Original Research

Food insecurity associated with higher COVID-19 infection in households with older adults

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ABSTRACT

Objectives: As a well-documented social determinant of health, food insecurity may be associated with COVID-19 infection in households with older adults. We examined whether older adults were vulnerable to COVID-19 infection during the early pandemic if they were food insecure versus food secure.
Study design: A cross-sectional study using a nationally representative population-based survey of US older adults.
Methods: We used a random subsample of Health and Retirement Study (HRS) drawn in June 2020 ($N = 3212$). We compared the odds of reporting COVID-19 infection in a household, COVID-19 infection and mortality among acquaintances, and respondent's perceived fair or poor health across household food insecurity status resulted from financial or non-financial barriers. Baseline health and socioeconomic circumstances were adjusted in the models.
Results: Results showed a higher COVID-19 infection rate among food-insecure households than among their food-secure counterparts during the pandemic. Food insecurity due to non-financial obstacles was associated with greater likelihood of COVID-19 infection both within respondents' households (adjusted odds ratio [aOR] = 1.73, 95% confidence interval [CI]: 1.03–2.90) and among their acquaintances (aOR = 1.32, 95% CI: 1.05–1.65). Food insecurity caused by both non-financial and financial constraints was associated with twice the likelihood of knowing someone who died from COVID-19 than their food-secure counterparts (aOR = 2.14, 95% CI: 1.27–3.61).
Conclusions: Food insecurity driven by non-financial constraints played an important role in the ongoing pandemic among US older adults. Policies addressing COVID-19 need to recognize the vulnerability of food-insecure older adults beyond lack of monetary resources.

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Introduction

The COVID-19 (COVID-19 hereafter) pandemic has caused great suffering around the globe, especially among older adults. Older adults are at particularly high risk of COVID-19 infection, hospitalization, and mortality because of their weakened immunity and other health vulnerabilities.[1,2] Poor nutrition and existing chronic conditions could further magnify the effect of COVID-19.[2,3] Food insecurity — the limited access to adequate food due to lack of money and other resources — is a serious public health issue in the developed countries,[4–6] affecting one in nine US households and 6.9 percent of households with elderly.[4] The mass unemployment and mobility restrictions due to the COVID-19 have exacerbated food insecurity.[7–10] Among seniors who are 60 years and older, food insufficiency — a measure of severe food insecurity — increased by 75% during the early stage of the pandemic.[11]

Food insecurity has been associated with a number of negative health outcomes among older adults,[12–22] including chronic conditions, infectious diseases, and health care utilization.[13,15,17,19,21,22] The food insecurity–health association has been robust and strong, above and beyond the mediation of income and assets.[16] Food insecurity may heighten risk of COVID-19 infection through the weakened immune system[2,23,24] and increased viral exposure.[8] Food-insecure adults still in the labour force may disproportionately work in crowded environments with little to no social distancing.[8,25] Non-financial constraints such as closure of or restricted access to food stores may hamper access to food, forcing older adults to visit crowded stores and

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food charities and use public transit, thus increasing their exposure to virus. Moreover, given the correlation between strength of social networks and COVID-19 spread,[26] it is likely that older adults from food-insecure households know other similarly disadvantaged people vulnerable to COVID-19 and,[27] as a consequence, have more acquaintances infected by and dead from COVID-19 than their food-secure counterparts.

According to the social ecological model[28] and theories on social determinants of health,[29] socioeconomically disadvantaged households should heighten the chance of contracting COVID-19 and knowing others infected by the virus due to neighbourhood adversities, health vulnerability, and economic instability among other household and community factors.[30] A few studies have associated aggregate measures of income with COVID-19 infection and the mortality rate in the US;[31—33] however, they may have masked important inter-household differences in COVID-19 infection. Income and food insecurity are related yet fundamentally different measures of economic well-being.[34] Compared to income, food insecurity more accurately captures experience of material hardships and appears to be a much more powerful predictor of health.[16] Past studies suggest food insecurity as an independent predictor of adverse health outcomes even among lower-income older adults.[18,35]

The official measure of food insecurity developed by the US Department of Agriculture (USDA) stressed lack of money as its underlying cause.[4] While financial constraints play a major role in determining food insecurity, the USDA measure may have overlooked common non-financial constraints among older adults such as health-related mobility issues.[36] This issue may be especially salient during the early stage of the pandemic,[7] when normal operation of stores and transport systems was disrupted by lockdowns and other restrictive measures. Living in food deserts with few retailers of nutritious food could further hamper food access.[37] Perceived long distance to the grocery store has been associated with food insecurity among older adults,[38] suggesting the need to look beyond income when studying their food insecurity.

