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Household Food Insecurity Positively Associated with Increased Hospital Charges for Infants

Introduction

Household food insecurity (HFI)--limited or uncertain access to enough nutritious food for all household members to lead an active and healthy life--is positively associated with poor health and development among young children and infants.[1–9] Increased childhood risks associated with HFI include iron deficiency anemia and other micronutrient undernutrition,[10-13] behavior problems,[14–16] and more frequent experiences of headaches, stomachaches, colds,[4] and chronic illnesses.[17] Although understudied in the United States, micronutrient malnutrition in underserved populations globally has been linked clinically with increased infections and reduced ability to recover from infections,[18–20] often resulting in hospitalizations.

Adverse health correlates of HFI have also been found in adults. Recently, HFI has been shown to predict increased health care utilization (including hospitalizations) and costs among Canadian working-age adults.[21] These Canadian findings raise the question whether HFI may also be correlated with increased hospitalizations among children, including infants, a relationship supported by evidence from research on young children (ages <48 months) in the United States.[1,3,7]

While a growing body of research has examined associations between food insecurity and an array of health outcomes in school-age and preschool-age children[1,3–5,9], relatively less attention has been given to the association of food insecurity with the health of infants. The studies demonstrating associations between HFI and worse child health and more hospitalizations indirectly imply that HFI may be associated with higher utilization of health care resources, and thus higher costs. Hospital stays are common and costly for infants. Moreover, emergency departments (EDs) are the setting from which most acute infant hospital admissions occur.[22] In 2011, approximately 60% of all admissions for children ages <12 months were from ED visits at the same hospital.[23,24]

A large portion of the costs of infant hospital stays in the US is borne by the public. Data from the Agency for Healthcare Research and Quality's (AHRQ) Healthcare Cost and Utilization Project Kids' Inpatient Database (H-CUP KID) indicate that approximately 52% of all non-neonatal infant hospitalizations in 2009 were paid for by public insurers or involved infants who were uninsured. Moreover, that same year, approximately 72% of all non-neonatal pediatric hospitalizations, either paid for by public insurers (eg, Medicaid) or of uninsured children, were for infants ages <12 months.[25] Still, we know of no studies that have directly assessed relationships between HFI and number of hospitalizations per year, length of hospital stays, or hospital charges for stays among infants under 1 year of age in the U.S.

Hospital charges for services, including inpatient hospital services, are based on hospitals' estimates of their total operating costs, factors related to each case's severity, whether the hospital cares for greater than average numbers of low-income patients, and whether the hospital is a teaching hospital. There is broad heterogeneity in hospitals' actual operating costs, within and across geographic areas, and in their target profit margins. As a result, hospital charges vary widely and are always higher than actual costs of services delivered.[26]

While the average length of non-neonatal stays for all infants ages <12 months hospitalized in 2009 was 3.76 days, the average length of stay for Medicaid-enrolled infants in this age group was 4.00 days.[25] Overall average cost per stay for infants <12 months of age funded by Medicaid in 2009 was $4,564, while mean charges for those infant stays was $14,561.[25] The large proportion of hospital stays, greater lengths of stay, and higher costs and charges among infants <12 months of age covered by Medicaid suggest that identifying and addressing the potentially preventable social determinants of those stays could play an important role in reducing public health care expenditures.

Thus, the goal of this study was to examine whether hospital charges for inpatient stays among low-income infants (<12 months of age) were associated with their household's concurrent food security status.

Patients and Methods

This study compared the number of hospitalizations, estimates of mean days hospitalized per year, charges per day, and total charges per year for hospitalizations among infants from food-secure and food-insecure households. These data were obtained by linking two bodies of data – Children's HealthWatch cross-sectional survey data and annual inpatient hospitalization charges derived from actual hospital billing data.

