UNIVERSITY OF CALIFORNIA

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Bridging the Gap between Food Safety and Quality: Context and Potential Effects of Chronic Disease on Foodborne Illness and Health Outcomes

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Epidemiology

by

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ABSTRACT OF THE DISSERTATION

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Doctor of Philosophy in Epidemiology

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Professor Frank Sorvillo, Chair

Although much has been documented about the foodborne pathogens *Salmonella* and *Toxoplasma gondii* and their respective mechanisms for causing acute disease, less is known about the burden these infections may place on certain populations and how chronic diseases contribute to these pathogens' impact on morbidity and mortality – i.e., how co-occurring chronic conditions or their treatments, such as steroid use, might mediate or accelerate disease severity and the pathways that can lead to premature death. One hypothesized mechanism in this continuum between infectious and chronic disease is the alteration or weakening of the immune response by such conditions (or their treatment) as HIV, diabetes, malignancies, and a range of autoimmune disorders.

A series of research studies were conducted to examine the burden of toxoplasmosis and salmonellosis outcomes in the United States and how co-occurring chronic conditions or their treatments might influence disease severity (Chapters 1 and 2). In addition, an evaluation of an intervention that made improvements to the nutrient content of school meals to reduce chronic disease risk (obesity) among children in grades K-12 (Chapter 3) was performed to describe the emerging impact of food quality interventions in the school cafeteria setting. The latter population is considered particularly vulnerable to foodborne infections and developing obesity – an independent risk factor for many chronic diseases in adulthood, including diabetes and some forms of cancer. Chapter 1 presents an analysis of the U.S. Multiple Cause-of-Death dataset, which showed a decline in the number of toxoplasmosis deaths with an HIV co-diagnosis during 2000-2010. However, in toxoplasmosis deaths without such a co-diagnosis, a decline was not observed. Chapter 2 presents a study using the U.S. Nationwide Inpatient Sample, which showed an increase in salmonellosis hospitalizations as well as costs. Positive associations were demonstrated between increased number of chronic conditions and four key hospitalization outcomes – in-hospital death, total charges, length of stay, and disease severity. Chapter 3 presents a series of studies, which enumerated reductions in key nutrients such as calories, sugar, and sodium content in school meals after 5 school districts in the U.S. implemented healthy food procurement interventions in their cafeterias.

Collectively, findings from this dissertation expand the current understanding of how foodborne illness outcomes can be affected by co-occurring chronic diseases, as well as demonstrates the substantial reach of nutrition interventions in the U.S. National School Breakfast and Lunch programs. These findings have important implications for national as well as local food policies and nutrition program planning.

The dissertation of Patricia Lynn Cummings is approved.

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2014

DEDICATION

This dissertation is dedicated to my mother and father who motivated me throughout my life to go above and beyond what I thought I was capable of; my brother, whose endless wisdom and advice was immeasurable; my fiancé, whose love, humor, and support was limitless; and to my dog Charlie, who spent countless hours with me writing and running analyses.

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Chapter 1 is a version of a manuscript that has been submitted to the American Journal of Tropical Medicine and Hygiene. The authorship is as follows: Cummings PL, Kuo T, Javanbakht M, Sorvillo F.

Chapter 3 was previously published as a series of papers: Paper 1: Cummings PL, Kuo T, Gase LN, Mugavero K. Integrating sodium reduction strategies in the procurement process and contracting of food venues in the County of Los Angeles government, 2010-2012. *Journal of Public Health Management and Practice*, 2014, 20(1), S16-S22. Wolters Kluwer Health Lippincott Williams & Wilkins© No modifications will be permitted. Paper 2: Cummings PL, Burbage L, Wood M, Butler RK, Kuo T. Evaluating changes to sodium content in school meals

at a large, urban school district in Los Angeles County, California. *Journal of Public Health Management and Practice,* 2014, 20(1), S43-S49. Wolters Kluwer Health Lippincott Williams & Wilkins© No modifications will be permitted. Paper 3: Cummings PL, Welch SB, Mason M, Burbage L, Kwon S, Kuo T. Nutrient content of school meals before and after implementation of nutrition recommendations in five school districts across two U.S. counties. *Preventive Medicine*, 2014. Permission to reprint was granted and the publisher for this copyrighted material is Elsevier.

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PUBLICATIONS

Peer-Reviewed Publications (in chronological order)

Piron J, Smith LV, Simon P, Cummings PL, Kuo T. Knowledge, attitudes and potential response to menu labeling in an urban public health clinic population. *Public Health Nutr* 2009; 13(4):550-555.

Cummings PL, Sorvillo F, Kuo T. Salmonellosis-related mortality in the United States, 1990-2006. *Foodborne Pathog Dis* Nov 2010; 7(11):1393-9.

Moschetti K, Cummings PL, Sorvillo F, Kuo T. The burden of Alzheimer's disease-related mortality in the United States, 1999-2008. *J Am Geriatr Soc* 2012, 60(8):1509-1514.

[*]Cummings PL, Burbage L, Wood M, Butler R, Kuo T. Reducing sodium content in school meals at a large, urban school district in Los Angeles County, California. *J Public Health Manag Pract* 2014, 20(1), S43-S49.

[*]Cummings PL, Kuo T, Gase LN, Mugavero K. Integrating sodium reduction strategies in the procurement process and contracting of food venues in the County of Los Angeles government, 2010-2012. *J Public Health Manag Pract* 2014, 20(1), S16-S22.

Moschetti K, Barragan N, Basurto-Davila R, Cummings PL, Sorvillo F, Kuo T. Mortality and productivity losses from Alzheimer disease among US adults aged 40 to 64 years, 1999 to 2010. *Alzheimer Dis Assoc Disord* 2014; Epub. Ahead of print.

[*]Cummings PL, Welch SH, Mason M, Burbage L, Kwon S, Kuo T. Nutrient content of school meals before and after implementation of nutrition recommendations in five school districts across two U.S. counties. *Prev Med* 2014 (in-press) DOI: 10.1016/j.ypmed.2014.03.004.

Book Chapter(s)

Cummings PL, Sorvillo F, Kuo T. Chapter 1: The Burden of Salmonellosis in the United States: mortality trends, comorbid conditions, and implications for policy. *ISBN* 978-953-307-782-6, January 2012. InTech, Croatia.

Reports and Other Articles (abbreviated list; in chronological order)

Kuo T, Villa V, Aranda M, Trejo L. State of Aging and Health among Latinos in Los Angeles, 2009. Cummings PL (ed.) Los Angeles Partnership for Evidence-Based Solutions in Elder Health; June 2009.

Cummings PL, Peńa MA, Tompkins J, Campbell R, Ford-Keach P, Fung V, Kuo T. Arthritis. [Issue Brief]. Los Angeles, CA: The Los Angeles Partnership for Evidence-Based Solutions in Elder Health, 2009.

[*] Included in dissertation, chapter 3.

CHAPTER 1

Mortality and Lost Productivity from Foodborne Illness

Mortality, associated medical conditions, and productivity losses attributed to toxoplasmosis in the United States, 2000-2010.

Abstract

Background. Toxoplasma gondii is a well-known parasitic infection associated with HIV, but its status as the second most common foodborne illness is often overlooked. Few studies have quantified toxoplasmosis mortality and productivity losses in the U.S.

Methods. We examined national multiple-cause-of-death data and estimated productivity losses due to toxoplasmosis during 2000-2010. Crude and age-standardized rates of disease mortality were calculated for sex, race and year. A matched case-control analysis examined associations between comorbid medical conditions and toxoplasmosis deaths. Productivity losses attributed to premature death from this infection were estimated using the human capital approach.

Results. A total of 789 toxoplasmosis deaths were identified during the 11-year study period with an annual percent change of -11.7% ($p<0.0001$). Blacks and Hispanics had the highest toxoplasmosis mortality as compared to whites; age-adjusted rate ratios were 8.30 (95% confidence interval [CI], 7.32-9.42) and 3.52 (95% CI, 3.09-4.01), respectively. Several medical conditions were associated with toxoplasmosis deaths, including HIV (matched odds ratio [MOR]=27.7; 95% CI, 21.78-35.37), leukemia (MOR=3.1; 95% CI, 1.95-4.85), and connective tissue disorders (MOR=4.4; 95% CI, 2.68-7.24). The number of toxoplasmosis deaths with an HIV co-diagnosis declined from 2000 to 2010; those without such a co-diagnosis remained static. Cumulative disease-related productivity losses for the 11-year period were nearly $815 million.

Conclusions. Although toxoplasmosis mortality has declined in the last decade, the infection remains costly and is an important cause of preventable death among non-HIV subgroups.

Introduction

Toxoplasmosis encephalitis is a highly recognized manifestation of *Toxoplasma gondii* infection associated with HIV/AIDS [1,2]. Yet, this protozoan zoonosis is underappreciated as the second most common cause of foodborne illness in the United States (U.S.) or as a preventable cause of other non-HIV disease [3].

With an estimated seroprevalence of about 10-15% in the general U.S. population, the clinical presentation of toxoplasmosis varies among several subgroups [4,5], ranging from no symptoms in most individuals, to cerebral involvement and/or widespread disseminated disease in individuals with severe immune suppression [6]. A number of contributing factors including age, gender, underlying medical conditions, and strain of parasite affect this disease's severity and clinical course [7,8]. For example, nearly one-third (30%) of all AIDS patients with seropositivity to this organism and who experienced CD4 counts below 100 cells/mm^3 have developed reactivated toxoplasmosis, especially in the absence of effective prophylaxis [9]. In non-HIV immune suppression (e.g., from cancer chemotherapy, prolonged steroid treatment for connective tissue disorders, post-transplantation therapy, or poorly controlled diabetes), this disease risk is still substantial, but generally not as well-characterized in the literature [10-12].

To contribute to this latter gap in the literature, we conducted a multi-part study using the national multiple cause-of-death (MCD) dataset from 2000 to 2010: (Part 1) quantification and trend analysis of toxoplasmosis mortality in the U.S.; (Part 2) a matched case-control analysis matching associated medical conditions to disease cases; and (Part 3) a cost analysis to enumerate the cumulative productivity losses attributed to premature death from this zoonosis during the 11-year study period. The analysis complements emerging research showing disparities in the number of toxoplasmosis hospitalizations by HIV status [13].

Methods

Through the National Vital Statistics System, monitored by the U.S. Department of Health and Human Services and the Centers for Disease Control and Prevention, the National Center for Health Statistics (NCHS) collects and publishes data on deaths obtained from registration offices of all 50 states in the U.S., including the District of Columbia. The U.S. Standard Certificate of Death form is completed by a medical certifier, most often the attending physician or coroner, and includes demographic information such as age, sex, race/ethnicity, and all conditions that led to death (i.e., underlying and associated causes). The underlying cause of death is the disease or injury that initiated the chain of events leading directly to death, whereas the associated cause(s) are conditions other than the underlying cause listed on the death certificate, both in the sections for the sequence of events and for other contributing conditions. Underlying and associated conditions reported from 2000-2010 are listed on the death certificates in accordance with the *International Classification of Diseases, 10th Revision* (ICD-10) [14].

Study sample

We examined toxoplasmosis mortality in the U.S. using MCD data for an 11-year period, starting from 2000 to 2010. Deaths from toxoplasmosis were defined as any observation either listed as the underlying cause or the associated cause of death, using the following ICD-10 codes: B58-B58.3, B58.8, B58.9, and P37.1; these codes include the diagnosis of congenital toxoplasmosis. Mortality rates were calculated using bridged-race population approximations from the NCHS [15]. Race bridging is a method used to make two different sets of race categories consistent with one another for estimation and comparison purposes. Age, sex, race/ethnicity, and year of death were included in these calculations, based on estimates from the U.S. Census Bureau for the 11-year period. Age at death was used to standardize and calculate age-specific rates and ratios, and to categorize decedent cases into the following groups: <1, 1-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, and ≥85 years. Race/ethnicity was categorized as white (non-Hispanic), Asian/Pacific Islander, black (non-Hispanic), Hispanic, and Native American (American Indian/Alaska Native). Due to changes in ICD coding in 1999 from the 9th version to the 10th version, we restricted our analysis to include only data from 2000 and onwards. Since this study relies on public, de-identified data on deceased individuals, it does not constitute research involving human subjects; this is in accordance with Title 45, part 45, of the Code of Federal Regulations [16].

Mortality and matched case-control analysis

Population data for deriving mortality rates were obtained from the U.S. Census Bureau. Toxoplasmosis mortality rates per 100,000 population per year were calculated for the U.S. Crude rates of toxoplasmosis mortality and 95% confidence intervals (CIs) were computed by age, sex, race/ethnicity, year, and state of residence. Using the 2000 U.S. standard population, age-adjusted rates were calculated for sex, race/ethnicity, year, and state [17]. Rate ratios, age-adjusted rate ratios, 95% CIs, and temporal trends were modeled using Poisson regression methods. Years of potential life lost (YPLL), a measure of the number of years not lived by an individual who dies before reaching a predetermined age, was calculated using the NCHS ceiling of 75 years of age [18]. Redelings and colleagues have previously validated the use of MCD data to investigate associations between conditions listed on death certificates [19]. Using these methods, the relationship between comorbid medical conditions and toxoplasmosis mortality was examined using a matched case-control analysis. To select controls, a random sample of non-toxoplasmosis deaths were drawn from the MCD dataset during the same time frame as cases (2000-2010) and matched in a 10:1 ratio (10 controls per case) by age, race/ethnicity, and sex. Co-occurring or comorbid medical conditions were selected and included in the analysis if they were: 1) known to be associated with toxoplasmosis, such as HIV/AIDS, and/or 2) known to impair an individual's immune response in the absence of HIV/AIDS (e.g., treatments for autoimmune conditions, cancer chemotherapy). Matched odds ratios (MORs) and 95% confidence intervals (CIs) were generated for each of the case-control pairs studied.

Since HIV is strongly related to fatal toxoplasmosis reactivation (i.e., more than half of the death certificates with toxoplasmosis listed as a cause of death also had HIV listed), we conducted a subgroup analysis to compare differences in mortality rates and rate ratios between toxoplasmosis deaths with HIV involvement versus those without HIV involvement. All analyses were conducted using the SAS 9.2 statistical software package (SAS Institute, Inc, Cary, NC).

Cost analysis: estimating productivity losses

Productivity losses due to premature death from toxoplasmosis were estimated using the human capital approach [20,21]. The number of deaths during each year of the 11-year period (2000-2010) were multiplied by the present value of lifetime productivity (PVLP), stratified by sex and age. Total costs from these losses were calculated and presented cumulatively for the entire period. The procedure to calculate PVLP has been described elsewhere in the literature [21,22].

PVLP calculations based on 2007 data (latest data available at the time of analysis) accounted for labor force participation, life expectancy, estimates of future values for housekeeping activities and caregiving. It also accounted for projected estimates of productivity growth. Estimates for years before and after 2007 were adjusted assuming an annual productivity growth of 0.5%. As recommended by the Panel of Cost-Effectiveness in Health and Medicine, a discounted rate of 3% was applied to the analysis [23]. All estimates were adjusted to 2013 dollars using the Employment Cost Index [24]. Similar methods to assess productivity losses using MCD data have been published in the literature [25,26].

Results

A total of 789 toxoplasmosis deaths were identified during the study period from 2000 to 2010 (Table 1); 271 of which were diagnosed with toxoplasmosis encephalitis and 71 with congenital toxoplasmosis. The annual percent change in mortality rates was -11.7% over the 11-year period (p-value <0.0001). Toxoplasmosis was reported as the underlying cause of death for 201 cases (25.5% of total) and as an associated cause of death for 588 cases (74.5% of total). The average age at death was 42.1 years (range 0-92; median=41.0). The age-adjusted mortality rates varied during the 11-year time frame (Figure 1), with an overall average age-adjusted mortality rate of 0.025 per 100,000 population (95% CI, 0.023-0.026) and a total 26,186 years of potential life lost (YPLL).

The highest absolute number of deaths and YPLLs attributed to toxoplasmosis occurred within the 35 to 44 age group – this represented 30.4% of all toxoplasmosis deaths (0.050 per 100,000 population; 95% CI, 0.044-0.057; n=240) (Table 1). In general, males were twice as likely to have toxoplasmosis listed as a cause of death than females (age-adjusted rate ratio (RR)= 2.00; 95% CI, 1.76-2.30). Black and Hispanic race/ethnicity had the highest toxoplasmosis mortality rates relative to whites (RR=8.30; 95% CI, 7.32-9.42 and RR=3.52; 95% CI, 3.09-4.01, respectively). Blacks experienced 11,971 YPLL; this was considerably more than any other race/ethnic group (Table 1). Florida had the highest frequency of deaths (n=114; 14.4%) with an age-adjusted mortality rate of 0.060 per 100,000 population (95% CI, 0.049-0.072). Total productivity losses from all toxoplasmosis deaths during 2000-2010 were estimated to be $814.5 million. Cost per death for each year was just over $1 million. Total lost productivity was highest in the 30-34 and 35-39 female age groups (~$84 million, combined).

In the matched case-control analysis, HIV was the most often listed co-diagnosis on the death certificates (n=440; 56% of total) and was strongly associated with toxoplasmosis deaths (MOR=27.75; 95% CI, 21.78-35.37). Other comorbid medical conditions strongly associated with toxoplasmosis deaths included: Hodgkin/non-Hodgkin lymphoma, leukemia, and connective tissue disorders (Table 2).

In total, there were 349 toxoplasmosis deaths *without* HIV ("non-HIV") as a co-diagnosis, as compared to 440 toxoplasmosis deaths *with* HIV ("HIV") as a co-diagnosis on the death certificates (Table 3). The average age at death for these subgroups (with and without HIV co-diagnosis) was similar to the overall sample (caseload) – 42.1 years, 41.9 years, and 42.1 years, respectively. The average age-adjusted mortality rate for toxoplasmosis deaths with no HIV co-diagnosis was 0.011 (95% CI, 0.010-0.012) as compared to 0.013 (95% CI, 0.012-0.015) for deaths with HIV co-diagnosis. Poisson trend analysis showed that the annual percent change in mortality rates among toxoplasmosis deaths without HIV involvement was -4.0% (95% CI, -6.6%, -0.18%; p-value=0.04), whereas for deaths with HIV involvement it was -18.4%. The annual percent change for the overall sample was -11.7% (Figure 2). The 35-to-44 age group comprising toxoplasmosis deaths without a HIV co-diagnosis had the highest absolute number of deaths.

Discussion

Toxoplasma gondii as a non-HIV disease in the U.S.

Toxoplasma gondii is generally not suspected in the clinical setting as a zoonosis that causes non-HIV disease. Yet, it was ranked second among 14 foodborne pathogens in annual disease burden based on a report released in 2011, with *Salmonella* (nontyphoidal serotypes) ranking first and *Campylobacter* ranking third [27]. According to the report, $3 billion in illness costs and 11,000 quality-of-adjusted-life-years (QALYs) were attributed to toxoplasmosis; the disease's high mortality rate contributed to its high ranking. In the present analysis, toxoplasmosis mortality averaged 71 deaths per year during the 11-year study period. This was considerably higher than *Salmonella* (about 53 deaths per year), the number one cause of foodborne illness in the U.S. The Centers for Disease Control and Prevention currently estimates that approximately 50% of toxoplasmosis cases are foodborne [28].

Productivity losses associated with toxoplasmosis premature deaths

The cumulative productivity losses associated with toxoplasmosis mortality during 2000-2010 were more than $815 million, representing a significant financial burden to society. Although the highest costs were found in the 35-39 age group, the 0-4 age subgroup contributed disproportionately to the amount. While the caseload for congenital toxoplasmosis was relatively small in the MCD dataset (<4% of total), the early losses of life summed up to a very large number of years lost from premature death. Congenital toxoplasmosis is a condition that can lead to miscarriage, stillbirth, or lifelong complications – e.g., neurological disorders, permanent vision loss, learning disabilities, and paralysis. It is also a condition that can be prevented. For example, among pregnant women, increased patient education should stress the importance of avoiding foodborne causes (e.g., eating raw ground beef, undercooked pork, rare lamb or locally-produced cured, dried, or smoked meat). The conventional advice of avoiding cats and their litter also applies.

The 11-year decline

In the present study, toxoplasmosis deaths declined substantively over an 11-year period, from 2000 to 2010. This overall decline is consistent with a similar decline in the prevalence of toxoplasmosis infections observed in another study of U.S. born individuals [4]. Parallel to this mortality trend (with some overlap), toxoplasmosis hospitalizations have also declined during the past 10-15 years – i.e., 10,583 in 1995 versus 3,000 in 2008 [13]. The decrease in toxoplasmosis hospitalizations has been attributed, partially, to a number of environmental and healthcare factors. For example, the overall prevalence of viable *T. gondii* in beef, chicken, and pork from retail meat stores in the U.S. was found to be very low in a 2005 study [29] and has been declining in humans and pigs [30]; this lowering of *T. gondii* contamination of the meat supply may be the result of enhanced efforts by the meat production industry to reduce *T. gondii* tissue cysts in meat [4]. Another, perhaps even stronger contributing factor was the introduction and subsequent widespread use of anti-retroviral therapy (e.g., HAART) to control HIV infection.

