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Food Insecurity and Health Outcomes Among Older Adults: The Role of Cost-Related Medication Underuse

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The purpose of this study is to examine the relationship between food security and cost-related medication underuse among older adults (persons aged 65 years and older) in the United States; and to determine if this relationship differs by sex, chronic disease status, and type of health insurance. Data are from a combined sample of older adults in the 2011 and 2012 National Health Interview Survey (N = 10,401). Both bivariate and multivariate analyses show a dose-response relationship between food insecurity and cost-related medication underuse among the elderly— increasing likelihood of cost-related medication underuse with increasing severity of food insecurity (P < 0.001). This association is not conditional on sex, chronic disease status, or type of health insurance. However, females and those with a chronic condition are more likely to report cost-related medication underuse than

males and those without a chronic condition respectively; and older adults with Medicare and Medicaid or other public insurance are less likely to report cost-related medication underuse than older adults with only Medicare.

KEYWORDS elderly, food insecurity, food security, health care, health outcomes

INTRODUCTION

Food insecurity (FI) contributes to a number of nutrition and non-nutrition issues that affect the health and well-being of Americans, including the older adults. Older adults—persons 65 years or older—are a large and growing segment of the population, numbering 39.6 million in 2009 and representing 12.9% of the U.S. population: about one out of every eight Americans (1). There is public investment in promoting the health of older adults through Medicare. In 2013, Medicare's total spending of $583 billion accounted for 14% of the federal budget (2). Nearly all of Medicare dollars are spent on individuals with chronic conditions (3). However, older adults facing FI and juggling health care costs, food, and other basic living expenses may not be able to comply with physician's recommendations and treatments, thus reducing the positive impact of Medicare investments.

Food insecurity refers to "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" (4). In 2013, 8.7% of households with older adults were food-insecure. The prevalence of FI is lower among older adults than among all U.S. households (14.3% in 2013), but the health effects of FI among older adults may be more serious (5). Two out of every three older persons in the United States are diagnosed with multiple chronic conditions, putting them at higher risk for poorer health in general and increasing the probability of difficulties to accomplish activities of daily living (6–9). In addition, FI among older adults is associated with lower nutrient intakes and worse health outcomes, including higher rates of diabetes, hypertension, heart problems, asthma, depression, frailty and functional impairment, and lack of social support (10–15). These associations are especially important in light of evidence that the number of older people experiencing food insecurity in the United States has increased since the recession. A recent report on the state of senior hunger in America showed that about 9.3 million seniors (i.e., 15.3% of seniors) faced the threat of hunger in 2012—an increase of 49% from 2007—with 5.3 million (8.8%) being food insecure—an increase of 63% from 2007 (16, 17).

FI may affect health outcomes of older adults through their inability to afford needed medications (18 19). Cost-related medication underuse (CRMU) is a term used to describe when individuals reduce, skip, delay, or

use lower-cost medications to compensate for lack of household resources. A number of recent studies have shown that CRMU is associated with poor health outcomes (20–24). But to our knowledge, only one study has examined the relationship between food security (FS) and CRMU in the United States using a nationally representative sample (18). This study, which was restricted to adults with chronic diseases, found that people living in food-insecure households were more likely to report CRMU. Similar findings have been demonstrated from smaller studies in different parts of the country among the non-elderly (25–29) and among low-income older adults (30–32).

Our study is distinct from these earlier studies in several ways. We use the nationally representative National Health Interview Survey, as did Berkowitz and colleagues, but focus on older adults, and we do not limit the analysis to those with chronic diseases (18). Bengle and colleagues (30) and Sattler and colleagues (31, 32) also focus on older adults, but their sample is limited to participants of the Older Americans Act Nutrition Program (receiving delivered meals or congregate meals) or those on a waitlist for services in Georgia. The association between FI and CRMU among older adults who sought out or were referred to nutrition assistance programs may differ from the general population of older adults.

Because of the increasing proportion of older adults in the population and the large investment in their health represented by spending on Medicare, we seek to further understand the relationship between FI and health-related outcomes in a nationally representative sample of older adults living in the United States. The objective of this analysis is to determine if older adults (65 years and older) living in food-insecure households in the United States are more likely to report CRMU than those in food-secure households. We also examine if the relationship between FI and CRMU differs by sex, chronic disease status, and type of health insurance.

METHODS

Data

We analyzed data from a combined sample of the 2011 and 2012 National Health Interview Survey (NHIS), an annual, nationally representative, cross-sectional survey that provides data on the health of the noninstitutionalized, civilian population in the United States. The NHIS methodology is described in detail elsewhere (33–36). One adult is randomly chosen from each family in the NHIS. The total number of sampled adults was 33,014 for 2011 and 34,525 for 2012, giving a combined sample of 67,539 adults. Because of the important relationship between FI and income, we worked only with observations with complete income data (57,547 adults): income data were missing for about 15% of the sample. Missing values on other key variables reduced the analytic sample to 54,975—81% of the full sample.

Of the 54,975 sampled adults remaining, 44,574 (81%) were 18–64 years and 10,401 (19%) 65 years and older. Initial analyses showed the association between FI and our outcomes differed significantly for those younger than 65 and those 65 years and older. This finding is consistent with prior research on disabilities and FI that found disabilities were more detrimental to FS for working-age adults (18–64 years) than older adults (≥65 years) (37). Therefore, we conducted separate analyses for these two age groups. The analysis presented here is restricted to adults 65 years and older ($N = 10,401$). Stata version 12 was used for data analysis.

Description of Variables

The key relationship is that between food security and cost-related medication underuse.

