,23.96	8.00 -7.20,23.21	8.34 -6.57,23.25
Q3	-4.63 -21.41,12.15	-4.89 -21.80,12.02	-3.89 -21.13,13.35	-3.78 -21.01,13.5	-2.03 -14.62,10.55	-2.15 -14.95,10.64	-2.22 -14.96,10.52	-1.60 -13.89,10.69
Q4	-9.30 -27.25,8.65	-9.80 -28.17,8.58	-8.92 -27.46,9.62	-8.62 -27.61,10.4	-6.95 -16.78,2.87	-8.70* -17.01,-.39	-9.34* -17.19,-1.5	-8.74* -17.17,-0.31
MECPP								
Continuous	-0.91 -5.06,3.25	-1.13 -5.54,3.28	-1.02 -5.38,3.34	-0.85 -5.19,3.49	-4.36** -6.84,-1.88	-4.72*** -6.96,-2.48	-4.91*** -7.12,-2.70	-4.77*** -7.13,-2.41
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.88 -11.22,20.99	2.84 -13.17,18.84	3.37 -12.36,19.11	4.45 -11.41,20.30	1.22 -11.38,13.82	2.03 -11.14,15.21	1.89 -11.19,14.97	1.98 -11.04,15.00
Q3	-2.20 -15.58,11.19	-3.42 -16.64,9.81	-2.95 -15.98,10.08	-2.32 -15.36,10.7	-7.29 -19.34,4.75	-7.36 -18.91,4.18	-7.42 -19.42,4.58	-6.83 -18.54,4.88
Q4	0.04 -14.99,15.06	-1.15 -16.37,14.07	-0.52 -15.89,14.85	0.42 -15.27,16.1	-8.55 -19.01,1.91	-10.39* -18.9,-1.9	-10.67* -19.5,-1.8	-10.25* -19.91,-.59

	Rubella 2003-2004, US-Born				Rubella 2003-2004, Foreign Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.57 -3.86,2.71	-1.55 -4.64,1.53	-1.24 -4.47,1.98	-1.11 -4.36,2.14	4.78+ -0.80,10.36	5.63 -1.83,13.10	5.59 -2.03,13.22	5.42 -2.03,12.8
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-3.67 -17.19,9.85	-1.88 -15.32,11.57	-1.34 -15.10,12.42	-1.17 -14.92,12.6	-11.21 -45.02,22.60	-10.44 -48.65,27.77	-12.19 -51.78,27.39	-11.25 -51.55,29.06
Q3	-8.01 -21.36,5.34	-10.10 -22.49,2.29	-9.16 -22.20,3.88	-8.58 -21.64,4.49	-24.32 -58.25,9.62	-29.54 -68.92,9.84	-32.76+ -71.65,6.12	-31.64 -70.81,7.52
Q4	-5.23 -19.14,8.68	-7.80 -20.81,5.20	-6.73 -20.40,6.94	-6.20 -20.15,7.76	-2.96 -29.14,23.22	-1.71 -33.46,30.05	-3.20 -35.36,28.96	-3.63 -35.75,28.49
MnBP								
Continuous	-2.41+ -5.26,0.44	-1.26 -4.30,1.79	-0.97 -4.14,2.20	-0.64 -3.91,2.62	2.99 -5.07,11.06	4.27 -4.26,12.80	3.40 -5.18,11.98	3.38 -5.07,11.82
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.37 -5.75,14.49	5.20 -4.31,14.72	5.63 -4.20,15.46	5.53 -4.20,15.25	5.72 -19.50,30.93	7.89 -17.31,33.08	4.89 -19.06,28.85	5.85 -17.95,29.66
Q3	-2.78 -13.78,8.21	-1.55 -13.29,10.18	-0.87 -13.53,11.78	-.43 -12.92,12.05	3.61 -17.03,24.24	4.57 -18.55,27.70	1.83 -21.26,24.93	3.53 -20.11,27.18
Q4	-4.75 -12.12,2.62	-2.66 -11.39,6.06	-1.77 -10.80,7.27	-0.66 -9.93,8.61	4.97 -22.00,31.95	10.43 -19.25,40.11	8.21 -21.34,37.76	7.78 -21.50,37.05
MiBP								
Continuous	-2.80 -7.16,1.56	-0.85 -5.30,3.59	-0.75 -5.37,3.87	-0.59 -5.17,4.00	2.55 -5.06,10.16	2.26 -7.59,12.11	1.37 -7.93,10.66	1.23 -8.18,10.64
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-9.45* -17.89,-1.01	-8.17+ -16.63,0.29	-7.77+ -16.35,0.81	-6.87 -15.51,1.77	10.69 -9.96,31.33	15.92 -4.92,36.76	14.57 -6.15,35.29	15.91 -3.64,35.46
Q3	-10.06+ -20.38,0.26	-7.44+ -16.26,1.38	-7.95+ -16.68,0.79	-7.71+ -16.45,1.0	-4.08 -23.66,15.49	-2.84 -22.94,17.25	-6.13 -26.58,14.31	-6.41 -26.56,13.74

Q4	-4.37 -18.29,9.54	0.99 -14.74,16.72	0.87 -15.61,17.35	1.75 -14.78,18.27	6.52 -9.44,22.48	8.37 -12.25,28.98	8.03 -12.42,28.48	7.91 -13.77,29.59
∑ DBP								
Continuous	-3.61* -7.20,-0.02	-1.61 -5.00,1.77	-1.29 -4.67,2.09	-1.07 -4.48,2.33	4.01 -4.60,12.63	3.08 -5.07,11.24	1.63 -6.77,10.02	1.33 -6.95,9.60
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.99 -14.30,16.27	-0.39 -15.74,14.96	0.04 -15.79,15.87	-.01 -15.77,15.74	-0.41 -20.40,19.59	-1.54 -25.25,22.17	-2.87 -25.30,19.55	-1.39 -23.28,20.49
Q3	-7.19 -21.58,7.19	-3.86 -19.19,11.47	-3.09 -19.22,13.04	-2.7 -18.77,13.43	5.62 -10.48,21.72	5.22 -10.18,20.61	1.69 -13.87,17.24	2.63 -12.61,17.86
Q4	-7.66 -19.78,4.46	-2.66 -15.40,10.07	-1.60 -14.81,11.61	-.98 -14.25,12.30	9.05 -12.76,30.87	1.32 -20.82,23.46	-3.77 -24.55,17.01	-4.80 -26.04,16.44
McPP								
Continuous	-3.78 -8.38,0.82	-1.17 -6.75,4.41	-1.18 -6.73,4.36	-0.97 -6.55,4.61	7.40+ -1.35,16.14	7.27+ -1.23,15.77	5.95 -4.70,16.60	5.92 -4.80,16.63
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -13.60,13.64	0.49 -13.10,14.09	1.19 -12.57,14.95	1.39 -12.33,15.11	16.79 -4.66,38.25	16.94 -7.70,41.58	17.13 -9.69,43.95	15.60 - 12.03,43.24
Q3	-12.92+ -26.45,0.61	-11.86* -23.2,-.48	-10.80+ -22.61,1.0	-9.87 -22.00,2.26	16.58 -3.63,36.79	13.18 -8.44,34.80	9.79 -12.63,32.21	8.96 -14.08,31.99
Q4	-6.34 -18.88,6.21	-1.38 -14.56,11.81	-1.06 -14.62,12.50	-.75 -14.18,12.67	13.84 -8.88,36.55	16.50+ -3.08,36.07	14.55 -8.04,37.13	14.66 -7.96,37.29
MBzP								
Continuous	-3.50* -6.97,-0.04	-1.55 -4.55,1.44	-1.18 -4.10,1.75	-1.00 -3.89,1.90	2.15 -7.11,11.42	0.92 -7.54,9.39	-0.36 -8.76,8.04	-0.67 -8.88,7.55
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	3.23 -11.99,18.45	2.38 -13.17,17.93	2.23 -13.63,18.09	2.19 -13.56,17.95	-13.17 -36.22,9.88	-11.97 -38.56,14.62	-12.33 -38.81,14.15	-10.55 - 36.84,15.75
Q3	-2.42 -15.47,10.63	0.77 -13.58,15.12	1.59 -13.43,16.61	2.14 -12.68,16.96	11.26 -9.06,31.58	11.91 -7.82,31.65	10.57 -11.07,32.21	11.76 -8.15,31.67
Q4	-5.83 -16.97,5.30	-0.98 -13.38,11.43	0.13 -12.58,12.84	0.55 -12.15,13.25	-1.04 -19.56,17.49	-5.23 -26.51,16.06	-8.79 -29.78,12.21	-10.15 - 31.34,11.04
∑ DEHP								
Continuous	-3.80** -5.83,-1.77	-2.99** -4.63,-1.34	-2.61* -4.53,-0.68	-2.48* -4.53,-0.43	1.76 -3.72,7.24	1.85 -4.60,8.30	1.41 -5.99,8.81	1.30 -6.01,8.61
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-5.55 -18.00,6.91	-2.71 -14.35,8.94	-1.86 -13.20,9.48	-1.48 -12.82,9.85	21.68+ -3.96,47.32	26.79* 3.29,50.29	27.13* 5.45,48.82	25.81* 4.05,47.56
Q3	-9.23+ -19.79,1.34	-7.13 -17.18,2.91	-6.16 -16.66,4.33	-5.69 -16.34,4.95	-2.87 -20.72,14.98	-1.68 -20.57,17.21	-1.65 -19.10,15.80	-1.91 -19.56,15.75
Q4	-10.24+ -20.62,0.13	-6.88 -16.16,2.39	-5.53 -15.52,4.45	-5.08 -15.56,5.40	12.76 -10.39,35.92	13.28 -13.08,39.63	12.61 -14.95,40.16	11.87 - 15.44,39.18
MEHP								
Continuous	-2.63* -5.11,-0.15	-2.67* -5.09,-0.26	-2.38+ -4.80,0.04	-2.25+ -4.71,0.22	2.34 -3.82,8.50	2.68 -3.90,9.26	2.95 -5.24,11.13	2.88 -5.08,10.84
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-11.79* -23.03,-0.56	-8.02 -17.89,1.84	-7.94+ -17.33,1.46	-7.54+ -16.7,1.62	5.88 -20.79,32.56	13.17 -12.87,39.20	10.78 -16.78,38.34	12.11 - 13.90,38.12
Q3	-3.13 -13.13,6.87	-0.44 -11.34,10.46	-0.59 -11.69,10.51	0.05 -10.73,10.84	6.95 -14.21,28.11	7.22 -17.13,31.57	6.12 -16.82,29.05	6.91 -16.57,30.40
Q4	-4.40 -9.93,1.13	-3.04 -8.82,2.75	-2.23 -8.25,3.79	-2.02 -7.97,3.93	4.80 -16.09,25.70	8.44 -11.57,28.44	6.70 -13.47,26.88	7.72 -11.82,27.26
MEHHP								
Continuous	-3.49** -5.49,-1.49	-2.82** -4.43,-1.20	-2.40* -4.29,-0.52	-2.31* -4.34,-0.28	1.54 -3.99,7.07	1.61 -4.78,8.01	1.08 -6.08,8.25	0.95 -6.14,8.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.33 -15.02,14.35	1.23 -12.47,14.94	1.65 -12.08,15.38	1.45 -12.50,15.41	21.20 -5.96,48.35	25.30+ -0.45,51.05	23.18+ -2.55,48.90	21.42 -4.89,47.73
Q3	-5.51 -18.08,7.07	-3.29 -15.63,9.06	-2.63 -15.76,10.49	-2.42 -15.64,10.8	-4.99 -21.60,11.63	-3.83 -21.39,13.73	-5.68 -22.05,10.69	-5.64 -22.19,10.92
Q4	-8.25+ -17.08,0.57	-5.54 -12.61,1.53	-4.17 -11.72,3.38	-4.04 -12.28,4.20	6.57 -16.25,29.40	6.68 -20.26,33.61	3.96 -23.98,31.89	2.86 -25.30,31.02
MEOHP								
Continuous	-3.72*** -5.63,-1.81	-2.84** -4.36,-1.31	-2.45* -4.27,-0.62	-2.31* -4.26,-0.36	1.17 -4.18,6.53	1.24 -5.20,7.67	0.45 -6.94,7.85	0.40 -6.87,7.67
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.82 -13.05,14.69	3.74 -9.65,17.14	4.10 -9.15,17.34	4.42 -8.83,17.67	23.03* 0.47,45.60	25.26* 0.23,50.29	22.69+ -1.66,47.05	20.60 -4.45,45.66
Q3	-3.64 -14.28,7.01	-0.66 -11.09,9.77	-0.08 -11.09,10.93	0.46 -10.40,11.33	-2.16 -23.67,19.36	0.52 -17.55,18.58	-0.96 -17.31,15.39	-0.81 -17.91,16.29

Q4	-8.35+ -17.20,0.49	-4.44 -11.59,2.71	-3.10 -10.55,4.34	-2.48 -10.07,5.10	5.15 -17.05,27.35	4.56 -20.13,29.25	1.24 -24.48,26.96	-0.25 -26.18,25.68
MECPP								
Continuous	-4.32** -6.58,-2.06	-3.37** -5.30,-1.43	-3.00* -5.19,-0.80	-2.87* -5.15,-0.59	1.92 -3.97,7.81	1.97 -5.01,8.95	1.62 -6.46,9.70	1.51 -6.44,9.47
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-2.47 -11.96,7.02	-0.84 -9.80,8.11	-0.03 -8.60,8.54	0.23 -8.46,8.91	13.19 -9.07,35.46	19.57 -4.88,44.03	20.37+ -3.50,44.24	19.38 -4.59,43.34
Q3	-9.31+ -19.01,0.38	-5.54 -14.67,3.60	-4.80 -14.17,4.57	-4.24 -13.70,5.22	-6.14 -24.31,12.03	-6.12 -25.62,13.37	-6.67 -26.45,13.11	-7.00 -27.07,13.07
Q4	-9.66+ -19.38,0.07	-6.32 -15.25,2.62	-4.95 -14.56,4.66	-4.47 -14.68,5.73	11.69 -9.27,32.66	13.14 -11.97,38.24	13.57 -12.78,39.92	12.86 -13.29,39.01
	Measles 2009-2010, Female				Measles 2009-2010, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.00 -0.11,0.11	-0.02 -0.13,0.09	-0.02 -0.13,0.09	-0.02 -0.13,0.09	0.08* 0.01,0.15	0.06+ -0.01,0.12	0.08* 0.00,0.16	0.08* 0.00,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.23 -0.13,0.60	0.18 -0.22,0.58	0.18 -0.22,0.58	0.18 -0.22,0.58	0.26 -0.11,0.64	0.27 -0.16,0.70	0.27 -0.14,0.68	0.27 -0.15,0.69
Q3	-0.11 -0.47,0.26	-0.19 -0.56,0.18	-0.17 -0.54,0.19	-0.18 -0.54,0.18	0.20 -0.21,0.60	0.22 -0.20,0.63	0.26 -0.18,0.69	0.21 -0.19,0.61
Q4	0.11 -0.26,0.48	0.04 -0.36,0.45	0.05 -0.36,0.46	0.05 -0.36,0.47	0.21 -0.06,0.48	0.11 -0.15,0.37	0.21 -0.08,0.50	0.21 -0.08,0.50
MnBP								
Continuous	0.12* 0.03,0.22	0.09 -0.02,0.20	0.09 -0.02,0.21	0.10+ -0.02,0.21	0.08 -0.03,0.19	0.08 -0.07,0.22	0.09 -0.05,0.23	0.09 -0.05,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.24 -0.17,0.65	0.17 -0.25,0.58	0.20 -0.22,0.62	0.20 -0.22,0.62	0.06 -0.38,0.50	0.06 -0.44,0.56	0.06 -0.43,0.55	0.08 -0.42,0.58
Q3	0.28 -0.21,0.78	0.19 -0.34,0.71	0.21 -0.31,0.72	0.22 -0.30,0.73	0.10 -0.13,0.33	0.12 -0.15,0.38	0.16 -0.11,0.43	0.18 -0.11,0.46
Q4	0.37* 0.06,0.69	0.26 -0.12,0.65	0.27 -0.12,0.66	0.28 -0.10,0.66	0.10 -0.22,0.42	0.11 -0.33,0.54	0.11 -0.32,0.54	0.12 -0.32,0.56
MiBP								
Continuous	0.09 -0.05,0.24	0.05 -0.08,0.19	0.06 -0.08,0.19	0.06 -0.07,0.19	0.06 -0.09,0.21	0.07 -0.09,0.23	0.10 -0.06,0.25	0.10 -0.07,0.26
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.20 -0.17,0.57	0.16 -0.19,0.52	0.19 -0.13,0.51	0.20 -0.11,0.51	0.22 -0.05,0.48	0.23* 0.01,0.44	0.22* 0.04,0.40	0.27* 0.05,0.49
Q3	0.13 -0.35,0.61	0.10 -0.33,0.53	0.12 -0.31,0.56	0.13 -0.30,0.56	0.21 -0.24,0.66	0.25 -0.20,0.70	0.33 -0.11,0.76	0.37 -0.10,0.85
Q4	0.27 -0.14,0.67	0.15 -0.21,0.50	0.16 -0.20,0.52	0.17 -0.18,0.53	0.19 -0.11,0.49	0.20 -0.10,0.50	0.25+ -0.05,0.56	0.28+ -0.05,0.61
∑ DBP								
Continuous	0.05 -0.08,0.18	0.01 -0.12,0.15	0.02 -0.11,0.15	0.02 -0.10,0.15	-0.00 -0.12,0.11	0.01 -0.14,0.16	0.02 -0.13,0.17	0.02 -0.13,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.06 -0.32,0.44	0.08 -0.31,0.48	0.09 -0.30,0.48	0.10 -0.29,0.48	-0.10 -0.62,0.42	-0.07 -0.59,0.46	-0.05 -0.56,0.47	-0.01 -0.55,0.52
Q3	-0.07 -0.44,0.31	-0.06 -0.37,0.25	-0.03 -0.33,0.27	-0.02 -0.32,0.28	0.13 -0.28,0.53	0.13 -0.31,0.58	0.16 -0.24,0.57	0.20 -0.24,0.64
Q4	0.16 -0.32,0.64	0.09 -0.39,0.57	0.09 -0.37,0.56	0.10 -0.37,0.56	-0.17 -0.50,0.15	-0.13 -0.53,0.28	-0.08 -0.49,0.33	-0.06 -0.49,0.38
McPP								
Continuous	0.08 -0.06,0.22	0.05 -0.11,0.21	0.06 -0.10,0.21	0.05 -0.10,0.21	0.03 -0.12,0.19	0.02 -0.15,0.19	0.03 -0.15,0.20	0.03 -0.15,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -0.38,0.40	-0.01 -0.38,0.35	-0.02 -0.39,0.36	-0.02 -0.39,0.36	0.39* 0.02,0.75	0.39+ -0.00,0.77	0.36+ -0.03,0.75	0.35+ -0.06,0.75
Q3	0.21+ -0.03,0.45	0.11 -0.14,0.36	0.10 -0.15,0.35	0.10 -0.15,0.35	0.59** 0.24,0.95	0.54* 0.12,0.96	0.58* 0.15,1.01	0.55* 0.12,0.98
Q4	0.14 -0.18,0.46	0.10 -0.28,0.48	0.10 -0.28,0.48	0.10 -0.27,0.47	0.42+ -0.07,0.91	0.43 -0.11,0.96	0.43 -0.12,0.97	0.42 -0.13,0.96
MBzP								
Continuous	0.05 -0.09,0.19	0.01 -0.11,0.14	0.02 -0.10,0.15	0.02 -0.10,0.15	0.01 -0.09,0.10	0.03 -0.09,0.15	0.04 -0.08,0.16	0.05 -0.08,0.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.15 -0.15,0.46	0.19 -0.13,0.51	0.19 -0.15,0.53	0.20 -0.14,0.54	-0.14 -0.67,0.39	-0.06 -0.62,0.51	-0.03 -0.56,0.51	0.01 -0.52,0.54
Q3	-0.06 -0.36,0.25	-0.05 -0.30,0.20	-0.02 -0.29,0.25	-0.01 -0.28,0.26	0.16 -0.15,0.46	0.23 -0.11,0.56	0.25 -0.06,0.55	0.29+ -0.06,0.63
Q4	0.28 -0.14,0.69	0.17 -0.21,0.56	0.18 -0.21,0.57	0.19 -0.20,0.58	-0.05 -0.38,0.28	0.03 -0.34,0.39	0.05 -0.30,0.41	0.07 -0.30,0.44
∑ DEHP								

Continuous	0.03 -0.06,0.11	-0.01 -0.11,0.09	-0.01 -0.11,0.10	-0.01 -0.11,0.10	-0.05 -0.18,0.09	-0.05 -0.20,0.09	-0.04 -0.19,0.10	-0.04 -0.19,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.04 -0.33,0.25	-0.11 -0.44,0.22	-0.09 -0.43,0.25	-0.09 -0.43,0.25	0.27+ -0.04,0.59	0.33* 0.04,0.62	0.35* 0.06,0.64	0.37* 0.07,0.68
Q3	0.10 -0.23,0.43	-0.00 -0.35,0.35	0.01 -0.34,0.36	0.01 -0.33,0.36	-0.04 -0.39,0.31	0.02 -0.35,0.39	0.04 -0.33,0.42	0.06 -0.35,0.47
Q4	0.01 -0.33,0.35	-0.08 -0.47,0.31	-0.07 -0.47,0.34	-0.08 -0.48,0.32	-0.20 -0.62,0.23	-0.19 -0.66,0.28	-0.19 -0.64,0.26	-0.17 -0.63,0.30
MEHP								
Continuous	-0.02 -0.14,0.10	-0.08 -0.21,0.05	-0.07 -0.21,0.06	-0.08 -0.20,0.05	-0.02 -0.18,0.14	-0.03 -0.19,0.14	-0.02 -0.19,0.15	-0.01 -0.19,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.14 -0.26,0.54	0.04 -0.40,0.47	0.05 -0.40,0.51	0.05 -0.40,0.50	0.15 -0.40,0.70	0.20 -0.33,0.72	0.22 -0.30,0.74	0.26 -0.29,0.80
Q3	-0.03 -0.30,0.23	-0.16 -0.41,0.09	-0.14 -0.40,0.13	-0.13 -0.39,0.12	0.37 -0.09,0.82	0.44+ -0.02,0.90	0.46* 0.01,0.91	0.48* 0.00,0.95
Q4	-0.02 -0.37,0.32	-0.22 -0.57,0.14	-0.21 -0.58,0.16	-0.21 -0.57,0.15	-0.10 -0.47,0.27	-0.10 -0.48,0.28	-0.07 -0.44,0.31	-0.05 -0.44,0.35
MEHHP								
Continuous	0.02 -0.08,0.11	-0.02 -0.12,0.09	-0.01 -0.12,0.10	-0.01 -0.12,0.09	-0.04 -0.18,0.10	-0.05 -0.20,0.10	-0.04 -0.19,0.11	-0.03 -0.19,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.18 -0.11,0.48	0.11 -0.24,0.45	0.13 -0.22,0.48	0.13 -0.23,0.48	0.33* 0.09,0.57	0.33* 0.07,0.60	0.32** 0.11,0.54	0.36** 0.11,0.60
Q3	0.09 -0.22,0.39	-0.03 -0.37,0.31	-0.02 -0.35,0.31	-0.02 -0.34,0.30	-0.02 -0.38,0.34	0.01 -0.38,0.39	0.06 -0.35,0.46	0.08 -0.37,0.52
Q4	-0.07 -0.42,0.28	-0.17 -0.55,0.21	-0.15 -0.53,0.23	-0.16 -0.55,0.22	-0.06 -0.50,0.38	-0.07 -0.53,0.39	-0.07 -0.50,0.37	-0.04 -0.49,0.41
MEOHP								
Continuous	0.01 -0.08,0.10	-0.03 -0.13,0.08	-0.02 -0.13,0.09	-0.02 -0.13,0.09	-0.05 -0.20,0.10	-0.05 -0.21,0.11	-0.05 -0.21,0.12	-0.04 -0.21,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.27,0.31	-0.08 -0.41,0.25	-0.06 -0.39,0.27	-0.06 -0.40,0.27	0.15 -0.09,0.40	0.24* 0.03,0.45	0.28** 0.08,0.48	0.32* 0.07,0.58
Q3	0.08 -0.21,0.38	-0.03 -0.36,0.30	-0.02 -0.35,0.30	-0.02 -0.34,0.29	-0.14 -0.54,0.26	-0.08 -0.47,0.31	-0.06 -0.45,0.34	-0.05 -0.46,0.36
Q4	-0.07 -0.47,0.33	-0.16 -0.58,0.25	-0.15 -0.58,0.28	-0.16 -0.58,0.27	-0.21 -0.64,0.22	-0.19 -0.66,0.28	-0.19 -0.64,0.26	-0.16 -0.62,0.30
MECPP								
Continuous	0.03 -0.05,0.11	-0.01 -0.11,0.10	-0.00 -0.11,0.11	-0.00 -0.11,0.11	-0.07 -0.21,0.07	-0.07 -0.22,0.08	-0.06 -0.21,0.09	-0.06 -0.22,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.38,0.21	-0.17 -0.50,0.17	-0.17 -0.51,0.17	-0.17 -0.51,0.17	0.19 -0.10,0.49	0.22 -0.13,0.57	0.25 -0.06,0.57	0.27* 0.00,0.54
Q3	-0.00 -0.30,0.29	-0.08 -0.39,0.23	-0.08 -0.40,0.24	-0.08 -0.39,0.23	-0.05 -0.33,0.24	0.02 -0.30,0.35	0.04 -0.29,0.37	0.05 -0.29,0.40
Q4	0.02 -0.27,0.31	-0.07 -0.43,0.28	-0.07 -0.42,0.29	-0.08 -0.45,0.29	-0.29 -0.70,0.13	-0.29 -0.76,0.18	-0.28 -0.72,0.16	-0.26 -0.73,0.21
	Measles 2009-2010, Adolescents				**Measles 2009-2010, Adults**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.01 -0.15,0.16	-0.02 -0.18,0.14	-0.02 -0.17,0.12	-0.02 -0.17,0.12	0.05 -0.02,0.12	0.03 -0.04,0.10	0.04 -0.04,0.11	0.03 -0.04,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.10 -0.41,0.61	0.04 -0.38,0.45	0.05 -0.35,0.45	0.05 -0.36,0.45	0.28 -0.08,0.64	0.26 -0.17,0.70	0.25 -0.17,0.67	0.26 -0.17,0.68
Q3	-0.31 -0.76,0.14	-0.47+ -0.95,0.01	-0.46+ -0.95,0.03	-0.46+ -0.95,0.03	0.13 -0.21,0.47	0.09 -0.26,0.43	0.09 -0.26,0.44	0.08 -0.26,0.43
Q4	0.26 -0.26,0.77	0.20 -0.27,0.67	0.22 -0.23,0.66	0.21 -0.23,0.66	0.18 -0.07,0.44	0.08 -0.20,0.36	0.11 -0.19,0.40	0.10 -0.20,0.40
MnBP								
Continuous	0.06 -0.17,0.30	0.01 -0.24,0.25	0.01 -0.24,0.25	0.00 -0.25,0.25	0.07+ -0.01,0.15	0.06 -0.04,0.17	0.07 -0.03,0.17	0.07 -0.03,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.19 -0.40,0.78	0.18 -0.49,0.86	0.18 -0.45,0.82	0.19 -0.45,0.82	0.18 -0.08,0.43	0.15 -0.18,0.48	0.16 -0.15,0.46	0.16 -0.15,0.47
Q3	0.05 -0.65,0.76	-0.06 -0.82,0.71	-0.04 -0.80,0.72	-0.05 -0.81,0.71	0.20 -0.10,0.51	0.18 -0.14,0.51	0.20 -0.13,0.52	0.19 -0.14,0.53
Q4	0.13 -0.56,0.83	0.04 -0.67,0.74	0.03 -0.67,0.73	0.03 -0.67,0.73	0.12 -0.16,0.39	0.09 -0.28,0.45	0.10 -0.26,0.46	0.09 -0.26,0.45
MiBP								
Continuous	0.02 -0.27,0.32	-0.01 -0.30,0.29	-0.01 -0.30,0.28	-0.01 -0.30,0.28	0.07 -0.04,0.18	0.06 -0.06,0.18	0.07 -0.05,0.19	0.07 -0.06,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.00 -0.52,0.51	-0.06 -0.52,0.39	-0.06 -0.49,0.37	-0.06 -0.49,0.37	0.30* 0.07,0.54	0.28* 0.03,0.53	0.30* 0.05,0.56	0.31* 0.06,0.55

Q3	0.20 -0.54,0.95	0.14 -0.57,0.86	0.16 -0.54,0.85	0.15 -0.54,0.85	0.19+ -0.00,0.38	0.22+ -0.00,0.45	0.25* 0.03,0.46	0.25* 0.02,0.49
Q4	0.03 -0.72,0.79	-0.13 -0.92,0.67	-0.12 -0.91,0.66	-0.13 -0.92,0.66	0.28* 0.02,0.54	0.25+ -0.05,0.55	0.28+ -0.03,0.58	0.27+ -0.04,.58
∑ DBP								
Continuous	0.08 -0.13,0.30	0.04 -0.17,0.26	0.04 -0.17,0.26	0.04 -0.17,0.26	-0.02 -0.14,0.10	-0.01 -0.15,0.14	-0.00 -0.14,0.13	-0.00 -0.14,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.33 -0.29,0.95	0.13 -0.51,0.78	0.15 -0.48,0.77	0.15 -0.47,0.77	-0.05 -0.32,0.21	0.02 -0.28,0.31	0.02 -0.28,0.33	0.02 -0.30,0.34
Q3	0.34 -0.16,0.84	0.20 -0.44,0.84	0.22 -0.41,0.86	0.22 -0.41,0.86	0.01 -0.37,0.38	0.05 -0.36,0.47	0.07 -0.33,0.46	0.07 -0.33,0.47
Q4	0.30 -0.33,0.94	0.13 -0.55,0.81	0.13 -0.54,0.80	0.12 -0.55,0.80	-0.20 -0.57,0.17	-0.15 -0.58,0.29	-0.13 -0.55,0.29	-0.12 -0.54,0.29
McPP								
Continuous	0.08 -0.15,0.32	0.06 -0.19,0.31	0.06 -0.19,0.32	0.06 -0.19,0.32	0.03 -0.09,0.15	0.02 -0.13,0.16	0.02 -0.12,0.17	0.02 -0.13,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.22 -0.31,0.75	0.19 -0.33,0.71	0.21 -0.31,0.72	0.21 -0.31,0.73	0.17 -0.15,0.50	0.17 -0.14,0.48	0.16 -0.14,0.47	0.16 -0.14,0.46
Q3	0.38+ -0.05,0.82	0.21 -0.36,0.77	0.20 -0.35,0.75	0.20 -0.35,0.75	0.42** 0.13,0.71	0.44* 0.10,0.79	0.45* 0.10,0.79	0.44* 0.09,0.78
Q4	0.29 -0.35,0.93	0.24 -0.43,0.92	0.27 -0.42,0.96	0.27 -0.42,0.96	0.17 -0.13,0.48	0.19 -0.19,0.56	0.19 -0.18,0.57	0.19 -0.19,0.58
MBzP								
Continuous	0.09 -0.10,0.28	0.05 -0.15,0.24	0.05 -0.15,0.24	0.05 -0.15,0.24	-0.03 -0.13,0.08	-0.00 -0.12,0.11	0.00 -0.11,0.11	-0.00 -0.11,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.27 -0.24,0.77	0.06 -0.51,0.62	0.06 -0.52,0.63	0.06 -0.51,0.63	-0.05 -0.37,0.27	0.03 -0.31,0.37	0.04 -0.31,0.39	0.04 -0.31,0.40
Q3	0.44 -0.18,1.06	0.27 -0.50,1.05	0.30 -0.42,1.02	0.30 -0.42,1.02	-0.01 -0.32,0.29	0.07 -0.25,0.39	0.09 -0.22,0.41	0.09 -0.24,0.43
Q4	0.35 -0.20,0.90	0.16 -0.45,0.76	0.16 -0.45,0.76	0.15 -0.46,0.76	-0.04 -0.32,0.25	0.02 -0.31,0.35	0.02 -0.29,0.32	0.02 -0.28,0.31
∑ DEHP								
Continuous	0.02 -0.19,0.24	0.05 -0.14,0.25	0.06 -0.14,0.25	0.05 -0.14,0.25	-0.03 -0.13,0.07	-0.04 -0.14,0.06	-0.03 -0.14,0.07	-0.03 -0.14,0.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -0.52,0.53	-0.05 -0.63,0.53	-0.04 -0.64,0.56	-0.04 -0.64,0.56	0.17 -0.05,0.39	0.18+ -0.01,0.37	0.20* 0.00,0.40	0.21+ -0.00,.43
Q3	-0.08 -0.84,0.67	0.00 -0.76,0.76	0.00 -0.77,0.77	-0.00 -0.78,0.77	-0.00 -0.28,0.27	-0.01 -0.31,0.28	0.00 -0.29,0.30	0.01 -0.30,0.32
Q4	0.03 -0.59,0.66	0.12 -0.45,0.69	0.13 -0.46,0.73	0.13 -0.47,0.73	-0.17 -0.49,0.15	-0.22 -0.56,0.11	-0.21 -0.53,0.12	-0.19 -0.54,0.16
MEHP								
Continuous	0.12 -0.13,0.36	0.10 -0.14,0.33	0.10 -0.13,0.34	0.10 -0.13,0.34	-0.05 -0.18,0.07	-0.08 -0.21,0.05	-0.08 -0.20,0.05	-0.07 -0.21,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.11 -0.60,0.37	-0.21 -0.67,0.25	-0.18 -0.67,0.30	-0.18 -0.67,0.30	0.21 -0.18,0.59	0.21 -0.17,0.59	0.23 -0.14,0.59	0.24 -0.15,0.63
Q3	0.26 -0.16,0.67	0.08 -0.38,0.54	0.09 -0.37,0.55	0.10 -0.36,0.56	0.18 -0.22,0.58	0.19 -0.22,0.60	0.23 -0.17,0.62	0.23 -0.18,0.63
Q4	0.14 -0.42,0.70	0.05 -0.52,0.61	0.06 -0.51,0.64	0.06 -0.52,0.63	-0.12 -0.44,0.19	-0.21 -0.52,0.09	-0.20 -0.50,0.10	-0.19 -0.51,0.13
MEHHP								
Continuous	0.04 -0.17,0.25	0.07 -0.13,0.26	0.07 -0.13,0.26	0.07 -0.13,0.26	-0.03 -0.14,0.08	-0.05 -0.16,0.07	-0.04 -0.15,0.07	-0.04 -0.15,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.12 -0.54,0.77	0.11 -0.58,0.79	0.12 -0.59,0.84	0.13 -0.59,0.85	0.27*** 0.16,.38	0.24*** 0.15,.33	0.24*** 0.14,.35	0.25*** .13,.38
Q3	0.02 -0.70,0.73	0.07 -0.62,0.75	0.07 -0.62,0.76	0.06 -0.63,0.76	-0.01 -0.22,0.19	-0.07 -0.33,0.19	-0.04 -0.32,0.24	-0.03 -0.34,0.27
Q4	0.08 -0.59,0.74	0.17 -0.42,0.76	0.18 -0.44,0.80	0.18 -0.44,0.81	-0.20 -0.53,0.14	-0.25 -0.58,0.08	-0.24 -0.56,0.08	-0.23 -0.57,0.11
MEOHP								
Continuous	0.06 -0.17,0.28	0.08 -0.13,0.29	0.08 -0.12,0.29	0.08 -0.13,0.29	-0.05 -0.16,0.06	-0.06 -0.18,0.05	-0.06 -0.17,0.06	-0.05 -0.17,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.04 -0.55,0.63	0.03 -0.61,0.67	0.04 -0.62,0.71	0.04 -0.62,0.71	0.11 -0.12,0.33	0.11 -0.10,0.32	0.13 -0.10,0.35	0.14 -0.12,0.40
Q3	-0.04 -0.82,0.75	0.02 -0.75,0.80	0.03 -0.76,0.81	0.02 -0.77,0.81	-0.11 -0.36,0.13	-0.15 -0.43,0.13	-0.14 -0.41,0.14	-0.13 -0.42,0.16
Q4	0.05 -0.60,0.70	0.15 -0.44,0.73	0.16 -0.45,0.76	0.16 -0.45,0.76	-0.28 -0.63,0.07	-0.31+ -0.66,.03	-0.30+ -0.63,.03	-0.29 -0.64,0.06
MECPP								
Continuous	-0.01 -0.23,0.22	0.04 -0.16,0.24	0.04 -0.16,0.24	0.04 -0.17,0.24	-0.03 -0.13,0.07	-0.05 -0.15,0.06	-0.04 -0.14,0.06	-0.04 -0.14,0.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-0.11 -0.79,0.57	-0.12 -0.70,0.47	-0.11 -0.71,0.49	-0.11 -0.71,0.49	0.07 -0.13,0.27	0.05 -0.17,0.27	0.06 -0.15,0.26	0.07 -0.13,0.27
Q3	-0.28 -1.10,0.53	-0.16 -0.89,0.57	-0.16 -0.89,0.57	-0.16 -0.91,0.58	-0.03 -0.30,0.24	0.00 -0.28,0.29	0.01 -0.27,0.30	0.02 -0.28,0.31
Q4	-0.25 -0.99,0.48	-0.16 -0.82,0.50	-0.16 -0.82,0.50	-0.16 -0.83,0.50	-0.18 -0.48,0.12	-0.23 -0.57,0.11	-0.21 -0.54,0.11	-0.20 -0.56,0.16
	Measles 2009-2010, US-Born				**Measles 2009-2010, Foreign Born**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.02 -0.06,0.11	0.00 -0.09,0.09	0.01 -0.08,0.10	0.01 -0.08,0.10	0.08 -0.03,0.19	0.05 -0.05,0.15	0.06 -0.05,0.17	0.06 -0.05,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.07,0.60	0.26 -0.15,0.67	0.26 -0.13,0.65	0.26 -0.13,0.65	0.23 -0.40,0.87	0.18 -0.42,0.78	0.18 -0.41,0.78	0.18 -0.40,0.77
Q3	0.04 -0.30,0.38	0.01 -0.36,0.37	0.03 -0.33,0.39	0.02 -0.34,0.39	0.10 -0.49,0.70	-0.09 -0.54,0.36	-0.04 -0.52,0.45	-0.05 -0.55,0.45
Q4	0.10 -0.17,0.38	0.01 -0.28,0.29	0.06 -0.26,0.38	0.05 -0.26,0.37	0.34 -0.14,0.82	0.29 -0.22,0.81	0.31 -0.21,0.84	0.32 -0.22,0.85
MnBP								
Continuous	0.09* 0.00,0.17	0.05 -0.05,0.14	0.05 -0.04,0.15	0.05 -0.04,0.14	0.16+ -0.01,0.34	0.23* 0.06,0.40	0.24** 0.07,0.40	0.24* 0.06,0.41
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.15 -0.17,0.46	0.14 -0.18,0.47	0.16 -0.14,0.46	0.16 -0.14,0.46	0.15 -0.49,0.79	0.09 -0.46,0.63	0.09 -0.45,0.63	0.09 -0.46,0.63
Q3	0.19 -0.10,0.47	0.09 -0.23,0.42	0.13 -0.19,0.45	0.13 -0.19,0.45	0.25 -0.24,0.74	0.47* 0.02,0.93	0.48* 0.04,0.91	0.48* 0.05,0.90
Q4	0.25+ -0.04,0.55	0.12 -0.22,0.46	0.13 -0.20,0.45	0.13 -0.20,0.45	0.23 -0.31,0.76	0.40 -0.10,0.90	0.42+ -0.07,0.91	0.42+ -0.07,0.91
MiBP								
Continuous	0.09 -0.03,0.21	0.05 -0.07,0.17	0.06 -0.06,0.18	0.06 -0.06,0.18	0.03 -0.28,0.33	0.18 -0.14,0.49	0.18 -0.14,0.50	0.18 -0.15,0.50
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.12 -0.10,0.33	0.12 -0.08,0.31	0.15 -0.05,0.35	0.16 -0.04,0.35	0.63* 0.09,1.17	0.46+ -0.03,0.94	0.46+ -0.04,0.95	0.46+ -0.04,0.96
Q3	0.16 -0.10,0.42	0.13 -0.13,0.39	0.18 -0.08,0.44	0.19 -0.08,0.46	0.22 -0.41,0.85	0.41 -0.23,1.06	0.40 -0.21,1.01	0.40 -0.24,1.04
Q4	0.21 -0.07,0.49	0.10 -0.18,0.38	0.15 -0.14,0.44	0.15 -0.15,0.44	0.36 -0.42,1.14	0.59 -0.16,1.34	0.60 -0.18,1.38	0.60 -0.19,1.39
∑ DBP								
Continuous	0.03 -0.07,0.12	-0.01 -0.13,0.10	-0.00 -0.11,0.10	-0.01 -0.11,0.10	0.08 -0.10,0.27	0.21+ -0.00,0.42	0.22* 0.02,0.43	0.23* 0.02,0.43
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.04 -0.25,0.17	-0.06 -0.27,0.14	-0.04 -0.24,0.16	-0.03 -0.26,0.19	0.14 -0.69,0.96	0.45 -0.41,1.30	0.46 -0.37,1.30	0.47 -0.36,1.29
Q3	0.00 -0.33,0.34	-0.04 -0.39,0.31	-0.01 -0.32,0.30	-0.00 -0.32,0.32	0.28 -0.36,0.92	0.50 -0.12,1.12	0.55+ -0.04,1.13	0.55* 0.01,1.10
Q4	-0.00 -0.30,0.29	-0.12 -0.47,0.24	-0.09 -0.41,0.23	-0.08 -0.42,0.25	-0.00 -0.65,0.64	0.49 -0.22,1.20	0.53 -0.17,1.23	0.54 -0.18,1.26
McPP								
Continuous	0.04 -0.04,0.13	0.01 -0.10,0.11	0.01 -0.09,0.12	0.02 -0.09,0.13	0.17 -0.05,0.39	0.26+ -0.03,0.55	0.28+ -0.02,0.57	0.28+ -0.01,0.57
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.16 -0.12,0.43	0.15 -0.13,0.43	0.14 -0.14,0.42	0.14 -0.13,0.42	0.27 -0.48,1.03	0.15 -0.56,0.86	0.13 -0.62,0.89	0.13 -0.62,0.88
Q3	0.31* 0.07,0.55	0.23 -0.07,0.54	0.24+ -0.04,0.52	0.23+ -0.04,0.51	0.73* 0.17,1.28	0.74* 0.18,1.30	0.72* 0.16,1.28	0.73* 0.16,1.29
Q4	0.25+ -0.03,0.53	0.19 -0.14,0.53	0.20 -0.13,0.53	0.21 -0.13,0.54	0.30 -0.14,0.74	0.51+ -0.03,1.05	0.51+ -0.10,1.12	0.53+ -0.06,1.11
MBzP								
Continuous	0.04 -0.05,0.13	0.01 -0.10,0.12	0.02 -0.08,0.12	0.02 -0.09,0.12	0.02 -0.15,0.20	0.17* 0.01,0.33	0.18* 0.03,0.34	0.18* 0.04,0.33
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.10 -0.20,0.41	0.10 -0.23,0.43	0.12 -0.21,0.46	0.13 -0.21,0.47	-0.29 -0.92,0.34	0.02 -0.58,0.62	0.03 -0.58,0.64	0.03 -0.58,0.63
Q3	0.13 -0.11,0.37	0.11 -0.13,0.34	0.16 -0.08,0.39	0.16 -0.09,0.41	-0.16 -0.79,0.48	0.12 -0.39,0.62	0.15 -0.35,0.64	0.15 -0.33,0.62
Q4	0.21 -0.06,0.47	0.10 -0.21,0.42	0.12 -0.18,0.41	0.12 -0.18,0.43	-0.19 -0.60,0.22	0.26 -0.19,0.70	0.30 -0.15,0.74	0.29 -0.18,0.77
∑ DEHP								
Continuous	-0.01 -0.11,0.08	-0.04 -0.14,0.07	-0.02 -0.13,0.08	-0.02 -0.14,0.09	-0.04 -0.24,0.16	-0.00 -0.26,0.25	-0.01 -0.27,0.25	-0.01 -0.27,0.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -0.20,0.23	-0.01 -0.25,0.24	0.02 -0.22,0.25	0.03 -0.23,0.28	0.59* 0.03,1.15	0.62+ -0.02,1.26	0.62+ -0.03,1.27	.62+ -0.03,1.26
Q3	-0.01 -0.29,0.27	-0.06 -0.38,0.25	-0.04 -0.35,0.28	-0.03 -0.37,0.30	0.15 -0.61,0.91	0.35 -0.41,1.11	0.33 -0.42,1.08	0.33 -0.41,1.07
Q4	-0.13 -0.43,0.17	-0.21 -0.54,0.11	-0.19 -0.51,0.13	-0.18 -0.52,0.17	-0.05 -0.63,0.53	-0.10 -0.84,0.64	-0.13 -0.88,0.62	-0.14 -0.93,0.65