Coupled to other efforts such as enhanced outreach and education of expectant mothers (by physicians) and the public (by public health authorities) about proper cooking of meat and better hygienic practices to avoid exposure to infective oocysts (e.g., from cat feces), this medical breakthrough likely helped reduce the absolute number of fatal opportunistic infections among individuals with HIV/AIDS. This is confirmed in our subgroup analysis, where a lower annual percent change in mortality rates was observed for toxoplasmosis deaths that did not contain an HIV co-diagnosis, as compared to deaths that did (-4.0% versus -18.4%; overall sample -11.7%). Yet, another contributing factor may have been the advancement in anti-*Toxoplasma* therapy [5, 31,32] and better use of chemoprophylaxis to prevent reactivation or disease progression [33].

Limitations

Although MCD data has several strengths (e.g., population-based, large sample size), there are a number of notable limitations and constraints attributed to abstracting information from NCHS death records [19]. First, the ordering of the underlying and associated causes of death on death certificates are dependent on the opinions of the reporting physician or coroner, rarely providing insights into how these conditions interacted and contributed to death. Second, death certificates often contain errors and/or missing information, confounded by a variety of factors, including quality of reporting. Third, MCD data are typically not linked to clinical information, which often are required to provide context to the diagnosis and to see how disease risk, co-morbidities, and social factors influenced the chain of events leading to death. Lastly, using MCD data as a primary data source to inform economic analyses may limit the breadth and comprehensiveness of the cost estimations. For instance, the present analysis does not capture productivity losses before death, costs attributed to treatment, or business costs related to replacement of a deceased employee.

Conclusions

Despite the observed decline in toxoplasmosis mortality in the U.S., the absolute number of deaths and productivity losses attributable to this protozoan zoonosis remained substantial during 2000-2010. Based on trend analyses, the notable improvements to disease burden were primarily related to the decline in cases associated with HIV infection. The mortality trends for cases without an HIV co-diagnosis on the death certificate, for example, remained static, suggesting that non-HIV related toxoplasmosis, especially from foodborne sources, continues to be important causes of preventable death in vulnerable subgroups. Public health surveillance and timely clinical management of this condition remain critical for disease control and prevention of the lethal consequences associated with this infectious disease.

Table 1. Mortality rate ratios and years of potential life lost from toxoplasmosis, United States, 2000-2010.

	Toxoplasmosis Deaths n (%)[a]	**Age-Adjusted Rate Ratio** (95% Confidence Interval)	**Years of Potential Life Lost** (Years)
Sex			
Female	268 (34.0%)	Referent	9,027
Male	521 (66.0%)	2.01 (1.76-2.30)	17,159
Race/ethnicity			
White	253 (32.1%)	Referent	7,430
Asian/Pacific Islander	13 (1.6%)	0.81 (0.67-0.99)	509
Black	355 (45.0%)	8.30 (7.32-9.42)	11,971
Hispanic	166 (21.0%)	3.52 (3.09-4.01)	6,213
Native American	2 (0.3%)	0.64 (0.51-0.80)	63
Age group (years)			
<1	24 (3.0%)	--	1,800
1-4	7 (0.9%)	--	511
5-14	20 (2.5%)	--	1,300
15-24	27 (3.4%)	--	1,476
25-34	148 (18.8%)	--	6,606
35-44	240 (37.0%)	--	8,548
45-54	171 (21.7%)	--	4,447
55-64	77 (9.8%)	--	1,250
65-74	40 (5.1%)	--	248
75-84	30 (3.8%)	--	0
>85	5 (0.6%)	--	0
Total	789 (100%)	--	26,186

[a] *n* is the frequency or number of decedents specified in each column.

Table 2. Comorbid conditions associated with toxoplasmosis deaths with matched odds ratios and 95% confidence intervals, United States, 2000-2010.

Medical conditions	**ICD-10 Codes**	**Toxoplasmosis cases** (n=789) n (%)[a]	**Matched controls**[b] (n=7,882) n (%)[a]	**Matched odds ratio**[c] (95% Confidence Interval)
Connetive tissue disorders	M30-M36	23 (2.9)	53 (0.7)	4.40 (2.68-7.24)
Diabetes	E10-E14	18 (2.3)	452 (5.7)	0.39 (0.24-0.62)
Heart disease	I00-I99	171 (21.7)	2877 (36.5)	0.46 (0.39-0.56)
HIV	B20-B24	440 (55.8)	414 (5.3)	27.75 (21.78-35.37)
Hodgkin, Non-Hodgkin Lymphoma	C81, C82, C83, C84, C85, C86	42 (5.3)	76 (1.0)	5.91 (4.03-8.69)
Leukemia	C91, C92, C93, C94, C95	25 (3.2)	82 (1.0)	3.07 (1.95-4.85)

[a] *n* is the frequency or number of decedents specified in each column.
[b] During the matching process, one case was only able to find two matched controls due to the characteristics of that case (i.e., in the 5-14 age range, female, and Asian).
[c] Cases were matched to controls by age, sex, and race/ethnicity.

Table 3. Decedent characteristics: toxoplasmosis cases with and without HIV co-diagnosis on the death certificates, United States, 2000-2010.

Characteristic(s)	Toxoplasmosis cases with *HIV* as a co-diagnosis (n=440) n (%)[c]	Toxoplasmosis cases without *HIV* as a co-diagnosis (n= 349) n (%)[c]	χ^{2d}	P-value
Sex				
Female	123 (28.0)	145 (41.5)		
Male	317 (72.0)	204 (58.5)	16	<0.001
Race/ethnicity[a]				
White	91 (20.9)	162 (46.4)		
Asian/Pacific Islander	<5	10 (2.9)		
Black	237 (54.5)	118 (33.8)		
Hispanic	107 (24.6)	59 (16.9)	70	<0.001
Age (in years)[b]				
<1	<5	23 (6.6)		
1-4	--	7 (2.0)		
5-14	--	20 (5.7)		
15-24	10 (2.3)	17 (4.9)		
25-34	96 (22.0)	52 (14.9)		
35-44	160 (36.7)	80 (22.9)		
45-54	123 (28.2)	48 (13.8)		
55-64	40 (9.2)	37 (10.6)		
65-74	7 (1.6)	33 (9.5)		
75-84	<5	27 (7.7)		
>85	--	5 (1.4)	154	<0.001

[a] Native American race was excluded due to small sample size (<5).
[b] Percentage calculated based on available information from cases and controls; excludes those with "missing" or incomplete "other" category information.
[c] *n* is the frequency or number of decedents specified in each column.
[d] Chi-square statistic for equality of distribution of characteristic over groups and p-value.

Figure 1. Number of toxoplasmosis deaths and age-adjusted mortality rates per 100,000 population, United States, 2000-2010

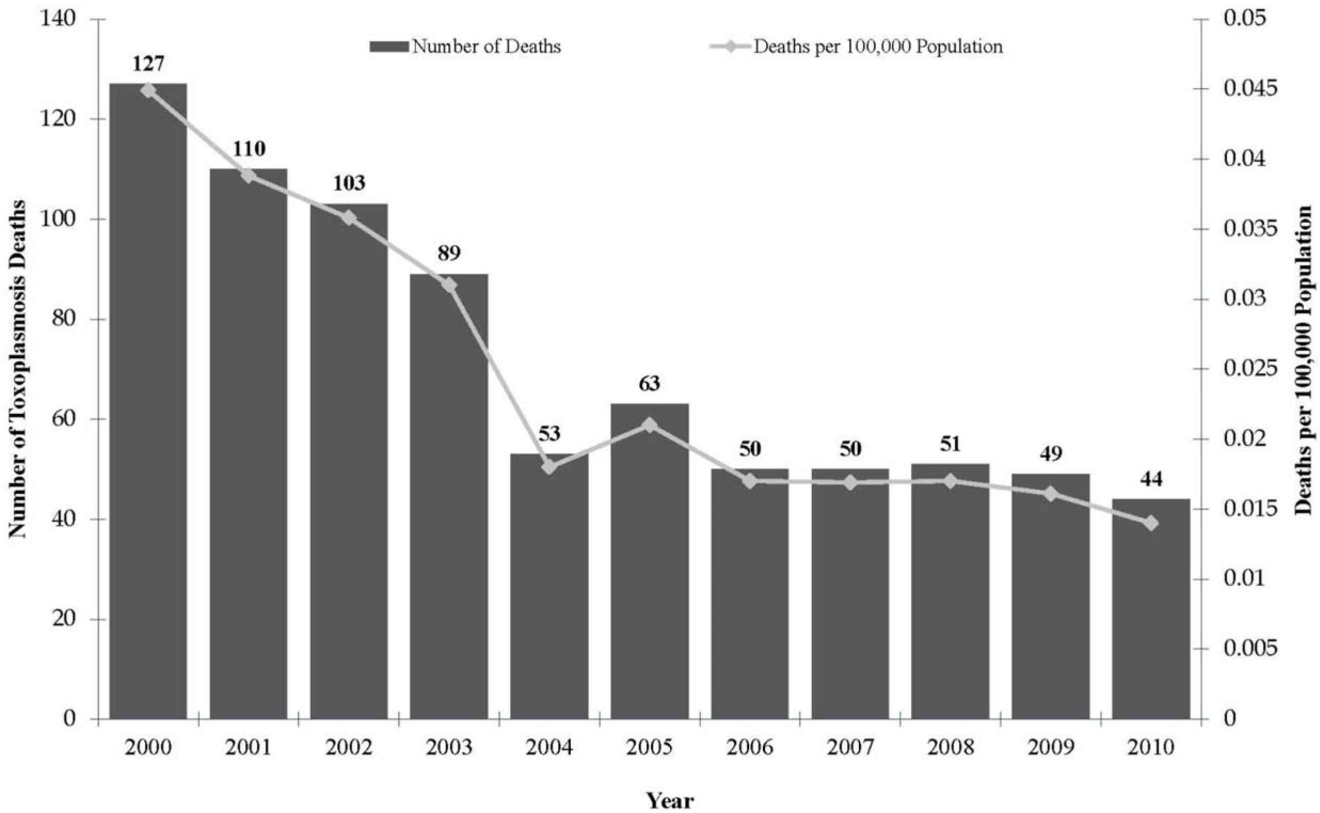
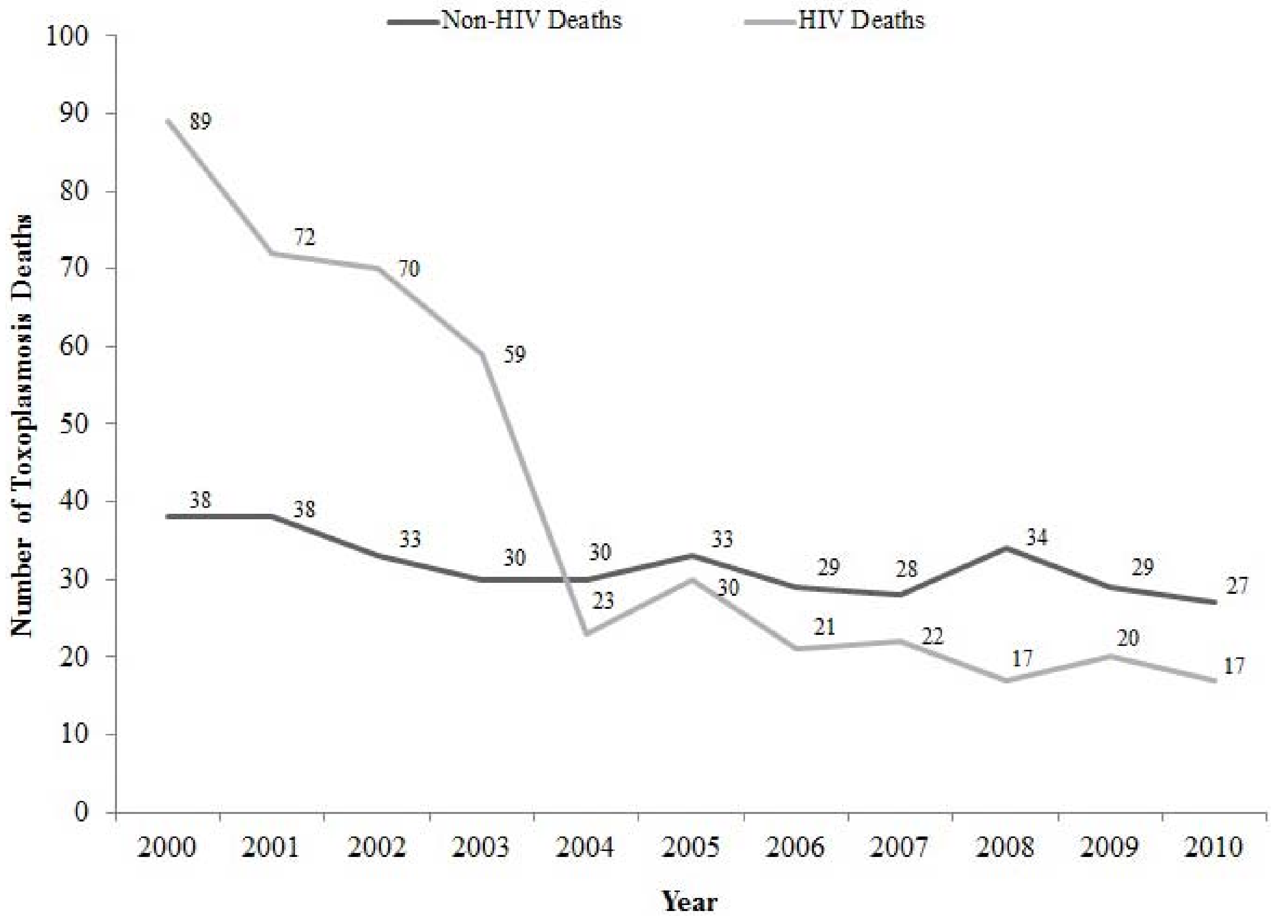


Figure 2. Number of toxoplasmosis cases with and without HIV co-diagnosis on the death certificates by year, United States, 2000-2010.



References

1. Antinori A, Larussa D, Cingolani A, et al. Prevalence, associated factors, and prognostic determinants of AIDS-related toxoplasmic encephalitis in the era of advanced highly active antiretroviral therapy. Clin Infect Dis, **2004**; 39: 1681-91.

2. Jones JL, Hanson DL, Chu SY, et al. Toxoplasmic encephalitis in HIV-infected persons: risk factors and trends. The Adult/Adolescent Spectrum of Disease Group. AIDS, **1996**; 10: 1393-1399.

3. Ash LR and Orihel TC. Ash & Orihel's Atlas of Human Parasitology, 5th Edition. Chicago, IL: American Society of Clinical Pathologists Press. **2007.**

4. Bartelink ML, Hoek L, Freriks JP, Rutten GE. Infections in patients with type 2 diabetes in general practice. Diabetes Res Clin Pract, **1998**; 40:15.

5. Batz MB, Hoffman S, Morris JG Jr. Ranking the risks: the 10 pathogen-food combinations with the greatest burden on public health. Emerging Pathogens Institute: University of Florida. **2011**.

6. Bradley CJ, Yabroff KR, Dahman B, Feuer EJ, Mariotto A, Brown ML. Productivity costs of cancer mortality in the United States: 2000-2020. J Natl Cancer Inst, **2008**; 100: 1763-1770.

7. Bretagne S, Costa JM, Foulet F, Jabot-Lestang L, Baud-Camus F, Cordonnier C. Prospective study of toxoplasma reactivation by polymerase chain reaction in allogeneic stem-cell transplant recipients. Transpl Infect Dis, **2000**; 2(3): 127-32.

8. Bristow BN, Casil J, Sorvillo F, Basurto-Dávila R, Kuo T. Melanoma-related mortality and productivity losses in the USA, 1990-2008. Melanoma Res, **2013**; 23(4): 331-335.

9. Dannemann B, McCutchan JA, Israelski D, et al. Treatment of toxoplasmic encephalitis in patients with AIDS. A randomized trial comparing pyrimethamine plus clindamycin to pyrimethamine plus sulfadiazine. The California Collaborative Treatment Group. Ann Intern Med, **1992**; 116:33.

10. Dubey JP, Hill DE, Jones JL, et al. Prevalence of viable *Toxoplasma gondii* in beef, chicken, and pork from retail meat stores in the United States: risk assessment to consumers. Immunology, **2005**; 91(5): 1082-1093.

11. Dubey JP and Jones JL. *Toxoplasma gondii* infection in humans and animals in the United States. Int J Parasitol, **2008** Sep; 38(11): 1257-78.

12. Falusi O, French AL, Seaberg EC, et al. Prevalence and predictors of Toxoplasma seropositivity in women with and at risk for human immunodeficiency virus infection. Clin Infect Dis, **2002**; 35:1414.

13. Fuentes I, Rubio JM, Ramírez, Alvar J. Genotypic characterization of *Toxoplasma gondii* strains associated with human toxoplasmosis in Spain: Direct analysis from clinical samples. J Clin Microbiol, **2001** Apr; 39(4): 1566-1570.

14. Grosse SD, Krueger KV, Mvundura M. Economic productivity by age and sex: 2007 estimates for the United States. Med Care, **2009**; 47: S94-S103.

15. Halfhill TR. Tom's Inflation Calculator, v7.5.3. Copyright 1997-2012. Available at http://www.halfhill.com/inflation.html, accessed October 1, 2012. (Online).

16. Jones JL, Kruszon-Moran D, Sanders-Lewis K, Wilson M. *Toxoplasma gondii* infection in the United States, 1999-2004, decline from the prior decade. Am J Trop Med Hyg, **2007**; 77(3): 405-410.

17. Jones JL and Roberts JM. Toxoplasmosis hospitalizations in the United States, 2008, and trends, 1993-2008. Clin Infect Dis, **2012**; 54(7): e58-61. Epub 2012 Jan 19.

18. Kaplan JE, Benson C, Holmes KH, et al. Guidelines for prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from CDC, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. MMWR Recomm Rep, **2009**; 58: 1-207.

19. Lipscomb J, Weinstein MC, Torrance GW. Time Preference. In: Gold M, Siegel J, Russell, et al. editors. Cost Effectiveness in Health and Medicine. New York: Oxford University Press; **1996**, p. 214-246.

20. Luft BJ, Hafner R, Korzun AH, et al. Toxoplasmic encephalitis in patients with acquired immune deficiency syndrome. JAMA, **1984**; 252: 913.

21. Moschetti K, Barragan N, Basurto-Dávila R, Cummings PL, Sorvillo F, Kuo T. Mortality and productivity losses from Alzheimer disease among U.S. adults aged 40 to 64 years, 1999 to 2010. Alzheimer Dis Assoc Disord, **2014**; [Epub].

22. Montoya JG and Liesenfeld D. Toxoplasmosis. Lancet, **2004** Jun 12; 363(9425):1965-76.

23. [NCHS, 2007] National Center for Health Statistics. Bridged-race intercensal estimates of the July 1, 2000-July 1, 2009. United States resident population from the Vintage 2006 postcensal series by year, county, age, sex, race, and Hispanic origin, prepared under collaborative arrangement with the U.S. Census Bureau. 2007. Available at www.cdc.gov/nchs/nvss/bridged_race.htm, accessed July 10, 2013. (Online).

24. [NCHS, 2010] National Center for Health Statistics. Life expectancies for 2000-2010 were calculated using a revised methodology and may differ from those previously published. National vital Statistics Reports (NVSR), Deaths: preliminary data for 2008,

59(2), December 2010. Available at http://www.census.gov/compendia/statab/2012/tables/12s0104.pdf, accessed July 11, 2012. (Online).

25. [NCHS, 2011] National Center for Health Statistics, Centers for Disease Control and Prevention (CDC), US Census Bureau. United States Bridged-Race Population Estimates 2010 - NCHS. Hyattsville, United States: National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC), 2011. Available at http://www.cdc.gov/nchs/nvss/bridged_race.htm, accessed October 10, 2013. (Online).

26. Nissapatorn V. Toxoplasmosis in HIV/AIDS: A living legacy. Review. Southeast Asian J Trop Med Public Health, **2009**; 40(6): 1158-78.

27. Redelings MD, Wise M, Sorvillo F. Using Multiple Cause-of-Death data to investigate associations and causality between conditions listed on the death certificate. Am J Epidemiol, **2007**; 166(1):104-108.

28. Robert-Gangneux F, Dardé ML. Epidemiology of and diagnostic strategies for toxoplasmosis. Clin Microbiol Rev, **2012**; 25(2):264-96. DOI: 10.1128/CMR.05013-11. Review. Erratum in: Clin Microbiol Rev, **2012**; 25(3):583.

29. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, Jones JL, Griffin PM. Foodborne illness acquired in the United States – major pathogens. Emerg Inf Dis, **2011**;17(1):7-15.

30. [USDHHS] United States Department of Health and Human Services: Protection of human subjects. *Title 45 Code of Federal Regulations, Pt 46* 2005. Retrieved on September 15, 2011 from: http://www.hhs.gov/ohrp/documents/OHRPRegulations.pdf

31. Voegele L, Cheerva AC, Bertolone S. Cerebral toxoplasmosis after tandem high-dose chemotherapy and autologous hematopoietic cell transplant for neuroblastoma. J Pediatr Hematol Oncol, **2013**;35(2):e50-2. DOI: 10.1097/MPH.0b013e3182677e84.