OUTCOME VARIABLES

A person is considered to have CRMU if they responded "yes" to any of five items that asked if, in the last 12 months they: (1) skipped medication doses to save money; (2) took less medication than prescribed to save money; (3) delayed filling a prescription to save money; (4) could not afford prescription medicine due to cost; or (5) asked a doctor for lower cost medication to save money. These are validated items adapted from the Medical Expenditure Panel Survey (38). Prior studies on CRMU used only the first three or four items (18, 19), but we included the fifth item because it loaded well with the set in principal component analysis. It also captures a potentially positive coping behavior without negative health implications if a cheaper alternative is available. We examined these variables individually and as a group (i.e., whether the respondent responded "yes" to any of the five questions).

FOCAL INDEPENDENT VARIABLE

FS was measured as a four-category variable obtained from the 10-item U.S. Adult Food Security Survey Module examining the household food situation in the past 30 days. Responses were scored based on guidelines from the U.S. Department of Agriculture to create a raw FS score. This was used to categorize respondents into four groups: high FS, marginal FS, low FS, and very low FS. Low and very low FS are often combined to represent FI. We used all categories because there were important differences between them. More information about standard procedures for measuring FI in the United States can be found in Coleman-Jensen and colleagues (4) and Bickel and associates (39).

CONTROL VARIABLES

Based on prior literature, we controlled for several factors that are potentially associated with FS and/or CRMU. These include:

Demographic variables: Age, gender, marital status, children in household, race/ethnicity, and citizenship.

Family socioeconomic status (SES): Family income (ratio of reported family income to the federal poverty threshold) and education (family member with the highest education). Because a large proportion of the elderly are retired, we controlled for any adults in household working and any adults in household looking for work, instead of employment status, which has little variability in the sample (and was not significant in preliminary analysis).

Type of insurance was coded as: Medicare only, Medicare and a private or military insurance, Medicare and Medicaid or other public insurance, No Medicare but has a private or military insurance, No Medicare but has some other public insurance, and no insurance.

Physical and mental health status and health behaviors: Whether the individual had a diagnosed chronic condition (including, hypertension, cardiovascular disease, diabetes, asthma, or arthritis), a functional limitation, or a severe mental illness (measured with the Kessler (K6) nonspecific distress scale) (40, 41).

Lifestyle behaviors were captured by Body Mass Index, smoking, and alcohol use. We also controlled for family health status using the proportion of adult family members reporting needing help with activities of daily living and limited in anyway; and any family member reporting fair or poor self-rated health status.

Statistical Analysis

We first examined univariate statistics, then bivariate associations between FS and CRMU using chi-squared tests. Multivariate logistic regressions were used to examine the relationship between FS and CRMU, net of the control variables. We also included interaction terms for FS and sex, FS and chronic disease, and FS and type of health insurance to check for conditional effects. We divided the sample weight provided by two to obtain individual level weights for the pooled data (2011 and 2012) as described in the NHIS survey documentation (33). These weights were then applied in all analyses to account for the complex sample design.

RESULTS

Descriptive Statistics

Twenty-three percent of older adult respondents reported CRMU in the preceding 12 months (Table 1). The most frequently reported behavior

TABLE 1 Distribution of Key Variables, U.S. Adults 65 Years and Older, NHIS 2011 and 2012 (*N* = 10,401)

Variables	*N*	Weighted proportion	95% CI	
Dependent variables				
Cost-related Medication Underuse				
Skipped Medications	379	0.035	0.031	0.039
Took less medication	427	0.040	0.035	0.044
Delayed filling prescription	485	0.046	0.042	0.051
Lower cost medication	2007	0.199	0.189	0.209
Couldn't afford medicine	490	0.045	0.041	0.049
One or more of the 5	2308	0.225	0.215	0.236
Key independent variable				
Food Security				
Food-secure	8944	0.877	0.869	0.885
Marginal food security	598	0.052	0.047	0.057
Low food security	552	0.045	0.040	0.049
Very low food security	307	0.026	0.023	0.030
Control variables				
Demographic and socioeconomic variables				
Female	6058	0.587	0.576	0.598
Age				
65–69 years	3419	0.326	0.316	0.336
70–74 years	2432	0.233	0.224	0.242
75–79 years	1855	0.178	0.168	0.187
80–84 years	1479	0.146	0.138	0.154
85 years plus	1216	0.118	0.110	0.125
Marital status				
Separated	178	0.014	0.011	0.016
Divorced	1728	0.167	0.159	0.175
Married	4272	0.416	0.403	0.429
Single/never married	625	0.060	0.054	0.066
Widowed	3598	0.343	0.332	0.355
Households with children	487	0.039	0.035	0.042
Race/ethnicity				
Hispanic	1109	0.078	0.072	0.085
Non-Hispanic White	7290	0.785	0.774	0.796
Non-Hispanic Black	1406	0.099	0.091	0.107
Non-Hispanic Asian or other	596	0.037	0.033	0.042
U.S. citizenship				
U.S. citizen	10,083	0.976	0.973	0.980
Non-U.S. Citizen	318	0.024	0.020	0.027
Income to Poverty Ratio				
< 1.00	1597	0.129	0.121	0.138
1.00–1.99	2837	0.263	0.253	0.273
2.00–2.99	1989	0.197	0.188	0.206
3.00–3.99	1277	0.128	0.120	0.136
4.00 or more	2701	0.282	0.270	0.295
Highest Family member Education				
Less than High School	1892	0.163	0.153	0.173
High school graduate/GED	2797	0.271	0.261	0.281
Some college/AA degree	2822	0.274	0.264	0.284
College grad or above	2890	0.292	0.280	0.304

(*Continued*)

