

Food Insecurity, Healthcare Utilization, and High Cost: A Longitudinal Cohort Study

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A disproportionately large share of healthcare costs is generated in the course of care for a small proportion of patients, which is often due to emergency department (ED) visits, inpatient hospitalizations, or long lengths of hospital stay.^{1,2} The desire to improve use of these services has prompted investigations into risk factors for high use and costs. Programs targeting patients with particularly high total healthcare costs³ (eg, those in the top 10%, 5%, or 1%) typically focus on clinical conditions or factors internal to the healthcare system, such as care coordination.² Because the impact of these programs can be modest,² there has recently been increased interest in addressing modifiable social determinants of health with the intention of reducing healthcare utilization and cost (eg, through the Accountable Health Communities model proposed by CMS).⁴

One particular area of focus is food insecurity, defined as lacking “access to enough food for an active, healthy life for all household members.”⁵ Food insecurity affects 12.7% of American households as of 2015⁵ and has been associated with increased prevalence of illness, as well as worsened chronic disease management.⁶⁻¹¹ It is hypothesized that food insecurity increases healthcare utilization and cost by making it more difficult to follow a healthy diet (exacerbating diet-dependent conditions, such as type 2 diabetes and congestive heart failure); forcing competing demands between food and other necessities, such as medications or transportation; and reducing the cognitive bandwidth necessary to manage chronic illness.^{9,12} Prior studies in both Canadian¹³ and American¹⁴⁻¹⁶ contexts have found that food insecurity is associated with higher average healthcare costs. However, several of these studies had limitations, including cross-sectional¹³ and ecological designs,^{15,16} and none focused on the most relevant group for population health management—those with the highest healthcare use. For population health management, the extremes of the distribution, rather than the mean, may be most relevant.

To address these issues, we tested the hypothesis that food insecurity is associated with higher utilization of ED services, inpatient hospital admissions, and length of stay and an increased

ABSTRACT

OBJECTIVES: Reducing utilization of high-cost healthcare services is a common population health goal. Food insecurity—limited access to nutritious food owing to cost—is associated with chronic disease, but its relationship with healthcare utilization is understudied. We tested whether food insecurity is associated with increased emergency department (ED) visits, hospitalizations, and related costs.

STUDY DESIGN: Retrospective analysis of a nationally representative cohort.

METHODS: Adults (≥18 years) completed a food insecurity assessment (using 10 items derived from the US Department of Agriculture Household Food Security Module) in the 2011 National Health Interview Survey and were followed in the 2012-2013 Medical Expenditures Panel Survey. Outcome measures were ED visits, hospitalizations, days hospitalized, and whether participants were in the top 10%, 5%, or 2% of total healthcare expenditures.

RESULTS: Of 11,781 participants, 2056 (weighted percentage, 13.2%) were in food-insecure households. Food insecurity was associated with significantly more ED visits (incidence rate ratio [IRR], 1.47; 95% CI, 1.12-1.93), hospitalizations (IRR, 1.47; 95% CI, 1.14-1.88), and days hospitalized (IRR, 1.54; 95% CI, 1.06-2.24) after adjustment for demographics, education, income, health insurance, region, and rural residence. Food insecurity was also associated with increased odds of being in the top 10% (odds ratio [OR], 1.73; 95% CI, 1.31-2.27), 5% (OR, 2.53; 95% CI, 1.51-3.37), or 2% (OR, 1.95; 95% CI, 1.09-3.49) of healthcare expenditures.

CONCLUSIONS: Food insecurity is associated with higher healthcare use and costs, even accounting for other socioeconomic factors. Whether food insecurity interventions improve healthcare utilization and cost should be tested.

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TAKEAWAY POINTS

- ▶ Food insecurity is an important risk factor for use of emergency department and inpatient healthcare services.
- ▶ Those with the highest healthcare costs are often food-insecure.
- ▶ Improving healthcare use for those with the highest costs may require addressing needs such as food insecurity along with medical needs.

risk of being in top percentiles (10%, 5%, and 2%) of total healthcare expenditures, accounting for socioeconomic covariates.

METHODS

Data Source and Study Sample

Data for this study were obtained from the 2011 National Health Interview Survey (NHIS)¹⁷ and the 2012-2013 Medical Expenditure Panel Survey (MEPS). The 2012-2013 panel of MEPS is drawn from respondents to the 2011 NHIS to be nationally representative, and the responses were linked by anonymized identification number.¹⁸ We included all adults (≥ 18 years at time of NHIS completion) with information on food security status (nonresponse rate for food insecurity items, $< 1\%$)¹⁹ in our analysis. Interviews were conducted by trained interviewers in English or Spanish.^{17,18}

The Human Research Committee at Partners Healthcare exempted this study from human subjects review, as it made use of deidentified data.

Food Insecurity

Food insecurity was assessed at the household level with a 30-day lookback period in the NHIS using a 10-item food insecurity instrument derived from the US Department of Agriculture Household Food Security Module.²⁰ An example item asked whether the respondent and their household often, sometimes, or never worried about whether “food would run out before [they] had money to get more.” An affirmative response to 3 or more items indicated food insecurity, in accord with standard scoring practices for this instrument.²⁰ Owing to sample size limitations, we did not further subdivide the food-insecure category into low versus very low food security. These data came from the 2011 NHIS.

Healthcare Utilization and Expenditures

Information on healthcare expenditures and use that occurred in 2012 and 2013 was taken from MEPS. Because they are often the focus of programs to reduce healthcare utilization,² we evaluated the number of ED visits not resulting in a hospital admission, the number of inpatient hospital admissions, and the number of days spent as a hospital inpatient. To provide context, we also examined the medical conditions associated with use of these services and outpatient service use. Because a disproportionate share of total healthcare costs is attributable to a small number of people with the highest costs, it is important to understand other parts of the

distribution of healthcare expenditures besides the mean. Therefore, we examined those in 3 commonly used thresholds: those in the top 10% of expenditures, those in the top 5%, and those in the top 2%.¹ Using the top 2% rather than the top 1% gives more stable estimates owing to the larger sample sizes. For consistency, we used the Consumer Price Index to convert all expenditures to 2015 dollars.

Other Measures

We considered several factors that may confound the relationships between food insecurity and healthcare utilization and expenditures. We used data from the 2011 NHIS to determine the participant's age (at time of NHIS interview), gender, race/ethnicity (categorized as non-Hispanic white, non-Hispanic black, Hispanic, or other), education (less than high school diploma, high school diploma, or greater than high school diploma), income expressed as a percentage of federal poverty level (which accounts for household size), and health insurance (private, Medicare, other public insurance [which includes Medicaid, Medicare/Medicaid dual-eligibility, and coverage through the Department of Veterans Affairs], or no health insurance). Because area of residence is associated with variation in healthcare expenditure and use, we used data from MEPS to assess Census region of residence (Northeast, Midwest, South, or West) and urban versus rural residence. We also assessed the presence of 4 common conditions (heart disease [coronary heart disease, angina pectoris, myocardial infarction, or other heart disease], diabetes, respiratory illness [asthma, emphysema, or chronic bronchitis], and hypertension) using data from MEPS.²¹

Statistical Analysis

When developing our analysis plan, we relied on a published conceptual model of food insecurity and poor health that recognizes that food insecurity may be associated with poor health both by increasing the prevalence of chronic conditions and by making these conditions more difficult to manage once present.¹² Therefore, our main analytic strategy was to adjust for sociodemographic covariates that may confound the association between food insecurity and poor health, but not to adjust for clinical characteristics that may mediate the association between food insecurity and poor health. However, because healthcare systems often implement disease-specific management programs (eg, a diabetes management program), we conducted sensitivity analyses that adjusted for 4 conditions commonly targeted by disease management programs: heart disease, diabetes, respiratory illness, and hypertension. This helped ensure that any differences observed were not solely due to different burden of common chronic disease and helped provide evidence regarding the association between food insecurity and healthcare use within levels of a specific condition (eg, whether those with food insecurity and diabetes have greater healthcare use than those with diabetes but without food insecurity). We used zero-inflated negative binomial

regression for our utilization analyses because many participants have zero healthcare utilization for a given type (eg, no ED visits).²² We conducted both unadjusted analyses and analyses adjusted for the covariates described above. To help understand differences in use and cost, we also analyzed whether participants had a routine source of care (using logistic regression) and their outpatient utilization (using zero-inflated negative binomial regression).