32. Weinstein MC, Siegel JE, Gold MR, Kamlet MS, Russell LB. Recommendations of the Panel on Cost-Effectiveness in Health and Medicine. JAMA, **1996**;276(15):1253-1258.

33. [WHO] World Health Organization. International Classification of Diseases, 10th Revision. Geneva, Switzerland: World Health Organization, 1992. Available at www.who.int/classifications/icd/en/, accessed July 10, 2012. (Online).

CHAPTER 2

Morbidity and Healthcare Costs from Foodborne Illness

Salmonellosis Hospitalizations in the United States: Trends, 2000-2011, Associated Medical Conditions and Costs, 2011

Abstract

Objectives. Although the federal surveillance system – FoodNet – tracks laboratory-confirmed *Salmonella* infections, it primarily serves to inform regulatory control of the food supply so as to protect against foodborne disease outbreaks. To date, less is known about the actual burden of salmonellosis in the hospital setting. The present study uses nationally representative data to address this gap in medical practice.

Methods. This is a retrospective study examining salmonellosis discharges using the Agency for Healthcare Research and Quality's Nationwide Inpatient Sample for 2011, which represents a 20% stratified sample of U.S. community hospitals. A supplemental trend analysis of salmonellosis hospitalizations was conducted from 2000 to 2011. Hospitalization characteristics, including the number of chronic conditions in a patient, were examined using multivariable regression models, with a focus on four outcome variables: in-hospital death, total charges, length of stay, and disease severity.

Results. A total of 116,361 primary and secondary diagnoses of salmonellosis were identified from discharge records during the 12-year period. There was a 27.2% increase in salmonellosis discharges from 2000 to 2011. The average age at death was 42.1 years. In 2011, there were 11,032 primary and secondary diagnoses of salmonellosis; 7,496 of which were primary only. The average length of stay was about 6 days. In multivariable analyses, greater number of chronic conditions (≥4) among salmonellosis patients was associated with in-hospital death, greater severity, longer length of stay and higher mean total charges.

Conclusions. Observed increases in U.S. salmonellosis hospitalizations and costs indicate that the burden of this foodborne illness remains substantial. The positive association between increased number of chronic conditions and the four hospitalization outcomes affirms the need for continual investments by public health and medicine to prevent foodborne illness and control infections to avoid costly complications and fatality in the hospital setting.

Introduction

Although deaths from non-typhoidal *Salmonella* infection have declined during the past decade, foodborne illness from this bacterial pathogen has remained substantial in the United States (U.S.) (CDC, 2011a; Cummings et al., 2010; Cummings et al., 2012). According to the Foodborne Diseases Active Surveillance Network (FoodNet), incident cases of salmonellosis have continued to rise during the same period (Chai et al., 2012). While risk factors for disease progression is well-documented in situations such as co-infection with HIV/AIDS or patients with severe immune-suppression (Galofré et al., 1994; Gordon, 2008; Dhanoa and Fatt, 2009), less is known about the differential contributions of other medical conditions which can affect disease severity, the need for hospitalization, and the costs of treating this infection in the hospital setting. Studies have suggested that the number and type of chronic conditions in a patient may play key roles in heightening disease severity and risk for death (Shimoni et al., 1999; Reed et al., 2014). Since one in four adults has multiple chronic conditions (Ward et al, 2014), enumerating these associations will be beneficial for proper treatment and care.

To address this gap in the literature, we describe the burden of salmonellosis hospitalizations in the U.S. using the Nationwide Inpatient Sample (NIS) for the year 2011. We examined a range of hospitalization characteristics, including the number of chronic conditions in a patient, as they relate to four hospital-related outcomes: length of stay, total charges, disease severity, and in-hospital death. The analysis also presents salmonellosis discharge trends for the period 2000-2011. The NIS is a nationally representative database approximating 97% of all hospital discharges in the U.S. (HCUP, 2013).

Methods

Nationwide Inpatient Sample

The Nationwide Inpatient Sample (NIS) is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ) (HCUP, 2013). It is the largest all-payer inpatient database that is publicly available in the U.S. It is designed to approximate a 20% sample of U.S. community hospitals (e.g., for any given year, about 1,000 hospitals selected for the NIS represent approximately 5,000 hospitals nationwide). Community hospitals are defined by the American Hospital Association as all nonfederal, short-term, general, and other specialty hospitals. To ensure geographic dispersion within participating states, the NIS sampling scheme sorts hospitals within strata by the first three digits of their zip code prior to systematic selection. The stratum for the NIS is defined by five hospital characteristics: hospital ownership and control, number of beds, hospital teaching status, urban/rural location, and U.S. region. For each hospital drawn into the NIS, 100% of all discharges are included, allowing for individual hospital estimates to be free of sampling error. For 2011, 46 states participated in the HCUP, representing more than 97% of the U.S. population with 8,023,590 unweighted observations/discharges estimating roughly 40 million hospitalizations (HCUP, 2011a).

Study period and sample description

Salmonellosis discharges in the NIS were examined for a 12-year period, starting from 2000 to 2011. Diagnoses of salmonellosis were defined as any observation listed as a primary or secondary diagnosis on the hospital discharge records, corresponding to the International Classification of Diseases, Ninth Revision, Clinical Modifications (ICD-9-CM) code 003 [003.0-003.9] (CDC/NCHS, 2013). HCUP sample weights for the NIS were used to generate national estimates for the U.S. For 2011 – the most recent year of the NIS, characteristics of salmonellosis discharges were compared to those with *Toxoplasma gondii* (ICD-9-CM 130.0-130.9, 771.2) and *Campylobacter jejuni* (ICD-9-CM 008.43). Following non-typhoidal Salmonella, these two agents are the second and third most common foodborne pathogens in the U.S. (Batz et al., 2011). Age, sex, median income for zip code, region, payer status, hospital characteristics (e.g., rural/urban, hospital type), length of stay (mean days), total charges ($, mean), total costs ($, mean costs derived using Centers for Medicare and Medicaid Services' cost-to-charge ratios), and in-hospital death were examined.

Statistical Analysis

Taking into account the NIS survey design, appropriate estimation methods for the study regression models were fitted to assess the independent association between *Salmonella* discharges and the four hospital-related outcomes of interest. Large sample sizes allowed for regression models to be restricted to 2011 discharges only. The four hospital-related outcome variables of interest included: in-hospital death (a binary variable); total charges (a continuous variable, mean dollars); length of stay (as a categorical variable); and disease severity (as a categorical variable). Data on total charges for each hospital represents the amount that a hospital is billed for the services including direct medical costs, but excluding physician fees.

For the first outcome variable, in-hospital death, a binary logistic regression model was fitted using the following covariates: age (as a continuous variable), sex, race/ethnicity, and number of chronic conditions (as categorical variables). Race/ethnicity was categorized as white, black, Hispanic, Asian/Pacific Islander, Native American, and other. The number of chronic conditions as identified on each discharge record were counted and grouped into three categories (0-1, 2-3, and 4 or more), based on data elements in the NIS Diagnosis and Procedures Groups File and on methods from a previously published analysis by Steiner and Friedman (2013). Other covariates in the model were selected based on the scientific literature and biologic plausibility. Directed acyclic graphs (DAGs) were used to examine biasing paths and potential causal relationships between salmonellosis, covariates, and the outcome of interest. DAGs represent a causal framework that allows the user to determine the direction of biases and decide when control of confounding is inadequate (VanderWeele et al., 2008).

For the second outcome variable, total charges, a multiple linear regression model was performed. To satisfy the model assumptions, total charges were log transformed and regressed on age, sex, race, number of chronic conditions, measures of disease severity, hospital location, and hospital control (as categorical variables). Measures of disease severity were defined using the All Patient Refined Diagnosis Related Group (APRDRG) subclasses: no class specified, minor loss of function (including cases with no comorbidity or complications), moderate loss of function, major loss of function, and extreme loss of function. Hospital location was defined as either rural or urban. The hospital control variable was categorized into the following categories: government or private (collapsed category); government, nonfederal, public; private, non-profit, voluntary; private, investor-own; and private (collapsed category).

For the remaining two outcome variables, length of stay and disease severity, ordinal logistic regressions were performed. Length of stay (categorized as 0-1 days, 2-3 days, 4-5 days, and 6+ days) was regressed on age, sex, race, APRDRG severity measure subclasses, hospital location, hospital control, the number of chronic conditions and the specific medical conditions known to impair the immune response (e.g., Acquired immune deficiency syndrome (AIDS) and lymphoma). The specified medical conditions, AIDS and lymphoma, were identified using the AHRQ Comorbidity Software provided by the HCUP (HCUP, 2011b). Similar to the methods used in the binary logistic regression for the in-hospital death outcome, covariates were included based on factors known to affect hospital length of stay as identified in the scientific literature and on biologic plausibility. Disease severity (categorized as no class specified/minor loss of function, moderate loss of function, and major/extreme loss of function) was likewise regressed on age, sex, race, hospital location, hospital control, medical conditions (AIDS, lymphoma), and number of chronic conditions.

For all models, observations which contained missing data for each of the outcome variables or for any of the covariates were excluded from the analyses. Measures assessing the fit of each model were calculated. Descriptive analyses were conducted using the SAS 9.3 statistical software package (SAS Institute, Inc, Cary, NC). Regression analyses were performed using Stata Statistical Software: Release 13 (College Station, TX: StataCorp LP). The present study relies on public, de-identified data and does not constitute research involving human subjects; this is in accordance with Title 45, part 45, of the Code of Federal Regulations.

Results

A total of 116,361 primary and secondary diagnoses of salmonellosis were identified on discharge records during the 12-year period from 2000 to 2011 (Figure 1). The percent change in salmonellosis discharges during this period was +27.2%. The average age at death was 42.1 years (range 0-92; median=41.0). In 2011, there were 11,032 primary and secondary diagnoses of salmonellosis; 7,496 of which were primary only. Compared to *Toxoplasma gondii* and *Campylobacter jejuni* (Table 1), the total number of discharges for *Salmonella* was the highest among all three foodborne pathogens. Of the three, however, *Toxoplasma* discharges had the longest length of stay (mean days=11.2) and the highest mean total charges and total costs. *Toxoplasma* discharges involved primarily Medicaid payers (57%) as compared to the discharges for the other two infectious diseases. Overall, the average length of stay for hospital patients diagnosed with salmonellosis was about 6 days (6.3 for males and 5.7 for females).

In-Hospital Death, Total Charges, Length of Stay, and Disease Severity of Salmonellosis

Increased number of chronic conditions (≥4) in a patient was associated with in-hospital death, longer length of stay, and higher mean total charges (Table 2). For example, after controlling for age, sex, and race, the odds of dying in the hospital for patients with four or more chronic conditions who were admitted with salmonellosis was 10 times that of patients with only one or no chronic condition (Table 3a). Similarly, Hispanic race/ethnicity was associated with increased in-hospital deaths when compared to whites (OR=2.56, 95% CI= 0.99, 6.62). Among all salmonellosis hospitalizations, there was a 30% increase in the average total charges for every one-unit increase in the number of chronic conditions (i.e., in the ≥4 category) (Table 3b). For patients with 2 to 3 chronic conditions the percent increase in average total charges was slightly lower (21.5%). The average total charges increased by number of chronic conditions: 0-5 = $20,413; 2-3 = $31,970, and 4 or more = $60,446 (Table 2). In the ordinal logistic regression models, having ≥4 chronic conditions was associated with higher length of stay and disease severity (Table 3c and 3d). Odds ratios for disease severity and age were also higher among older age categories (Table 3d).

Discussion

Our findings indicate that the burden of salmonellosis hospitalizations in the U.S. is considerable and increasing, and is amplified by coexisting chronic conditions. Disease severity was elevated in older persons and Hispanics. Although the 2013 FoodNet report showed a 9% decrease in laboratory-confirmed *Salmonella* infections in the U.S. (Crim et al., 2014), the data collected prior to this year (2010-2012) mirrored the increase found in the present analysis. Both data sources (NIS and FoodNet) showed *Salmonella* infection rates were significantly above the national *Healthy People* target of 11.4 cases per 100,000 population, indicating that continual need for disease surveillance, food safety measures, and foodborne illness prevention remain a key priority for public health and health authorities (Mead et al., 1999).

Increased number of chronic medical conditions was associated with increased in-hospital death, longer length of stay, and higher mean total charges for patients hospitalized with salmonellosis; these increases in hospital-related outcome measures remained statistically significant even after controlling for age, sex, race, and hospital location. Given the growing burden of chronic disease and related healthcare costs, understanding how co-occurring conditions that can complicate disease progression of infections (e.g., salmonellosis) may help hospitals, clinicians, and public health authorities invest in and develop more effective strategies for controlling foodborne illness, improving hospital care, and preventing disease complications for patients hospitalized with salmonellosis (Anderson and Horvath, 2004).

The NIS sample is a large, representative sample of U.S. hospitalizations which allows for examination of relatively rare conditions without leading to issues of sparse data, especially during stratification of cases by variables (e.g., age, sex, race/ethnicity) (HCUP, 2013). Although salmonellosis is considered a common foodborne infection (typically resolves in immune-competent adults without hospitalization), systemic and metastatic pathogenesis of bacteremia leading to hospitalization and death are rare. In this regard, the size of the NIS sample allows for trend analyses of salmonellosis with greater precision and strength in the estimates. In addition, the NIS sampling procedure is also well documented and published in the yearly NIS release (HCUP, 2013), allowing for appropriate corrections of estimates, when needed.

The NIS, however, has a number of limitations. First, the ICD-9-CM coding for disease diagnosis was not originally designed to track infection and has been criticized as being inaccurate, potentially leading to case misclassification (Noskin et al., 2005). Other common errors may include incorrect reporting (e.g., by patient) and incorrect transcription (e.g., by hospital personnel). Misclassification rates can vary and have been found to be higher or lower in different hospitals based on the categories of variables being examined. Second, the lack of personal identification codes in the discharge records can distort true estimates of salmonellosis discharges (i.e., hospitalization of individual patients versus multiple hospitalizations of the same patient). Third, patients with severe infection may self-select to the database because they were more likely to seek medical attention as compared to those with mild to moderate manifestations, thus, possibly skewing the rates of hospital admission and distribution of disease severity. Lastly, HCUP has made a number of structural changes to the dataset in recent years (e.g., increase in the number of states participating in the effort), potentially adding to the complexity of analyzing data across multiple years.

Conclusions

The observed increases in U.S. salmonellosis hospitalization and costs indicate that the burden of this foodborne pathogen remains substantial. The positive association between the increased number of chronic conditions (especially 4 or more) and salmonellosis hospitalization outcomes suggests that vigilance, risk stratification, and more proactive treatment approaches are needed to help reduce unnecessary morbidity and fatality in the hospital setting. Public health investments in disease surveillance and prevention should also continue to reduce the health and economic consequences associated with this disease.

Table 1. Nationwide Inpatient Sample characteristics for primary diagnoses of the top three foodborne pathogens in the U.S. – Non-typhoidal *Salmonella* sp, *Toxoplasma gondii*, and *Campylobacter jejuni*, 2011

	Salmonella **Discharges** n (%)[a]	***Toxoplasma*** **Discharges** n (%)[a]	***Campylobacter*** **Discharges** n (%)[a]
Gender			
Female	4,030 (53.8)	229 (41.8)	2,016 (51.0)
Male	3,421 (45.6)	319 (58.2)	1,915 (48.4)
Age group (years)			
<1	565 (7.5)	415 (75.8)	56 (1.4)
1-17	1,318 (17.6)	<10	466 (11.8)
18-44	1,448 (19.3)	73 (13.3)	1,023 (25.9)
45-64	1,906 (25.4)	<10	1,214 (30.7)
65-84	1,903 (25.4)	<10	1,034 (26.1)
85+	343 (4.6)	<10	164 (4.1)
Payer			
Medicare	2,588 (34.5)	<10	1,376 (34.8)
Medicaid	1,374 (18.3)	313 (57.2)	527 (13.3)
Private Insurance	2,768 (36.9)	159 (29.1)	1,623 (41.0)
Uninsured	419 (5.6)	<10	262 (6.6)
Other	306 (4.1)	<10	162 (4.1)
Median income for zip code	2,364 (31.5)	211 (38.5)	1,090 (27.6)
Low	4,978 (66.4)	318 (58.0)	2,803 (70.9)
Not low			
Hospital characteristics			
Owner			
Government	1,066 (14.2)	53 (9.6)	303 (7.7)
Private, not-for-profit	5,332 (71.1)	424 (77.4)	3,104 (78.5)
Private, for-profit	999 (13.3)	66 (12.0)	479 (12.1)
Teaching status			
Nonteaching	4,131 (55.1)	109 (19.9)	2,266 (57.3)
Teaching	3,266 (43.6)	433 (79.0)	1,621 (41.0)
Location			
Non-metropolitan	1,137 (15.2)	58 (10.6)	550 (13.9)
Metropolitan	6,261 (83.5)	484 (88.4)	3,337 (84.4)
Bedsize			
Small	937 (12.5)	63 (11.5)	534 (13.5)
Medium	1,934 (25.8)	95 (17.3)	944 (23.9)
Large	4,526 (60.4)	385 (70.2)	2,408 (60.9)
Region			
Northeast	1,375 (18.3)	<10	624 (15.8)

Midwest	1,091 (14.6)	132 (24.0)	1,063 (26.9)
South	4,227 (56.4)	316 (57.7)	1,430 (36.1)
West	804 (10.7)	66 (12.0)	839 (21.2)
Length of stay, days (mean)	5.0	11.2	3.8
Total charges, $ (mean)	29,373	56,748	22,725
Total costs, $ (mean)	8,341	18,264	6,496
In-hospital deaths	86 (1.2)	<10	<10
Total	7,496 (100.0)	548 (100.0)	3,956 (100.0)

Table 2. Hospitalizations with a primary diagnosis of salmonellosis, by number of chronic conditions, Nationwide Inpatient Sample, 2011.

	Number of Chronic Conditions		
Hospitalization Outcomes	**0-1**	**2-3**	**≥4**
In-hospital death*	5	14	146
Length of stay, mean days (95% confidence interval)	4.1 (3.9, 4.4)	5.2 (4.6, 5.7)	7.8 (7.1, 8.5)
Charge, mean dollars (95% confidence interval)	$20,413 (17353, 23473)	$31,970 (26914, 37025)	$60,446 (49046, 71845)

*Weighted counts, no confidence interval calculated; Pearson chi-square converted F-statistic = 14.2, $p<0.001$

Table 3a. Binary logistic regression analysis of in-hospital deaths among hospitalizations with a primary diagnosis of salmonellosis, Nationwide Inpatient Sample, 2011.

Covariate	Parameter estimate (95% CI)	Odds Ratio (95% CI)
Number of chronic conditions (referent: 0-1)		
2-3	1.04 (-1.44, 3.51)	2.82 (0.24, 33.35)
>=4	2.32 (-0.06, 4.70)[a]	10.17 (0.94, 109.71)
Age	0.02 (-0.00, 0.04)	1.02 (1.00, 1.05)
Gender (referent: male)		
Female	-0.10 (-0.82, 0.63)	0.90 (0.44, 1.86)
Race/ethnicity (referent: white)		
Black	0.64 (-0.37, 1.65)	1.90 (0.69, 5.23)
Hispanic	0.94 (-0.01, 1.89)[a]	2.56 (0.99, 6.62)
Asian/Pacific Islander	0.79 (-1.24, 2.82)	2.21 (0.44, 16.84)
Other (including Native American)	0.27 (-1.73, 2.27)	1.31 (0.79, 9.64)

Note: Analysis conducted on the subsample of salmonellosis hospitalizations with no missing data for any of the covariates of interest, n=2,014. Native American was collapsed into the 'other' category due to small sample size. CI= confidence interval.
[a] $p \leq .05$.

Table 3b. Multiple linear regression analysis of log total charges among hospitalizations with a primary diagnosis of salmonellosis, Nationwide Inpatient Sample, 2011.

Covariate	Parameter estimate (95% CI)
Number of chronic conditions (referent: 0-1)	
2-3	0.14 (0.03, 0.26)[a]
>=4	0.30 (0.17, 0.44)[a]
Age (referent: <1)	
1-4	-0.10 (-0.28, 0.08)
5-14	-0.05 (-0.22, 0.12)
15-24	0.25 (0.05, 0.46)
25-34	0.26 (0.04, 0.47)
35-44	0.20 (-0.01, 0.41)
45-54	0.24 (0.03, 0.46)
55-64	0.18 (-0.05, 0.41)
65-74	0.11 (-0.12, 0.33)
75-84	0.23 (-0.02, 0.48)
85+	0.09 (-0.18, 0.37)
Gender (referent: male)	
Female	-0.07 (-0.13, 0.00)[a]
Race/ethnicity (referent: white)	
Black	0.06 (-0.08, 0.21)
Hispanic	0.44 (0.33, 0.55)[a]
Asian/Pacific Islander	0.44 (0.20, 0.69)[a]
Native American	-0.12 (-0.55, 0.32)
Other	0.10 (-0.07, 0.28)
APRDRG Severity Measures (referent: Minor loss of function)	
Moderate loss of function	0.29 (0.19, 0.39)[a]
Major loss of function	0.59 (0.47, 0.71)[a]
Extreme loss of function	1.55 (1.36, 1.73)[a]
Hospital location (referent: rural)	
Urban	0.56 (0.43, 0.69)
Hospital control (referent: government/ private collapsed)	
Government, nonfederal, public	-0.20 (-0.37, -0.03)
Private, non-profit, voluntary	-0.07 (-0.21, 0.07)
Private, investor-owned	0.24 (0.08, 0.40)
Private, collapsed category	0.08 (-0.19, 0.35)

Note: Analysis conducted on the subsample of salmonellosis hospitalizations with no missing data for any of the covariates of interest, n=1,987. CI= confidence interval; APRDRG = All Patient Refined Diagnosis Related Group.
[a] $p \leq .05$.