MEHP								
Continuous	-0.04 -0.17,0.09	-0.08 -0.20,0.05	-0.06 -0.19,0.06	-0.06 -0.19,0.07	0.00 -0.20,0.20	-0.01 -0.33,0.31	-0.01 -0.33,0.31	-0.01 -0.34,0.31
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.12 -0.23,0.46	0.09 -0.26,0.44	0.12 -0.23,0.47	0.13 -0.24,0.51	0.25 -0.66,1.16	0.26 -0.49,1.01	0.25 -0.50,1.01	0.25 -0.50,1.00
Q3	0.10 -0.20,0.41	0.02 -0.30,0.34	0.05 -0.25,0.36	0.05 -0.27,0.37	0.45 -0.29,1.19	0.68+ -0.03,1.39	0.67+ -0.04,1.37	0.67+ -0.03,1.36
Q4	-0.11 -0.37,0.15	-0.24+ -0.48,0.01	-.21+ -0.46,0.04	-0.20 -0.47,0.07	0.01 -0.65,0.67	-0.06 -0.84,0.72	-0.06 -0.84,0.73	-0.06 -0.85,0.73
MEHHP								
Continuous	-0.02 -0.13,0.08	-0.04 -0.15,0.07	-0.03 -0.14,0.09	-0.02 -0.14,0.10	-0.02 -0.22,0.18	-0.01 -0.26,0.25	-0.01 -0.27,0.25	-0.01 -0.28,0.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.18** 0.07,0.28	0.16* 0.02,0.29	0.17* 0.04,0.29	0.18* 0.04,0.32	0.61+ -0.03,1.26	0.49 -0.26,1.25	0.49 -0.27,1.25	0.49 -0.27,1.25
Q3	-0.00 -0.29,0.28	-0.07 -0.39,0.25	-0.03 -0.36,0.30	-0.03 -0.38,0.33	0.17 -0.54,0.89	0.24 -0.40,0.88	0.23 -0.41,0.86	0.22 -0.41,0.86
Q4	-0.07 -0.34,0.21	-0.12 -0.40,0.15	-0.10 -0.37,0.18	-0.08 -0.38,0.22	-0.16 -0.78,0.45	-0.28 -1.00,0.44	-0.29 -1.01,0.43	-0.31 -1.09,0.47
MEOHP								
Continuous	-0.03 -0.13,0.08	-0.05 -0.16,0.06	-0.04 -0.15,0.08	-0.04 -0.16,0.08	-0.01 -0.22,0.20	0.02 -0.26,0.30	0.02 -0.27,0.30	0.01 -0.27,0.30
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.02 -0.21,0.17	-0.03 -0.22,0.15	-0.01 -0.19,0.17	0.00 -0.21,0.22	0.60+ -0.03,1.23	0.68+ -0.02,1.38	0.67+ -0.03,1.37	0.67+ -0.02,1.36
Q3	-0.06 -0.31,0.19	-0.14 -0.44,0.16	-0.12 -0.41,0.17	-0.12 -0.42,0.19	0.14 -0.53,0.81	0.30 -0.35,0.94	0.29 -0.36,0.93	0.29 -0.36,0.93
Q4	-0.17 -0.47,0.13	-0.24 -0.54,0.07	-0.21 -0.52,0.09	-0.20 -0.53,0.13	-0.08 -0.65,0.50	-0.14 -0.90,0.61	-0.15 -0.91,0.60	-0.19 -1.01,0.64
MECPP								
Continuous	-0.01 -0.10,0.07	-0.04 -0.14,0.06	-0.03 -0.14,0.08	-0.03 -0.14,0.09	-0.09 -0.29,0.11	-0.03 -0.29,0.23	-0.04 -0.30,0.23	-0.04 -0.31,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.26,0.11	-0.10 -0.33,0.14	-0.08 -0.30,0.13	-0.08 -0.29,0.14	0.62+ -0.07,1.30	0.59+ -0.12,1.30	0.59 -0.14,1.31	0.58 -0.14,1.30
Q3	-0.02 -0.27,0.22	-0.08 -0.37,0.20	-0.07 -0.35,0.22	-0.06 -0.36,0.23	-0.11 -0.76,0.54	0.23 -0.37,0.83	0.21 -0.38,0.80	0.20 -0.38,0.78
Q4	-0.15 -0.42,0.11	-0.23 -0.54,0.09	-0.21 -0.52,0.10	-0.20 -0.53,0.14	-0.17 -0.78,0.44	-0.23 -0.97,0.50	-0.26 -1.03,0.50	-0.27 -1.08,0.53
	Mumps 2009-2010, Female				**Mumps 2009-2010, Male**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.05 -0.15,0.04	-0.09+ -0.18,0.00	-0.08+ -0.17,0.02	-0.08+ -0.17,0.02	-0.05 -0.12,0.02	-0.09* -0.15,-0.02	-0.08* -0.15,-0.01	-0.08* -0.15,-.01
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.17,0.34	0.01 -0.22,0.24	0.02 -0.20,0.24	0.02 -0.21,0.25	0.01 -0.28,0.30	-0.01 -0.32,0.30	-0.05 -0.35,0.26	-0.04 -0.34,0.25
Q3	-0.25+ -0.53,0.04	-0.34* -0.64,-0.03	-0.33* -0.61,-0.05	-0.33* -0.61,-0.04	-0.07 -0.36,0.23	-0.05 -0.34,0.24	-0.03 -0.32,0.25	-0.08 -0.35,0.20
Q4	-0.07 -0.46,0.33	-0.25 -0.61,0.11	-0.19 -0.55,0.17	-0.19 -0.56,0.18	-0.21 -0.54,0.12	-0.36* -0.67,-0.05	-0.34* -0.67,-0.02	-0.34* -0.67,-.02
MnBP								
Continuous	-0.06 -0.19,0.07	-0.07 -0.21,0.07	-0.06 -0.20,0.08	-0.06 -0.20,0.08	-0.02 -0.18,0.13	-0.01 -0.19,0.17	0.00 -0.18,0.18	0.00 -0.18,0.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.27 -0.70,0.17	-0.34 -0.79,0.11	-0.29 -0.74,0.15	-0.29 -0.74,0.15	-0.12 -0.43,0.20	-0.14 -0.45,0.17	-0.14 -0.46,0.17	-0.13 -0.41,0.16
Q3	-0.20+ -0.44,0.03	-0.25* -0.48,-0.01	-0.18 -0.43,0.06	-0.18 -0.43,0.06	-0.11 -0.48,0.26	-0.04 -0.44,0.36	0.01 -0.38,0.39	0.03 -0.34,0.39
Q4	-0.12 -0.56,0.31	-0.16 -0.64,0.32	-0.13 -0.59,0.33	-0.13 -0.59,0.33	0.06 -0.38,0.49	0.11 -0.38,0.59	0.10 -0.42,0.62	0.11 -0.41,0.63
MiBP								
Continuous	-0.00 -0.19,0.19	-0.01 -0.20,0.18	0.01 -0.18,0.19	0.01 -0.18,0.20	-0.02 -0.22,0.18	-0.03 -0.22,0.16	-0.00 -0.18,0.18	-0.00 -0.17,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.63*** -0.94,-0.33	-.68*** -1.03,0.33	-0.64** -1.01,-.27	-0.64** -1.01,-.27	-0.34 -0.90,0.23	-0.35 -0.87,0.17	-0.30 -0.75,0.16	-0.26 -0.69,0.17
Q3	-0.55*** -0.77,-0.32	-0.55*** -0.78,.32	-0.49*** -0.73,.25	-0.49*** -.73,.25	-0.41+ -0.89,0.07	-0.40 -0.89,0.10	-0.28 -0.70,0.15	-0.24 -0.66,0.18
Q4	-0.22 -0.62,0.17	-0.28 -0.65,0.10	-0.21 -0.59,0.17	-0.21 -0.59,0.17	-0.22 -0.78,0.34	-0.21 -0.75,0.33	-0.12 -0.63,0.39	-0.10 -0.57,0.36
∑ DBP								
Continuous	-0.15* -0.30,-0.00	-0.14+ -0.31,0.03	-0.12 -0.30,0.05	-0.12 -0.30,0.05	-0.09 -0.23,0.05	-0.06 -0.21,0.10	-0.05 -0.20,0.09	-0.05 -0.19,0.09

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.25 -0.70,0.21	-0.26 -0.72,0.20	-0.22 -0.65,0.22	-0.22 -0.65,0.22	-0.26 -0.69,0.17	-0.27 -0.69,0.15	-0.22 -0.61,0.17	-0.19 -0.58,0.20
Q3	-0.42* -0.74,-0.09	-0.41* -0.77,-0.06	-0.35+ -0.73,0.03	-0.35+ -0.73,0.03	-0.19 -0.56,0.18	-0.14 -0.55,0.28	-0.13 -0.54,0.29	-0.10 -0.51,0.32
Q4	-0.35 -0.77,0.08	-0.30 -0.80,0.19	-0.26 -0.75,0.23	-0.26 -0.75,0.23	-0.30 -0.77,0.17	-0.21 -0.71,0.29	-0.16 -0.66,0.34	-0.14 -0.61,0.33
McPP								
Continuous	-0.12 -0.29,0.05	-0.12 -0.31,0.06	-0.10 -0.29,0.08	-0.10 -0.28,0.08	-0.08 -0.20,0.05	-0.06 -0.22,0.09	-0.06 -0.20,0.09	-0.06 -0.20,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.04 -0.35,0.26	-0.08 -0.39,0.24	-0.06 -0.33,0.22	-0.06 -0.33,0.22	0.12 -0.39,0.63	0.16 -0.41,0.72	0.14 -0.42,0.70	0.13 -0.43,0.69
Q3	-0.02 -0.49,0.45	-0.07 -0.52,0.39	-0.06 -0.48,0.37	-0.06 -0.48,0.37	0.04 -0.34,0.42	0.05 -0.30,0.41	0.03 -0.31,0.37	-0.00 -0.37,0.37
Q4	-0.24 -0.64,0.17	-0.25 -0.68,0.17	-0.20 -0.59,0.19	-0.20 -0.58,0.19	-0.16 -0.48,0.16	-0.08 -0.43,0.28	-0.09 -0.43,0.25	-0.09 -0.44,0.25
MBzP								
Continuous	-0.11 -0.27,0.04	-0.10 -0.28,0.08	-0.08 -0.26,0.10	-0.08 -0.26,0.10	-0.11 -0.25,0.03	-0.07 -0.20,0.06	-0.07 -0.20,0.05	-0.07 -0.18,0.05
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.10 -0.55,0.35	-0.10 -0.55,0.34	-0.07 -0.50,0.36	-0.07 -0.51,0.36	-0.28+ -0.57,0.01	-0.23 -0.52,0.07	-0.19 -0.44,0.07	-0.16 -0.40,0.08
Q3	-0.52* -0.96,-0.08	-0.50* -0.97,-0.03	-0.44+ -0.92,0.05	-0.44+ -0.92,0.05	-0.21 -0.54,0.11	-0.11 -0.46,0.24	-0.08 -0.41,0.24	-0.05 -0.38,0.27
Q4	-0.20 -0.67,0.28	-0.14 -0.70,0.43	-0.11 -0.67,0.46	-0.11 -0.67,0.46	-0.20 -0.72,0.33	-0.08 -0.58,0.42	-0.09 -0.56,0.37	-0.08 -0.49,0.34
∑ DEHP								
Continuous	-0.09 -0.25,0.07	-0.10 -0.27,0.07	-0.08 -0.24,0.09	-0.08 -0.24,0.09	0.00 -0.14,0.14	0.01 -0.16,0.17	0.01 -0.14,0.17	0.01 -0.14,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.24 -0.64,0.15	-0.22 -0.65,0.22	-0.17 -0.60,0.26	-0.17 -0.60,0.25	0.06 -0.44,0.56	0.12 -0.32,0.55	0.09 -0.30,0.49	0.11 -0.25,0.47
Q3	0.01 -0.34,0.37	-0.02 -0.41,0.37	0.03 -0.32,0.39	0.03 -0.32,0.39	0.02 -0.28,0.32	0.14 -0.11,0.39	0.16 -0.09,0.40	0.17 -0.07,0.42
Q4	-0.12 -0.62,0.38	-0.12 -0.63,0.39	-0.05 -0.56,0.45	-0.06 -0.56,0.44	0.03 -0.51,0.57	0.08 -0.51,0.67	0.07 -0.51,0.66	0.09 -0.47,0.65
MEHP								
Continuous	-0.11 -0.28,0.07	-0.13 -0.31,0.04	-0.12 -0.30,0.05	-0.12 -0.30,0.05	0.02 -0.18,0.22	0.01 -0.23,0.24	0.02 -0.21,0.24	0.02 -0.20,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.34* -0.61,-0.07	-0.34* -0.64,-0.05	-0.32* -0.59,-0.05	-0.32* -0.59,-0.05	-0.02 -0.35,0.31	0.02 -0.28,0.32	0.08 -0.23,0.38	0.11 -0.17,0.38
Q3	-0.21 -0.62,0.19	-0.21 -0.62,0.20	-0.18 -0.59,0.22	-0.18 -0.59,0.22	0.13 -0.19,0.46	0.17 -0.16,0.51	0.19 -0.13,0.51	0.20 -0.10,0.50
Q4	-0.26 -0.64,0.12	-0.39* -0.76,-0.03	-0.38* -0.74,-0.03	-0.38* -0.74,-0.03	-0.03 -0.51,0.45	-0.05 -0.59,0.48	-0.01 -0.52,0.51	0.01 -0.48,0.51
MEHHP								
Continuous	-0.08 -0.24,0.07	-0.10 -0.26,0.06	-0.07 -0.23,0.08	-0.07 -0.23,0.08	0.01 -0.14,0.16	0.01 -0.15,0.18	0.02 -0.14,0.18	0.02 -0.13,0.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.21 -0.61,0.19	-0.20 -0.64,0.25	-0.17 -0.59,0.25	-0.17 -0.59,0.25	0.18 -0.26,0.62	0.19 -0.22,0.60	0.18 -0.20,0.55	0.20 -0.13,0.54
Q3	0.04 -0.29,0.37	-0.01 -0.35,0.32	0.04 -0.28,0.36	0.04 -0.28,0.35	0.16 -0.20,0.51	0.23 -0.09,0.56	0.25+ -0.05,0.56	0.27+ -0.02,0.57
Q4	-0.28 -0.76,0.20	-0.30 -0.77,0.18	-0.24 -0.70,0.23	-0.24 -0.69,0.22	0.01 -0.52,0.54	0.01 -0.55,0.58	0.01 -0.53,0.55	0.03 -0.48,0.55
MEOHP								
Continuous	-0.10 -0.26,0.07	-0.11 -0.27,0.05	-0.08 -0.25,0.08	-0.08 -0.25,0.08	0.01 -0.15,0.17	0.02 -0.16,0.20	0.03 -0.15,0.20	0.03 -0.15,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.34+ -0.70,0.02	-0.33+ -0.72,0.06	-0.30 -0.67,0.07	-0.30 -0.67,0.07	0.04 -0.39,0.47	0.10 -0.27,0.47	0.09 -0.24,0.43	0.13 -0.18,0.44
Q3	0.01 -0.35,0.37	-0.03 -0.43,0.36	0.00 -0.38,0.39	0.00 -0.38,0.39	-0.03 -0.39,0.33	0.09 -0.23,0.40	0.11 -0.21,0.42	0.11 -0.18,0.41
Q4	-0.24 -0.70,0.22	-0.25 -0.70,0.21	-0.18 -0.63,0.27	-0.18 -0.63,0.26	0.07 -0.47,0.61	0.14 -0.44,0.72	0.13 -0.45,0.71	0.16 -0.40,0.72
MECPP								
Continuous	-0.09 -0.26,0.08	-0.09 -0.27,0.09	-0.06 -0.24,0.12	-0.06 -0.24,0.12	0.00 -0.13,0.14	0.01 -0.15,0.16	0.01 -0.14,0.17	0.01 -0.14,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.35* -0.69,-0.02	-0.33+ -0.71,0.05	-0.28 -0.65,0.08	-0.28 -0.65,0.08	-0.00 -0.45,0.44	0.02 -0.41,0.45	-0.00 -0.45,0.44	0.01 -0.40,0.43
Q3	-0.03 -0.35,0.29	-0.01 -0.35,0.34	0.05 -0.27,0.38	0.05 -0.27,0.38	-0.05 -0.40,0.30	0.05 -0.25,0.35	0.06 -0.24,0.36	0.07 -0.22,0.36
Q4	-0.22 -0.69,0.25	-0.20 -0.67,0.27	-0.13 -0.60,0.35	-0.13 -0.59,0.33	0.06 -0.33,0.44	0.11 -0.32,0.54	0.10 -0.34,0.54	0.12 -0.30,0.55
	Mumps 2009-2010, Adolescents				**Mumps 2009-2010, Adults**			

	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.07 -0.21,0.08	-0.10 -0.24,0.03	-0.08 -0.19,0.03	-0.08 -0.19,0.03	-0.04 -0.14,0.06	-0.07 -0.16,0.02	-0.07 -0.16,0.02	-0.08+ -0.17,0.01
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.33 -0.11,0.77	0.18 -0.25,0.62	0.24 -0.19,0.67	0.24 -0.19,0.67	0.01 -0.28,0.30	-0.02 -0.32,0.27	-0.05 -0.32,0.23	-0.04 -0.32,0.23
Q3	-0.02 -0.60,0.56	-0.08 -0.70,0.53	-0.04 -0.64,0.56	-0.04 -0.64,0.56	-0.17 -0.41,0.07	-.23+ -0.48,0.02	-0.25* -0.48,-.01	-0.26* -.48,-.03
Q4	-0.10 -0.55,0.35	-0.28 -0.73,0.16	-0.16 -0.57,0.25	-0.16 -0.57,0.25	-0.10 -0.56,0.36	-0.24 -0.65,0.18	-0.24 -0.67,0.18	-0.25 -0.68,0.18
MnBP								
Continuous	-0.12 -0.28,0.04	-0.16+ -0.34,0.01	-0.16+ -0.33,0.02	-0.16+ -0.33,0.02	-0.05 -0.19,0.09	-0.06 -0.22,0.09	-0.06 -0.21,0.10	-0.06 -0.21,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.31 -0.89,0.27	-0.35 -0.94,0.24	-0.34 -0.95,0.28	-0.34 -0.96,0.28	-0.18 -0.53,0.17	-0.24 -0.60,0.13	-0.25 -0.60,0.11	-0.24 -0.59,0.10
Q3	-0.42+ -0.91,0.06	-0.41+ -0.89,0.08	-0.35 -0.84,0.14	-0.34 -0.83,0.14	-0.11 -0.46,0.23	-0.18 -0.49,0.14	-0.15 -0.46,0.16	-0.15 -0.46,0.16
Q4	-0.42* -0.78,-0.06	-0.45* -0.82,-0.08	-0.46* -0.86,-0.06	-0.46* -0.86,-0.06	0.03 -0.38,0.44	0.00 -0.48,0.48	0.01 -0.46,0.48	0.01 -0.46,0.48
MiBP								
Continuous	-0.12 -0.27,0.04	-0.16* -0.30,-0.02	-0.15* -0.29,-0.01	-0.15* -0.29,-0.01	0.01 -0.20,0.22	-0.03 -0.25,0.20	-0.01 -0.23,0.21	-0.01 -0.23,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.36 -1.32,0.59	-0.49 -1.33,0.35	-0.44 -1.29,0.41	-0.44 -1.29,0.41	-0.56** -0.89,-.23	-0.59** -0.93,-.26	-0.55** -.88,-.22	-0.55** -.88,-.22
Q3	-0.64* -1.15,-0.13	-0.62* -1.22,-0.02	-0.56+ -1.18,0.05	-0.56+ -1.18,0.05	-0.44* -0.84,-0.04	-0.45* -0.83,-0.07	-0.39* -0.73,-.05	-0.39* -0.74,-.04
Q4	-0.50+ -1.00,0.01	-0.66* -1.15,-0.18	-0.63* -1.12,-0.15	-0.63* -1.12,-0.15	-0.15 -0.57,0.26	-0.20 -0.65,0.25	-0.14 -0.59,0.31	-0.14 -0.58,0.29
∑ DBP								
Continuous	-0.07 -0.25,0.11	-0.06 -0.25,0.13	-0.05 -0.25,0.14	-0.05 -0.25,0.14	-0.18** -0.31,-0.05	-0.17* -0.32,-0.02	-0.17* -0.32,-0.02	-0.17* -0.32,-.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.28 -0.95,0.39	-0.52* -1.04,-0.00	-0.47+ -1.00,0.05	-0.48+ -1.00,0.05	-0.27 -0.63,0.08	-0.25 -0.62,0.11	-0.23 -0.59,0.12	-0.23 -0.60,0.14
Q3	-0.06 -0.63,0.51	-0.22 -0.77,0.32	-0.18 -0.72,0.35	-0.18 -0.72,0.35	-0.30+ -0.66,0.05	-0.27 -0.66,0.12	-0.28 -0.68,0.12	-0.28 -0.68,0.12
Q4	-0.35 -0.81,0.11	-0.41+ -0.90,0.08	-0.38 -0.90,0.14	-0.38 -0.89,0.13	-0.42* -0.83,-.01	-0.38 -0.86,0.10	-0.36 -0.84,0.13	-0.35 -0.83,0.13
McPP								
Continuous	0.01 -0.19,0.21	0.00 -0.21,0.22	0.01 -0.21,0.23	0.01 -0.21,0.23	-0.15* -0.27,-0.03	-0.15* -0.29,-0.02	-0.15* -0.28,-0.02	-0.14* -0.28,-.01
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.21 -0.99,0.56	-0.29 -1.00,0.42	-0.27 -0.99,0.45	-0.27 -0.99,0.46	0.08 -0.22,0.38	0.07 -0.25,0.39	0.08 -0.23,0.39	0.07 -0.23,0.38
Q3	-0.27 -0.96,0.42	-0.31 -1.00,0.38	-0.25 -0.91,0.42	-0.25 -0.91,0.42	0.04 -0.40,0.47	0.04 -0.38,0.46	0.01 -0.42,0.44	0.00 -0.43,0.43
Q4	-0.10 -0.71,0.51	-0.15 -0.70,0.40	-0.12 -0.66,0.43	-0.12 -0.66,0.43	-0.31* -0.59,-.04	-0.30* -0.59,-.01	-0.28+ -0.57,.01	-0.28+ -0.57,.01
MBzP								
Continuous	-0.10 -0.28,0.08	-0.09 -0.27,0.08	-0.09 -0.27,0.09	-0.09 -0.27,0.09	-0.17* -0.30,-0.04	-0.15* -0.29,-0.01	-0.16* -0.30,-0.01	-0.16* -0.30,-.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.27 -0.49,1.02	-0.07 -0.62,0.48	-0.08 -0.65,0.49	-0.08 -0.65,0.49	-0.27+ -0.56,0.03	-0.22 -0.53,0.10	-0.20 -0.50,0.11	-0.19 -0.50,0.12
Q3	-0.25 -0.65,0.16	-0.41* -0.81,-0.01	-0.34+ -0.73,0.04	-0.34+ -0.73,0.04	-0.37* -0.69,-.05	-0.32+ -0.70,.06	-0.30 -0.68,0.07	-0.30 -0.69,0.09
Q4	-0.18 -0.77,0.41	-0.28 -0.81,0.24	-0.29 -0.83,0.26	-0.29 -0.82,0.25	-0.25 -0.69,0.19	-0.19 -0.68,0.30	-0.22 -0.71,0.26	-0.22 -0.69,0.24
∑ DEHP								
Continuous	0.10 -0.11,0.30	0.09 -0.11,0.29	0.09 -0.12,0.29	0.09 -0.12,0.29	-0.08 -0.21,0.05	-0.09 -0.23,0.06	-0.08 -0.22,0.06	-0.08 -0.22,0.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.50 -1.12,0.13	-0.42 -1.11,0.26	-0.37 -1.08,0.33	-0.37 -1.08,0.33	-0.06 -0.39,0.28	-0.03 -0.35,0.30	-0.05 -0.36,0.26	-0.04 -0.35,0.28
Q3	-0.12 -0.60,0.36	-0.05 -0.53,0.44	-0.02 -0.50,0.46	-0.02 -0.50,0.47	-0.01 -0.34,0.31	0.00 -0.33,0.33	0.03 -0.28,0.35	0.04 -0.28,0.36
Q4	0.07 -0.52,0.65	0.14 -0.48,0.76	0.14 -0.46,0.74	0.14 -0.46,0.75	-0.12 -0.57,0.33	-0.11 -0.65,0.43	-0.09 -0.62,0.44	-0.07 -0.61,0.46
MEHP								
Continuous	0.12 -0.13,0.37	0.10 -0.17,0.38	0.09 -0.18,0.35	0.09 -0.18,0.35	-0.08 -0.24,0.09	-0.09 -0.28,0.10	-0.09 -0.27,0.10	-0.08 -0.27,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.31+ -0.63,0.01	-0.39+ -0.84,0.06	-0.40+ -0.83,0.04	-0.40+ -0.83,0.04	-0.19* -0.36,-.02	-0.18+ -0.37,.01	-0.14 -0.34,0.05	-0.13 -0.33,0.07

Q3	-0.02 -0.41,0.38	-0.03 -0.45,0.39	-0.06 -0.47,0.35	-0.06 -0.47,0.35	-0.05 -0.39,0.29	-0.02 -0.39,0.35	-0.00 -0.36,0.35	-0.00 -0.38,0.37
Q4	0.15 -0.35,0.65	0.03 -0.55,0.60	-0.02 -0.56,0.52	-0.01 -0.55,0.53	-0.26 -0.58,0.06	-0.32+ -0.66,.03	-0.30+ -0.64,.05	-0.29+ -0.63,.06
MEHHP								
Continuous	0.11 -0.07,0.29	0.11 -0.08,0.30	0.10 -0.08,0.29	0.10 -0.08,0.29	-0.07 -0.21,0.06	-0.08 -0.22,0.07	-0.07 -0.21,0.08	-0.07 -0.21,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.34 -0.84,0.16	-0.27 -0.88,0.34	-0.20 -0.83,0.44	-0.20 -0.84,0.44	-0.03 -0.39,0.32	-0.03 -0.40,0.33	-0.05 -0.41,0.30	-0.04 -0.41,0.32
Q3	-0.05 -0.54,0.45	-0.03 -0.47,0.42	-0.01 -0.43,0.42	-0.00 -0.43,0.42	0.11 -0.21,0.43	0.11 -0.22,0.44	0.13 -0.18,0.45	0.14 -0.18,0.46
Q4	0.16 -0.43,0.75	0.21 -0.39,0.82	0.22 -0.36,0.80	0.22 -0.36,0.80	-0.30 -0.72,0.13	-0.31 -0.80,0.18	-0.29 -0.78,0.20	-0.28 -0.76,0.21
MEOHP								
Continuous	0.09 -0.11,0.30	0.09 -0.12,0.30	0.08 -0.13,0.29	0.08 -0.13,0.29	-0.07 -0.22,0.07	-0.08 -0.24,0.08	-0.07 -0.23,0.09	-0.07 -0.23,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.41 -1.10,0.28	-0.35 -1.04,0.34	-0.29 -1.01,0.43	-0.29 -1.01,0.43	-0.17 -0.47,0.13	-0.15 -0.43,0.14	-0.17 -0.43,0.10	-0.16 -0.44,0.12
Q3	-0.10 -0.53,0.32	-0.08 -0.49,0.33	-0.06 -0.45,0.33	-0.06 -0.45,0.34	-0.04 -0.40,0.33	-0.03 -0.42,0.36	-0.01 -0.39,0.37	-0.01 -0.39,0.37
Q4	0.04 -0.58,0.65	0.09 -0.53,0.71	0.09 -0.50,0.68	0.09 -0.50,0.68	-0.18 -0.57,0.22	-0.16 -0.64,0.32	-0.14 -0.62,0.33	-0.13 -0.60,0.34
MECPP								
Continuous	0.10 -0.12,0.32	0.10 -0.12,0.32	0.10 -0.12,0.31	0.10 -0.12,0.31	-0.08 -0.22,0.05	-0.09 -0.24,0.07	-0.08 -0.23,0.07	-0.07 -0.23,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.51 -1.21,0.19	-0.40 -1.14,0.33	-0.37 -1.13,0.40	-0.37 -1.13,0.40	-0.14 -0.49,0.21	-0.15 -0.52,0.22	-0.17 -0.52,0.18	-0.15 -0.51,0.20
Q3	-0.11 -0.58,0.36	-0.06 -0.51,0.39	-0.04 -0.50,0.41	-0.04 -0.50,0.42	-0.12 -0.42,0.19	-0.07 -0.39,0.26	-0.04 -0.36,0.28	-0.04 -0.36,0.29
Q4	0.07 -0.65,0.79	0.13 -0.52,0.78	0.11 -0.53,0.76	0.12 -0.53,0.76	-0.16 -0.53,0.21	-0.15 -0.61,0.31	-0.13 -0.58,0.32	-0.11 -0.56,0.35

