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Does Empowerment Predict Vaccine Uptake?
Identifying Early Adopters of Recently-Introduced
Childhood Vaccines in Malawi

A thesis submitted in partial satisfaction
of the requirements for the degree Master of Science
in Community Health Sciences

by

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ABSTRACT OF THE THESIS

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The Human papillomavirus (HPV) vaccine was introduced to Malawi to reduce the high rate of cervical cancer mortality among Malawian women. This thesis analyzed 2015-16 Malawi Demographic and Health Survey data collected from currently married or partnered women ages 15-49 to identify characteristics associated with adoption of two recently-introduced childhood vaccines (rotavirus and pneumococcal), which served as a proxy for the HPV vaccine. Multivariate logistic regression was conducted to identify early adopters who had vaccinated their youngest child against rotavirus and pneumococcal infection. The results of my analyses show that women's empowerment, assessed through participation in family decisions and attitudes towards violence, women's exposure to media, and women's employment status were positively associated with adoption of both the rotavirus and pneumococcal vaccines. Identifying

which Malawian women are less likely to vaccinate their children could inform specialized interventions designed to reach these sub-populations. Identifying determinants of vaccine adoption is an important step towards improving HPV vaccine uptake and ultimately reducing cervical cancer mortality in Malawi.

The thesis of Kimberly Clair is approved.

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INTRODUCTION

Malawi has the highest incidence of cervical cancer in the world (Campbell et al. 2016). Each year, approximately 3,684 Malawian women are diagnosed with the disease, 80% of whom will die prematurely due to cervical cancer (Maseko et al., 2015:2; Fort et al., 2011:125). Cervical cancer can be prevented by protecting sexually active women from Human papillomavirus (HPV), including through vaccination. Two brands of the vaccine, *Gardasil*® and *Cervarix*®, have proven 95% efficacious in preventing infection from the most high-risk type of HPV: strains 16 and 18 (Cutts et al., 2007; Perlman et al., 2014). From 2013-2016, a pilot demonstration that took place in two districts in Malawi successfully vaccinated 26,766 in-school girls aged 13 following informed written consent obtained from caregivers, resulting in over 80% coverage (Mysyamboza et al., 2017). Following this small-scale pilot demonstration, the Malawi Ministry of Health launched a national HPV vaccine campaign in January 2019 that aims to vaccinate a cohort of 240,000 girls aged 9 across the country before expanding to include 1.5 million girls ages 9-14 (Magombo-Mana, 2019). Vaccinating girls before they become sexually active may help reduce the spread of HPV, which can in turn reduce cervical cancer mortality in Malawi.

Although the HPV vaccine is provided at no cost through this government rollout, it remains unclear whether Malawian families will take advantage of the opportunity to vaccinate their daughters. Previous studies in sub-Saharan Africa have shown that limited knowledge about cervical cancer, as well as concerns about the vaccine's side effects may discourage uptake of the HPV vaccine (Vermandere et al., 2014). Malawian families may also have concerns about the fact that the HPV vaccine targets young girls, aims to prevent a sexually transmitted disease, and requires more than one dose in order to be effective. Similar concerns have emerged in other

settings, including the United States (Sipp et al., 2018). However, because the HPV vaccine is new to Malawi, little is known about whether such attitudes, behaviors, or characteristics among Malawian families will be associated with uptake of the HPV vaccine. This thesis aims to identify whether Malawian women's health service utilization and empowerment are positively associated with uptake of other recently-introduced vaccines, which will serve as a proposed proxy for their willingness to uptake the HPV vaccine.

Preventing Cervical Cancer in Malawi

Sub-Saharan Africa has the highest cervical cancer rates in the world, and rates are projected to increase within the next twenty years (De Vuyst et al, 2013; Denny, 2013). To prevent new cases from occurring, the World Health Organization (WHO) published a guidebook on cervical cancer control with recommended approaches for governments and health agencies. Vaccinating girls ages 9-13 with at least two doses of the HPV vaccine is recommended as a primary prevention strategy (WHO, 2014). For secondary prevention, women aged 30 and older are encouraged to receive cervical cancer screenings, which can detect the presence of precancerous cells. Countries with available screening have seen a reduction in cervical cancer incidence rates by as much as 80% (American Cancer Society, 2012: 26). At the tertiary level of prevention, community mobilization, health education, and counselling are recommended to increase awareness about cervical cancer among community members (including parents, educators, health professionals, and leaders), which may in turn increase rates of cervical cancer screening and vaccination. Since almost all cases of cervical cancer are attributable to HPV infection (Sankaranarayanan, Qiao & Keita, 2015; De Martel et al., 2017), promoting awareness of cervical cancer, HPV, and safe sex behaviors are recommended to prevent the spread of HPV. Finally, the guide recommends addressing poverty, gender

inequality, and barriers to accessing health facilities, which also impact women's ability to effectively prevent and/or treat cervical cancer.

Cervical Cancer Screening

In the last decade, Malawi has seen an increase in the number of cervical cancer deaths—a pattern also observed in other developing countries (Maseko et al., 2015:2). Since 2004, the Malawi Ministry of Health has implemented a national Cervical Cancer Control Programme (CECAP), which focuses primarily on promoting cervical cancer screenings among eligible women (United Nations Population Fund [UNPFA], 2017). In low or middle-income countries (LMICs), the World Health Organization recommends a “screen-and-treat” or a “screen, diagnose, and treat” approach (WHO, 2019). In Malawi, visual inspection with acetic acid (VIA) is used to offer detection of precancerous cells on the cervix, followed immediately with cryotherapy, or loop electrosurgical excision for removal of these cells (Fort et al., 2011: 125-26; Campbell et al., 2016: 908). However, successfully implementing cervical cancer screening programs has been a challenge due to a lack of available trained health personnel, medical supplies, and access to facilities (Maseko et al., 2015: 2). For treatment using cryotherapy, inconsistent gas supplies, malfunctioning machines, and the costs of running and transporting equipment have also interfered with delivery of screening services (Campbell et al., 2016). An analysis of data collected by the Malawi Cervical Cancer Control Programme (2011-2015) found that only 43.3% of 2,311 women who were referred for treatment following VIA actually received treatment, primarily as a result of malfunctioning or missing cryotherapy machines (Msyamboza et al., 2016: 1).

Additional barriers to cervical cancer screening uptake among Malawian women include difficulty accessing transportation to visit and/or return to healthcare facilities; failure to obtain a

referral for screening; low public awareness about the relationship between screening and treatment procedures; and failure to obtain permission from one's husband to return for follow-up care (Fort et al., 2011; Kunckler et al., 2017). Although Malawi saw an increase in the number of women who had ever been screened for cervical cancer (from 14% in 2012 to 27.3% in 2015), the coverage rate continues to fall below the targeted rate of 80% (UNPFA, 2017: 25).

Vaccination

As a primary prevention strategy, vaccinating Malawian girls before they become sexually active can eliminate many of the aforementioned challenges. National immunization programs that include vaccinations against HPV 16 and 18 infections have been introduced in more than 60 countries (Sankaranarayanan, Qiao & Keita, 2015). However, the high cost of the vaccine, misinformation about the side effects and effectiveness of the vaccine, and problems with service delivery have hampered efforts to implement such programs in low resource settings (Sankaranarayanan, Qiao & Keita, 2015: 203). The vaccine's multiple dose requirement can also interfere with successful coverage. In LMICs, it is recommended that girls receive two doses of HPV over a 2-year period, with an interval of at least 6 months and no more than 12 months between each dose (Sankaranarayanan, Qiao & Keita, 2015). Achieving successful coverage of the HPV vaccine can be considerably more challenging than for one-time, one-shot vaccinations, such as the measles-rubella or yellow fever vaccines (World Health Organization [WHO], 2016: 10). However, some studies have suggested that receiving only one dose of bivalent HPV vaccine may sustain antibody responses for up to four years following vaccination (Kreimer et al., 2015; Sankaranarayanan et al., 2018).

In Malawi, the Global Alliance for Vaccines and Immunization (GAVI) has helped reduce the cost of the HPV vaccine and supported the 2013-16 pilot demonstration project,

which was carried out in Rumphu (Northern Malawi) and Zomba (Southern Malawi) (UNFPA, 2017). Although this pilot project achieved a coverage rate of 90% for both districts, coverage was substantially lower for girls who received vaccinations from a health facility compared to girls who received school-based delivery (Msyamboza, 2017; UNFPA, 2017). In addition, school-based delivery resulted in vaccination of girls outside of the recommended age range (both younger than 9 and older than 14), resulting in an inappropriate use of limited resources (vaccines) and may have interfered with vaccine effectiveness, since a 3-dose schedule is recommended for girls ages 14 and older (Msyamboza, 2017: 5).

Uptake of the HPV vaccine is influenced by multiple factors, including individual knowledge and awareness of the vaccine, attitudes towards the vaccine, and perceived benefits of and barriers to adopting the vaccine. HPV awareness has been defined as having ever heard of HPV or “a shot to prevent cervical cancer,” while HPV knowledge includes an accurate understanding of the relationship between HPV and cervical cancer, modes of HPV transmission, and HPV treatment methods (Allen, 2010; Francis et al, 2011; Morales-Campos & Vanderpool, 2017). A systematic review of HPV acceptability and related factors among African adults reported considerable variations in HPV-related knowledge and consistently low levels of HPV awareness (Cunningham, Davison & Aronson, 2014). Similarly, a systematic review of findings from 13 sub-Saharan African countries (excluding Malawi) found low levels of knowledge and awareness of cervical cancer, HPV, or the HPV vaccine (Perlman et al., 2014). Low knowledge/awareness of HPV has been identified in Uganda (Katahoire et al., 2008), Tanzania (Remes et al., 2012), Botswana (DiAngi et al., 2011), Mali (De Groot et al., 2017), and Nigeria (Bisi-Onyemaechi et al. 2018).