TABLE 1 Continued

Variables	N	Weighted proportion	95% CI	
One or more family members employed	2864	0.271	0.261	0.282
One or more family members looking for work	303	0.027	0.024	0.031
Health care access, health and lifestyle				
Type of Insurance				
Medicare only	3475	0.332	0.320	0.344
Medicare and Private or Military	5337	0.536	0.522	0.550
Medicare and Medicaid or other public	1057	0.084	0.077	0.091
No Medicare, Private and or Military	339	0.032	0.029	0.036
No Medicare, other public	93	0.007	0.006	0.009
No insurance	100	0.008	0.006	0.010
Diagnosed with chronic condition	8880	0.851	0.843	0.859
Has a functional limitation	6952	0.668	0.657	0.680
Severe Mental Illness	281	0.025	0.021	0.028
Proportion family members need help with ADLs (mean)	10,401	0.054	0.050	0.059
BMI category				
Underweight (<18.5)	236	0.021	0.018	0.024
Normal weight (18.5–24.99)	3443	0.335	0.325	0.344
Overweight (25–29.99)	3900	0.375	0.365	0.386
Obese (30–39.99)	2513	0.239	0.231	0.248
Severely obese (>40)	309	0.029	0.026	0.033
Smoking				
Current	1075	0.098	0.092	0.105
Former	4082	0.407	0.396	0.417
Never	5244	0.495	0.484	0.506
Alcohol use				
Lifetime abstainer	2857	0.252	0.242	0.263
Former drinker	2769	0.258	0.248	0.268
Infrequent, light, or moderate	4395	0.450	0.439	0.462
Current heavy	380	0.039	0.035	0.044
At least one family member in poor/fair health	3107	0.277	0.267	0.288
Region of residence in US				
Northeast	1791	0.186	0.172	0.200
Midwest	2225	0.231	0.216	0.245
South	3832	0.366	0.351	0.382
West	2553	0.217	0.204	0.231
Year				
2011	5039	0.497	0.485	0.509
2012	5362	0.503	0.491	0.515

was "asking a doctor for lower cost medication to save money" (20%). About 4%–5% engaged in each of the other CRMU behaviors. About 7% percent of older adult respondents lived in food-insecure households, with 4.5% reporting low FS, and 2.6% very low FS. Five percent reported marginal FS. Average respondent age was 74 years and 59% were female.

Bivariate Results

We found a dose-response relationship between FS and CRMU among older adults—increasing likelihood of engaging in all the behaviors with increasing severity of FI (Table 2). For example, among the food-secure, only 2% reported skipping medication to save money, compared to 6% among those with marginal FS, 15% among those with low FS, and 28% among those with very low FS ($P < 0.001$). Fifty-six percent of those with very low FS reported any CRMU behavior compared to 21% of the food-secure ($P < 0.001$). Other bivariate relationships are shown in Table 2.

Multivariate Results

Net of other factors, FI is still positively associated with CRMU—in a dose-response fashion (Table 3). For example, compared to older adults with high FS, the odds of skipping medications to save money is about two times more for those with marginal FS, five times more for low FS, and nine times more for very low FS. The odds of reporting any CRMU among older adults with very low FS is about four times that of those with high FS (Odds Ratio (OR) = 1.2 for marginal FS, 2.3 for low FS, and 4.0 for very low FS). The dose-response relationship is present for all the outcomes and all are significant at $P < 0.001$.

There is no significant difference in skipping medications, taking less medicine, and not being able to afford medications by sex among older adults, but females have a higher odds of delaying filling prescriptions and asking for lower cost medications. Net of other factors, CRMU still decreases with age, albeit small (OR = 0.96, $P < 0.001$, for at least one of the five).[1]

All older adults in households with an income-to-poverty ratio less than four have higher odds of CRMU than those in households with income-to-poverty ratio ≥4 (ORs from 1.2 to 3.5). However, the odds ratios for older adults in the middle income groups (1.00–1.99 and 2.00–2.99) are larger than those for older adults with household incomes below poverty or with an income-to-poverty ratio of 3.00–3.99, and are more consistently significant across the different measures. Unlike the bivariate association where higher education was associated with a lower likelihood of CRMU, in the multivariate analysis, the association between education and CRMU is either not significant or is positive. Net of other factors, all educational levels have higher odds of engaging in at least one of the behaviors than those with less than a high school degree (OR = 1.4, 1.9, and 1.9 for high school graduate/GED, some college, and college graduate respectively), but most of this effect

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[1]Adding age-squared gives the same results, and the squared term is not significant for all the outcomes except asking for lower cost medications, where the age variable is not significant and squared term is significant at $P = 0.03$ (OR = 0.998, CI[1.00,1.00].

TABLE 2 Cross Tabulation of Independent Variables by Cost-Related Medication Underuse Measures, U.S. Adults 65 Years and Older, NHIS 2011 and 2012 ($N = 10,401$)