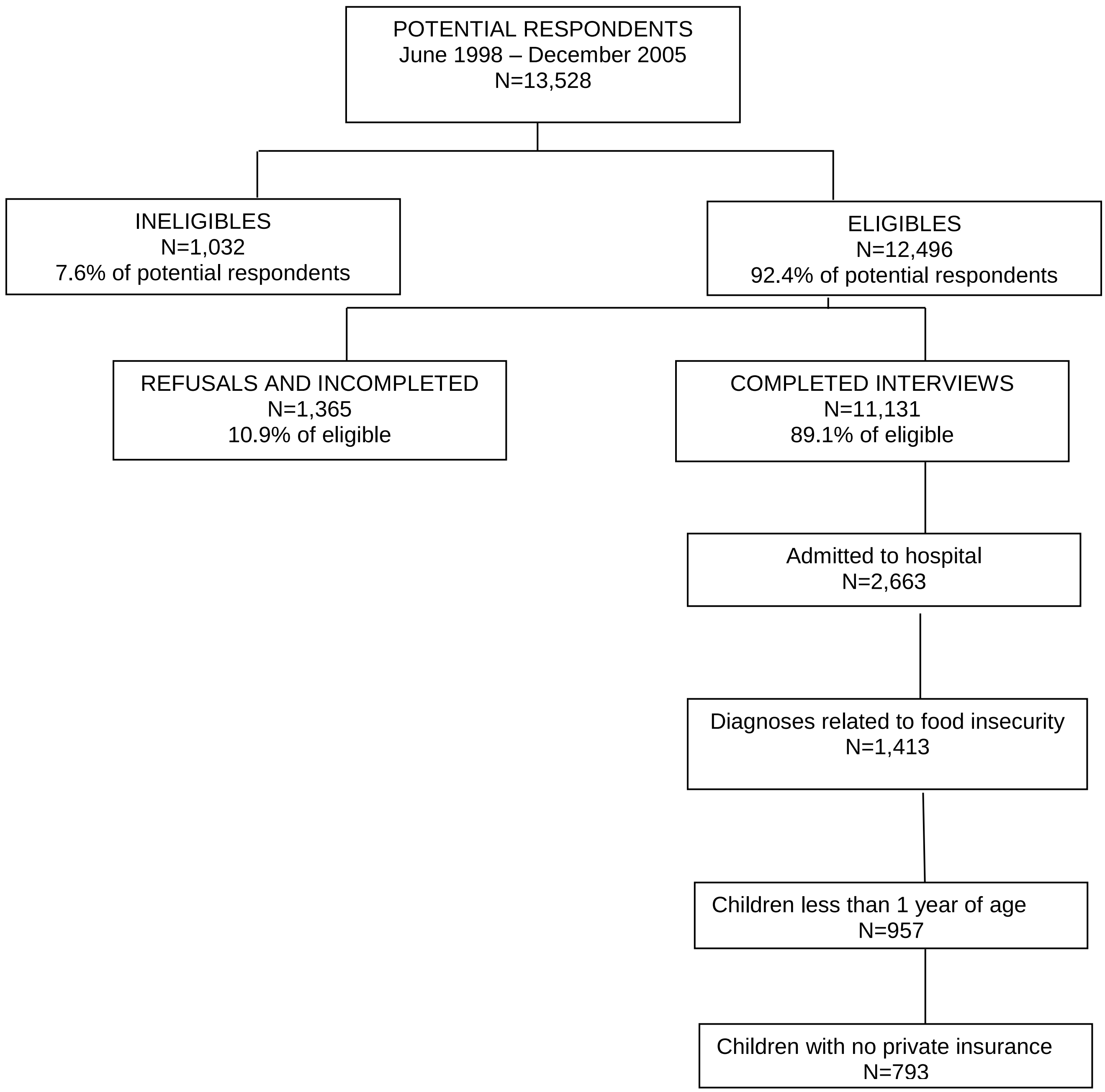
Study Sample: Survey data included household food insecurity status and demographic characteristics, including mothers' race/ethnicity, infants' birth weight, and breastfeeding practices from an ongoing study in urban emergency departments (EDs) and ambulatory care clinics that investigates the impacts of material hardships and public assistance programs and policies on the health and well-being of young children and their caregivers. Data for this study were drawn from two ED study sites with university affiliations: Boston Medical Center in Boston, MA (a general

Disproportionate Share Hospital--DSH) and Arkansas Children's Hospital in Little Rock, AR (a not-for-profit, free-standing children's hospital).