The decision to vaccinate one's daughter is also influenced by perceived severity of cervical cancer, perceived susceptibility to cervical cancer, the belief that vaccination reduces the risk of cervical cancer and/or provides other health benefits, and a perceived absence of barriers to taking preventative action (Vermandere et al., 2016). Perceived benefits of HPV vaccine uptake include protection against future HPV infection and/or protection against cervical cancer and promotion of girls' reproductive health (Francis et al., 2011). The perceived barriers to HPV vaccine uptake among families in sub-Saharan Africa include concerns about the cost of the vaccine, difficulties finding or accessing health facilities, perceived risks associated with receiving the vaccine, and concerns about the vaccine's safety and/or effectiveness (PATH, 2009; Becker-Dreps, 2010; Coleman, 2011; DiAngi, 2011; Francis et al., 2011; Bisi-Onyemaechi et al. 2018). These perceived barriers intersect with self-efficacy, which, in the context of HPV vaccine uptake, refers to a family's perceived ability to make decisions about their daughter's health and to act on these decisions. In sub-Saharan Africa, decisions about child health, including vaccinations, are typically considered a mother's responsibility (Ports, 2013). However, women's perceived ability to act on these types of decisions is associated with a number of factors related to women's "autonomy" or "empowerment"—such as needing approval from her husband/partner. A study on HPV vaccine acceptability in Kenya found that perceived disapproval of the HPV vaccine from husbands/partners lowered women's acceptability of the HPV vaccine for their daughters (Vermandere et al., 2014).

Despite low levels of HPV-related knowledge and awareness, research has consistently shown that HPV vaccine acceptability—willingness and intention to vaccinate—is high among parents in sub-Saharan Africa and is influenced by the degree to which trusted community members support or oppose HPV vaccination (Coleman, 2011; Francis et al., 2011; Cunningham,

Davison & Aronson, 2014). For example, a systematic review of HPV vaccine knowledge, awareness, acceptability, and willingness to vaccinate found high levels of acceptability in 12 of the 13 sub-Saharan African countries evaluated, with some countries achieving HPV vaccine coverage rates above 90% (Perlman et al., 2014). HPV vaccine acceptability among parents has been associated with having a recommendation from a healthcare provider (Francis et al., 2010; Makwe et al., 2012; Ports et al., 2013) or from the government (Remes et al., 2012). Favorable attitudes of community members towards the HPV vaccine was also associated with HPV vaccine acceptance in Uganda, Nigeria, and Ghana (Iliyasu et al., 2010; Katahoire et al., 2008; Coleman et al., 2011). Additionally, the views of school officials, health workers, and political leaders have been shown to influence parents' HPV vaccination decisions (PATH, 2009: 18).

Social norms and attitudes concerning girls' sexuality may act as additional barriers to HPV vaccine uptake. Fears that the HPV vaccine would encourage sexual promiscuity among girls has influenced HPV vaccine acceptability among parents in Uganda and Nigeria (Ezeanochie & Olagbuki, 2014: 154) and among male teachers in Tanzania (Remes et al., 2012). In the HPV vaccine pilot demonstration project that took place in Rumpha and Zombi (Malawi), researchers found that the belief that the HPV vaccine was "not good for girls" contributed to vaccination refusals (Msyamboza et al., 2017:3). Interpersonal relationships, media, policies, and institutional/health-systems factors also influence individual attitudes towards and decisions about the HPV vaccine (Allen, 2010: 4034). In addition, prior experience with immunization may impact acceptability. Vaccine acceptability among parents in Malawi was linked to having previously vaccinated one's child and having a positive experience (Ports et al., 2013) while in Uganda, HPV vaccine acceptability was correlated with perceived effectiveness of previously received vaccines (Katahoire, 2008).

THEORETICAL FRAMEWORK

This thesis is grounded in the theory of “diffusion of innovation” (Rogers, 1983), which is concerned with the processes associated with adoption or rejection of a new idea, practice, or object (Rogers, 1983: 11). Diffusion is defined as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 1983: 6). For Rogers, diffusion differs from other types of communication in that it involves a new idea, practice or object, and, as a result, brings uncertainty about the innovation’s anticipated consequences (Rogers, 1983: 7). The process of deciding whether to adopt or reject the innovation involves a complex interaction of individual, interpersonal, and societal/environmental factors. Rogers identifies five steps in the innovation-decision process at the individual-level, including 1) knowledge of the innovation’s existence and functions, 2) persuasion, or, the formation of a favorable or unfavorable attitude toward the innovation, 3) decision, or activities that lead to the adoption or rejection of the innovation, 4) implementation, or utilization the innovation to use, 5) confirmation (and potential reversal of) one’s previous decisions regarding the innovation (Rogers, 1983: 20-21).

Rogers examines the relative rate of adoption, an individual’s social status, and the and communication systems available in a particular social system to develop “adopter categories,” which help describe an individual’s attitudes towards “innovativeness,” or, the degree to which an individual is early in adopting innovations relative to other members of the social system (Rogers, 1983: 22). At the earliest end of the spectrum are “innovators,” who have a high degree of exposure to new information (either through media or social/informal networks), are active information-seekers, and have a higher tolerance for uncertainty than individuals at other ends of the adoption spectrum (Rogers, 1983: 22). Others have identified innovators as risk-takers who

are typically more educated, cosmopolitan, and have a higher degree of appreciation for technology than their peers (Haider & Kreps, 2004; Kaminski, 2011). Additional adopter categories include early adopters, early majority, late majority, laggards, and non-adopters. Laggards and non-adopters, who are skeptical or suspicious of innovations, are theorized to have lower education and weaker peer-network connections than adopters (Rogers, 1983: 292; Haider & Kreps, 2004).

Rogers has identified key differences between early adopters and later adopters with respect to socio-economic status, personality traits, and communication behaviors (Rogers, 1983: 279). Early adopters tend to have more years of education, higher levels of literacy, higher socio-economic status, and greater degree of upward social mobility compared to late adopters (Rogers, 1983: 279). Earlier adopters may also have greater tendency towards empathy, a greater ability to deal with abstractions, a positive attitude towards change, and higher achievement motivation (Rogers, 1983: 279; Haider & Kreps, 2004). In contrast, late adopters are characterized by lower levels of education, lower social status, and lower utilization of mass media channels compared to early adopters. Late adopters may be forced to adopt an innovation due to social or economic pressures and, as a result, are more likely to discontinue utilization of an innovation (Rogers, 1983: 188). With respect to communication, Rogers suggests that early adopters find mass media channels more important than interpersonal communication while for later adopters, the immediacy of interpersonal networks has a greater influence over the decision to adopt or reject an innovation (Rogers, 1983: 201). Early adopters are also more likely to engage in active information-seeking, have greater knowledge of innovations, and belong to interconnected social systems compared to late adopters (Rogers, 1983: 270).

Additional factors that influence the innovation-decision process include the relative advantage of an innovation over a previous idea, practice, or product; the compatibility of the innovation with an individual's values, beliefs, and past experiences; the degree of complexity, or perceived difficulty in understanding or using the innovation; "trialability"—the degree to which an innovation may be experimented with on a limited basis; and observability, or, the degree to which the results of an innovation are visible to others (Rogers, 1983: 15). These factors are considered the strongest predictors of an individual's intention to adopt an innovation (D'Souza et al., 2013).

Theories of diffusion of innovation may be modified by the particular characteristics of an innovation and/or the environment in which an innovation is introduced. For example, Rogers has suggested that innovation decision-making and adoption behaviors may differ for "preventive innovations," or innovations that aim to avoid the potential occurrence of an unwanted future event, such as a natural disaster (Rogers, 1983: 171). Because the unwanted event may occur regardless of whether the innovation is adopted, an individual's uncertainty is likely to be higher and the rate of adoption is likely to be slower (Rogers, 1983: 171). The reward of adopting a preventive innovation may be delayed, intangible, and have a lower relative advantage than non-preventive innovations (Rogers, 2002: 991). Increasing the rate and frequency of adoption for a preventive innovation requires a different set of strategies (Rogers, 2002: 992).

The role of "opinion leaders" may be enhanced in instances of preventive diffusion. For Rogers, an opinion leader is an innovator who frequently influences other individuals' attitudes and/or behavior such that "the success or failure of diffusion programs rests in part on the role of opinion leaders" (Rogers, 1983: 27). First, opinion leaders may be able to lower levels of

uncertainty or perceived risk, which are typically higher for preventive innovations or innovations about which little is known (Rogers, 1983: 168). Second, opinion leaders can add nuance and personalized information to the “one-size-fits-all” approach that often characterizes mass media campaigns, making information about an innovation more relevant to members of the opinion leader’s peer or community group (Rosen & Goodson, 2014: 44). According to Rogers, opinion leaders are able to appeal to the affective dimension of the innovation-decision process by helping individuals form an attitude or feeling toward a particular innovation (Rogers, 1983: 170). Third, by occupying an intermediary role within a large social network, opinion leaders may facilitate communication across diverse social groups. A study of U.S.-based school nurses found that nurses were well-positioned to disseminate information about the HPV vaccine to students, in part because of their ability to act as liaisons for families, school staff, healthcare professionals and communities (Rosen & Goodson, 2014: 44). Fourth, opinion leaders can help ensure maintenance of an adopted behavior. In Malawi, women who had continual contact with health workers and were able to discuss the benefits of the intervention with these opinion leaders both adopted and maintained a chlorine water treatment intervention (Wood et al., 2012).