The existing body of literature points to the plausible variation in COVID-19 infection risk by older adults' food insecurity status, with potential distinction between food insecurity driven by financial scarcity and non-financial barriers. Relative to the food-secure older adults, food-insecure older adults may also be more likely to know someone with COVID-19 because of their stronger social connections with the vulnerable population. We capitalize on a recent nationally representative population-based health survey to evaluate the associations of household food insecurity with COVID-19 infection and health status among U.S. older adults.

Methods

Data and sample

Data are from a random 25 percent subsample of the Health and Retirement Study (HRS) participants who completed a COVID-19 module introduced in June 2020.[39] The HRS is a nationally representative longitudinal survey of U.S. adults with ages 51 and older and their spouses of any age. Detailed survey design can be found in Sonnega and colleagues.[40] The sample included 3266 persons. Following the convention of past geriatric studies,[41—43] we excluded 54 respondents younger than 50 to reach our analytic sample with 3212 persons of age 50 and above.

Measurements

Dependent variables

COVID-19 infection in respondent's household. Self-reported COVID-19 diagnoses of respondent and respondent's coresidents were assessed with two questions: "Have you had or do you now have COVID-19, the disease caused by the novel coronavirus?"; "Has anyone in your household other than you been diagnosed with COVID-19?" Given the high likelihood of intra-household COVID-19 spread,[44—46] a single dichotomous outcome was created to indicate COVID-19 infection of anyone in respondent's household.

COVID-19 infection and death of respondent's acquaintances. We created two binary outcomes for COVID-19 infection and deaths from COVID-19 of respondent's acquaintances, respectively, based on the questions "Has anyone else you know been diagnosed with COVID-19?" and "Has anyone you know died from COVID-19?" (*yes*; *no*).

Low self-rated health. Self-rated health status was assessed using a single item, "Would you say your health is excellent, very good, good, fair, or poor?" We dichotomized this variable, where 'poor or fair' was coded 1, and 'good, very good, or excellent' was coded 0. Collapsing 'poor' and 'fair' categories has been a standard approach in studying self-rated health.[47—50]

Focal independent variable

Food insecurity during the COVID-19 pandemic. The survey evaluated whether a respondent did not have enough money to buy food, and had trouble buying food even though they had money (*yes*; *no*). The first item stresses the financial constraints, while the second emphasizes the non-financial aspects. We created four mutually exclusive categories: *food-secure* (reference); *finance-driven food insecurity only*; *non-finance-driven food insecurity only*; and *both finance- and non-finance-driven food insecurity*. In addition, we created a dummy variable indicating food insecurity status: *food-secure* (reference); *food-insecure* (i.e. either finance- or non-finance-driven food insecurity).

Covariates

We controlled for factors that may confound the association between food insecurity and COVID-19 infection.[51,52] Demographic and socioeconomic controls include age, sex, race/ethnicity, marital status, number of household members, living arrangement, education, employment status, total household income, liquid wealth, and non-liquid wealth. Health covariates included depressive symptoms (range: 0 to 8) assessed using a subset of items from the Center for Epidemiologic Studies Depression scale[53] and the number of chronic health conditions (high blood pressure, diabetes, cancer, lung disease, heart problems, stroke, psychiatric problems, or arthritis, range: 0 to 8).

Analytic plan

We first compared the four food insecurity categories on all variables included in the analysis, using one-way analysis of variance (ANOVA) tests. We estimated multivariate logistic regression models predicting (a) household COVID-19 infection (Panel A), (b) COVID-19 infection among acquaintances (Panel B), (c) COVID-19 deaths among acquaintances (Panel C), and (d) respondent's perceived health status (Panel D). Specification I used binary food insecurity status [food-secure (reference); food-insecure]. Specification II used four-category food insecurity [fo*od-secure* (reference); *finance-driven food insecurity only*; *non-finance-driven food insecurity only*; and *both finance- and non-finance-driven food insecurity*]. For each specification, we presented an unadjusted model and a fully adjusted model controlling for health, demographic, and socioeconomic characteristics. The perceived health status model (Panel D) did not adjust for health covariates due to collinearity. In addition, we conducted several sensitivity analyses to assess the robustness of the results. Previous literature suggests that household income and liquid wealth are common drivers of food

Table 1
Sample characteristics by food insecurity status, HRS COVID-19, 2020 ($N = 3212$).