	Mumps 2009-2010, US-Born				Mumps 2009-2010, Foreign Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.05 -0.14,0.03	-0.09* -0.16,-0.02	-0.08* -0.15,-0.00	-0.08* -0.15,-0.01	-0.07 -0.18,0.03	-0.12* -0.23,-0.01	-0.11* -0.22,-0.00	-0.11* -0.22,-0.00
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.09,0.25	0.04 -0.11,0.19	0.03 -0.11,0.16	0.03 -0.10,0.17	-0.05 -0.47,0.37	-0.21 -0.65,0.22	-0.21 -0.65,0.23	-0.21 -0.65,0.22
Q3	-0.13 -0.41,0.16	-0.20 -0.48,0.09	-0.18 -0.45,0.09	-0.18 -0.44,0.07	-0.13 -0.62,0.36	-0.33 -0.95,0.29	-0.23 -0.81,0.35	-0.23 -0.82,0.35
Q4	-0.16 -0.51,0.20	-0.34* -0.63,-0.04	-0.28+ -0.61,0.05	-0.28+ -0.61,0.04	-0.18 -0.69,0.34	-0.39 -0.95,0.17	-0.37 -0.92,0.18	-0.37 -0.92,0.19
MnBP								
Continuous	-0.07 -0.20,0.05	-0.08 -0.23,0.06	-0.07 -0.22,0.08	-0.07 -0.22,0.07	0.11 -0.06,0.27	0.13+ -0.02,0.28	0.14+ -0.02,0.30	0.14+ -0.02,0.3
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.47,0.19	-0.15 -0.49,0.19	-0.12 -0.45,0.21	-0.12 -0.44,0.20	-0.45+ -0.99,0.08	-0.64** -1.09,-.19	-0.64** -1.09,-.19	-0.65** -1.09,-.2
Q3	-0.14 -0.36,0.07	-0.16 -0.39,0.07	-0.09 -0.33,0.15	-0.09 -0.33,0.15	-0.10 -0.48,0.29	-0.07 -0.46,0.32	-0.06 -0.47,0.34	-0.07 -0.47,0.33
Q4	-0.09 -0.48,0.30	-0.12 -0.59,0.36	-0.10 -0.57,0.36	-0.11 -0.57,0.36	0.36 -0.20,0.91	0.41 -0.12,0.93	0.43 -0.11,0.97	0.42 -0.10,0.95
MiBP								
Continuous	-0.03 -0.20,0.13	-0.05 -0.25,0.14	-0.02 -0.21,0.17	-0.02 -0.21,0.17	0.12 -0.10,0.34	0.14 -0.09,0.38	0.14 -0.09,0.38	0.14 -0.09,0.38
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.59*** -0.80,-0.37	-0.59*** -.83,-.35	-0.53*** -.75,-.31	-0.52*** -.74,-.31	-0.03 -0.60,0.54	-0.22 -0.72,0.29	-0.23 -0.78,0.31	-0.24 -0.77,0.30
Q3	-0.54** -0.83,-0.25	-0.53** -0.83,-.22	-0.43** -0.69,-.16	-0.42** -0.69,-.15	-0.18 -0.73,0.37	-0.24 -0.75,0.26	-0.28 -0.80,0.24	-0.29 -0.80,0.22
Q4	-0.33* -0.61,-0.05	-0.38* -0.72,-0.05	-0.29+ -0.64,0.06	-0.29+ -0.63,0.05	0.39 -0.33,1.11	0.48 -0.17,1.13	0.47 -0.22,1.15	0.46 -0.20,1.13
∑ DBP								
Continuous	-0.11** -0.19,-0.03	-0.09+ -0.19,0.02	-0.07 -0.17,0.03	-0.07 -0.17,0.03	-0.09 -0.35,0.17	-0.06 -0.33,0.20	-0.05 -0.30,0.20	-0.05 -0.31,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18 -0.53,0.17	-0.22 -0.57,0.13	-0.15 -0.47,0.17	-0.14 -0.48,0.19	-0.44 -1.10,0.22	-0.31 -0.94,0.32	-0.28 -0.91,0.35	-0.28 -0.91,0.34
Q3	-0.31+ -0.63,0.00	-0.30+ -0.66,0.06	-0.24 -0.60,0.11	-0.24 -0.60,0.12	-0.00 -0.62,0.61	0.12 -0.59,0.82	0.17 -0.53,0.88	0.17 -0.53,0.88
Q4	-0.27* -0.52,-0.02	-0.22 -0.51,0.08	-0.15 -0.46,0.16	-0.14 -0.45,0.17	-0.37 -1.22,0.49	-0.26 -1.09,0.57	-0.22 -0.96,0.52	-0.22 -0.99,0.55
McPP								

Continuous	-0.11* -0.19,-0.03	-0.10* -0.18,-0.01	-0.08* -0.16,-0.00	-0.08* -0.15,-0.00	-0.03 -0.31,0.25	-0.05 -0.40,0.30	-0.05 -0.38,0.28	-0.05 -0.39,0.28
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.06 -0.21,0.33	0.06 -0.25,0.37	0.06 -0.23,0.35	0.06 -0.23,0.34	-0.10 -0.63,0.43	-0.15 -0.68,0.37	-0.17 -0.75,0.40	-0.17 -0.76,0.41
Q3	0.01 -0.34,0.36	0.01 -0.34,0.36	0.01 -0.34,0.35	-0.00 -0.34,0.34	-0.17 -0.70,0.35	-0.11 -0.66,0.43	-0.14 -0.69,0.40	-0.15 -0.66,0.37
Q4	-0.21+ -0.42,0.01	-0.16 -0.38,0.06	-0.13 -0.34,0.07	-0.13 -0.33,0.07	-0.12 -0.65,0.41	-0.13 -0.71,0.46	-0.13 -0.67,0.42	-0.13 -0.68,0.42
MBzP								
Continuous	-0.10* -0.18,-0.01	-0.07 -0.18,0.04	-0.06 -0.17,0.05	-0.06 -0.17,0.05	-0.07 -0.35,0.20	-0.02 -0.27,0.23	-0.00 -0.26,0.25	-0.01 -0.25,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.11 -0.48,0.26	-0.15 -0.53,0.23	-0.09 -0.43,0.26	-0.08 -0.43,0.27	-0.37 -0.82,0.08	-0.17 -0.57,0.24	-0.15 -0.58,0.27	-0.15 -0.58,0.27
Q3	-0.32* -0.61,-0.02	-0.29+ -0.65,0.06	-0.22 -0.55,0.11	-0.21 -0.55,0.13	-0.25 -0.70,0.20	-0.18 -0.70,0.34	-0.12 -0.64,0.39	-0.13 -0.63,0.38
Q4	-0.13 -0.42,0.15	-0.07 -0.43,0.28	-0.05 -0.38,0.29	-0.04 -0.38,0.29	-0.10 -1.16,0.96	0.06 -0.96,1.08	0.11 -0.91,1.13	0.11 -0.88,1.10
∑ DEHP								
Continuous	-0.06 -0.16,0.03	-0.05 -0.16,0.06	-0.03 -0.14,0.08	-0.03 -0.14,0.08	-0.03 -0.15,0.10	-0.01 -0.17,0.15	-0.02 -0.18,0.14	-0.02 -0.19,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -0.52,0.19	-0.10 -0.46,0.27	-0.09 -0.43,0.26	-0.07 -0.43,0.28	0.14 -0.34,0.62	0.15 -0.30,0.59	0.15 -0.32,0.61	0.15 -0.32,0.61
Q3	-0.03 -0.25,0.19	0.04 -0.21,0.28	0.08 -0.13,0.30	0.09 -0.13,0.31	0.12 -0.39,0.62	0.19 -0.33,0.71	0.16 -0.34,0.67	0.16 -0.34,0.66
Q4	-0.12 -0.49,0.26	-0.07 -0.51,0.37	-0.04 -0.49,0.40	-0.02 -0.47,0.42	0.06 -0.49,0.62	0.12 -0.53,0.77	0.07 -0.54,0.69	0.07 -0.59,0.73
MEHP								
Continuous	-0.07 -0.21,0.07	-0.08 -0.23,0.07	-0.07 -0.22,0.08	-0.06 -0.22,0.09	-0.01 -0.21,0.19	0.02 -0.20,0.24	0.02 -0.19,0.23	0.02 -0.21,0.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.21+ -0.42,0.01	-0.17 -0.43,0.09	-0.12 -0.38,0.14	-0.11 -0.37,0.15	-0.19 -0.85,0.46	-0.29 -0.92,0.34	-0.31 -0.94,0.32	-0.31 -0.94,0.33
Q3	-0.12 -0.39,0.16	-0.08 -0.36,0.21	-0.06 -0.34,0.22	-0.06 -0.35,0.23	0.10 -0.57,0.76	0.19 -0.45,0.84	0.16 -0.51,0.82	0.16 -0.50,0.82
Q4	-0.25 -0.56,0.07	-0.30+ -0.64,0.04	-0.26 -0.60,0.08	-0.25 -0.59,0.09	-0.02 -0.41,0.37	-0.06 -0.51,0.39	-0.06 -0.51,0.40	-0.06 -0.53,0.42
MEHHP								
Continuous	-0.05 -0.15,0.04	-0.04 -0.16,0.07	-0.03 -0.14,0.09	-0.02 -0.14,0.09	-0.02 -0.14,0.10	-0.00 -0.16,0.16	-0.01 -0.17,0.15	-0.01 -0.17,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.48,0.20	-0.07 -0.43,0.29	-0.06 -0.42,0.29	-0.05 -0.41,0.31	0.40+ -0.07,0.86	0.33 -0.20,0.85	0.33 -0.23,0.88	0.32 -0.22,0.87
Q3	0.01 -0.21,0.22	0.05 -0.18,0.27	0.09 -0.10,0.28	0.10 -0.10,0.30	0.42 -0.14,0.97	0.42+ -0.08,0.92	0.39+ -0.07,0.85	.39+ -0.07,0.85
Q4	-0.21 -0.52,0.11	-0.16 -0.54,0.22	-0.13 -0.51,0.26	-0.11 -0.50,0.28	-0.08 -0.42,0.26	-0.11 -0.58,0.36	-0.13 -0.61,0.36	-0.14 -0.66,0.38
MEOHP								
Continuous	-0.06 -0.16,0.05	-0.05 -0.18,0.07	-0.03 -0.16,0.09	-0.03 -0.16,0.10	0.01 -0.12,0.15	0.04 -0.13,0.21	0.03 -0.14,0.20	0.03 -0.15,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.25 -0.56,0.06	-0.17 -0.49,0.14	-0.17 -0.46,0.13	-0.15 -0.45,0.15	0.16 -0.40,0.72	0.21 -0.32,0.74	0.19 -0.35,0.73	0.19 -0.35,0.73
Q3	-0.07 -0.29,0.14	-0.02 -0.27,0.22	0.01 -0.22,0.24	0.01 -0.22,0.25	0.25 -0.21,0.71	0.25 -0.16,0.66	0.23 -0.15,0.62	0.23 -0.15,0.62
Q4	-0.13 -0.43,0.16	-0.08 -0.45,0.30	-0.04 -0.42,0.33	-0.03 -0.40,0.34	-0.03 -0.53,0.47	0.01 -0.63,0.64	-0.01 -0.64,0.62	-0.02 -0.69,0.64
MECPP								
Continuous	-0.06 -0.15,0.03	-0.04 -0.16,0.07	-0.02 -0.14,0.09	-0.02 -0.13,0.10	-0.04 -0.18,0.09	-0.02 -0.20,0.16	-0.03 -0.21,0.14	-0.03 -0.22,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.29* -0.58,-0.00	-0.22 -0.54,0.09	-0.20 -0.50,0.10	-0.19 -0.49,0.10	0.19 -0.31,0.70	0.13 -0.29,0.54	0.13 -0.30,0.55	0.12 -0.30,0.55
Q3	-0.10 -0.28,0.08	-0.03 -0.27,0.21	0.02 -0.22,0.25	0.02 -0.22,0.26	0.09 -0.49,0.67	0.25 -0.30,0.80	0.21 -0.35,0.77	0.21 -0.34,0.77
Q4	-0.13 -0.40,0.13	-0.07 -0.39,0.25	-0.03 -0.36,0.29	-0.02 -0.35,0.31	0.03 -0.56,0.61	0.03 -0.65,0.72	-0.00 -0.62,0.62	-0.00 -0.66,0.66

	Rubella 2009-2010, Female				Rubella 2009-2010, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.06* -0.11,-0.01	-0.08** -0.14,-.03	-0.07* -0.13,-0.01	-0.07* -0.13,-0.01	0.10* 0.01,0.20	0.08+ -0.02,0.17	0.10* 0.00,0.19	0.10* 0.00,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.02 -0.43,0.39	-0.07 -0.48,0.34	-0.06 -0.44,0.32	-0.06 -0.43,0.32	0.17 -0.24,0.57	0.17 -0.17,0.51	0.17 -0.15,0.48	0.17 -0.14,0.48

Q3	-0.21+ -0.43,0.01	-0.27* -0.51,-0.03	-0.26* -0.48,-0.05	-0.26* -0.47,-0.05	0.26 -0.21,0.73	0.23 -0.24,0.71	0.27 -0.22,0.75	0.25 -0.20,0.70
Q4	-0.18+ -0.37,0.01	-0.28* -0.51,-0.05	-0.22+ -0.46,0.02	-0.22+ -0.46,0.02	0.42* 0.04,0.79	0.32+ -0.04,0.68	0.39* 0.03,0.74	0.39* 0.03,0.75
MnBP								
Continuous	-0.01 -0.07,0.06	-0.03 -0.11,0.05	-0.02 -0.09,0.05	-0.02 -0.10,0.05	-0.04 -0.17,0.08	-0.04 -0.17,0.08	-0.04 -0.17,0.10	-0.03 -0.17,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.15 -0.59,0.30	-0.19 -0.64,0.27	-0.16 -0.60,0.27	-0.16 -0.60,0.27	-0.33+ -0.68,0.03	-0.40* -0.77,-.04	-0.40* -0.79,-.02	-0.40* -0.79,-.01
Q3	-0.03 -0.21,0.15	-0.07 -0.28,0.14	-0.01 -0.19,0.18	-0.01 -0.20,0.18	0.03 -0.31,0.37	0.10 -0.25,0.44	0.13 -0.24,0.50	0.14 -0.25,0.52
Q4	0.00 -0.20,0.21	-0.07 -0.32,0.18	-0.05 -0.30,0.21	-0.05 -0.30,0.21	-0.07 -0.35,0.21	-0.02 -0.31,0.28	-0.02 -0.34,0.31	-0.01 -0.35,0.32
MiBP								
Continuous	-0.01 -0.10,0.08	-0.01 -0.10,0.07	0.00 -0.08,0.09	0.00 -0.09,0.09	-0.12 -0.27,0.03	-0.12 -0.27,0.03	-0.10 -0.25,0.05	-0.10 -0.25,0.05
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.13 -0.51,0.25	-0.12 -0.50,0.25	-0.09 -0.46,0.29	-0.09 -0.47,0.29	-0.40+ -0.86,0.07	-0.42+ -0.85,0.01	-0.42* -0.82,-0.01	-0.40+ -0.82,0.02
Q3	-0.18 -0.44,0.09	-0.18 -0.46,0.09	-0.13 -0.43,0.16	-0.14 -0.43,0.15	-0.47* -0.92,-0.01	-0.51* -0.91,-0.11	-0.45* -0.84,-0.06	-0.44* -0.84,-.03
Q4	-0.09 -0.40,0.22	-0.10 -0.40,0.19	-0.04 -0.32,0.24	-0.04 -0.32,0.24	-0.42+ -0.88,0.05	-0.42+ -0.87,0.04	-0.37 -0.85,0.10	-0.37 -0.85,0.12
∑ DBP								
Continuous	-0.06 -0.17,0.05	-0.04 -0.15,0.06	-0.03 -0.13,0.08	-0.03 -0.13,0.08	-0.09 -0.21,0.03	-0.07 -0.22,0.08	-0.06 -0.22,0.09	-0.06 -0.22,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.41,0.24	-0.07 -0.41,0.28	-0.02 -0.35,0.31	-0.02 -0.35,0.31	-0.05 -0.36,0.26	-0.06 -0.39,0.27	-0.03 -0.38,0.32	-0.02 -0.36,0.32
Q3	-0.12 -0.46,0.22	-0.08 -0.40,0.25	-0.02 -0.36,0.32	-0.02 -0.37,0.32	-0.24 -0.62,0.13	-0.24 -0.61,0.14	-0.22 -0.65,0.21	-0.21 -0.65,0.23
Q4	-0.14 -0.42,0.15	-0.08 -0.34,0.17	-0.04 -0.29,0.21	-0.04 -0.29,0.21	-0.25 -0.60,0.11	-0.17 -0.63,0.28	-0.13 -0.62,0.35	-0.12 -0.62,0.37
McPP								
Continuous	-0.03 -0.13,0.07	-0.02 -0.12,0.08	0.00 -0.10,0.11	0.00 -0.10,0.11	-0.09 -0.27,0.08	-0.08 -0.28,0.13	-0.08 -0.29,0.14	-0.08 -0.29,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.27+ -0.55,0.01	-0.29* -0.57,-0.01	-0.27+ -0.55,0.01	-0.27+ -0.55,0.02	-0.01 -0.42,0.40	0.02 -0.42,0.46	0.00 -0.44,0.45	-0.00 -0.45,0.45
Q3	0.02 -0.27,0.31	-0.00 -0.30,0.29	0.01 -0.27,0.29	0.01 -0.27,0.29	0.08 -0.38,0.54	0.05 -0.41,0.51	0.06 -0.44,0.55	0.04 -0.44,0.53
Q4	-0.11 -0.37,0.15	-0.09 -0.37,0.19	-0.03 -0.30,0.24	-0.03 -0.30,0.25	-0.05 -0.48,0.38	0.04 -0.46,0.55	0.04 -0.50,0.58	0.03 -0.50,0.57
MBzP								
Continuous	-0.05 -0.16,0.06	-0.03 -0.14,0.08	-0.02 -0.12,0.09	-0.02 -0.13,0.09	-0.07 -0.18,0.03	-0.04 -0.16,0.08	-0.04 -0.16,0.09	-0.03 -0.17,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.19+ -0.41,0.03	-0.17 -0.41,0.07	-0.13 -0.36,0.11	-0.13 -0.37,0.11	-0.22 -0.56,0.13	-0.24 -0.59,0.10	-0.21 -0.57,0.15	-0.20 -0.56,0.16
Q3	-0.23 -0.50,0.05	-0.19 -0.44,0.07	-0.12 -0.39,0.14	-0.13 -0.40,0.14	-0.18 -0.47,0.11	-0.17 -0.45,0.11	-0.16 -0.45,0.13	-0.15 -0.44,0.15
Q4	-0.08 -0.38,0.23	0.01 -0.30,0.33	0.04 -0.26,0.35	0.04 -0.27,0.35	-0.18 -0.53,0.18	-0.08 -0.48,0.31	-0.06 -0.47,0.34	-0.06 -0.47,0.36
∑ DEHP								
Continuous	-0.07 -0.19,0.04	-0.09 -0.20,0.03	-0.07 -0.18,0.04	-0.07 -0.17,0.04	-0.08 -0.24,0.07	-0.09 -0.25,0.07	-0.09 -0.25,0.08	-0.09 -0.25,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18+ -0.38,0.02	-0.22+ -0.45,0.02	-0.19+ -0.41,0.03	-0.19+ -0.41,0.02	-0.05 -0.41,0.30	-0.03 -0.38,0.33	-0.03 -0.36,0.30	-0.02 -0.36,0.31
Q3	-0.14 -0.39,0.11	-0.19 -0.47,0.09	-0.14 -0.38,0.10	-0.14 -0.38,0.10	-0.27 -0.63,0.09	-0.22 -0.60,0.16	-0.20 -0.58,0.18	-0.20 -0.59,0.20
Q4	-0.27 -0.64,0.11	-0.31 -0.68,0.07	-0.25 -0.62,0.11	-0.25 -0.61,0.11	-0.38 -0.91,0.15	-0.39 -0.92,0.13	-0.40 -0.93,0.14	-0.39 -0.93,0.15
MEHP								
Continuous	-0.06 -0.18,0.06	-0.09 -0.21,0.04	-0.08 -0.20,0.04	-0.08 -0.20,0.04	-0.06 -0.24,0.12	-0.09 -0.26,0.07	-0.08 -0.25,0.08	-0.08 -0.25,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.22* -0.39,-0.04	-0.23** -0.39,-.07	-0.21** -0.34,-.08	-0.21** -0.35,-.07	0.21 -0.12,0.54	0.23 -0.13,0.59	0.25 -0.15,0.66	0.27 -0.13,0.66
Q3	-0.23 -0.58,0.11	-0.24 -0.59,0.11	-0.23 -0.56,0.11	-0.23 -0.57,0.11	-0.07 -0.41,0.27	-0.06 -0.42,0.29	-0.06 -0.41,0.29	-0.05 -0.40,0.29
Q4	-0.15 -0.37,0.08	-0.25* -0.48,-0.02	-0.25* -0.46,-0.03	-0.25* -0.46,-0.03	-0.21 -0.59,0.18	-0.27 -0.65,0.11	-0.24 -0.63,0.16	-0.23 -0.62,0.16
MEHHP								
Continuous	-0.07 -0.19,0.04	-0.09 -0.21,0.03	-0.07 -0.19,0.04	-0.07 -0.18,0.04	-0.09 -0.24,0.06	-0.11 -0.26,0.05	-0.10 -0.26,0.06	-0.10 -0.26,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-0.09 -0.33,0.15	-0.12 -0.39,0.15	-0.11 -0.35,0.13	-0.11 -0.35,0.13	-0.17 -0.45,0.12	-0.18 -0.46,0.11	-0.19 -0.45,0.08	-0.18 -0.44,0.09
Q3	-0.11 -0.34,0.11	-0.17 -0.42,0.08	-0.12 -0.34,0.09	-0.12 -0.34,0.09	-0.16 -0.54,0.22	-0.14 -0.53,0.25	-0.12 -0.49,0.26	-0.11 -0.50,0.28
Q4	-0.31+ -0.68,0.06	-0.35+ -0.71,0.02	-0.30+ -0.65,0.05	-0.30+ -0.64,0.05	-0.42 -0.96,0.13	-0.45+ -0.97,0.08	-0.45+ -0.99,0.09	-0.44 -0.99,0.10
MEOHP								
Continuous	-0.08 -0.20,0.03	-0.09 -0.21,0.02	-0.07 -0.19,0.04	-0.07 -0.18,0.04	-0.09 -0.26,0.07	-0.10 -0.27,0.07	-0.10 -0.27,0.08	-0.10 -0.27,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.35,0.07	-0.20 -0.45,0.05	-0.18 -0.42,0.05	-0.18 -0.42,0.05	-0.11 -0.45,0.23	-0.11 -0.45,0.24	-0.10 -0.43,0.24	-0.08 -0.43,0.27
Q3	-0.15 -0.41,0.12	-0.20 -0.50,0.10	-0.17 -0.43,0.10	-0.17 -0.43,0.10	-0.32+ -0.67,0.03	-0.29 -0.66,0.08	-0.27 -0.63,0.08	-0.27 -0.63,0.09
Q4	-0.27 -0.62,0.09	-0.31+ -0.67,0.06	-0.25 -0.61,0.11	-0.25 -0.61,0.11	-0.32 -0.80,0.16	-0.33 -0.79,0.14	-0.33 -0.80,0.14	-0.32 -0.80,0.16
MECPP								
Continuous	-0.08 -0.19,0.04	-0.09 -0.20,0.03	-0.06 -0.17,0.05	-0.06 -0.17,0.05	-0.08 -0.25,0.09	-0.08 -0.26,0.09	-0.07 -0.25,0.11	-0.07 -0.25,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.10 -0.29,0.09	-0.17 -0.41,0.08	-0.12 -0.35,0.11	-0.12 -0.35,0.11	-0.06 -0.36,0.24	-0.04 -0.35,0.27	-0.04 -0.34,0.27	-0.03 -0.32,0.26
Q3	-0.19 -0.44,0.06	-0.23+ -0.50,0.04	-0.17 -0.41,0.07	-0.17 -0.41,0.07	-0.35* -0.64,-0.06	-0.30+ -0.62,0.02	-0.29+ -0.62,0.04	-0.29+ -0.63,0.06
Q4	-0.25 -0.56,0.06	-0.28+ -0.60,0.03	-0.22 -0.51,0.08	-0.22 -0.50,0.07	-0.33 -0.84,0.19	-0.32 -0.85,0.22	-0.31 -0.84,0.21	-0.31 -0.85,0.23
	Rubella 2009-2010, Adolescents				**Rubella 2009-2010, Adults**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.10+ -0.00,0.21	0.06 -0.06,0.19	0.08 -0.04,0.21	0.08 -0.04,0.21	0.02 -0.03,0.08	0.01 -0.04,0.07	0.02 -0.04,0.07	0.02 -0.04,0.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.16,0.68	0.15 -0.25,0.54	0.19 -0.22,0.60	0.20 -0.21,0.61	0.07 -0.35,0.50	0.08 -0.31,0.48	0.08 -0.30,0.45	0.08 -0.30,0.46
Q3	0.15 -0.21,0.50	-0.07 -0.42,0.27	-0.04 -0.42,0.34	-0.05 -0.43,0.33	0.05 -0.26,0.36	0.06 -0.28,0.39	0.04 -0.29,0.36	0.03 -0.29,0.35
Q4	0.46* 0.11,0.81	0.31 -0.10,0.72	0.40+ -0.01,0.81	0.41* 0.02,0.80	0.15 -0.09,0.39	0.10 -0.15,0.35	0.11 -0.13,0.36	0.11 -0.14,0.36
MnBP								
Continuous	0.00 -0.15,0.16	-0.05 -0.22,0.13	-0.04 -0.21,0.14	-0.03 -0.21,0.14	-0.05 -0.13,0.03	-0.07+ -0.15,0.01	-0.07 -0.15,0.02	-0.07 -0.15,0.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.42,0.46	-0.05 -0.54,0.44	-0.03 -0.54,0.49	-0.04 -0.57,0.48	-0.29 -0.65,0.08	-0.36+ -0.74,0.03	-0.36+ -0.75,0.03	-0.36+ -0.75,0.03
Q3	0.01 -0.48,0.49	-0.12 -0.58,0.34	-0.08 -0.54,0.39	-0.06 -0.54,0.41	0.04 -0.28,0.35	0.04 -0.31,0.38	0.07 -0.26,0.40	0.07 -0.28,0.41
Q4	0.00 -0.42,0.42	-0.10 -0.58,0.37	-0.08 -0.57,0.41	-0.08 -0.57,0.41	-0.07 -0.26,0.13	-0.13 -0.37,0.11	-0.12 -0.38,0.13	-0.12 -0.38,0.13
MiBP								
Continuous	0.03 -0.14,0.20	-0.01 -0.20,0.19	0.00 -0.20,0.21	0.01 -0.19,0.21	-0.08+ -0.17,0.01	-0.11+ -0.22,0.00	-0.09+ -0.21,0.02	-0.10+ -0.21,0.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.30 -0.92,0.31	-0.34 -1.03,0.34	-0.35 -1.02,0.31	-0.35 -0.99,0.30	-0.23 -0.66,0.20	-0.22 -0.62,0.18	-0.20 -0.59,0.19	-0.20 -0.59,0.19
Q3	-0.21 -0.93,0.52	-0.29 -1.06,0.49	-0.26 -1.05,0.53	-0.25 -1.03,0.53	-0.32+ -0.66,0.02	-0.35* -0.66,-0.03	-0.31* -0.61,-0.01	-0.31* -0.61,-.00
Q4	0.00 -0.58,0.59	-0.15 -0.83,0.53	-0.12 -0.82,0.58	-0.10 -0.78,0.58	-0.26+ -0.56,0.05	-0.29 -0.65,0.07	-0.25 -0.61,0.11	-0.25 -0.62,0.11
∑ DBP								
Continuous	-0.01 -0.18,0.16	-0.05 -0.23,0.13	-0.04 -0.23,0.15	-0.03 -0.22,0.15	-0.11* -0.19,-0.03	-0.10* -0.19,-0.00	-0.09+ -0.18,0.00	-0.09+ -0.18,0.00
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.03 -0.47,0.42	-0.20 -0.68,0.28	-0.18 -0.65,0.29	-0.20 -0.68,0.29	-0.06 -0.36,0.24	-0.05 -0.38,0.28	-0.02 -0.37,0.33	-0.02 -0.36,0.32
Q3	0.01 -0.53,0.56	-0.15 -0.70,0.39	-0.12 -0.66,0.43	-0.12 -0.66,0.43	-0.19 -0.50,0.12	-0.16 -0.48,0.16	-0.15 -0.49,0.18	-0.15 -0.49,0.19
Q4	-0.09 -0.60,0.41	-0.25 -0.80,0.30	-0.23 -0.79,0.32	-0.22 -0.77,0.33	-0.27* -0.52,-.02	-0.23 -0.51,0.05	-0.20 -0.50,0.09	-0.20 -0.49,0.09
McPP								
Continuous	-0.00 -0.13,0.12	-0.02 -0.17,0.13	-0.01 -0.16,0.14	-0.01 -0.16,0.14	-0.09+ -0.21,0.02	-0.10 -0.22,0.02	-0.09 -0.21,0.04	-0.09 -0.21,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.22 -0.64,0.20	-0.26 -0.70,0.17	-0.25 -0.70,0.21	-0.25 -0.72,0.22	-0.14 -0.47,0.19	-0.16 -0.48,0.16	-0.14 -0.46,0.18	-0.14 -0.46,0.18
Q3	-0.06 -0.60,0.48	-0.19 -0.78,0.40	-0.17 -0.76,0.43	-0.17 -0.78,0.44	0.09 -0.26,0.45	0.04 -0.31,0.38	0.04 -0.30,0.38	0.03 -0.31,0.38
Q4	0.07 -0.29,0.44	0.01 -0.42,0.43	0.05 -0.40,0.50	0.05 -0.41,0.52	-0.21 -0.57,0.16	-0.20 -0.59,0.19	-0.17 -0.56,0.22	-0.17 -0.57,0.23

MBzP								
Continuous	-0.00 -0.17,0.17	-0.04 -0.22,0.14	-0.03 -0.22,0.15	-0.03 -0.21,0.16	-0.09+ -0.18,0.00	-0.07 -0.17,0.03	-0.07 -0.17,0.03	-0.07 -0.17,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.18 -0.19,0.54	0.06 -0.36,0.49	0.06 -0.36,0.47	0.04 -0.39,0.47	-0.25* -0.50,-.00	-0.24+ -0.50,0.01	-0.21 -0.48,0.05	-0.21 -0.47,0.05
Q3	0.07 -0.33,0.47	-0.11 -0.54,0.31	-0.06 -0.50,0.38	-0.06 -0.51,0.38	-0.20 -0.47,0.08	-0.15 -0.42,0.11	-0.14 -0.41,0.14	-0.14 -0.42,0.14
Q4	0.03 -0.48,0.54	-0.13 -0.66,0.40	-0.12 -0.66,0.43	-0.11 -0.65,0.44	-0.15 -0.39,0.10	-0.06 -0.34,0.21	-0.07 -0.35,0.21	-0.07 -0.35,0.20
∑ DEHP								
Continuous	-0.03 -0.14,0.09	-0.04 -0.16,0.09	-0.03 -0.17,0.11	-0.03 -0.17,0.11	-0.08 -0.22,0.05	-0.11+ -0.24,0.02	-0.10 -0.23,0.03	-0.10 -0.23,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.05 -0.61,0.51	-0.08 -0.72,0.55	-0.06 -0.69,0.57	-0.06 -0.69,0.57	-0.16+ -0.34,0.01	-0.15+ -0.31,0.02	-0.15+ -0.31,0.01	-0.15+ -0.31,0.02
Q3	-0.08 -0.40,0.24	-0.04 -0.34,0.27	-0.02 -0.33,0.29	0.00 -0.31,0.31	-0.26+ -0.56,0.03	-0.33* -0.63,-0.04	-0.30* -0.59,-0.01	-0.30* -0.60,-0.0
Q4	-0.11 -0.47,0.25	-0.14 -0.56,0.27	-0.12 -0.55,0.31	-0.11 -0.56,0.33	-0.39+ -0.83,0.04	-0.47* -0.92,-0.03	-0.45* -0.89,-0.02	-0.44* -0.88,-0.0
MEHP								
Continuous	0.02 -0.10,0.15	0.00 -0.14,0.14	0.00 -0.14,0.15	0.01 -0.13,0.15	-0.06 -0.19,0.07	-0.10+ -0.21,0.02	-0.09 -0.21,0.02	-0.09 -0.21,0.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.19 -0.57,0.20	-0.15 -0.56,0.27	-0.13 -0.55,0.28	-0.14 -0.56,0.29	0.05 -0.19,0.28	0.05 -0.20,0.30	0.08 -0.18,0.33	0.09 -0.16,0.34
Q3	0.12 -0.20,0.45	0.09 -0.23,0.41	0.08 -0.22,0.38	0.07 -0.26,0.40	-0.20 -0.49,0.08	-0.22 -0.51,0.07	-0.21 -0.51,0.09	-0.21 -0.51,0.10
Q4	-0.04 -0.37,0.29	-0.08 -0.41,0.26	-0.08 -0.42,0.27	-0.05 -0.40,0.29	-0.18 -0.44,0.09	-0.28* -0.52,-0.03	-0.26* -0.52,-0.01	-0.26* -0.51,-.01
MEHHP								
Continuous	-0.03 -0.14,0.08	-0.04 -0.16,0.09	-0.03 -0.16,0.10	-0.03 -0.17,0.10	-0.09 -0.23,0.05	-0.12+ -0.25,0.02	-0.11 -0.24,0.02	-0.10 -0.24,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.36,0.52	0.08 -0.40,0.56	0.12 -0.34,0.58	0.11 -0.39,0.60	-0.19+ -0.42,0.04	-0.19+ -0.42,0.04	-0.20+ -0.42,0.03	-0.19+ -0.42,0.04
Q3	0.07 -0.31,0.45	0.09 -0.28,0.46	0.10 -0.25,0.45	0.12 -0.24,0.48	-0.18 -0.50,0.14	-0.26 -0.58,0.06	-0.22 -0.54,0.09	-0.22 -0.54,0.10
Q4	-0.01 -0.31,0.30	-0.01 -0.33,0.31	0.02 -0.31,0.35	0.01 -0.33,0.36	-0.46+ -0.95,0.03	-0.55* -1.01,-0.10	-0.53* -0.98,-0.08	-0.52* -0.98,-.07
MEOHP								
Continuous	-0.03 -0.15,0.09	-0.04 -0.18,0.10	-0.03 -0.18,0.11	-0.03 -0.17,0.11	-0.09 -0.24,0.05	-0.12+ -0.26,0.01	-0.11+ -0.25,0.02	-0.11 -0.25,0.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.03 -0.56,0.63	0.03 -0.66,0.71	0.05 -0.63,0.73	0.05 -0.63,0.73	-0.19 -0.49,0.11	-0.20 -0.49,0.09	-0.20 -0.49,0.08	-0.20 -0.49,0.09
Q3	-0.07 -0.47,0.33	-0.05 -0.46,0.35	-0.04 -0.44,0.35	-0.02 -0.43,0.38	-0.30* -0.55,-.06	-0.38** -0.64,-.12	-0.35* -0.61,-0.09	-0.35* -0.61,-.09
Q4	-0.07 -0.41,0.27	-0.09 -0.45,0.27	-0.07 -0.43,0.30	-0.07 -0.45,0.31	-0.36+ -0.78,0.05	-0.44* -0.83,-0.04	-0.42* -0.81,-0.03	-0.41* -0.81,-.02
MECPP								
Continuous	-0.03 -0.16,0.09	-0.03 -0.17,0.10	-0.03 -0.17,0.12	-0.02 -0.17,0.12	-0.08 -0.22,0.05	-0.11 -0.25,0.03	-0.10 -0.23,0.04	-0.10 -0.23,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.09 -0.56,0.74	0.08 -0.60,0.76	0.11 -0.59,0.81	0.11 -0.59,0.81	-0.14 -0.32,.05	-0.16 -0.37,0.05	-0.15 -0.36,0.05	-0.15 -0.35,0.05
Q3	-0.14 -0.53,0.26	-0.08 -0.47,0.31	-0.06 -0.47,0.35	-0.04 -0.45,0.37	-0.33** -0.57,-.10	-0.39** -0.64,-.14	-0.36** -0.62,-.10	-0.36* -0.62,-.09
Q4	0.01 -0.43,0.45	-0.00 -0.43,0.42	0.02 -0.43,0.47	0.02 -0.44,0.48	-0.37+ -0.81,.07	-0.44* -0.89,-0.00	-0.42+ -0.84,0.01	-0.41+ -0.84,0.02