Criticisms of diffusion research point to its reliance on generalizations, its underlying “pro-innovation” bias, its potential for recall bias, its emphasis on individual-level behaviors, and issues with equality (Rogers, 1983: 91; Haider & Kreps, 2004: 7). The “pro-innovation” bias refers to the assumption that innovations are inherently “good,” associated with progress, improvement, or other positive or socially desirable qualities. This assumption not only overlooks the possibility of “bad” or harmful innovations; it also tends to reduce the complex ways in which individuals interact with innovations into a dichotomy of adoption/rejection (Haider & Kreps, 2004: 7). Diffusion research has also been criticized for its reliance on

individual recall to identify the timing of innovation adoption, which increases the likelihood of measurement bias (Rogers, 1983: 113). In addition, diffusion research has been criticized for examining individual decision-making processes and behaviors without sufficient attention to the social and political systems in which individuals operate. Marketing research has suggested attention to three domains: individual users, the community of users, and the innovating industry or market (MacVaugh & Schiavone, 2010: 206). Others have suggested that diffusion research pays insufficient attention to the socio-political consequences of innovation-stratification, in which social divisions based on wealth and education may be reified or magnified (Haider & Kreps, 2004: 7).

Effects of Empowerment on Innovation Adoption

While certain individual characteristics may prove useful for predicting uptake of a health innovation, these factors cannot be analyzed separately from the broader socio-political environment, which determines individuals' exposure to information, ability to access innovations, and ability to act on the decision to take up an innovation. For this reason, studies of women's decision-making processes and behaviors must attend to issues of gender inequality. Gender inequality has been defined as systematic discrimination against women and girls that creates disadvantages in economic status, educational attainment, health outcomes, and other aspects of human development and significantly constrains women's and girls' capabilities and opportunities (UNDP, 2019). Efforts to identify and evaluate gender equality in relation to women's health service uptake behaviors have relied on concepts such as "empowerment," "autonomy," or "agency" (Malhotra, Schuler & Boender, 2002). This thesis uses the term "empowerment" to refer to a range of factors influencing women's ability to make and act on informed decisions.

Empowerment remains a challenging concept to define, quantify, and measure. Social science researchers have defined empowerment as an ability to make choices, a function of women's economic decision-making power, and a measure of "achievements," including educational attainment, literacy, employment, and exposure to mass media (Kabeer 1999; Anderson & Eswaran, 2009). Empowerment has also been linked to women's social inclusion, as marked by their participation in civil society and kinship networks, and their ability to alter power dynamics or remove constraints that adversely impact their health and well-being (Malhotra, Schuler & Boender, 2002). Self-determination, self-confidence, and self-efficacy—the perceived ability to act on one's knowledge and attitudes—have also variously factored into measures of empowerment, suggesting that researchers conceptualize "empowerment" as a dynamic process rather than a fixed position (Asaolu et al., 2018).

To measure women's empowerment, studies typically rely on composite measures that address economic, socio-cultural, familial/interpersonal, legal, political, and psychological dimensions of women's lives (Malhotra, Schuler & Boender, 2002). For example, Kabeer suggests viewing empowerment as a combination of resources (a reflection of a woman's pre-existing socio-economic standing), agency (a woman's ability to pursue her personal life goals), and achievements (Kabeer, 1999: 437-438). For Kabeer, agency refers not only to the authorial decision-making power associated with community leaders and household heads but also an internalized "sense" of power—that is, the ability to "define one's goals and act upon them" (Kabeer, 1999: 438). The 2015-16 Malawi Demographic and Health Survey identifies women's employment and control over earnings, ownership of property, participation in major household decisions, and attitudes towards wife beating as indicators of women's empowerment (NSO, 2017: 251). To create consistency across analyses of empowerment using DHS data from Africa,

the Survey-Based Women's Empowerment (SWPER) Index was developed and consists of three domains: women's attitudes towards violence, social independence, and decision-making power (Ewerling et al., 2017). However, subsequent factor analyses have suggested that only attitudes toward violence, access to healthcare, and labor force participation are consistently relevant indicators of empowerment in African countries (Asaolu et al., 2018). The Malawi DHS measures women's decision-making power in relation to their participation in four different types of decisions: the respondent's healthcare, making large household purchases, visiting family or relatives, and spending money the husband/partner earned (NSO, 2017). Quantitative studies on Malawian women's empowerment have operationalized these variables in different ways, such as selecting only those variables that identify women's participation in economic decisions (Chol et al., 2019) or integrating these variables into a larger empowerment index (Palamuleni & Adebawale, 2014).

Despite significant variation in definitions of empowerment and resulting measurement processes, empowerment—as a reflection of the economic, social, and psychosocial constraints that impact women's decision-making around, and potential uptake of, an innovation—remains a significant component in women's adoption of new health technologies. In sub-Saharan Africa, empowerment has been shown to influence women's decision-making processes and uptake behaviors for maternal and child health services and childhood vaccinations. In Botswana, respondents who thought they would be involved in the decision to vaccinate their daughters against HPV were more than twice as likely to express HPV vaccine acceptability than those who thought they would not be involved in the decision-making process (DiAngi et al., 2011). Although women are often considered to be responsible for child's health, fathers with more authority in the home may have the final say on child immunization (PATH, 2009: 18). Analyses

of data from 31 sub-Saharan African countries found that women’s autonomy—defined as women’s attitudes towards sexual and domestic violence and women’s participation in financial and household decisions—was associated with utilization of maternal healthcare services (Chol et al., 2019).

In Malawi, gender inequality persists within women’s marital and sexual relationships, educational attainment, economic activity, and political participation. Malawian women face high rates of gender-based violence, with 34% of women having experienced physical violence since age 15 (NSO, 2017). Malawian women also have lower literacy, wage equality, and political participation compared to men (United States Agency for International Development [USAID], 2018). Among adult Malawian women, only 16.7% have at least a secondary education compared to 25.4% of adult Malawian men (UNDP, 2018). In the United Nations Development Programme 2017 Gender Inequality Index, which measures women’s reproductive health, education, political participation, and labor market participation, Malawi ranked 148 out of 160 countries (UNDP, 2018). Nevertheless, these indicators may not fully capture women’s subjective experiences of negotiating unequal power relationships within their daily lives (Masset, 2015). Examining empowerment through quantitative measures alone is likely to produce an incomplete picture of Malawian women’s relationships to power.

JUSTIFICATION OF STUDY VARIABLES

Although there is no known published information on predictors of HPV vaccine uptake among Malawian families, diffusion of innovation theory suggests that the adoption of this health innovation may be associated with certain socio-demographic characteristics (education, wealth, and employment), greater access to information, greater access to and familiarity with related health technologies, and indicators of women’s empowerment. To identify factors associated

with uptake of the HPV vaccine, a new health technology, my analysis of DHS data incorporates variables associated with utilization of other new health technologies and services, women's empowerment, and women's socio-demographic characteristics.

Vaccine Adoption

Because the HPV vaccine is new to most Malawians, studies examining uptake of other recently-introduced childhood vaccines—such as the pneumococcal conjugate (PCV13) and monovalent human rotavirus (RV1) vaccines—may be a unique source of insight for estimating factors that might be linked to HPV vaccine uptake. PCV13 and RV1 are the most recent introductions to Malawi's national immunization program (November 2011 and October 2012, respectively) (NSO, 2017: 143). Like the HPV vaccine, both RV1 and PCV13 require multiple doses. A recent analysis of 2015-16 MDHS data used uptake of RV1 and PCV13 as an outcome variable to identify socio-demographic characteristics of Malawian families associated with full vaccination. In this study, “uptake” was defined as children ages 12-35 months who, prior to turning 1 year old, had received all three doses of PCV13 or the full two doses of RV1 (Ntenda et al., 2018: 3). The study found that, compared to children from the Southern region, the odds of PCV13 uptake were higher for children from the Northern region and slightly lower for children from the Central region while differences observed in RV1 uptake were not statistically significant (Ntenda et al., 2018: 7-9). Women who did not attend a baby postnatal care check two months after birth and women with no education were also significantly less likely to have vaccinated their child with either RV1 or PCV13 (Ntenda et al., 2018). In addition, women with low levels of media exposure were significantly less likely to achieve uptake of PCV13 compared to women with high media exposure in the unadjusted regression analysis (Ntenda et al., 2018).

Some research has explored determinants of basic childhood vaccination in Malawi (one dose of the tuberculosis vaccine, three doses of the polio vaccine, one dose of the measles vaccine, and three doses of the vaccine against diphtheria, pertussis, and tetanus) (NSO, 2017: 142). Young children (12-23 months) from rural areas were more likely to have received all basic vaccinations than children in urban areas, and children were more likely to have received vaccinations if their mother had a secondary education or higher compared to no education (NSO, 2017: 143). However, in Malawi, the majority of these vaccines have been available to families since 1979 through the Expanded Programme on Immunization (EPI) (Munthali, 2007). For this reason, RV1 and PCV2 are more appropriate substitutes for the HPV vaccine.