Independent variables	Skipped medications[a]	Took less medicine[a]	Delay filling prescriptions[a]	Lower cost medications[a]	Not afford medicines[a]	At least one[a]
Food Security						
Food-secure	0.020	0.023	0.028	0.189	0.025	0.205
Marginal food security	0.058	0.070	0.080	0.197	0.100	0.252
Low food security	0.150	0.160	0.189	0.285	0.186	0.399
Very low food security	0.278	0.313	0.369	0.403	0.354	0.556
Gender						
Female	0.039	0.044	0.056	0.211	0.050	0.241
Male	0.029	0.033	0.033	0.182	0.038	0.203
Age						
65–69 years	0.052	0.058	0.068	0.225	0.067	0.262
70–74 years	0.038	0.044	0.053	0.229	0.049	0.256
75–79 years	0.021	0.028	0.026	0.191	0.031	0.211
80–84 years	0.023	0.025	0.034	0.160	0.023	0.173
85 years plus	0.014	0.016	0.020	0.131	0.023	0.149
Marital status						
Separated	0.072	0.077	0.082	0.181	0.105	0.243
Divorced	0.054	0.063	0.071	0.209	0.072	0.251
Married	0.026	0.029	0.032	0.224	0.034	0.241
Single/never married	0.044	0.054	0.055	0.134	0.040	0.169
Widowed	0.032	0.037	0.049	0.177	0.044	0.202
Households with children						
No	0.033	0.037	0.044	0.199	0.042	0.223
Yes	0.089	0.097	0.114	0.213	0.114	0.283
Race/ethnicity						
Hispanic	0.049	0.057	0.052	0.168	0.058	0.202
Non-Hispanic White	0.031	0.035	0.043	0.209	0.038	0.230
Non-Hispanic Black	0.058	0.065	0.073	0.167	0.093	0.224
Non-Hispanic Asian/other	0.028	0.028	0.032	0.142	0.044	0.184
U.S. citizenship						
U.S. citizen	0.034	0.039	0.046	0.199	0.044	0.225
Non-U.S. Citizen	0.054	0.070	0.059	0.209	0.094	0.245
Income to Poverty Ratio						
<1.00	0.047	0.058	0.071	0.150	0.075	0.208
1.00–1.99	0.059	0.067	0.080	0.231	0.071	0.270
2.00–2.99	0.037	0.041	0.047	0.252	0.048	0.272
3.00–3.99	0.020	0.023	0.022	0.198	0.031	0.213
4.00 or more	0.012	0.013	0.015	0.156	0.011	0.165

(Continued)

TABLE 2 Continued

Independent variables	Skipped medications[a]	Took less medicine[a]	Delay filling prescriptions[a]	Lower cost medications[a]	Not afford medicines[a]	At least one[a]
Highest family education						
Less than High School	0.042	0.047	0.053	0.165	0.058	0.206
High school grad/GED	0.041	0.046	0.060	0.215	0.051	0.248
Some college/ AA degree	0.036	0.041	0.051	0.219	0.052	0.239
College grad or above	0.024	0.028	0.027	0.185	0.025	0.201
Family member employed						
None	0.035	0.042	0.049	0.197	0.044	0.223
One or more	0.033	0.032	0.040	0.206	0.047	0.232
Family member looking for work						
None	0.032	0.037	0.044	0.197	0.043	0.222
One or more	0.119	0.129	0.121	0.268	0.123	0.337
Type of insurance						
Medicare only	0.047	0.053	0.065	0.231	0.064	0.269
Medicare & Private/Military	0.026	0.030	0.033	0.193	0.028	0.207
Medicare & Medicaid/other public	0.038	0.042	0.056	0.146	0.072	0.188
No Medicare, other insurance	0.025	0.034	0.031	0.138	0.052	0.169
No insurance	0.113	0.138	0.104	0.192	0.098	0.276
Diagnosed with chronic condition						
No	0.014	0.011	0.016	0.085	0.019	0.096
Yes	0.038	0.045	0.052	0.219	0.050	0.248
Has a functional limitation						
Not limited in any way	0.014	0.015	0.020	0.137	0.023	0.151
Has a functional limitation	0.045	0.052	0.060	0.230	0.056	0.262
Severe Mental Illness						
No	0.031	0.035	0.042	0.195	0.041	0.220
Yes	0.189	0.204	0.242	0.385	0.219	0.452
BMI category						
Underweight (<18.5)	0.056	0.060	0.063	0.154	0.059	0.187
Normal weight (18.5–24.99)	0.030	0.036	0.040	0.179	0.036	0.203
Overweight (25–29.99)	0.028	0.030	0.040	0.192	0.039	0.217
Obese (30–39.99)	0.045	0.052	0.058	0.239	0.057	0.266
Severely obese (>40)	0.074	0.078	0.100	0.227	0.112	0.293

(Continued)

TABLE 2 Continued

Independent variables	Weighted proportions					
	Skipped medications[a]	Took less medicine[a]	Delay filling prescriptions[a]	Lower cost medications[a]	Not afford medicines[a]	At least one[a]
Smoking						
Current	0.058	0.068	0.075	0.218	0.088	0.264
Former	0.033	0.037	0.045	0.208	0.042	0.230
Never	0.032	0.036	0.042	0.188	0.039	0.214
Alcohol use						
Lifetime abstainer	0.031	0.035	0.044	0.163	0.046	0.193
Former drinker	0.042	0.053	0.058	0.207	0.055	0.237
Infrequent, light, or moderate	0.033	0.035	0.042	0.216	0.040	0.238
Current heavy	0.035	0.030	0.040	0.184	0.031	0.207
Family member in poor/fair health						
No	0.022	0.026	0.029	0.180	0.030	0.200
Yes	0.066	0.076	0.091	0.248	0.085	0.290
Region of residence in United States						
Northeast	0.026	0.030	0.038	0.159	0.032	0.185
Midwest	0.034	0.039	0.044	0.214	0.038	0.239
South	0.039	0.044	0.053	0.223	0.058	0.250
West	0.036	0.041	0.044	0.177	0.042	0.203
Year						
2011	0.035	0.044	0.047	0.198	0.047	0.227
2012	0.035	0.036	0.045	0.200	0.043	0.224

Note. All significant at $P < 0.05$ except for the following: households with children is not significant for asking for lower cost medications (meds); citizenship is not significant for skipped meds, delay prescription, and lower cost meds; any family employed is not significant for skipped meds, delay prescription, lower cost meds, and not afford meds; alcohol use is not significant for skip meds; region of residence is not significant for skip meds, less meds and delay prescription; and year is not significant for skipped meds, delay prescription, lower cost meds, and not afford meds.
[a]Dependent variable.

is from asking for lower cost medications. Older adults with a family member looking for work have higher odds of reporting CRMU, except asking for lower cost medication, while those with a family member working are only more likely to report not being able to afford medications.