Variables	Mean ± SD or %					F-statistic ($df = 3$)	Significant subgroup differences
	Total sample	Food-secure[a]	Food insecure				
			Finance-driven food-insecure only[b]	Non-finance-driven food-insecure only[c]	Both finance- and non-finance-driven food-insecure[d]		
COVID-19 infection and mortality							
Self or coresident had COVID-19	3.2	2.7	3.6	5.3	6.3	3.748**	ac
Anyone knows had COVID-19	37.5	36.7	33.7	43.2	38.0	2.525	
Anyone knows died from COVID-19	19.8	19.0	16.3	21.8	39.2	7.421***	ad, bd, cd
Health characteristics							
Self-rated health (1 = Poor/fair)	29.0	25.8	44.0	36.4	57.0	25.549***	ab, ac, ad, cd
Depressive symptoms (CES-D, 0−8)	1.37 ± 1.97	1.14 ± 1.76	2.36 ± 2.52	2.00 ± 2.36	3.20 ± 2.49	66.885***	ab, ac, ad, bd, cd
Number of chronic conditions (0−8) [e]	2.13 ± 1.48	2.06 ± 1.45	2.31 ± 1.54	2.42 ± 1.53	2.57 ± 1.78	15.233***	ab, ac, ad
Sociodemographic characteristics							
Age (in years)	68.60 ± 10.46	69.10 ± 10.57	65.10 ± 9.65	68.10 ± 9.94	62.61 ± 7.92	17.405***	ab, ad, bc, cd
50−64 years old	41.2	39.4	54.8	41.3	68.4	13.548***	ab, ad, bc, cd
65−79 years old	39.7	40.2	33.7	41.8	26.6	3.057*	cd
80 years and older	19.1	20.4	11.4	16.9	5.1	6.883***	ab, ad
Sex (1 = Female)	59.2	58.1	56.6	65.2	68.4	3.619*	bd
Race/ethnicity							
Non-Hispanic White	58.1	61.1	32.3	55.6	28.0	27.683***	ab, ad, bc, cd
Non-Hispanic Black	21.0	20.1	28.5	20.4	36.0	5.625***	ad, cd
Hispanic of any race	16.0	13.8	32.9	19.7	32.0	20.846***	ab, ad, bc, cd
Non-Hispanic Asian/other race	5.0	5.1	6.3	4.3	4.0	0.396	
Marital status							
Married	54.2	56.1	44.6	51.7	26.6	11.866***	ab, ad, bd, cd
Separated or divorced	19.5	18.1	30.1	20.4	36.7	10.092***	ab, ad, bc, cd
Widowed	18.8	19.1	12.0	20.2	16.5	1.984	
Never married	7.4	6.6	13.3	7.7	20.3	9.897***	ab, ad, cd
Number of household members	2.41 ± 1.32	2.35 ± 1.25	2.94 ± 1.78	2.51 ± 1.37	2.81 ± 1.58	14.208***	ab, ad, bc
Living arrangement							
Living alone	20.5	20.3	21.1	20.6	21.5	0.041	
Years of education	13.06 ± 3.22	13.24 ± 3.09	11.27 ± 3.87	12.98 ± 3.36	11.54 ± 3.34	25.231***	ab, ad, bc, cd
Employment status							
Currently working	27.9	29.3	21.1	24.1	17.7	4.441**	ad
Retired	46.8	48.5	31.3	47.6	21.5	13.198***	ab, ad, bc, cd
Not working [f]	25.3	22.3	47.6	28.3	60.8	38.056***	ab, ad, bc, cd
Total household income ($)	87,068 ± 281,736	94,007 ± 312,619	41,250 ± 58,518	73,588 ± 114,869	34,120 ± 38,652	3.242*	ad
Total household liquid wealth ($)	347,120 ± 1,228,599	384,451 ± 1,346,031	101,575 ± 327,649	271,556 ± 686,327	76,957 ± 390,840	4.825**	ab, ad
Total household non-liquid wealth ($)	132,380 ± 206,046	140,296 ± 210,553	69,961 ± 108,009	127,345 ± 216,200	36,874 ± 69,668	12.196***	ab, ad, bc, cd
N	3212	2536	166	431	79		
%	100	79	5.2	13.4	2.5		