To examine whether food insecurity was associated with being in the top 10%, 5%, and/or 2% of expenditures, we conducted additional analyses. We tested unadjusted associations using χ^2 tests. Next, we constructed adjusted logistic regression models that included age (both linear and quadratic), gender, race/ethnicity, education, income, health insurance, region of residence, and rural versus urban residence.

To determine the difference in the mean expenditures between those with and without food insecurity by insurance coverage, we fit a generalized linear regression using a gamma distribution and log link and calculated the marginal differences, adjusting for other covariates.^{23,24} The gamma regression approach was selected on the basis of a modified Park test as the distribution best fit to the healthcare expenditures data.²⁴

Finally, although sample size limitations prevented detailed exploration of the diagnoses associated with ED and inpatient use, we conducted exploratory analyses focused on the top 20 conditions responsible for ED visits and the top 20 responsible for inpatient admissions, which, when combined, yielded 30 total condition categories.²⁵

Analyses were conducted using SAS version 9.4 (SAS Institute; Cary, North Carolina) and Stata SE 14.1 (StataCorp; College Station, Texas). All analyses accounted for survey design information (sampling strata and weights).

RESULTS

The study included 11,781 adults. Of these, 13.2% (n = 2056; percentage is weighted) belonged to households that reported food insecurity in 2011. Those in food-insecure households were more likely to be younger, racial/ethnic minorities, and poorer compared with those in food-secure households (Table 1).

Among study participants, unadjusted utilization was highly right-skewed, with most participants having no utilization (eAppendix Table 1; eAppendix Figure 1A-1C [eAppendix available at ajmc.com]). In zero-inflated negative binomial models, adjusted for age, age squared, gender, race/ethnicity, education, income, health insurance, region, and living in a rural area, food insecurity was associated with significantly more ED visits (incidence rate ratio [IRR], 1.47; 95% CI, 1.12-1.93) (Table 2). Similarly, food insecurity was associated with more inpatient hospitalizations (IRR, 1.47; 95% CI, 1.14-1.88) and greater number of days hospitalized (IRR, 1.54; 95% CI, 1.06-2.24). The adjusted differences for those with Medicare were: difference in ED visits, 0.42 visits (P = .01); difference in inpatient admissions, 0.25 admissions (P = .01); and difference in days hospitalized, 1.93 days

TABLE 1. Demographic and Clinical Characteristics of Included Participants*

	Food-Secure (n = 9725)	Food-Insecure (n = 2056)	P
Age, years, mean (SE)	47.06 (0.32)	41.52 (0.54)	<.0001
Female, n (%)	5190 (51.80)	1169 (53.43)	.18
Race/ethnicity, n (%)			<.0001
Non-Hispanic white	4033 (68.89)	537 (54.91)	
Non-Hispanic black	1851 (10.43)	585 (18.36)	
Hispanic	2712 (13.33)	842 (23.49)	
Asian/multiple/other	1129 (7.35)	92 (3.24)	
Education, n (%)			<.0001
Less than HS diploma	1818 (12.35)	708 (25.52)	
HS diploma	2564 (25.66)	621 (33.28)	
Higher than HS diploma	5201 (61.99)	687 (41.20)	
Income, n (%)			<.0001
<100% FPL	1324 (9.99)	839 (35.04)	
100-199% FPL	1700 (15.14)	597 (33.76)	
≥200% FPL	5672 (74.88)	438 (31.20)	
Census region, n (%)			.13
Northeast	1711 (18.27)	335 (18.00)	
Midwest	1731 (22.12)	328 (19.18)	
South	3472 (35.99)	852 (42.08)	
West	2802 (23.62)	539 (20.75)	
Rural residence, n (%)	1139 (13.94)	274 (16.80)	.17
Insurance, n (%)			<.0001
Private	5559 (68.31)	507 (34.95)	
Medicare	863 (9.86)	228 (11.16)	
Other public	1046 (6.67)	490 (19.15)	
Uninsured	2096 (15.16)	778 (34.74)	
Health conditions, n (%)			
Heart disease	1291 (15.62)	325 (19.49)	.008
Diabetes	891 (8.30)	266 (12.46)	<.0001
Respiratory illness	978 (10.91)	331 (19.25)	<.0001
Hypertension	3401 (36.23)	805 (39.59)	.08

FPL indicates federal poverty level; HS, high school; NHIS, National Health Interview Survey; SE, standard error.

*Percentages presented are weighted, not directly calculable from n.

Source: 2011 NHIS and 2012-2013 Medical Expenditure Panel Survey. Sample: adults ≥18 years at time of NHIS completion).

(P = .04). (P values represent comparison between predicted values for those with and without food insecurity when insurance type is Medicare.) The adjusted differences for other public insurance, which includes Medicaid and dual eligibility, were 0.39 visits (P <.0001), 0.10 admissions (P = .005), and 0.62 days (P = .03), respectively (full models in eAppendix Tables 2-4).

In zero-inflated negative binomial models that additionally included high-priority clinical conditions, results were generally similar to those of analyses without clinical conditions, with no qualitative or significant changes in the results. Food insecurity was associated with more ED visits (IRR, 1.41; 95% CI, 1.12-1.78), inpatient

TABLE 2. Adjusted Differences in Healthcare Utilization, by Food Security Status^a

	ED Visits			Inpatient Admissions			Hospital Days		
	IRR (95% CI)	Difference in Events/Year	P	IRR (95% CI)	Difference in Events/Year	P	IRR (95% CI)	Difference in Events/Year	P
Main Analyses, Without Clinical Characteristics									
Food-insecure	1.47 (1.12-1.93)	0.14	.006	1.47 (1.14-1.88)	0.04	.003	1.54 (1.06-2.24)	0.29	.02
Food-secure	ref	–	ref	ref	–	ref	ref	–	ref
Sensitivity Analyses, With Clinical Characteristics									
Food-insecure	1.41 (1.12-1.78)	0.19	.004	1.28 (1.01-1.61)	0.04	.04	1.61 (1.12-2.31)	0.45	.01
Food-secure	ref	–	ref	ref	–	ref	ref	–	ref

ED indicates emergency department; IRR, incidence rate ratio; NHIS, National Health Interview Survey; ref, reference.

^aAll results from zero-inflated negative binomial regression model adjusted for age, age squared, gender, race/ethnicity, education, income, health insurance, region, and rurality and accounting for survey design characteristics. Sensitivity analyses further adjusted for the presence of heart disease, diabetes, respiratory illness, and hypertension. Differences in events per year reflected model predictions [predictive margins].

Source: 2011 NHIS and 2012-2013 Medical Expenditure Panel Survey. Sample: adults ≥18 years at time of NHIS completion.

admissions (IRR, 1.28; 95% CI, 1.01-1.61), and days hospitalized (IRR, 1.61; 95% CI, 1.12-2.31) (full models in [eAppendix Tables 5-7](#)).