	Rubella 2009-2010, US-Born				**Rubella 2009-2010, Foreign Born**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.02 -0.08,0.03	-0.03 -0.10,0.03	-0.02 -0.08,0.04	-0.02 -0.08,0.04	0.14 -0.03,0.31	0.07 -0.08,0.21	0.08 -0.05,0.21	0.08 -0.05,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.06 -0.25,0.37	0.05 -0.22,0.32	0.05 -0.20,0.30	0.05 -0.20,0.30	0.30 -0.28,0.89	0.17 -0.32,0.66	0.15 -0.30,0.60	0.14 -0.29,0.57
Q3	-0.01 -0.28,0.26	-0.02 -0.29,0.25	-0.01 -0.26,0.24	-0.01 -0.26,0.23	0.33 -0.19,0.84	0.08 -0.41,0.57	0.05 -0.43,0.54	0.01 -0.49,0.51
Q4	-0.04 -0.25,0.17	-0.11 -0.32,0.10	-0.06 -0.28,0.16	-0.06 -0.28,0.16	0.59+ -0.12,1.29	0.28 -0.37,0.92	0.27 -0.31,0.85	0.29 -0.28,0.85
MnBP								
Continuous	-0.05 -0.11,0.02	-0.04 -0.11,0.02	-0.04 -0.11,0.03	-0.04 -0.11,0.03	0.07 -0.10,0.25	-0.04 -0.16,0.09	-0.02 -0.15,0.11	-0.02 -0.16,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-0.31* -0.60,-0.03	-0.35* -0.64,-0.06	-0.34* -0.64,-0.04	-0.34* -0.63,-0.04	0.23 -0.54,1.01	0.12 -0.60,0.84	0.13 -0.53,0.79	0.10 -0.54,0.75
Q3	-0.04 -0.32,0.24	-0.04 -0.30,0.22	0.00 -0.27,0.27	0.00 -0.27,0.27	0.24 -0.38,0.87	0.07 -0.38,0.52	0.12 -0.35,0.58	0.09 -0.35,0.53
Q4	-0.13 -0.33,0.08	-0.11 -0.31,0.09	-0.11 -0.33,0.12	-0.11 -0.33,0.12	0.47 -0.24,1.17	0.13 -0.46,0.71	0.19 -0.42,0.79	0.16 -0.43,0.76
MiBP								
Continuous	-0.08+ -0.17,0.01	-0.07+ -0.16,0.01	-0.05 -0.14,0.03	-0.06 -0.14,0.03	0.03 -0.10,0.15	-0.05 -0.22,0.13	-0.01 -0.20,0.17	-0.03 -0.21,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.39* -0.76,-0.02	-0.36+ -0.72,0.01	-0.34+ -0.69,0.02	-0.33+ -0.69,0.03	0.29 -0.33,0.91	0.20 -0.31,0.71	0.29 -0.25,0.83	0.27 -0.28,0.83
Q3	-0.34* -0.66,-0.01	-0.34* -0.66,-0.03	-0.29+ -0.60,0.02	-0.29+ -0.60,0.02	-0.24 -0.70,0.23	-0.49* -0.92,-.06	-0.36+ -0.77,0.05	-0.42+ -0.86,0.01
Q4	-0.36* -0.62,-0.09	-0.35* -0.63,-0.06	-0.29* -0.59,-0.00	-0.30* -0.59,-0.00	0.25 -0.36,0.87	0.11 -0.47,0.68	0.22 -0.38,0.83	0.18 -0.41,0.78
∑ DBP								
Continuous	-0.07+ -0.16,0.01	-0.05 -0.13,0.03	-0.04 -0.13,0.05	-0.04 -0.13,0.05	0.10 -0.11,0.30	0.09 -0.07,0.25	0.10 -0.08,0.29	0.09 -0.09,0.27
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.34,0.18	-0.07 -0.34,0.20	-0.02 -0.31,0.26	-0.02 -0.30,0.26	0.03 -0.42,0.49	0.02 -0.48,0.51	-0.03 -0.45,0.39	-0.04 -0.47,0.38
Q3	-0.22+ -0.49,0.04	-0.21 -0.48,0.06	-0.17 -0.47,0.13	-0.17 -0.47,0.13	0.30 -0.14,0.74	0.33* 0.01,0.65	0.29+ -0.03,0.62	0.26 -0.06,0.57
Q4	-0.19 -0.48,0.10	-0.13 -0.43,0.17	-0.09 -0.40,0.22	-0.09 -0.40,0.22	0.28 -0.30,0.86	0.35 -0.27,0.98	0.43 -0.26,1.12	0.40 -0.26,1.06
McPP								
Continuous	-0.04 -0.16,0.08	-0.04 -0.16,0.09	-0.03 -0.15,0.10	-0.03 -0.15,0.10	-0.05 -0.17,0.08	-0.08 -0.22,0.06	-0.02 -0.21,0.16	-0.04 -0.21,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.39,0.16	-0.11 -0.40,0.19	-0.10 -0.40,0.20	-0.10 -0.40,0.20	-0.25 -0.83,0.33	-0.43 -0.96,0.11	-0.33 -0.90,0.24	-0.32 -0.89,0.24
Q3	0.10 -0.28,0.48	0.04 -0.32,0.40	0.05 -0.31,0.41	0.04 -0.32,0.40	-0.21 -0.71,0.29	-0.25 -0.68,0.19	-0.25 -0.68,0.17	-0.28 -0.70,0.14
Q4	-0.05 -0.39,0.28	-0.02 -0.38,0.34	0.01 -0.35,0.37	0.01 -0.35,0.37	-0.01 -0.31,0.29	-0.03 -0.43,0.37	0.11 -0.36,0.58	0.07 -0.39,0.53
MBzP								
Continuous	-0.06 -0.14,0.02	-0.03 -0.11,0.05	-0.02 -0.11,0.06	-0.02 -0.11,0.06	0.17 -0.06,0.40	0.17+ -0.01,0.34	0.15+ -0.03,0.33	0.14 -0.04,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.27* -0.51,-0.02	-0.27* -0.53,-0.02	-0.23+ -0.51,0.04	-0.23+ -0.51,0.04	0.15 -0.46,0.76	0.18 -0.36,0.72	0.14 -0.31,0.58	0.13 -0.31,0.57
Q3	-0.23* -0.43,-0.03	-0.20+ -0.41,0.00	-0.16 -0.38,0.06	-0.16 -0.38,0.06	0.30 -0.38,0.99	0.21 -0.27,0.70	0.15 -0.26,0.56	0.12 -0.30,0.54
Q4	-0.14 -0.38,0.10	-0.05 -0.30,0.19	-0.04 -0.29,0.22	-0.04 -0.29,0.22	0.51 -0.15,1.18	0.63+ -0.02,1.29	0.58+ -0.10,1.25	0.54 -0.12,1.20
∑ DEHP								
Continuous	-0.09+ -0.20,0.01	-0.09 -0.20,0.02	-0.08 -0.19,0.04	-0.08 -0.19,0.04	-0.03 -0.19,0.12	-0.09 -0.26,0.08	-0.06 -0.25,0.13	-0.07 -0.26,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.34,0.09	-0.11 -0.31,0.10	-0.10 -0.29,0.10	-0.09 -0.29,0.10	-0.13 -0.41,0.15	-0.19 -0.47,0.10	-0.14 -0.45,0.18	-0.15 -0.46,0.16
Q3	-0.25+ -0.55,0.04	-0.25+ -0.51,0.00	-0.22+ -0.46,0.02	-0.22+ -0.47,0.03	0.17 -0.31,0.64	0.06 -0.45,0.57	0.10 -0.48,0.68	0.08 -0.49,0.66
Q4	-0.36* -0.70,-0.02	-0.34* -0.67,-0.01	-0.32+ -0.66,0.01	-0.32+ -0.66,0.03	-0.27 -0.67,0.14	-0.57* -0.99,-.16	-0.45+ -0.92,0.02	-0.50* -.97,-.03
MEHP								
Continuous	-0.13* -0.23,-0.03	-0.13* -0.23,-0.03	-0.12* -0.23,-0.02	-0.12* -0.23,-0.01	0.11 -0.09,0.31	0.07 -0.15,0.29	0.08 -0.16,0.31	0.06 -0.16,0.28
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.10 -0.31,0.11	-0.09 -0.31,0.13	-0.06 -0.29,0.17	-0.05 -0.28,0.17	0.49+ -0.08,1.06	0.37 -0.13,0.87	0.37 -0.15,0.90	0.38 -0.13,0.90
Q3	-0.19 -0.42,0.04	-0.19 -0.45,0.06	-0.19 -0.44,0.07	-0.19 -0.45,0.07	-0.07 -0.57,0.43	-0.13 -0.60,0.33	-0.06 -0.58,0.47	-0.09 -0.62,0.44
Q4	-0.36** -0.55,-0.17	-0.39*** -.57,-.21	-0.37*** -.55,-.18	-0.36*** -.55,-.17	0.35 -0.12,0.82	0.13 -0.29,0.54	0.12 -0.32,0.55	0.08 -0.35,0.51
MEHHP								
Continuous	-0.10+ -0.21,0.01	-0.10+ -0.21,0.01	-0.09 -0.20,0.03	-0.09 -0.20,0.03	-0.02 -0.18,0.14	-0.08 -0.26,0.09	-0.06 -0.25,0.13	-0.07 -0.26,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.16 -0.37,0.06	-0.14 -0.35,0.07	-0.14 -0.34,0.07	-0.13 -0.34,0.08	-0.01 -0.39,0.38	-0.04 -0.36,0.28	0.00 -0.37,0.37	-0.01 -0.38,0.36
Q3	-0.19 -0.49,0.11	-0.19 -0.46,0.08	-0.16 -0.41,0.09	-0.16 -0.42,0.10	0.22 -0.20,0.65	0.04 -0.38,0.46	0.11 -0.39,0.61	0.11 -0.39,0.62
Q4	-0.41* -0.75,-0.07	-0.39* -0.73,-.05	-0.37* -0.72,-0.01	-0.36* -0.73,-0.00	-0.21 -0.62,0.20	-0.43* -0.85,-.01	-0.37 -0.84,0.11	-0.43+ -0.92,0.06
MEOHP								

Continuous	-0.10+ -0.21,0.01	-0.10+ -0.22,0.02	-0.09 -0.21,0.03	-0.09 -0.21,0.04	-0.00 -0.17,0.17	-0.07 -0.26,0.12	-0.05 -0.25,0.16	-0.06 -0.26,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.40,0.12	-0.13 -0.39,0.13	-0.13 -0.38,0.13	-0.12 -0.38,0.14	-0.08 -0.48,0.33	-0.14 -0.50,0.21	-0.09 -0.49,0.31	-0.09 -0.49,0.30
Q3	-0.26* -0.51,-0.02	-0.28* -0.49,-0.07	-0.25* -0.45,-0.05	-0.25* -0.46,-0.05	0.09 -0.38,0.56	-0.13 -0.56,0.30	-0.08 -0.57,0.41	-0.08 -0.57,0.42
Q4	-0.33* -0.62,-0.05	-0.31* -0.59,-0.03	-0.29+ -0.58,0.00	-0.28+ -0.58,0.01	-0.15 -0.59,0.30	-0.39+ -0.82,0.05	-0.33 -0.83,0.18	-0.41+ -0.89,0.07
MECPP								
Continuous	-0.09 -0.20,0.03	-0.08 -0.20,0.04	-0.07 -0.19,0.05	-0.06 -0.19,0.06	-0.06 -0.22,0.09	-0.11 -0.29,0.07	-0.07 -0.27,0.13	-0.08 -0.28,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.32,0.08	-0.11 -0.32,0.11	-0.09 -0.29,0.12	-0.08 -0.28,0.12	0.00 -0.34,0.34	-0.08 -0.35,0.19	-0.04 -0.32,0.23	-0.05 -0.32,0.23
Q3	-0.34** -0.57,-0.11	-0.34** -0.54,-.13	-0.30** -0.51,-.10	-0.30** -0.51,-.09	0.11 -0.38,0.60	0.10 -0.38,0.57	0.13 -0.42,0.68	0.11 -0.45,0.66
Q4	-0.30+ -0.63,0.03	-0.28+ -0.61,0.05	-0.25 -0.57,0.07	-0.24 -0.57,0.09	-0.27 -0.67,0.13	-0.57** -0.97,-0.16	-0.44+ -0.90,0.03	-0.48* -0.95,-.00
	Polio virus 1 2009-2010, Female				**Polio virus 1 2009-2010, Male**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.18* -0.31,-0.04	-0.20** -0.31,-.08	-0.18** -0.30,-.05	-0.18** -0.30,-.05	-0.04 -0.27,0.18	-0.02 -0.26,0.22	0.01 -0.22,0.24	0.01 -0.22,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.03 -0.56,0.50	-0.06 -0.67,0.56	-0.05 -0.68,0.58	-0.06 -0.69,0.58	-0.29 -0.86,0.28	-0.21 -0.85,0.42	-0.24 -0.92,0.44	-0.23 -0.91,0.44
Q3	-0.37 -1.00,0.26	-0.45 -1.04,0.14	-0.45 -1.04,0.13	-0.46 -1.03,0.12	-0.12 -0.85,0.61	-0.03 -0.74,0.68	-0.02 -0.75,0.70	-0.08 -0.71,0.55
Q4	-0.78* -1.54,-0.01	-0.92* -1.68,-0.16	-0.85* -1.64,-0.05	-0.84* -1.64,-0.05	-0.17 -1.12,0.79	-0.04 -1.10,1.03	0.09 -0.92,1.10	0.09 -0.93,1.11
MnBP								
Continuous	-0.14 -0.41,0.13	-0.10 -0.37,0.17	-0.07 -0.35,0.20	-0.07 -0.35,0.21	-0.19+ -0.40,0.02	-0.19 -0.42,0.05	-0.20 -0.45,0.05	-0.19 -0.45,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -0.69,0.36	-0.24 -0.78,0.31	-0.15 -0.67,0.38	-0.14 -0.67,0.38	-0.28 -0.94,0.38	-0.19 -0.85,0.47	-0.26 -0.92,0.41	-0.23 -0.93,0.46
Q3	-0.55 -1.30,0.20	-0.48 -1.27,0.31	-0.41 -1.16,0.34	-0.40 -1.17,0.36	-0.07 -0.64,0.50	-0.16 -0.75,0.43	-0.19 -0.82,0.43	-0.16 -0.79,0.46
Q4	-0.43 -1.08,0.22	-0.35 -1.05,0.34	-0.27 -0.98,0.44	-0.27 -0.98,0.44	-0.26 -0.95,0.43	-0.18 -0.93,0.57	-0.23 -1.03,0.56	-0.22 -1.05,0.61
MiBP								
Continuous	-0.19 -0.49,0.12	-0.15 -0.47,0.16	-0.12 -0.43,0.18	-0.12 -0.43,0.19	-0.25 -0.57,0.06	-0.29+ -0.62,0.04	-0.29+ -0.63,0.05	-0.29+ -0.63,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.15 -1.05,0.74	-0.14 -1.01,0.73	-0.05 -0.93,0.82	-0.04 -0.93,0.85	-0.33 -0.91,0.26	-0.26 -0.79,0.28	-0.29 -0.85,0.27	-0.23 -0.79,0.32
Q3	-0.62 -1.67,0.43	-0.60 -1.61,0.42	-0.48 -1.42,0.47	-0.47 -1.43,0.48	-0.75+ -1.61,0.11	-0.69 -1.60,0.23	-0.69 -1.63,0.25	-0.64 -1.57,0.29
Q4	-0.54 -1.49,0.40	-0.51 -1.47,0.45	-0.40 -1.34,0.54	-0.39 -1.34,0.56	-0.50 -1.23,0.23	-0.53 -1.29,0.24	-0.53 -1.32,0.26	-0.50 -1.29,0.29
∑ DBP								
Continuous	-0.07 -0.33,0.18	-0.02 -0.28,0.25	0.02 -0.24,0.29	0.02 -0.24,0.29	-0.12 -0.35,0.11	-0.13 -0.36,0.09	-0.15 -0.39,0.09	-0.15 -0.39,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.26 -1.14,0.63	-0.29 -1.18,0.60	-0.23 -1.03,0.57	-0.22 -1.03,0.59	-0.18 -0.88,0.52	-0.02 -0.70,0.65	-0.04 -0.67,0.59	0.00 -0.61,0.61
Q3	-0.38 -1.01,0.24	-0.30 -0.95,0.35	-0.20 -0.89,0.50	-0.19 -0.90,0.52	0.00 -0.67,0.67	-0.04 -0.69,0.61	-0.13 -0.74,0.48	-0.09 -0.71,0.54
Q4	-0.26 -0.99,0.46	-0.12 -0.90,0.65	-0.03 -0.79,0.74	-0.03 -0.79,0.74	-0.16 -0.70,0.38	-0.12 -0.68,0.44	-0.15 -0.75,0.46	-0.12 -0.74,0.50
McPP								
Continuous	0.00 -0.29,0.30	0.04 -0.24,0.33	0.09 -0.16,0.35	0.09 -0.16,0.34	-0.29* -0.54,-0.05	-0.33* -0.57,-0.08	-0.33* -0.58,-0.08	-0.33* -0.58,-.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.14 -0.73,1.01	0.15 -0.69,1.00	0.19 -0.59,0.97	0.19 -0.58,0.97	-0.41 -1.08,0.26	-0.43 -1.16,0.31	-0.41 -1.14,0.33	-0.42 -1.15,0.30
Q3	-0.10 -1.14,0.94	-0.04 -1.11,1.02	-0.02 -1.04,1.00	-0.02 -1.03,0.99	-0.55+ -1.13,0.03	-0.63* -1.26,-0.00	-0.63* -1.25,-0.02	-0.67* -1.24,-.11
Q4	0.03 -0.83,0.89	0.14 -0.70,0.97	0.24 -0.52,1.00	0.24 -0.52,0.99	-0.70* -1.32,-0.08	-0.80* -1.44,-0.16	-0.80* -1.45,-0.15	-0.80* -1.45,-.16
MBzP								
Continuous	-0.11 -0.35,0.12	-0.06 -0.32,0.20	-0.03 -0.31,0.24	-0.03 -0.31,0.25	-0.05 -0.29,0.18	-0.07 -0.29,0.15	-0.09 -0.32,0.15	-0.08 -0.32,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.16 -0.75,0.42	-0.16 -0.73,0.42	-0.12 -0.66,0.42	-0.11 -0.66,0.43	-0.19 -0.79,0.40	-0.10 -0.71,0.52	-0.12 -0.68,0.43	-0.08 -0.67,0.50

Q3	-0.54+ -1.11,0.03	-0.43 -1.00,0.14	-0.35 -0.96,0.26	-0.34 -0.96,0.28	-0.13 -0.68,0.41	-0.19 -0.64,0.26	-0.26 -0.77,0.25	-0.21 -0.73,0.30
Q4	-0.17 -0.92,0.57	-0.02 -0.87,0.83	0.04 -0.81,0.89	0.05 -0.81,0.90	-0.03 -0.64,0.59	-0.02 -0.65,0.61	-0.11 -0.78,0.56	-0.09 -0.77,0.59
∑ DEHP								
Continuous	-0.07 -0.34,0.20	-0.04 -0.33,0.26	0.01 -0.29,0.31	0.00 -0.29,0.30	-0.29*** -.43,-.16	-0.27** -0.45,-.10	-0.26** -0.44,-.09	-0.26** -.44,-.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.57* -1.13,-0.00	-0.50+ -1.08,0.08	-0.44 -1.05,0.16	-0.45 -1.06,0.16	-0.09 -0.50,0.33	-0.07 -0.51,0.37	-0.06 -0.51,0.39	-0.03 -0.45,0.39
Q3	-0.41 -1.14,0.32	-0.44 -1.22,0.34	-0.34 -1.07,0.38	-0.34 -1.06,0.38	-0.75* -1.34,-0.16	-0.81* -1.43,-0.19	-0.78* -1.40,-0.16	-0.76* -1.38,-.13
Q4	-0.04 -0.73,0.65	0.11 -0.66,0.88	0.20 -0.59,0.99	0.19 -0.59,0.98	-1.06*** -1.56,-.57	-1.03** -1.59,-.46	-1.02** -1.57,-.46	-0.99** -1.56,-.43
MEHP								
Continuous	-0.07 -0.33,0.20	-0.02 -0.32,0.28	0.00 -0.31,0.31	-0.00 -0.31,0.31	-0.31** -0.50,-.12	-0.27* -0.51,-0.04	-0.25* -0.48,-0.03	-0.25* -0.48,-.02
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.34 -1.09,0.40	-0.34 -1.05,0.38	-0.32 -1.02,0.37	-0.33 -1.02,0.36	-0.38+ -0.80,0.05	-0.25 -0.74,0.24	-0.20 -0.70,0.31	-0.16 -0.65,0.34
Q3	-0.40 -1.13,0.32	-0.35 -1.15,0.44	-0.31 -1.09,0.48	-0.30 -1.08,0.47	-0.46+ -0.94,0.02	-0.51* -1.00,-0.03	-0.42 -0.94,0.10	-0.40 -0.95,0.14
Q4	-0.22 -0.89,0.45	-0.21 -0.94,0.52	-0.20 -0.92,0.52	-0.20 -0.92,0.52	-1.09*** -1.56,-0.61	-1.00** -1.53,-.47	-0.94** -1.48,-.40	-0.92** -1.46,-.38
MEHHP								
Continuous	-0.05 -0.30,0.21	-0.01 -0.29,0.26	0.03 -0.25,0.31	0.02 -0.26,0.30	-0.29*** -.43,-.15	-0.27** -0.45,-.10	-0.27** -0.44,-.09	-0.26** -.44,-.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.57+ -1.19,0.04	-0.58+ -1.22,0.06	-0.54 -1.23,0.14	-0.55 -1.24,0.14	0.17 -0.29,0.62	0.26 -0.21,0.72	0.24 -0.21,0.70	0.28 -0.14,0.71
Q3	-0.10 -0.68,0.49	-0.14 -0.75,0.48	-0.06 -0.63,0.52	-0.06 -0.62,0.51	-0.57+ -1.18,0.05	-0.59+ -1.20,0.03	-0.52+ -1.15,0.10	-0.50 -1.12,0.13
Q4	-0.27 -0.96,0.43	-0.17 -0.99,0.65	-0.07 -0.93,0.78	-0.08 -0.94,0.77	-1.03** -1.58,-0.48	-0.97** -1.54,-.40	-0.96** -1.52,-.40	-0.92** -1.49,-.35
MEOHP								
Continuous	-0.09 -0.36,0.19	-0.06 -0.35,0.23	-0.02 -0.32,0.29	-0.02 -0.32,0.28	-0.31*** -.47,-.15	-0.29** -0.50,-.08	-0.28* -0.49,-0.07	-0.28* -0.49,-.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.59* -1.07,-0.10	-0.52* -1.03,-0.02	-0.49+ -1.02,0.04	-0.50+ -1.03,0.04	-0.06 -0.50,0.37	0.01 -0.44,0.45	0.02 -0.42,0.46	0.07 -0.35,0.48
Q3	-0.32 -0.94,0.31	-0.35 -0.99,0.29	-0.28 -0.90,0.33	-0.28 -0.89,0.33	-0.66* -1.27,-0.05	-0.67* -1.30,-0.05	-0.64* -1.27,-0.01	-0.63+ -1.26,0.00
Q4	-0.18 -0.94,0.58	-0.06 -0.89,0.78	0.06 -0.82,0.93	0.05 -0.82,0.92	-1.03** -1.61,-0.45	-0.97** -1.64,-.30	-0.97** -1.62,-.32	-0.94** -1.60,-.28
MECPP								
Continuous	-0.08 -0.37,0.21	-0.04 -0.36,0.29	0.01 -0.32,0.33	0.01 -0.32,0.33	-0.29*** -.42,-.15	-0.27** -0.44,-.09	-0.26** -0.43,-.08	-0.25** -.43,-.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.58* -1.06,-0.10	-0.52+ -1.06,0.02	-0.46+ -0.97,0.05	-0.46+ -0.97,0.04	-0.40+ -0.86,0.07	-0.36 -0.82,0.09	-0.36 -0.80,0.09	-0.33 -0.76,0.09
Q3	-0.31 -1.02,0.40	-0.19 -1.01,0.63	-0.09 -0.83,0.66	-0.09 -0.83,0.65	-0.67* -1.28,-0.06	-0.70* -1.33,-0.07	-0.68* -1.29,-0.06	-0.66* -1.28,-.03
Q4	-0.19 -0.93,0.55	-0.08 -0.88,0.72	0.03 -0.78,0.84	0.02 -0.78,0.81	-1.17*** -1.73,-.62	-1.11** -1.76,-.47	-1.10** -1.73,-.48	-1.08** -1.70,-.46

	Polio virus 1 2009-2010, Adolescent				Polio virus 1 2009-2010, Adult			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.01 -0.23,0.21	-0.08 -0.27,0.11	-0.02 -0.23,0.19	-0.02 -0.23,0.19	-0.10 -0.27,0.07	-0.08 -0.24,0.08	-0.06 -0.22,0.09	-0.07 -0.22,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.24 -1.53,1.06	-0.46 -1.73,0.81	-0.32 -1.56,0.91	-0.33 -1.57,0.91	-0.05 -0.57,0.46	0.01 -0.50,0.52	-0.01 -0.55,0.52	-0.01 -0.55,0.53
Q3	-0.30 -1.47,0.88	-0.63 -1.63,0.38	-0.55 -1.51,0.42	-0.54 -1.50,0.43	-0.08 -0.70,0.55	-0.00 -0.57,0.56	-0.02 -0.60,0.55	-0.03 -0.58,0.52
Q4	-0.09 -0.93,0.76	-0.35 -1.24,0.54	-0.10 -0.97,0.78	-0.10 -0.97,0.76	-0.45 -1.31,0.41	-0.40 -1.25,0.46	-0.32 -1.13,0.49	-0.32 -1.12,0.48
MnBP								
Continuous	0.09 -0.13,0.32	0.08 -0.13,0.29	0.12 -0.11,0.36	0.12 -0.11,0.36	-0.25* -0.47,-0.03	-0.20+ -0.42,0.02	-0.20+ -0.44,0.04	-0.20+ -0.44,0.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.36 -1.04,0.31	-0.63* -1.24,-0.02	-0.58+ -1.20,0.04	-0.57+ -1.20,0.05	-0.15 -0.70,0.40	-0.09 -0.68,0.50	-0.13 -0.70,0.44	-0.13 -0.71,0.44
Q3	-0.00 -0.76,0.76	-0.11 -0.70,0.48	-0.01 -0.60,0.58	-0.02 -0.60,0.57	-0.51+ -1.11,0.09	-0.47 -1.07,0.13	-0.46 -1.11,0.18	-0.46 -1.12,0.19
Q4	0.00 -0.80,0.80	-0.10 -0.87,0.66	-0.02 -0.88,0.84	-0.02 -0.88,0.84	-0.47 -1.12,0.19	-0.30 -0.95,0.36	-0.31 -1.02,0.41	-0.31 -1.04,0.42

MiBP								
Continuous	0.02 -0.23,0.27	-0.04 -0.32,0.25	0.01 -0.32,0.33	0.00 -0.32,0.33	-0.28+ -0.58,0.02	-0.23 -0.54,0.08	-0.22 -0.54,0.10	-0.22 -0.54,0.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.59+ -1.24,0.06	-0.65* -1.28,-0.03	-0.56+ -1.13,0.01	-0.56+ -1.12,0.01	-0.26 -0.90,0.39	-0.20 -0.79,0.38	-0.22 -0.83,0.39	-0.22 -0.83,0.39
Q3	-1.06** -1.80,-0.31	-1.17** -1.96,-.37	-1.04** -1.78,-.29	-1.04* -1.80,-0.28	-0.64+ -1.36,0.09	-0.54 -1.21,0.13	-0.53 -1.25,0.19	-0.53 -1.26,0.21
Q4	-0.17 -0.91,0.57	-0.37 -1.08,0.34	-0.27 -0.99,0.46	-0.28 -1.01,0.45	-0.65+ -1.43,0.12	-0.50 -1.27,0.27	-0.49 -1.29,0.31	-0.49 -1.30,0.32
∑ DBP								
Continuous	0.02 -0.21,0.26	0.03 -0.21,0.27	0.06 -0.19,0.30	0.06 -0.19,0.30	-0.15 -0.39,0.08	-0.10 -0.35,0.15	-0.10 -0.37,0.18	-0.10 -0.37,0.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.29 -1.10,0.53	-0.53 -1.41,0.35	-0.44 -1.24,0.37	-0.42 -1.24,0.39	-0.24 -0.71,0.24	-0.08 -0.53,0.38	-0.07 -0.57,0.42	-0.07 -0.57,0.43
Q3	-0.04 -1.04,0.96	-0.28 -1.26,0.71	-0.18 -1.16,0.80	-0.18 -1.17,0.80	-0.26 -0.81,0.29	-0.14 -0.70,0.41	-0.17 -0.76,0.42	-0.16 -0.77,0.44
Q4	-0.12 -0.82,0.58	-0.13 -0.88,0.63	-0.02 -0.74,0.70	-0.03 -0.75,0.69	-0.29 -0.82,0.25	-0.11 -0.72,0.51	-0.10 -0.79,0.60	-0.09 -0.80,0.62
McPP								
Continuous	0.00 -0.25,0.26	0.06 -0.20,0.33	0.09 -0.20,0.38	0.09 -0.20,0.38	-0.17 -0.41,0.07	-0.16 -0.41,0.08	-0.15 -0.40,0.10	-0.15 -0.40,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.58 -1.52,0.36	-0.59 -1.56,0.38	-0.54 -1.45,0.37	-0.54 -1.45,0.37	0.01 -0.80,0.83	0.03 -0.76,0.82	0.05 -0.72,0.82	0.04 -0.72,0.81
Q3	-0.65 -1.67,0.37	-0.70 -1.69,0.29	-0.55 -1.51,0.41	-0.55 -1.51,0.42	-0.28 -1.19,0.63	-0.28 -1.22,0.66	-0.25 -1.17,0.68	-0.25 -1.16,0.65
Q4	0.02 -0.81,0.84	0.06 -0.84,0.96	0.15 -0.79,1.09	0.15 -0.79,1.09	-0.42 -1.09,0.24	-0.37 -1.02,0.29	-0.33 -0.99,0.33	-0.33 -0.99,0.34
MBzP								
Continuous	0.03 -0.22,0.27	0.01 -0.27,0.28	0.03 -0.24,0.31	0.03 -0.24,0.30	-0.14 -0.36,0.07	-0.08 -0.31,0.16	-0.08 -0.34,0.17	-0.08 -0.34,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.60,0.63	-0.17 -0.87,0.54	-0.17 -0.79,0.44	-0.16 -0.79,0.47	-0.22 -0.79,0.36	-0.07 -0.63,0.48	-0.07 -0.56,0.43	-0.07 -0.57,0.44
Q3	-0.10 -0.86,0.66	-0.39 -1.20,0.41	-0.26 -1.04,0.52	-0.26 -1.04,0.53	-0.44* -0.79,-0.08	-0.31 -0.71,0.08	-0.32 -0.75,0.11	-0.32 -0.76,0.11
Q4	-0.05 -0.85,0.75	-0.14 -1.07,0.79	-0.07 -0.97,0.83	-0.08 -0.98,0.81	-0.07 -0.68,0.54	0.13 -0.56,0.82	0.09 -0.65,0.82	0.09 -0.65,0.83
∑ DEHP								
Continuous	-0.05 -0.32,0.22	-0.05 -0.33,0.22	-0.05 -0.34,0.23	-0.05 -0.34,0.23	-0.20* -0.39,-0.02	-0.17 -0.37,0.04	-0.15 -0.36,0.06	-0.15 -0.36,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.14 -0.57,0.86	0.13 -0.65,0.91	0.22 -0.59,1.03	0.22 -0.59,1.02	-0.43+ -0.87,0.01	-0.36+ -0.79,0.07	-0.34 -0.79,0.10	-0.34 -0.80,0.12
Q3	0.27 -0.43,0.97	0.26 -0.33,0.85	0.33 -0.23,0.89	0.32 -0.23,0.87	-0.88** -1.42,-.34	-0.88** -1.50,-.25	-0.84* -1.47,-0.22	-0.84* -1.48,-.20
Q4	-0.06 -0.91,0.79	-0.06 -0.90,0.79	-0.01 -0.84,0.83	-0.01 -0.85,0.83	-0.63* -1.17,-0.10	-0.45+ -0.95,0.05	-0.42+ -0.92,0.07	-0.42 -0.92,0.09
MEHP								
Continuous	-0.13 -0.44,0.18	-0.11 -0.43,0.22	-0.13 -0.47,0.20	-0.13 -0.47,0.20	-0.19+ -0.38,0.00	-0.13 -0.34,0.08	-0.12 -0.33,0.09	-0.12 -0.34,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.77,0.53	0.01 -0.69,0.72	-0.04 -0.74,0.65	-0.04 -0.74,0.65	-0.45 -1.03,0.14	-0.35 -1.01,0.31	-0.31 -0.96,0.34	-0.30 -0.97,0.36
Q3	-0.08 -0.66,0.50	-0.13 -0.87,0.61	-0.20 -0.88,0.49	-0.18 -0.89,0.53	-0.50+ -1.04,0.04	-0.41 -1.00,0.17	-0.35 -0.92,0.21	-0.35 -0.93,0.22
Q4	-0.53 -1.29,0.23	-0.43 -1.21,0.34	-0.50 -1.29,0.30	-0.52 -1.31,0.27	-0.62** -1.04,-.20	-0.56* -0.98,-0.13	-0.54* -0.98,-0.10	-0.53* -0.98,-.08
MEHHP								
Continuous	-0.07 -0.33,0.20	-0.07 -0.34,0.20	-0.06 -0.34,0.21	-0.06 -0.34,0.21	-0.19* -0.37,-0.00	-0.16 -0.36,0.04	-0.14 -0.35,0.06	-0.14 -0.35,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.24 -0.65,1.12	0.26 -0.55,1.07	0.40 -0.41,1.21	0.41 -0.38,1.20	-0.28 -0.81,0.24	-0.23 -0.74,0.27	-0.25 -0.75,0.24	-0.25 -0.76,0.26
Q3	0.56 -0.15,1.27	0.56+ -0.10,1.23	0.63* 0.04,1.22	0.62* 0.04,1.20	-0.68* -1.30,-0.05	-0.70* -1.39,-0.01	-0.62+ -1.30,0.06	-0.62+ -1.31,0.07
Q4	-0.23 -0.91,0.44	-0.20 -0.84,0.44	-0.14 -0.75,0.47	-0.13 -0.75,0.49	-0.74* -1.42,-0.06	-0.61+ -1.26,0.05	-0.59+ -1.24,0.07	-0.58+ -1.25,0.09
MEOHP								
Continuous	-0.10 -0.40,0.20	-0.09 -0.41,0.22	-0.09 -0.41,0.23	-0.09 -0.41,0.23	-0.22* -0.42,-0.02	-0.19+ -0.41,0.03	-0.17 -0.40,0.05	-0.17 -0.40,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.86,1.02	0.06 -0.77,0.89	0.17 -0.63,0.97	0.17 -0.62,0.97	-0.40* -0.78,-0.03	-0.33+ -0.69,0.02	-0.32+ -0.69,0.05	-0.31 -0.70,0.08
Q3	0.26 -0.34,0.86	0.23 -0.33,0.80	0.29 -0.20,0.78	0.28 -0.20,0.76	-0.74** -1.24,-.24	-0.73* -1.28,-0.18	-0.70* -1.25,-0.14	-0.69* -1.26,-.13