Table 3c. Ordinal logistic regression analysis of length of stay among hospitalizations with a primary diagnosis of salmonellosis, Nationwide Inpatient Sample, 2011.

Covariate	Parameter estimate (95% CI)	Odds Ratio (95% CI)
Number of chronic conditions (referent: 0-1)		
2-3	0.18 (-0.14, 0.49)	1.19 (0.87, 1.63)
>=4	0.76 (0.44, 1.08)[a]	2.13 (1.55, 2.94)
Age (referent: <1)		
1-4	-0.16 (-0.59, 0.28)	0.86 (0.56, 1.32)
5-14	-0.33 (-0.72, 0.07)	0.72 (0.49, 1.07)
15-24	-0.27 (-0.77, 0.22)	0.76 (0.46, 1.24)
25-34	-0.16 (-0.56, 0.24)	0.85 (0.57, 1.27)
35-44	-0.25 (-0.73, 0.24)	0.78 (0.48, 1.27)
45-54	-0.06 (-0.51, 0.39)	0.94 (0.60, 1.47)
55-64	-0.10 (-0.58, 0.37)	0.90 (0.56, 1.45)
65-74	0.02 (-0.45, 0.50)	1.02 (0.63, 1.65)
75-84	0.31 (-0.21, 0.84)	1.37 (0.81, 2.32)
85+	0.28 (-0.33, 0.88)	1.32 (0.72, 2.42)
Gender (referent: male)		
Female	-0.01 (-0.18, 0.15)	0.98 (0.84, 1.16)
Race/ethnicity (referent: white)		
Black	0.39 (0.09, 0.69)[a]	1.48 (1.10, 2.00)
Hispanic	0.14 (-0.15, 0.43)	1.15 (0.86, 1.54)
Asian/Pacific Islander	0.13 (-0.34, 0.60)	1.14 (0.71, 1.82)
Native American	0.69 (-0.25, 1.63)	1.99 (0.78, 5.10)
Other	0.46 (-0.03, 0.95)	1.59 (0.97, 2.59)
APRDRG Severity Measures (referent: no/minor loss of function)		
Moderate loss of function	0.63 (0.35, 0.90)[a]	1.87 (1.42, 2.47)
Major/extreme loss of function	1.47 (1.16, 1.78)[a]	4.35 (3.18, 5.93)
Comorbidity Present (referent: comorbidity not present)		
AIDS	-0.99 (-2.20, 0.22)	0.37 (0.11, 1.24)
Lymphoma	0.11 (-0.56, 0.79)	1.12 (0.57, 2.19)
Hospital location (referent: rural)		
Urban	0.24 (-0.06, 0.54)	1.27 (0.94, 1.72)
Hospital control (referent: government/ private collapsed)		
Government, nonfederal, public	-0.09 (-0.42, 0.23)	0.91 (0.66, 1.26)
Private, non-profit, voluntary	-0.12 (-0.40, 0.16)	0.88 (0.67, 1.17)
Private, investor-owned	-0.40 (-0.68, -0.12)[a]	0.67 (0.51, 0.89)
Private, collapsed category	-0.62 (-1.24, 0.00)[a]	0.54 (0.29, 1.00)

Note: Analysis conducted on the subsample of salmonellosis hospitalizations with no missing data for any of the covariates of interest, n=1,990. CI= confidence interval; APRDRG = All Patient Refined Diagnosis Related Group; AIDS= Acquired Immune Deficiency Syndrome.

[a] p≤.05.

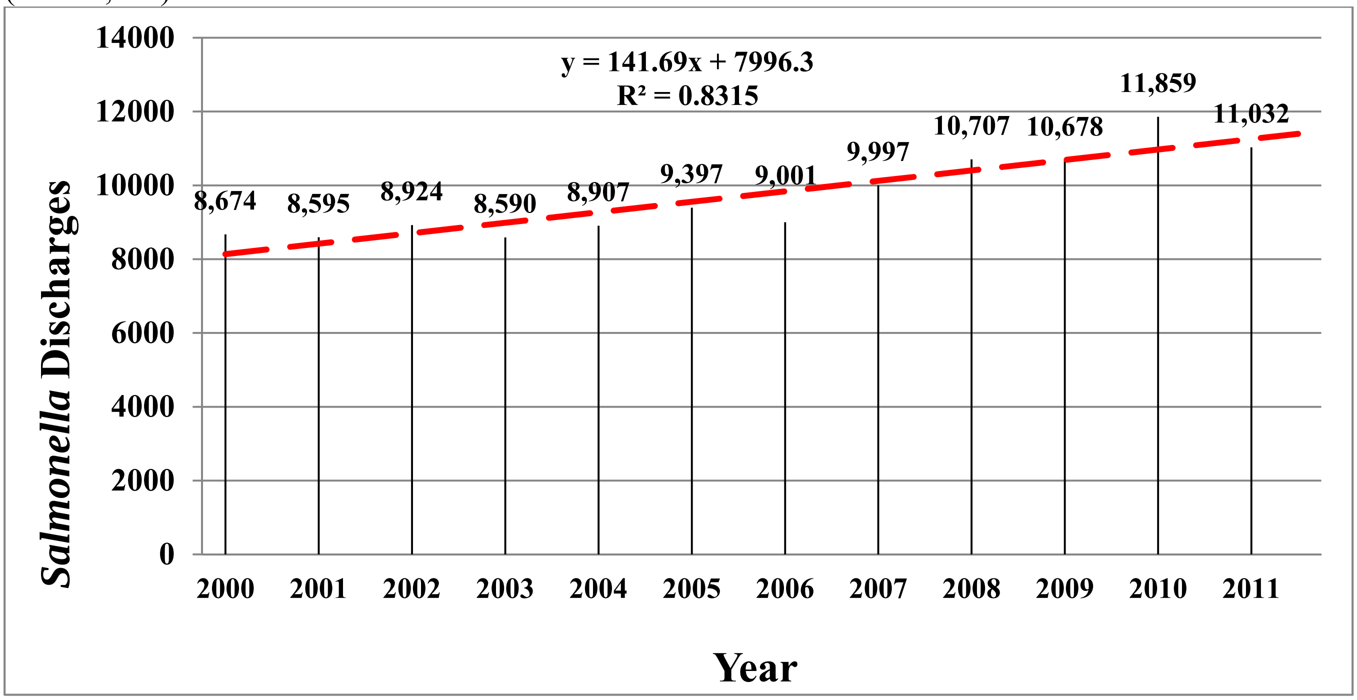
Table 3d. Ordinal logistic regression analysis of disease severity among hospitalizations with a primary diagnosis of salmonellosis, Nationwide Inpatient Sample, 2011.

Covariate	Parameter estimate (95% CI)	Odds Ratio (95% CI)
Number of chronic conditions (referent: 0-1)		
2-3	1.23 (0.93, 1.54)[a]	3.42 (2.52, 4.65)
>=4	2.31 (1.97, 2.66)[a]	10.11 (7.15, 14.29)
Age (referent: <1)		
1-4	0.06 (-0.35, 0.48)	1.07 (0.70, 1.61)
5-14	-0.11 (-0.57, 0.34)	0.89 (0.57, 1.41)
15-24	0.60 (0.09, 1.11)[a]	1.82 (1.10, 3.03)
25-34	0.77 (0.27, 1.27)[a]	2.16 (1.31, 3.57)
35-44	0.73 (0.23, 1.22)[a]	2.07 (1.26, 3.40)
45-54	1.08 (0.56, 1.59)[a]	2.94 (1.75, 4.93)
55-64	0.94 (0.39, 1.50)[a]	2.57 (1.48, 4.46)
65-74	1.34 (0.82, 1.87)[a]	3.83 (2.26, 6.50)
75-84	1.46 (0.90, 2.01)[a]	4.29 (2.46, 7.48)
85+	1.52 (0.75, 2.29)[a]	4.58 (2.13, 9.86)
Gender (referent: male)		
Female	-0.17 (-0.37, 0.03)	0.84 (0.69, 1.03)
Race/ethnicity (referent: white)		
Black	0.69 (0.38, 1.00)[a]	1.93 (1.41, 2.64)
Hispanic	0.16 (-0.15, 0.47)	1.16 (0.84, 1.59)
Asian/Pacific Islander	0.68 (0.22, 1.34)[a]	1.98 (1.05, 3.73)
Other (including Native American)	0.28 (-0.17, 0.72)	1.26 (0.80, 1.99)
Comorbidity Present (referent: comorbidity not present)		
AIDS	0.75 (-0.23, 1.73)	2.02 (0.71, 5.75)
Lymphoma	1.44 (0.30, 2.59)[a]	4.42 (1.42, 13.78)
Hospital location (referent: rural)		
Urban	0.02 (-0.39, 0.43)	1.01 (0.67, 1.51)
Hospital control (referent: government/ private collapsed)		
Government, nonfederal, public	-0.41 (-0.82, 0.00)[a]	0.67 (0.44, 1.02)
Private, non-profit, voluntary	-0.06 (-0.33, 0.21)	0.95 (0.73, 1.25)
Private, investor-owned	-0.04 (-0.29, 0.37)	1.04 (0.75, 1.44)
Private, collapsed category	-0.59 (-1.23, 0.05)	0.57 (0.30, 1.07)

Note: Analysis conducted on the subsample of salmonellosis hospitalizations with no missing data for any of the covariates of interest, n=1,990. Native American was collapsed into the ‘other’ category due to small sample size. CI= confidence interval; AIDS= Acquired Immune Deficiency Syndrome.

[a] $p \leq .05$.

Figure 1. *Salmonella* discharges from the Nationwide Inpatient Sample, 2000 to 2011, United States (N=116,361).*



*Includes primary and secondary (all-listed) salmonellosis diagnoses.

References

Anderson G, Horvath J. The growing burden of chronic disease in America. *Public Health Rep* 2004 May-Jun; 119(3):263-270.

Batz MB, Hoffman S, Glenn Morris J. Ranking the risks: the 10 pathogen-food combinations with the greatest burden on public health. Emerging Pathogens Institute, University of Florida. 2011.

Centers for Disease Control & Prevention (2011a). Making food safer to eat: reducing contamination from the farm to the table. *Vital Signs.* June 2011. Accessed on July 22, 2013. Available at: http://www.cdc.gov/VitalSigns/pdf/2011-06-vitalsigns.pdf.

Centers for Disease Control & Prevention, National Center for Health Statistics (2013). International classification of diseases, ninth revision, clinical modification (ICD-9-CM). Last updated: June 2013. Accessed on May 4, 2014. Available at: http://www.cdc.gov/nchs/icd/icd9cm.htm.

Chai SJ, White PL, Lathrop SL, Solghan SM, Medus C, McGlinchey BM, Tobin-D'Angelo M, Marcus R, Mahon BE. *Salmonella enterica* Serotype Enteritidis: Increasing Incidence of Domestically Acquired Infections.

Crim SM, Iwamoto M, Huang JY, et al. Incidence and trends of infection with pathogens transmitted commonly through food – Foodborne Diseases Active Surveillance Network, 10 U.S. sites, 2006-2013. *MMWR* April 18, 2014. 63(15): 328-332.

Cummings PL, Sorvillo F, Kuo T. Salmonellosis-related mortality in the United States, 1990-2006. Foodborne Pathog Dis 2010 Nov; 7(11):1393-9.

Dhanoa A and Fatt QK. Non-tyhoidal *Salmonella* bacteraemia: epidemiology, clinical characteristics and its association with severe immunosuppression. *Ann Clin Microbiol Antimicrob.* 2009 May 18;8:15.

Galofré, J., Moreno, A., Mensa, J., Miró, J. M., Gatell, J. M., Almela, M., and Soriano, E. (1994). Analysis of factors influencing the outcome and development of septic metastasis or relapse in Salmonella bacteremia. *Clin Infect Dis*, 18(6):873-878.

Gordon MA. Salmonella infections in immunocompromised adults. *J Infect.* 2008 Jun;56(6):413-22.

HCUP Databases. Healthcare Cost and Utilization Project (HCUP). July 2013. Agency for Healthcare Research and Quality, Rockville, MD. Last updated July 8, 2013. Accessed on July 26, 2013. Available at: www.hcup-us.ahrq.gov/nisoverview.jsp.

HCUP Nationwide Inpatient Sample. Healthcare Cost and Utilization Project (HCUP). 2011a. Agency for Healthcare Research and Quality, Rockville, MD.

HCUP Comorbidity Software. Healthcare Cost and Utilization Project (HCUP). 2011b. Agency for Healthcare Research and Quality, Rockville, MD.

Mead PS, Slutsker L, Dietz V, McCaig LF, Bresee JS, Shapiro C, Griffin PM, Tauxe RV. Food-related illness and death in the United States. *Emerg Infect Dis.* Sept-Oct 1999; 5(5): 607-625.

Noskin GA, Rubin RJ, Schentag JJ, Kluytmans J, Hedblom EC, Smulders M, Lapetina E, Gemmen E. The burden of Staphylococcus aureus infections on hospitals in the United States: an analysis of the 2000 and 2001 Nationwide Inpatient Sample Database. *Arch Intern Med*. 2005 Aug 8-22;165(15):1756-61.

Reed C, Chaves SS, Perez A, D'Mello T, Kirley PD, Aragon D, Meek JI, Farley MM, Ryan P, Lynfield R, Morin CA, Hancock EB, Bennett NM, Zansky SM, Thomas A, Lindegren ML, Schaffner W, Finelli L. Complications among adults hospitalized with influenza: a comparison of seasonal influenza and the 2009 H1N1 pandemic. *Clin Infect Dis* 2014 Apr 29. [Epub].

Shimoni Z, Pitlik S, Leibovici L, Samra Z, Konigsberger H, Drucker M, Agmon V, Ashkenazi S, Weinberger M. Nontyphoid Salmonella bacteremia: age-related differences in clinical presenation, bacteriology, and outcome. *Clin Infect Dis* 1999; 28(4): 822-827.

VanderWeele TJ, Hernán MA, Robins JM. Causal directed acyclic graphs and the direction of unmeasured confounding bias. *Epidemiol* 2008 Sep;19(5):720-8.

Ward BW, Schiller JS, Goodman RA. Multiple chronic conditions among US adults: a 2012 update. *Prev Chronic Dis* 2014; 11:130389.

CHAPTER 3

Food Quality as an Emerging Factor in Food Safety and Health

Integrating Sodium Reduction Strategies in the Procurement Process and Contracting of Food Venues in the County of Los Angeles Government, 2010-2012

Patricia L. Cummings, MPH; Tony Kuo, MD, MSHS; Lauren N. Gase, MPH; Kristy Mugavero, MSN, MPH, RN

Since sodium is ubiquitous in the food supply, recent approaches to sodium reduction have focused on increasing the availability of lower-sodium products through system-level and environmental changes. This article reviews integrated efforts by the Los Angeles County Sodium Reduction Initiative to implement these strategies at food venues in the County of Los Angeles government. The review used mixed methods, including a scan of the literature, key informant interviews, and lessons learned during 2010-2012 to assess program progress. Leveraging technical expertise and shared resources, the initiative strategically incorporated sodium reduction strategies into the overall work plan of a multipartnership food procurement program in Los Angeles County. To date, 3 County departments have incorporated new or updated nutrition requirements that included sodium limits and other strategies. The strategic coupling of sodium reduction to food procurement and general health promotion allowed for simultaneous advancement and acceleration of the County's sodium reduction agenda.

KEY WORDS: County, healthy food procurement, program intervention, sodium limits

The average amount of sodium that Americans consume remains considerably higher than the *Dietary Guidelines for Americans* recommendations.[1,2] As indicated throughout this journal supplement, the main sources of sodium come from sodium added to restaurant and processed foods before purchase,[3,4] which leaves consumers (eg, patrons of food venues, including vending) with very little choice about how much sodium they consume or avoid. Multiple studies have shown that foods consumed away from home are less nutritious than foods consumed at home and have a higher sodium density.[5-7] Consumer choice is further reduced because acquiring nutrition information while eating away from home can be challenging, leaving consumers without the knowledge they need to make healthier choices.

Since sodium is ubiquitous in the food supply, recent approaches to sodium reduction have focused on increasing the availability of lower-sodium products through system-level and/or environmental changes. For example, implementing nutrition standards and best practices as part of healthy food procurement has become increasingly popular and an accepted approach for creating healthier food environments.[3,8] Healthy food procurement encompasses a process of

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procuring, distributing, selling, and/or serving food by which an entity gives priority to options that meet healthy nutrition standards and/or put in place environmental modifications that specifically encourage selection of healthier foods and beverages.[9] An underlying premise for intervening at the level of the food environment is the belief that increased demand for lower-sodium food products from manufacturers and food suppliers can be achieved through changes in organizational operation and contracting—that is, making healthy eating the “default” choice for patrons of these food venues.[10] Organizational priority to procure and serve more healthful foods can additionally drive demand and place competitive pressure on food manufacturers to reformulate, produce, and distribute more lower-sodium products.[11,12] Sodium limits can be proposed as part of nutritional requirements or as a condition for food service contract execution.[9,12]

In 2010, the Los Angeles County Department of Public Health (DPH) received funding from the Centers for Disease Control and Prevention’s (CDC) Sodium Reduction in Communities Program (SRCP) to reduce sodium consumption at the community level.[13] This funding allowed DPH to accelerate its sodium reduction agenda by establishing the Los Angeles County Sodium Reduction Initiative (LACSRI) to introduce and incorporate sodium reduction approaches into the Department’s Healthy Food Procurement Initiative (HFPI). The HFPI initiative targeted food venues within the County government, at several school districts, and in 10 cities. The SRCP funding allowed the DPH to add key staff to provide technical support and strategic guidance to the HFPI. Started in 2009, the program initiative comprised members from the DPH Nutrition and Physical Activity Program, representatives from several community-based organizations, and staff from the local Communities Putting Prevention to Work obesity prevention program, RENEW LA County.[14] At its inception, the HFPI primarily convened planning meetings to develop strategic directions for the initiative.

This article describes the process of integrating sodium reduction into DPH’s broader, more comprehensive effort to advance healthy food procurement in the County of Los Angeles government (County). It also reviews programmatic achievements and lessons learned from the LACSRI during 2010-2012.

Sodium Reduction Efforts in Los Angeles County, California

Context

Larger than 42 states combined, Los Angeles County is one of the most diverse regions in the United States, with approximately 9.8 million residents and more than 100 different spoken languages.[15] Geopolitically, the jurisdiction is home to a complex array of governing agencies and municipalities. This includes 88 incorporated cities (among them the City of Los Angeles), 80 school districts, and the largest county government in the nation—County of Los Angeles. The latter comprises 37 departments and more than 100 000 employees.[15] Within this landscape exist important opportunities to transform food environments through system-level and environmental changes.

Early assessment

In fall 2009, the DPH conducted a criteria-based assessment (methods including key informant interviews are described elsewhere[16]) of different options for reducing sodium consumption in the local population. The results of this assessment suggested that a potentially effective approach to accomplishing this task was through the use of governmental food procurement strategies aimed at changing food and/or vending practices.[16] A subsequent study found that developing or changing practices for procuring, distributing, selling, and/or serving food represented a potentially feasible strategy for reducing sodium consumption in food venues controlled by the County of Los Angeles government and that by addressing the unique needs and constraints of these diverse venues through the use of department-specific, “venue-based” approaches, the changes could be more sustainable over time.[17] In an organization with a heterogeneous infrastructure and that serves diverse functions, this approach was considered ideal, as it allowed for some customization of standards and requirements by department and by food service venue. For example, a cafeteria in a juvenile hall, which primarily serves children and adolescents, can have different nutrient standards for meals served, as compared with a cafeteria located in the Department of Public Works where they serve employees and the general public.