Across all the models, older adults with Medicare and Medicaid or other public insurance are less likely to report CRMU than older adults with only Medicare. There is no significant difference between the elderly with no insurance and those with only Medicare in reporting CRMU, except for one outcome: those with no insurance have more than two times higher odds of using less medicine to save money than those with Medicare only

TABLE 3 Weighted Multivariate Logistic Regressions of Cost-Related Medication Underuse on Food Security and Relevant Controls, U.S. Adults 65 Years and Older, NHIS 2011 and 2012 ($N = 10,401$)

Predictors	Skipped medications OR [95% CI]	Use less medications OR [95% CI]	Delay filling prescription OR [95% CI]	Lower cost medication OR [95% CI]	Cannot afford medication OR [95% CI]	At least one of the five OR [95% CI]
Food security						
Food-secure (Ref)						
Marginal food security	1.92** [1.22, 3.02]	2.02** [1.33, 3.07]	1.95** [1.26, 3.01]	0.98 [0.76, 1.26]	2.58*** [1.68, 3.94]	1.15 [0.89, 1.47]
Low food security	5.16*** [3.58, 7.45]	4.71*** [3.29, 6.76]	4.63*** [3.31, 6.48]	1.64*** [1.28, 2.10]	4.68*** [3.34, 6.56]	2.29*** [1.84, 2.86]
Very Low food security	9.10*** [5.99, 13.8]	9.08*** [6.11, 13.5]	9.97*** [6.92, 14.3]	2.54*** [1.85, 3.50]	9.15*** [6.18, 13.5]	4.02*** [3.05, 5.30]
Female	1.17 [0.87, 1.57]	1.16 [0.89, 1.52]	1.53** [1.16, 2.02]	1.34*** [1.18, 1.52]	1.1 [0.87, 1.40]	1.34*** [1.19, 1.52]
Age	0.94*** [0.91, 0.96]	0.93*** [0.91, 0.95]	0.93** [0.91, 0.95]	0.96*** [0.95, 0.97]	0.94*** [0.92, 0.96]	0.96*** [0.95, 0.97]
Marital status						
Married (Ref)						
Never married	1.17 [0.70, 1.96]	1.32 [0.84, 2.07]	1.23 [0.79, 1.92]	0.52*** [0.40, 0.69]	0.76 [0.44, 1.29]	0.56*** [0.43, 0.73]
Separated/divorced	1.34 [0.93, 1.93]	1.39 [0.99, 1.95]	1.37 [0.97, 1.93]	0.78* [0.66, 0.93]	1.39 [1.00, 1.92]	0.82* [0.70, 0.97]
Widowed	1.22 [0.87, 1.72]	1.25 [0.91, 1.72]	1.47* [1.09, 1.98]	0.76** [0.65, 0.89]	1.32 [0.98, 1.77]	0.78** [0.67, 0.91]
Households with children	1.13 [0.74, 1.74]	1.18 [0.79, 1.77]	1.18 [0.78, 1.78]	0.82 [0.60, 1.10]	0.97 [0.63, 1.49]	0.91 [0.71, 1.18]
Race/ethnicity						
Non-Hispanic White (Ref)						
Hispanic	1.04 [0.64, 1.70]	1.12 [0.72, 1.75]	0.7 [0.45, 1.10]	0.70** [0.54, 0.90]	0.79 [0.55, 1.14]	0.70** [0.55, 0.89]
Non-Hispanic Black	1.22 [0.89, 1.67]	1.17 [0.86, 1.58]	0.96 [0.73, 1.25]	0.66*** [0.55, 0.80]	1.41* [1.07, 1.87]	0.76** [0.64, 0.90]
Non-Hispanic Asian/Other	0.86 [0.43, 1.72]	0.89 [0.43, 1.86]	0.82 [0.41, 1.61]	0.75 [0.54, 1.03]	0.95 [0.55, 1.63]	0.86 [0.64, 1.14]
Non-U.S. citizen	1.2 [0.60, 2.43]	1.41 [0.70, 2.83]	1.22 [0.64, 2.32]	1.58* [1.08, 2.30]	2.07* [1.17, 3.67]	1.39 [0.98, 1.96]
Income-to-poverty ratio						
<1.00	1.75 [0.95, 3.23]	2.21* [1.20, 4.04]	1.99* [1.12, 3.54]	1.2 [0.88, 1.63]	2.48** [1.34, 4.61]	1.41* [1.07, 1.86]
1.00–1.99	2.96*** [1.72, 5.11]	3.26*** [1.94, 5.47]	2.99*** [1.89, 4.75]	1.81*** [1.49, 2.20]	3.46*** [2.01, 5.93]	1.92*** [1.58, 2.34]
2.00–2.99	2.33*** [1.37, 3.96]	2.55*** [1.53, 4.23]	2.16*** [1.36, 3.42]	1.94*** [1.61, 2.33]	3.12*** [1.88, 5.20]	1.94*** [1.62, 2.34]
3.00–3.99	1.42 [0.74, 2.72]	1.57 [0.86, 2.85]	1.16 [0.64, 2.09]	1.30* [1.05, 1.61]	2.24* [1.24, 4.07]	1.31 [1.06, 1.61]
4.00 or more (Ref)						