Q4	-0.15 -1.05,0.75	-0.15 -1.01,0.72	-0.11 -0.92,0.71	-0.11 -0.93,0.72	-0.70* -1.32,-0.09	-0.51+ -1.08,0.06	-0.49+ -1.06,0.08	-0.48 -1.07,0.11
MECPP								
Continuous	-0.04 -0.32,0.24	-0.05 -0.34,0.24	-0.05 -0.34,0.25	-0.05 -0.35,0.25	-0.21* -0.41,-0.02	-0.17 -0.39,0.06	-0.15 -0.38,0.07	-0.15 -0.38,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.24 -0.61,1.09	0.17 -0.71,1.04	0.23 -0.70,1.16	0.22 -0.70,1.15	-0.59* -1.03,-0.16	-0.52* -0.97,-0.07	-0.49* -0.93,-0.04	-0.48* -0.94,-.02
Q3	0.65 -0.15,1.45	0.62+ -0.13,1.38	0.67+ -0.05,1.39	0.66+ -0.07,1.39	-0.83* -1.45,-0.21	-0.67+ -1.38,0.03	-0.63+ -1.34,0.07	-0.63+ -1.34,0.09
Q4	0.23 -0.48,0.94	0.23 -0.54,1.00	0.24 -0.51,0.99	0.24 -0.51,0.99	-0.86** -1.41,-.30	-0.70* -1.28,-0.12	-0.66* -1.24,-0.09	-0.66* -1.24,-.07
	Polio virus 1 2009-2010, US-Born				**Polio virus 1 2009-2010, Foreign-Born**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.09 -0.27,0.08	-0.11 -0.27,0.04	-0.08 -0.23,0.07	-0.08 -0.23,0.07	-0.15 -0.40,0.10	-0.05 -0.27,0.18	-0.02 -0.24,0.19	-0.03 -0.24,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -0.63,0.30	-0.13 -0.60,0.33	-0.13 -0.64,0.39	-0.12 -0.64,0.40	-0.12 -1.09,0.85	-0.06 -1.14,1.01	-0.11 -1.18,0.95	-0.11 -1.19,0.97
Q3	-0.27 -0.85,0.31	-0.28 -0.82,0.26	-0.24 -0.78,0.29	-0.25 -0.77,0.27	-0.14 -1.29,1.01	-0.12 -1.06,0.83	-0.09 -0.95,0.77	-0.03 -0.96,0.90
Q4	-0.39 -1.25,0.47	-0.48 -1.30,0.33	-0.34 -1.12,0.45	-0.34 -1.12,0.44	-0.60 -1.90,0.70	-0.07 -1.30,1.16	-0.05 -1.20,1.11	-0.08 -1.26,1.11
MnBP								
Continuous	-0.15 -0.33,0.03	-0.13 -0.31,0.05	-0.12 -0.32,0.09	-0.12 -0.33,0.09	-0.20 -0.68,0.28	-0.18 -0.62,0.26	-0.15 -0.59,0.29	-0.14 -0.59,0.30
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.23 -0.64,0.19	-0.24 -0.69,0.22	-0.25 -0.66,0.16	-0.24 -0.66,0.18	-0.32 -1.21,0.58	-0.04 -0.99,0.91	-0.04 -0.95,0.87	-0.01 -0.94,0.92
Q3	-0.28 -0.74,0.18	-0.28 -0.70,0.14	-0.26 -0.70,0.19	-0.26 -0.72,0.21	-0.58 -1.29,0.14	-0.55 -1.34,0.24	-0.53 -1.31,0.24	-0.51 -1.28,0.27
Q4	-0.32 -0.88,0.23	-0.25 -0.84,0.35	-0.24 -0.90,0.41	-0.24 -0.91,0.43	-0.40 -1.96,1.16	-0.26 -1.57,1.04	-0.17 -1.48,1.15	-0.13 -1.48,1.21
MiBP								
Continuous	-0.21+ -0.46,0.04	-0.21+ -0.43,0.00	-0.19+ -0.42,0.04	-0.19 -0.42,0.04	-0.20 -0.72,0.32	-0.24 -0.73,0.26	-0.19 -0.67,0.29	-0.18 -0.67,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.20 -0.78,0.37	-0.17 -0.70,0.37	-0.16 -0.71,0.39	-0.15 -0.71,0.40	-0.43 -1.30,0.45	-0.37 -1.23,0.50	-0.26 -1.13,0.60	-0.25 -1.12,0.62
Q3	-0.53 -1.22,0.17	-0.50 -1.13,0.13	-0.46 -1.13,0.22	-0.45 -1.13,0.24	-1.75* -3.18,-0.33	-1.59* -3.08,-0.09	-1.51* -2.99,-0.03	-1.48+ -3.04,0.08
Q4	-0.51 -1.17,0.16	-0.50+ -1.08,0.07	-0.45 -1.05,0.14	-0.45 -1.06,0.16	-0.61 -1.76,0.55	-0.53 -1.63,0.56	-0.40 -1.42,0.63	-0.37 -1.44,0.70
∑ DBP								
Continuous	-0.11 -0.31,0.10	-0.09 -0.30,0.12	-0.07 -0.30,0.16	-0.07 -0.31,0.16	-0.20 -0.44,0.05	-0.06 -0.38,0.26	-0.04 -0.37,0.29	-0.02 -0.36,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.05 -0.51,0.41	-0.02 -0.40,0.36	0.02 -0.38,0.41	0.02 -0.38,0.42	-1.01+ -2.18,0.15	-0.66 -1.87,0.55	-0.74 -1.93,0.45	-0.74 -1.93,0.45
Q3	-0.14 -0.56,0.28	-0.14 -0.56,0.28	-0.13 -0.60,0.35	-0.12 -0.61,0.37	-0.61 -1.49,0.27	-0.20 -1.08,0.67	-0.19 -1.02,0.63	-0.12 -0.96,0.71
Q4	-0.21 -0.74,0.32	-0.13 -0.69,0.43	-0.08 -0.72,0.56	-0.07 -0.73,0.59	-0.37 -1.33,0.59	-0.07 -1.22,1.09	0.05 -1.29,1.39	0.09 -1.23,1.41
McPP								
Continuous	-0.13 -0.36,0.10	-0.13 -0.35,0.10	-0.11 -0.34,0.12	-0.10 -0.34,0.13	-0.29 -0.72,0.15	-0.12 -0.58,0.33	-0.04 -0.49,0.40	-0.03 -0.47,0.41
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.91,0.67	-0.07 -0.84,0.69	-0.07 -0.80,0.66	-0.07 -0.80,0.66	-0.06 -1.40,1.27	-0.06 -1.61,1.48	0.04 -1.37,1.45	0.03 -1.39,1.46
Q3	-0.19 -1.04,0.65	-0.19 -1.07,0.69	-0.14 -1.02,0.73	-0.15 -1.01,0.72	-0.86+ -1.76,0.04	-0.67 -1.60,0.26	-0.73 -1.67,0.20	-0.70 -1.69,0.28
Q4	-0.29 -0.99,0.41	-0.25 -0.92,0.43	-0.20 -0.87,0.46	-0.20 -0.87,0.47	-0.67 -1.66,0.33	-0.39 -1.56,0.78	-0.15 -1.31,1.00	-0.12 -1.24,1.00
MBzP								
Continuous	-0.10 -0.27,0.07	-0.08 -0.25,0.10	-0.07 -0.27,0.13	-0.07 -0.27,0.13	-0.14 -0.56,0.29	-0.06 -0.54,0.42	-0.09 -0.57,0.39	-0.07 -0.57,0.44
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.56,0.32	-0.10 -0.58,0.38	-0.08 -0.49,0.34	-0.07 -0.50,0.36	-0.52 -1.57,0.53	-0.32 -1.35,0.70	-0.40 -1.34,0.54	-0.41 -1.36,0.54
Q3	-0.40** -0.68,-0.12	-0.40** -0.69,-.11	-0.38* -0.71,-0.05	-0.37* -0.71,-0.03	-0.28 -1.21,0.65	0.08 -0.93,1.08	-0.01 -0.97,0.96	0.04 -0.90,0.98
Q4	-0.17 -0.63,0.30	-0.06 -0.56,0.43	-0.05 -0.58,0.48	-0.05 -0.60,0.50	-0.05 -1.75,1.66	0.04 -1.90,1.97	-0.03 -1.95,1.88	0.02 -1.94,1.97
∑ DEHP								
Continuous	-0.12 -0.29,0.05	-0.11 -0.30,0.09	-0.08 -0.28,0.11	-0.08 -0.28,0.12	-.48*** -.73,-0.23	-.39** -.67,-0.12	-0.37* -0.66,-0.08	-0.36* -0.65,-0.07

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.28 -0.72,0.16	-0.20 -0.63,0.23	-0.16 -0.63,0.30	-0.15 -0.63,0.33	-0.58 -1.49,0.32	-0.76 -1.71,0.19	-0.74 -1.67,0.19	-0.73 -1.68,0.22
Q3	-0.55* -1.00,-0.10	-0.49+ -0.99,0.01	-0.43+ -0.90,0.04	-0.43+ -0.91,0.06	-0.79+ -1.68,0.11	-1.13** -1.92,-0.33	-1.11* -1.93,-0.29	-1.09* -1.92,-0.27
Q4	-0.36+ -0.77,0.05	-0.31 -0.77,0.15	-0.27 -0.74,0.20	-0.25 -0.74,0.23	-1.62*** -2.43,-0.81	-1.14* -2.03,-0.24	-1.04* -1.91,-0.16	-0.99* -1.87,-0.11
MEHP								
Continuous	-0.09 -0.28,0.10	-0.07 -0.28,0.13	-0.05 -0.26,0.15	-0.05 -0.26,0.16	-.59*** -.75,-0.44	-.50*** -.73,-0.26	-.49** -0.77,-0.21	-.47** -.77,-.18
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.27 -0.87,0.33	-0.19 -0.83,0.45	-0.16 -0.79,0.46	-0.15 -0.79,0.49	-0.90+ -1.88,0.08	-0.87 -1.99,0.24	-0.94+ -2.02,0.15	-0.94+ -2.03,0.15
Q3	-0.38 -0.88,0.12	-0.32 -0.83,0.20	-0.27 -0.74,0.19	-0.27 -0.76,0.21	-0.63 -1.71,0.45	-0.76 -1.83,0.30	-0.71 -1.78,0.35	-0.69 -1.80,0.42
Q4	-0.43* -0.83,-0.03	-0.41+ -0.84,0.02	-0.37+ -0.80,0.06	-0.36 -0.81,0.08	-1.62*** -2.41,-0.83	-1.50** -2.31,-0.69	-1.52** -2.35,-0.68	-1.49** -2.33,-0.65
MEHHP								
Continuous	-0.12 -0.27,0.04	-0.10 -0.28,0.08	-0.08 -0.27,0.11	-0.08 -0.27,0.12	-.46*** -.68,-0.25	-.38** -.64,-0.12	-0.36* -0.64,-0.08	-0.35* -.63,-.07
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.58,0.33	-0.08 -0.54,0.39	-0.07 -0.54,0.41	-0.05 -0.55,0.44	-0.61 -1.67,0.46	-0.70 -1.77,0.38	-0.71 -1.78,0.36	-0.70 -1.78,0.38
Q3	-0.30 -0.69,0.08	-0.27 -0.74,0.21	-0.19 -0.64,0.26	-0.18 -0.64,0.28	-0.52 -1.35,0.31	-0.70+ -1.41,0.01	-0.64+ -1.38,0.09	-0.64+ -1.37,0.10
Q4	-0.50* -0.89,-0.11	-0.48* -0.91,-0.04	-0.44+ -0.89,0.02	-0.42+ -0.89,0.06	-1.78*** -2.62,-0.95	-1.40** -2.36,-0.44	-1.34** -2.28,-0.41	-1.31* -2.27,-0.35
MEOHP								
Continuous	-0.14 -0.32,0.04	-0.13 -0.33,0.08	-0.10 -0.32,0.11	-0.10 -0.32,0.12	-.55*** -.74,-0.35	-.45*** -.64,-0.27	-.44*** -.63,-0.24	-.42*** -.62,-.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.28 -0.63,0.08	-0.19 -0.53,0.15	-0.16 -0.53,0.22	-0.14 -0.53,0.24	-0.54 -1.55,0.47	-0.69 -1.64,0.26	-0.70 -1.66,0.26	-0.70 -1.66,0.25
Q3	-0.42* -0.81,-0.04	-0.37+ -0.79,0.04	-0.33 -0.75,0.08	-0.33 -0.76,0.10	-0.94* -1.88,-0.01	-1.04* -1.83,-0.25	-0.99* -1.80,-0.19	-0.99* -1.79,-0.19
Q4	-0.46* -0.88,-0.03	-0.40+ -0.87,0.07	-0.36 -0.85,0.13	-0.34 -0.85,0.17	-1.58*** -2.41,-0.75	-1.13* -2.02,-0.24	-1.08* -1.95,-0.21	-1.02* -1.93,-0.10
MECPP								
Continuous	-0.12 -0.31,0.06	-0.11 -0.32,0.10	-0.08 -0.29,0.13	-0.08 -0.29,0.14	-.50** -.84,-0.16	-0.39* -.73,-0.06	-0.36* -0.71,-0.01	-0.35+ -0.70,0.01
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.40+ -0.80,0.00	-0.32 -0.72,0.08	-0.27 -0.68,0.13	-0.27 -0.68,0.15	-0.87+ -1.90,0.15	-1.09* -2.02,-0.16	-1.08* -1.99,-0.16	-1.07* -2.00,-0.14
Q3	-0.43 -0.98,0.12	-0.33 -0.94,0.28	-0.27 -0.84,0.30	-0.27 -0.85,0.31	-0.82* -1.51,-0.13	-0.85** -1.46,-0.25	-0.87* -1.51,-0.22	-0.85* -1.50,-0.19
Q4	-0.52* -0.99,-0.04	-0.46+ -0.99,0.06	-0.41 -0.95,0.13	-0.40 -0.94,0.15	-1.69** -2.61,-0.78	-1.18* -2.07,-0.29	-1.03* -1.93,-0.13	-0.99* -1.90,-0.08

	Polio Virus 2 2009-2010, Female				Polio Virus 2 2009-2010, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.06+ -0.13,0.00	-0.06 -0.13,0.01	-0.04 -0.11,0.03	-0.04 -0.11,0.03	-0.06 -0.17,0.04	-0.04 -0.15,0.07	-0.05 -0.16,0.07	-0.05 -0.16,0.06
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18 -0.80,0.43	-0.18 -0.85,0.48	-0.18 -0.85,0.50	-0.17 -0.84,0.49	-0.32+ -0.71,0.06	-0.32 -0.77,0.13	-0.37+ -0.80,0.06	-0.36+ -0.79,0.07
Q3	-0.25 -0.82,0.31	-0.28 -0.82,0.27	-0.26 -0.81,0.29	-0.26 -0.80,0.28	-0.32 -0.96,0.32	-0.26 -0.89,0.37	-0.25 -0.84,0.34	-0.32 -0.81,0.18
Q4	-0.29 -0.69,0.12	-0.29 -0.72,0.13	-0.23 -0.70,0.24	-0.23 -0.69,0.23	-0.38* -0.75,-0.00	-0.29 -0.72,0.14	-0.33 -0.78,0.13	-0.32 -0.78,0.14
MnBP								
Continuous	0.00 -0.15,0.16	0.03 -0.13,0.19	0.05 -0.11,0.21	0.05 -0.12,0.21	0.08 -0.08,0.24	0.05 -0.13,0.23	0.05 -0.14,0.23	0.05 -0.14,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.32,0.84	0.23 -0.34,0.80	0.31 -0.23,0.84	0.31 -0.23,0.85	0.03 -0.38,0.45	0.10 -0.29,0.49	0.07 -0.30,0.44	0.09 -0.29,0.48
Q3	-0.06 -0.62,0.50	-0.02 -0.59,0.55	0.04 -0.55,0.63	0.03 -0.57,0.63	0.28 -0.14,0.71	0.18 -0.32,0.69	0.17 -0.35,0.69	0.21 -0.33,0.74
Q4	0.06 -0.49,0.60	0.09 -0.46,0.65	0.15 -0.38,0.68	0.14 -0.39,0.68	0.32 -0.19,0.83	0.23 -0.38,0.84	0.23 -0.39,0.86	0.25 -0.40,0.89
MiBP								

Continuous	-0.09 -0.29,0.11	-0.09 -0.28,0.11	-0.06 -0.25,0.13	-0.07 -0.26,0.12	0.04 -0.14,0.23	-0.00 -0.22,0.21	0.00 -0.22,0.23	0.01 -0.22,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.19 -0.66,1.03	0.28 -0.53,1.09	0.36 -0.42,1.14	0.36 -0.43,1.14	-0.26 -1.15,0.64	-0.25 -1.09,0.60	-0.15 -1.02,0.71	-0.08 -0.97,0.80
Q3	0.06 -0.60,0.73	0.12 -0.57,0.81	0.19 -0.47,0.86	0.19 -0.47,0.86	0.03 -0.76,0.83	-0.00 -0.88,0.88	0.06 -0.83,0.96	0.13 -0.77,1.03
Q4	-0.09 -0.82,0.63	-0.09 -0.78,0.59	-0.01 -0.67,0.64	-0.02 -0.67,0.64	-0.09 -0.73,0.56	-0.23 -0.90,0.45	-0.16 -0.86,0.55	-0.12 -0.83,0.59
∑ DBP								
Continuous	0.06 -0.15,0.26	0.08 -0.14,0.31	0.11 -0.11,0.34	0.11 -0.12,0.34	0.12+ -0.02,0.26	0.09 -0.07,0.25	0.08 -0.08,0.23	0.08 -0.08,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.29 -0.32,0.89	0.26 -0.39,0.91	0.31 -0.30,0.93	0.31 -0.30,0.92	-0.51 -1.20,0.17	-0.41 -1.10,0.28	-0.41 -1.08,0.26	-0.37 -1.03,0.29
Q3	0.03 -0.59,0.65	0.11 -0.52,0.74	0.20 -0.44,0.84	0.19 -0.45,0.84	-0.02 -0.71,0.67	0.00 -0.64,0.65	-0.05 -0.64,0.54	0.00 -0.63,0.63
Q4	0.24 -0.30,0.79	0.28 -0.33,0.89	0.36 -0.24,0.95	0.36 -0.24,0.95	0.16 -0.23,0.56	0.10 -0.38,0.58	0.09 -0.39,0.57	0.12 -0.37,0.61
McPP								
Continuous	0.10 -0.11,0.30	0.06 -0.15,0.27	0.09 -0.11,0.29	0.10 -0.11,0.30	-0.07 -0.28,0.13	-0.14 -0.36,0.08	-0.15 -0.37,0.07	-0.15 -0.37,0.08
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.18 -0.56,0.93	0.19 -0.57,0.95	0.20 -0.56,0.97	0.20 -0.56,0.97	-0.43 -1.08,0.21	-0.60+ -1.28,0.09	-0.61+ -1.27,0.05	-0.62+ -1.29,0.04
Q3	0.06 -0.63,0.75	-0.05 -0.69,0.60	-0.04 -0.66,0.57	-0.04 -0.66,0.58	-0.29 -0.96,0.38	-0.52 -1.23,0.19	-0.60+ -1.31,0.11	-0.65+ -1.31,0.02
Q4	0.24 -0.27,0.76	0.19 -0.32,0.69	0.24 -0.24,0.73	0.25 -0.25,0.75	-0.31 -0.86,0.24	-0.53 -1.19,0.13	-0.54 -1.21,0.12	-0.55+ -1.21,0.11
MBzP								
Continuous	0.04 -0.14,0.22	0.08 -0.12,0.28	0.11 -0.09,0.31	0.10 -0.10,0.31	0.18* 0.03,0.34	0.16+ -0.00,0.33	0.15+ -0.01,0.30	0.15+ -0.00,0.31
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.38 -0.08,0.84	0.38 -0.12,0.88	0.43+ -0.04,0.90	0.43+ -0.04,0.89	-0.05 -0.78,0.68	0.05 -0.74,0.84	0.06 -0.73,0.85	0.10 -0.71,0.91
Q3	0.06 -0.55,0.66	0.17 -0.44,0.78	0.25 -0.37,0.87	0.25 -0.37,0.87	0.03 -0.49,0.55	0.09 -0.44,0.62	0.09 -0.44,0.61	0.14 -0.41,0.70
Q4	0.39 -0.10,0.88	0.47+ -0.05,1.00	0.53* 0.01,1.05	0.52+ -0.00,1.05	0.58* 0.09,1.07	0.57+ -0.01,1.15	0.52+ -0.04,1.08	0.55+ -0.02,1.12
∑ DEHP								
Continuous	-0.05 -0.20,0.10	-0.04 -0.19,0.11	-0.01 -0.17,0.14	-0.01 -0.17,0.14	0.01 -0.13,0.14	-0.00 -0.13,0.12	-0.01 -0.13,0.12	-0.00 -0.13,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.04 -0.54,0.45	0.00 -0.49,0.49	0.04 -0.45,0.54	0.05 -0.46,0.55	-0.14 -0.59,0.30	-0.14 -0.57,0.29	-0.22 -0.64,0.20	-0.18 -0.61,0.24
Q3	-0.24 -0.70,0.22	-0.24 -0.73,0.26	-0.17 -0.63,0.28	-0.18 -0.63,0.28	-0.06 -0.64,0.52	-0.15 -0.73,0.44	-0.16 -0.73,0.41	-0.13 -0.71,0.45
Q4	-0.39* -0.77,-0.01	-0.37+ -0.78,0.03	-0.31 -0.73,0.12	-0.30 -0.72,0.12	0.02 -0.53,0.57	-0.04 -0.61,0.52	-0.06 -0.62,0.50	-0.03 -0.60,0.54
MEHP								
Continuous	-0.20 -0.44,0.04	-0.16 -0.40,0.08	-0.14 -0.39,0.10	-0.14 -0.39,0.11	-0.04 -0.23,0.15	-0.01 -0.20,0.18	0.00 -0.20,0.20	0.01 -0.20,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.33 -0.12,0.78	0.31 -0.09,0.71	0.32+ -0.05,0.70	0.33+ -0.06,0.71	-0.26 -0.69,0.17	-0.21 -0.71,0.29	-0.19 -0.67,0.29	-0.14 -0.64,0.35
Q3	-0.09 -0.69,0.51	-0.07 -0.66,0.52	-0.03 -0.59,0.53	-0.03 -0.59,0.52	-0.03 -0.49,0.42	-0.02 -0.56,0.51	-0.01 -0.57,0.56	0.02 -0.57,0.61
Q4	-0.44+ -0.95,0.07	-0.43+ -0.95,0.09	-0.42 -0.97,0.12	-0.42 -0.97,0.12	-0.22 -0.70,0.27	-0.15 -0.64,0.35	-0.10 -0.64,0.44	-0.07 -0.60,0.46
MEHHP								
Continuous	-0.08 -0.21,0.06	-0.06 -0.19,0.07	-0.03 -0.17,0.11	-0.03 -0.17,0.11	-0.00 -0.14,0.14	-0.01 -0.15,0.12	-0.02 -0.15,0.12	-0.01 -0.15,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.07 -0.51,0.37	-0.06 -0.50,0.38	-0.03 -0.48,0.41	-0.03 -0.48,0.42	0.10 -0.40,0.60	0.10 -0.38,0.59	0.06 -0.42,0.55	0.11 -0.37,0.59
Q3	-0.17 -0.54,0.21	-0.19 -0.65,0.26	-0.14 -0.56,0.29	-0.14 -0.57,0.29	0.16 -0.37,0.68	0.09 -0.42,0.59	0.04 -0.50,0.57	0.07 -0.47,0.61
Q4	-0.43+ -0.87,0.01	-0.42+ -0.86,0.02	-0.36 -0.82,0.10	-0.35 -0.81,0.11	0.08 -0.43,0.59	0.03 -0.47,0.53	0.01 -0.50,0.53	0.06 -0.46,0.57
MEOHP								
Continuous	-0.10 -0.25,0.05	-0.09 -0.23,0.06	-0.06 -0.21,0.10	-0.06 -0.21,0.10	-0.00 -0.15,0.15	-0.02 -0.17,0.12	-0.02 -0.16,0.12	-0.02 -0.16,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.09 -0.44,0.62	0.17 -0.35,0.70	0.20 -0.33,0.73	0.20 -0.33,0.74	0.02 -0.52,0.57	0.07 -0.45,0.59	0.00 -0.52,0.52	0.05 -0.46,0.57
Q3	-0.20 -0.56,0.15	-0.23 -0.67,0.20	-0.19 -0.59,0.20	-0.19 -0.59,0.21	0.19 -0.26,0.63	0.15 -0.22,0.51	0.13 -0.24,0.51	0.15 -0.23,0.53
Q4	-0.31 -0.83,0.20	-0.28 -0.81,0.25	-0.21 -0.77,0.35	-0.20 -0.77,0.36	0.10 -0.44,0.64	0.04 -0.51,0.59	0.03 -0.52,0.58	0.07 -0.48,0.63

MECPP								
Continuous	-0.03 -0.19,0.14	-0.02 -0.19,0.15	0.01 -0.17,0.18	0.01 -0.17,0.19	0.02 -0.13,0.17	0.00 -0.13,0.13	0.00 -0.13,0.13	0.01 -0.12,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.43,0.27	-0.06 -0.45,0.34	-0.03 -0.43,0.38	-0.03 -0.43,0.38	0.06 -0.50,0.62	0.02 -0.55,0.60	-0.05 -0.63,0.53	-0.01 -0.57,0.54
Q3	-0.16 -0.69,0.37	-0.12 -0.68,0.45	-0.05 -0.58,0.47	-0.06 -0.58,0.47	0.05 -0.47,0.58	-0.03 -0.56,0.49	-0.05 -0.57,0.48	-0.02 -0.54,0.50
Q4	-0.23 -0.69,0.24	-0.26 -0.74,0.22	-0.19 -0.70,0.31	-0.19 -0.69,0.31	0.11 -0.44,0.65	0.03 -0.53,0.59	0.02 -0.54,0.57	0.05 -0.50,0.60
	Polio Virus 2 2009-2010, Adolescent				Polio Virus 2 2009-2010, Adult			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.15+ -0.32,0.02	-0.17+ -0.34,0.00	-0.14 -0.34,0.06	-0.14 -0.34,0.06	-0.03 -0.12,0.07	-0.01 -0.13,0.10	-0.01 -0.13,0.10	-0.02 -0.12,0.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.20 -1.15,0.76	-0.36 -1.35,0.62	-0.29 -1.29,0.70	-0.30 -1.29,0.69	-0.30 -0.83,0.23	-0.31 -0.82,0.21	-0.34 -0.84,0.16	-0.33 -0.82,0.16
Q3	-0.40 -1.33,0.54	-0.51 -1.43,0.41	-0.46 -1.37,0.45	-0.45 -1.37,0.46	-0.16 -0.68,0.36	-0.13 -0.63,0.38	-0.13 -0.63,0.38	-0.14 -0.62,0.34
Q4	-0.43 -1.19,0.34	-0.52 -1.38,0.34	-0.39 -1.35,0.57	-0.40 -1.35,0.56	-0.25 -0.74,0.23	-0.21 -0.79,0.36	-0.22 -0.81,0.37	-0.23 -0.80,0.34
MnBP								
Continuous	-0.03 -0.29,0.23	-0.04 -0.30,0.22	-0.03 -0.28,0.23	-0.03 -0.28,0.22	-0.01 -0.13,0.12	0.03 -0.10,0.16	0.04 -0.08,0.16	0.04 -0.09,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.55,0.59	-0.22 -0.86,0.41	-0.22 -0.87,0.43	-0.21 -0.87,0.45	0.16 -0.28,0.59	0.23 -0.21,0.67	0.23 -0.20,0.66	0.23 -0.20,0.66
Q3	-0.32 -1.19,0.56	-0.43 -1.34,0.48	-0.41 -1.30,0.47	-0.42 -1.30,0.46	0.09 -0.37,0.55	0.16 -0.25,0.58	0.18 -0.28,0.63	0.18 -0.30,0.65
Q4	-0.00 -0.81,0.81	-0.04 -0.95,0.87	-0.01 -0.90,0.87	-0.01 -0.89,0.86	0.07 -0.43,0.58	0.14 -0.33,0.62	0.16 -0.30,0.63	0.16 -0.30,0.62
MiBP								
Continuous	-0.08 -0.34,0.17	-0.16 -0.48,0.15	-0.16 -0.48,0.15	-0.17 -0.47,0.14	-0.05 -0.25,0.16	0.01 -0.20,0.21	0.02 -0.19,0.23	0.02 -0.20,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.05* -1.87,-0.22	-1.06* -1.85,-0.27	-0.97* -1.77,-0.17	-0.97* -1.77,-0.17	0.00 -0.65,0.66	0.08 -0.52,0.67	0.13 -0.47,0.73	0.14 -0.45,0.72
Q3	-0.91* -1.75,-0.07	-0.97* -1.86,-0.07	-0.90+ -1.83,0.03	-0.90+ -1.83,0.03	0.14 -0.21,0.49	0.23 -0.07,0.53	0.29+ -0.06,0.64	0.30+ -0.04,0.64
Q4	-0.62+ -1.36,0.11	-0.85* -1.67,-0.04	-0.82* -1.63,-0.00	-0.83* -1.62,-0.04	-0.14 -0.76,0.47	-0.02 -0.62,0.59	0.04 -0.60,0.67	0.03 -0.60,0.66
∑ DBP								
Continuous	-0.01 -0.29,0.26	0.05 -0.23,0.32	0.06 -0.20,0.32	0.05 -0.20,0.31	0.05 -0.10,0.20	0.10 -0.06,0.26	0.10 -0.05,0.25	0.10 -0.05,0.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.33 -1.34,0.67	-0.34 -1.46,0.79	-0.27 -1.36,0.81	-0.26 -1.36,0.83	-0.07 -0.58,0.44	0.05 -0.48,0.57	0.06 -0.47,0.59	0.06 -0.47,0.60
Q3	-0.22 -1.17,0.73	-0.24 -1.23,0.75	-0.19 -1.17,0.79	-0.19 -1.17,0.79	0.04 -0.47,0.55	0.18 -0.29,0.66	0.19 -0.28,0.66	0.19 -0.29,0.68
Q4	-0.20 -1.11,0.70	-0.05 -1.02,0.91	-0.01 -0.94,0.92	-0.02 -0.94,0.91	0.16 -0.23,0.55	0.30 -0.13,0.73	0.33 -0.09,0.74	0.34+ -0.07,0.75
McPP								
Continuous	-0.11 -0.39,0.16	-0.06 -0.35,0.23	-0.05 -0.34,0.25	-0.05 -0.34,0.25	0.00 -0.13,0.13	-0.02 -0.17,0.13	-0.01 -0.16,0.14	-0.01 -0.16,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.55 -1.28,0.17	-0.56 -1.35,0.22	-0.56 -1.31,0.19	-0.56 -1.31,0.20	-0.06 -0.73,0.61	-0.09 -0.76,0.59	-0.10 -0.77,0.58	-0.10 -0.78,0.57
Q3	-0.91** -1.51,-0.31	-1.15** -1.89,-.40	-1.08** -1.83,-.34	-1.08** -1.84,-.33	-0.09 -0.63,0.45	-0.12 -0.69,0.44	-0.17 -0.77,0.44	-0.18 -0.78,0.41
Q4	-0.38 -1.05,0.30	-0.31 -1.12,0.51	-0.27 -1.05,0.51	-0.27 -1.06,0.51	-0.06 -0.45,0.34	-0.08 -0.50,0.34	-0.07 -0.52,0.37	-0.07 -0.53,0.40
MBzP								
Continuous	0.04 -0.27,0.35	0.08 -0.24,0.41	0.09 -0.22,0.40	0.09 -0.22,0.39	0.06 -0.12,0.25	0.14 -0.05,0.34	0.14 -0.04,0.33	0.14 -0.05,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.20 -1.17,0.77	-0.24 -1.27,0.78	-0.24 -1.21,0.72	-0.23 -1.21,0.74	0.18 -0.29,0.65	0.30 -0.16,0.76	0.31 -0.14,0.77	0.32 -0.14,0.77
Q3	-0.10 -1.07,0.87	-0.15 -1.27,0.98	-0.09 -1.22,1.03	-0.09 -1.22,1.04	0.00 -0.56,0.57	0.16 -0.39,0.72	0.19 -0.38,0.75	0.19 -0.38,0.76
Q4	-0.09 -1.18,1.01	-0.01 -1.24,1.22	0.01 -1.17,1.19	0.00 -1.17,1.18	0.52* 0.00,1.03	0.73* 0.18,1.28	0.72** 0.20,1.24	0.72** 0.20,1.24
∑ DEHP								
Continuous	-0.07 -0.35,0.22	-0.05 -0.32,0.23	-0.04 -0.32,0.23	-0.05 -0.32,0.23	-0.05 -0.20,0.10	-0.02 -0.16,0.13	-0.01 -0.16,0.14	-0.01 -0.15,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference

Q2	-0.00 -0.75,0.75	-0.05 -0.77,0.67	-0.04 -0.73,0.66	-0.04 -0.73,0.66	-0.12 -0.72,0.48	-0.03 -0.62,0.57	-0.05 -0.62,0.53	-0.03 -0.61,0.55
Q3	-0.14 -1.26,0.98	-0.01 -1.04,1.02	0.02 -1.00,1.04	0.01 -1.01,1.03	-0.29 -0.86,0.28	-0.22 -0.81,0.36	-0.21 -0.78,0.36	-0.20 -0.78,0.38
Q4	-0.25 -0.97,0.46	-0.18 -0.88,0.51	-0.16 -0.85,0.52	-0.17 -0.86,0.53	-0.28 -0.80,0.23	-0.18 -0.72,0.35	-0.18 -0.71,0.35	-0.15 -0.69,0.38
MEHP								
Continuous	-0.23 -0.59,0.13	-0.20 -0.53,0.14	-0.20 -0.54,0.14	-0.21 -0.55,0.14	-0.10 -0.30,0.10	-0.03 -0.22,0.17	-0.02 -0.22,0.19	-0.01 -0.22,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.36 -1.07,0.36	-0.18 -0.95,0.60	-0.22 -0.99,0.55	-0.22 -0.99,0.55	0.01 -0.40,0.42	0.09 -0.32,0.51	0.12 -0.29,0.53	0.14 -0.29,0.57
Q3	-0.74+ -1.64,0.15	-0.77 -1.76,0.21	-0.79 -1.79,0.20	-0.78 -1.81,0.24	-0.07 -0.53,0.38	0.08 -0.34,0.50	0.11 -0.33,0.55	0.11 -0.35,0.56
Q4	-0.80+ -1.68,0.08	-0.68+ -1.44,0.08	-.69+ -1.46,0.07	-0.71+ -1.47,0.05	-0.27 -0.71,0.17	-0.11 -0.56,0.34	-0.08 -0.57,0.41	-0.07 -0.55,0.41
MEHHP								
Continuous	-0.08 -0.36,0.20	-0.05 -0.32,0.22	-0.05 -0.33,0.23	-0.05 -0.33,0.23	-0.07 -0.21,0.08	-0.04 -0.17,0.10	-0.03 -0.17,0.11	-0.03 -0.16,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.00 -0.79,0.79	-0.07 -0.78,0.64	-0.03 -0.71,0.64	-0.02 -0.70,0.65	-0.04 -0.59,0.51	0.06 -0.49,0.60	0.04 -0.50,0.58	0.05 -0.48,0.59
Q3	0.15 -0.82,1.13	0.28 -0.60,1.15	0.31 -0.55,1.16	0.30 -0.55,1.15	-0.23 -0.73,0.28	-0.21 -0.76,0.35	-0.21 -0.75,0.33	-0.20 -0.74,0.34
Q4	-0.39 -1.25,0.47	-0.32 -1.14,0.50	-0.29 -1.11,0.53	-0.28 -1.11,0.54	-0.22 -0.77,0.33	-0.09 -0.62,0.44	-0.09 -0.63,0.45	-0.07 -0.61,0.47
MEOHP								
Continuous	-0.10 -0.40,0.20	-0.07 -0.36,0.22	-0.07 -0.36,0.22	-0.07 -0.36,0.22	-0.08 -0.24,0.08	-0.05 -0.21,0.10	-0.05 -0.20,0.10	-0.05 -0.20,0.11
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.22 -0.68,1.12	0.12 -0.67,0.91	0.16 -0.61,0.94	0.17 -0.61,0.94	0.00 -0.62,0.62	0.13 -0.44,0.71	0.11 -0.45,0.67	0.13 -0.44,0.70
Q3	0.08 -0.87,1.02	0.20 -0.63,1.02	0.24 -0.57,1.04	0.22 -0.58,1.02	-0.19 -0.69,0.31	-0.15 -0.65,0.36	-0.14 -0.64,0.36	-0.13 -0.64,0.38
Q4	-0.24 -1.28,0.80	-0.18 -1.20,0.84	-0.16 -1.16,0.84	-0.16 -1.16,0.85	-0.18 -0.72,0.36	-0.04 -0.58,0.49	-0.03 -0.58,0.51	-0.02 -0.57,0.54
MECPP								
Continuous	-0.05 -0.34,0.24	-0.04 -0.32,0.25	-0.04 -0.32,0.25	-0.04 -0.32,0.24	-0.04 -0.20,0.12	0.00 -0.16,0.16	0.01 -0.15,0.17	0.01 -0.15,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.95,1.00	-0.12 -1.01,0.77	-0.15 -1.05,0.74	-0.16 -1.05,0.74	-0.07 -0.58,0.45	0.01 -0.53,0.54	-0.02 -0.54,0.50	-0.00 -0.52,0.51
Q3	-0.02 -1.01,0.97	0.08 -0.82,0.98	0.08 -0.81,0.97	0.07 -0.82,0.97	-0.23 -0.81,0.34	-0.10 -0.68,0.48	-0.10 -0.67,0.48	-0.09 -0.66,0.49
Q4	0.01 -1.06,1.07	0.00 -1.04,1.04	-0.02 -1.05,1.01	-0.02 -1.05,1.01	-0.22 -0.73,0.29	-0.16 -0.71,0.39	-0.15 -0.70,0.40	-0.12 -0.67,0.42
	Polio Virus 2 2009-2010, US-Born				Polio Virus 2 2009-2010, Foreign-Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.04 -0.11,0.03	-0.05 -0.13,0.03	-0.04 -0.13,0.05	-0.05 -0.13,0.04	-0.07 -0.26,0.12	0.01 -0.14,0.16	0.04 -0.09,0.17	0.03 -0.10,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.27 -0.67,0.13	-0.28 -0.69,0.13	-0.30 -0.73,0.13	-0.29 -0.72,0.14	-0.20 -1.64,1.23	-0.27 -1.47,0.92	-0.33 -1.42,0.76	-0.33 -1.42,0.76
Q3	-0.28 -0.76,0.19	-0.30 -0.76,0.16	-0.28 -0.76,0.20	-0.28 -0.74,0.18	-0.27 -1.18,0.63	-0.37 -1.25,0.51	-0.39 -1.32,0.55	-0.36 -1.33,0.61
Q4	-0.26 -0.64,0.11	-0.31 -0.72,0.11	-0.28 -0.75,0.19	-0.29 -0.74,0.16	-0.31 -1.27,0.64	0.12 -0.56,0.80	0.13 -0.49,0.75	0.12 -0.51,0.74
MnBP								
Continuous	0.02 -0.05,0.09	0.01 -0.05,0.08	0.02 -0.04,0.08	0.02 -0.04,0.08	0.16 -0.21,0.53	0.15 -0.17,0.47	0.19 -0.14,0.52	0.20 -0.14,0.53
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -0.25,0.26	0.00 -0.26,0.26	0.01 -0.23,0.24	0.01 -0.22,0.25	0.73 -0.76,2.21	1.01 -0.53,2.54	1.01 -0.43,2.44	1.04 -0.42,2.50
Q3	0.14 -0.22,0.49	0.10 -0.22,0.42	0.12 -0.23,0.46	0.12 -0.24,0.47	-0.15 -1.25,0.96	-0.08 -1.14,0.97	-0.08 -1.14,0.98	-0.05 -1.10,1.00
Q4	0.08 -0.24,0.41	0.05 -0.28,0.37	0.06 -0.25,0.37	0.06 -0.26,0.37	0.79 -0.47,2.05	0.81 -0.29,1.92	0.94 -0.22,2.10	0.97 -0.22,2.17
MiBP								
Continuous	-0.04 -0.21,0.13	-0.07 -0.21,0.08	-0.05 -0.19,0.08	-0.06 -0.19,0.08	0.10 -0.28,0.49	0.03 -0.32,0.39	0.09 -0.27,0.45	0.11 -0.25,0.47
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.05 -0.51,0.61	0.09 -0.44,0.61	0.15 -0.37,0.67	0.16 -0.34,0.66	-0.39 -1.67,0.88	-0.44 -1.46,0.59	-0.30 -1.40,0.80	-0.28 -1.36,0.79
Q3	0.20 -0.18,0.58	0.20 -0.20,0.60	0.26 -0.17,0.70	0.28 -0.13,0.69	-0.98 -2.19,0.22	-0.83+ -1.78,0.13	-0.72 -1.74,0.29	-0.69 -1.69,0.31
Q4	-0.08 -0.61,0.44	-0.16 -0.56,0.23	-0.10 -0.50,0.29	-0.11 -0.49,0.28	-0.04 -1.39,1.32	-0.23 -1.43,0.96	-0.05 -1.24,1.14	-0.02 -1.19,1.15