To guide the work of the LACSRI, the project team reviewed the scientific literature as well as the broader evidence base of reports, Web sites, and the assessments described earlier. The team also considered the feasibility of implementing various sodium reduction strategies in a large organizational setting.[9,16-20] Of particular interest to the team were interventions that would be feasible to implement concurrently, including the following:

1. Incorporating sodium limits and other health and sustainability guidelines (eg, nutrition standards) in institutional food service environments.[12,21]

2. Developing a gradual sodium reduction plan to improve the quality and quantity of lower-sodium food products over time.[11]
3. Improving patron choice by providing information about sodium content at the point-of-purchase or point-of-selection (eg, menu labeling).[9,20,22-24]
4. Influencing patron food selection through the use of signage to promote lower-sodium products.[21,25]
5. Promoting fresh fruit and vegetable intake and water consumption.[26]
6. Using pricing incentives or disincentives to make lower-sodium products more competitive with existing products that are higher in sodium content.[9,27]

An opportunity to change County food environments

In March 2011, the County of Los Angeles Board of Supervisors passed a motion requiring all County departments involved in purchasing, distributing, selling, and/or serving food to consult with the DPH prior to the release of any Request for Proposals (RFPs) for new or renewing food service and vending contracts.[28] In response to this motion, the LACSRI project team, in collaboration with members from the HFPI, developed and established a 5-phase process to support DPH's newly assigned function and to guide responses to forthcoming workload.[8] The 5 phases are as follows: (1) needs assessment, (2) stakeholder education and strategy development, (3) system change adoption, (4) program or project implementation, and (5) compliance monitoring and quality improvement. These phases were developed to streamline and expedite DPH's internal process for reviewing new and renewing food service and vending contracts. Typically, only departments with new or an existing contract that is up for renewal are required to consult with the DPH.

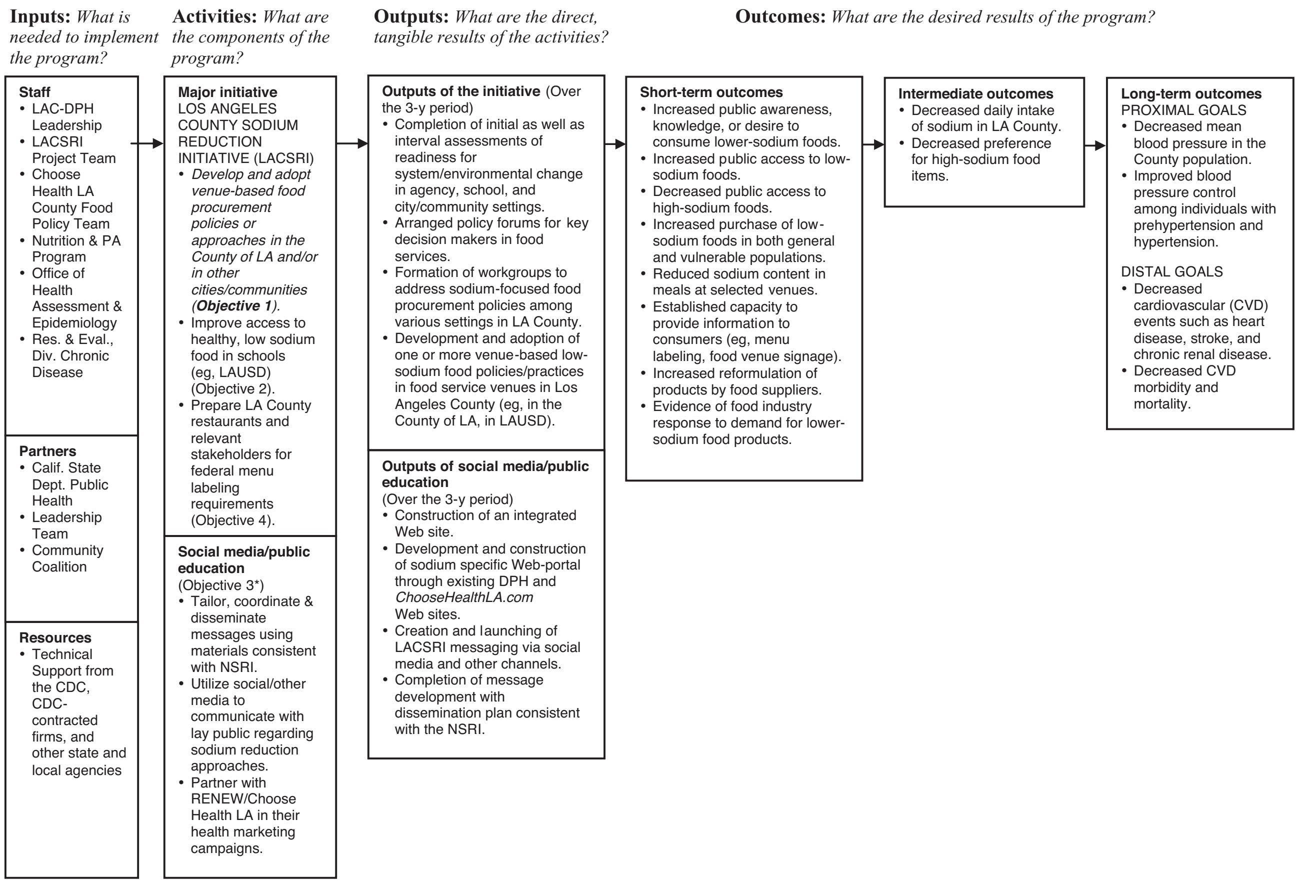
The LACSRI project team recognized that integrating sodium reduction as part of the HFPI would be challenging, especially because the processes involved were programmatically complex and would require extensive coordination of outreach, stakeholder education, and evaluation within multiple organizational units in the DPH as well as with other County departments. The DPH's earlier work in promoting good nutrition by reducing sugary drink consumption was supported by personnel from RENEW LA County and in-kind staffing from the DPH; however, this arrangement did not provide optimal staffing and resources to address new system-level and environmental changes that were expected as a result of the County motion. Thus, to address these needs, the DPH designated a full-time equivalent position to facilitate and manage the 5-phase planning process. An important advantage of integrating sodium reduction into the HFPI was the increased access to registered dietitians and policy analysts who can assist with developing gradual sodium reduction plans and other field interventions designed to reduce sodium content in foods served by County departments.

The LACSRI project team viewed adoption of the motion on food procurement by the County as an unprecedented opportunity to integrate sodium reduction into the contracting process and operations of a large number of County food venues (*Objective 1*, Figure 1). County food venues serve a broad spectrum of patrons, ranging from employees, incarcerated individuals, seniors, children, and the general public. Both the LACSRI and the HFPI favored department-specific, venue-based approaches as previously described. To date, project staff have worked with several departments to better understand their food practices, existing nutrition standards, and opportunities for increasing the healthfulness of the food they served. Staff from each of the departments, for example, were interviewed to assess food procurement practices related to sodium as well as to other nutrients. The Countywide assessment revealed which departments were involved in procuring, distributing, and/or selling food and the number of employees in each of the 12 departments that were identified (Table 1). Figure 2 shows the average number of meals served per day by these departmental food service environments (eg, worksite cafeterias, mobile trucks, snack shops). The Countywide needs assessment also provided LACSRI and HFPI staff a deeper understanding of the processes and concerns of each department and information to estimate the forthcoming workload (eg, number of upcoming RFPs and contracts).

Following the needs assessment, LACSRI project staff began educating stakeholders and worked closely with other HFPI staff to develop a strategy to codify the board motion. During this early stage of the effort, they worked closely with stakeholders from 3 departments (described later) to develop plausible strategies that can be included in their food service and vending RFPs. Through the RFP process, each selected food vendor must comply with the specifications outlined by the agency soliciting bids. These specifications were based on DPH recommendations. The recommendations were not limited to only sodium but also included other nutrition-related procurement strategies that are designed to improve overall nutrition. Sodium-specific recommendations that were incorporated into these RFPs have included but were not limited to the following:

- Limiting sodium for meals/entrées to 600 mg or less per meal/entrée, for sides to 360 mg or less per side, and for snacks to 360 mg or less per snack (Table 2).

FIGURE 1 ● Programmatic Framework for the Los Angeles County Sodium Reduction Initiative—Objective 1 (Under Major Initiative)



Abbreviations: CDC, Centers for Disease Control and Prevention; DPH, Department of Public Health; LA, Los Angeles; LAC, Los Angeles County; LAUSD, Los Angeles Unified School District; LACSRI, Los Angeles County Sodium Reduction Initiative; NSRI, National Salt Reduction Initiative; PA, Physical Activity.

- Developing a plan to gradually reduce the sodium of foods served.
- Providing nutrient information on menus.
- Using signage and product placement that promotes low-sodium food options (eg, fruit and vegetables placed at checkout stands).
- Replacing canned foods with fresh food; but when this is not feasible, lower-sodium versions of canned foods are recommended.
- Implementing price incentives to encourage consumption of lower-sodium options in venues where patrons directly purchase food.

Although these sodium-specific recommendations are considered core elements for inclusion in most RFPs/contracts, they are not universally applicable, as conditions may vary by department and by food venue. For instance, the use of signage and product placement is generally not applicable in institutionalized populations (eg, in juvenile halls and probation camps), as most meals are planned without patron input in these settings.

Achievements to Date

Three of the 12 County departments that procure, distribute, sell, and/or serve food (Table 1) during 2010-2012 incorporated new or updated nutrition standards and requirements into their food service and vending processes. These new or updated standards and requirements included sodium limits and several best practices in healthy food procurement (eg, use of signage, pricing incentives, and menu labeling) (Table 2). They were established through modifications of existing administrative procedures or included as part of the RFP or contracting process. The Department of Corrections (Probation), for instance, incorporated sodium limits into their RFP process for selected food vendors that serve meals to children and adolescents in juvenile halls and probation camps. The Department of Public Works incorporated both sodium limits and other best practices in healthy food procurement as part of their RFP and in the subsequent vendor contract for its

TABLE 1 ● Organizational Structure in the County of Los Angeles Government, 2010-2012

Organizational Structure	n
Total number of departments	37
Total number of departments that procure, distribute, sell, and/or serve food	12[a]
Approximate number of departments that provide services to the following groups[a]:	
Children	3
Seniors (age 65+)	1
Institutionalized populations	2
Employees	9
Community members/visitors	4
Approximate numbers of employees in the 12 departments that procure, distribute, sell, and/or serve food	
Beaches & Harbors	255
Chief Executive Office	501
Children & Family Services	6 500
Community Development	480
Senior Services	504
Fire Department	5 000
Health Services	21 700
Parks and Recreation	1 461
Probation	5 800
Public Works	5 000
Sheriff's	18 000
Internal Services	2 235

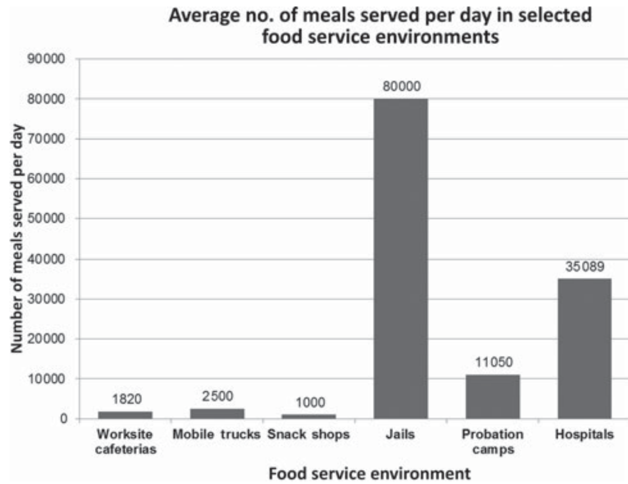
[a]Approximation based on a *Countywide* departmental assessment.

central cafeteria; the cafeteria serves not only the Department of Public Works staff but also other staff from other departments housed in adjacent offices. The Department of Health Services took similar action to include sodium limits, menu labeling, and signage as part of their hospital cafeteria RFP; these specifications, however, have not taken effect due to administrative delays in vendor selection. Collectively, these sodium reduction strategies in the 3 departments have the potential to affect more than 100 000 meals served per day in the County of Los Angeles (Figure 2). As the LACSRI continues to work alongside the HFPI, further sodium reduction innovations may come to fruition, as forthcoming RFPs/contracts present additional opportunities to advance and evaluate food procurement strategies in the County of Los Angeles.

Lessons Learned

Although the County departments described in this article varied in their mission, organizational structure, and geopolitical landscape, 3 key lessons emerged from the SRCP experience in Los Angeles County.

FIGURE 2 ● Food Service Environments in the County of Los Angeles Government, 2010-2012



1. *Implementation takes time and effort*. The County of Los Angeles Board Motion granting authority to the DPH to review and make recommendations on all new or renewing food service and vending contracts served as an important foundation for improving the food environment in County departments. However, adoption of this mandate was only the first step of a lengthy process for codifying the innovative changes in practice. The presence of the motion, for example, did not automatically change the environmental context, potential barriers to implementation, or the work needed to sustain the practice innovations. In most instances, technical assistance was required to assist each department and its vendor(s) with compliance and implementation of the required practices. This process, as well as buy-in from the department, vendor, and food venue patrons, has taken some time to achieve.
2. *Multiple strategies to reduce sodium content in food can work synergistically*. The LACSRI took advantage of the opportunity to implement an array of sodium reduction strategies by integrating them into a broader County initiative supported by multiple efforts (eg, RENEW LA County, Choose Health LA) to promote healthy food procurement. During the SRCP, procurement requirements were changed to include not only sodium limits but also other nutrient limits and practices that had the potential to decrease sodium consumption (eg, promotion of fruit and vegetables using signage, portion control). Each of these strategies led to positive changes in the food environment and, together, reinforced and supported sodium reduction in the overall food procurement effort. An important lesson learned in this process was the synergies that

TABLE 2 ● **Strategies Adopted to Reduce Sodium Content in Foods Procured, Distributed, Sold, and/or Served by Food Venues in the County of Los Angeles, 2010-2012[a]**

Recommendations	What Was Affected?
Sodium limits established for meals/entrées and sides: ≤600 mg per meal/entrée ≤360 mg per side	The following food categories must meet recommended sodium limits[b]: Main dish/entrées Side items Combination meals
Sodium limits established for snacks: ≤360 mg per snack	All snacks sold (including those in vending machines) must follow established sodium limits as recommended by the Los Angeles County Department of Public Health
Other recommended practices that may reduce sodium consumption	Departments with new or renewing food service and vending contracts were asked by the Los Angeles County Department of Public Health to integrate the following practices that may help reduce sodium content or intake: Menu labeling Signage and product placement that promote low-sodium food options (eg, fresh fruit and vegetables) No salt added or elimination of canned foods, if feasible Gradual sodium reduction plan

[a]Standards specific to County of Los Angeles hospital and workplace cafeterias (ie, does not include standards for distributive meal programs).
[b]These standards are for food sold by cafeterias and concession services on government property.

multiple sodium reduction strategies created with other food environment interventions.

3. *Advantages of coupling sodium reduction to broader efforts to improve nutrition*. Incorporating sodium reduction as part of a broader nutrition message was advantageous to the LACSRI because it allowed the subject to be introduced and discussed innocuously as part of an overall agenda on health. Not having to singularly convince food service directors or managers to consider sodium reduction by itself enabled the project team to focus more attention on other barriers to implementation, such as the complex and time-consuming administrative procedures in contracting, the nuances of writing contract language, and the variable levels of consumer acceptance of lower-sodium food offerings.[16]

Applying an integrative approach to sodium reduction in the County of Los Angeles allowed for simultaneous advancement and acceleration of several food procurement changes in County venues and in other local food service and vending environments. In concert with other efforts in schools, in the retail environment, and through public education or health marketing, multisectoral partnerships are emerging as necessary components for achieving the full benefits of reducing sodium consumption in the population.[29] These local efforts, together with national efforts,[2] can cumulatively lead to a potential shift in the demand for lower-sodium products and serve as the first big step toward changing the food supply toward a healthier norm.

Conclusion

The LACSRI experience in the County of Los Angeles provides real-world context and lessons learned on the plausibility and potential of local efforts to reduce sodium consumption in the community, featuring workable models of practice and cross-learning opportunities for other jurisdictions to consider, especially among those that are ready to take action.

REFERENCES

1. US Department of Agriculture. *Dietary Guidelines for Americans*. Washington, DC: US Government Printing Office; 2010.
2. Levings J, Cogswell M, Curtis CJ, Gunn J, Neiman A, Angell SY. Progress toward sodium reduction in the United States. *Rev Panam Salud Publica*. 2012;32(4):301-306.
3. Institute of Medicine. *Strategies to Reduce Sodium Intake in the United States*. Washington, DC: The National Academies Press; 2010.
4. Mattes RD, Donnelly D. Relative contributions of dietary sodium sources. *J Am Coll Nutr*. 1991;10(4):383-393.
5. Okrent AM, Alston JM. *The Demand for Disaggregated Food-Away-From-Home and Food-at-Home Products in the United States*, ERR-139. Washington, DC: US Department of Agriculture, Economic Research Service; 2012.
6. USDA Amber Waves. http://www.ers.usda.gov/media/783958/Datafeature.pdf. Accessed December 2, 2012.
7. Centers for Disease Control and Prevention. Vital signs: food categories contributing the most to sodium consumption—United States, 2007-2008. *MMWR Morb Mortal Wkly Rep*. 2012;61(5):92-98.
8. Robles B, Wood M, Kimmons J, Kuo T. Comparison of nutrition standards and other recommended procurement practices for improving institutional food offerings in Los Angeles County, 2010-2012. *Adv Nutr*. 2013;4:191-202.
9. Centers for Disease Control and Prevention. *Improving the Food Environment Through Nutrition Standards: A Guide for Government Procurement*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division for Heart Disease and Stroke Prevention; 2011.
10. Booth SL, Sallis JF, Ritenbaugh C, et al. Environmental and societal factors affect food choice and physical activity:

rationale, influences, and leverage points. *Nutr Rev*. 2001;59(3, pt 2):S21-S39; discussion S57-S65.
11. Wang G, Labarthe D. The cost-effectiveness of interventions designed to reduce sodium intake. *J Hypertens*. 2011;29(9):1693-1699.
12. Kimmons J, Jones S, McPeak HH, Bowden B. Developing and implementing health and sustainability guidelines for institutional food service. *Adv Nutr*. 2012;3:337-342.
13. Mugavero K, Losby JL, Gunn JP, Levings JL, Lane RI. Reducing sodium intake at the community level: the Sodium Reduction in Communities Program. *Prev Chronic Dis*. 2012;9:120081. doi:http://dx.doi.org/10.5888/pcd9.120081.
14. Bunnell R, O'Neil D, Soler R, et al. Communities Putting Prevention to Work Program Group. Fifty communities putting prevention to work: accelerating chronic disease prevention through policy, systems, and environmental change. *J Community Health*. 2012;37(5):1081-1090. doi:10.1007/s10900-012-9542-3.
15. LA county.gov. Los Angeles County (LAC) residents. http://www.lacounty.info/wps/portal/lac/residents/. Accessed November 13, 2012.
16. Gase LN, Kuo T, Dunet DO, Simon PA. Facilitators and barriers to implementing a local policy to reduce sodium consumption in the County of Los Angeles government, California, 2009. *Prev Chronic Dis.* 2011;8(2):A33.
17. Gase LN, Kuo T, Dunet D, Schmidt SM, Simon PA, Fielding JE. Estimating the potential health impact and costs of implementing a local policy for food procurement to reduce the consumption of sodium in the County of Los Angeles. *Am J Public Health.* 2011;101(8):1501-1507.
18. National Prevention Council. *National Prevention Strategy*. Washington, DC: Office of the Surgeon General, US Department of Health and Human Services; 2011.
19. Community Preventive Services Taskforce. The guide to community preventive services (the community guide). http://www.thecommunityguide.org/index.html. Accessed November 13, 2012.
20. Corby-Edwards AK. *Nutrition Labeling of Restaurant Menus*. Washington, DC: Congressional Research Service; 2012.
21. Kumanyika SK, Obarzanek E, Stettler N, et al. American Heart Association Council on Epidemiology and Prevention, Interdisciplinary Committee for Prevention. Population-based prevention of obesity: the need for comprehensive promotion of healthful eating, physical activity, and energy balance: a scientific statement from American Heart Association Council on Epidemiology and Prevention, Interdisciplinary Committee for Prevention (formerly the expert panel on population and prevention science). *Circulation*. 2008;118(4):428-464.
22. Kozup KC, Creyer EH, Burton S. Making healthful food choices: the influence of health claims and nutrition information on consumers' evaluations of packaged food products and restaurant menu items. *J Market.* 2003;67(2):19-34.
23. Burton S, Creyer EH. What consumers don't know can hurt them: consumer evaluations and disease risk perceptions of restaurant menu items. *J Consumer Aff*. 2004;38(1):121-145.
24. Kuo T, Jarosz CJ, Simon P, Fielding JE. Menu labeling as a potential strategy for combating the obesity epidemic: a health impact assessment. *Am J Public Health*. 2009;99(9):1680-1686.
25. Hawkes C. Identifying innovative interventions to promote healthy eating using consumption-oriented food supply chain analysis. *J Hunger Environ Nutr*. 2009;4:336-356.
26. Ashe M, Graff S, Spector C. Changing places: policies to make a healthy choice the easy choice. *Public Health*. 2011;125(12):889-895.
27. Harvie J, Mikkelsen L, Shak L. A new health care prevention agenda: sustainable food procurement and agricultural policy. *J Hunger Environ Nutr.* 2009;4:409-429.
28. County of Los Angeles Board of Supervisors. *Healthy Food Promotion in LA County Food Services Contracts* March 22, 2011. Motion introduced by Supervisor Mark Ridley-Thomas.
29. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. *Annu Rev Public Health.* 2008;29:253-272.