	(1)	(2)	(3)	(4)	(5)	(6)
Highest family education						
≤High School (Ref)						
High school graduate/GED	1.28 [0.87, 1.86]	1.39, [0.96, 2.01]	1.67** [1.22, 2.28]	1.35* [1.10, 1.65]	1.3 [0.91, 1.86]	1.32** [1.10, 1.59]
Some college/AA degree	1.16 [0.80, 1.68]	1.34 [0.95, 1.91]	1.45* [1.07, 1.96]	1.36** [1.10, 1.67]	1.39 [0.99, 1.93]	1.24* [1.03, 1.50]
College grad or above	1.37 [0.86, 2.20]	1.74*, [1.14, 2.67]	1.36 [0.94, 1.98]	1.41** [1.12, 1.79]	1.2 [0.79, 1.84]	1.33* [1.06, 1.66]
Family member looking for work	2.36*** [1.47, 3.81]	2.29** [1.40, 3.74]	1.80* [1.11, 2.90]	1.38 [0.97, 1.95]	1.84* [1.13, 3.01]	1.55** [1.14, 2.09]
Family member employed	1.17 [0.89, 1.54]	0.89 [0.67, 1.17]	1.08 [0.84, 1.39]	1.14 [0.99, 1.31]	1.45** [1.10, 1.91]	1.15* [1.01, 1.31]
Type of insurance						
Medicare only (Ref)						
Medicare & Private/Military	0.88 [0.65, 1.18]	0.89 [0.67, 1.18]	0.75* [0.58, 0.97]	0.78** [0.68, 0.90]	0.65** [0.50, 0.85]	0.74*** [0.65, 0.85]
Medicare & Medicaid/other public	0.38** [0.25, 0.60]	0.34*** [0.22, 0.52]	0.37*** [0.24, 0.57]	0.54*** [0.42, 0.69]	0.53*** [0.38, 0.76]	0.49*** [0.38, 0.62]
Other insurance, no Medicare	0.55 [0.25, 1.22]	0.68 [0.32, 1.43]	0.49 [0.22, 1.10]	0.55*** [0.39, 0.78]	0.8 [0.46, 1.40]	0.56*** [0.40, 0.77]
No insurance	2.02 [0.95, 4.31]	2.25* [1.10, 4.61]	1.37 [0.61, 3.07]	0.91 [0.52, 1.58]	1.01 [0.46, 2.21]	1.12 [0.69, 1.82]
Diagnosed with chronic condition	1.93* [1.13, 3.31]	2.95*** [1.71, 5.08]	2.34*** [1.46, 3.77]	2.63*** [2.08, 3.33]	1.96* [1.30, 2.95]	2.76*** [2.21, 3.43]
Has a functional limitation	2.05** [1.40, 3.00]	2.18*** [1.53, 3.09]	1.63*** [1.18, 2.27]	1.52*** [1.31, 1.76]	1.41** [1.02, 1.94]	1.57*** [1.35, 1.81]
Severe mental illness	2.46*** [1.49, 4.06]	2.29*** [1.40, 3.76]	2.35*** [1.53, 3.61]	1.72** [1.24, 2.39]	2.15*** [1.41, 3.28]	1.68*** [1.23, 2.29]
Proportion adult family members						
Needing help with activities of daily living	0.66 [0.35, 1.23]	0.69 [0.41, 1.17]	0.86 [0.53, 1.40]	0.82 [0.60, 1.12]	1.07 [0.65, 1.76]	0.77 [0.58, 1.04]
Limited in any way	1.29** [1.08, 1.54]	1.09 [0.91, 1.31]	1.28** [1.08, 1.52]	1.22*** [1.12, 1.34]	1.40*** [1.19, 1.65]	1.23*** [1.12, 1.34]
Family member in poor/fair health	1.50* [1.09, 2.07]	1.63*** [1.23, 2.17]	1.71*** [1.30, 2.25]	1.16* [1.01, 1.32]	1.29 [0.97, 1.72]	1.17 [1.02, 1.34]

(Continued)

TABLE 3 Continued

Predictors	Skipped medications OR [95% CI]	Use less medications OR [95% CI]	Delay filling prescription OR [95% CI]	Lower cost medication OR [95% CI]	Cannot afford medication OR [95% CI]	At least one of the five OR [95% CI]
Body Mass Index category						
Underweight (<18.5)	1.61 [0.80, 3.26]	1.36 [0.67, 2.78]	1.25 [0.65, 2.41]	0.81 [0.54, 1.21]	1.35 [0.65, 2.77]	0.87 [0.60, 1.24]
Normal weight (Ref)						
Overweight (25–29.99)	0.82 [0.58, 1.16]	0.72* [0.52, 0.99]	0.91 [0.67, 1.23]	1 [0.87, 1.16]	1 [0.74, 1.34]	0.99 [0.86, 1.14]
Obese (30–39.99)	0.99 [0.72, 1.37]	0.91 [0.68, 1.22]	0.95 [0.71, 1.28]	1.08 [0.92, 1.26]	1.11 [0.82, 1.50]	1.02 [0.88, 1.19]
Severely obese (>40)	1.04 [0.58, 1.89]	0.85 [0.49, 1.49]	0.96 [0.57, 1.61]	0.81 [0.58, 1.15]	1.54 [0.89, 2.64]	0.91 [0.65, 1.27]
Smoking status						
Never smoked (Ref)						
Current smoker	0.99 [0.66, 1.48]	1.05 [0.72, 1.55]	1 [0.72, 1.39]	0.96 [0.78, 1.19]	1.41* [1.01, 1.98]	1 [0.81, 1.23]
Former smoker	0.98 [0.75, 1.29]	0.99 [0.77, 1.28]	1.1 [0.87, 1.39]	1 [0.88, 1.13]	1.12 [0.87, 1.43]	0.99 [0.87, 1.12]
Alcohol use						
Lifetime abstainer (Ref)						
Former drinker	1.26 [0.90, 1.78]	1.53* [1.10, 2.14]	1.28 [0.94, 1.74]	1.28** [1.07, 1.53]	1.1 [0.81, 1.50]	1.27** [1.07, 1.49]
Current light or moderate	1.65** [1.18, 2.31]	1.57** [1.16, 2.14]	1.56** [1.17, 2.08]	1.59*** [1.34, 1.88]	1.29 [0.95, 1.76]	1.58*** [1.34, 1.87]
Current heavy	1.77 [0.87, 3.61]	1.25 [0.58, 2.71]	1.55 [0.79, 3.04]	1.3 [0.93, 183]	1.06 [0.48, 2.31]	1.33 [0.95, 1.86]
Region of residence in United States						
South (ref)						
Northeast	0.84 [0.58, 1.22]	0.82 [0.59, 1.14]	0.88 [0.66, 1.17]	0.68*** [0.57, 0.81]	0.68** [0.51, 0.91]	0.72*** [0.61, 0.86]
Midwest	1.08 [0.77, 1.53]	1.1 [0.79, 1.53]	0.98 [0.73, 1.32]	0.92 [0.79, 1.08]	0.79 [0.57, 1.09]	0.96 [0.81, 1.12]
West	1.07 [0.76, 1.50]	1.05 [0.76, 1.44]	0.94 [0.70, 1.26]	0.72*** [0.60, 0.87]	0.8 [0.60, 1.08]	0.76** [0.64, 0.91]
Year (ref: 2011)						
Year 2012	1.00 [0.78, 1.28]	0.78* [0.61, 0.99]	0.96 [0.78, 1.18]	1.02 [0.91, 1.16]	0.91 [0.73, 1.13]	0.99 [0.88, 1.10]
Constant	0.19 [0.034, 1.04]	0.18* [0.036, 0.90]	0.42 [0.089, 1.94]	0.57 [0.24, 1.36]	0.29 [0.055, 1.55]	0.94 [0.41, 2.16]
N	10401	10401	10401	10401	10401	10401