Health Service Utilization

According to diffusion of innovation theory, a major barrier to adoption is an individual's uncertainty about an innovation, which may be marked by a lack of knowledge of or experience with products or services related to a particular innovation. For Rogers, compatibility, or "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters," significantly influences decision-making processes around innovation adoption as well as the rate of adoption (Rogers, 1983: 15). With respect to health innovations, the compatibility aspect of innovation adoption suggests that individuals who have prior experience accessing health services and utilizing available health technologies are more likely to be "early adopters" of a newly introduced vaccine than those who are less familiar with, and more uncertain about, related health services. This logic informed my development of a health service utilization index, which aimed to distinguish individuals with prior experience utilizing and accessing maternal, newborn and child health (MNCH) services from those with lower levels of MNCH service access and uptake.

Within quantitative analyses of DHS data, studies of MNCH service utilization have examined uptake of antenatal care, postnatal care, delivery of one's child at a hospital or clinic that offers basic essential obstetric care services ("facility delivery"), and having the assistance of a skilled birth attendant or qualified doctor during delivery ("skilled delivery") as indicators of adequate use of MNCH services (Fotso et al., 2009). To improve safe delivery among women in LMICs, the World Health Organization recommends at least four ANC visits occurring between 8 and 12 weeks of gestation, between 24 and 26 weeks, at 32 weeks, and between 36 and 38 weeks—commonly referred to as the Focused ANC model (WHO, 2016: 86). However, uptake of ANC care remains low across sub-Saharan Africa, particularly among poor and rural households (Kuuire et al., 2017). An analysis of Malawi DHS data found that women were less likely to receive the recommended four ANC visits in 2013 compared to 2000 (Kuuire et al., 2017). Use of informal obstetric services, such as an unqualified birth attendant, and delivering outside of a health facility have been associated with increased risk of maternal morbidity and mortality (Essendi et al., 2011; Anyait et al., 2012). In contrast, women who utilize ANC services are more likely to be exposed to information on optimal breastfeeding and newborn care practices, which can drastically improve child health (Moran et al., 2009; Kimani-Murage et al., 2016).

This index also included an assessment of women's ability to access health services. In the Malawi DHS survey, women were asked whether accessing medical treatment would be difficult based on their knowledge of where to go, reluctance to go alone, distance to a facility, and need for permission and/or money for treatment (NSO, 2017). In Malawi, difficulty accessing transportation and obtaining permission from one's husband/partner have been identified as barriers to uptake of cervical cancer services (Fort et al., 2011; Kunckler et al.,

2017), while male control over household decisions and resources has also been shown to reduce women's uptake of obstetric services in Ghana (Story et al., 2016).

Finally, this index included women's adoption of modern contraceptives as an indicator of familiarity and prior experience with a relatively new health technology. In 1992, the modern contraceptive prevalence rate among married Malawian women of reproductive age was only 7.4% (NSO, 2017: 93). With the development of a national family planning policy in the late 1990s, which expanded family planning services, Malawi has seen a steady increase in modern contraceptive use among currently married women. In 2015-16, 59% of currently married women ages 15-49 were found to use some form of contraception, with almost all of them using modern contraception¹ (NSO, 2017: 94).

Quantitative analyses of modern contraceptive use in Malawi have identified significant associations with many of the characteristics Rogers identifies among "early adopters," including higher education and wealth and greater exposure to media. An analysis of 2010 Malawi DHS data found that women who belong to the richest wealth quintile were more likely to currently use or have ever used modern contraception compared to Malawian women in the lowest wealth quintile (Adebowale et al., 2014). In an analysis of 2015-16 MDHS data, women who were older than 19, women from the Southern or Central regions, women who were currently or formerly married, women with primary or secondary education, women who were currently employed, and women who had visited a health facility in the last 12 months had significantly higher odds of modern contraceptive uptake than their counterparts (Mandiwa et al., 2018). Among teen mothers in Malawi, utilization of other health services, including antenatal care, and exposure to

¹ The Malawi DHS report defines "modern contraceptives" as injectables, intrauterine devices (IUDs), contraceptive pills, implants, male/female condoms, male/female sterilization, the standard days method, lactational amenorrhea, or emergency contraception (NSO, 2017: 94). However, most studies that analyze MDHS data adopt a stricter definition.

media were found to predict modern contraceptive use (Machira & Palamuleni, 2017). Other predictors of modern contraceptive use in Malawi include respondent's and partners' approval of family planning and having a family planning discussion with one's partner (Palamuleni, 2013).

Empowerment Indicators

As noted above, empowerment is an important component of women's decision-making processes around, and adoption of, innovative health technologies. Despite having adequate information about and favorable attitudes towards a health innovation, women who need to consult with or seek permission from their husbands/partners may be unable to act on their willingness to adopt a new health technology. A systematic review of studies in low-resource countries found that quantitative measures of empowerment were positively associated with women's uptake of maternal and child health services, including antenatal care, skilled attendance at birth, contraceptive use, and full vaccination of children, with economic empowerment, health empowerment, and social empowerment among the most commonly used indicators (Pratley, 2016). Similarly, a systematic review of studies on child immunization in South Asia and Africa found that women's agency, which commonly included decision-making ability and financial control, was positively associated with complete vaccination of children (Thorpe et al., 2016).

Research on empowerment and reproductive health service utilization suggests that there may be an interaction effect between women's use of contraceptives and decision-making power within the family. For example, despite high knowledge and awareness of modern contraceptives reported among reproductive-aged women in Ghana, uptake was low and was positively associated with receiving consent and support from husbands/partners (Beson, Appiah & Adomah-Afari, 2018). In Ethiopia, women who had communicated with their husbands about

family planning were 2.58 times more likely to use modern contraceptives compared to women who had not (Debebe, Andualem & Biadgo, 2017). Malawian women who use Long Acting and Permanent Contraceptives Methods (LAPCM) were found to have higher empowerment scores—an index that included women’s educational attainment, work status, ability to refuse to have sex with partner(s), and perception of ability to ask their partner to use condom (Palamuleni & Adebawale, 2014: 64). Women were allocated points for each domain of empowerment; these points were then summed and categorized into four groupings: not empowered, poorly empowered, fairly empowered, and highly empowered (Palamuleni & Adebawale, 2014: 66). Similarly, a multilevel analysis of 32 sub-Saharan countries found that women’s empowerment was positively associated with whether women had ever used contraception (Yaya et al., 2018). In this study, empowerment was defined by current employment status, attitudes towards violence against women, ability to participate in decisions regarding household expenses and the respondents’ healthcare, and a knowledge index consisting of educational level and exposure to media.

Women’s perceptions towards violence against women have also been operationalized as an indicator of empowerment (Pratley, 2016). In an analysis of 2015-16 DHS data in Malawi, attitudes that accept violence against women were more common among both women and men in rural areas compared to urban areas and among women with lower levels of education (NSO, 2017: 257). An analysis of Eritrean DHS data found that the belief that violence against women was justified was positively associated with having never used modern contraceptives (Woldemicael, 2008).

This study examines women’s empowerment through an index of decision-making power and women’s attitudes towards violence. Although women’s exposure to media, women’s

employment status, and women’s educational levels have been incorporated into composite measures of empowerment, this study examined media exposure as one of several socio-demographic characteristics (i.e., access to information) hypothesized to predict innovation adoption according to diffusion of innovation theory. Employment status, education, wealth, and husband/partner’s education were also included within women’s socio-demographic characteristics to test whether these particular traits, hypothesized as characteristics of “early adopters,” were associated with uptake of recently-introduced childhood vaccines. Table 1 identifies variables used from the Malawi DHS to evaluate women’s health service utilization, empowerment, and socio-demographic characteristics.

Table 1. Justification for selection of study variables

Theoretical Construct	Dimensions	MDHS Variables
"Compatibility"	Prior experience with an innovation Favorable attitudes towards an innovation	<i>Health service utilization index</i> Modern contraceptive use Antenatal care visits (≥ 3) Postnatal care check Facility delivery No problem accessing medical care
"Empowerment"	Ability to make decisions and affect outcomes Ability to control resources and life options Self-efficacy	<i>Decision-making power</i> Respondent's healthcare Large household purchases Visiting friends / relatives Attitudes towards violence
"Early adopter" characteristics	Participation in social/economic life Access to information	Maternal education Husband/partner's education Employment status Wealth <i>Media exposure</i>

* *Index constructed from existing DHS variables*

RESEARCH QUESTIONS

This thesis aims to address the following hypotheses using data collected from the 2015-16

Malawi Demographic and Health Survey:

Hypothesis 1: Compared to women with low levels of health service utilization, women with high levels of health service utilization will have *increased* likelihood of RV1/PCV13 adoption.

Hypothesis 2: Compared to women who participate in 0 family decisions, women who participate in 3 family decisions will have *increased* likelihood of RV1/PCV13 adoption.

Hypothesis 3: Compared to women who accept violence against women, women who do not accept violence against women will have *increased* likelihood of RV1/PCV13 adoption.

METHODS

To examine whether Malawian women's health service utilization and empowerment indicators were associated with uptake of the RV1 and PCV13 vaccines, I performed a secondary analysis of data collected from the 2015-16 Malawi Demographic and Health Survey (MDHS, 2017). This dataset includes responses from 24,562 currently married or partnered women ages 15-49 who had children younger than 5 years of age at the time the survey was conducted. The sample is considered both nationally and regionally representative of Malawians aged 15-49 (MDHS, 2017). I analyzed data from the Individual Women's Questionnaire, which includes information on women's sociodemographic characteristics, reproductive behavior and intentions, contraceptive use, antenatal and postnatal care utilization, and children's health.

Study Sample

The 2015-16 Malawi Demographic and Health Survey (MDHS) sampled 26,261 households, 24,562 female respondents, and 7,478 male respondents to identify population characteristics and health issues relevant to Malawian citizens and key stakeholders. Data from the Malawi Population and Housing Census (MPHC) were used to inform the sampling frame for the MDHS by providing a list of standard enumeration areas (SEA), which were used to identify households (NSO, 2017: 2).