Notes. Table shows the percentage distribution of the categorical variables and mean values and standard deviation of the continuous variables. We consider a household as food insecure whether the driver was financial, non-financial, or both. Asterisks denote significance level of F-statistic, where * $P < 0.05$; **$P < 0.01$; ***$P < 0.001$. *Post hoc* comparisons were conducted using ANOVA; significant ($P < 0.05$) subgroup differences are denoted as *ab*: food-secure vs finance-driven food-insecure only; *ac*: food-secure vs non-finance−driven food-insecure only; *ad*: food-secure vs both finance- and non-finance−driven food-insecure; *bc*: finance-driven food-insecure only vs non-finance-driven food-insecure only; *bd*: finance-driven food-insecure only vs both finance- and non-finance-driven food-insecure; *cd*: non-finance−driven food-insecure only vs both finance- and non-finance−driven food-insecure.
[e] Chronic health conditions included ever had high blood pressure, diabetes, cancer, lung disease, heart problems, stroke, psychiatric problems, or arthritis.
[f] Unemployed, temporarily laid off, disabled, or other. SD, standard deviation.

Table 2
Odds ratios of food insecurity on COVID-19 infection and health status among older adults, 2020 (N = 3212).

Variables	Panel A Self or coresident had COVID-19		Panel B Anyone knows had COVID-19		Panel C Anyone knows died from COVID-19		Panel D Poor or fair perceived health status	
	Unadjusted OR (95% CI)	Adjusted	Unadjusted OR (95% CI)	Adjusted	Unadjusted OR (95% CI)	Adjusted	Unadjusted OR (95% CI)	Adjusted
Specification I: Food insecurity status								
Food-secure (reference)								
Food-insecure (either non-finance—or finance-driven)	1.922** (1.262, 2.928)	1.477 (0.928, 2.350)	1.161 (0.976, 1.381)	1.131 (0.931, 1.374)	1.233* (1.003, 1.515)	1.105 (0.876, 1.394)	1.969*** (1.649, 2.352)	1.507*** (1.235, 1.840)
Covariates		adjusted		adjusted		adjusted		adjusted
Intercept	0.028***	0.018***	0.580***	0.017***	0.235***	0.022***	0.348***	9.809***
−2 log likelihood	895.891	824.112	4245.534	3786.638	3190.074	2777.817	3810.897	3279.916
Nagelkerke R^2	0.011	0.056	0.001	0.111	0.002	0.125	0.024	0.186
Specification II: Food insecurity types								
Food-secure (reference)								
Finance-driven food-insecure only	1.361 (0.582, 3.184)	0.816 (0.313, 2.126)	0.878 (0.630, 1.223)	0.777 (0.536, 1.127)	0.826 (0.540, 1.262)	0.640 (0.399, 1.027)	2.254*** (1.638, 3.102)	1.342 (0.940, 1.915)
Non-finance—driven food-insecure only	2.046** (1.261, 3.321)	1.725* (1.027, 2.897)	1.309** (1.064, 1.610)	1.320* (1.054, 1.654)	1.186 (0.924, 1.521)	1.157 (0.881, 1.520)	1.645*** (1.327, 2.041)	1.488** (1.172, 1.888)
Both non-finance— and -finance-driven food-insecure	2.452 (0.961, 6.260)	1.710 (0.630, 4.646)	1.055 (0.665, 1.674)	0.914 (0.550, 1.520)	2.745*** (1.729, 4.359)	2.143** (1.273, 3.606)	3.801*** (2.413, 5.986)	2.089** (1.260, 3.461)
Covariates		adjusted		adjusted		adjusted		adjusted
Intercept	0.028***	0.019***	0.580***	0.019***	0.235***	0.024***	0.348***	9.806***
−2 log likelihood	894.780	821.630	4240.869	3779.417	3174.845	2764.738	3798.405	3277.713
Nagelkerke R^2	0.012	0.059	0.003	0.114	0.009	0.131	0.030	0.187

Notes. Exponentiated betas (odds ratios) and confidence intervals are presented; Covariates included health conditions, demographic, and socioeconomic characteristics for Panels A, B, and C. Panel D adjusted for demographic and socioeconomic characteristics but did not adjust for health covariates; Statistical significance denoted as ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$. CI, confidence interval; OR, odds ratio.

insecurity.[34] Thus, we experimented with models without those two in the sensitivity tests.