∑ DBP								
Continuous	0.06 -0.04,0.16	0.07 -0.03,0.17	0.07+ -0.01,0.16	0.07 -0.02,0.16	-0.00 -0.46,0.46	0.10 -0.36,0.55	0.12 -0.34,0.58	0.14 -0.35,0.62
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.50,0.55	0.04 -0.51,0.58	0.06 -0.47,0.60	0.07 -0.47,0.62	-0.71 -1.65,0.22	-0.39 -1.43,0.65	-0.50 -1.50,0.50	-0.50 -1.50,0.50
Q3	-0.00 -0.42,0.42	0.03 -0.41,0.47	0.04 -0.38,0.46	0.05 -0.38,0.48	-0.25 -1.24,0.74	0.35 -0.66,1.36	0.36 -0.62,1.34	0.43 -0.62,1.49
Q4	0.15 -0.17,0.46	0.16 -0.17,0.49	0.19 -0.12,0.50	0.20 -0.12,0.52	0.09 -1.33,1.51	0.22 -1.26,1.69	0.35 -1.19,1.89	0.39 -1.20,1.99
McPP								
Continuous	0.01 -0.12,0.14	-0.00 -0.13,0.13	0.00 -0.13,0.13	0.01 -0.13,0.14	-0.18 -0.42,0.07	-0.22 -0.52,0.07	-0.14 -0.36,0.09	-0.13 -0.38,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.09 -0.68,0.50	-0.11 -0.71,0.50	-0.12 -0.72,0.47	-0.13 -0.73,0.47	-0.22 -1.45,1.02	-0.22 -1.65,1.22	-0.12 -1.37,1.14	-0.12 -1.38,1.14
Q3	0.03 -0.47,0.53	-0.08 -0.62,0.45	-0.11 -0.67,0.45	-0.12 -0.68,0.43	-0.89+ -1.82,0.05	-0.83 -1.94,0.28	-0.89 -2.00,0.21	-0.88 -2.03,0.27
Q4	-0.02 -0.45,0.42	-0.04 -0.47,0.39	-0.04 -0.48,0.40	-0.04 -0.50,0.43	-0.42 -1.09,0.25	-0.48 -1.30,0.33	-0.21 -0.86,0.43	-0.19 -0.85,0.46
MBzP								
Continuous	0.07 -0.04,0.17	0.08 -0.03,0.19	0.08+ -0.00,0.17	0.08+ -0.01,0.17	0.12 -0.49,0.74	0.29 -0.33,0.91	0.26 -0.36,0.87	0.28 -0.36,0.93
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.19 -0.21,0.59	0.22 -0.19,0.64	0.25 -0.17,0.67	0.26 -0.17,0.69	-0.08 -1.26,1.11	0.11 -1.26,1.48	0.03 -1.27,1.33	0.03 -1.29,1.34
Q3	-0.06 -0.38,0.27	-0.01 -0.35,0.34	0.02 -0.32,0.36	0.04 -0.31,0.38	0.15 -1.39,1.68	0.68 -1.21,2.58	0.57 -1.26,2.41	0.62 -1.24,2.48
Q4	0.35* 0.00,0.70	0.39* 0.04,0.75	0.40* 0.10,0.70	0.40* 0.09,0.72	0.73 -0.93,2.40	1.20 -0.56,2.97	1.13 -0.62,2.88	1.19 -0.61,2.98
∑ DEHP								
Continuous	-0.01 -0.11,0.09	-0.01 -0.10,0.09	-0.00 -0.09,0.09	0.00 -0.09,0.10	-0.09 -0.36,0.17	-0.08 -0.34,0.19	-0.04 -0.30,0.23	-0.03 -0.28,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.02 -0.41,0.37	0.01 -0.41,0.43	-0.01 -0.41,0.39	0.01 -0.39,0.41	-0.51+ -1.02,0.01	-0.42 -1.10,0.26	-0.41 -1.06,0.24	-0.39 -1.04,0.25
Q3	-0.27 -0.71,0.18	-0.25 -0.71,0.21	-0.23 -0.66,0.21	-0.22 -0.65,0.22	0.40 -0.35,1.15	0.59 -0.33,1.52	0.64 -0.37,1.66	0.66 -0.37,1.69
Q4	-0.07 -0.44,0.30	-0.10 -0.45,0.25	-0.09 -0.44,0.26	-0.06 -0.42,0.30	-0.61 -1.51,0.30	-0.48 -1.42,0.46	-0.32 -1.14,0.51	-0.27 -1.06,0.53
MEHP								
Continuous	-0.07 -0.24,0.10	-0.06 -0.23,0.11	-0.04 -0.22,0.13	-0.04 -0.22,0.14	-0.18 -0.49,0.14	-0.10 -0.47,0.27	-0.09 -0.49,0.32	-0.07 -0.46,0.33
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.09 -0.30,0.48	0.11 -0.26,0.49	0.13 -0.24,0.50	0.15 -0.23,0.54	-0.38 -1.17,0.42	-0.12 -1.02,0.79	-0.20 -1.16,0.75	-0.21 -1.18,0.76
Q3	-0.00 -0.42,0.42	0.02 -0.40,0.45	0.04 -0.40,0.49	0.05 -0.41,0.51	-0.32 -1.17,0.53	-0.01 -0.82,0.81	0.06 -0.78,0.90	0.10 -0.75,0.95
Q4	-0.26 -0.72,0.20	-0.25 -0.71,0.21	-0.22 -0.71,0.28	-0.20 -0.69,0.29	-0.43 -1.40,0.53	-0.09 -1.01,0.83	-0.11 -1.03,0.81	-0.06 -0.98,0.85
MEHHP								
Continuous	-0.03 -0.12,0.06	-0.03 -0.11,0.06	-0.02 -0.10,0.06	-0.01 -0.09,0.07	-0.09 -0.35,0.18	-0.06 -0.34,0.22	-0.03 -0.30,0.24	-0.02 -0.28,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.28,0.44	0.09 -0.29,0.47	0.09 -0.28,0.45	0.11 -0.25,0.47	-0.50 -1.31,0.32	-0.49 -1.19,0.20	-0.52 -1.22,0.19	-0.51 -1.22,0.20
Q3	-0.09 -0.43,0.25	-0.08 -0.46,0.29	-0.08 -0.45,0.29	-0.07 -0.43,0.29	0.26 -0.43,0.94	0.39 -0.39,1.18	0.49 -0.34,1.33	0.50 -0.34,1.34
Q4	-0.11 -0.47,0.24	-0.13 -0.45,0.19	-0.12 -0.45,0.20	-0.09 -0.42,0.24	-0.48 -1.43,0.47	-0.39 -1.34,0.56	-0.31 -1.21,0.59	-0.26 -1.11,0.60
MEOHP								
Continuous	-0.04 -0.14,0.06	-0.04 -0.13,0.05	-0.03 -0.12,0.05	-0.03 -0.11,0.06	-0.11 -0.40,0.19	-0.09 -0.39,0.21	-0.06 -0.35,0.24	-0.04 -0.33,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.11 -0.28,0.51	0.16 -0.25,0.57	0.15 -0.24,0.54	0.17 -0.22,0.57	-0.30 -1.15,0.55	-0.14 -0.89,0.60	-0.17 -0.92,0.59	-0.17 -0.92,0.59
Q3	-0.03 -0.36,0.29	-0.02 -0.35,0.31	-0.01 -0.32,0.31	-0.00 -0.31,0.31	-0.08 -0.97,0.81	0.19 -0.71,1.09	0.28 -0.66,1.21	0.28 -0.66,1.22
Q4	-0.08 -0.45,0.29	-0.10 -0.43,0.23	-0.08 -0.42,0.25	-0.06 -0.41,0.29	-0.20 -1.08,0.68	-0.02 -0.98,0.93	0.06 -0.88,0.99	0.14 -0.79,1.07
MECPP								
Continuous	0.01 -0.10,0.13	0.01 -0.10,0.12	0.02 -0.09,0.13	0.02 -0.08,0.13	-0.11 -0.40,0.18	-0.10 -0.37,0.18	-0.04 -0.33,0.25	-0.03 -0.32,0.26
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.33,0.48	0.09 -0.35,0.53	0.07 -0.34,0.48	0.08 -0.32,0.48	-0.36 -1.06,0.35	-0.61+ -1.28,0.06	-0.61+ -1.24,0.03	-0.60+ -1.23,0.03
Q3	-0.18 -0.63,0.26	-0.19 -0.66,0.29	-0.17 -0.61,0.27	-0.16 -0.61,0.28	0.62+ -0.09,1.32	0.92* 0.15,1.70	0.94* 0.11,1.78	0.97* 0.11,1.82

Q4	0.04 -0.41,0.50	0.01 -0.44,0.46	0.02 -0.43,0.48	0.05 -0.39,0.50	-0.63 -1.50,0.24	-0.76+ -1.53,0.00	-0.58 -1.36,0.20	-0.54 -1.33,0.26
	Polio Virus 3 2009-2010, Female				Polio Virus 3 2009-2010, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.27*** -0.39,-0.16	-0.26*** -.39,-.12	-0.24*** -.36,-.11	-0.23*** -.36,-.11	-0.08 -0.25,0.10	-0.07 -0.25,0.10	-0.03 -0.21,0.14	-0.04 -0.22,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18 -0.83,0.46	-0.21 -0.96,0.55	-0.21 -0.90,0.49	-0.23 -0.92,0.46	-0.06 -0.69,0.56	0.01 -0.64,0.67	-0.02 -0.58,0.53	-0.02 -0.57,0.54
Q3	-0.80* -1.43,-0.16	-0.82* -1.47,-0.17	-0.86* -1.57,-0.15	-0.88* -1.58,-0.18	-0.21 -1.04,0.62	-0.21 -1.03,0.62	-0.14 -1.03,0.74	-0.20 -1.01,0.61
Q4	-1.01*** -1.54,-0.49	-0.94** -1.53,-.34	-0.86** -1.41,-.31	-0.85** -1.42,-.28	-0.24 -0.87,0.39	-0.18 -0.82,0.46	-0.03 -0.67,0.61	-0.03 -0.68,0.63
MnBP								
Continuous	-0.09 -0.38,0.21	-0.10 -0.39,0.19	-0.07 -0.34,0.21	-0.06 -0.33,0.21	0.27* 0.02,0.52	0.15 -0.09,0.39	0.16 -0.08,0.40	0.16 -0.08,0.41
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.12 -0.94,0.70	-0.12 -0.95,0.71	-0.02 -0.75,0.70	-0.01 -0.74,0.72	0.25 -0.39,0.89	0.39 -0.20,0.97	0.33 -0.12,0.77	0.35 -0.10,0.80
Q3	-0.28 -1.24,0.68	-0.26 -1.18,0.66	-0.19 -1.06,0.69	-0.15 -1.01,0.71	1.01*** 0.48,1.54	0.79** 0.37,1.22	0.82** 0.37,1.27	0.85** 0.38,1.32
Q4	-0.26 -1.04,0.52	-0.26 -1.09,0.57	-0.15 -0.97,0.66	-0.13 -0.92,0.66	0.83* 0.12,1.53	0.51 -0.16,1.18	0.49 -0.16,1.15	0.51 -0.17,1.18
MiBP								
Continuous	-0.22 -0.58,0.13	-0.26 -0.63,0.11	-0.22 -0.57,0.12	-0.21 -0.56,0.13	0.10 -0.08,0.27	-0.02 -0.19,0.16	0.02 -0.16,0.19	0.02 -0.16,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.37 -1.39,0.66	-0.26 -1.30,0.79	-0.17 -1.20,0.87	-0.14 -1.18,0.90	-0.32 -1.22,0.57	-0.31 -1.07,0.46	-0.26 -1.10,0.59	-0.20 -1.02,0.62
Q3	-0.77+ -1.65,0.10	-0.77 -1.76,0.22	-0.63 -1.49,0.24	-0.61 -1.47,0.26	0.04 -0.54,0.61	-0.03 -0.52,0.46	0.10 -0.45,0.64	0.15 -0.33,0.63
Q4	-0.70 -1.88,0.47	-0.76 -1.99,0.46	-0.64 -1.79,0.52	-0.60 -1.76,0.55	0.18 -0.37,0.73	-0.15 -0.69,0.39	-0.03 -0.60,0.53	-0.01 -0.59,0.58
∑ DBP								
Continuous	-0.07 -0.35,0.20	-0.13 -0.40,0.15	-0.09 -0.35,0.18	-0.08 -0.35,0.18	0.35** 0.10,0.60	0.26* 0.01,0.50	0.25* 0.02,0.48	0.25* 0.01,0.49
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.25 -1.20,0.70	-0.34 -1.32,0.65	-0.27 -1.13,0.60	-0.25 -1.12,0.62	0.05 -0.59,0.69	0.17 -0.43,0.78	0.20 -0.36,0.76	0.24 -0.29,0.77
Q3	-0.53 -1.45,0.40	-0.53 -1.48,0.41	-0.43 -1.40,0.54	-0.40 -1.39,0.58	0.63 -0.26,1.52	0.58 -0.26,1.41	0.55 -0.13,1.23	0.59+ -0.07,1.25
Q4	-0.18 -0.89,0.53	-0.30 -0.96,0.36	-0.20 -0.82,0.43	-0.19 -0.81,0.43	0.84* 0.20,1.47	0.61+ -0.05,1.27	0.64* 0.02,1.27	0.67* 0.04,1.31
McPP								
Continuous	-0.02 -0.24,0.20	-0.09 -0.31,0.12	-0.02 -0.24,0.19	-0.04 -0.24,0.17	0.22 -0.10,0.53	0.12 -0.22,0.46	0.12 -0.22,0.47	0.12 -0.22,0.47
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.34,0.86	0.13 -0.46,0.72	0.20 -0.33,0.73	0.20 -0.32,0.72	0.10 -0.56,0.77	0.03 -0.74,0.80	-0.00 -0.81,0.81	-0.01 -0.84,0.81
Q3	-0.10 -0.71,0.51	-0.35 -0.97,0.27	-0.30 -0.87,0.26	-0.32 -0.87,0.24	0.48 -0.34,1.29	0.18 -0.58,0.95	0.16 -0.67,0.98	0.12 -0.70,0.94
Q4	-0.13 -0.73,0.46	-0.30 -0.87,0.27	-0.16 -0.70,0.37	-0.18 -0.69,0.33	0.52 -0.19,1.23	0.28 -0.54,1.10	0.28 -0.59,1.14	0.27 -0.59,1.14
MBzP								
Continuous	-0.10 -0.38,0.17	-0.14 -0.44,0.15	-0.13 -0.41,0.16	-0.11 -0.41,0.18	0.36* 0.09,0.63	0.26+ -0.01,0.53	0.25* 0.01,0.50	0.26* 0.01,0.51
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.16 -1.09,0.76	-0.24 -1.19,0.71	-0.19 -1.07,0.68	-0.17 -1.04,0.71	0.19 -0.64,1.01	0.23 -0.63,1.09	0.26 -0.56,1.07	0.30 -0.51,1.11
Q3	-0.48 -1.17,0.21	-0.49 -1.26,0.28	-0.42 -1.23,0.40	-0.39 -1.22,0.43	0.52 -0.40,1.45	0.46 -0.39,1.30	0.44 -0.39,1.28	0.50 -0.32,1.31
Q4	-0.22 -1.04,0.60	-0.36 -1.14,0.42	-0.31 -1.05,0.43	-0.29 -1.04,0.46	1.09* 0.27,1.91	0.86* 0.00,1.73	0.82* 0.10,1.55	0.85* 0.11,1.58
∑ DEHP								
Continuous	-0.03 -0.33,0.26	-0.08 -0.37,0.22	-0.02 -0.30,0.25	-0.03 -0.30,0.24	0.07 -0.10,0.25	0.02 -0.16,0.19	0.03 -0.14,0.21	0.04 -0.13,0.21
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.39 -1.21,0.44	-0.44 -1.29,0.42	-0.40 -1.21,0.42	-0.41 -1.21,0.39	0.07 -0.43,0.58	0.08 -0.35,0.51	0.04 -0.40,0.49	0.07 -0.35,0.49
Q3	-0.30 -1.09,0.49	-0.36 -1.22,0.49	-0.24 -0.93,0.45	-0.23 -0.90,0.44	0.02 -0.63,0.66	-0.27 -0.89,0.36	-0.23 -0.85,0.40	-0.20 -0.82,0.42
Q4	-0.10 -1.12,0.92	-0.15 -1.18,0.87	-0.03 -1.06,1.00	-0.07 -1.09,0.94	0.10 -0.62,0.82	-0.20 -0.82,0.43	-0.19 -0.82,0.44	-0.16 -0.79,0.46
MEHP								
Continuous	-0.15 -0.45,0.15	-0.14 -0.45,0.17	-0.12 -0.42,0.18	-0.13 -0.42,0.17	-0.14 -0.39,0.11	-0.18 -0.49,0.12	-0.15 -0.44,0.14	-0.14 -0.43,0.14

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.38 -0.97,0.21	-0.57+ -1.17,0.03	-0.55+ -1.13,0.02	-0.57* -1.13,-0.01	0.06 -0.38,0.51	0.17 -0.28,0.61	0.24 -0.20,0.68	0.28 -0.11,0.67
Q3	-0.67+ -1.40,0.05	-0.68+ -1.46,0.09	-0.64+ -1.29,0.01	-0.62+ -1.28,0.03	-0.43 -1.06,0.21	-0.58+ -1.26,0.10	-0.51 -1.21,0.19	-0.49 -1.18,0.20
Q4	-0.32 -1.04,0.41	-0.37 -1.11,0.37	-0.34 -1.06,0.37	-0.35 -1.06,0.35	-0.47* -0.85,-.09	-0.61* -1.11,-0.12	-0.50+ 1.06,0.06	-0.47+ -0.99,0.05
MEHHP								
Continuous	-0.05 -0.33,0.23	-0.08 -0.37,0.20	-0.03 -0.29,0.23	-0.04 -0.30,0.22	0.05 -0.11,0.20	0.01 -0.16,0.18	0.02 -0.15,0.19	0.03 -0.14,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.38 -1.03,0.27	-0.55+ -1.18,0.09	-0.54+ -1.12,0.05	-0.55+ -1.13,0.03	0.09 -0.45,0.63	0.14 -0.42,0.69	0.09 -0.48,0.67	0.13 -0.44,0.70
Q3	-0.16 -0.86,0.54	-0.24 -1.03,0.56	-0.13 -0.78,0.52	-0.13 -0.76,0.50	0.17 -0.40,0.73	0.00 -0.62,0.63	0.07 -0.56,0.70	0.09 -0.54,0.73
Q4	-0.09 -1.04,0.85	-0.25 -1.17,0.67	-0.13 -1.01,0.76	-0.16 -1.04,0.71	0.08 -0.44,0.60	-0.13 -0.71,0.45	-0.12 -0.70,0.45	-0.09 -0.66,0.48
MEOHP								
Continuous	-0.09 -0.38,0.19	-0.14 -0.42,0.14	-0.09 -0.35,0.18	-0.09 -0.35,0.17	0.10 -0.08,0.28	0.04 -0.16,0.23	0.06 -0.14,0.25	0.06 -0.14,0.26
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.41 -1.03,0.20	-0.51+ -1.12,0.09	-0.51+ -1.09,0.07	-0.52+ -1.09,0.04	-0.06 -0.66,0.54	-0.04 -0.53,0.45	-0.06 -0.60,0.48	-0.02 -0.54,0.51
Q3	-0.26 -0.88,0.37	-0.33 -0.96,0.31	-0.24 -0.77,0.29	-0.24 -0.74,0.26	0.38 -0.11,0.87	0.20 -0.36,0.76	0.24 -0.33,0.80	0.25 -0.30,0.81
Q4	-0.21 -1.05,0.63	-0.34 -1.14,0.46	-0.19 -0.99,0.60	-0.22 -1.00,0.56	0.15 -0.60,0.89	-0.15 -0.84,0.54	-0.15 -0.82,0.52	-0.12 -0.78,0.55
MECPP								
Continuous	0.01 -0.31,0.34	-0.05 -0.37,0.28	0.02 -0.29,0.33	0.01 -0.30,0.31	0.09 -0.10,0.29	0.03 -0.15,0.21	0.05 -0.13,0.23	0.05 -0.13,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.47 -1.38,0.45	-0.56 -1.53,0.41	-0.48 -1.38,0.42	-0.49 -1.38,0.40	0.47 -0.18,1.11	0.46+ -0.09,1.01	0.44 -0.17,1.05	0.47 -0.13,1.06
Q3	-0.20 -0.94,0.53	-0.28 -1.07,0.51	-0.13 -0.79,0.54	-0.12 -0.77,0.53	0.08 -0.58,0.74	-0.20 -0.75,0.34	-0.18 -0.71,0.34	-0.16 -0.70,0.37
Q4	-0.08 -1.10,0.95	-0.22 -1.24,0.79	-0.06 -1.08,0.96	-0.10 -1.11,0.90	0.50 -0.38,1.38	0.24 -0.51,0.98	0.25 -0.50,1.01	0.28 -0.48,1.04

	Polio Virus 3 2009-2010, Adolescent				Polio Virus 3 2009-2010, Adult			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.09 -0.35,0.17	-0.14 -0.40,0.12	-0.03 -0.30,0.24	-0.03 -0.30,0.24	-0.10 -0.24,0.05	-0.09 -0.23,0.05	-0.09 -0.23,0.05	-0.09 -0.23,0.05
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.17 -1.28,0.93	-0.46 -1.52,0.60	-0.18 -1.19,0.84	-0.17 -1.18,0.84	-0.03 -0.81,0.75	0.05 -0.74,0.85	0.00 -0.74,0.75	0.00 -0.75,0.76
Q3	-0.03 -1.12,1.07	-0.24 -1.13,0.65	-0.05 -0.96,0.86	-0.06 -0.97,0.85	-0.33 -0.91,0.25	-0.29 -0.94,0.36	-0.33 -0.99,0.34	-0.33 -0.98,0.33
Q4	-0.32 -1.27,0.64	-0.54 -1.55,0.48	-0.18 -1.19,0.84	-0.10 -1.08,0.88	-0.30 -0.93,0.33	-0.25 -0.90,0.40	-0.23 -0.87,0.42	-0.22 -0.87,0.42
MnBP								
Continuous	-0.04 -0.40,0.31	-0.06 -0.38,0.27	0.01 -0.25,0.26	0.01 -0.25,0.27	-0.07 -0.27,0.14	-0.04 -0.27,0.18	-0.05 -0.27,0.16	-0.05 -0.26,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.05 -0.80,0.91	-0.13 -0.86,0.60	-0.08 -0.88,0.73	-0.09 -0.92,0.73	-0.03 -0.72,0.67	0.14 -0.60,0.87	0.05 -0.62,0.72	0.05 -0.62,0.72
Q3	-0.18 -1.10,0.73	-0.40 -1.38,0.59	-0.27 -1.23,0.69	-0.26 -1.22,0.69	0.17 -0.48,0.83	0.33 -0.36,1.02	0.30 -0.37,0.98	0.30 -0.37,0.98
Q4	-0.06 -0.94,0.83	-0.10 -1.03,0.84	0.04 -0.66,0.74	0.04 -0.66,0.75	-0.13 -0.80,0.53	-0.05 -0.77,0.68	-0.07 -0.78,0.64	-0.07 -0.77,0.64
MiBP								
Continuous	-0.26+ -0.57,0.05	-0.29+ -0.61,0.03	-0.24 -0.54,0.05	-0.24 -0.54,0.06	-0.17 -0.42,0.09	-0.12 -0.41,0.16	-0.12 -0.40,0.15	-0.12 -0.40,0.15
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.96 -2.23,0.31	-1.06+ -2.15,0.02	-0.78+ -1.69,0.14	-0.77+ -1.71,0.16	-0.26 -0.96,0.44	-0.11 -0.81,0.58	-0.12 -0.83,0.59	-0.12 -0.83,0.59
Q3	-1.24+ -2.54,0.06	-1.45* -2.68,-0.23	-1.22* -2.34,-0.09	-1.21* -2.33,-0.09	-0.36 -0.97,0.25	-0.19 -0.80,0.42	-0.17 -0.77,0.43	-0.17 -0.77,0.42
Q4	-0.73 -1.64,0.18	-0.91* -1.80,-0.03	-0.73+ -1.55,0.10	-0.71+ -1.54,0.13	-0.49 -1.30,0.32	-0.37 -1.21,0.48	-0.35 -1.19,0.49	-0.35 -1.19,0.49
∑ DBP								
Continuous	-0.04 -0.40,0.32	-0.03 -0.37,0.30	0.01 -0.28,0.29	0.01 -0.27,0.30	-0.04 -0.25,0.17	0.01 -0.20,0.23	-0.01 -0.21,0.19	-0.01 -0.21,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.80 -1.90,0.30	-0.86 -2.03,0.30	-0.65 -1.63,0.33	-0.67 -1.65,0.30	-0.16 -0.87,0.55	-0.04 -0.69,0.60	-0.07 -0.71,0.57	-0.07 -0.71,0.57
Q3	-0.44 -1.48,0.59	-0.60 -1.77,0.57	-0.40 -1.52,0.71	-0.41 -1.52,0.70	-0.08 -0.71,0.55	0.04 -0.59,0.67	-0.06 -0.60,0.49	-0.06 -0.60,0.48

Q4	-0.50 -1.63,0.62	-0.54 -1.64,0.56	-0.38 -1.29,0.52	-0.37 -1.29,0.54	0.00 -0.52,0.53	0.17 -0.37,0.71	0.14 -0.39,0.67	0.14 -0.39,0.68
McPP								
Continuous	-0.05 -0.54,0.44	-0.05 -0.54,0.44	-0.01 -0.48,0.47	-0.01 -0.48,0.47	-0.06 -0.27,0.14	-0.06 -0.28,0.16	-0.06 -0.29,0.16	-0.06 -0.29,0.16
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.15 -1.03,0.73	-0.13 -1.05,0.79	-0.05 -0.95,0.86	-0.05 -0.95,0.85	-0.05 -0.66,0.56	-0.05 -0.68,0.58	-0.02 -0.63,0.58	-0.02 -0.63,0.58
Q3	-0.69* -1.33,-0.05	-1.08* -2.07,-0.09	-0.79+ -1.70,0.13	-0.79+ -1.70,0.12	-0.11 -0.79,0.56	-0.13 -0.82,0.55	-0.14 -0.82,0.55	-0.13 -0.81,0.55
Q4	-0.11 -1.10,0.89	-0.15 -1.27,0.96	-0.02 -1.08,1.04	-0.02 -1.09,1.05	-0.25 -0.76,0.27	-0.21 -0.74,0.32	-0.18 -0.72,0.35	-0.18 -0.72,0.35
MBzP								
Continuous	0.01 -0.33,0.36	0.01 -0.33,0.35	0.04 -0.24,0.33	0.05 -0.24,0.34	-0.06 -0.31,0.19	0.01 -0.26,0.28	-0.02 -0.28,0.24	-0.02 -0.28,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.74 -1.92,0.44	-0.87 -2.23,0.50	-0.88 -2.02,0.27	-0.90 -2.04,0.24	0.01 -0.80,0.81	0.08 -0.78,0.94	0.05 -0.76,0.86	0.05 -0.76,0.86
Q3	-0.23 -1.27,0.81	-0.41 -1.70,0.88	-0.15 -1.33,1.03	-0.16 -1.34,1.01	-0.16 -0.85,0.52	-0.04 -0.74,0.66	-0.10 -0.78,0.58	-0.10 -0.78,0.58
Q4	-0.33 -1.54,0.87	-0.38 -1.66,0.90	-0.29 -1.37,0.79	-0.28 -1.36,0.81	0.15 -0.66,0.96	0.33 -0.56,1.23	0.23 -0.60,1.06	0.23 -0.60,1.06
∑ DEHP								
Continuous	-0.03 -0.44,0.38	-0.06 -0.45,0.33	-0.05 -0.42,0.32	-0.05 -0.41,0.32	-0.06 -0.27,0.15	-0.04 -0.25,0.17	-0.04 -0.24,0.17	-0.04 -0.25,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.11 -1.07,0.84	-0.17 -1.26,0.93	-0.07 -1.21,1.06	-0.07 -1.21,1.06	-0.35 -0.98,0.28	-0.27 -0.93,0.38	-0.33 -0.97,0.31	-0.33 -0.98,0.31
Q3	0.11 -0.85,1.07	0.10 -0.84,1.04	0.22 -0.68,1.11	0.24 -0.65,1.13	-0.60+ -1.31,0.10	-0.58 -1.33,0.18	-0.59 -1.32,0.14	-0.59 -1.32,0.14
Q4	-0.25 -1.53,1.04	-0.34 -1.48,0.79	-0.25 -1.22,0.72	-0.25 -1.21,0.71	-0.19 -0.91,0.53	-0.13 -0.82,0.55	-0.14 -0.82,0.53	-0.15 -0.83,0.53
MEHP								
Continuous	-0.22 -0.80,0.36	-0.16 -0.72,0.40	-0.17 -0.75,0.40	-0.17 -0.73,0.40	-0.12 -0.33,0.09	-0.10 -0.32,0.12	-0.09 -0.31,0.13	-0.09 -0.31,0.12
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.38 -1.27,0.52	-0.00 -0.98,0.97	-0.07 -1.07,0.93	-0.07 -1.06,0.91	-0.26 -0.70,0.18	-0.18 -0.63,0.28	-0.15 -0.58,0.29	-0.15 -0.58,0.28
Q3	-0.63 -1.98,0.71	-0.52 -2.01,0.97	-0.57 -2.11,0.98	-0.58 -2.09,0.93	-0.78* -1.35,-0.21	-0.71* -1.27,-0.16	-0.70* -1.23,-0.16	-0.70* -1.23,-.16
Q4	-0.85 -2.25,0.55	-0.56 -1.96,0.83	-0.59 -2.00,0.82	-0.57 -1.95,0.82	-0.37 -0.84,0.10	-0.33 -0.84,0.18	-0.30 -0.83,0.24	-0.30 -0.83,0.24
MEHHP								
Continuous	-0.07 -0.47,0.32	-0.09 -0.46,0.28	-0.08 -0.43,0.27	-0.08 -0.42,0.27	-0.05 -0.26,0.15	-0.03 -0.25,0.18	-0.03 -0.24,0.17	-0.03 -0.24,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.11 -0.64,0.87	0.11 -0.70,0.93	0.31 -0.49,1.11	0.28 -0.52,1.09	-0.42+ -0.87,0.04	-0.34 -0.82,0.14	-0.41+ -0.91,0.08	-0.42+ -0.91,0.08
Q3	0.35 -0.62,1.33	0.42 -0.57,1.40	0.53 -0.35,1.42	0.55 -0.31,1.41	-0.45 -1.12,0.23	-0.43 -1.17,0.31	-0.42 -1.14,0.29	-0.43 -1.14,0.29
Q4	-0.41 -1.59,0.76	-0.46 -1.55,0.63	-0.33 -1.30,0.64	-0.34 -1.29,0.62	-0.20 -0.79,0.39	-0.15 -0.71,0.41	-0.15 -0.70,0.40	-0.16 -0.71,0.40
MEOHP								
Continuous	-0.10 -0.53,0.33	-0.11 -0.52,0.29	-0.11 -0.49,0.28	-0.10 -0.48,0.27	-0.07 -0.29,0.15	-0.05 -0.27,0.17	-0.05 -0.26,0.17	-0.05 -0.26,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.15 -1.03,0.72	-0.29 -1.22,0.65	-0.13 -1.04,0.78	-0.14 -1.05,0.77	-0.36 -0.87,0.15	-0.32 -0.83,0.20	-0.37 -0.89,0.16	-0.37 -0.90,0.15
Q3	0.16 -0.62,0.94	0.19 -0.58,0.96	0.31 -0.40,1.01	0.33 -0.37,1.03	-0.28 -0.82,0.26	-0.24 -0.85,0.38	-0.24 -0.85,0.36	-0.25 -0.85,0.36
Q4	-0.16 -1.50,1.18	-0.23 -1.53,1.07	-0.14 -1.30,1.02	-0.14 -1.29,1.00	-0.25 -0.87,0.36	-0.23 -0.74,0.29	-0.23 -0.73,0.27	-0.24 -0.74,0.27
MECPP								
Continuous	0.01 -0.43,0.44	-0.04 -0.47,0.39	-0.03 -0.43,0.37	-0.03 -0.43,0.37	-0.05 -0.27,0.17	-0.03 -0.25,0.19	-0.02 -0.24,0.19	-0.02 -0.24,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.21 -0.52,0.95	0.02 -0.71,0.74	0.01 -0.79,0.82	0.01 -0.79,0.82	-0.21 -0.89,0.47	-0.12 -0.79,0.56	-0.12 -0.76,0.52	-0.12 -0.77,0.52
Q3	0.24 -0.55,1.02	0.23 -0.52,0.98	0.28 -0.43,0.99	0.30 -0.42,1.01	-0.58+ -1.20,0.04	-0.48 -1.11,0.15	-0.47 -1.07,0.13	-0.47 -1.07,0.13
Q4	0.35 -1.01,1.71	0.17 -1.11,1.45	0.16 -0.98,1.30	0.16 -0.96,1.29	-0.15 -0.88,0.58	-0.12 -0.83,0.59	-0.10 -0.79,0.60	-0.10 -0.81,0.60

	Polio Virus 3 2009-2010, US-Born				Polio Virus 3 2009-2010, Foreign-Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.20*** -0.31,-0.10	-0.19** -0.33,-0.05	-0.15* -0.30,-0.01	-0.15* -0.29,-0.02	-0.04 -0.38,0.30	-0.02 -0.29,0.26	0.01 -0.26,0.28	0.01 -0.25,0.27