Sampling Methods

Sampling was conducted in two stages. First, Malawi's 28 administrative districts were stratified into urban or rural areas. Second, systematic selection was conducted to determine the number of households sampled per urban/rural cluster (NSO, 2017: 2). Oversampling was used to account for small regional populations and uneven population distribution. Weights were applied to adjust for the greater population density of Malawi's Southern region (46% of the population) compared to the Northern region (12% of the population) (NSO, 2017: 31). All women aged 15-49 who were permanent residents of the selected household or had spent the night at the selected household were eligible for interview while one-third of men who met these same characteristics were eligible for interview (NSO 2017: 2).

Data Collection Methods

Data from the Malawi Demographic and Health Survey were collected between October 2015 and February 2016 by the National Statistical Office (NSO) of Malawi. The response rate was 99% for household data, 98% for data collected from women, and 95% for data collected from men (NSO, 2017: 7). Thirty-seven field teams collected the data, which were stored securely and processed at the NSO in Zomba, Malawi. The 2015-16 MDHS consists of the Household Questionnaire, the Woman's Questionnaire, the Man's Questionnaire, and the

Biomarker Questionnaire, all of which are based on standard questionnaires developed by the DHS Program (NSO, 2017: 2). The questionnaires were produced in English, translated into Chichewa and Tumbuku, and administered via computer- assisted personal interviewing (CAPI), allowing respondents to choose the language in which the survey was conducted (NSO, 2017: 3). The Household Questionnaire collected basic demographic information about household members (age, sex, marital status, education, and relationship to the head of household) as well as information about the residence (amenities, building materials, and ownership of “various durable goods”) —a measure that was used to determine wealth (NSO, 2017: 11).

The Woman’s Questionnaire collected information on women’s background characteristics (age, educational attainment, occupation, exposure to media), reproductive and maternal health (pregnancy outcomes, number of children, breastfeeding, antenatal care, postnatal care, delivery), family planning knowledge and behaviors (knowledge and use of contraception, sources of information on contraception), fertility preferences (ideal number of children, desire for more children), child health (immunization coverage, illnesses), marriage and sexual activity (marital status, recent sexual activity, use of condoms), knowledge of STDs and HIV, exposure to and attitudes towards domestic violence, and mortality. Data on knowledge and use of family planning methods were collected from all women by asking if they had ever heard of each of the 13 methods included in the questionnaire (female sterilization, male sterilization, injectables, intrauterine devices (IUDs), implants, contraceptive pills, male condoms, female condoms, emergency contraception, the standard days method, lactational amenorrhea method, the rhythm method, withdrawal) or a different method not mentioned in the questionnaire that men or women can use to avoid pregnancy (NSO, 2017: 563). Respondents who had knowledge

of the method were also asked if they had ever used the method. If respondents had knowledge of or had ever used a particular method, they were asked if they currently used the method.

The questionnaire on child immunization records contains a checklist for the following vaccines: oral polio vaccine, DPT-HEPB-HIB, PCV/Pneumococcal, rotavirus, measles, and Vitamin A (NSO, 2017: 582). DHS interviewers first asked if respondents had a Health Passport where the child's vaccinations were written. Using respondents' health passport or other documents, interviewers recorded the date, if available, on which the respondents' children received each required dose for each of the above vaccines. If the respondent did not have documentation of vaccinations, interviewers asked if the child had ever received one of the above vaccinations using a description of how the vaccines are administered to help respondents remember. For the pneumococcal vaccine, interviewers asked if the child had ever received "an injection in the thigh to prevent pneumonia" and, if yes, how many times (NSO, 2017: 584). For the rotavirus vaccine, interviewers asked if the child had ever received "liquid in the mouth to prevent diarrhea" (NSO, 2017: 584). Vaccination data were collected on living children ages 0-35 months.

STUDY VARIABLES

Dependent Variable

My primary variable of interest was whether women had vaccinated their children with the rotavirus and pneumococcal vaccines. Using data on the youngest child in each household, I defined routine vaccine adopters ("adopters") as women whose youngest child received the full dose of both the monovalent human rotavirus (RV1, two doses) and the pneumococcal conjugate (PCV13, three doses) vaccines by age 3 (35 months). Women whose first child received partial doses of either vaccine, received the full dose of only one of the vaccines, or did not know

whether their child had received the vaccines were coded as 0 (“non-adopters”). Vaccination status was measured by confirming markings or dates on the child’s vaccination card or mother’s self-report.

Independent Variables

Independent variables were grouped into three domains: health service utilization, empowerment, and socio-demographic characteristics. Women’s health service utilization was measured through an index constructed from five binary variables: current modern contraceptive use, antenatal care visits, postnatal check, facility-based delivery, and healthcare access. Each of these binary indicators was constructed from existing variables. To identify modern contraceptive users, I first created a subsample of currently married/partnered women who were not currently pregnant, not sterilized or declared infecund, non-abstinent (i.e., had had sex in the last four weeks), not currently breastfeeding, had not given birth in the past year, and who either do not want any more children or want to wait at least two years before having more children. Within this sample, I identified modern contraceptive users as women who reported current use of either the pill, IUD, injections or implants/Norplant. Women who were not currently using contraceptives, were currently pregnant, or used a different type of contraceptive were classified as non-users.

Binary variables were also constructed to identify whether respondents had received three or more antenatal care visits, whether respondents had a postnatal care check for their youngest child at 12 months, and whether they delivered their youngest child at a health facility (vs. at home/other). Finally, women’s ability to access health services was constructed as a binary variable based on whether any of the following were considered a “big problem” (vs. not a big problem) for the respondent in case she became ill: getting permission to go to a health facility,

getting money needed for treatment, perceived distance to the health facility, and not wanting to go alone. Respondents were coded as 0 if any of the above presented a problem accessing medical advice or treatment; otherwise, they were coded as 1. Using these five binary variables, I then constructed an index of health service utilization, with 1 point allocated for each service utilized and 1 point allocated if accessing health care was not perceived as a big problem. This index was recoded into three categories: low service utilization (< 2 points), medium service utilization (2-3 points), and high service utilization (4-5 points).

Two variables were included to examine women's empowerment: decision-making power and attitudes towards violence. Decision-making power was assessed through an index of women's ability to make decisions about their own healthcare, large household purchases, and visits to friends or relatives. This index, which did not include respondent's participation in decisions about what to do with her husband/partner's earnings, has been validated in other assessments of empowerment using DHS data (Asaolu et al., 2018). The index assigned a value of 1 for each of these decisions that women reported making alone or jointly with their partner/husband. Women whose husband/partner or someone else made the decision were coded as 0. The index summed these scores for a household decision-making index that ranged from 0-3. To evaluate women's attitudes towards violence, I constructed a binary variable based on whether respondents believed a husband was justified in beating his wife in any one of five circumstances: if she goes out without telling him, if she neglects the children, if she argues with him, if she refuses to have sex with him, and if she burns the food. Respondents were coded as 0 if they believed that violence was justified in any one of the above circumstances and as 1 if they believed that violence against women was never justified.

Women's socio-demographic characteristics included education (none, primary level, secondary or higher), wealth quintile (based on a validated household asset index), current employment status (yes/no), and husband's education (none, primary level, secondary or higher). To test whether women's access to information was positively associated with their most recent child's RV1 and PCV13 vaccination status, I included an index of exposure to media based on how often respondents read a newspaper or magazine, how often they listened to the radio, and how often they watched television. Respondents who had no exposure to any of the above media sources were coded as 0 while respondents who were exposed to any of the above media sources less than once per week were coded as 1, and respondents who were exposed to any of the above media at least once per week were coded as 2.

Covariates

Based on previous studies examining vaccine uptake and studies on women's empowerment, covariates for maternal background characteristics, child's background characteristics, and community characteristics were included. Child characteristics included child's gender and age (12-36 months). Maternal characteristics included mother's age. Community characteristics included the region of residence (Northern, Central or Southern region), and urban/rural status.

ANALYTICAL PLAN

The analysis plan described below describes the procedures used to assess the relationship between the independent variables and the dependent variable: complete coverage of RV1/PCV13. All analyses were conducted with statistical analysis software (Stata) for Mac, version 15 (StataCorp, 2017). Descriptive statistical analyses and bivariate analyses were

conducted using a sample weight that was generated for the dataset to account for differences in sampling probabilities.

Descriptive Statistics

Descriptive statistics and frequencies of the study variables were generated to assess the proportion of missing cases and characteristics of the sample population (Table 1). Variables indicating mother's education and husband's education were recoded into 3-category variables. Responses of "don't know" were recoded as missing for youngest child's uptake of the rotavirus and pneumococcal vaccines, number of ANC visits, PNC check, attitudes towards violence, and husband or partner's education. For variables used to construct the household decision-making index, women who responded that someone other than her husband, herself, or someone else made the decision—fewer than 0.75% of respondents—were reclassified as missing.

Bivariate Analysis

Cross-tabulations were used to explore the relationship between the independent variables and the dependent outcome variable (full uptake of the RV1 and PCV13 vaccines). The Pearson's chi-square and t-test statistics and respective p-values were used to determine statistical significance.