Interviewers elicited caregivers' verbal responses to the survey, including the 18-item US Household Food Security Scale (HFSS). As published previously,[27–29] participants were caregivers of infants for whom they sought medical care in EDs. Eligibility to participate in the survey included speaking English or Spanish, state residency, and knowledge of the child's household. Caregivers of critically ill or injured infants were excluded, as were those who had been interviewed previously. Institutional review board (IRB) approval was obtained at each site prior to data collection and renewed annually.

Of all caregivers approached at the two sites between June 1998 and December 2005, 11,131 completed the interview. Among those with completed interviews, 2,663 also had recorded non-neonatal admission data at one of the two ED sites (Figure 1).

Figure 1. Description of Analytic Sample Selection



As published elsewhere, as a proxy for low household income, we restricted the sample to infants with public or no insurance.[30] Among those with private insurance, 76% were from Arkansas while 24% were from Boston. Lack of private insurance is often a marker for households with lower incomes, where food insecurity is most prevalent.

To reduce potential bias in mean hospitalization charge data from very high (or low) charges for conditions not likely to be influenced by food insecurity (for example, appendicitis, motor vehicle accident, single gene disorders), we excluded infants with such diagnoses from further analysis. In addition, included diagnoses were ones that would not require referral to a specialty children's hospital (eg, cancer) and were representative of diagnoses for both hospitals.

Admissions eligible for analysis included those infants receiving a billing diagnosis included on a list of diagnoses judged by two or more of a panel of three reviewing pediatricians to be potentially associated with food insecurity (Table 1). The three pediatricians were all members of the research team and experts in failure to thrive as well as food insecurity. All three were also directors of outpatient clinics for children with failure to thrive. There were several consecutive rounds of voting to determine the final set of diagnoses to include. Disagreements were discussed and majority consensus was reached (two out of three pediatricians). Group agreement was obtained prior to analysis and initially focused on broad categories of diagnoses that could plausibly be affected by food insecurity. These included several types of infections, such as respiratory or intestinal infections, on the basis of their plausible relationship to immune function and nutrition. Specific diagnoses within the selected larger categories, such as nausea and vomiting (within "Symptoms [signs and ill-defined conditions]") or otitis media (within ear conditions), were also selected. This process is very similar to that undertaken by Sonik in his study of inpatient Medicaid costs for people in Massachusetts before and after a program-wide increase in monthly SNAP benefits.[31] In that study, researchers consulted with four physicians "to develop a list of conditions that practitioners saw as particularly sensitive to food insecurity."[30]

Table 1. Diagnoses Agreed to Be Plausibly Related to Food Insecurity

Diagnosis Code	Diagnosis Category	Diagnosis Level 3 Code	Level 3 Diagnoses Included in Analysis
1	Other infections, including parasitic		
1.1	Bacterial infection		
1.2	Mycoses		
1.3	Viral infection		