We next examined use of outpatient services and having a usual source of care. In models adjusted for age, age squared, gender, race/ethnicity, education, income, health insurance, region, and living in a rural area, we found that participants with food insecurity had higher rates of outpatient visits (IRR, 1.30; 95% CI, 1.11-1.52) but were less likely to report having a usual source of care (odds ratio [OR], 0.69; 95% CI, 0.51-0.93) (full models in [eAppendix Tables 8-9](#)).

Examining high-cost participants, those in the top 10% had expenditures of \$26,201 or greater over the 2-year period, those in the top 5% had expenditures of \$42,116 or greater, and those in the top 2% had expenditures of \$68,314 or greater. In unadjusted, likely confounded analyses, participants from food-insecure households were not more likely to be in the top 10% (11.6% of food-insecure participants in top 10% vs 9.8% of food-secure; *P* = .09) but were more likely to be in the top 5% (6.9% vs 4.7%, respectively; *P* = .01) or top 2% (3.0% vs 1.9%; *P* = .03) of expenditures. In the fully adjusted models, food insecurity was associated with increased odds of being in the top 10% (OR, 1.73; 95% CI, 1.31-2.27), top 5% (OR, 2.53; 95% CI, 1.51-3.37), or top 2% (OR, 1.95; 95% CI, 1.09-3.49) of expenditures (full models in [eAppendix Tables 10-12](#)).

In gamma regression modeling, with total cost as the outcome and adjusting for the same factors, the mean annual cost difference between a food-insecure and a food-secure Medicare beneficiary was \$5527.06 (95% CI, \$2552.39-\$8501.73; *P* < .0001), and that difference between a food-insecure and a food-secure participant with public health insurance other than Medicare was \$1826.40 (95% CI, \$797.69-\$2855.11; *P* = .001) (full model in [eAppendix Table 13](#)).

Exploratory logistic regression models examining the clinical conditions associated with ED and inpatient use are presented in the [eAppendix \(eAppendix Figure 2\)](#). Point estimates suggest that visits related to diabetes and respiratory illnesses were more common in those with food insecurity, but, owing to small sample sizes, CIs were wide and often crossed 1.

DISCUSSION

In this study of nationally representative healthcare utilization and expenditure data in adults, we found that food insecurity was associated with significantly greater healthcare utilization, including ED visits and inpatient admissions, which are common targets of programs to reduce healthcare use. We further found that food insecurity was associated with increased odds of subsequently being a high-cost healthcare user. We found that the higher use of ED and inpatient services in food-insecure participants occurred despite higher use of outpatient services.

The findings in this study are consistent with and extend those in previous work.^{26,27} Higher ED and inpatient service use despite higher outpatient service use suggests that, rather than food insecurity being associated with less healthcare access, the healthcare system, as currently structured, may be unable to address the factors that worsen health for these patients. Fragmentation of care, as indicated by food-insecure participants being less likely to report having a usual source of care, may help explain this finding. A single-center study of food-insecure patients with diabetes had a similar finding.²⁸ Two prior studies have estimated the total burden of food insecurity on healthcare costs in the United States, but they relied on ecological methods in which the healthcare costs of individuals experiencing food insecurity were not assessed.^{15,16} A prior cross-sectional study of food insecurity and healthcare costs based in Canada¹³ found that mean costs are higher in those who experience food insecurity, and a longitudinal study based in the United States reached a similar conclusion.¹⁴ The study presented here used individual-level, nationally representative, longitudinal data to delve further into these findings by examining the distribution of healthcare costs. We found that very high use by a few participants greatly affects total healthcare expenditures and thus may be an important focus of interventions.

This study has several important implications. The longitudinal nature of these data may be particularly useful for care management programs. The ability to target resources to those likely to generate

high healthcare costs in the subsequent 2 years is highly relevant for population health management efforts. Newly validated tools such as brief 2-item screeners for food insecurity may help accomplish this in clinical settings.^{29,30} Programs that assess for unmet needs in clinical care and then link patients to community resources that help meet these needs may be 1 strategy to aid patients.³¹⁻³³ We also think it is important to note that ED visits or inpatient admissions are not necessarily to be avoided in all situations. Often, they represent appropriate care.³⁴⁻³⁶ But given the clear association between food insecurity and these types of healthcare use, which are often disruptive to patients and represent worsening of clinical conditions, interventions to determine whether addressing food insecurity can help alter healthcare use in a way beneficial to both patients and the healthcare system are warranted.

Limitations

This study should be interpreted in light of several important limitations. We cannot exclude the possibility of unmeasured confounding, and the associations between food insecurity and healthcare use and cost cannot be viewed as causal. Because food insecurity is often episodic, the single assessment, with just a 30-day lookback period, used in NHIS may have resulted in misclassifying some participants who did experience food insecurity during the study period as food-secure. This would tend to reduce the magnitude of observed associations. Finally, given the low number of ED visits or inpatient admissions for any given clinical condition and lack of clinic detail about the health service use, we were not able to investigate the causes of the observed differences in great depth in this study, and we were not able to adjust for the specific diagnoses associated with the ED visit or admission.

CONCLUSIONS

Food insecurity is closely associated with higher use of ED visits, higher inpatient admissions, and having high healthcare costs. Although we do not yet know whether addressing food insecurity helps improve these outcomes, food insecurity indicates a group at high risk. Further work to integrate interventions on social determinants of health, such as food insecurity, into routine care may be an important step toward improving health and healthcare for vulnerable populations. ■