Logistic Regression

Multivariate logistic regression was used to examine which characteristics were associated with uptake of the RV1 and PCV13 vaccines. This approach was selected because the dependent variable is binary. Models were constructed to include 1) a main effects model with no covariates, 2) a main effects model with covariates, 3) an interaction model that tested for an interaction effect between household-decision-making and maternal education, and 4) an interaction model that tested for an interaction effect between household-decision-making and

maternal wealth. The best-fitting model was selected using R-squared, AIC and BIC scores as well as the statistical significance of the interaction term (Appendix: Table A). Crude and adjusted odds ratios and their 95% confidence intervals (95% CI) were estimated. Statistical significance was set at a p-value of less than 0.05.

RESULTS

Sample Characteristics

The final, weighted analytic sample included 951 women. Characteristics of this sample are presented in Table 2. The mean age of respondents was 28.7 years old (SD=9.25). Respondents had high levels of health service utilization, with 46% having a score of 4-5 (high) and 53% having a score of 2-3 (medium). Nearly 44% of respondents were able to participate in all three types of family decisions measured while only 15% participated in no family decisions. The majority of respondents believed that violence towards women was not justified in any circumstance (84.9%). Most respondents lived in rural areas (79%), with 45% residing in the Southern region, 43% from the Central region, and 11.9% from the Northern region. More than two-thirds of women were currently employed (69%) and the majority had received a primary school level of education (63.9%) while 7.6% of respondents had no education. 39% of respondents were not exposed to any media sources (newspaper/magazine, radio, television) while 42% were exposed to any one of these sources at least once per week. A comparison of health service utilization, decision-making, attitudes towards violence, and media exposure between respondents in the final analytic sample and MDHS respondents who were not included in the final analytic sample is presented in Figure 1.

Table 2. Characteristics of study participants (n = 951)

Outcome variable	<i>n</i>	<i>%</i>
Adopters (complete RV1 and PCV13)	760	79.92

Health service utilization

Low (0 -1)	12	1.21
Medium (2-3)	501	52.67
High (4-5)	439	46.12

Empowerment

Decision-making power

0	146	15.38
1	168	17.70
2	220	23.12
3	417	43.81

Attitudes toward violence (never justified)	808	84.90
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Socio-demographic characteristics

Maternal education

None	72	7.57
Primary	607	63.90
Secondary and above	272	28.60

Wealth index

Poorest	153	16.11
Poorer	225	23.67
Middle	165	17.39
Richer	182	19.12
Richest	226	23.72

Currently employed	654	68.69
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Husband's education

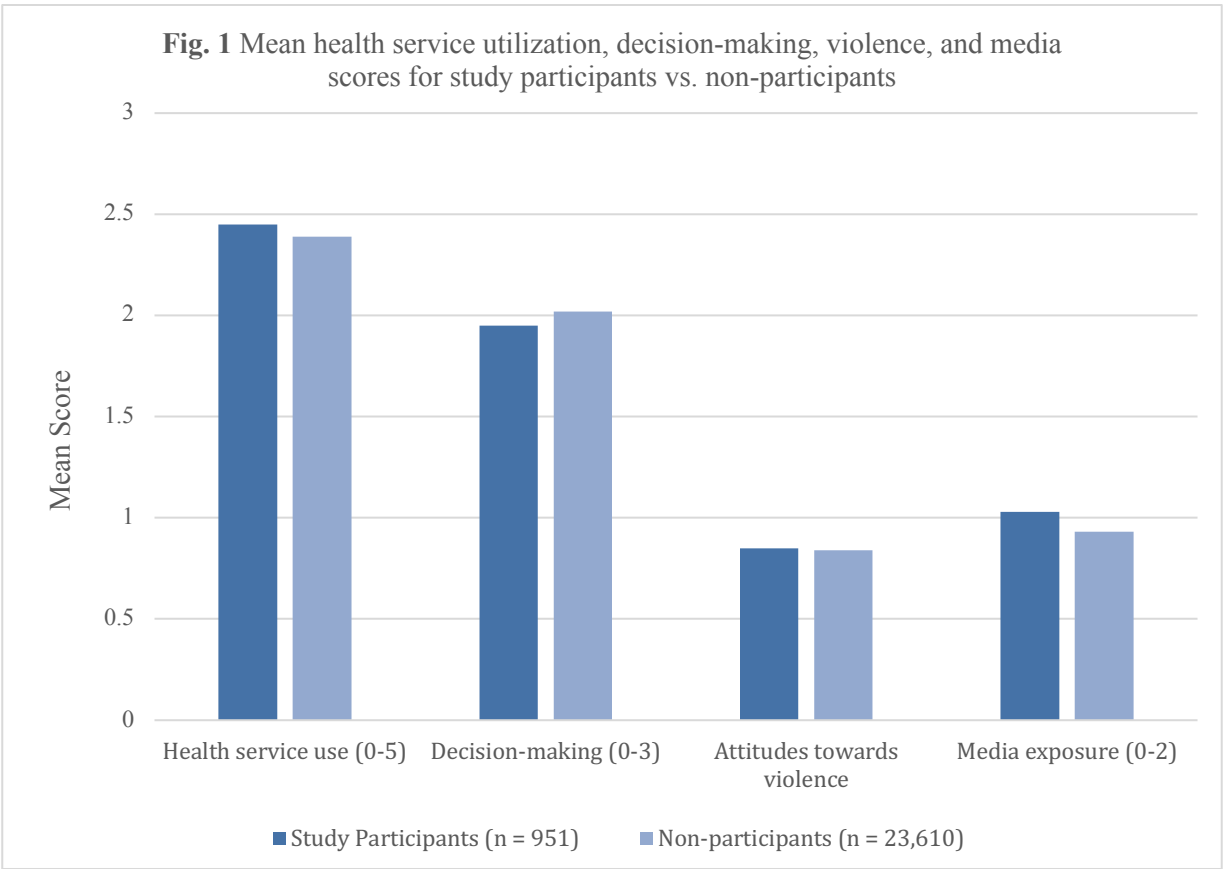
No education	54	5.70
Primary	510	53.65
Secondary and above	387	40.65

Media Exposure

0	372	39.13
1	178	18.70
2	401	42.17

Child characteristics		
Female	477	50.15
Age		
13-24 months	197	20.74
25-36 months	754	79.26
Maternal age (years)		
15-19	27	2.87
20-24	255	26.80
25-29	254	26.65
30-34	221	23.26
35-49	194	20.39
Mean (years)	28.7	
Community characteristics		
Geographical region		
Northern	113	11.88
Central	412	43.32
Southern	426	44.80
Rural	753	79.12
Total (n)	951	100%

Source: MDHS, 2015-16



Bivariate Analysis

Bivariate analysis of RV1/PCV13 adopters’ and non-adopters’ background characteristics is presented in Table 3. Among respondents in the lowest age category, approximately half were adopters and half were non-adopters. For all other age categories, adopters comprised the majority. Adopters were on average slightly older than non-adopters (28.9 vs. 27.8 years old); however, this difference was not statistically significant. No significant differences were observed between adopters and non-adopters with respect to their youngest child’s gender, child’s mean age, and place of residence.

Table 3. Bivariate associations between RV1/PCV13 adoption and respondents’ background characteristics (n = 951)

	Non-adopters	Adopters	<i>p-value</i>
Child characteristics			
Female	90 (18.9%)	387 (81.09%)	0.462

Age			
13-24 months	36 (18.11%)	162 (81.89%)	
25-36 months	155 (20.59%)	599 (79.41%)	
Mean (months)	27.7	27.9	0.693
Maternal age (years)			
15-19	13 (48.81%)	14 (51.19%)	
20-24	56 (22.11%)	199 (77.9%)	
25-29	49 (19.17%)	205 (80.83%)	
30-34	41 (18.75%)	180 (81.25%)	
35-49	31 (16.05%)	163 (83.95%)	
Mean (years)	27.8	28.9	0.078
Community characteristics			
Geographical region			
Northern	18 (15.49%)	96 (84.51%)	
Central	73 (17.66%)	339 (82.34%)	
Southern	101 (23.63%)	326 (76.37%)	
Rural	147 (19.46%)	761 (79.92%)	0.526
Total (n)	191	760	

Source: MDHS, 2015-16

Bivariate analysis of adoption of RV1/PCV13 and key independent variables is presented in Table 4. Adopters had a higher mean score of health service utilization (2.47) compared to non-adopters (2.37), although this difference was not statistically significant ($p = 0.095$). Adopters also had higher mean decision-making scores (2.01 vs. 1.74) and higher mean media exposure compared to non-adopters (1.09 vs. 0.78), and these differences were statistically significant. Among respondents who believed that violence was never justified, 81.6% were adopters and 18.3% were non-adopters ($p = 0.015$).

Adopters and non-adopters also differed on socio-economic characteristics. Adopters had on average 6.7 years of education while non-adopters had 5.6 ($p = 0.002$). Among respondents

who were currently employed, 83.6% were adopters and 16.4% were non-adopters ($p = 0.003$). Adopters' husbands/partners had slightly higher mean education levels compared to non-adopters (7.86 vs. 7.18); however, this difference was not statistically significant ($p = 0.063$).