6.1	Central nervous system infection		
6.5	Headache, including migraine	6.5.2.	Other headache
6.8	Ear conditions	6.8.1	Otitis media and related conditions (92.)
		6.8.1.1	Suppurative and unspecified otitis media
		6.8.1.2	Other otitis media and related conditions
8.1	Respiratory infections		
10.1	Diseases of the urinary system	10.1.4	Urinary tract infections
		10.1.4.1	Infections of the kidney
		10.1.4.2	Cystitis and urethritis
		10.1.4.3	Urinary tract infection; site not specified
13.1	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease)		
14.4	Nervous system congenital anomalies	14.4.1	Spina bifida
17.1	Symptoms (signs and ill-defined conditions)	17.1.1	Syncope
		17.1.2	Fever of unknown origin
		17.1.3	Lymphadenitis
		17.1.6	Nausea and vomiting
		17.1.7	Abdominal pain
17.2	Factors influencing health care	17.2.2	Administrative/social admission
58.	Other nutritional, endocrine, and metabolic disorders		
52.	Nutritional deficiencies		
55.	Fluid and electrolyte disorders		
	Anemia		
135.	Intestinal infection		
136.	Disorders of teeth		

	and jaw		
197.	Skin and subcutaneous tissue infections		

Source: Based on Clinical Classification Software (where a Level 3 diagnosis is listed, only those conditions within that category are included): https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp

Altogether, these inclusion criteria resulted in 1,413 potential participants. Of those, 793 (56.1%) included an infant <12 months of age with public or no health insurance (Figure 1).

ANALYTIC SAMPLE

Hospital Billing Data: Diagnoses and inpatient hospital billing charges were obtained for all infants under 12 months of age admitted between June 1, 1998, and December 31, 2005, from EDs at Boston Medical Center and Arkansas Children's Hospital. Billing charges did not include separately billed physician charges because they were not available to us. Identifying information for those infants was then matched to the survey dataset to select infants whose caregivers had been interviewed. Since the US HFSS asks about the prior 12-month period, admissions occurring within 6 months before or after the survey interview date were included. Immediate postpartum nursery hospitalizations were excluded. Due to the non-normal distribution of data, charge data were transformed to the natural log scale for initial modeling.

Predictor Variable: Food Security Status: The primary predictor variable for this study was household food security status in dichotomous form (food secure vs food insecure) assigned using responses to the 18-item HFSS, scored and scaled in standard fashion. Food-secure households included those categorized as having either "high food security" or "marginal food security". Food-insecure households included those categorized as having either "low food security" or "very low food security".[32]

Covariates: Potential confounders were selected based on the literature and clinical knowledge. These included site, mother's race/ethnicity, foreign-born status (US born vs foreign born), marital status, educational attainment, and employment; child's low birth weight status (< 2500 g), breastfeeding history, and number of children and adults living in the household.

Statistical Techniques: Descriptive statistics were obtained for sample demographics, breastfeeding history, low birth weight, and number of children and adults in the household for the overall sample and stratified by food security status. Bivariate associations were assessed via chi-square analysis, and t-tests as appropriate. Unadjusted comparisons focused on differences in annualized mean charges for hospital stays by food-insecure infants versus those for sociodemographically similar food-secure peers, all identified through the ED and including all hospitalizations of eligible infants. Log-transformed data on annual inpatient hospitalization charges for eligible infants were analyzed using Analysis of Covariance (in SAS' Generalized Linear Model procedure) to test for differences in mean annual charges per infant, controlling for hospital location. Data were analyzed using total charges and charges per day of hospital stays. Duan retransformation was used for transforming log mean charges because of skewed cost differences between research sites.[33]

To assess associations between food insecurity status and inpatient hospital charges, multiple linear regression models were fit and adjusted for covariates noted previously. Results are presented as original units in dollars and the associated 95% confidence intervals (95% CI) after retransformation of the mean regression estimates. All analyses were conducted using two-sided tests and a significance level of 0.05. Statistical analyses were performed using SAS software (version 9.3; SAS Institute, Cary, NC).