Evaluating Changes to Sodium Content in School Meals at a Large, Urban School District in Los Angeles County, California

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Context: Children consume more than one-third of their daily food intake in schools, suggesting that these environments are ideal places for intervening on poor dietary behaviors. **Objective:** To assess the impact of strategy-focused menu planning on the sodium content of student meals served in the Los Angeles Unified School District (LAUSD). **Design:** Pre- and post-LAUSD menu change analyses for school years (SY) 2010-2011 and 2011-2012 were performed using nutritional analysis data and food production records. The analyses assessed changes in sodium content by meal categories. **Setting:** 900+ schools, grades K-12, operated by the LAUSD. **Participants:** The LAUSD Food Services Branch, which serves about 650 000 meals per day. **Intervention:** A multistage menu planning approach that focused on implementing evidence-based strategies to improve the nutritional content of school breakfast and lunch menus. Engagement and formation of multisectoral partnerships, including public health and parent/student groups, were vital elements of the intervention process. **Main Outcome Measure(s):** Sodium content changes in the LAUSD menu, SY 2010-2011 versus SY 2011-2012; other measures include documentation of program reach. **Results:** From SY 2010-2011 to SY 2011-2012, the mean *unweighted* sodium levels for *elementary* (K-5) breakfast and for *secondary* (6-12) breakfast and lunch decreased. These changes met or exceeded the 2014-2015 US Department of Agriculture sodium targets for school meals and for *secondary* breakfast, the 2022-2023 target(s). These results, however, were not as notable once student food selection patterns (weighted data) and condiments were considered in the analysis. **Conclusions:** Use of strategy-focused menu planning as a mechanism to reduce sodium in school meals appeared to be promising, demonstrating favorable declines in mean sodium levels for at least 3 of 4 meal categories in the LAUSD. Student food selection patterns and condiments use, however, can affect the strength of the intervention.

KEY WORDS: **healthy food procurement, school health, school meal program, sodium limits**

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The importance of sodium reduction to decrease cardiovascular disease risk cannot be overstated.[1] A large body of evidence supports the health benefits of lowering sodium in the diet of the average person and for special populations (eg, children, African

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Americans, those with cardiovascular disease, and older adults).[2-4] The average amount of sodium that Americans (including children) consume daily remains substantial (>3400 mg per day) and significantly higher than the *Dietary Guidelines for Americans* recommendations (no more than 1500 mg per day for almost half of US adults and children).[5,6] Although individual choice plays an important role, the environment is the critical driving force for this public health problem.[7-12] As stated throughout this supplement, the main sources of sodium are restaurant and processed foods, including foods served in school cafeterias.[3,13]

The literature suggests that access to foods in schools influences children's dietary behaviors, both in the short term and in the long term.[2,14] Thus, schools are increasingly seen as ideal places to improve nutrition, since US children consume more than one-third of their daily food intake in these environments.[15,16] The recent updates to the US Department of Agriculture's (USDA's) nutritional requirements for the federally subsidized National School Lunch Program (NSLP) and the School Breakfast Program (SBP), for example, represent transformative opportunities for public health to incorporate and further accelerate sodium reduction in the daily processes of school districts, especially in low-income, urban areas. In Los Angeles County, this translated to an unprecedented opportunity to affect change in the nation's second largest school meal program—the program operated by the Food Services Branch (FSB) of the Los Angeles Unified School District (LAUSD).

In 2010, the Los Angeles County Department of Public Health (DPH) received funding from the Centers for Disease Control and Prevention's Sodium Reduction in Communities Program (SRCP) to reduce sodium consumption at the community level through the use of system-level and environmental change strategies.[17] This funding allowed the DPH to accelerate its sodium-reduction effort (the *Los Angeles County Sodium Reduction Initiative*) by adding staff support and technical assistance resources to an existing departmental *healthy food procurement* initiative; the initiative is described elsewhere in this journal supplement.[18] The LAUSD school meal program was among the institutional settings that were targeted by this sodium-reduction effort. For this particular program objective, the DPH in collaboration with the LAUSD was successful in introducing and incorporating a number of sodium-reduction strategies into the LAUSD-FSB menu planning process. The strategy-focused approaches that were introduced and implemented included the following: (1) sodium limits as part of the school district's comprehensive nutrition policy, menu planning (eg, taste tests with students and parents), and food procurement (eg, working with vendors to procure lower-sodium foods); (2) environmental modifications such as signage at point-of-selection or health education materials to promote consumption of more fruits and vegetables; and (3) an awareness campaign (*I'm In*) to prepare students and parents for forthcoming changes to the menu (Table 1).

In this article, we discuss the evaluation of menu changes made to the LAUSD school meal program, comparing the mean sodium levels by meal categories for school years (SY) 2010-2011 (pre–menu change) and 2011-2012 (post–menu change). Of particular

TABLE 1 ● Sodium Limits and Other Menu Changes in the LAUSD School Meal Program, SY 2010-2011 Versus SY 2011-2012

Category	SY 2010-2011	SY 2011-2012
Menus (by grade category) that must meet recommended school nutrition standards	Elementary breakfast[a] Elementary lunch[a] Secondary breakfast[c] Secondary lunch[c]	Breakfast[b] Elementary lunch[a] Secondary lunch[c]
Planning of nutrition standards for meals	Nutrient-based menu planning	Food-based menu planning, including new sodium limits, from the USDA's *Final Rule*, which is based on the Institute of Medicine recommendations
Sodium limits	Less than 1100 mg of sodium averaged over the week[d] Less than 1500 mg of sodium per meal[d]	Less than 1100 mg of sodium averaged over the week[d] Less than 1500 mg of sodium per meal[d] Other alternatives for achieving the sodium-level requirements[e]: offer more fruits and vegetables; offer more reduced sodium food options; adopt age-appropriate portion control guidelines

Abbreviations: LAUSD, Los Angeles Unified School District; SY, school year; USDA, US Department of Agriculture.
[a]In general, includes grades K-5.
[b]Includes grades K-12.
[c]In general, includes grades 6 to 12.
[d]Not specified under the National School Meals Program standards; specific to the LAUSD.
[e]First sodium targets go into effect in SY 2014-2015.

interest is whether the incorporation of sodium limits in the new school meal program menu for 2011-2012 resulted in actual lowering of the mean sodium content for the meals served by the LAUSD-FSB and whether the changes in the sodium content met the sodium targets recommended by the Institute of Medicine (IOM); these targets were later adopted (post–menu change) by the USDA's *Final Rule* for school meals on January 26, 2012.[2,3] The article concludes by discussing the implications of these changes to other school districts in Los Angeles County and nationally for districts interested in taking similar action.

Methods

The USDA NSLP and the SBP require reporting from all participating school districts for compliance purposes.[19] In the LAUSD, interval reporting is based on analyses of nutritional content of the NSLP and SBP menus and monitoring of food production by meal categories: *elementary* (K-5) breakfast and lunch and *secondary* (6-12) breakfast and lunch. The OneSource Point-of-Service software (Horizon Software International, Duluth, Georgia) was used to analyze all 4 menus for nutritional content. OneSource uses the USDA database as the source for food nutrient data. The software is continually updated to provide necessary data as required by the USDA NSLP. The menu items were entered into the Point-of-Service system and analyzed for total fat, saturated fat, trans fat, food energy (kilocalories), carbohydrates, cholesterol, dietary fiber, protein, iron, calcium, sodium, and vitamins A and C; this article presents data for sodium only. Through a data-sharing arrangement with the LAUSD-FSB, the DPH gained access to these nutritional analysis data for the months of October 2010 and October 2011, which corresponded to the pre– and post–menu change periods that were selected for analysis. The DPH also gained access to the food production records (up to a total of 9 months per school year); the food production records provided information on leftovers and patterns of food selection among students by food categories (eg, entrées, sides, dairy products, condiments). Both data sets (nutritional analysis and food production records) were rigorously cleaned and processed iteratively by the DPH prior to the analysis.

Comparative analysis

The mean sodium levels before and after the new menu changes were estimated by analyzing the food offerings outlined in the menus. The corresponding nutritional analysis data and food production records were extracted from the data files for October 2010 and October 2011. The month of October was selected for this comparative analysis because it offered a reasonable time window of at least 6 weeks from the start of the school year to allow for all menu changes to be fully implemented. A length of 12 months between pre–menu change (SY 2010-2011) and post–menu change (SY 2011-2012) was selected to account for operational factors (eg, procurement costs that might affect the number and type of entrées/sides produced and offered; seasonal variability, such as quality and quantity of fruits and vegetables offered; and attrition [eg, elimination of flavored milk during the school year]). For SY 2010-2011, 4 different meal categories were offered at the LAUSD: *elementary* breakfast, *elementary* lunch, *secondary* breakfast, and *secondary* lunch. For SY 2011-2012, the breakfast categories were consolidated into one category because meal offerings were the same for both *elementary* and *secondary* breakfasts. In general, the choice of offerings for *elementary* breakfast and lunch (meal categories) was served to students in grades K-5 whereas *secondary* breakfast and lunch (meal categories) were served to students in grades 6 to 12. In some schools, the grade levels were mixed (eg, K-12, continuation schools, special education); these schools were excluded after sensitivity analyses revealed no difference in mean estimates when these schools were included versus excluded from the analysis. Schools that had missing data were also excluded from the analysis. In SY 2010-2011, the LAUSD comprised 916 schools; this number increased to 938 schools in SY 2011-2012. After applying the aforementioned exclusion criteria, final sample sizes for the comparative analysis were as follows: n = 683 for SY 2010-2011 and n = 728 for SY 2011-2012. These numbers reflect the availability of the data for the school site and the completeness of food production records to weight the data. Characteristics of the schools, including enrollment for SY 2010-2011 and SY 2011-2012, are given in Table 2.

Nutritional content data: Estimating mean sodium level per meal, by meal category

The nutritional content of the SY 2010-2011 and SY 2011-2012 menus was determined using the nutritional composition records for each menu item provided by the LAUSD; these data were ascertained using the nutritional analysis software described earlier to analyze information contained in menu recipes. Each *meal* in each meal category was offered as an assortment or a combination of entrées, at least one side, a milk option, and condiments related to the entrée choice. To account for variation in student selection of entrées (eg, meat vs vegetable options), weights were determined using the food production records provided by the LAUSD and were applied to the mean estimates

TABLE 2 ● Characteristics of the Los Angeles Unified School District at Baseline (SY 2010-2011) and at Post–Menu Change (SY 2011-2012) for the National School Lunch Program and School Breakfast Program[a]

District Characteristics	SY 2010-2011 [Total for SY, n = 688 138 Students], n (%)	SY 2011-2012 [Total for SY, n = 662 140 Students], n (%)
Total school sites	916[b]	938[c]
Student enrollment (K-12)		
Elementary schools (grades K-5)	310 012 (45.1)	309 545 (45.1)
Middle schools (grades 6-8)	125 631 (18.3)	122 729 (18.3)
High schools (grades 9-12)	187 200 (27.2)	182 570 (27.2)
K-12 schools (all grades)	11 906 (1.7)	13 718 (1.7)
Other schools and centers (eg, special education)	32 502 (4.7)	33 578 (4.7)
Race/ethnicity		
Hispanic	505 093 (73.4)	478 727 (72.3)
Black, not Hispanic	68 126 (9.9)	63 565 (9.6)
White, not Hispanic	60 556 (8.8)	66 876 (10.1)
Asian	26 837 (3.9)	26 486 (4.0)
Other[d]	26 837 (3.9)	25 823 (3.9)
Free or reduced price meal enrollment (proxy for low-income or poverty status in the community, as it relates to the location of the school)	523 673 (76.1)	499 916 (75.5)

[a]From California Department of Education *Data Quest*.
[b]A total of 683 schools (of the 916) were included in the present analysis.
[c]A total of 728 schools (of the 938) were included in the present analysis.
[d]Other category includes Filipino, Pacific Islander, American Indian/Alaska Native, and multiple or no response (ie, information not reported).

of sodium levels for each of the entrées offered in the menus. The number of entrées selected was calculated by subtracting the leftovers from the total food offered for each day. This number was used to determine the fraction of the total number of entrées served out of the total number of entrées made that day for students. Although the menu would often repeat itself throughout the month, nutritional content varied according to the daily popularity of each of the entrées. For example, the Café LA Coffee Cake was served on several occasions for breakfast in October 2010; however, the amount of sodium this item contributed to the daily nutritional content varied depending on how many students selected it compared with the other entrée available. On any given day, for all meal categories, there were at least 2 entrée options to choose from for both breakfast and lunch. The mean sodium levels for each meal were estimated on the basis of a formulaic series of calculations. These calculations took into account the mean estimates for entrées weighted by student selection pattern (as described earlier); the absolute or mean estimates for sides (sometimes only one side is offered during the meal period); the mean estimates for the choice of milk; and the mean estimates for condiments added (see equations A and B). The final estimates were based on averaging daily meal offering estimates over the month. Confidence intervals (95% CIs) were calculated for each mean estimate and used to assess whether a significant change was present in sodium content due to the new menu changes. Mean sodium levels were then compared against the IOM and USDA standards outlined in the final rule for school meals.[2]

The following formulas (equations A and B) for estimating mean sodium level per meal, based on the number of choices offered during the meal period, were used:

$$\text{Weighted entrée (1 choice out of 2)} + \text{sides}_{1\,\ldots\,n}\text{ (mean)} + \text{choice of milk (mean)} + \text{condiments (mean)} \quad \text{(A)}$$

$$\text{Weighted entrée (1 choice out of 3)} + \text{sides}_{1\,\ldots\,n}\text{ (mean)} + \text{choice of milk (mean)} + \text{condiments (mean)} \quad \text{(B)}$$

Data analysis and institutional review board considerations

All calculations were performed using Statistical Analysis Software (version 9.3; SAS Institute, Cary, North Carolina). Prior to the analysis, all data sets, data management protocols, and estimation procedures were reviewed and approved by the Los Angeles County DPH's institutional review board. Since nutritional analysis data and food production records contained no individual identifying information, they were considered exempt by the institutional review board.

Results

From SY 2010-2011 (pre–menu change) to SY 2011-2012 (post–menu change), the mean unweighted sodium levels per meal for *elementary* and *secondary* breakfast decreased by 33.8% and 53.5%, respectively. Post–menu change, the mean unweighted sodium levels per meal for *elementary* and *secondary* breakfast were both 494.3 mg (95% CI, 424.0-564.6), which met the IOM and USDA 2014-2015 *elementary* breakfast target and the 2022-2023 *secondary* breakfast target (Table 3). For *secondary* lunch, the mean unweighted sodium level per meal was 1089.8 mg (95% CI, 962.1-1217.6) post–menu change, a decrease of 4.2% from SY 2010-2011. For *elementary* lunch, however, the mean unweighted sodium level per meal increased by 10.2%.

Results were not as notable once student food selection patterns (weighted data) and condiments were considered in the analysis. After weighting, *elementary* breakfast mean sodium level per meal (including condiments) decreased by only 13.3% (mean difference = 79.5 mg) as opposed to the 33.8% decrease (mean difference = 252.5 mg) observed for the unweighted data. Similarly, the mean sodium level per meal for *secondary* lunch (including condiments) increased with weighting, diminishing the magnitude of the difference seen between SY 2010-2011 and SY 2011-2012 (Table 3).

Discussion

With the support of the LAUSD Board of Education and early engagement of students, parents, and community stakeholders, the LAUSD-FSB in partnership with the DPH successfully changed the food offerings of the school meal program for SY 2011-2012. In concert with the *Los Angeles County Sodium Reduction Initiative*, the DPH was able to strategically integrate sodium reduction (eg, sodium limits and other environmental modifications such as promotion of fruits and vegetables, which are low-sodium food options) into the broader, more comprehensive agenda on health, which was adopted by the LAUSD-FSB in its menu planning for SY 2011-2012. The present findings reflect these efforts and highlight the favorable changes that took place during the SRCP experience in the LAUSD.

Indeed, the present comparative analysis indicates that mean unweighted sodium levels for 3 of 4 meal categories decreased post–menu change, suggesting that applying sodium limits to school meals is a plausible intervention for large, urban school districts such as the LAUSD, which serves about 650 000 meals per day. The addition of weighting procedures to account

TABLE 3 ● Mean Sodium Levels by Meal Category, October 2010 Versus October 2011[a]

Meal Category	October 2010 (n = 21 days)		October 2011 (n = 21 days)		Sodium Targets (USDA/IOM)[c]		
	Unweighted	Weighted[b]	Unweighted	Weighted[b]	2014-2015	2017-2018	2022-2023
Elementary breakfast	746.8 (95% CI, 677.4-816.1)	595.9 (95% CI, 540.6-651.2)	494.3 (95% CI, 424.0-564.6)	516.4 (95% CI, 434.7-598.0)	<540 mg	<485 mg	≤430 mg
Elementary lunch	1010.6 (95% CI, 945.5-1075.7)	969.2 (95% CI, 909.7-1031.6)	1113.8 (95% CI, 803.3-1424.3)	1308.9 (95% CI, 1087.1-1530.7)	<1230 mg	<935 mg	≤640 mg
Secondary breakfast	1063.5 (95% CI, 1002.7-1124.3)	1030.5 (95% CI, 971.6-1089.5)	494.3 (95% CI, 424.0-564.6)	550.5 (95% CI, 459.9-641.1)	<640 mg	<570 mg	≤500 mg
Secondary lunch	1137.2 (95% CI, 1052.4-1222.0)	1113.4 (95% CI, 1030.3-1196.4)	1089.8 (95% CI, 962.1-1217.6)	1206.5 (95% CI, 1002.3-1410.7)	<1420 mg	<1080 mg	≤740 mg

Abbreviations: CI, confidence interval; IOM, Institute of Medicine; SY, school year; USDA, US Department of Agriculture.
[a]Note regarding condiments: *elementary breakfast* 2010: condiments, on average, contributed 44.3 mg of sodium per meal (range: 10-130 mg); *elementary breakfast* 2011: condiments, on average, contributed 95.2 mg of sodium per meal (range: 0-255 mg); *elementary lunch* 2010: condiments, on average, contributed 293.1 mg of sodium per meal (range: 120-409.8 mg); *elementary lunch* 2011: condiments, on average, contributed 172.4 mg of sodium per meal (range: 0-545 mg); *secondary breakfast* 2010: condiments, on average, contributed 109.8 mg of sodium per meal (range: 105-130 mg); *secondary breakfast* 2011: condiments, on average, contributed 94.8 mg of sodium per meal (range: 0-255 mg); *secondary lunch* 2010: condiments, on average, contributed 317.9 mg of sodium per meal (range: 120-490 mg); and *secondary lunch* 2011: condiments, on average, contributed 177.6 mg of sodium per meal (range: 0-545 mg).
[b]Results were weighted using student selection/consumption patterns for relevant food categories—data courtesy of LAUSD's food production records for the SY 2010-2011 and SY 2011-2012.
[c]These sodium targets were based on the IOM recommendations and adopted by the USDA *Final Rule* for the National School Lunch Program and School Breakfast Program.

for student selection pattern in the mean sodium estimates (per meal) was both innovative (not previously done with regularity for this type of analysis) and necessary to draw more realistic conclusions about this strategy's impact, as individual student choices play a critical role in determining the strength of system-level and environmental change interventions.[11,14] The weighted results, for example, likely reflected variations in the student selection of entrées (eg, the students consistently chose more meat options than vegetable options). Similarly, condiments played a role and affected the magnitude of the decline in sodium averages. Condiments can add in excess of 44.3 to 317.9 mg of sodium to each meal (see footnotes in Table 3). Finally, the differences observed between the menus for SY 2010-2011 and SY 2011-2012 should be interpreted conservatively, ideally within the context of LAUSD's conversion from a nutrient-based menu planning process to one that is based on food categories (food-based) (Table 1). This conversion was undertaken in response to the new USDA *Final Rule* and likely contributed to the further lowering of mean sodium levels by the addition of more fruits and vegetables offered in the SY 2011-2012 menu.

Limitations

Results from the present analysis are subject to several limitations. First, the nutritional analysis data from the LAUSD were compiled using nutritional software that analyzed information from menu recipes. While this is generally considered an acceptable, high-quality alternative to laboratory nutrient analysis (gold standard), possible data entry and software user errors may have occurred and lessened the internal validity of the method.[20] Second, cleaning, managing, and analyzing food production records was labor- and resource-intensive since these records are not collected for the sole purpose of evaluation. The records were also subject to a variety of coding errors. For example, schools sometimes coded an entrée using the incorrect recipe ID or they mislabeled the meal category (eg, *elementary* breakfast rather than *secondary* lunch). Unlike entrées and sides, recordings of condiments quantity were frequently inconsistent in these records. Third, there was a small difference in the number of schools from SY 2010-2011 to SY 2011-2012 (difference = 45 schools) included in the analysis for each of the 2 years, which reflects the availability of food production records for each school. However, the results were not significantly influenced by this difference. Finally, missing data were commonly encountered during data analysis. This, however, was expected, as real-world data files are generally not as complete or rigorously cleaned as data collected for the sole purpose of research.