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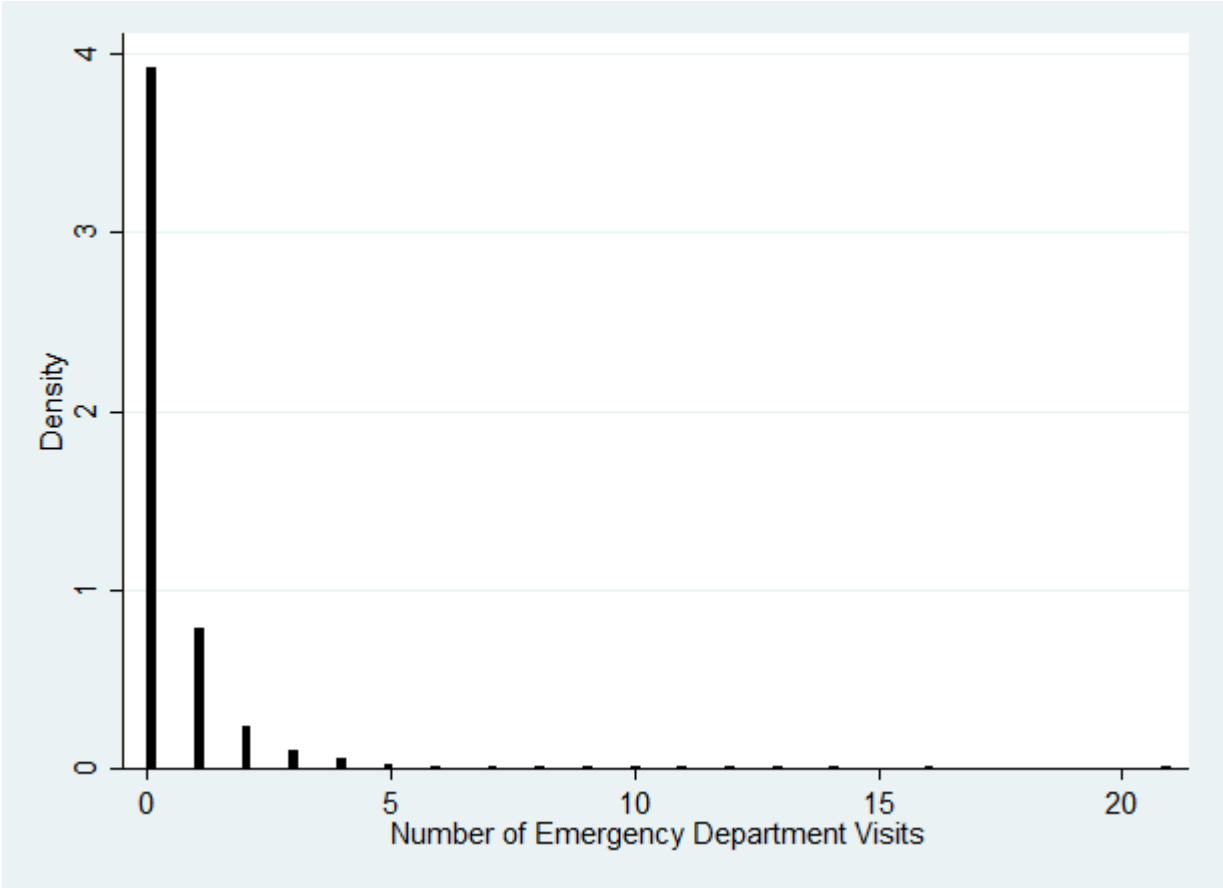
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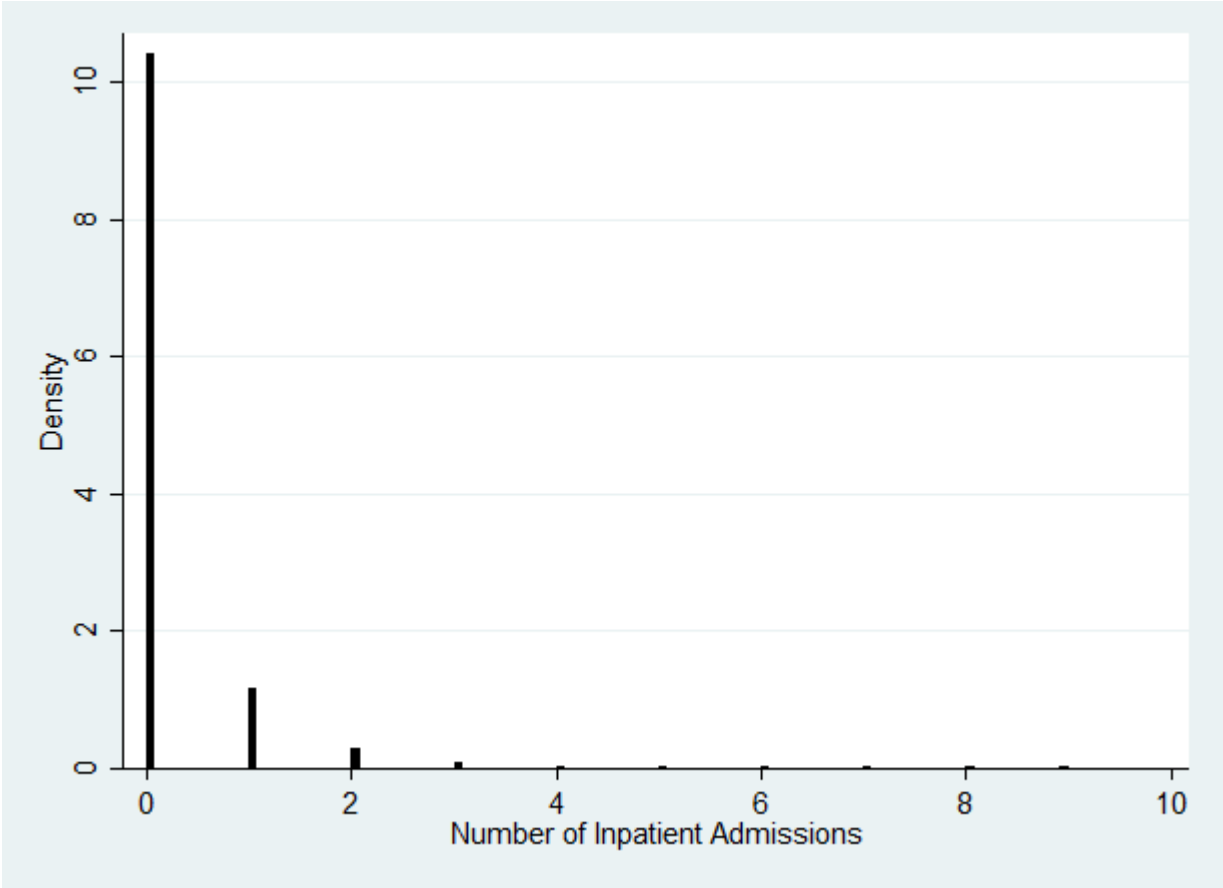
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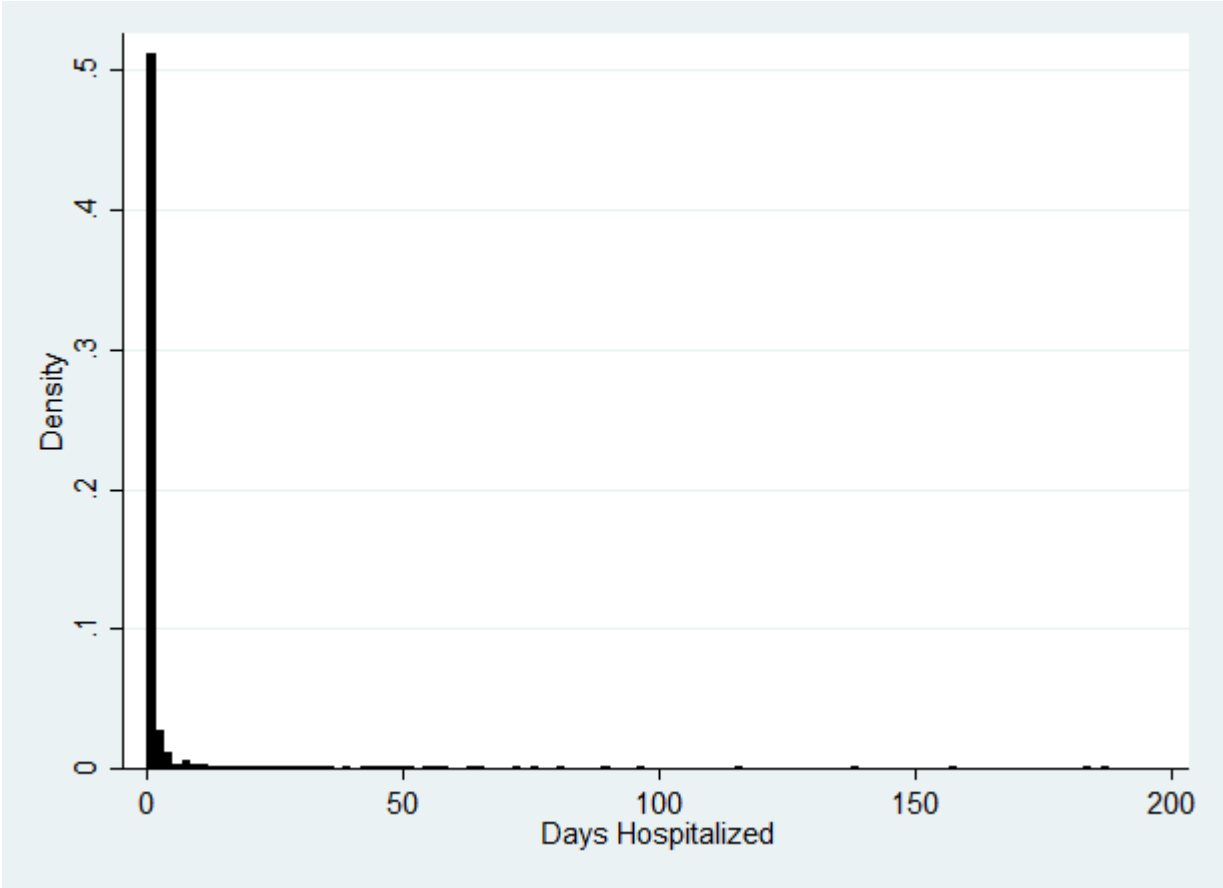
eAppendix Figure 1A. Density Plot of Number of Emergency Department Visits