Results

Of 793 infants <12 months of age hospitalized with at least one diagnosis plausibly related to food insecurity, 158 (19.9%) lived in households that reported HFI (Table 2). The comparison groups did not differ on caregiver employment, marital status, or education, nor on whether infants were low birth weight. Among the infants exposed to HFI, 60.1% were breastfed and 23.6% were born low birth weight. The race/ethnicity of mothers with HFI were either Black (51.3%) or Latina (29.7%). Only 17.1% of caregivers from food-insecure households were non-Latina white and 1.9% were other races/ethnicities. Among caregivers from households with HFI, 31.2% were employed, 30.6% were married and 68.4% had a high school education or higher (Table 2).

Table 2: Sample Demographics by Household Food Security Status

	Household Food Secure	**Household Food Insecure**	**P-value**
Sample: N=793	635 (80.1%)	158 (19.9)	

Study Site			
Boston	332 (52.3%)	106 (67.1%)	<0.001
Little Rock	303 (47.7%)	52 (32.9%)	
Mother's place of birth			
US born	506 (79.8%)	95 (60.1%)	<0.001
Immigrant	128 (20.2%)	63 (39.9%)	
Child gender			
Female	294 (46.3%)	71 (44.9%)	0.76
Male	341 (53.7%)	87 (55.1%)	
Child age (mo)			
Mean (SD)	4.8 (3.2)	4.7 (3.3)	0.69
Mother's race/ethnicity			
Black	372 (58.6%)	81 (51.3%)	0.001
White	150 (23.6%)	27 (17.1%)	
Latina	102 (16.1%)	47 (29.7%)	
Other	11 (1.7%)	3 (1.9%)	
Caregiver married/partnered	183 (28.8%)	48 (30.6%)	0.67
Caregiver education			
< High school	208 (32.8%)	50 (31.6%)	0.81
High school	273 (43.1%)	66 (41.8%)	
Technical school/ college graduate/ master's or higher	153 (24.1%)	42 (26.6%)	
Mother's age (y)			
Mean (SD)	25.1 (6.2)	26.5 (6.2)	0.01
Caregiver employed	241 (38.1%)	49 (31.2%)	0.11

Child ever breastfed	273 (43.1%)	95 (60.1%)	<0.001
Child birth weight			
Low	142 (22.5%)	37 (23.6%)	0.78
Normal	488 (77.5%)	120 (76.4%)	
Number in household--individuals			
Mean (SD)	4.5 (1.8)	4.9 (2.2)	0.02

Source: Children's HealthWatch, 1998-2005.

Among all infants, 24% of those from food-insecure households vs 16% from food-secure households had 2 or more hospital admissions over the 12 study months (p=0.02, by chi-square test; Table 3A). Median length of stay per admission was 3 days for infants from food-insecure households compared to 2 days for infants from food-secure households (p=0.03 by Wilcoxon rank sum test; data not shown).

Overall mean annual hospitalization charges for the sample were $6,474 per patient (SD = $11,899). Adjusted average annual charges for infants exposed to HFI were statistically significantly higher than charges for infants not exposed to HFI (P = 0.03 - Table 3B). Using the Duan re-transformation method[33] and controlling for covariates, mean annual charges per patient from food-secure households were $5,735 (95% CI: $5,394, $6,097), compared to $6,707 (95% CI: $5,920, $7,599) per patient in food-insecure households. Adjusted for inflation[34] in inpatient hospital services from 2005 to 2017 using the not-seasonally adjusted all US city average CPI-U for inpatient hospital services (base period December 1996 = 100), these annual charges reflect $11,442 and $13,382 in 2017 dollars, respectively.

Adjusted average charges per day did not differ for the two groups (retransformed costs of $1,437 (95% CI: $1,392, $1,482) and $1,416 (95% CI: $1,328, $1,509), P = 0.69). However, average annual number of hospital days was significantly higher for infants exposed to HFI, compared to those not exposed (P = 0.01). After Duan retransformation, infants exposed to HFI had an average of 4.79 (95% CI: 4.26, 5.38) hospital days per year, compared to 4.03 (95% CI: 3.81, 4.27) days for infants from food-secure households.