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(OR $= 2.25$, $P < 0.05$). The other factors that are significantly associated with higher odds of engaging in all five of the CRMU behaviors in the multivariate models are the health status variables: the odds of reporting any CRMU among older adults with a diagnosed chronic condition, a functional limitation, or a severe mental illness, is about two to three times that of those without these conditions (OR $= 2.8$, 1.6, and 1.7, respectively). Having a family member in fair or poor health, and a high proportion of family members limited in anyway, are positively associated with most of the CRMU behaviors.

Conditional Effects

The interactions between FS and sex, FS and chronic disease, and FS and type of health insurance were not significant; suggesting the association between FI and CRMU does not differ substantially between men and women, between people with and without chronic disease, or between people with different types of insurance.

Sensitivity Analysis

Because a large proportion of the sample was missing information on income, a variable closely related to FS, we conducted sensitivity analyses using the detailed income categories and the imputed income files that were provided with NHIS. The results from these analyses were very similar to the analyses presented. The effects of FS on the dependent variables using the imputed files were just slightly higher than those presented here (most differences in ORs less than 0.5). Because income is a key confounding variable, we decided to present the un-imputed results, which we believe are robust and at worst underestimate the actual effect of FI.

DISCUSSION

Controlling for other factors including income, older adults living in food-insecure households were more likely to report CRMU. The odds of engaging in these behaviors were higher with more severe levels of FI. These findings are consistent with our analysis of nonelderly adults in the United States (not shown), but different in an important way: the proportion of older adults reporting CRMU (23%) is slightly lower than that for nonelderly adults (26%), but the magnitude of the effect of FS on CRMU is much larger (adjusted ORs up to 9 for the very low food-secure compared to the food-secure among older adults, compared to up to about 4 for nonelderly). These results suggest that FI among older adults in particular, has serious

implications for compliance with prescribed medication, hence medical management of disease.

Although prior studies focused on specific populations, the results are generally consistent (18, 25–29, 42). Berkowitz and colleagues (18) found that FI was associated with CRMU among adults with chronic disease, and Seligman and associates (25) and Billimek and Sorkin (26) found that FI was associated with delays in filling prescriptions among adults with diabetes. Bengle and colleagues (30) and Sattler and Lee (31) also found that FI was associated with cost-related medication nonadherence among low-income older adults in community-dwellings in Georgia. Our findings suggest the association between FI and CRMU is not only limited to those with chronic conditions or low income older adults but to the general population of older adults, and the association persists after controlling for chronic conditions, income, and other covariates. In addition, the effects are not conditional on diagnosis of a chronic condition.

One important finding from this analysis is the effect of health insurance. That older adults with no insurance do not differ substantially from those with only Medicare, except for using less medicine to save money, is unexpected. However, because very few older adults have no insurance in our sample, it is difficult to draw any firm conclusions from this finding. The interesting finding from our analysis is the protective effect of having extra coverage from some other source, especially having Medicaid or other public insurance in addition to Medicare. This seems to suggest Medicare alone does not meet the medication needs of older adults, which may be due to high out-of-pocket expenses for people with only Medicare. The proportion of older adults with only a public non-Medicare insurance in our sample is too small ($<1\%$; about 95% have Medicare) to examine it as a separate category. But we found that older adults with non-Medicare insurance (public or private) did not differ significantly from those with only Medicare in all the CRMU measures, except for one: those on non-Medicare insurance were less likely to ask for lower cost medication than those on Medicare only. In addition, older adults with public insurance in addition to Medicare were consistently less likely to report CRMU. These findings suggest an important contribution of non-Medicare insurance, especially other public insurance, in reducing the burden of cost of medication among older adults. The effect of FS on CRMU was not modified by type of insurance in this analysis.