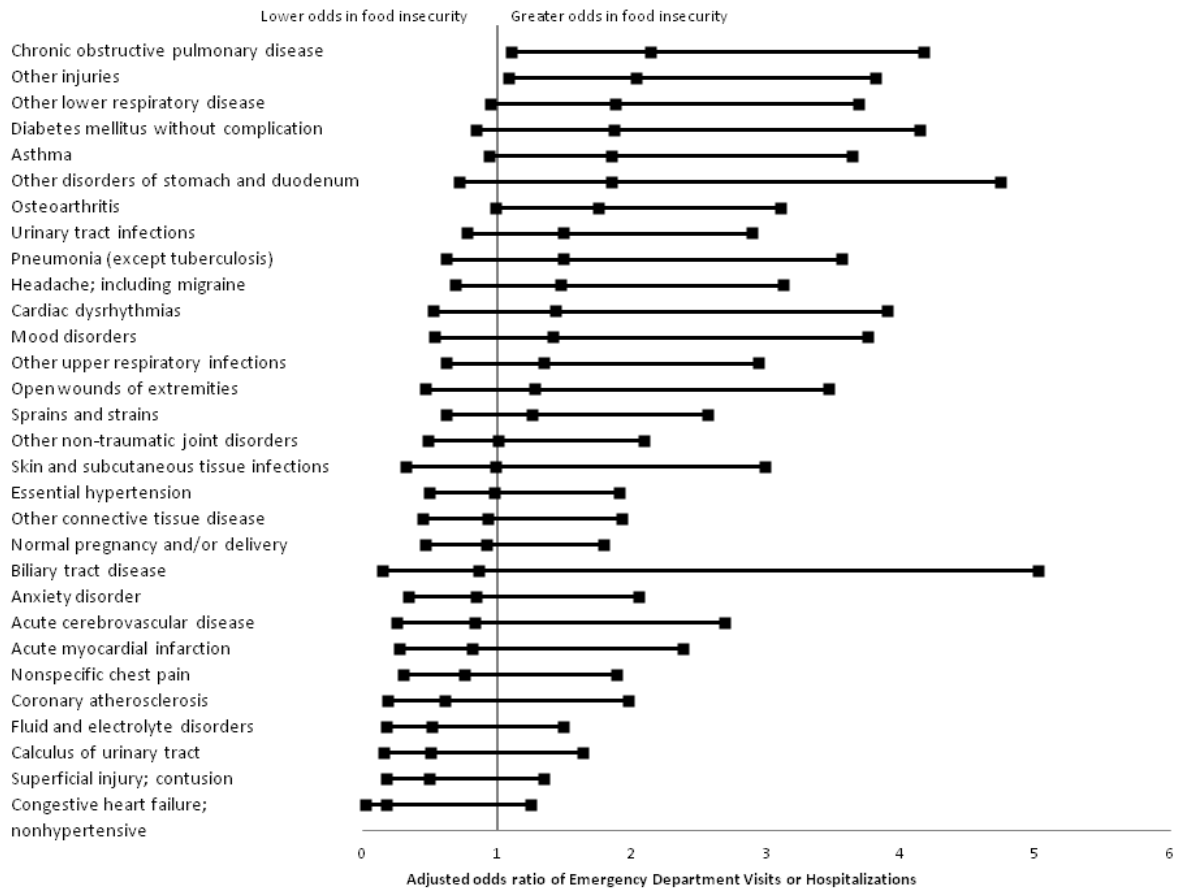
eAppendix Figure 1B. Density Plot of Number of Inpatient Admissions



eAppendix Figure 1C. Density Plot of Number of Days Hospitalized



eAppendix Figure 2. Adjusted Odds of Emergency Department Visit or Hospitalization by Condition



Legend: Forest plot of odds ratios and 95% confidence intervals of having an emergency department visit or hospitalization for a given condition during the study period, among those with the condition. Models adjusted for age, age squared, gender, race/ethnicity, education, income, health insurance, region, and living in a rural area.

eAppendix Table 1. Unadjusted Distribution of Healthcare Utilization and Expenditure, by Food Security Status

	Food Secure	Food Insecure
Emergency Department Visits*		
Mean	0.35	0.71
Median	0	0
25 th percentile	0	0
75 th percentile	0	0.52
Inpatient Admissions*		
Mean	0.20	0.26
Median	0	0
25 th percentile	0	0
75 th percentile	0	0
Hospital Days*		
Mean	0.93	1.26
Median	0	0
25 th percentile	0	0
75 th percentile	0	0
Healthcare Expenditures, 2015 \$*		
Mean	9778.92	11075
Median	3139.99	2486.21
25 th percentile	689.19	290.47
75 th percentile	10495.00	9796.69
90 th percentile	25667.00	29686.00
95 th percentile	40879.00	53770.00
98 th percentile	65674.00	82936.00
99 th percentile	88706.00	123605.00

*Over 2-year MEPS period

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

eAppendix Table 2. Full Adjusted Zero Inflated Negative Binomial Models for
Emergency Department Visits

Negative Binomial Model				
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.47	1.12	1.93	0.006
Age (years)	0.99	0.97	1.01	0.316
Age Squared	1.00	1.00	1.00	0.171
Female	1.44	1.02	2.05	0.041
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.96	0.78	1.18	0.72
Hispanic	0.56	0.40	0.77	<.0001
Asian/Multi-/Other	0.72	0.31	1.68	0.445
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	0.97	0.63	1.48	0.874
> HS Diploma	0.88	0.67	1.17	0.377
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.75	0.42	1.32	0.317
≥200% FPL	0.75	0.41	1.37	0.349
Insurance				
Private	Ref	Ref	Ref	
Medicare	1.47	1.00	2.17	0.05
Other Public	1.58	1.09	2.28	0.016
Uninsured	1.11	0.80	1.53	0.526
Rural Residence	1.06	0.85	1.33	0.587
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.96	0.68	1.36	0.825
South	1.12	0.83	1.51	0.468
West	1.08	0.74	1.58	0.694
Logistic Model				
Food Insecure	0.12	0.00	11660.11	0.72
Age (years)	1.14	1.02	1.27	0.02
Age Squared	1.00	1.00	1.00	0.003
Female	0.89	0.17	4.80	0.895
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.40	0.07	2.09	0.273
Hispanic	0.50	0.01	20.71	0.713

Asian/Multi-/Other	2.08	0.28	15.65	0.475
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.69	0.12	24.37	0.7
> HS Diploma	1.38	0.18	10.57	0.754
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.09	0.00	30.71	0.413
≥200% FPL	0.94	0.04	21.07	0.968
Insurance				
Private	Ref	Ref	Ref	
Medicare	1.45	0.08	27.32	0.805
Other Public	0.63	0.07	6.00	0.686
Uninsured	1.03	0.22	4.77	0.966
Rural Residence	0.98	0.37	2.63	0.972
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.94	0.09	9.52	0.958
South	2.36	0.34	16.55	0.384
West	2.06	0.47	8.95	0.334