CONCLUSIONS

The use of strategy-focused menu planning as a mechanism to reduce sodium in school meals appeared to be promising, demonstrating favorable declines in mean sodium levels for at least 3 of 4 meal categories in the LAUSD. Student food selection patterns and condiments use, however, appeared to affect the strength of the intervention. More research and evaluation are clearly warranted to study these and other complex food selection behaviors and menu change interventions in public schools. Findings and lessons learned from this analysis provide real-world context and data that have utility for informing menu planning in other school districts interested in taking similar action as the LAUSD.

REFERENCES

1. Centers for Disease Control and Prevention. Vital signs: food categories contributing the most to sodium consumption—United States, 2007-2008. *MMWR Morb Mortal Wkly Rep.* 2012;61(5):92-98.
2. Institute of Medicine of the National Academies. School meals: building blocks for healthy children. http://www.iom.edu/Reports/2009/School-Meals-Building-Blocks-for-Healthy-Children.aspx. Published 2009. Accessed November 13, 2012.
3. Institute of Medicine. *Strategies to Reduce Sodium Intake in the United States.* Washington, DC: The National Academies Press; 2010.
4. Community Preventive Services Taskforce. The guide to community preventive services (the community guide). http://www.thecommunityguide.org/index.html. Accessed November 13, 2013.
5. US Department of Agriculture. *Dietary Guidelines for Americans, 2010*. Washington, DC: US Government Printing Office; 2010.
6. Levings J, Cogswell M, Curtis CJ, Gunn J, Neiman A, Angell SY. Progress toward sodium reduction in the United States. *Rev Panam Salud Publica*. 2012;32(4):301-306.
7. Booth SL, Sallis JF, Ritenbaugh C, et al. Environmental and societal factors affect food choice and physical activity: rationale, influences, and leverage points. *Nutr Rev.* 2001; 59(3, pt 2):S21-S39; discussion S57-S65.
8. Ashe M, Graff S, Spector C. Changing places: policies to make a healthy choice the easy choice. *Public Health*. 2011;125(12):889-895.
9. Bunnell R, O'Neil D, Soler R, et al. Communities Putting Prevention to Work Program Group. Fifty communities putting prevention to work: accelerating chronic disease prevention through policy, systems, and environmental change. *J Community Health*. 2012;37(5):1081-1090. doi:10.1007/s10900-012-9542-3.
10. Centers for Disease Control and Prevention, US Department of Health and Human Services and General Services Administration. Health and sustainability guide-

lines for federal concessions and vending operations. http://www.cdc.gov/chronicdisease/pdf/Guidelines_for_Federal_Concessions_and_Vending_Operations.pdf. Accessed November 13, 2012.

11. Kimmons J, Jones S, McPeak HH, Bowden B. Developing and implementing health and sustainability guidelines for institutional food service. *Adv Nutr.* 2012;3:337-342.
12. Robles B, Wood M, Kimmons J, Kuo T. Comparison of nutrition standards and other recommended procurement practices for improving institutional food offerings in Los Angeles County, 2010-2012. *Adv Nutr.* 2013;4:1-13.
13. Mattes RD, Donnelly D. Relative contributions of dietary sodium sources. *J Am Coll Nutr*. 1991;10(4):383-393.
14. Johnston Y, Denniston R, Morgan M, Bordeau M. Rock on Cafe: achieving sustainable systems changes in school lunch programs. *Health Promot Pract.* 2009;10(2):100S-108S.
15. Briefell RR, Crepinsek MK, Cabili C, et al. School food environments and practices affect dietary behaviors of US public school children. *J Am Diet Assoc.* 2009;109(suppl 2):S91-S107.
16. Finkelstein DM, Hill EL, Whitaker RC. School food environments and policies in U.S. public schools. *Pediatrics*. 2010;122(1):e251-e259.
17. Mugavero K, Losby JL, Gunn JP, Levings JL, Lane RI. Reducing sodium intake at the community level: the Sodium Reduction in Communities Program. *Prev Chronic Dis.* 2012;9:120081. doi:http://dx.doi.org/10.5888/pcd9.120081.
18. Cummings PL, Kuo T, Gase LN, Mugavero K. Integrating sodium reduction strategies in the procurement process and contracting of food venues in the County of Los Angeles government, 2010-2012. *J Public Health Manag Pract*. 2014;20(suppl 1):S16-S22.
19. US Department of Agriculture. Food and Nutrition Service. 7 CFR Parts 210-220. Nutrition Standards in the National School Lunch and School Breakfast Programs; Final Rule. *Fed Regist.* 2012;77(17):4087-4167. http://www.gpo.gov/fdsys/pkg/FR-2012-01-26/pdf/2012-1010.pdf. Accessed June 3, 2013.
20. Drake MA. Menu evaluation, nutrient intake of young children, and nutrition knowledge of menu planners in child care centers in Missouri. *J Nutr Educ.* 1992;24:145-148.

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Nutrient content of school meals before and after implementation of nutrition recommendations in five school districts across two U.S. counties

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ABSTRACT

Objective. To compare changes in nutrient levels of school meals before and after implementation of nutrition interventions at five school districts in two, large U.S. counties. School menu changes were compared against national school meal recommendations.

Methods. A large urban school district in Los Angeles County (LAC), California and four school districts in suburban Cook County (SCC), Illinois implemented school meal nutrition interventions. Nutrition analyses were conducted for school breakfast and lunch before and after changes were made to the meal programs. Means, % change, and net calories (kilocalories or kcal) offered as a result of the nutrition interventions were calculated.

Results. School districts in both counties made district-wide changes in their school breakfast and lunch menus. Menu changes resulted in a net reduction of calories, sugar, and sodium content offered in the meals. Net fewer calories offered as a result of the nutrition interventions were estimated to be about 64,075 kcal per student per year for LAC and 22,887 kcal per student per year for SCC.

Conclusions. Nutrition interventions can have broad reach through changes in menu offerings to school-aged children and adolescents. However, further research is needed to examine how these changes affect student food selection and consumption.

Introduction

The prevalence of childhood obesity in the United States (U.S.)[1] has doubled for children and tripled for adolescents in the past 30 years. This is approximately 17% (12.5 million) of all children and adolescents ages 2–19 who are now obese (NCHS, 2012; Ogden and Carroll, 2010). Combating childhood obesity has been challenging due in part to the many and complex factors that are involved — the food environment being the most important of these factors (Drewnowski, 2004). For children and adolescents, school nutrition programs are a major component of the food environment. Recognizing the central role that school nutrition can play in protecting health, a number of recent federal initiatives have invested substantively in school-based nutrition interventions aimed at improving the quality of foods served in school breakfast and lunch programs (Briefell et al., 2009; Bunnell et al., 2012; USDA, 2010). Improving the nutritional quality of food through the establishment of nutrient limits and other healthy food procurement practices in schools has emerged as a viable strategy for assuring a balanced diet and reducing childhood obesity in the U.S. (Briefell et al., 2009; Robles et al., 2013). National agencies, such as the Institute of Medicine (IOM)[2] and the Alliance for a Healthier Generation, are supportive and have recommended this strategy as a way to lower caloric content in school meals, while preserving or improving their nutritional value (Alliance for a Healthier Generation, 2011; IOM, 2009).

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[1] U.S. = United States.

[2] IOM = Institute of Medicine.

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Although studies of school-based nutrition interventions are abundant in the literature (Doak et al., 2006; Katz et al., 2008; Roseman et al., 2011), few have described the core elements of design or the process by which these approaches can be implemented successfully in practice. To date, there are limited comparisons of nutrient changes in school menus after the implementation of school meal standards consistent with the Institute of Medicine, Alliance for a Healthier Generation, or the U.S. Department of Agriculture (USDA)[3], especially for communities with a high prevalence of child obesity.

In 2011, a large, urban school district in Los Angeles County (LAC)[4], California incorporated IOM recommendations in their menu planning of school meals for the school year (SY)[5] 2011–12. Four school districts in suburban Cook County (SCC)[6], Illinois implemented similar changes in their school meal programs; these changes aligned with the Alliance for a Healthier Generation school meal recommendations. In both counties, the nutrition interventions were implemented in advance of the USDA Final Rule for the National School Breakfast and Lunch Programs (NSBP/NSLP)[7] (USDA, 2012). Both counties were also awardees of the Centers for Disease Control and Prevention's (CDC's)[8] *Communities Putting Prevention to Work* (CPPW)[9] program during 2010–2012 (Bunnell et al., 2012). Because the reach and impact of these nutrition strategies are often not well characterized in the literature, we described key meal program changes by nutrient categories for the five school districts that modified their SY 2011–12 menus to meet nutrition standards recommended by the IOM and the Alliance.

Methods

Nutrition interventions, school year 2010–11 to 2011–12

In addition to following the IOM and Alliance recommendations, LAC and SCC included other strategies as part of their nutrition interventions (Table 1). These nutrition interventions were developed and implemented using food-based menu planning and aligned closely with anticipated changes to the USDA nutrition standards for school meals (USDA, 2012). For this comparison, LAC and SCC were selected for the following reasons: 1) school districts in both counties have parallel missions and similar operational scope; 2) LAC is one of, and SCC is located within one of, the largest counties in the nation and both have the most diverse student populations in the U.S. (Table 2); 3) they implemented comparable district-wide nutrition interventions that utilized healthy food procurement strategies (Table 1); 4) they periodically evaluated their school meal programs using nutrient analysis to monitor food quality; and 5) they were awardees of the national CPPW program during 2010–2012.

Nutrient analysis in Los Angeles County

In order to ensure adherence with the USDA nutrition standards, nutrient analyses of meal program menus are routinely performed by participants of the NSBP and NSLP. Through a data-sharing agreement with the Los Angeles Unified School District (LAUSD)[10] Food Services Branch (FSB)[11], the Los Angeles County Department of Public Health (DPH)[12] gained access to the nutrient analysis data for the months of October 2010 and October 2011, corresponding to the pre- and post-menu changes that took place as part of the school-based nutrition interventions implemented in LAC. The nutritional analysis was performed using the OneSource Point-of-Service software (Horizon Software International, Duluth, Georgia). OneSource uses the USDA food nutrient database to analyze recipes of food items on the menu; the database is continually updated to align with the NSBP and NSLP requirements. LAC analyzed the following nutrients: total fat, saturated fat, trans-fat, food energy (kilocalories or "kcal"), sugar, carbohydrates, cholesterol, dietary fiber, protein, iron, calcium, sodium, and vitamins A and C. In this article, we present nutrient data only for those collected by both LAC and SCC — i.e., trans-fat, carbohydrates, cholesterol, iron, and calcium were not included in the comparison analysis.

Data for the month of October were used for both school years because they: 1) allowed for assessments at two time points spaced apart by a 12-month interval, and 2) accounted for a 4–6 week start-up window, during which time the new menu underwent selected adjustments. The 900+ schools (grades kindergarten [K]–12) of the LAUSD were included in the analysis for LAC. Detailed methods for the analysis methods have been described elsewhere (Cummings et al., 2014). Briefly, the analysis examined mean levels, 95% confidence intervals (CIs), and changes in nutrient content for student meals served during SY 2010–11 (n = 931 schools) and SY 2011–12 (n = 947 schools). The difference in number of schools included reflects the availability of the data for the two different academic years.

In SY 2010–11, four different meal categories were offered by the FSB: elementary breakfast, elementary lunch, secondary breakfast, and secondary lunch. Elementary grades include K–5 and secondary grades include 6–12. FSB served the same breakfast offerings for elementary and secondary grades in SY 2011–12; thus, these categories were combined for this school year. Each meal in each category (e.g., elementary lunch, secondary lunch) was offered to students as an assortment of entrées, at least one side option, milk, and condiments. Using estimation methods published previously by Cummings et al. (2014), nutritional content of the entrées, milk, and condiments were averaged and all sides were added into the total. These daily estimates were averaged for the entire month. For secondary school meals, the three lunch entrée options were averaged and for elementary school meals the two lunch entrée options were averaged. All analytic calculations were performed using the SAS statistical software package, version 9.3 (SAS Institute, Cary, North Carolina, USA). The LAC protocol was reviewed and approved by the Los Angeles County Department of Public Health Institutional Review Board (IRB).[13] Since nutrient analysis data contained no individual identifying information, they were considered "exempt" by the IRB.

Nutrient analysis in suburban Cook County

Four school districts (n = 42 schools, grades prekindergarten [PK]–8) were randomly selected from a sample of seven eligible school districts in SCC to participate in SCC's CPPW Model Communities' Program. To be eligible, districts had to include elementary schools; as a result, the four participating districts in the program were strictly elementary school districts with a grade range of PK through 8. Each school district in SCC was required to post-menus and nutritional content online or make the information available to the public upon request. Menus for each of the four participating districts for the time periods May–June 2011 and March–May 2012 were collected and verified for adherence through observational audits during mealtime, randomly sampling approximately 25% of the schools, yielding 10 schools from the four districts. Utilizing similar nutritional analysis software as LAC, the main dish entrée, any side dishes listed on the menu, and the lowest calorie milk option for school meal nutrients were estimated as part of the daily totals. In cases where a range of side dishes were offered, only one of each was used in the calculation (e.g., for schools where students may choose up to 2 fruits or vegetables and up to 2 bread options, only 1 piece of fruit and 1 piece of bread was included in the calculation). This is based on the assumption that most students, on average, will take one of each side offered. Daily nutrient averages for each week were estimated by summing the daily total for each school and dividing by the total number of school days with menu data for that specific week. These weekly estimates were averaged for the three weeks. Unlike LAC, the selected school districts in SCC are small and preferred not to be identified by name. Thus, in the analysis they are labeled as District A, B, C, and D. The SCC protocol was reviewed and approved by the Ann and Robert H. Lurie Children's Hospital of Chicago Research Center Institutional Review Board.

Comparison

All LAUSD schools in LAC and all schools in the four selected school districts in SCC were included in the comparison described for the school years (SY) 2010–11 to 2011–2012. To compare the changes in nutrient levels after

[3] USDA = U.S. Department of Agriculture.
[4] LAC = Los Angeles County.
[5] SY = School Year.
[6] SCC = suburban Cook County.
[7] NSBP/NSLP = National School Breakfast Program/National School Lunch Program.
[8] CDC = Centers for Disease Control and Prevention.
[9] CPPW = Communities Putting Prevention to Work.
[10] LAUSD = Los Angeles Unified School District.
[11] FSB = Food Services Branch.
[12] DPH = Los Angeles County Department of Public Health.
[13] IRB = Institutional Review Board.

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Table 1
Communities Putting Prevention to Work nutrition interventions and food procurement strategies implemented in Los Angeles County, California and suburban Cook County, Illinois, 2010–2012.

Los Angeles County, California
Implement limits for food energy (kilocalories), sugar, sodium, and other nutrients for school breakfast and lunch programs district-wide, as recommended by the Institute of Medicine.[a]
Adopt an institutional nutrition policy that aligns menus with Institute of Medicine recommendations.
Assist with cafeteria improvements through healthy eating messaging and signage in school cafeterias (e.g., "I'm IN" campaign).
Work with executive chef and food vendors on new recipe development.
Conduct student and parent taste tests before rolling out the new menu (e.g., performed 30,000+ taste tests with students).
Implement a new food procurement model for the school district (e.g., converting to food-based menu planning, using categorical food partners, integrating marketing as a focus area in vendor contracts, purchasing from local sources — within a 200-mile radius).
Increase purchase and promotion of fresh fruits and vegetables (e.g., utilize approaches in behavioral economics to help increase selection).
Suburban Cook County, Illinois
Initiate school breakfast programs (if not already present) and promote these programs to parents and students.
Alter school breakfast and lunch programs district-wide to align with the Alliance for a Healthier Generation Healthy School Program nutritional standards.[b]
Assist with cafeteria improvements through healthy eating messaging and signage in school cafeterias.
Conduct healthy meal planning and budgeting workshops with student families.
Integrate fruits and vegetables into the school food environment through summer snack programs and school gardens.

[a] Institute of Medicine, 2009 recommendations for all students (tier 1 foods): <35% of total kilocalories from fat; <10% total kilocalories from saturated fat; 0 g trans-fat; ≤35% of kilocalories from total sugars; ≤200 mg sodium per portion; water, low-fat or fat-free milk; and 100% fruit juice.

[b] Alliance for a Healthier Generation Healthy School Program nutritional standards: 1%, 1/2% or fat-free milk; use of whole grains in bread, pasta and pizza crust; non-fried foods; no-added-sugar fruits and vegetables; low-fat lunch entrée with no more than 12 g of total fat, 4.5 g saturated fat, 0 g trans-fat, and 480 mg sodium; use of unsaturated zero trans-fat oils; protein products with less than 10 g fat, 4.5 g or less saturated fat, and less than 95 mg cholesterol per serving and per 100 g; non-fried fish; and salad dressings with no more than 80 kilocalories per serving.

implementation of the nutrition interventions in both counties, we used the October 2010 school breakfast and lunch menus for elementary and secondary schools in LAUSD and compared them to the October 2011 menus. For SCC, we used the May–June 2011 (three consecutive weeks) school breakfast and lunch menus for elementary schools and compared them to the March–May 2012 (three consecutive weeks) menus. These comparison time points were chosen based on the timeline of intervention implementation in each county, accounting for lag time between the two locales, but preserving the pre- and post-intervention interval at approximately 12 months apart. The post intervention results were then examined to see if they aligned with the IOM (for LAUSD) and Alliance for a Healthier Generation (for SCC) school meal recommendations.

Both counties had data for the following nutrients: food energy (kcal), protein (grams "g"), fiber (g), total fat (g), saturated fat (g), sugar (g), and sodium (milligrams "mg"). Means, 95% CIs, and percent change of nutrient levels pre- and post-intervention were compared for all LAUSD schools and all schools in the four districts in SCC. T-tests were performed to determine if nutrient changes were significant; where appropriate, log transformations were employed. Participation frequency (i.e., the number of students participating in school breakfast and lunch), average change in kilocalories per meal for breakfast and lunch, and the number of serving days per year were calculated and used to estimate net calories (kcal) offered annually for full-time (5 days per week) meal program participants (per student per year).

Results

Nutrition interventions implemented by LAUSD, which were based on IOM recommendations for healthy school meals (IOM, 2009), resulted in significant reductions in mean caloric and mean sugar content of breakfast and lunch school meals (Table 3). Similarly, for most meal categories, mean sodium content dropped. The most dramatic reductions were observed in the breakfast category for mean sugar, mean total fat, and mean sodium content. Although protein increased in the lunch meal category for elementary schools, the nutrient decreased in all other meal categories. Dietary fiber also decreased in all meal categories.

In SCC, where interventions were aligned with recommendations from the Alliance for a Healthier Generation, changes in nutrient content of meals were inconsistent (Tables 4A and 4B). Districts A and D, for instance, were able to significantly reduce mean sugar content in their lunch meals, whereas District C's mean sugar content for the same meal category slightly increased (Tables 4A and 4B). Aside from a slight increase in protein, District D did not improve on most of the nutrients for breakfast and District A's breakfast data were incomplete. District B baseline data for fiber, sugar, and sodium breakfast nutrients

Table 2
Characteristics of Los Angeles Unified School District (LAUSD) and the selected suburban Cook County school districts (SCC SD), 2010–2012.

Characteristics	LAUSD[a] n (%)	SCC SD A[b] n (%)	SCC SD B[b] n (%)	SCC SD C[b] n (%)	SCC SD D[b] n (%)
Total	662,140	5040	5253	13,333	2431
Grades					
Kindergarten–5	312,434 (47.2)	3325 (66.0)[c]	3626 (69.0)[c]	9200 (69.0)[c]	1696 (69.8)[c]
6–12	349,706 (52.8)	1715 (34.0)[d]	1627 (31.0)[d]	4133 (31.0)[d]	735 (30.2)[d]
Sex					
Male	339,142 (51.2)	2535 (50.3)	2730 (52.0)	6768 (50.8)	1212 (49.9)
Female	322,998 (48.8)	2505 (49.7)	2523 (48.0)	6565 (49.2)	1219 (50.1)
Race/ethnicity					
Black	63,714 (9.6)	43 (0.8)	1977(37.6)	241(1.8)	1880 (77.3)
Hispanic	478,943 (72.3)	257 (5.1)	3094 (58.9)	12,537 (94.0)	485 (20.0)
White	66,833 (10.1)	4126 (81.9)	101 (1.9)	432 (3.2)	9 (0.4)
Asian/Pacific Islander[e]	43,251 (6.6)	352 (7.0)	26 (0.5)	17 (0.1)	34 (1.4)
Other[f]	9399 (1.4)	262 (5.2)	55 (1.1)	106 (0.8)	23 (0.9)
Obesity					
All grades	174,143 (26.3)[g]	77 (9.1)[h,i]	341 (28.4)[h]	661 (32.3)[h]	189 (25.7)[h]

[a] Source: California Department of Education, school-year 2011–12.
[b] Source: Illinois State Department of Education, school-year 2011–12.
[c] Includes prekindergarten students.
[d] Includes only grades 6–8.
[e] Includes Filipino.
[f] Includes American Indian/Alaskan Native, two or more races (not Hispanic), and not reported.
[g] Source: California Physical Fitness Testing Program (FITTNESGRAM©), grades 5, 7, and 9.
[h] Source: Cook County Department of Public Health. 2013. Unpublished, sample includes students from kindergarten and 6th grade.
[i] Includes only kindergarten students.