Results

Bivariate analyses

Descriptive statistics for the sample characteristics by food insecurity categories are presented in Table 1. We contrasted the COVID-19 infection rates, and the health, demographic, and socioeconomic characteristics of the four food insecurity categories by conducting ANOVA and Tukey's *post hoc* tests; the right-hand column denoted statistically significant contrasts between specific pairs of food insecurity categories (Table 1). During the early months of the COVID-19 pandemic, 3.2% of study participants reported that they or other members in the household were diagnosed with COVID-19, with significantly different rates across the food insecurity categories. The results showed higher COVID-19 infection rate among food-insecure households, particularly non-finance−driven food-insecure households than among their food-secure counterparts. Nearly two in five participants reported that someone else they knew were diagnosed with COVID-19, with similar rates across the four food insecurity categories. One-fifth reported that someone they knew died from COVID-19. Older adults with *both* financial and non-financial obstacles towards food security were twice as likely as food-secure persons to report that someone they knew died from COVID-19 (39.2 vs 19.0%). The COVID-19 death rate was not different between food-secure people's acquaintances and acquaintances of people experiencing *either* finance-driven or non-finance-driven food insecurity. Compared to all other food insecurity groups, *both* finance- and non-finance-driven food-insecure older adults reported significantly higher COVID-19 death rates for their acquaintances during the pandemic.

Multivariate analyses

Risk of experiencing food insecurity and COVID-19 infection

Table 2 presents multivariate logistic regressions predicting within-household COVID-19 infection, COVID-19 infection and mortality among acquaintances, and respondent's perceived health status during the COVID-19 pandemic among older adults. In Specification I, the results showed that the unadjusted odds of food-insecure households having COVID-19 infection among household members were 1.92 ($P < 0.01$, 95% CI = 1.26, 2.93, Panel A) times that of food-secure households. The odds of food-insecure households reporting COVID-19 infection and mortality among their acquaintances were 1.16 ($P = 0.093$, 95% CI = 0.98, 1.38, Panel B) and 1.23 ($P < 0.05$, 95% CI = 1.00, 1.52, Panel C) times that of food-secure households, respectively. The odds ratios attenuated slightly and were no longer statistically significant after adjusting for health, demographic, and socioeconomic factors.

In Specification II, we used the four-category food insecurity variable. Table 2 shows that non-finance-driven food-insecure households were roughly twice as likely as the food-secure to report COVID-19 infection among household members (OR = 2.05, $P < 0.01$, 95% CI = 1.26, 3.32, Panel A). The odds ratio declined slightly; however, it remained statistically significant after adjusting for all covariates (OR = 1.73, $P < 0.05$, 95% CI = 1.03, 2.90, Panel A). Similarly, non-finance−driven food-insecure persons had significantly higher odds of reporting that someone else they knew was diagnosed with COVID-19 infection, relative to food-secure persons (OR = 1.31, $P < 0.01$, 95% CI = 1.06, 1.61, Panel B). This association persisted after confounders

Table 3
Sensitivity analysis: Without adjusting for total household income and liquid wealth, 2020 (N = 3212).