Table 3A. Annual Hospital Admissions by Household Food Security Status

Annual Admissions	Household Food Secure	Household Food Insecure	Chi-sq p-value
1	84%	76%	
≥ 2	16%	24%	0.02

Table 3B. Hospitalization cost outcomes for food-secure versus food-insecure infants <12 months old

Variable	N	Household Food Secure Adjusted Mean	SE	N	Household Food Insecure Adjusted Mean	SE	p-value
Log annual cost	635	8.27	.03	158	8.43	.06	0.03
Duan retransformed value		$5,735 ($5,394, $6,097)			$6,707 ($5,920, $7,599)		

Variable	N	Household Food Secure Adjusted Mean	SE	N	Household Food Insecure Adjusted Mean	SE	p-value
Log annual hospital days	635	1.09	.03	158	1.26	.06	0.01
Duan retransformed value		4.03 days (3.81, 4.27)			4.79 days (4.26, 5.38)		

Variable	N	Household Food Secure Adjusted Mean	SE	N	Household Food Insecure Adjusted Mean	SE	p-value
Log charges/day	635	7.19	.02	158	7.17	.03	0.69
Duan retransformed value		$1,437 ($1,392, $1,482)			$1,416 ($1,328, $1,509)		

Variable	N	Food Secure Adjusted Mean	SE	N	Food Insecure Adjusted Mean	SE	p-value
Annual admissions	635	1.21 (1.17, 1.26)	.02	158	1.34 (1.24, 1.44)	.05	0.02

Source: Children's HealthWatch, 1998-2005. Models adjusted for site, mother's race/ethnicity, country of birth, marital status, educational attainment, employment, child's gender, low birthweight, breastfeeding history, and number of children and adults living in the household.

Use of Duan smearing estimator to retransform the mean regression estimates to the original units in dollars.

Discussion

In this study, rates of HFI are comparable to national statistics during the period over which these hospital stays occurred. In national data (which are not reported for infants separately), HFI was detected in 16.6% of households with children under 18 years and 16.9% of households with children under 6 years compared to 19.9% in this sample overall and 24% among those hospitalized twice or more.[35]

The higher annual hospitalization charges for infants from food-insecure households appear to be due to either more hospital admissions or increased length of stay per admission, or both, but not to higher charges per day. Thus, these results suggest that HFI may be associated with higher hospital charges as a result of more hospital days when infants < 12 months of age in food-insecure households have any hospital stays for reasons other than birth.

Although HFI was found to be associated with greater mean numbers of annual hospital days for stays involving a broadly comparable set of diagnoses, our available data do not elucidate the mechanisms for this finding. Micronutrient deficiencies (eg, zinc, vitamin A, iron) have been implicated in depressed immune system function,[9,36] and under-nutrition or inadequate food intake could worsen an illness or its symptoms, thus contributing to longer or more frequent stays. HFI might also indirectly exacerbate an illness as part of overall family financial stress that prevents, delays, or interferes with timely diagnosis and treatment, leading to eventual need for admission, as has been shown in adults.[37]

HFI could also indirectly exacerbate an illness by interfering with treatment or care (such as purchasing medications) after a diagnosis is made and treatment is started, thus contributing to overall costs if admission ultimately results. Moreover, HFI could be a direct or indirect factor in diminished ability of a caregiver to provide needed nutrition or care for a child, or adhere to prescribed treatment,[38] perhaps because of HFI-associated stress, distress, or depression.[27,39,40] To the extent that these factors impair caregivers' perceived ability to provide needed care for infants, they could contribute to clinicians’ decisions to admit or discharge.