Table 4. Bivariate associations between RV1/PCV13 adoption and independent variables (n = 951)

	Non-adopters	Adopters	<i>p-value</i>
Health service utilization			
Low (0 -1)	2 (15.88%)	10 (84.12%)	
Medium (2-3)	115 (22.21%)	386 (77.01%)	
High (4-5)	74 (16.86%)	365 (83.14%)	
Mean	2.37	2.47	0.095
Empowerment			
Decision-making power			
0	38 (26.24%)	108 (73.76%)	
1	40 (23.7%)	128 (76.3%)	
2	46 (21.06%)	174 (78.94%)	
3	66 (15.93%)	350 (84.07%)	
Mean	1.74	2.01	0.011
Attitudes toward violence (never justified)	148 (18.34%)	660 (81.66%)	0.015
Socio-demographic characteristics			
Maternal education			
None	22 (30.11%)	50 (69.89%)	
Primary	132 (21.76%)	475 (78.24%)	
Secondary and above	37 (13.66%)	235 (86.34%)	
Mean (years)	5.6	6.7	0.002
Wealth index			
Poorest	41 (26.81%)	112 (73.19%)	
Poorer	46 (20.55%)	179 (79.45%)	
Middle	32 (19.16%)	134 (80.84%)	
Richer	38 (20.70%)	144 (79.30%)	
Richest	34 (15.20%)	191 (84.80%)	
Currently employed	107 (16.37%)	547 (83.63%)	0.003

Husband's education			
No education	19 (34.39%)	36 (65.61%)	
Primary	104 (20.43%)	406 (79.57%)	
Secondary and above	68 (17.61%)	319 (82.39%)	
Mean (years)	7.18	7.86	0.063
Media Exposure			
0	102 (27.37%)	270 (72.63%)	
1	29 (16.51%)	149 (83.5%)	
2	60 (14.89%)	342 (85.11%)	
Mean	0.78	1.09	<0.001
Total (n)	191	760	

Source: MDHS, 2015-16

Logistic Regression

Logistic regression analysis of factors associated with being a routine vaccine adopter (having complete coverage of both the RV1 and PCV13 vaccines for one's youngest child) are presented in Table 5. Although the odds of being an adopter increased with health service utilization scores, health service utilization was not significantly associated with vaccine adoption in either the unadjusted or adjusted regression analyses. However, as hypothesized, women's decision-making power was positively associated with RV1/PCV13 adoption. Compared to women who participated in zero family decision, women who participated in all three types of family decisions were 65% more likely to be routine vaccine adopters ($p < 0.05$). In the unadjusted model, the odds of RV1/PCV13 adoption increased incrementally with decision-making power, but this trend did not hold for the adjusted model.

Women who believed that violence against women was never justified had significantly higher odds of being vaccine adopters in both the adjusted and unadjusted models. Compared to women who believed that violence was justified in any one of five circumstances, women who

believed that violence against women was not justified were 55% more likely to be vaccine adopters ($p < 0.05$).

With respect to women’s socio-demographic characteristics, only employment and media exposure were significantly associated with being a vaccine adopter in the unadjusted regression analysis. Compared to women who were not currently employed, employed women were 44% more likely to be an adopter ($p < 0.05$). Compared to women with no media exposure, women who were exposed to newspaper or magazine, radio, or television at least once per week were 57% more likely to be adopters of the RV1/PCV13 vaccines ($p < 0.05$). In the unadjusted regression, the odds of being an adopter increased significantly with increasing exposure to media. In the unadjusted analysis, women with a secondary level of education or higher and women belonging to the highest wealth quintile were more than twice as likely as their counterparts to be vaccine adopters ($p < 0.01$); however, these effects diminished in the adjusted model. A similar pattern was observed with respect to women’s husband’s/partner’s educational level. Women whose husbands/partners had a primary education were 89% more likely to be adopters than women whose husbands/partners had no education ($p < 0.05$) while women whose husbands/partners had a secondary education or higher were 2.4 times more likely to be adopters ($p < 0.01$). Husband’s/partner’s education was not statistically significant in the adjusted model.

Table 5. Logistic regression of factors associated with routine vaccine adopters

	CrOR (95%CI)	P-value	aOR (95%CI)	P-value
Health service utilization (Ref: low)	1.00		1.00	
Medium (2-3)	0.71	0.668	0.51	0.424
High (4-5)	1.10	0.901	0.73	0.705
Empowerment				
Decision-making power (Ref: 0)	1.00		1.00	
1	1.32	0.294	1.39	0.233
2	1.79	0.024	1.74	0.041

3	1.94	0.003	1.65	0.035
Violence (Ref: justified)	1.00		1.00	
Never justified	1.65	0.013	1.55	0.040
Socio-demographic characteristics				
Maternal education (Ref: none)	1.00		1.00	
Primary	1.53	0.123	1.28	0.420
Secondary and above	2.47	0.004	1.57	0.222
Wealth index (Ref: poorest)	1.00		1.00	
Poorer	1.16	0.558	1.13	0.650
Middle	1.39	0.220	1.19	0.547
Richer	1.36	0.250	0.96	0.889
Richest	2.21	0.004	1.32	0.440
Currently employed (Ref: no)	1.00		1.00	
Yes	1.61	0.004	1.44	0.040
Husband's education (Ref: none)	1.00		1.00	
Primary	1.89	0.034	1.86	0.056
Secondary and above	2.38	0.005	1.76	0.113
Media Exposure (Ref: 0)	1.00		1.00	
1	1.82	0.010	1.54	0.080
2	2.03	0.000	1.57	0.025

Source: MDHS, 2015-16

Interaction effects between women's decision-making power and education and between women's decision-making power and wealth were also tested but did not improve model fit (Appendix, Table 1). In a model that tested each of the health service utilization index variables separately, only antenatal care visits were significantly associated with being a vaccine adopter, with women who had three or more ANC visits 80% more likely to be an adopter than women with fewer than three visits ($p < 0.05$) (Appendix, Table 2).

DISCUSSION

This study suggests that factors associated with Malawian women's empowerment, including their ability to participate in family decisions and their attitudes towards violence against women, are positively associated with adoption of a recently-introduced health technology: the RV1 and PCV13 vaccines. Women's access to information, as measured through media exposure, and women's participation in socio-economic life, as measured through current employment status, were also positively associated with adoption of new childhood vaccines even after including a number of important covariates, such as child's age, women's age, and region of residence. These findings are consistent with characteristics associated with "early adopters" of health innovations as proposed through diffusion of innovation theory.

In contradiction to diffusion of innovation theory, women's prior experience with and ability to access existing health technologies (assessed through an index of health service utilization) were not significantly associated with adoption of the RV1 and PCV13 vaccines. One possible explanation for this finding involves significant differences between attitudes and uptake behaviors surrounding childhood vaccines (particularly the RV1 and PCV13 vaccines) and attitudes and uptake behaviors associated with the services included in the utilization index. For example, although modern contraceptives may be considered an innovative health technology, women's use of modern contraceptives is perhaps a better indication of their beliefs about, and ability to control, their own reproductive and sexual health rather than their beliefs and ability to make decisions about their children's health. In addition, this study analyzed vaccination outcomes for children ages 12-35 months. However, women's utilization of postnatal care checks within the child's first two months of life and women's decision to deliver at a facility reflect service uptake behaviors associated with infant health rather than children

who are at least one year of age. It is unclear why other factors associated with characteristics of early adopters, including educational attainment and wealth, were not significant predictors of RV1/PCV13 adoption.

The results of this study also suggest the need for further research on the relationship between women's decision-making power within the family and vaccine uptake behavior for their children. Women's ability to make decisions about their children's health is often used as an indication of her empowerment or autonomy, which is in turn associated with utilization of maternal and child health services (Palamuleni & Adebawale, 2014; Ghose et al., 2017; Chol et al., 2019). My findings provide further evidence for this association, as women who participated in multiple household decisions had greater odds of adopting recently-introduced childhood vaccines. However, it is unclear why women who participated in two household decisions were 74% more likely to adopt the RV1 and PCV13 vaccines than women who participated in no decisions, while women who participated in all three household decisions were only 65% more likely to adopt the RV1 and PCV13 vaccines. It is possible that women's participation in decisions about their children's health is more widely accepted than women's participation in other types of family decisions, particularly economic expenditures. Further research is needed to understand how women's participation in different types of household decisions impact their willingness and ability to adopt health innovations for their children.

Strengths and Limitations

The major strength of this study is use of a large, nationally representative dataset with validated measures. Use of this dataset makes the findings of this study generalizable to other currently married/partnered Malawian mothers ages 15-49. In addition, this study represents a novel approach towards analyzing vaccine uptake behavior. To my knowledge, this is the first

study that has attempted to predict HPV vaccine uptake behavior among Malawian families using publicly available DHS data.

This study is limited primarily by the use of RV1 and PCV13 vaccines as a proxy for the HPV vaccine. While RV1 and PCV13 offer the closest approximation to the HPV vaccine based on its relatively recent introduction to Malawian society, important distinctions between RV1/PCV13 and the HPV vaccine may limit the accuracy of this study's predictions. The HPV vaccine targets pre-adolescent Malawian girls and aims to protect against a sexually transmitted infection. Its association with sexual behavior among a unique target population may raise concerns among parents and community members about the vaccine's effects on girls' sexual and reproductive health (PATH, 2009; Ezeanochie & Olagbuki, 2014)—concerns that are not associated with the RV1 and PCV13 vaccines. This study is also limited by its exclusive focus on mothers as decision-makers for vaccine uptake. Studies in Uganda have found that adolescent girls' themselves may play a key role in deciding whether to receive the HPV vaccine (PATH, 2009). The role of Malawian girls in HPV vaccine uptake has received insufficient attention within the literature. Additional limitations surrounding assessment of RV1/PCV13 uptake include possible reporting bias on vaccine data (Bar-Zeev et al., 2015).