Variables	Panel A Self or coresident had COVID-19		Panel B Anyone knows had COVID-19		Panel C Anyone knows died from COVID-19		Panel D Poor or fair perceived health status	
	OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Specification I: *Food insecurity status*								
Food-secure (reference)								
Food-insecure (either non-finance– or finance-driven)	1.477 (0.928, 2.349)	1.493 (0.938, 2.374)	1.131 (0.932, 1.374)	1.129 (0.930, 1.370)	1.106 (0.876, 1.395)	1.112 (0.881, 1.402)	1.500*** (1.229, 1.830)	1.545*** (1.268, 1.883)
Covariates	adjusted	adjusted	adjusted	adjusted	adjusted	adjusted	adjusted	adjusted
Intercept	0.015***	0.014***	0.040***	0.041***	0.027***	0.026***	4.440***	4.078***
−2 log likelihood	824.309	825.691	3800.336	3800.516	2778.109	2779.046	3293.841	3312.535
Nagelkerke R^2	0.056	0.054	0.105	0.105	0.125	0.124	0.180	0.173
Specification II: *Food insecurity types*								
Food-secure (reference)								
Finance-driven food-insecure only	0.822 (0.316, 2.140)	0.845 (0.324, 2.201)	0.760 (0.524, 1.102)	0.757 (0.523, 1.097)	0.638 (0.398, 1.023)	0.647 (0.404, 1.036)	1.363 (0.956, 1.944)	1.447* (1.017, 2.059)
Non-finance–driven food-insecure only	1.716* (1.022, 2.881)	1.722* (1.026, 2.892)	1.334** (1.066, 1.671)	1.333* (1.065, 1.669)	1.160 (0.883, 1.523)	1.162 (0.886, 1.526)	1.465* (1.155, 1.859)	1.489*** (1.175, 1.886)
Both non-finance– and finance-driven food-insecure	1.725 (0.636, 4.678)	1.744 (0.643, 4.732)	0.902 (0.544, 1.495)	0.900 (0.543, 1.491)	2.139** (1.271, 3.599)	2.157** (1.282, 3.629)	2.103** (1.271, 3.481)	2.190** (1.326, 3.615)
Covariates	adjusted	adjusted	adjusted	adjusted	adjusted	adjusted	adjusted	adjusted
Intercept	0.015***	0.014***	0.041***	0.042***	0.027***	0.026***	4.432***	4.061***
−2 log likelihood	821.887	823.424	3792.134	3792.216	2764.944	2766.044	3291.621	3310.286
Nagelkerke R^2	0.059	0.057	0.109	0.109	0.131	0.130	0.181	0.173

Notes. Exponentiated betas (odds ratios) and confidence intervals are presented; Model 1 did not adjust for total household income; Model 2 did not adjust for total household income and liquid wealth; Statistical significance denoted as ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$. CI, confidence interval; OR, odds ratio.

adjustment (OR = 1.32, $P < 0.05$, 95% CI = 1.05, 1.65, Panel B). Households experiencing *both* finance- and non-finance–-driven food insecurity were 2.75 times as likely as the food-secure households to know someone who died from COVID-19 (OR = 2.75, $P < 0.001$, 95% CI = 1.73, 4.36, Panel C). The association was attenuated yet persisted in the adjusted model (OR = 2.14, $P < 0.01$, 95% CI = 1.27, 3.61, Panel C). Finance-driven food insecurity alone was not related to COVID-19 outcomes, with or without confounders adjustment.

Food insecurity and perceived health status during the COVID-19 pandemic

Panel D in Table 2 presents logistic regression predicting perceived health status (poor/fair vs good/very good/excellent) among older adults. Compared with food-secure persons, food-insecure persons were more likely to report poor or fair health status (OR = 1.97, $P < 0.001$, 95% CI = 1.65, 2.35) in Specification I. This association still remained significant after adjusting for demographic and socioeconomic characteristics (OR = 1.51, $P < 0.001$, 95% CI = 1.24, 1.84). In Specification II, food-insecure persons were more likely to report poor or fair health status than food-secure persons regardless of the cause of food insecurity. Food insecurity due to *both* financial and non-financial obstacles was associated with the worst health status. The magnitudes of these significant associations were attenuated yet persisted at the $P < 0.001$ level after covariates adjustment, with the exception of finance-driven food insecurity.

We reran the adjusted model without accounting for total household income and liquid wealth, which yielded virtually the same results as those from the main analyses (Table 3).

Discussion

Using a nationally representative sample of U.S. older adults, we found that food insecurity due to non-financial obstacles was associated with poorer health and greater likelihood of COVID-19 infection both within respondents' households and among their acquaintances. Food insecurity caused by *both* non-financial barriers and financial constraints was associated with twice the likelihood of knowing someone who died from COVID-19. Our study is among the first illustrating the differential COVID-19 infection risk across households of different food insecurity status while contributing to the growing body of literature that links food insecurity to poor health outcomes among older adults.