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 3. Full Adjusted Zero Inflated Negative Binomial Models for Inpatient Admissions

Negative Binomial Model				
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.47	1.14	1.88	0.003
Age (years)	0.96	0.94	0.98	<.0001
Age Squared	1.00	1.00	1.00	<.0001
Female	0.94	0.78	1.14	0.514
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.87	0.73	1.05	0.149
Hispanic	0.75	0.62	0.92	0.005
Asian/Multi-/Other	0.68	0.46	1.01	0.054
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	0.92	0.74	1.14	0.456
> HS Diploma	0.95	0.77	1.17	0.637
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.99	0.78	1.26	0.924
≥200% FPL	0.77	0.60	1.00	0.048
Insurance				
Private	Ref	Ref	Ref	
Medicare	1.59	1.31	1.94	<.0001
Other Public	1.20	0.90	1.59	0.212
Uninsured	0.75	0.58	0.96	0.025
Rural Residence	1.32	1.04	1.69	0.023
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.89	0.65	1.23	0.488
South	0.88	0.65	1.18	0.389
West	0.83	0.57	1.20	0.316
Logistic Model				
Food Insecure	1.05	0.49	2.27	0.891
Age (years)	0.98	0.89	1.09	0.738
Age Squared	1.00	1.00	1.00	0.187
Female	0.00	0.00	0.00	<.0001
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.85	0.35	2.03	0.71
Hispanic	0.97	0.48	1.98	0.933

Asian/Multi-/Other	1.21	0.30	4.81	0.789
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.20	0.50	2.88	0.676
> HS Diploma	2.34	1.08	5.03	0.03
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.61	0.27	1.39	0.235
≥200% FPL	0.59	0.25	1.39	0.227
Insurance				
Private	Ref	Ref	Ref	
Medicare	0.00	0.00	10180655.93	0.242
Other Public	0.37	0.16	0.84	0.017
Uninsured	1.07	0.43	2.62	0.889
Rural Residence	1.02	0.44	2.36	0.958
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.37	0.12	1.13	0.081
South	0.67	0.25	1.82	0.435
West	0.79	0.31	2.06	0.633

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 4. Full Adjusted Negative Binomial Models for Hospital Days

Negative Binomial Model				
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.54	1.06	2.24	0.023
Age (years)	0.99	0.83	1.19	0.911
Age Squared	1.00	1.00	1.00	0.778
Female	0.76	0.39	1.48	0.419
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	1.26	0.80	2.00	0.316
Hispanic	1.07	0.46	2.47	0.875
Asian/Multi-/Other	0.66	0.31	1.42	0.292
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.04	0.70	1.56	0.833
> HS Diploma	1.01	0.58	1.75	0.975
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.97	0.67	1.40	0.865
≥200% FPL	0.94	0.40	2.23	0.894
Insurance				
Private	Ref	Ref	Ref	
Medicare	1.75	1.02	2.98	0.041
Other Public	1.14	0.68	1.92	0.613
Uninsured	1.20	0.60	2.38	0.607
Rural Residence	1.29	0.95	1.76	0.102
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.75	0.40	1.41	0.366
South	0.79	0.51	1.24	0.31
West	0.68	0.43	1.09	0.11
Logistic Model				
Food Insecure	0.79	0.45	1.38	0.398
Age (years)	1.12	1.04	1.21	0.002
Age Squared	1.00	1.00	1.00	0.065
Female	0.18	0.00	9.90	0.398
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	1.38	0.69	2.78	0.36
Hispanic	1.36	0.60	3.06	0.46
Asian/Multi-/Other	1.29	0.37	4.56	0.69

Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.41	0.50	4.01	0.515
> HS Diploma	1.75	0.20	15.61	0.615
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.73	0.23	2.33	0.598
≥200% FPL	1.17	0.27	5.16	0.83
Insurance				
Private				
Medicare	0.25	0.00	98.77	0.647
Other Public	0.48	0.12	1.87	0.289
Uninsured	1.86	1.09	3.15	0.023
Rural Residence	0.79	0.47	1.33	0.377
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.55	0.08	3.78	0.541
South	0.76	0.28	2.07	0.588
West	0.75	0.25	2.22	0.604

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 5. Full Adjusted Negative Binomial Models for Emergency

Department Visits With Clinical Factors

Negative Binomial Model				
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.41	1.12	1.78	0.004
Age (years)	0.98	0.96	1.00	0.063
Age Squared	1.00	1.00	1.00	0.076
Female	1.38	1.16	1.63	<.0001
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	1.04	0.89	1.20	0.636
Hispanic	0.69	0.56	0.83	<.0001
Asian/Multi-/Other	0.78	0.55	1.10	0.153
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	0.97	0.81	1.16	0.728
> HS Diploma	0.93	0.77	1.13	0.469
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.78	0.64	0.95	0.012
≥200% FPL	0.74	0.60	0.92	0.008
Insurance				
Private				
Medicare	1.23	0.99	1.52	0.058
Other Public	1.40	1.13	1.74	0.002
Uninsured	1.18	0.95	1.45	0.127
Rural Residence	1.07	0.88	1.31	0.485
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.93	0.71	1.22	0.608
South	1.00	0.81	1.24	0.974
West	1.05	0.81	1.36	0.698
Health Conditions				
Heart Disease	1.64	1.37	1.96	<.0001
Diabetes	1.19	1.00	1.42	0.05
Respiratory illness	1.61	1.33	1.94	<.0001
Hypertension	1.08	0.84	1.38	0.555
Logistic Model				
	Odds Ratio	Lower 95% CI	Upper 95% CI	P

Food Insecure	0.56	0.21	1.51	0.253
Age (years)	1.10	0.98	1.25	0.108
Age Squared	1.00	1.00	1.00	0.123
Female	0.68	0.34	1.36	0.276
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.65	0.27	1.57	0.336
Hispanic	1.16	0.63	2.14	0.641
Asian/Multi-/Other	2.39	0.90	6.36	0.08
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.47	0.54	4.02	0.447
> HS Diploma	1.64	0.62	4.34	0.321
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.28	0.06	1.46	0.131
≥200% FPL	0.73	0.30	1.79	0.491
Insurance				
Private	Ref	Ref	Ref	
Medicare	0.75	0.23	2.42	0.632
Other Public	0.53	0.17	1.60	0.257
Uninsured	1.10	0.54	2.24	0.8
Rural Residence	1.24	0.58	2.64	0.576
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.68	0.20	2.27	0.524
South	1.50	0.52	4.29	0.452
West	1.46	0.60	3.57	0.406
Health Conditions				
Heart Disease	0.20	0.00	8.17	0.39
Diabetes	0.43	0.04	4.96	0.501
Respiratory illness	1.11	0.47	2.60	0.817
Hypertension	0.00	0.00	3.4E+28	0.633

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 6. Full Adjusted Zero Inflated Negative Binomial Models for Inpatient Admissions with Clinical Factors