CONCLUSION

Reducing rates of cervical cancer in Malawi remains a challenge. The findings of this study can be used to improve HPV vaccine coverage across Malawi by targeting families in which women have lower levels of empowerment, less exposure to media, and lower rates of employment. My research also suggests that different strategies may be needed to increase HPV vaccine uptake in different populations. For example, although the diffusion of innovation theory suggests that women who have higher levels of education and higher wealth status are more

likely to adopt a health innovation, my findings suggest that differences in empowerment, employment, and media exposure may have greater bearing on vaccination uptake behaviors than wealth and education alone. By identifying characteristics of families who are less likely to vaccinate their daughters with the HPV vaccine, my research can inform HPV vaccine implementation and information campaigns to increase coverage rates—a critical step towards reducing cervical cancer mortality in Malawi.

Further research is needed to assess whether these same associations emerge when measuring actual HPV vaccine uptake in Malawi. Although the RV1 and PCV13 vaccines were selected as the closest approximation of the HPV vaccine within the MDHS dataset, differences between these vaccines highlight the need for further research on determinants of HPV vaccine uptake among Malawian families. Qualitative research may provide a more nuanced examination of processes of innovation decision-making and adoption behaviors and how these processes intersect with uptake of newly introduced vaccines for their children. Additional quantitative research may provide insight into other individual or community-level characteristics that determine uptake of new vaccines.

APPENDIX

Appendix Table 1. Model selection for logistic regression analysis

	Model 1	Model 2	Model 3	Model 4
Health service utilization (Ref: low)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
Health service utilization - med	0.572 (0.464)	0.514 (0.428)	0.547 (0.450)	0.516 (0.430)
Health service utilization - high	0.777 (0.635)	0.729 (0.609)	0.781 (0.647)	0.768 (0.644)
Decision-making (Ref: 0)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
Decision-making: 1	1.340 (0.366)	1.393 (0.387)	1.113 (0.972)	1.285 (1.453)
Decision-making: 2	1.666 (0.445)	1.741+ (0.472)	1.997 (1.824)	4.923 (5.635)
Decision-making: 3	1.640+ (0.384)	1.653+ (0.394)	3.772 (3.152)	9.155+ (9.666)
Attitudes towards violence	1.496 (0.310)	1.548+ (0.329)	1.585+ (0.340)	1.650+ (0.361)
Mother's Education (Ref: None)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
Mother's education - primary	1.271 (0.374)	1.275 (0.385)	1.659 (1.197)	1.743 (1.318)
Mother's education -secondary/higher	1.548 (0.561)	1.574 (0.585)	2.789 (2.353)	2.253 (2.005)
Wealth quintile (Ref: poorest)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
Wealth quintile - poorer	1.106 (0.290)	1.128 (0.300)	1.144 (0.307)	1.668 (1.094)
Wealth quintile - middle	1.267 (0.354)	1.188 (0.339)	1.188 (0.343)	2.288 (1.565)
Wealth quintile - richer	1.053 (0.296)	0.960 (0.280)	0.954 (0.280)	3.404 (2.615)
Wealth quintile - richest	1.320 (0.429)	1.319 (0.474)	1.366 (0.494)	5.093 (4.443)
Employed	1.453+ (0.251)	1.442+ (0.256)	1.443+ (0.258)	1.455+ (0.263)
Husband's education (Ref: none)	1.000	1.000	1.000	1.000

	(0.000)	(0.000)	(0.000)	(0.000)
Husband's education - primary	1.763	1.861	1.847	1.686
	(0.562)	(0.605)	(0.610)	(0.570)
Husband's education - secondary/higher	1.663	1.764	1.733	1.525
	(0.582)	(0.632)	(0.629)	(0.565)
Media exposure (Ref: 0)	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)
Media exposure - 1	1.521	1.542	1.539	1.504
	(0.372)	(0.382)	(0.383)	(0.379)
Media exposure - 2	1.607+	1.572+	1.551+	1.594+
	(0.320)	(0.317)	(0.316)	(0.330)
Mother's age (Ref: 15-19)		1.000	1.000	1.000
		(0.000)	(0.000)	(0.000)
Mother's age - 20-24		2.168	2.245	2.433+
		(0.925)	(0.957)	(1.053)
Mother's age - 25-29		2.479+	2.604+	2.759+
		(1.064)	(1.121)	(1.204)
Mother's age - 30-34		3.043+	3.222*	3.465*
		(1.341)	(1.425)	(1.549)
Mother's age - 35-49		2.763+	2.911+	3.251*
		(1.232)	(1.300)	(1.471)
Child Gender (Ref: Male)		1.352	1.371	1.386
		(0.228)	(0.233)	(0.239)
Child Age (Ref: 13-24 months)		1.000	1.000	1.000
		(0.000)	(0.000)	(0.000)
Child Age - 25-36 months		0.847	0.847	0.864
		(0.171)	(0.171)	(0.178)
Region (Ref: Northern)		1.000	1.000	1.000
		(0.000)	(0.000)	(0.000)
Region - Central		0.783	0.766	0.716
		(0.205)	(0.202)	(0.192)
Region - South		0.648	0.649	0.623
		(0.160)	(0.162)	(0.157)
Rural		1.192	1.177	1.192
		(0.301)	(0.299)	(0.307)
Decision-making(1) x No education			1.000	1.000
			(0.000)	(0.000)
Decision-making(1) x Primary education			1.449	1.428
			(1.353)	(1.388)
Decision-making(1) x Secondary education			0.906	1.098

	(0.998)	(1.299)
Decision-making(2) x No education	1.000	1.000
	(0.000)	(0.000)
Decision-making(2) x Primary education	0.945	1.035
	(0.912)	(1.032)
Decision-making(2) x Secondary education	0.613	1.162
	(0.676)	(1.360)
Decision-making(3) x No education	1.000	1.000
	(0.000)	(0.000)
Decision-making(3) x Primary education	0.430	0.415
	(0.378)	(0.376)
Decision-making(3) x Secondary education	0.317	0.394
	(0.317)	(0.416)
Decision-making(1) x Poorest		1.000
		(0.000)
Decision-making(1) x Poorer		1.408
		(1.247)
Decision-making(1) x Middle		0.895
		(0.851)
Decision-making(1) x Richer		0.502
		(0.501)
Decision-making(1) x Richest		0.451
		(0.535)
Decision-making(2) x Poorest		1.000
		(0.000)
Decision-making(2) x Poorer		0.752
		(0.684)
Decision-making(2) x Middle		0.295
		(0.274)
Decision-making(2) x Richer		0.144+
		(0.139)
Decision-making(2) x Richest		0.108+
		(0.114)
Decision-making(3) x Poorest		1.000
		(0.000)
Decision-making(3) x Poorer		0.464
		(0.366)
Decision-making(3) x Middle		0.421
		(0.345)
Decision-making(3) x Richer		0.198

				(0.176)
Decision-making(3) x Richest				0.229
				(0.223)
Constant	0.715	0.248	0.162	0.085
	(0.656)	(0.275)	(0.212)	(0.123)
Observations	961	961	961	961
AIC	956.7	960.1	968.8	981.8
BIC	1044.3	1091.6	1129.4	1200.9
-2 Log Likelihood	-460.4	-453.1	-451.4	-445.9
df	17	26	32	44
Pseudo R-Squared	0.0476	0.0627	0.0662	0.0775

Standard errors in parentheses

** p<0.001, * p<0.01, + p<0.05

Source: MDHS, 2015-16

Appendix Table 2. Logistic regression analysis of RV1/PCV13 adoption with independent health service utilization indicators

	aOR
Modern contraceptive use (Ref: non-user)	1.427
	(0.329)
Antenatal care (Ref: < 3 visits)	1.808+
	(0.459)
Postnatal care check within 2 months (Ref: No)	1.091
	(0.192)
Facility delivery (Ref: Home/other)	0.774
	(0.258)
Medical Care Access (Ref: Big problem)	1.252
	(0.243)
Decision-making (Ref: 0)	1.000
	(0.000)
Decision-making: 1	1.329
	(0.371)
Decision-making: 2	1.650
	(0.450)
Decision-making: 3	1.594
	(0.382)
Attitudes towards violence	1.553+
	(0.332)

Mother's Education (Ref: None)	1.000 (0.000)
Mother's education - primary	1.234 (0.376)
Mother's education -secondary/higher	1.512 (0.567)
Wealth quintile (Ref: poorest)	1.000 (0.000)
Wealth quintile - poorer	1.135 (0.305)
Wealth quintile - middle	1.196 (0.343)
Wealth quintile - richer	0.969 (0.286)
Wealth quintile - richest	1.319 (0.477)
Employed	1.407 (0.251)
Husband's education (Ref: none)	1.000 (0.000)
Husband's education - primary	1.793 (0.586)
Husband's education - secondary/higher	1.665 (0.600)
Media exposure (Ref: 0)	1.000 (0.000)
Media exposure - 1	1.559 (0.388)
Media exposure - 2	1.580+ (0.321)
Mother's age (Ref: 15-19)	1.000 (0.000)
Mother's age - 20-24	2.233 (0.960)
Mother's age - 25-29	2.521+ (1.090)
Mother's age - 30-34	3.117+ (1.384)
Mother's age - 35-49	2.797+ (1.262)

Child Gender (Ref: Male)	1.315 (0.222)
Child Age (Ref: 13-24 months)	1.000 (0.000)
Child Age - 25-36 months	0.821 (0.168)
Region (Ref: Northern)	1.000 (0.000)
Region - Central	0.742 (0.200)
Region - South	0.644 (0.163)
Rural	1.134 (0.289)
Constant	0.094* (0.084)
Observations	961
AIC	961.2
BIC	1107.2
-2 Log Likelihood	-450.6
df	29
Pseudo R-Squared	0.0678

Standard errors in parentheses

** p<0.001, * p<0.01, + p<0.05

Source: MDHS, 2015-16

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