Most of the findings in this analysis are consistent with what one would expect theoretically. However, there are some deviations. First, is the lack of a dose-response relationship between poverty and CRMU. We find that although groups with income less than four times the poverty threshold generally have greater odds of reporting CRMU than those with incomes four or more times the poverty threshold, those with incomes at or below the poverty threshold tend to have lower odds of reporting CRMU than those

just above the threshold. There is no difference in asking for lower cost medication and skipping medications between those with incomes below the poverty threshold and those with incomes four or more times the poverty threshold. Berkowitz and colleagues (18) also had similar findings among people with chronic diseases. As mentioned before, this finding might be because those in the lowest income groups have more access to public health assistance, than those just above the poverty threshold, hence the greater vulnerability of people just above the cut-off for eligibility to assistance programs (18). Also, the lowest income category includes some households that have very low incomes and low resources, as well as households that may have temporarily low income and/or have other resources available to meet their needs; thus, households in the lowest income category are better off than expected in terms of food security (43).

The second unexpected finding is that respondents with family members working or looking for work were more likely to report CRMU. Given that this analysis is of older adults, those that have the financial resources to retire are likely to do so. Older adults with family members working may not have adequate retirement to support their basic living expenses, or they may be in mixed age or generation households. Cross tabulations show that households that include someone working or looking for work are more likely to include children (11% of households with someone working and 21% of households with someone looking for work have children, compared to 2% and 4%, respectively, for households with no one working and no one looking for work). The sampled adults in households with someone working or looking for work are also more likely to be in the youngest age groups, and so may be waiting to draw on Social Security and retirement.

Another exception is the effect of education. The bivariate analysis showed that CRMU was lower in households with more highly educated members. However, when we introduced other variables, particularly income and employment variables, this association was no longer significant for most, and those with more educated family members were more likely to ask for lower cost medication. If we exclude the results for asking for lower cost medication in this analysis for older adults, the results are more consistent with other studies that found no association between education and CRMU (18, 44). Berkowitz and colleagues (18) suggested that the lack of association between education and CRMU may be due to people with chronic illness and lower education receiving assistance from prescription drug benefit programs. While this is a possibility, our analysis shows that other factors, especially employment, income, and health insurance, mediate the relationship between education and CRMU, such that, once these are controlled, education is no longer a significant factor. The reversed effect for asking for lower cost medication, on the other hand, may suggest a positive coping behavior for more educated people, who are more likely

to be aware of alternative medication options, and so more likely to ask for lower cost alternatives; the effect is however not seen in the bivariate model because it is suppressed by other factors, such as income, and therefore only emerges when we control for those factors.

Limitations, Strengths, and Conclusions

These analyses are based on cross-sectional data. Therefore, our ability to infer causality is limited. Participants were not directly asked whether they sacrificed the medications for food, thus we cannot conclusively say these behaviors were to increase money for food (18). However, the hypothesis underlying this study is that rationing of resources between competing needs results in medication underuse, when resources are constrained to the extent that FI occurs (i.e., it is not FI per se that causes medication underuse). In terms of causality, reverse causality seems unlikely. A plausible alternative explanation for the observed associations is that it is other unmeasured material hardships that coexist with FI that cause medication underuse. But this will not invalidate the findings here. Work based on more sophisticated econometric methods to address this endogenous effect suggest that analysis such as ours are more likely to underestimate, rather than overestimate, the causal impacts of food insecurity on health outcomes (45). In addition, many of the health status and health behaviors for which we control, which are associated with CRMU, have also been found to be consequences of food insecurity (10, 46). These variables are thus potential mediators of the relationship between food insecurity and CRMU (47), which implies our findings are likely conservative. Finally, because the data were based on self-report, the report of both FS and CRMU may be subject to social desirability bias, although we have no reason to suspect this has biased our results (18).

The study has major strengths that can be used to strengthen causal inference as well as increase generalizability. The first is the availability and use of a large number of covariates, which allows us to rule out many alternative factors that may explain the relationship between FS and CRMU. Additionally, the measures of both FS and CRMU are based on well-validated instruments, which increase the reliability of the findings. In addition, unlike prior studies, we use the detailed FS measure, and find a dose-response relationship in the association between FS and CRMU. Finally, we use a nationally representative sample of older adults and do not restrict the analysis to certain groups like those with a chronic disease, which allows us to examine the effect of having a chronic condition on CRMU; this also makes the findings applicable to many older adults in the United States.

The findings have a number of implications. First, prior studies suggest FI is associated with poor health outcomes, including poor control of diabetes and other chronic diseases; as well as associations with risk factors like obesity and smoking (48–51). Older adults are also more likely to have

poor health outcomes. Thus, a combination of poor health outcomes and noncompliance with medications due to cost may lead to even worse consequences for older adults in food-insecure households. We cannot state conclusively from this study that older adults in food-insecure households are using these behaviors as mechanisms to deal with lack of money for food. However, this is a plausible explanation that merits further study. That individuals in food-insecure households are more likely to engage in these behaviors suggests the need for removing cost barriers to accessing medications in this group. Policies that make medications more available to older adults in food-insecure households will not only ensure they are compliant with medications but may also increase disposable income for these families (52). We add voice to suggestions for using FI as a risk factor for assessing CRMU (18). This could potentially help increase the identification of individuals who may need assistance purchasing medications as well as improve health outcomes for individuals living in food-insecure households. This is especially important among older adults who are more likely to have other comorbidities that may lead to medication underuse.

TAKE AWAY POINTS

- Older adults living in food-insecure households are significantly more likely to report cost-related medication underuse than older adults in food-secure households.
- The likelihood of reporting cost-related medication underuse increases with increasing severity of food insecurity among older adults.
- The association between food insecurity and cost-related medication underuse among older adults is not conditional on sex, chronic disease status, or type of health insurance; although females and those with a chronic condition are more likely to report cost-related medication underuse than males and those without a chronic condition respectively. Older adults with Medicare and Medicaid or other public insurance are less likely to report cost-related medication underuse than older adults with only Medicare.
- More research is needed to understand the interaction of food security and type of insurance on cost-related medication underuse among older adults.

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