Table 3

(A) Breakfast menu: mean nutrient content for elementary and secondary schools in Los Angeles Unified School District, October 2010 and October 2011, grades kindergarten–12.
(B) Lunch menu: mean nutrient content for elementary and secondary schools in Los Angeles Unified School District, October 2010 and October 2011, grades kindergarten–12.

Key nutrients	October 2010 mean (95% CI)[a]	October 2011 mean (95% CI)[a]	% change	October 2010 mean (95% CI)[a]	October 2011 mean (95% CI)[a]	% change
	Elementary (grades k–5)			Secondary (grades 6–12)		
(A)						
Food energy (kcal)	603.2 (564.7, 641.7)	388.3 (354.7, 421.8)	−35.6[b,c]	834.6 (781.1, 888.2)	388.3 (354.7, 421.8)	−53.5[b,c]
Protein (g)	20.8 (19.0, 22.6)	17.6 (16.6, 18.6)	−15.5[c]	27.7 (26.3, 29.1)	17.6 (16.6, 18.6)	−36.5[c]
Dietary fiber (g)	5.5 (4.8 6.2)	3.2 (2.5, 3.9)	−40.9[c]	7.7 (7.4, 8.0)	3.2 (2.5, 3.9)	−58.1[c]
Total fat (g)	13.6 (11.3, 15.8)[d]	7.9 (6.0, 9.7)[d]	−42.0[b,c]	19.5 (16.8, 22.1)[d]	7.9 (6.0, 9.7)[d]	−59.6[b,c]
Saturated fat (g)	3.7 (3.3, 4.1)	2.3 (1.9, 2.6)	−39.5[c]	5.6 (5.2, 5.9)	2.3 (1.9, 2.6)	−59.6[b,c]
Sugar (g)	35.7 (29.5, 41.9)	14.3 (9.6, 18.9)	−60.1[b,c]	39.0 (32.4, 45.6)	14.3 (9.6, 18.9)	−67.6[b,c]
Sodium (mg)	746.8 (677.4, 816.1)	494.3 (424.0, 564.6)	−34.4[b,c]	1064.3 (1003.5, 1125.1)	494.3 (424.0, 564.6)	−53.5[b,c]
(B)						
Food energy (kcal)	714.9 (688.9, 740.8)	681.1 (627.1, 735.1)	−4.7[b]	790.7 (750.9, 830.5)	634.8 (598.4, 671.3)	−19.7[b,c]
Protein (g)	30.3 (28.8, 31.8)[d]	37.8 (31.1, 44.5)[d]	24.6[b,c]	33.4 (31.9, 34.9)	30.7 (28.4, 33.1)	−8.0[c]
Dietary fiber (g)	9.6 (9.0, 10.3)	8.3 (7.5, 9.0)	−14.3[c]	10.9 (10.2, 11.7)	7.6 (6.6, 8.7)	−30.2[c]
Total fat (g)	21.4 (20.2, 22.7)[d]	24.3 (18.2, 30.3)[d]	13.1	22.9 (21.4, 24.4)	21.1 (18.9, 23.3)	−8.0[b]
Saturated fat (g)	5.2 (4.9, 5.5)[d]	5.6 (4.1, 7.0)[d]	7.1[b]	5.4 (5.1, 5.8)	4.7 (4.3, 5.2)	−13.4[b,c]
Sugar (g)	16.7 (11.1, 22.3)	13.8 (10.6, 17.0)	−29.9[b]	17.9 (12.5, 23.3)	12.9 (10.8, 14.9)	−38.3[b,c]
Sodium (mg)	1000.6 (941.0, 1072.3)	1327.0 (1093.3, 1560.7)	31.8[c]	1139.0 (1054.1, 1223.9)	1089.8 (962.1, 1217.6)	−4.3[b]

Other abbreviations: kcal = kilocalories; g = grams.
[a] CI = confidence interval.
[b] Change in desired direction.
[c] Significant at p value < .05.
[d] log transformation performed.

were missing, thus percent changes were not calculated for these nutrients. For the school lunch programs, Districts A, C and D were able to achieve more substantive improvements (Tables 4A and 4B). District A reduced mean calories by 15.7%, mean sugar by 32.4%, and mean sodium by 21.6% for its lunches. District D was able to achieve similar results, while District B reduced mean calories by only 2.9% and did not possess baseline data to assess for changes in fiber, sugar, or sodium nutrient content. Although District C increased overall calories, fat, saturated fat, and sugar, it was able to reduce sodium and increase dietary fiber and protein in their lunch offerings.

Collectively, the estimated number of children and adolescents reached by the school-based nutrition interventions in both counties was estimated to be 688,197 students for the SY 2011–12 (Table 2). Net fewer calories (kcal) offered as a result of the nutrition interventions was estimated to be about 64,075 kcal per student per year for LAC and 22,887 kcal per student per year for SCC.

Discussion

Overall, reductions in calories, sugar and sodium content of student meals offered by LAC and SCC schools were achieved in the five school districts that modified their SY 2011–12 menus. These results, however, reflect only average nutrient changes by meal categories; they do not correspond to other salient factors that may also influence student nutrition — e.g., food presentation and appeal; taste of the new items; perceptions of freshness and food quality; density, composition or quality of the individual offerings including the number and type (variety) of entrées or sides prepared or available to choose from; and student food selection and actual consumption (or waste). In LAC and SCC, for example, the entrée or side variety changed from SY 2010–11 to SY 2011–12, reflecting the school districts' emphasis on not only meeting nutrient limits, but also addressing the context leading to food selection and consumption — i.e., using a food-based menu planning approach. In

Table 4A

Breakfast menu: mean nutrient content for school Districts B, C, and D in suburban Cook County, Illinois, May–June 2011 and March–May 2012, grades prekindergarten–8.

Key nutrients	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change
	District B			District C			District D		
Food energy (kcal)	561.4 (525.6, 597.2)	546.4 (515.6, 577.1)	−2.7[b]	531.2 (468.0, 594.4)	534.8 (476.3, 593.2)	0.7	348.0 (303.7, 392.3)	406.6 (305.4, 507.7)	16.8
Protein (g)	15.0 (13.8, 16.1)[c]	14.1 (13.1, 15.0)[c]	−6.0	14.1 (12.7, 15.4)	15.3 (13.2, 17.5)	8.5[b]	11.2 (10.2, 12.2)[e]	12.2 (11.0, 13.4)[e]	8.9[b]
Fiber (g)	–[d]	3.4 (3.0, 3.9)	–[d]	2.8 (2.0, 3.6)[e]	4.3 (1.9, 6.7)[e]	53.6[b]	1.9 (1.5, 2.3)	1.3 (0.7, 2.0)	−31.6
Total fat (g)	14.3 (12.4, 16.2)	13.2 (11.2, 15.2)	−7.7[b]	12.3 (9.3, 15.2)	12.9 (9.5, 16.3)	4.9	6.9 (5.7, 8.1)	9.6 (5.4, 13.7)	39.1
Saturated fat (g)	4.3 (3.8, 4.8)	3.9 (3.4, 4.5)	−9.3[b]	3.5 (2.9, 4.2)	4.0 (2.9, 5.0)	14.3	3.3 (2.7, 3.8)	3.7 (2.2, 5.2)	12.1
Sugar (g)	–[d]	42.2 (38.7, 45.7)	–[d]	44.3 (37.3, 51.4)	41.8 (36.0, 47.7)	−5.6[b]	36.2 (32.0, 40.4)	41.8 (33.6, 50.0)	15.5
Sodium (mg)	–[d]	515.5 (460.4, 570.6)	–[d]	543.7 (455.1, 632.3)	571.5 (460.1, 682.9)	5.1	315.5 (285.0, 346.0)	339.1 (266.4, 411.8)	7.5

Other abbreviations: kcal = kilocalories; g = grams.
Note: District A is not shown in the table because it did not offer school breakfast.
[a] CI = confidence interval.
[b] Change in the desired direction.
[c] Sine transformation performed.
[d] "–" indicates missing data.
[e] Cosine transformation performed.

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Table 4B
Lunch menu: mean nutrient content for school Districts A, B, C, and D in suburban Cook County, Illinois, May–June 2011 and March–May 2012, grades prekindergarten–8.

Key nutrients	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change	2010–11 mean (95% CI)[a]	2011–12 mean (95% CI)[a]	% change
	District A			District B			District C			District D		
Food energy (kcal)	748.3 (722.1, 774.6)	630.9 (602.3, 659.5)	−15.7[b,c]	779.4 (754.4, 804.4)	756.6 (723.0, 790.3)	−2.9[b]	663.2 (616.3, 710.1)	672.9 (637.6, 708.2)	1.5	725.3 (691.1, 759.5)	645.7 (606.2, 685.2)	−10.9[b,c]
Protein (g)	32.2 (31.0, 33.4)	35.1 (33.1, 37.1)	9.0[b,c]	31.3 (29.1, 33.5)	31.8 (30.3, 33.2)	1.6[b]	28.4 (25.0, 31.8)	28.8 (27.1, 30.6)	1.4[b]	31.6 (29.3, 33.9)	28.3 (26.1, 30.6)	−10.4[c]
Fiber (g)	9.4 (8.8, 10.0)	9.5 (8.8, 10.1)	1.1[b]	–[d]	8.5 (7.6, 9.5)	–[d]	6.5 (4.9, 8.1)	7.0 (5.7, 8.3)	7.7[b]	6.1 (5.4, 6.8)	4.7 (4.0, 5.5)	−22.9[c]
Total fat (g)	19.8 (18.4, 21.3)	15.8 (14.4, 17.1)	−20.2[b,c]	23.4 (21.9, 24.8)	24.3 (23.0, 25.6)	3.8	20.7 (18.8, 22.7)	21.2 (18.9, 23.5)	2.4	29.9 (26.7, 33.1)	28.9 (26.2, 31.7)	−3.3[b]
Saturated fat (g)	6.4 (5.8, 6.9)[e]	4.5 (3.9, 5.0)[e]	−29.7[b,c]	6.7 (6.1, 7.4)	8.1 (7.0, 9.3)	20.9[c]	6.5 (5.4, 7.5)[e]	7.2 (5.9, 8.6)[e]	10.8	10.8 (9.5, 12.1)	10.6 (9.3, 12.0)	−1.9[b]
Sugar (g)	45.1 (44.0, 46.1)[e]	30.5 (29.5, 31.4)[e]	−32.4[b,c]	–[d]	43.2 (40.2, 46.2)	–[d]	39.5 (35.9, 43.0)[e]	42.6 (38.8, 46.3)[e]	7.8	33.5 (29.7, 37.4)	26.8 (24.3, 29.3)	−20.0[b,c]
Sodium (mg)	1193.7 (1139.8, 1247.4)	935.5 (859.9, 1011.1)	−21.6[b,c]	–[d]	1265.1 (1131.5, 1398.7)	–[d]	1279.1 (1127.2, 1431.1)	1107.8 (973.3, 1242.3)	−13.4[b]	1050.9 (962.9, 1138.9)	1041.9 (929.2, 1154.7)	−0.9[b]

Other abbreviations: kcal = kilocalories; g = grams.
[a] CI = confidence interval.
[b] Change in the desired direction.
[c] Significant at $p < .05$.
[d] "–" indicates missing data.
[e] Cosine transformation performed.

LAC, the 2010–11 lunch menu had items such as beef chalupa, pepperoni pizza, and Italian calzone with turkey pepperoni; whereas, the new 2011–12 lunch menu included black eyed pea salad, vegetable curry, Ancho chili chicken with yakisoba, and quinoa and veggie salads. Likewise, in SCC District A, the 2010–11 lunch menu had items such as nachos, chicken nuggets, hot dogs, and cheese pizza; whereas, the new 2011–12 lunch menu offered turkey burgers, black bean burgers, tuna salad subs, and stuffed salmon. Clearly, taken together, more can be learned from the experiences in LAC and SCC. Further research using methods such as dietary pattern scores is needed and could provide additional insights on the impacts of these food-based offerings or strategies on student eating behaviors.

A multicomponent approach

The LAUSD experience in LAC suggests that a multicomponent approach was beneficial for introducing, integrating, and supporting healthy food modifications to the SY 2011–12 menus. The "I'm IN" public education campaign, for example, augmented the student and parent taste testing by LAUSD by helping to prepare students for the new menu items that were introduced (Table 1). Age-appropriate portion sizes for some of the meal categories also enabled reductions in key nutrients without significant modifications to food composition or taste. However, this latter action did contribute to unintended effects — e.g., the lowering of desirable nutrients such as protein and fiber. In addition, these complementary strategies do not necessarily improve nutrition for everyone. For instance, for those children whose energy intake is appropriate, simply reducing portion size does not alter the food selection or the composition of their diet, which may still be poor. Children can also compensate for lost energy intake by consuming undesirable foods from other sources.

School districts in the U.S. that are contemplating similar menu changes to their student meal program may find food-based menu planning more logistically feasible and in line with the USDA Final Rule (USDA, 2012). Protein, fiber, and other healthful nutrients are vital for ensuring proper nutrient intake among students and should be taken into account when making menu changes. Another factor to consider is children and adolescents who are not receiving adequate nutrient intake (i.e., poor diet composition with excess energy intake). This can occur even among children who are obese, not just for those who are underweight. Moderately active children, ages 4–8, for example, need 1400–1600 kcal per day; those, ages 9–13, need 1800–2200 kcal per day. Sedentary children and adolescents require the lower end of this range (USDA, 2010). In LAC and SCC, the average school meal caloric ranges were between 380 and 830 kcal per meal.

Recognizing the influential role that taste can play in food selection, the LAUSD (in LAC) conducted 30,000+ taste tests prior to finalizing the menu for SY 2011–12 (Table 1). SCC took similar actions to improve the appeal of their new menu items to increase student receptivity (Mason et al., 2012). SCC school districts, for example, made changes to the formula of the school meals while concurrently providing public education to parents and students about the benefits of healthy eating (Table 1). The collective experiences of the four SCC districts point to the importance of having staff role models and stakeholder buy-ins during the menu planning stage. In one district, union regulations stalled the implementation of breakfast in the classroom.

It should be noted that there were key differences between the two counties. The sheer size of LAUSD translated to greater purchasing power and easier negotiations for better pricing from food suppliers, which in turn probably contributed to the district's capacity to offer a wider range of healthy food options (Robles et al., 2013). In SCC, each school district conceptualized and implemented different interventions based on their unique needs, assets and operating capacity. Differences in these factors likely contributed to the differences seen in the nutrient changes in the different school districts during SY 2010–11 to 2011–12.

Overlapping strategies in all five districts made this evaluation salient and interesting, as they point to alternative lessons learned about effective ways to improve school nutrition. SCC schools customized their food procurement strategies based on district and school-level capacity, leading to more targeted changes that are specific to individual school cafeterias; whereas LAUSD's interventions were standardized and incremental but had broad reach due to the district's sheer size and centralized infrastructure.

Limitations

The present analysis is subject to a number of limitations. First, using nutrient analysis as an approach for program evaluation provides an incomplete picture of student nutrition in the school setting. On the other hand, examining nutrient changes by meal categories using standard nutrient-estimation protocols represents a practical approach for comparing institutional improvements in food offerings across different schools. Second, the nutrient analysis records from LAUSD and from the four school districts in SCC were compiled using nutritional software that analyzed information from menu recipes. While this is generally considered an acceptable alternative to laboratory nutrient analysis (gold standard), user errors can occur (Drake, 1992). Third, the nutrient analysis in this evaluation provides only a cross-sectional snapshot of the mean change per meal for each nutrient; it does not provide longitudinal confirmation of intervention effectiveness nor sustainability, since only one month during each school year was analyzed. Changes in certain nutrients, such as total fat, for example, may not equate to actual improvements in food offerings.

Although the strength of the analysis is its pre- and post-intervention design, factors such as student food selection pattern, taste, meal appeal, and receptivity to the menu changes all can attenuate the magnitude of the observed effects. For instance, in a prior analysis of LAUSD data, Cummings et al. (2014) demonstrated that changes to mean sodium content were not as substantial once student food selection patterns were accounted for. Other methods, such as plate waste studies represent potentially better measures of student food selection and consumption. In 2011, a plate waste study was conducted in LAC using a random sample of four middle schools; preliminary results suggest a relatively large amount of fruit and vegetable wastage after introduction of these plant-based food options.

Finally, the lack of homogeneity in the school-based nutrition interventions likely led to bias in the results. Given the diversity of the intervention components (from food service staff training to incorporation of new contract language), it is difficult to disentangle the contributions of each component. For example, LAC used a categorical food partner model to work with vendors on developing new recipes that included more fresh fruits and vegetables on the menu, while also utilizing behavioral economics approaches to promote fruit and vegetable selection (e.g., putting fruits in an attractive basket near check-out stands). These strategies likely worked synergistically to increase selection of these items by students.

Conclusions

Collectively, school-based nutrition interventions in LAC and SCC appeared to have contributed favorably to changes in the school cafeteria environment, including improvements to the overall nutrient base of school meals served. This suggests that federal as well as local initiatives in obesity prevention and in cardiovascular health promotion should continue to invest in these kinds of system and environmental changes aimed at creating healthier food environments for children and adolescents in the U.S.

Conflict of interest statement

The authors report no financial disclosures or conflicts of interest.

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References

Alliance for a Healthier Generation, 2011. Alliance school meals criteria. (Available at) https://schools.healthiergeneration.org/_asset/gxljhk/11-2736_SMCriteria.pdf (Accessed on August 23, 2013).

Briefell, R.R., Crepinsek, M.K., Cabili, C., Wilson, A., Gleason, P.M., 2009. School food environments and practices affect dietary behaviors of US public school children. J. Am. Diet. Assoc. 109 (2 Suppl.), S91–S107.

Bunnell, R., O'Neil, D., Soler, R., et al., 2012. Communities Putting Prevention to Work Program Group. Fifty communities putting prevention to work: accelerating chronic disease prevention through policy, systems, and environmental change. J. Community Health 37, 1081–1090. http://dx.doi.org/10.1007/s10900-012-9542-3 (epub).

Cummings, P.L., Burbage, L., Wood, M., Butler, R., Kuo, T., 2014. Evaluating changes to sodium content in school meals at a large, urban school district in Los Angeles County, California. J. Public Health Manag. Pract. 20 (1 Suppl. 1), S43–S49. http://dx.doi.org/10.1097/PHH.0b013e31829f2e50.

Doak, C.M., Visscher, T.L.S., Renders, C.M., Seidell, J.C., 2006. The prevention of overweight and obesity in children and adolescents: a review of interventions and programmes. Obes. Rev. 7, 111–130.

Drake, M.A., 1992. Menu evaluation, nutrient intake of young children, and nutrition knowledge of menu planners in child care centers in Missouri. J. Nutr. Educ. 24, 145–148.

Drewnowski, A., 2004. Obesity and the food environment: dietary energy density and diet costs. Am. J. Prev. Med. 27 (3 Suppl.), 154–162.

Institute of Medicine (IOM) of the National Academies, 2009. School meals: building blocks for healthy children. (Available at) http://www.iom.edu/Reports/2009/School-Meals-Building-Blocks-for-Healthy-Children.aspx (Accessed on August 23, 2013).

Katz, D.L., O'Connell, M., Njike, V.Y., Yeh, M.C., Nawaz, H., 2008. Strategies for the prevention and control of obesity in the school setting: systematic review and meta-analysis. Int. J. Obes. 32, 1780–1789.

Mason, M., Chávez, N., Kwon, S., Cedeño, A., 2012. Student school meal perception, participation, and consumption: implication for future school based nutritional interventions. Paper presented at: American Public Health Association. 140th Annual Meeting and Exposition. October 28-31, 2012; San Francisco, California.

National Center for Health Statistics (NCHS), 2012. Health, United States, 2011: With Special Features on Socioeconomic Status and Health. U.S. Department of Health and Human Services, Hyattsville, MD.

Ogden, C., Carroll, M., 2010. Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963–1965 through 2007–2008. National Center for Health Statistics (June 2010).

Robles, B., Wood, M., Kimmons, J., Kuo, T., 2013. Comparison of nutrition standards and other recommended procurement practices for improving institutional food offerings in Los Angeles County, 2010–2012. Adv. Nutr. 4 (2), 191–202. http://dx.doi.org/10.3945/an.112.003285.

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Roseman, M.G., Riddell, M.C., Haynes, J.N., 2011. A content analysis of kindergarten–12th grade school-based nutrition interventions: taking advantage of past learning. J. Nutr. Educ. Behav. 43 (1), 2–18.
U.S. Department of Agriculture (USDA), 2010. Dietary Guidelines for Americans, 2010. U.S. Government Printing Office, Washington D.C.
U.S. Department of Agriculture (USDA), 2012. Food and Nutrition Service. 7 CFR Parts 210–220. Nutrition Standards in the National School Lunch and School Breakfast Programs; Final Rule. Fed. Regist. 77 (17), 4087–4167 (Retrieved at http://www.gpo.gov/fdsys/pkg/FR-2012-01-26/pdf/2012-1010.pdf. Last accessed: November 15, 2013).

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