Negative Binomial Model				
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.28	1.01	1.61	0.037
Age (years)	0.94	0.92	0.96	<.0001
Age Squared	1.00	1.00	1.00	<.0001
Female	1.03	0.79	1.34	0.834
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.82	0.68	0.99	0.038
Hispanic	0.79	0.65	0.97	0.026
Asian/Multi-/Other	0.69	0.47	1.02	0.063
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	0.92	0.73	1.16	0.488
> HS Diploma	0.99	0.80	1.24	0.96
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.98	0.76	1.27	0.875
≥200% FPL	0.81	0.61	1.07	0.134
Insurance				
Private	Ref	Ref	Ref	
Medicare	1.52	1.25	1.86	<.0001
Other Public	1.16	0.89	1.51	0.283
Uninsured	0.75	0.58	0.98	0.034
Rural Residence	1.33	1.05	1.69	0.019
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.94	0.68	1.30	0.709
South	0.88	0.64	1.21	0.434
West	0.86	0.59	1.25	0.422
Health Conditions				
Heart Disease	1.67	1.32	2.12	<.0001
Diabetes	1.38	1.11	1.71	0.003
Respiratory illness	1.23	0.99	1.52	0.065
Hypertension	1.67	1.34	2.07	<.0001
Logistic Model				
	Odds Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.95	0.60	6.29	0.265

Age (years)	0.92	0.81	1.05	0.217
Age Squared	1.00	1.00	1.00	0.897
Female	0.00	0.00	0.00	<.0001
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	0.68	0.26	1.79	0.434
Hispanic	0.89	0.40	2.01	0.781
Asian/Multi-/Other	0.96	0.22	4.23	0.953
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.32	0.44	3.97	0.617
> HS Diploma	2.71	0.99	7.42	0.053
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	0.63	0.17	2.30	0.479
≥200% FPL	0.48	0.09	2.68	0.401
Insurance				
Private				
Medicare	0.17	0.00	13.88	0.43
Other Public	0.61	0.24	1.55	0.299
Uninsured	0.74	0.20	2.73	0.646
Rural Residence	1.12	0.47	2.71	0.792
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.46	0.12	1.71	0.244
South	0.79	0.21	2.93	0.725
West	0.96	0.21	4.46	0.961
Health Conditions				
Heart Disease	0.09	0.00	6.57	0.265
Diabetes	0.39	0.04	3.57	0.402
Respiratory illness	0.75	0.16	3.60	0.717
Hypertension	1.42	0.55	3.72	0.468

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 7. Full Adjusted Zero Inflated Negative Binomial Models for Hospital Days With Clinical Factors

Negative Binomial Model				
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.61	1.12	2.31	0.01
Age (years)	1.01	0.96	1.07	0.67
Age Squared	1.00	1.00	1.00	0.885
Female	0.85	0.58	1.26	0.417
Race/ethnicity				
Non-Hispanic white	Ref	Ref	Ref	
Non-Hispanic black	1.21	0.82	1.80	0.337
Hispanic	1.10	0.73	1.67	0.644
Asian/Multi-/Other	0.74	0.42	1.30	0.293
Education				
<HS Diploma	Ref	Ref	Ref	
HS Diploma	1.09	0.75	1.60	0.64
> HS Diploma	0.98	0.66	1.45	0.931
Income				
<100% FPL ^a	Ref	Ref	Ref	
100-199% FPL	1.04	0.72	1.49	0.842
≥200% FPL	1.04	0.72	1.50	0.849
Insurance				
Private	Ref	Ref	Ref	
Medicare	1.61	1.09	2.37	0.017
Other Public	1.13	0.72	1.77	0.587
Uninsured	1.13	0.73	1.75	0.576
Rural Residence	1.25	0.95	1.65	0.111
Census Region				
Northeast	Ref	Ref	Ref	
Midwest	0.75	0.45	1.26	0.276
South	0.79	0.52	1.19	0.257
West	0.73	0.46	1.18	0.197
Health Conditions				
Heart Disease	0.92	0.65	1.29	0.611
Diabetes	1.16	0.80	1.69	0.438
Respiratory illness	0.94	0.67	1.32	0.717
Hypertension	1.25	0.87	1.78	0.223
Logistic Model				
	Odds Ratio	Lower 95% CI	Upper 95% CI	P
Food Insecure	1.20	0.83	1.73	0.328

Age (years)		1.11	1.06	1.17	<.0001
Age Squared		1.00	1.00	1.00	<.0001
Female		0.28	0.18	0.44	<.0001
Race/ethnicity					
Non-Hispanic white	Ref		Ref	Ref	
Non-Hispanic black		1.42	0.96	2.10	0.081
Hispanic		1.25	0.90	1.75	0.182
Asian/Multi-/Other		1.35	0.72	2.51	0.343
Education					
<HS Diploma	Ref		Ref	Ref	
HS Diploma		1.29	0.85	1.98	0.232
> HS Diploma		1.34	0.84	2.13	0.22
Income					
<100% FPL ^a	Ref		Ref	Ref	
100-199% FPL		0.92	0.62	1.36	0.682
≥200% FPL		1.14	0.76	1.71	0.524
Insurance					
Private	Ref		Ref	Ref	
Medicare		0.50	0.26	0.98	0.042
Other Public		0.65	0.42	1.02	0.06
Uninsured		1.46	0.98	2.17	0.059
Rural Residence		0.77	0.52	1.14	0.187
Census Region					
Northeast	Ref		Ref	Ref	
Midwest		0.63	0.35	1.12	0.117
South		0.82	0.52	1.29	0.384
West		0.85	0.48	1.50	0.573
Health Conditions					
Heart Disease		0.20	0.10	0.41	<.0001
Diabetes		0.48	0.25	0.93	0.029
Respiratory illness		0.59	0.33	1.04	0.068
Hypertension		0.54	0.38	0.78	0.001

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 8. Full Adjusted Zero Inflated Negative Binomial Models for Outpatient Visits

Negative Binomial Model			
	Incidence Rate Ratio	Lower 95% CI	Upper 95% CI
Food Insecure	1.30	1.11	1.52
Age (years)	1.03	1.02	1.05
Age Squared	1.00	1.00	1.00
Female	1.51	1.39	1.65
Race/ethnicity			
Non-Hispanic white	Ref	Ref	Ref
Non-Hispanic black	0.71	0.63	0.81
Hispanic	0.70	0.63	0.79
Asian/Multi-/Other	0.67	0.55	0.80
Education			
<HS Diploma	Ref	Ref	Ref
HS Diploma	1.03	0.90	1.18
> HS Diploma	1.26	1.11	1.43
Income			
<100% FPL ^a	Ref	Ref	Ref
100-199% FPL	0.87	0.77	0.99
≥200% FPL	0.98	0.86	1.12
Insurance			
Private	Ref	Ref	Ref
Medicare	1.54	1.35	1.76
Other Public	1.19	1.02	1.37
Uninsured	0.70	0.60	0.81
Rural Residence	0.93	0.81	1.07
Census Region			
Northeast	Ref	Ref	Ref
Midwest	0.91	0.77	1.06
South	0.79	0.69	0.91
West	0.95	0.82	1.10
Logistic Model			
Food Insecure	1.34	0.89	2.02
Age (years)	0.98	0.90	1.07
Age Squared	1.00	1.00	1.00
Female	0.10	0.05	0.18
Race/ethnicity			
Non-Hispanic white	Ref	Ref	Ref
Non-Hispanic black	1.11	0.59	2.09
Hispanic	1.93	1.16	3.22

Asian/Multi-/Other	2.98	1.42	6.29
Education			
<HS Diploma	Ref	Ref	Ref
HS Diploma	0.61	0.37	1.00
> HS Diploma	0.30	0.17	0.53
Income			
<100% FPL ^a	Ref	Ref	Ref
100-199% FPL	1.20	0.75	1.92
≥200% FPL	0.72	0.45	1.16
Insurance			
Private			
Medicare	0.00	0.00	0.00
Other Public	2.01	0.88	4.58
Uninsured	6.06	3.03	12.14
Rural Residence	0.17	0.03	0.90
Census Region			
Northeast	Ref	Ref	Ref
Midwest	0.55	0.25	1.20
South	0.75	0.43	1.32
West	0.92	0.54	1.58

^aFPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

Note: For zero-inflated negative binomial models, both the negative binomial and the logistic model should be used together to generate model predictions

eAppendix Table 9. Full Logistic Regression Model, Report of Having a Usual Source of Care

	Odds Ratio	Lower 95% CI	Upper 95% CI
Food Insecure	0.69	0.51	0.93
Food Secure	Ref	--	--
Age	1.03	0.99	1.07
Age Squared	1.00	1.00	1.00
Male (ref: Female)	0.43	0.34	0.53
Race/ethnicity			
Non-Hispanic white	1.07	0.72	1.59
Non-Hispanic black	1.36	0.84	2.20
Hispanic	0.79	0.53	1.20
Asian/Multi/Other	Ref	--	--
Education			
< HS Diploma	1.30	0.91	1.85
HS Diploma	1.26	0.98	1.62
>HS Diploma	Ref	--	--
Income			
<100% FPL	0.65	0.45	0.93
100-199% FPL	0.75	0.56	1.00
≥ 200% FPL	Ref	--	--
Health Insurance			
Private	7.00	5.36	9.15
Medicare	5.66	3.04	10.55
Other Public	9.01	5.80	13.99
Uninsured	Ref	--	--
Urban Residence (ref: Rural)	1.07	0.73	1.57
Region of U.S.	0.86	0.59	1.24
Northeast	0.99	0.71	1.37
Midwest	1.10	0.78	1.54
South	1.05	0.81	1.35
West	Ref	--	--

*FPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure

Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

eAppendix Table 10. Full Logistic Regression Model, Top 10% of Healthcare Expenditures

	Odds Ratio	Lower 95% CI	Upper 95% CI
Food Insecure	1.73	1.31	2.27
Food Secure	Ref	--	--
Age	1.08	1.04	1.12
Age Squared	1.00	1.00	1.00
Male (ref: Female)	0.87	0.72	1.06
Race/ethnicity			
Non-Hispanic white	2.01	1.40	2.88
Non-Hispanic black	1.57	1.04	2.36
Hispanic	1.12	0.73	1.71
Asian/Multi/Other	Ref	--	--
Education			
< HS Diploma	0.88	0.67	1.15
HS Diploma	0.95	0.75	1.19
>HS Diploma	Ref	--	--
Income			
<100% FPL	1.30	0.96	1.75
100-199% FPL	1.21	0.91	1.61
≥ 200% FPL	Ref	--	--
Health Insurance			
Private	2.59	1.82	3.68
Medicare	4.45	3.10	6.39
Other Public	2.96	1.93	4.55
Uninsured	Ref	--	--
Urban Residence (ref: Rural)	0.87	0.67	1.12
Region of U.S.			
Northeast	1.14	0.80	1.62
Midwest	1.13	0.82	1.56
South	0.99	0.73	1.34
West	Ref	--	--

*FPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure

Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

eAppendix Table 11. Full Logistic Regression Model, Top 5% of Healthcare Expenditures

	Odds Ratio	Lower 95% CI	Upper 95% CI
Food Insecure	2.25	1.51	3.37
Food Secure	Ref	--	--
Age	1.08	1.02	1.13
Age Squared	1.00	1.00	1.00
Male (ref: Female)	0.88	0.67	1.16
Race/ethnicity			
Non-Hispanic white	1.62	1.04	2.50
Non-Hispanic black	1.41	0.85	2.35
Hispanic	1.17	0.71	1.93
Asian/Multi/Other	Ref	--	--
Education			
< HS Diploma	0.97	0.69	1.38
HS Diploma	0.89	0.66	1.18
>HS Diploma	Ref	--	--
Income			
<100% FPL	1.32	0.86	2.01
100-199% FPL	1.10	0.78	1.54
≥ 200% FPL	Ref	--	--
Health Insurance			
Private	3.50	2.10	5.85
Medicare	4.90	2.84	8.46
Other Public	3.53	2.06	6.05
Uninsured	Ref	--	--
Urban Residence (ref: Rural)	0.86	0.59	1.24
Region of U.S.	0.86	0.59	1.24
Northeast	1.23	0.80	1.88
Midwest	0.99	0.66	1.50
South	0.88	0.60	1.29
West	Ref	--	--

*FPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure

Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

eAppendix Table 12. Full Logistic Regression Model, Top 2% of Healthcare Expenditures

	Odds Ratio	Lower 95% CI	Upper 95% CI
Food Insecure	1.95	1.09	3.48
Food Secure	Ref	--	--
Age	1.08	1.00	1.17
Age Squared	1.00	1.00	1.00
Male (ref: Female)	1.09	0.74	1.60
Race/ethnicity			
Non-Hispanic white	1.40	0.72	2.75
Non-Hispanic black	1.74	0.84	3.63
Hispanic	1.12	0.52	2.41
Asian/Multi/Other	Ref	--	--
Education			
< HS Diploma	1.20	0.74	1.97
HS Diploma	1.01	0.68	1.50
>HS Diploma	Ref	--	--
Income			
<100% FPL	1.60	0.79	3.24
100-199% FPL	1.08	0.64	1.83
≥ 200% FPL	Ref	--	--
Health Insurance			
Private	3.81	1.78	8.15
Medicare	7.21	3.26	15.93
Other Public	3.84	1.76	8.37
Uninsured	Ref	--	--
Urban Residence (ref: Rural)	0.86	0.48	1.52
Region of U.S.			
Northeast	1.49	0.83	2.67
Midwest	1.07	0.57	2.02
South	0.89	0.50	1.58
West	Ref	--	--

*FPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey

Sample: Adults (age ≥18 years at time of NHIS completion)

eAppendix Table 13. Full Gamma Regression Model for Healthcare Expenditures

	Regression Coefficient	Lower 95% CI	Upper 95% CI
Food Insecure	0.382	0.21	0.55
Food Secure	Ref	--	--
Age	0.036	0.02	0.05
Age Squared	0.000	0.00	0.00
Male (ref: Female)	0.393	0.29	0.50
Race/ethnicity			
Non-Hispanic white	Ref	--	--
Non-Hispanic black	-0.126	-0.30	0.05
Hispanic	-0.372	-0.53	-0.21
Asian/Multi/Other	-0.317	-0.52	-0.12
Education			
< HS Diploma	Ref	--	--
HS Diploma	0.050	-0.12	0.22
>HS Diploma	0.096	-0.06	0.26
Income			
<100% FPL	Ref	--	--
100-199% FPL	0.031	-0.16	0.22
≥ 200% FPL	-0.018	-0.18	0.15
Health Insurance			
Private	Ref	--	--
Medicare	0.377	0.22	0.53
Other Public	0.026	-0.17	0.22
Uninsured	-0.751	-0.91	-0.59
Urban Residence (ref: Rural)	0.073	-0.10	0.25
Region of U.S.			
Northeast	Ref	--	--
Midwest	0.031	-0.15	0.21
South	-0.139	-0.30	0.02
West	-0.049	-0.24	0.14

*FPL = Federal Poverty Level

Data Source: 2011 National Health Interview Survey and 2012-2013 Medical Expenditure Panel Survey. Sample: Adults (age ≥18 years at time of NHIS completion)

Note: Owing to differences in inclusion criteria, this model is different than that presented in Berkowitz SA, Basu S, Meigs JB, Seligman HK. Food Insecurity and Health Care Expenditures in the United States, 2011-2013. Health Serv Res. 2017 Jun 13. doi: 10.1111/1475-6773.12730.

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