Implementation of the Affordable Care Act and its strong emphasis on decreasing overall medical expenditures through preventive programs has created possibilities for innovative approaches to improving population health in the U.S.[41] Reducing HFI-related hospitalizations among young infants, however, will require that health professionals, hospital administrators, and policymakers develop strategies for identifying, addressing, and alleviating food insecurity in families with young children, ideally before hospitalization becomes necessary. Recognizing the impact of food insecurity on the health of patients, several health care systems across the nation have incorporated brief, validated, clinical screeners for food insecurity into routine medical histories,[42,43] a protocol now recognized as a best practice by the American Academy of Pediatrics.[44] Treating food insecurity as a vital sign (the “Hunger Vital Sign™”), and recording results of the screener in patients' electronic health records (EHRs)[45], facilitates appropriate referrals for immediate assistance from the private food assistance system, and applications for public food assistance. Several hospitals have initiated on-site “food pharmacies” that provide food to families in need, addressing specific health conditions indicated on "prescriptions for food" written by clinicians. While this is an immediate, short-term response to a positive screen for food insecurity, longer-term solutions are also needed,

For example, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP) have both been shown to reduce food insecurity in families with children.[9,46,47] Ease of access to services can be further facilitated by co-location of WIC offices within hospital facilities[48,49] and provision of meals funded by programs such as the Summer Food Service Program or the Child and Adult Care Food Program within hospitals.[50]

Integrating applications for other publicly funded programs, such as health insurance (eg, Medicaid), with means-tested nutrition programs like WIC and SNAP can also enable greater access to nutrition supports that promote health and well-being while reducing administrative costs**.**[49,51–54] Careful evaluation will be needed to assess whether implementation of these practices proves an important step in decreasing infant and child hospitalization charges.

Limitations

We acknowledge several limitations of our study. Data were obtained from cross-sectional surveys in just two hospitals, thus limiting generalizability. However, they are two very different hospitals – one an urban general DSH and the other a not-for-profit freestanding children's hospital. Given this diversity, the findings suggest a need for efforts to replicate these analyses in other inpatient settings. These data precede the implementation in 2006 of Massachusetts' health care reform and the 2010 implementation of the national Affordable Care Act, which greatly expanded health care coverage for many.[41,55] They also predate the Great Recession and its dramatic increase in food insecurity, so these findings may underestimate more recent impacts of household food insecurity on infant hospitalization charges.[56]

We examined a number of potentially confounding factors, and controlled for those correlated with both exposure and outcome variables, in addition to those chosen on theoretical grounds. There may be other unmeasured confounders.

Inpatient billing charges are usually higher than actual costs which could mean these results overestimate actual costs reimbursed. This is offset somewhat since charges used did not include physician billing charges and therefore may underestimate actual total charges. Moreover, the sickest infants (those critically ill or injured) were excluded because their caregivers could not be ethically or pragmatically approached for interview in EDs, so total charges for the sickest infants are not included. Finally, as in all studies demonstrating association, positive findings may identify risk factors that are associated with, but not causal of, the outcome.

However, a strength of this work is that the charges reported here reflect actual hospital billing data (rather than imputation or estimates from other sources). The inclusion of diagnoses considered plausibly related to food insecurity was determined by three practicing pediatrician-researchers with expertise and experience in researching the health effects of food insecurity and treating young patients from food-insecure households.[57] There is some potential, however, that chosen diagnoses may not all be linked to food insecurity. One of the diagnoses, spina bifida, reflects prenatal rather than postnatal nutrition. However, food insecurity is a known predictor of neural tube defects;[58] given the young age of the infants and given that food insecurity questions ask about household level access to nutritious foods during the last 12 months, maternal prenatal food insecurity could have plausibly influenced the infants' postnatal health and, in turn, their number of hospital days.[58,59]

Conclusion

These results provide the first evidence we are aware of that household food insecurity may be associated with increased charges for infant hospitalizations and with increased number and longer duration of hospital stays among infants. Additional research is needed using larger nationally representative samples, with data subsequent to the implementation of the Affordable Care Act, and for children beyond infancy. Such research could further clarify whether household food insecurity is associated with disparities in charges for hospitalizations in children under current medical practices and economic conditions, and if so, the mechanisms of associations.

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