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.21 -0.71,0.29	-0.20 -0.75,0.35	-0.21 -0.68,0.26	-0.21 -0.68,0.27	0.43 -0.65,1.51	0.85 -0.27,1.96	0.80 -0.24,1.85	0.80 -0.22,1.82
Q3	-0.58* -1.07,-0.08	-0.59+ -1.19,0.01	-0.56+ -1.22,0.11	-0.56+ -1.22,0.11	-0.14 -1.04,0.75	-0.13 -1.37,1.12	-0.14 -1.43,1.14	-0.23 -1.61,1.15
Q4	-0.69** -1.13,-0.26	-0.61* -1.15,-0.08	-0.45+ -0.99,0.08	-0.45+ -0.98,0.07	-0.07 -1.58,1.44	0.25 -0.94,1.44	0.26 -0.86,1.37	0.30 -0.79,1.39
MnBP								
Continuous	0.05 -0.13,0.24	-0.02 -0.21,0.17	0.01 -0.18,0.19	0.01 -0.17,0.19	0.24 -0.26,0.74	0.19 -0.15,0.54	0.22 -0.12,0.57	0.21 -0.13,0.55
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.46,0.62	0.10 -0.47,0.68	0.10 -0.35,0.56	0.10 -0.36,0.56	-0.12 -0.94,0.71	0.47 -0.43,1.37	0.47 -0.39,1.32	0.43 -0.43,1.29
Q3	0.41+ -0.00,0.83	0.28 -0.16,0.72	0.34+ -0.03,0.71	0.34+ -0.03,0.71	-0.05 -1.26,1.16	0.30 -0.91,1.52	0.31 -0.88,1.50	0.28 -0.91,1.48
Q4	0.20 -0.38,0.78	0.02 -0.61,0.66	0.06 -0.58,0.69	0.06 -0.57,0.69	0.63 -0.68,1.94	0.70 -0.34,1.74	0.81 -0.21,1.83	0.77 -0.22,1.77
MiBP								
Continuous	-0.12 -0.35,0.10	-0.19* -0.38,-0.01	-0.15+ -0.33,0.02	-0.15+ -0.33,0.02	0.18 -0.37,0.73	0.13 -0.27,0.53	0.18 -0.25,0.60	0.16 -0.26,0.57
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.32 -0.88,0.25	-0.30 -0.77,0.18	-0.25 -0.73,0.23	-0.25 -0.73,0.23	-0.42 -0.98,0.14	-0.06 -0.95,0.83	0.06 -0.76,0.87	0.03 -0.82,0.87
Q3	-0.31+ -0.66,0.03	-0.39* -0.76,-0.02	-0.27+ -0.59,0.05	-0.27+ -0.59,0.05	-0.75 -1.78,0.28	-0.19 -1.11,0.73	-0.10 -1.05,0.85	-0.17 -1.12,0.78
Q4	-0.35 -0.97,0.28	-0.54+ -1.13,0.05	-0.43 -0.99,0.13	-0.43 -0.99,0.13	0.17 -1.11,1.44	0.16 -0.85,1.17	0.32 -0.65,1.29	0.26 -0.72,1.24
∑ DBP								
Continuous	0.11 -0.06,0.28	0.03 -0.11,0.17	0.05 -0.08,0.18	0.05 -0.08,0.18	0.16 -0.22,0.54	0.21 -0.18,0.61	0.23 -0.15,0.62	0.21 -0.20,0.62
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.09 -0.78,0.60	-0.05 -0.66,0.56	0.02 -0.51,0.56	0.02 -0.51,0.56	-0.18 -1.28,0.92	-0.05 -0.77,0.67	-0.14 -0.76,0.49	-0.14 -0.76,0.48
Q3	0.04 -0.62,0.70	-0.01 -0.59,0.57	0.04 -0.42,0.50	0.04 -0.43,0.51	-0.16 -1.31,0.99	0.08 -0.98,1.14	0.09 -0.85,1.04	0.02 -0.94,0.99
Q4	0.26 -0.19,0.71	0.06 -0.32,0.45	0.14 -0.21,0.49	0.14 -0.22,0.50	0.57 -0.74,1.88	0.69 -0.72,2.10	0.81 -0.66,2.28	0.77 -0.76,2.30
McPP								
Continuous	0.08 -0.14,0.30	-0.01 -0.21,0.20	0.02 -0.18,0.23	0.02 -0.18,0.23	0.05 -0.28,0.37	0.12 -0.29,0.52	0.21 -0.22,0.63	0.19 -0.26,0.64
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.33 -0.22,0.88	0.18 -0.34,0.70	0.19 -0.30,0.68	0.19 -0.30,0.68	-0.62 -1.81,0.57	-0.30 -1.79,1.19	-0.23 -1.57,1.11	-0.22 -1.55,1.10
Q3	0.24 -0.36,0.84	-0.06 -0.69,0.58	-0.01 -0.66,0.64	-0.01 -0.66,0.64	-0.14 -1.33,1.05	-0.14 -1.26,0.99	-0.19 -1.30,0.92	-0.24 -1.37,0.88
Q4	0.27 -0.32,0.87	0.04 -0.54,0.63	0.10 -0.46,0.66	0.10 -0.46,0.67	-0.51 -1.46,0.45	-0.27 -1.19,0.65	-0.07 -0.92,0.78	-0.13 -1.04,0.77
MBzP								
Continuous	0.11 -0.08,0.29	0.04 -0.14,0.22	0.05 -0.12,0.22	0.05 -0.12,0.22	0.13 -0.49,0.75	0.15 -0.43,0.72	0.12 -0.42,0.67	0.10 -0.47,0.66
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.07 -0.76,0.63	-0.01 -0.68,0.66	0.06 -0.51,0.64	0.06 -0.52,0.64	0.32 -1.00,1.63	0.09 -1.01,1.19	0.02 -0.99,1.03	0.03 -0.97,1.03
Q3	-0.01 -0.51,0.50	-0.03 -0.50,0.44	0.03 -0.38,0.44	0.03 -0.39,0.44	-0.29 -1.78,1.20	-0.19 -1.68,1.30	-0.29 -1.68,1.10	-0.34 -1.74,1.06
Q4	0.38 -0.30,1.05	0.23 -0.46,0.92	0.26 -0.34,0.86	0.26 -0.34,0.86	0.56 -1.43,2.55	0.50 -1.45,2.46	0.44 -1.44,2.31	0.37 -1.54,2.28
∑ DEHP								
Continuous	0.02 -0.17,0.20	-0.05 -0.25,0.15	-0.02 -0.21,0.18	-0.02 -0.21,0.18	0.07 -0.20,0.35	0.12 -0.20,0.44	0.16 -0.18,0.49	0.14 -0.22,0.50
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.22 -0.76,0.32	-0.26 -0.77,0.26	-0.25 -0.74,0.23	-0.25 -0.74,0.24	0.10 -0.97,1.18	0.20 -0.87,1.27	0.22 -0.79,1.23	0.20 -0.79,1.20
Q3	-0.21 -0.77,0.35	-0.35 -0.94,0.23	-0.28 -0.76,0.21	-0.28 -0.77,0.21	0.14 -0.98,1.25	0.15 -0.86,1.17	0.19 -0.88,1.26	0.16 -0.93,1.25
Q4	-0.04 -0.73,0.66	-0.25 -0.92,0.41	-0.20 -0.87,0.47	-0.20 -0.88,0.48	0.20 -0.87,1.28	0.41 -0.68,1.51	0.56 -0.54,1.66	0.48 -0.70,1.66
MEHP								
Continuous	-0.16 -0.38,0.06	-0.20 -0.47,0.06	-0.17 -0.44,0.09	-0.17 -0.44,0.09	-0.01 -0.29,0.28	0.11 -0.25,0.47	0.12 -0.28,0.52	0.09 -0.33,0.51
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.18 -0.54,0.18	-0.24 -0.61,0.13	-0.19 -0.56,0.18	-0.19 -0.55,0.17	-0.12 -1.21,0.97	0.02 -1.08,1.11	-0.06 -1.20,1.08	-0.05 -1.17,1.06
Q3	-0.64* -1.18,-0.10	-0.74* -1.29,-0.18	-0.71** -1.21,-.21	-0.71** -1.21,-.21	-0.00 -0.93,0.93	0.23 -0.64,1.10	0.29 -0.62,1.19	0.23 -0.65,1.11
Q4	-0.41+ -0.89,0.06	-0.58* -1.12,-0.03	-0.50+ -1.03,0.03	-0.50+ -1.03,0.03	-0.18 -1.27,0.91	0.05 -0.92,1.02	0.04 -0.97,1.04	-0.02 -1.06,1.01
MEHHP								

Continuous	-0.00 -0.17,0.17	-0.05 -0.25,0.14	-0.02 -0.21,0.17	-0.02 -0.21,0.17	0.04 -0.22,0.29	0.10 -0.21,0.41	0.13 -0.20,0.46	0.11 -0.24,0.46
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.14 -0.51,0.23	-0.25 -0.58,0.08	-0.27+ -0.59,0.05	-0.27 -0.60,0.06	-0.27 -1.27,0.73	-0.11 -1.22,0.99	-0.13 -1.23,0.97	-0.14 -1.19,0.91
Q3	-0.07 -0.54,0.41	-0.18 -0.70,0.34	-0.10 -0.55,0.35	-0.10 -0.55,0.35	0.26 -0.62,1.14	0.40 -0.40,1.19	0.48 -0.36,1.32	0.46 -0.39,1.31
Q4	-0.00 -0.54,0.53	-0.23 -0.75,0.29	-0.18 -0.68,0.33	-0.18 -0.69,0.33	-0.11 -1.01,0.79	-0.01 -1.03,1.01	0.06 -1.01,1.12	-0.05 -1.17,1.08
MEOHP								
Continuous	0.01 -0.18,0.20	-0.06 -0.27,0.15	-0.03 -0.24,0.18	-0.03 -0.24,0.18	0.03 -0.23,0.28	0.08 -0.20,0.37	0.11 -0.19,0.41	0.09 -0.23,0.40
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.32+ -0.67,0.03	-0.37* -0.70,-0.04	-0.37* -0.69,-0.05	-0.37* -0.70,-0.05	0.13 -0.74,1.00	0.06 -0.91,1.03	0.04 -0.94,1.02	0.04 -0.91,0.99
Q3	0.06 -0.42,0.53	-0.06 -0.56,0.44	-0.01 -0.45,0.42	-0.01 -0.45,0.43	-0.13 -1.26,1.01	0.05 -0.83,0.93	0.12 -0.76,0.99	0.11 -0.76,0.98
Q4	-0.09 -0.71,0.54	-0.32 -0.92,0.28	-0.26 -0.86,0.34	-0.26 -0.86,0.35	0.20 -0.70,1.10	0.21 -0.72,1.15	0.28 -0.74,1.29	0.16 -0.90,1.23
MECPP								
Continuous	0.05 -0.16,0.26	-0.03 -0.25,0.18	0.01 -0.20,0.22	0.01 -0.21,0.22	0.11 -0.22,0.44	0.15 -0.21,0.52	0.21 -0.18,0.59	0.19 -0.22,0.60
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.01 -0.58,0.60	-0.08 -0.61,0.45	-0.03 -0.53,0.46	-0.03 -0.53,0.46	-0.09 -1.14,0.97	0.02 -1.14,1.17	0.02 -1.07,1.12	0.01 -1.07,1.09
Q3	-0.13 -0.63,0.36	-0.32 -0.79,0.15	-0.22 -0.56,0.12	-0.22 -0.57,0.12	0.18 -0.96,1.31	0.26 -0.70,1.21	0.26 -0.76,1.28	0.23 -0.82,1.28
Q4	0.17 -0.65,0.98	-0.08 -0.82,0.66	0.00 -0.75,0.76	0.00 -0.76,0.77	0.41 -0.89,1.70	0.57 -0.53,1.68	0.77 -0.38,1.92	0.71 -0.50,1.92

	Toxoplasma 2009-2010, Female				Toxoplasma 2009-2010, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.82 -1.51,3.14	-0.65 -2.90,1.60	-0.69 -2.73,1.35	-0.69 -2.75,1.38	0.54 -1.90,2.97	-0.97 -2.77,0.83	-1.00 -2.89,0.89	-0.98 -2.85,0.89
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.33 -2.49,11.15	2.32 -6.31,10.94	2.40 -6.23,11.03	2.25 -6.35,10.85	-1.28 -10.14,7.58	-0.12 -7.94,7.70	-0.11 -8.37,8.15	0.06 -8.15,8.26
Q3	-0.32 -8.91,8.28	-3.94 -13.71,5.83	-3.58 -12.89,5.72	-3.80 -13.24,5.64	-3.37 -14.15,7.41	-6.50 -16.82,3.83	-7.05 -16.94,2.83	-6.63 -16.38,3.11
Q4	4.62 -3.84,13.08	-1.66 -10.92,7.60	-1.70 -10.13,6.74	-1.68 -10.21,6.85	4.21 -6.60,15.03	-1.24 -10.03,7.54	-1.30 -10.19,7.59	-1.31 -10.20,7.58
MnBP								
Continuous	1.32 -0.80,3.44	0.21 -2.40,2.81	0.07 -2.46,2.60	0.16 -2.47,2.78	-1.75 -5.01,1.50	-1.88 -4.86,1.10	-2.10 -5.27,1.06	-2.11 -5.27,1.04
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	6.97 -1.75,15.69	7.21 -2.99,17.41	6.68 -3.29,16.65	6.76 -3.23,16.76	0.79 -10.75,12.34	-0.51 -9.70,8.67	-0.19 -9.29,8.92	-0.17 -9.15,8.82
Q3	3.33 -1.97,8.62	2.95 -4.04,9.94	2.99 -3.74,9.71	3.19 -3.67,10.06	-2.50 -13.11,8.12	-3.27 -11.76,5.22	-3.66 -12.51,5.20	-3.80 -12.52,4.92
Q4	1.30 -6.55,9.15	-0.69 -9.96,8.58	-1.04 -10.20,8.12	-0.77 -10.22,8.68	-4.64 -14.57,5.29	-5.38 -14.93,4.17	-5.73 -15.29,3.84	-5.83 -15.42,3.76
MiBP								
Continuous	0.60 -3.20,4.39	0.38 -3.78,4.54	0.44 -3.45,4.33	0.53 -3.44,4.51	1.18 -2.60,4.97	1.31 -2.69,5.31	1.36 -2.73,5.46	1.34 -2.73,5.41
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.67 -10.86,7.52	-0.33 -9.94,9.29	-0.58 -10.92,9.75	-0.43 -10.79,9.92	0.92 -8.22,10.05	0.40 -6.58,7.38	0.38 -6.84,7.59	0.06 -7.27,7.38
Q3	2.41 -7.03,11.86	4.33 -6.60,15.25	3.66 -7.07,14.39	3.75 -7.03,14.53	3.36 -8.84,15.56	4.60 -5.95,15.15	4.32 -6.46,15.11	4.01 -6.58,14.59
Q4	-0.34 -9.18,8.50	-0.52 -10.29,9.24	-0.45 -9.68,8.78	-0.18 -9.57,9.20	-1.75 -10.00,6.50	-1.18 -8.33,5.98	-1.03 -8.34,6.27	-1.21 -8.41,5.99
∑ DBP								
Continuous	0.52 -2.20,3.24	0.65 -2.95,4.25	0.51 -3.01,4.03	0.59 -2.95,4.13	-2.64* -5.13,-0.14	-2.22+ -4.69,0.24	-2.58+ -5.22,0.07	-2.59* -5.14,-.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	1.92 -4.58,8.43	2.35 -3.86,8.56	2.59 -3.22,8.41	2.74 -3.02,8.51	1.63 -7.57,10.82	0.54 -10.38,11.46	0.35 -10.95,11.65	-.01 -11.32,11.31
Q3	0.89 -4.61,6.38	1.43 -5.28,8.15	1.17 -5.09,7.43	1.42 -4.90,7.73	-0.05 -9.61,9.50	1.21 -9.04,11.47	1.05 -9.81,11.91	0.77 -9.62,11.17
Q4	0.27 -9.91,10.46	1.17 -10.67,13.02	0.81 -10.72,12.35	0.98 -10.59,12.54	-5.08 -11.93,1.77	-3.19 -11.14,4.76	-4.34 -12.25,3.57	-4.53 -12.20,3.14
McPP								
Continuous	-0.11 -2.76,2.55	0.23 -2.61,3.06	0.17 -2.50,2.83	0.14 -2.52,2.81	-2.76+ -5.53,0.01	-1.31 -3.72,1.11	-1.37 -3.88,1.14	-1.37 -3.84,1.10
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	8.41 -2.08,18.91	8.41+ -1.30,18.13	8.45+ -0.84,17.74	8.49+ -0.78,17.76	-5.36 -15.38,4.66	-3.98 -13.59,5.64	-3.23 -13.09,6.62	-3.11 -12.85,6.64

Q3	1.76 -3.89,7.41	2.11 -3.12,7.34	2.20 -3.34,7.74	2.23 -3.26,7.71	0.30 -11.47,12.07	4.25 -7.39,15.88	4.24 -8.00,16.47	4.62 -7.61,16.84
Q4	4.04 -2.50,10.59	4.94 -3.34,13.23	5.11 -2.62,12.83	5.17 -2.62,12.95	-8.36+ -17.72,1.00	-4.62 -12.94,3.70	-4.39 -13.06,4.28	-4.33 -12.91,4.25
MBzP								
Continuous	0.79 -2.16,3.73	0.88 -3.10,4.86	0.75 -3.14,4.64	0.87 -3.04,4.77	-1.43 -3.88,1.02	-1.44 -4.35,1.47	-1.88 -4.84,1.08	-1.90 -4.75,0.96
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-1.44 -7.06,4.17	-0.14 -3.83,3.55	0.14 -4.12,4.40	0.28 -4.00,4.55	-2.49 -11.55,6.56	-4.45 -13.15,4.25	-4.78 -13.49,3.94	-4.98 -13.64,3.67
Q3	4.81 -3.90,13.52	5.60 -4.26,15.47	5.80 -3.65,15.24	5.91 -3.57,15.39	3.26 -9.39,15.91	3.42 -8.30,15.13	2.79 -9.01,14.58	2.48 -9.10,14.06
Q4	-3.26 -10.16,3.65	-3.47 -12.98,6.03	-3.72 -12.96,5.53	-3.49 -12.74,5.75	-5.40 -12.11,1.30	-5.65 -13.99,2.70	-6.94+ -15.15,1.27	-6.95+ -15.00,1.1
∑ DEHP								
Continuous	1.57 -1.07,4.22	1.50 -1.29,4.29	1.46 -1.69,4.62	1.49 -1.69,4.66	-2.65* -5.25,-0.04	-1.64 -4.33,1.05	-1.46 -4.31,1.40	-1.49 -4.33,1.35
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	11.83* 1.81,21.85	11.59* 2.13,21.05	11.50* 1.98,21.03	11.5* 1.96,21.05	-2.64 -12.98,7.70	-2.54 -13.01,7.93	-1.93 -11.78,7.91	-1.98 -11.99,8.04
Q3	3.76 -3.23,10.76	3.38 -3.41,10.18	3.19 -3.59,9.97	3.40 -3.41,10.21	-9.00+ -18.81,0.80	-7.63 -17.35,2.09	-7.09 -16.85,2.67	-7.31 -17.03,2.40
Q4	6.27 -6.14,18.67	7.00 -5.98,19.98	6.92 -7.00,20.83	6.88 -7.09,20.85	-11.46* -19.93,3.0	-8.66+ -18.28,0.96	-7.84 -17.94,2.26	-8.00 -18.13,2.14
MEHP								
Continuous	1.67 -2.15,5.50	2.22 -2.22,6.66	1.88 -2.47,6.22	1.90 -2.42,6.21	-2.38 -5.39,0.64	-1.27 -4.36,1.82	-1.00 -4.16,2.17	-1.10 -4.23,2.03
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	2.11 -6.37,10.58	3.63 -5.94,13.21	3.81 -6.07,13.69	3.73 -6.23,13.68	1.67 -6.58,9.93	5.12 -2.85,13.09	6.68* 0.29,13.08	6.32+ -0.29,12.93
Q3	6.13 -2.86,15.12	8.87 -2.17,19.92	8.32 -2.17,18.80	8.43 -2.05,18.92	-1.75 -11.63,8.13	1.20 -10.33,12.73	2.47 -9.10,14.04	2.26 -9.44,13.96
Q4	3.63 -5.45,12.70	3.75 -6.85,14.35	3.10 -6.67,12.88	3.16 -6.65,12.97	-4.46 -12.90,3.98	-2.43 -10.88,6.02	-1.37 -9.88,7.15	-1.77 -10.23,6.70
MEHHP								
Continuous	1.92 -1.14,4.99	1.68 -1.48,4.85	1.62 -1.86,5.11	1.65 -1.86,5.15	-2.78* -5.25,-0.30	-1.87 -4.50,0.75	-1.73 -4.51,1.06	-1.78 -4.55,0.99
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	7.93 -1.74,17.59	7.39 -2.51,17.29	7.49 -2.20,17.19	7.44 -2.30,17.18	-2.10 -11.28,7.08	-2.27 -11.13,6.59	-1.87 -10.43,6.69	-2.12 -10.75,6.51
Q3	5.49 -1.97,12.94	5.00 -1.43,11.43	4.82 -1.99,11.63	4.92 -1.87,11.72	-8.91+ -18.18,0.36	-8.38+ -16.78,0.02	-7.75+ -16.68,1.18	-8.04+ -16.9,0.84
Q4	4.42 -9.60,18.43	4.28 -10.33,18.89	4.10 -11.39,19.58	4.07 -11.45,19.58	-11.16* -19.5,-2.8	-8.97* -17.89,-.06	-8.30+ -17.70,1.10	-8.61+ -18.6,0.83
MEOHP								
Continuous	1.53 -1.43,4.48	1.64 -1.64,4.93	1.59 -2.06,5.25	1.64 -2.02,5.31	-3.06* -5.80,-0.31	-2.07 -4.97,0.84	-1.92 -4.98,1.14	-1.96 -5.00,1.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	7.69+ -0.41,15.78	8.25+ -1.11,17.62	8.13+ -1.22,17.48	8.12+ -1.26,17.50	-1.19 -14.28,11.91	-2.44 -15.44,10.55	-2.33 -15.43,10.78	-2.67 -15.93,10.6
Q3	3.59 -2.11,9.28	4.38 -1.54,10.30	4.31 -1.89,10.52	4.49 -1.65,10.62	-10.61+ -21.4,0.17	-10.66* -20.5,-.81	-10.27* -20.2,-.34	-10.4* -20.3,-.47
Q4	4.67 -8.11,17.44	5.45 -8.37,19.28	5.22 -9.51,19.96	5.27 -9.45,19.98	-10.34* -20.3,-.31	-7.94 -18.56,2.68	-7.32 -18.44,3.80	-7.62 -18.80,3.56
MECPP								
Continuous	1.27 -1.29,3.82	1.27 -1.35,3.90	1.25 -1.75,4.25	1.26 -1.78,4.29	-2.55+ -5.24,0.13	-1.36 -4.15,1.43	-1.15 -4.14,1.84	-1.17 -4.15,1.81
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	10.81+ -0.04,21.65	9.04+ -0.33,18.40	9.16+ -0.34,18.66	9.18+ -0.30,18.67	-0.55 -12.83,11.74	0.46 -11.66,12.57	0.62 -11.06,12.29	0.53 -11.37,12.43
Q3	2.63 -4.42,9.67	2.14 -5.11,9.38	2.08 -4.94,9.11	2.26 -4.76,9.29	-9.07 -20.60,2.46	-7.91 -19.05,3.23	-7.36 -18.75,4.02	-7.47 -18.87,3.94
Q4	4.67 -5.30,14.64	5.15 -5.11,15.42	5.10 -6.20,16.40	5.04 -6.32,16.40	-10.17* -17.6,-2.8	-6.24 -14.44,1.96	-5.85 -14.60,2.90	-5.99 -14.64,2.66

	Toxoplasma 2009-2010, Adolescent				Toxoplasma 2009-2010, Adult			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.35 -1.99,1.28	-0.65 -2.39,1.10	-1.91 -5.44,1.61	-1.87 -5.38,1.64	1.74 -3.70,7.17	-2.28 -7.51,2.94	-1.90 -7.28,3.49	-1.90 -7.31,3.52
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.52 -13.22,14.26	-0.35 -12.43,11.73	-2.10 -10.51,6.32	-1.86 -10.21,6.48	4.68 -3.68,13.04	3.78 -3.54,11.10	4.23 -3.52,11.98	4.17 -3.49,11.83
Q3	-4.53 -10.76,1.70	-8.47* -16.52,-.43	-10.06+ -20.41,.28	-10.0+ -20.35,0.3	-0.80 -10.26,8.67	-5.14 -14.82,4.55	-5.34 -14.97,4.29	-5.22 -15.06,4.63
Q4	-1.90 -9.20,5.40	-2.17 -10.88,6.54	-6.40 -20.18,7.39	-5.92 -19.33,7.49	4.41 -3.67,12.49	-3.19 -10.92,4.55	-2.96 -10.46,4.54	-2.94 -10.52,4.64
MnBP								

Continuous	-1.05 -3.19,1.08	-1.96+ -4.24,0.33	-2.66 -6.23,0.92	-2.52 -5.96,0.92	-0.29 -6.49,5.91	-5.28+ -11.39,0.84	-5.50+ -11.71,0.70	-5.47+ -11.57,0.63
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	12.37 -5.77,30.52	14.87 -5.12,34.86	13.36+ -2.85,29.6	13.2+ -2.75,29.16	1.86 -7.10,10.82	-0.08 -9.48,9.32	-0.05 -9.52,9.42	-0.10 -9.63,9.44
Q3	0.13 -2.01,2.27	0.31 -2.38,3.00	-1.37 -5.19,2.45	-1.08 -4.70,2.55	4.07 -6.32,14.47	0.03 -9.72,9.77	0.51 -9.04,10.07	0.50 -8.90,9.90
Q4	-0.52 -4.63,3.59	-2.99 -6.96,0.97	-4.55 -10.49,1.39	-4.36 -10.10,1.38	2.70 -5.57,10.97	-2.74 -12.93,7.44	-3.22 -13.67,7.23	-3.20 -13.82,7.43
MiBP								
Continuous	-1.03 -2.99,0.92	-1.95+ -4.27,0.36	-2.94 -7.02,1.14	-2.79 -6.67,1.09	3.05 -2.25,8.36	-0.64 -7.38,6.10	-0.85 -7.72,6.01	-0.80 -7.58,5.99
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.18 -8.73,9.09	1.66 -8.70,12.02	2.02 -9.36,13.39	1.97 -9.28,13.22	1.47 -7.03,9.97	-0.31 -8.79,8.17	-0.13 -8.40,8.13	-0.20 -8.67,8.26
Q3	6.07 -8.24,20.38	7.37 -8.21,22.95	5.51 -6.05,17.07	5.49 -6.03,17.01	5.16 -6.51,16.83	3.17 -7.80,14.14	3.43 -6.95,13.80	3.31 -7.05,13.67
Q4	-0.27 -4.11,3.57	-0.98 -5.83,3.87	-2.57 -8.70,3.57	-2.13 -7.72,3.45	8.16 -2.16,18.47	1.71 -9.16,12.57	2.04 -8.46,12.55	2.05 -8.43,12.53
∑ DBP								
Continuous	-2.34* -4.66,-0.03	-3.52* -6.45,-0.60	-4.03* -7.52,-0.53	-3.85* -7.18,-0.52	0.30 -7.82,8.42	-1.12 -6.17,3.92	-0.90 -5.74,3.94	-0.78 -5.51,3.96
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	10.74 -8.81,30.30	11.57 -7.80,30.93	11.55 -5.20,28.31	11.50 -5.03,28.04	-0.44 -9.64,8.76	-1.21 -11.59,9.16	-0.62 -11.14,9.90	-0.66 -11.29,9.97
Q3	-0.59 -7.83,6.66	-1.40 -7.84,5.04	-2.34 -9.44,4.76	-2.29 -9.27,4.70	3.51 -5.35,12.38	2.18 -7.50,11.86	2.40 -7.03,11.82	2.37 -6.88,11.62
Q4	-4.23+ -9.21,0.75	-6.83* -13.43,-.24	-7.71* -14.64,-.78	-7.32* -14.23,-.41	-0.24 -7.51,7.03	-3.79 -11.95,4.38	-3.95 -12.06,4.17	-4.07 -12.19,4.05
McPP								
Continuous	-2.39 -5.40,0.61	-4.18* -8.30,-0.05	-4.63+ -9.29,0.02	-4.50* -8.96,-0.04	-.46 -12.30,11.38	-0.09 -6.77,6.59	0.11 -6.12,6.33	0.23 -6.09,6.55
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	6.12 -10.96,23.19	5.72 -10.81,22.25	4.98 -8.71,18.67	4.93 -8.66,18.5	5.02 -4.96,14.99	4.85 -5.15,14.84	5.47 -4.56,15.49	5.55 -4.36,15.46
Q3	-0.74 -5.76,4.29	-2.83 -8.38,2.72	-4.80 -11.76,2.15	-4.54 -11.08,2.00	5.02 -4.14,14.18	5.34 -3.37,14.04	5.55 -3.53,14.63	5.72 -3.45,14.90
Q4	-3.57 -9.04,1.90	-8.51* -16.29,-.73	-9.88* -18.26,-1.5	-9.59* -17.67,-1.5	0.56 -8.61,9.74	-0.61 -9.23,8.02	-0.29 -9.18,8.59	-0.31 -9.14,8.53
MBzP								
Continuous	-1.92* -3.83,-0.02	-2.84* -5.26,-0.42	-3.29* -6.02,-0.57	-3.09* -5.73,-0.46	1.78 -3.60,7.15	-1.10 -7.08,4.87	-0.84 -6.93,5.25	-0.72 -6.52,5.09
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.66 -7.05,5.73	1.07 -5.26,7.41	2.48 -5.23,10.19	2.42 -5.27,10.12	-4.90 -14.39,4.58	-6.98 -15.93,1.97	-6.63 -15.42,2.17	-6.69 -15.54,2.15
Q3	6.91 -8.26,22.08	6.12 -9.61,21.85	3.87 -7.19,14.94	3.88 -7.07,14.84	5.68 -5.14,16.50	3.95 -6.95,14.85	4.06 -6.12,14.23	4.03 -6.07,14.12
Q4	-4.51+ -9.93,0.90	-6.63+ -13.66,0.40	-7.25* -14.37,-.12	-6.79+ -13.91,.34	0.67 -7.52,8.87	-6.84 -17.40,3.73	-7.32 -18.18,3.55	-7.36 -18.26,3.53
∑ DEHP								
Continuous	-3.13 -7.35,1.09	-3.68+ -8.05,0.68	-4.14+ -8.90,0.63	-4.06+ -8.68,0.55	-3.00 -9.26,3.25	-0.58 -5.18,4.01	-1.05 -5.32,3.23	-0.98 -5.27,3.31
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-9.33 -28.24,9.59	-8.64 -26.41,9.13	-8.63 -25.69,8.43	-8.43 -25.08,8.22	7.45+ -0.35,15.25	5.42 -1.16,12.01	6.04+ -0.48,12.57	5.91+ -0.78,12.59
Q3	-13.67 -31.62,4.29	-12.99 -29.07,3.08	-14.08+ -30.07,1.92	-13.61+ -28.96,1.74	3.62 -3.61,10.85	-0.14 -7.09,6.81	0.22 -6.93,7.36	0.13 -7.04,7.29
Q4	-11.04 -29.97,7.88	-13.34 -31.10,4.41	-14.84 -33.86,4.18	-14.65 -33.24,3.95	3.33 -5.78,12.44	1.77 -9.38,12.92	2.13 -9.13,13.39	1.92 -9.59,13.44
MEHP								
Continuous	-3.90 -9.73,1.94	-3.94 -9.50,1.62	-3.98 -9.42,1.45	-3.86 -9.12,1.39	-3.31 -11.34,4.71	-0.75 -7.70,6.19	-0.89 -7.40,5.63	-0.79 -7.43,5.85
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-8.99 -26.66,8.68	-6.64 -22.66,9.37	-6.94 -22.90,9.02	-6.86 -22.73,9.01	9.66** 2.81,16.51	6.19+ -0.49,12.86	6.87+ -0.28,14.02	6.67+ -0.71,14.05
Q3	-9.53 -27.40,8.34	-8.19 -22.80,6.42	-7.21 -19.88,5.46	-7.21 -19.84,5.42	9.42* 0.69,18.15	6.33 -3.93,16.59	6.80 -3.89,17.48	6.79 -3.96,17.54
Q4	-11.38 -28.25,5.49	-10.25 -25.99,5.49	-10.49 -25.93,4.94	-10.0 -24.74,4.73	8.83* 2.25,15.42	2.38 -7.23,11.98	2.44 -7.42,12.30	2.28 -7.79,12.35
MEHHP								
Continuous	-2.96 -6.82,0.90	-3.55+ -7.61,0.50	-4.01+ -8.50,0.48	-3.96+ -8.33,0.40	-3.34 -8.92,2.24	-1.12 -5.67,3.44	-1.50 -5.70,2.69	-1.45 -5.63,2.74
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-8.08 -26.06,9.90	-6.46 -23.32,10.41	-7.06 -24.71,10.58	-7.31 -24.97,10.35	4.80 -2.92,12.53	2.55 -4.62,9.72	3.08 -4.05,10.21	2.94 -4.37,10.25
Q3	-12.54 -29.38,4.30	-11.80 -27.79,4.18	-12.39 -27.83,3.05	-12.03 -26.84,2.78	6.39+ -1.35,14.13	2.61 -5.49,10.72	3.23 -5.33,11.79	3.09 -5.37,11.56

Q4	-10.08 -27.83,7.66	-11.58 -28.10,4.93	-13.10 -31.26,5.07	-13.15 -31.14,4.85	2.24 -7.88,12.36	-0.88 -13.69,11.92	-0.47 -13.35,12.40	-.66 -13.76,12.43
MEOHP								
Continuous	-3.17 -7.28,0.95	-3.91+ -8.39,0.57	-4.33+ -9.19,0.52	-4.24+ -8.92,0.44	-3.60 -9.89,2.69	-1.23 -6.62,4.15	-1.66 -6.54,3.23	-1.59 -6.47,3.30
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-4.28 -21.31,12.75	-2.84 -19.00,13.31	-2.58 -18.09,12.94	-2.44 -17.60,12.72	5.45 -1.92,12.83	2.61 -4.84,10.05	2.90 -4.34,10.14	2.71 -4.78,10.21
Q3	-10.80 -27.39,5.78	-10.21 -25.99,5.57	-10.63 -25.16,3.91	-10.14 -23.87,3.60	3.29 -2.68,9.26	-0.79 -6.35,4.77	-0.44 -6.14,5.26	-0.52 -6.19,5.15
Q4	-8.45 -25.73,8.83	-10.14 -26.87,6.58	-11.21 -28.57,6.15	-11.08 -28.08,5.92	2.93 -6.83,12.70	0.23 -12.14,12.61	0.33 -11.90,12.57	0.16 -12.31,12.64
MECPP								
Continuous	-3.18 -7.64,1.28	-3.80 -8.44,0.84	-4.33+ -9.49,0.82	-4.26+ -9.26,0.74	-3.30 -10.08,3.47	-0.10 -4.50,4.31	-0.61 -4.96,3.75	-0.54 -4.94,3.85
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-7.26 -26.99,12.46	-7.18 -26.48,12.13	-7.38 -26.00,11.23	-7.13 -25.21,10.95	5.73 -4.75,16.21	3.58 -6.26,13.43	4.05 -5.50,13.61	3.90 -5.70,13.51
Q3	-11.44 -30.20,7.32	-9.51 -25.85,6.82	-10.53 -26.46,5.39	-10.05 -25.19,5.09	2.88 -6.51,12.27	-1.24 -10.19,7.71	-0.94 -9.72,7.85	-1.02 -9.87,7.82
Q4	-10.35 -29.74,9.03	-12.74 -32.09,6.60	-14.10 -33.85,5.65	-13.89 -33.17,5.38	3.33 -4.67,11.33	3.04 -6.06,12.14	3.19 -5.87,12.25	2.96 -6.19,12.10

	Toxoplasma 2009-2010, US-Born				Toxoplasma 2009-2010, Foreign-Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	-0.10 -2.05,1.84	-0.90 -2.52,0.73	-0.89 -2.52,0.74	-0.88 -2.50,0.74	0.22** 0.08,0.37	0.12+ -0.02,0.26	0.10 -0.03,0.23	0.10 -0.05,0.26
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.73 -5.54,7.00	1.01 -5.52,7.53	-11.25 -51.55,29.06	0.23 -0.40,0.87	9.90 -9.01,28.82	3.67 -12.07,19.41	2.31 -14.25,18.87	2.24 -14.01,18.49
Q3	-3.94 -11.39,3.50	-4.82 -12.51,2.86	-31.64 -70.81,7.52	0.10 -0.49,0.70	12.64 -10.51,35.78	-5.90 -27.65,15.85	-3.99 -25.21,17.23	-3.82 -24.91,17.28
Q4	0.52 -6.90,7.94	-2.70 -9.15,3.75	-3.63 -35.75,28.49	0.34 -0.14,0.82	10.64 -6.64,27.91	-6.26 -19.67,7.16	-4.96 -18.67,8.75	-5.06 -18.94,8.82
MnBP								
Continuous	-0.51 -2.33,1.31	-0.06 -1.57,1.46	-0.19 -1.68,1.30	-0.15 -1.68,1.38	0.04 -0.18,0.25	0.08 -0.13,0.29	0.07 -0.16,0.29	0.08 -0.16,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	5.12 -3.24,13.48	5.28 -2.44,13.01	5.85 -17.95,29.66	0.15 -0.49,0.79	-0.24 -23.61,23.13	-4.35 -23.78,15.08	-5.27 -24.61,14.07	-5.17 -25.00,14.66
Q3	0.05 -4.95,5.05	0.98 -3.17,5.14	3.53 -20.11,27.18	0.25 -0.24,0.74	0.85 -16.81,18.51	-9.05 -26.31,8.21	-9.00 -25.22,7.23	-8.92 -25.16,7.32
Q4	-2.88 -9.21,3.44	-1.71 -7.62,4.20	7.78 -21.50,37.05	0.23 -0.31,0.76	-1.04 -24.48,22.41	-15.46 -38.60,7.67	-17.33 -41.03,6.37	-17.22 -41.18,6.73
MiBP								
Continuous	-0.53 -3.66,2.59	0.51 -2.49,3.51	0.73 -2.02,3.49	0.77 -2.02,3.57	0.07 -0.12,0.27	0.11 -0.09,0.32	0.12 -0.09,0.33	0.13 -0.06,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.82 -5.38,3.75	-0.10 -3.83,3.62	15.91 -3.64,35.46	0.63* 0.09,1.17	-3.98 -31.40,23.44	-5.68 -27.44,16.08	-7.30 -28.97,14.36	-7.19 -28.91,14.53
Q3	2.19 -4.53,8.91	4.48 -1.46,10.41	-6.41 -26.56,13.74	0.22 -0.41,0.85	2.10 -23.79,27.98	-2.73 -32.86,27.39	-5.62 -34.78,23.54	-5.43 -34.17,23.32
Q4	-2.98 -10.09,4.12	-0.54 -6.62,5.54	7.91 -13.77,29.59	0.36 -0.42,1.14	-1.24 -18.60,16.12	-8.45 -28.57,11.67	-9.94 -30.60,10.73	-9.79 -30.29,10.72
∑ DBP								
Continuous	0.30 -0.76,1.36	1.09+ -0.21,2.40	0.94 -0.33,2.21	0.96 -0.31,2.24	0.09 -0.10,0.28	0.15+ -0.03,0.32	0.15 -0.05,0.34	0.22* 0.03,0.42
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.24 -1.86,10.35	4.49 -1.14,10.12	-1.39 -23.28,20.49	0.14 -0.69,0.96	-1.92 -24.55,20.72	-1.59 -26.18,23.00	-1.03 -24.76,22.70	-0.95 -24.68,22.79
Q3	3.81 -1.06,8.69	5.39* 0.95,9.84	2.63 -12.61,17.86	0.28 -0.36,0.92	-4.79 -23.61,14.02	-3.27 -22.89,16.35	-2.64 -22.71,17.42	-2.37 -22.39,17.65
Q4	1.37 -1.50,4.24	3.98* 1.06,6.90	-4.80 -26.04,16.44	-0.00 -0.65,0.64	3.41 -14.89,21.71	3.52 -15.89,22.92	5.47 -15.25,26.18	5.91 -14.54,26.36
McPP								
Continuous	-0.64 -2.48,1.19	0.24 -1.60,2.07	0.34 -1.40,2.08	0.32 -1.42,2.07	0.06 -0.22,0.34	0.19 -0.09,0.48	0.17 -0.12,0.46	0.26+ -0.01,0.52
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	4.86 -1.35,11.07	5.82+ -0.51,12.15	15.60 -12.03,43.24	0.27 -0.48,1.03	-8.60 -25.50,8.29	-8.43 -25.24,8.38	-8.65 -25.22,7.92	-8.67 -25.23,7.88
Q3	2.16 -4.05,8.37	4.12 -2.30,10.54	8.96 -14.08,31.99	0.73* 0.17,1.28	1.57 -19.15,22.30	5.02 -14.80,24.85	2.94 -16.06,21.94	3.37 -15.17,21.91
Q4	0.41 -4.31,5.14	2.59 -2.16,7.33	14.66 -7.96,37.29	0.30 -0.14,0.74	-1.01 -29.37,27.34	1.00 -17.96,19.95	1.95 -16.86,20.76	2.47 -16.63,21.58
MBzP								
Continuous	1.01+ -0.14,2.16	1.85* 0.45,3.24	1.61* 0.34,2.88	1.64* 0.38,2.91	0.08 -0.10,0.25	0.12 -0.04,0.28	0.13 -0.06,0.31	0.20* 0.01,0.39

Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.37 -5.87,6.61	1.17 -3.72,6.06	-10.55 -36.84,15.75	-0.29 -0.92,0.34	-5.01 -18.74,8.72	-13.16* -24.35,-2.	-13.49* -25.55,-1.4	-13.53* -25.42,- 1.7
Q3	6.91* 0.60,13.21	8.77** 2.65,14.89	11.76 -8.15,31.67	-0.16 -0.79,0.48	3.09 -14.19,20.36	-3.15 -20.83,14.54	-1.54 -19.80,16.72	-1.37 -19.38,16.64
Q4	-1.52 -6.40,3.37	1.13 -3.53,5.79	-10.15 -31.34,11.04	-0.19 -0.60,0.22	12.32 -15.40,40.05	-0.16 -36.04,35.72	1.21 -34.40,36.82	1.86 -34.03,37.75
∑ DEHP								
Continuous	-0.25 -2.13,1.63	0.44 -1.62,2.51	0.75 -1.52,3.01	0.74 -1.53,3.01	-0.01 -0.21,0.20	0.01 -0.18,0.21	-0.01 -0.21,0.19	0.04 -0.15,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	3.67 -2.68,10.03	4.47 -2.04,10.98	25.81* 4.05,47.56	0.59* 0.03,1.15	14.82 -15.46,45.10	8.40 -24.52,41.32	7.18 -24.30,38.66	7.29 -24.03,38.62
Q3	-0.96 -6.39,4.48	0.86 -4.39,6.11	-1.91 -19.56,15.75	0.15 -0.61,0.91	-3.80 -36.68,29.08	-8.32 -37.48,20.85	-8.72 -36.50,19.06	-8.58 -36.44,19.27
Q4	-1.18 -8.09,5.73	1.18 -6.85,9.22	11.87 -15.44,39.18	-0.05 -0.63,0.53	-8.83 -28.35,10.68	-2.75 -21.71,16.21	-5.25 -23.89,13.39	-5.00 -23.55,13.54
MEHP								
Continuous	-0.85 -3.24,1.54	0.49 -2.14,3.12	0.66 -2.01,3.32	0.62 -2.07,3.30	0.02 -0.16,0.20	0.01 -0.20,0.22	0.02 -0.21,0.24	0.04 -0.20,0.29
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-2.80 -7.60,2.01	0.37 -5.35,6.09	12.11 -13.90,38.12	0.25 -0.66,1.16	33.86** 14.22,53.5	23.00** 9.17,36.83	21.69** 8.17,35.21	21.87** 8.52,35.22
Q3	-0.33 -8.53,7.88	3.00 -6.53,12.54	6.91 -16.57,30.40	0.45 -0.29,1.19	17.39 -7.81,42.60	15.18 -15.05,45.40	13.50 -14.88,41.87	13.79 - 14.85,42.44
Q4	-3.05 -7.47,1.37	-0.09 -5.80,5.61	7.72 -11.82,27.26	0.01 -0.65,0.67	6.53 -13.39,26.44	2.60 -19.13,24.33	2.43 -18.02,22.88	2.69 -17.70,23.09
MEHHP								
Continuous	-0.02 -2.01,1.97	0.55 -1.68,2.77	0.81 -1.59,3.21	0.79 -1.61,3.20	-0.04 -0.25,0.17	-0.02 -0.21,0.18	-0.03 -0.23,0.17	0.01 -0.18,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	3.66 -1.98,9.29	3.61 -1.94,9.16	21.42 -4.89,47.73	0.61+ -0.03,1.26	3.77 -22.21,29.75	2.97 -25.90,31.84	1.02 -26.41,28.45	1.06 -26.21,28.34
Q3	-0.86 -6.58,4.87	0.13 -5.07,5.33	-5.64 -22.19,10.92	0.17 -0.54,0.89	2.06 -27.02,31.15	-4.00 -32.10,24.10	-5.63 -33.01,21.75	-5.60 -32.94,21.73
Q4	-1.48 -8.13,5.17	0.21 -7.47,7.89	2.86 -25.30,31.02	-0.16 -0.78,0.45	-12.85 -29.81,4.11	-5.46 -22.03,11.12	-5.79 -23.03,11.45	-5.51 -22.40,11.37
MEOHP								
Continuous	-0.29 -2.35,1.77	0.54 -1.75,2.83	0.82 -1.66,3.30	0.82 -1.67,3.30	-0.03 -0.24,0.18	-0.00 -0.20,0.20	-0.02 -0.22,0.18	0.03 -0.17,0.22
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	2.44 -4.61,9.50	2.91 -3.92,9.73	20.60 -4.45,45.66	0.60+ -0.03,1.23	10.56 -14.83,35.94	7.01 -23.14,37.16	4.78 -23.92,33.49	4.80 -23.80,33.39
Q3	-2.51 -8.40,3.37	-0.82 -6.37,4.73	-0.81 -17.91,16.29	0.14 -0.53,0.81	-2.40 -30.32,25.53	-8.57 -35.94,18.81	-8.70 -35.09,17.70	-8.64 -35.01,17.74
Q4	-1.59 -8.80,5.62	0.81 -7.46,9.07	-0.25 -26.18,25.68	-0.08 -0.65,0.50	-7.48 -26.66,11.71	-1.99 -21.57,17.60	-3.85 -22.49,14.79	-3.59 -22.28,15.10
MECPP								
Continuous	-0.41 -2.24,1.43	0.38 -1.63,2.39	0.71 -1.54,2.97	0.71 -1.55,2.96	0.03 -0.18,0.23	0.05 -0.16,0.25	0.02 -0.18,0.22	0.07 -0.13,0.27
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	3.16 -4.80,11.12	3.50 -4.34,11.34	19.38 -4.59,43.34	0.62+ -0.07,1.30	12.66 -11.81,37.14	12.87 -15.05,40.79	11.57 -14.94,38.09	11.65 - 14.87,38.17
Q3	-3.72 -8.75,1.31	-2.01 -7.06,3.04	-7.00 -27.07,13.07	-0.11 -0.76,0.54	1.01 -38.96,40.97	-1.45 -34.27,31.37	-2.15 -32.82,28.53	-2.00 -32.84,28.83
Q4	-1.42 -7.31,4.46	1.28 -5.33,7.90	12.86 -13.29,39.01	-0.17 -0.78,0.44	-10.00 -27.79,7.79	-1.58 -16.13,12.97	-3.75 -19.44,11.93	-3.55 -19.40,12.30

	Epstein-Barr Virus 2003-2010, Female				Epstein-Barr Virus 2003-2010, Male			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.26*** 0.14,0.38	0.08 -0.04,0.21	0.09 -0.04,0.22	0.11 -0.02,0.24	0.22*** 0.13,0.31	0.07 -0.04,0.18	0.05 -0.06,0.16	0.05 -0.07,0.17
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.52* 0.09,0.95	0.25 -0.17,0.67	0.25 -0.17,0.68	0.30 -0.13,0.74	0.37+ -0.01,0.75	0.20 -0.16,0.56	0.15 -0.22,0.53	0.18 -0.23,0.58
Q3	0.70** 0.22,1.18	0.22 -0.24,0.69	0.24 -0.23,0.71	0.29 -0.17,0.75	0.56** 0.15,0.97	0.22 -0.20,0.64	0.15 -0.28,0.59	0.12 -0.39,0.63
Q4	1.04*** 0.60,1.48	0.43+ -0.07,0.93	0.45+ -0.06,0.96	0.49+ -0.01,0.99	0.86*** 0.49,1.23	0.30 -0.11,0.71	0.24 -0.19,0.66	0.20 -0.26,0.66
MnBP								

Continuous	0.16* 0.03,0.30	0.13+ -0.01,0.26	0.13+ -0.01,0.26	0.14+ -0.01,0.28	0.10 -0.04,0.23	0.12+ -0.01,0.25	0.11 -0.02,0.24	0.14+ -0.00,0.28
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.55,0.39	-0.25 -0.68,0.17	-0.25 -0.67,0.18	-0.31 -0.78,0.16	0.10 -0.38,0.57	0.06 -0.40,0.52	0.04 -0.42,0.49	0.06 -0.40,0.52
Q3	0.65* 0.16,1.13	0.42+ -0.05,0.89	0.41+ -0.06,0.87	0.47+ -0.02,0.97	0.14 -0.26,0.54	0.23 -0.18,0.64	0.23 -0.19,0.64	0.21 -0.23,0.64
Q4	0.51* 0.09,0.93	0.29 -0.12,0.70	0.29 -0.12,0.71	0.31 -0.14,0.75	0.15 -0.26,0.55	0.15 -0.24,0.55	0.12 -0.28,0.52	0.17 -0.24,0.58
MiBP								
Continuous	0.16+ -0.00,0.33	0.06 -0.09,0.20	0.06 -0.08,0.20	0.07 -0.08,0.23	0.18* 0.04,0.31	0.11+ -0.00,0.23	0.11+ -0.01,0.23	0.11+ -0.02,0.25
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.24 -0.25,0.72	0.07 -0.37,0.52	0.06 -0.39,0.51	0.02 -0.45,0.48	-0.10 -0.53,0.33	-0.02 -0.45,0.41	-0.05 -0.49,0.40	-0.02 -0.49,0.44
Q3	0.37 -0.09,0.83	0.07 -0.37,0.50	0.05 -0.39,0.49	0.06 -0.40,0.52	0.38+ -0.00,0.77	0.37+ -0.03,0.76	0.36+ -0.04,0.76	0.38+ -0.03,0.78
Q4	0.56* 0.11,1.01	0.27 -0.12,0.67	0.28 -0.12,0.68	0.30 -0.13,0.73	0.40* 0.02,0.78	0.29 -0.07,0.65	0.27 -0.09,0.63	0.32 -0.08,0.71
∑ DBP								
Continuous	0.07 -0.06,0.21	0.08 -0.05,0.22	0.08 -0.05,0.22	0.08 -0.06,0.23	0.06 -0.07,0.19	0.13* 0.01,0.25	0.12* 0.01,0.24	0.16* 0.03,0.28
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.11 -0.47,0.70	-0.02 -0.52,0.47	-0.04 -0.53,0.46	-0.09 -0.63,0.44	0.16 -0.29,0.60	0.12 -0.31,0.54	0.10 -0.33,0.54	0.13 -0.35,0.61
Q3	0.39 -0.17,0.94	0.21 -0.26,0.69	0.22 -0.25,0.70	0.25 -0.25,0.75	0.06 -0.38,0.50	0.23 -0.23,0.68	0.21 -0.25,0.67	0.26 -0.22,0.74
Q4	0.30 -0.17,0.78	0.22 -0.23,0.67	0.21 -0.24,0.66	0.18 -0.31,0.67	0.17 -0.25,0.59	0.31 -0.11,0.73	0.30 -0.12,0.71	0.36 -0.09,0.81
McPP								
Continuous	-0.06 -0.24,0.12	0.05 -0.12,0.23	0.05 -0.12,0.22	0.06 -0.13,0.24	-0.05 -0.23,0.12	0.13 -0.06,0.31	0.14 -0.04,0.31	0.16+ -0.02,0.35
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.23 -0.24,0.70	0.22 -0.26,0.69	0.21 -0.29,0.70	0.22 -0.31,0.76	0.56** 0.18,0.94	0.69*** 0.31,1.06	0.68*** 0.30,1.05	0.76*** .35,1.17
Q3	0.27 -0.19,0.74	0.28 -0.12,0.67	0.27 -0.13,0.67	0.23 -0.19,0.65	0.18 -0.16,0.52	0.45* 0.11,0.79	0.43* 0.09,0.77	0.45* 0.07,0.84
Q4	0.08 -0.30,0.46	0.27 -0.10,0.65	0.27 -0.10,0.64	0.27 -0.13,0.66	0.02 -0.37,0.41	0.47* 0.09,0.85	0.47* 0.08,0.86	0.61** 0.18,1.04
MBzP								
Continuous	0.11+ -0.00,0.23	0.09 -0.03,0.21	0.09 -0.03,0.21	0.09 -0.04,0.22	0.06 -0.05,0.17	0.11* 0.00,0.21	0.10+ -0.01,0.20	0.12* 0.00,0.24
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.44 -0.12,0.99	0.28 -0.26,0.82	0.28 -0.24,0.81	0.19 -0.38,0.76	0.11 -0.43,0.64	0.16 -0.36,0.69	0.20 -0.34,0.74	0.30 -0.30,0.90
Q3	0.51+ -0.05,1.06	0.24 -0.25,0.72	0.25 -0.24,0.73	0.27 -0.24,0.78	0.08 -0.46,0.63	0.18 -0.37,0.73	0.17 -0.38,0.72	0.24 -0.32,0.80
Q4	0.51* 0.03,1.00	0.33 -0.14,0.81	0.32 -0.15,0.79	0.26 -0.24,0.76	0.14 -0.34,0.61	0.28 -0.18,0.74	0.27 -0.21,0.74	0.36 -0.16,0.89
∑ DEHP								
Continuous	0.09+ -0.01,0.20	0.05 -0.06,0.17	0.05 -0.06,0.17	0.06 -0.05,0.18	0.01 -0.10,0.12	0.01 -0.11,0.13	0.01 -0.11,0.13	0.02 -0.09,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.30 -0.20,0.79	0.27 -0.22,0.77	0.27 -0.22,0.77	0.33 -0.16,0.81	-0.18 -0.73,0.36	-0.12 -0.67,0.43	-0.17 -0.71,0.37	-0.15 -0.72,0.43
Q3	0.25 -0.18,0.68	0.20 -0.24,0.64	0.19 -0.25,0.64	0.18 -0.27,0.63	0.12 -0.30,0.55	0.16 -0.26,0.58	0.11 -0.31,0.53	0.05 -0.38,0.48
Q4	0.35+ -0.05,0.75	0.28 -0.14,0.70	0.27 -0.15,0.69	0.35 -0.08,0.78	-0.02 -0.45,0.40	0.04 -0.38,0.46	0.01 -0.42,0.44	0.05 -0.38,0.48
MEHP								
Continuous	0.11+ -0.02,0.23	-0.00 -0.13,0.12	0.00 -0.13,0.13	0.01 -0.12,0.14	0.07 -0.07,0.22	0.01 -0.14,0.17	0.03 -0.12,0.18	0.04 -0.11,0.19
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.02 -0.49,0.53	-0.06 -0.55,0.42	-0.08 -0.58,0.41	0.00 -0.53,0.53	-0.16 -0.58,0.27	-0.15 -0.56,0.27	-0.16 -0.56,0.24	-0.11 -0.53,0.32
Q3	0.02 -0.42,0.46	-0.13 -0.56,0.30	-0.12 -0.55,0.32	-0.05 -0.56,0.47	-0.22 -0.64,0.19	-0.18 -0.60,0.23	-0.21 -0.63,0.20	-0.24 -0.69,0.20
Q4	0.29 -0.15,0.74	0.01 -0.44,0.45	-0.00 -0.45,0.44	0.09 -0.39,0.57	0.18 -0.25,0.61	0.05 -0.40,0.49	0.06 -0.38,0.51	0.11 -0.34,0.57
MEHHP								
Continuous	0.08 -0.02,0.18	0.04 -0.07,0.15	0.04 -0.07,0.15	0.05 -0.06,0.16	0.02 -0.09,0.13	0.02 -0.10,0.14	0.02 -0.09,0.14	0.03 -0.08,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.20,0.71	0.20 -0.26,0.65	0.20 -0.25,0.66	0.25 -0.19,0.70	0.15 -0.39,0.69	0.21 -0.33,0.75	0.14 -0.40,0.68	0.18 -0.42,0.79
Q3	0.20 -0.28,0.68	0.08 -0.40,0.57	0.07 -0.42,0.57	0.07 -0.43,0.58	0.45* 0.04,0.87	0.47* 0.05,0.89	0.44* 0.02,0.86	0.35 -0.08,0.79
Q4	0.35+ -0.04,0.73	0.22 -0.17,0.61	0.21 -0.18,0.60	0.30 -0.10,0.70	0.11 -0.30,0.51	0.14 -0.27,0.54	0.11 -0.30,0.53	0.14 -0.29,0.57

	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEOHP								
Continuous	0.10+ -0.01,0.20	0.06 -0.06,0.18	0.06 -0.06,0.17	0.07 -0.05,0.19	0.00 -0.11,0.12	0.01 -0.12,0.14	0.01 -0.12,0.14	0.02 -0.10,0.14
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.37 -0.18,0.92	0.33 -0.19,0.84	0.32 -0.19,0.82	0.40 -0.12,0.92	0.28 -0.28,0.84	0.38 -0.20,0.97	0.32 -0.27,0.92	0.35 -0.29,0.98
Q3	0.32 -0.15,0.78	0.19 -0.26,0.64	0.18 -0.27,0.64	0.23 -0.25,0.70	0.33 -0.08,0.75	0.38+ -0.03,0.79	0.35+ -0.06,0.75	0.22 -0.20,0.64
Q4	0.45* 0.05,0.85	0.36+ -0.05,0.77	0.35+ -0.06,0.76	0.46* 0.02,0.89	0.09 -0.33,0.52	0.16 -0.26,0.59	0.14 -0.30,0.59	0.16 -0.27,0.60
MECPP								
Continuous	0.09+ -0.02,0.20	0.07 -0.05,0.19	0.07 -0.05,0.19	0.08 -0.05,0.20	0.00 -0.12,0.12	0.00 -0.12,0.13	-0.00 -0.13,0.12	0.01 -0.11,0.13
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.26 -0.33,0.84	0.19 -0.39,0.77	0.21 -0.38,0.79	0.16 -0.44,0.76	0.04 -0.42,0.50	0.11 -0.38,0.59	0.05 -0.44,0.53	0.09 -0.43,0.61
Q3	0.18 -0.28,0.63	0.13 -0.33,0.60	0.13 -0.33,0.60	0.12 -0.32,0.56	0.26 -0.15,0.66	0.30 -0.09,0.68	0.26 -0.13,0.64	0.27 -0.15,0.68
Q4	0.43+ -0.01,0.86	0.34 -0.13,0.82	0.35 -0.13,0.82	0.37 -0.13,0.87	0.10 -0.29,0.49	0.16 -0.24,0.56	0.11 -0.29,0.51	0.15 -0.22,0.53

	Epstein-Barr Virus 2003-2010, Adolescent				Epstein-Barr Virus 2003-2010, Adult			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.14 0.14,0.14	0.07 0.07,0.07	0.05 0.05,0.05	0.05 0.05,0.05				
Q1	reference	reference	reference	reference				
Q2	0.29 0.29,0.29	0.29 0.29,0.29	0.25 0.25,0.25	0.25 0.25,0.25				
Q3	0.33 0.33,0.33	0.15 0.15,0.15	0.08 0.08,0.08	0.08 0.08,0.08				
Q4	0.56 0.56,0.56	0.33 0.33,0.33	0.25 0.25,0.25	0.25 0.25,0.25				
MnBP								
Continuous	0.18 0.18,0.18	0.13 0.13,0.13	0.11 0.11,0.11	0.11 0.11,0.11				
Q1	reference	reference	reference	reference				
Q2	-0.07 -0.07,-0.07	-0.12 -0.12,-0.12	-0.16 -0.16,-0.16	-0.14 -0.14,-0.14				
Q3	0.56 0.56,0.56	0.47 0.47,0.47	0.44 0.44,0.44	0.45 0.45,0.45				
Q4	0.48 0.48,0.48	0.34 0.34,0.34	0.29 0.29,0.29	0.29 0.29,0.29				
MiBP								
Continuous	0.23 0.23,0.23	0.13 0.13,0.13	0.13 0.13,0.13	0.13 0.13,0.13				
Q1	reference	reference	reference	reference				
Q2	0.09 0.09,0.09	0.02 0.02,0.02	0.00 0.00,0.00	0.00 0.00,0.00				
Q3	0.45 0.45,0.45	0.25 0.25,0.25	0.23 0.23,0.23	0.23 0.23,0.23				
Q4	0.62 0.62,0.62	0.41 0.41,0.41	0.40 0.40,0.40	0.41 0.41,0.41				
∑ DBP								
Continuous	0.12 0.12,0.12	0.10 0.10,0.10	0.09 0.09,0.09	0.09 0.09,0.09				
Q1	reference	reference	reference	reference				
Q2	-0.05 -0.05,-0.05	-0.13 -0.13,-0.13	-0.17 -0.17,-0.17	-0.18 -0.18,-0.18				
Q3	0.29 0.29,0.29	0.27 0.27,0.27	0.23 0.23,0.23	0.22 0.22,0.22				
Q4	0.28 0.28,0.28	0.20 0.20,0.20	0.16 0.16,0.16	0.15 0.15,0.15				
McPP								
Continuous	0.10 0.10,0.10	0.13 0.13,0.13	0.14 0.14,0.14	0.14 0.14,0.14				
Q1	reference	reference	reference	reference				
Q2	0.37 0.37,0.37	0.35 0.35,0.35	0.35 0.35,0.35	0.34 0.34,0.34				
Q3	0.28 0.28,0.28	0.29 0.29,0.29	0.26 0.26,0.26	0.26 0.26,0.26				
Q4	0.36 0.36,0.36	0.41 0.41,0.41	0.42 0.42,0.42	0.42 0.42,0.42				
MBzP								
Continuous	0.10 0.10,0.10	0.07 0.07,0.07	0.05 0.05,0.05	0.05 0.05,0.05				
Q1	reference	reference	reference	reference				

Q2	0.08 0.08,0.08	0.13 0.13,0.13	0.14 0.14,0.14	0.16 0.16,0.16				
Q3	0.28 0.28,0.28	0.30 0.30,0.30	0.26 0.26,0.26	0.26 0.26,0.26				
Q4	0.25 0.25,0.25	0.19 0.19,0.19	0.14 0.14,0.14	0.14 0.14,0.14				
∑ DEHP								
Continuous	0.02 0.02,0.02	0.02 0.02,0.02	0.02 0.02,0.02	0.02 0.02,0.02				
Q1	reference	reference	reference	reference				
Q2	0.07 0.07,0.07	0.01 0.01,0.01	-0.04 -0.04,-0.04	-0.05 -0.05,-0.05				
Q3	0.25 0.25,0.25	0.19 0.19,0.19	0.14 0.14,0.14	0.13 0.13,0.13				
Q4	0.12 0.12,0.12	0.07 0.07,0.07	0.06 0.06,0.06	0.05 0.05,0.05				
MEHP								
Continuous	0.08 0.08,0.08	0.05 0.05,0.05	0.06 0.06,0.06	0.06 0.06,0.06				
Q1	reference	reference	reference	reference				
Q2	-0.03 -0.03,-0.03	-0.06 -0.06,-0.06	-0.10 -0.10,-0.10	-0.11 -0.11,-0.11				
Q3	-0.05 -0.05,-0.05	-0.11 -0.11,-0.11	-0.13 -0.13,-0.13	-0.13 -0.13,-0.13				
Q4	0.26 0.26,0.26	0.14 0.14,0.14	0.15 0.15,0.15	0.15 0.15,0.15				
MEHHP								
Continuous	0.02 0.02,0.02	0.02 0.02,0.02	0.03 0.03,0.03	0.03 0.03,0.03				
Q1	reference	reference	reference	reference				
Q2	0.11 0.11,0.11	0.04 0.04,0.04	-0.02 -0.02,-0.02	-0.04 -0.04,-0.04				
Q3	0.21 0.21,0.21	0.13 0.13,0.13	0.09 0.09,0.09	0.08 0.08,0.08				
Q4	0.17 0.17,0.17	0.11 0.11,0.11	0.10 0.10,0.10	0.09 0.09,0.09				
MEOHP								
Continuous	0.03 0.03,0.03	0.02 0.02,0.02	0.03 0.03,0.03	0.03 0.03,0.03				
Q1	reference	reference	reference	reference				
Q2	0.19 0.19,0.19	0.18 0.18,0.18	0.11 0.11,0.11	0.09 0.09,0.09				
Q3	0.38 0.38,0.38	0.30 0.30,0.30	0.26 0.26,0.26	0.25 0.25,0.25				
Q4	0.17 0.17,0.17	0.13 0.13,0.13	0.11 0.11,0.11	0.11 0.11,0.11				
MECPP								
Continuous	0.01 0.01,0.01	0.01 0.01,0.01	0.01 0.01,0.01	0.01 0.01,0.01				
Q1	reference	reference	reference	reference				
Q2	0.18 0.18,0.18	0.12 0.12,0.12	0.07 0.07,0.07	0.06 0.06,0.06				
Q3	0.24 0.24,0.24	0.17 0.17,0.17	0.14 0.14,0.14	0.13 0.13,0.13				
Q4	0.12 0.12,0.12	0.07 0.07,0.07	0.05 0.05,0.05	0.04 0.04,0.04				
	Epstein-Barr Virus 2003-2010, US-Born				Epstein-Barr Virus 2003-2010, Foreign-Born			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
MEP								
Continuous	0.24*** 0.16,0.32	0.07 -0.02,0.17	0.07 -0.03,0.16	0.07 -0.03,0.17	0.22** 0.08,0.37	0.12+ -0.02,0.26	0.10 -0.03,0.23	0.10 -0.05,0.26
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.40* 0.08,0.72	0.19 -0.13,0.50	0.17 -0.16,0.49	0.19 -0.15,0.54	1.03** 0.28,1.78	0.86* 0.12,1.61	0.85* 0.15,1.54	0.99** 0.32,1.66
Q3	0.64*** 0.34,0.95	0.23 -0.09,0.55	0.21 -0.12,0.54	0.20 -0.17,0.57	0.57 -0.15,1.29	0.30 -0.36,0.95	0.27 -0.36,0.89	0.30 -0.35,0.95
Q4	0.93*** 0.61,1.26	0.35+ -0.02,0.72	0.33+ -0.05,0.71	0.32 -0.08,0.72	1.12** 0.44,1.79	0.68* 0.09,1.26	0.61* 0.04,1.18	0.62+ -0.03,1.27
MnBP								
Continuous	0.15** 0.05,0.24	0.13* 0.03,0.24	0.13* 0.03,0.23	0.14* 0.03,0.26	0.04 -0.18,0.25	0.08 -0.13,0.29	0.07 -0.16,0.29	0.08 -0.16,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.07 -0.31,0.45	-0.01 -0.39,0.36	-0.02 -0.39,0.35	-0.06 -0.43,0.32	-0.63 -1.53,0.28	-0.96* -1.79,-.12	-0.95* -1.76,-.14	-0.70+ -1.46,0.05
Q3	0.41* 0.07,0.74	0.37* 0.04,0.71	0.36* 0.03,0.70	0.37* 0.02,0.72	-0.17 -1.03,0.69	-0.31 -1.15,0.53	-0.33 -1.15,0.49	-0.21 -0.96,0.54
Q4	0.37* 0.05,0.70	0.26 -0.08,0.60	0.25 -0.09,0.59	0.27 -0.08,0.62	-0.01 -0.69,0.66	-0.04 -0.72,0.65	-0.05 -0.75,0.65	0.10 -0.60,0.81

MiBP								
Continuous	0.17** 0.05,0.30	0.09 -0.02,0.19	0.08 -0.02,0.19	0.09 -0.03,0.21	0.07 -0.12,0.27	0.11 -0.09,0.32	0.12 -0.09,0.33	0.13 -0.06,0.32
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.07 -0.27,0.40	0.03 -0.31,0.38	0.02 -0.32,0.37	0.01 -0.36,0.37	-0.27 -1.10,0.55	-0.07 -0.75,0.61	-0.29 -0.92,0.35	-0.34 -1.15,0.48
Q3	0.36* 0.05,0.67	0.22 -0.10,0.54	0.22 -0.10,0.54	0.22 -0.11,0.54	0.74* 0.18,1.31	0.59+ -0.03,1.21	0.48 -0.15,1.11	0.47 -0.12,1.06
Q4	0.49** 0.16,0.82	0.28+ -0.02,0.59	0.28+ -0.02,0.59	0.30+ -0.03,0.63	0.21 -0.41,0.83	0.38 -0.25,1.01	0.29 -0.34,0.92	0.31 -0.29,0.90
∑ DBP								
Continuous	0.07 -0.02,0.16	0.11* 0.03,0.20	0.11* 0.02,0.19	0.12* 0.02,0.22	0.09 -0.10,0.28	0.15+ -0.03,0.32	0.15 -0.05,0.34	0.22* 0.03,0.42
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.17 -0.17,0.51	0.08 -0.24,0.39	0.05 -0.26,0.36	0.02 -0.31,0.36	-0.14 -1.02,0.73	-0.21 -1.02,0.60	-0.20 -0.99,0.59	0.03 -0.68,0.74
Q3	0.23 -0.16,0.61	0.25 -0.12,0.62	0.24 -0.13,0.61	0.26 -0.12,0.65	0.13 -0.47,0.74	-0.03 -0.78,0.71	-0.05 -0.77,0.67	0.10 -0.54,0.75
Q4	0.28+ -0.02,0.58	0.30+ -0.00,0.59	0.28+ -0.01,0.57	0.28+ -0.04,0.59	0.07 -0.68,0.82	0.26 -0.42,0.93	0.32 -0.35,0.99	0.55 -0.14,1.24
McPP								
Continuous	-0.06 -0.19,0.06	0.09 -0.04,0.22	0.10 -0.02,0.22	0.11 -0.02,0.24	0.06 -0.22,0.34	0.19 -0.09,0.48	0.17 -0.12,0.46	0.26+ -0.01,0.52
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.43** 0.13,0.73	0.50** 0.19,0.81	0.48** 0.16,0.80	0.53** 0.20,0.85	-0.16 -0.84,0.52	-0.19 -0.99,0.62	-0.22 -1.00,0.55	-0.09 -0.74,0.57
Q3	0.22 -0.04,0.49	0.38** 0.13,0.63	0.36** 0.12,0.61	0.33* 0.08,0.58	0.23 -0.50,0.96	0.18 -0.63,0.99	0.15 -0.66,0.97	0.35 -0.34,1.05
Q4	0.08 -0.21,0.36	0.42** 0.15,0.69	0.42** 0.15,0.69	0.46** 0.18,0.75	-0.43 -1.17,0.31	-0.14 -0.91,0.63	-0.16 -0.93,0.60	0.09 -0.60,0.79
MBzP								
Continuous	0.09* 0.02,0.17	0.11** 0.03,0.18	0.10* 0.02,0.18	0.11* 0.02,0.20	0.08 -0.10,0.25	0.12 -0.04,0.28	0.13 -0.06,0.31	0.20* 0.01,0.39
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.34+ -0.05,0.72	0.29 -0.09,0.67	0.31 -0.09,0.70	0.29 -0.12,0.70	-0.12 -1.12,0.88	-0.27 -1.16,0.62	-0.26 -1.13,0.61	-0.05 -0.81,0.70
Q3	0.31 -0.11,0.74	0.25 -0.18,0.67	0.24 -0.18,0.66	0.26 -0.16,0.69	0.27 -0.34,0.88	0.12 -0.55,0.79	0.12 -0.54,0.77	0.27 -0.38,0.91
Q4	0.38* 0.04,0.72	0.35* 0.00,0.70	0.34+ -0.01,0.69	0.33+ -0.05,0.71	0.10 -0.71,0.90	0.20 -0.45,0.85	0.24 -0.40,0.89	0.48 -0.20,1.15
∑ DEHP								
Continuous	0.06 -0.01,0.13	0.04 -0.04,0.12	0.04 -0.04,0.12	0.05 -0.03,0.13	-0.01 -0.21,0.20	0.01 -0.18,0.21	-0.01 -0.21,0.19	0.04 -0.15,0.23
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.08 -0.32,0.48	0.09 -0.29,0.48	0.07 -0.30,0.44	0.13 -0.22,0.47	0.15 -0.57,0.88	-0.02 -0.71,0.66	-0.07 -0.74,0.60	-0.18 -0.84,0.48
Q3	0.23 -0.08,0.54	0.23 -0.09,0.55	0.21 -0.11,0.53	0.18 -0.14,0.49	-0.18 -0.92,0.57	-0.29 -1.05,0.46	-0.52 -1.25,0.21	-0.50 -1.24,0.25
Q4	0.19 -0.08,0.46	0.19 -0.08,0.47	0.19 -0.08,0.46	0.25+ -0.01,0.52	-0.15 -0.96,0.66	-0.11 -0.84,0.62	-0.25 -0.94,0.44	-0.13 -0.81,0.55
MEHP								
Continuous	0.10* 0.01,0.19	0.01 -0.09,0.11	0.02 -0.07,0.12	0.03 -0.07,0.13	0.02 -0.16,0.20	0.01 -0.20,0.22	0.02 -0.21,0.24	0.04 -0.20,0.29
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	-0.08 -0.44,0.29	-0.10 -0.45,0.26	-0.11 -0.46,0.24	-0.05 -0.42,0.31	0.17 -0.53,0.87	-0.06 -0.71,0.59	-0.17 -0.81,0.47	0.05 -0.63,0.72
Q3	-0.12 -0.43,0.20	-0.15 -0.47,0.17	-0.15 -0.47,0.17	-0.14 -0.51,0.22	-0.09 -0.83,0.65	-0.12 -0.76,0.51	-0.34 -0.94,0.27	-0.11 -0.78,0.55
Q4	0.26 -0.06,0.58	0.06 -0.27,0.38	0.07 -0.26,0.40	0.14 -0.19,0.48	-0.05 -0.69,0.58	-0.22 -0.80,0.35	-0.28 -0.85,0.29	-0.14 -0.76,0.47
MEHHP								
Continuous	0.06+ -0.01,0.13	0.04 -0.04,0.11	0.04 -0.03,0.12	0.05 -0.02,0.12	-0.04 -0.25,0.17	-0.02 -0.21,0.18	-0.03 -0.23,0.17	0.01 -0.18,0.20
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.23 -0.15,0.61	0.23 -0.12,0.58	0.21 -0.13,0.55	0.27 -0.06,0.60	0.14 -0.58,0.85	-0.02 -0.73,0.69	-0.23 -0.94,0.48	-0.35 -1.11,0.41
Q3	0.38* 0.05,0.71	0.34+ -0.01,0.69	0.33+ -0.02,0.68	0.28 -0.07,0.63	-0.19 -0.93,0.55	-0.35 -1.09,0.38	-0.47 -1.19,0.24	-0.45 -1.20,0.30
Q4	0.26* 0.00,0.52	0.22 -0.04,0.48	0.21 -0.04,0.47	0.27* 0.02,0.53	-0.24 -1.04,0.57	-0.24 -0.97,0.49	-0.40 -1.09,0.29	-0.23 -0.91,0.45
MEOHP								
Continuous	0.06+ -0.01,0.13	0.04 -0.04,0.12	0.05 -0.04,0.13	0.05 -0.02,0.13	-0.03 -0.24,0.18	-0.00 -0.20,0.20	-0.02 -0.22,0.18	0.03 -0.17,0.22
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.36 -0.08,0.79	0.37+ -0.01,0.76	0.35+ -0.03,0.73	0.42* 0.04,0.80	0.41 -0.28,1.10	0.33 -0.33,0.99	0.09 -0.58,0.77	-0.04 -0.71,0.63
Q3	0.38* 0.07,0.69	0.36* 0.04,0.67	0.34* 0.03,0.65	0.29+ -0.03,0.62	-0.23 -0.99,0.52	-0.37 -1.14,0.39	-0.47 -1.22,0.28	-0.43 -1.19,0.33

Q4	0.31* 0.03,0.59	0.30* 0.01,0.58	0.29* 0.02,0.57	0.36* 0.09,0.64	-0.06 -0.83,0.71	-0.02 -0.71,0.67	-0.15 -0.81,0.52	0.02 -0.64,0.68
MECPP								
Continuous	0.05 -0.03,0.12	0.04 -0.05,0.12	0.04 -0.05,0.12	0.05 -0.03,0.13	0.03 -0.18,0.23	0.05 -0.16,0.25	0.02 -0.18,0.22	0.07 -0.13,0.27
Q1	reference	reference	reference	reference	reference	reference	reference	reference
Q2	0.19 -0.11,0.48	0.20 -0.10,0.51	0.18 -0.12,0.49	0.17 -0.13,0.47	-0.35 -1.19,0.50	-0.55 -1.30,0.21	-0.61 -1.37,0.15	-0.47 -1.28,0.33
Q3	0.26 -0.05,0.57	0.28+ -0.05,0.60	0.27+ -0.05,0.59	0.26 -0.07,0.59	-0.22 -1.11,0.67	-0.46 -1.24,0.31	-0.69+ -1.42,0.04	-0.63 -1.41,0.16
Q4	0.28* 0.02,0.53	0.29+ -0.01,0.58	0.28+ -0.02,0.57	0.29+ -0.00,0.58	-0.02 -0.82,0.79	-0.09 -0.82,0.64	-0.22 -0.91,0.46	0.04 -0.65,0.73

TABLE NOTES

Model 1 is the unadjusted association between the phthalate metabolite concentration and antibody titer. Model 2 is adjusted for demographics (sex, age, race/ethnicity, and income). Model 3 is adjusted for demographics (sex, age, race/ethnicity, and income) and health behaviors (cotinine levels and BMI). Model 4 is adjusted for demographics (sex, age, race/ethnicity, and income), health behaviors (cotinine levels and BMI), and immune health status (CRP).

Phthalate metabolites were Log10 transformed. Analyses were run with a 1) phthalate concentration as a continuous measure and 2) phthalate metabolites broken into quartiles. Quartile 1 is reference category for quartiles 2, 3, and 4. Significance assessed at + $p < 0.1$, * $p < 0.05$, ** p < 0.01, and *** p < 0.001. Sample sizes vary by phthalate metabolite.

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