That food-insecure older adults showed 50% higher odds of reporting poor or fair health than their food-secure counterparts is in line with prior evidence.[12] However, only food insecurity driven by non-financial factors was relevant to COVID-19 infection while food insecurity due to financial and non-financial causes — but not either cause alone — was associated with COVID-19 mortality among respondents' acquaintances. These findings suggest that food insecurity is a correlate of COVID-19 and health in general among older adults insofar as non-financial factors are concerned. One possible explanation is that non-finance−driven food insecurity indicates mobility issues caused by disability or chronic conditions. People of poor health are more likely to contract COVID-19 and experience disease symptoms than those who are in better health.[3] There is also emerging evidence that comorbidity such as hypertension and diabetes are risk factors for death from COVID-19.[54] Food insecurity and the consequent inadequate nutrition, heightened inflammation, and psychological stress could only further inflate the risk of COVID-19 infection.[2,21,23,24] Another possibility is that policies restricting

mobility and interrupting business may have forced many to shop for food in more crowded environments (e.g. food pantries and grocery stores with reduced hours and increased demand),[55] increasing their risk of viral infection.

The lack of association between finance-driven food insecurity and COVID-19 infection was somewhat unexpected and stands in contrast to the prior findings connecting poor health to food insecurity presumably caused by financial constraints.[21,22] This might be because access to COVID-19 testing remained limited during early pandemic in neighbourhoods with higher social vulnerability,[56] where food insecurity due to financial constraints may be particularly prevalent. Lack of internet access and technological competency may pose additional barriers to COVID-19 testing among financially deprived older adults − more so compared to their better off counterparts, further exacerbating undercount of COVID-19 cases among the former. Stigma about the virus that disproportionately affect the lower-resource food-insecure people could also lead to underreporting of COVID-19 cases. Indeed, COVID-19 was associated with substantial stigma during the early pandemic;[57] those with greater financial constraints may seek to minimize such stigma through underreport. Moreover, the food insecurity questions used in our study differed significantly from the USDA questionnaire used in previous research, which would have led to the result discrepancies. More detailed comparison of the two questionnaires is warranted to better understand the findings we observed.

Food-insecure persons, due to *both* financial and non-financial obstacles, are significantly more likely than food-secure persons to report that someone else they knew died from COVID-19 during the pandemic. One explanation is that food-insecure people with low financial resources and non-financial obstacles such as health issues are the ones with the greatest socioeconomic disadvantages (and therefore may know other disadvantaged people with substantial exposure to COVID-19) and least resource to cope with its consequences.[27] Economically disadvantaged people are more likely to live in overcrowded housing with minimal social distancing and hold public-facing front-line jobs that do not provide opportunities to work from home and put them at high risk of infection.[58] In addition, chronic conditions may be more prevalent among acquaintances of food-insecure versus food-secure adults, which, along with social disadvantages, can further increase exposure to and mortality from the COVID-19.[3,54,58]

Income supplement has been associated with reduced food insecurity. In the US, receipt of unemployment insurance was associated with large reduction in food insecurity during the pandemic.[59] Enrollment in Supplemental Nutrition Assistance Program (SNAP) has been shown to attenuate the association between very low food security and poor physical health among older adults, though the stigma attached to SNAP participation may offset its benefit on mental health.[60] Food security barriers seemingly unrelated to household finance such as disability and mobility restrictions may also be partially overcome by adequate social capital (e.g. food sharing from family and friends) and income (e.g. paying for food delivery).[61,62]

Even prior to the COVID-19 pandemic, researchers have raised concerns regarding local food environments for disadvantaged residents, who disproportionately relied on nearby stores with more limited food items.[63] Low-income households may visit several food stores to get access to the most affordable food, often traveling long distances to acquire food.[63] Although many innovative strategies have been adopted to mitigate the devastating impact of pandemic on food insecurity for children from low-income households (e.g. delivering food to families by using school buses driving along their regular routes,[64] grab-and-go food pick-up for multiple days' worth of meals at one time),[65] only few strategies have been implemented

to fulfil daily nutritional needs and alleviate food insecurity challenges for older adults. It is important to ensure that the nutritional needs of vulnerable population are met to reduce exacerbating disparities in health outcomes,[65] particularly older adults with functional and cognitive impairments. Policies addressing COVID-19 need to recognize the vulnerability of food-insecure older adults beyond lack of monetary resources.

We have seen significant growth of the online grocery delivery sector during the pandemic;[66] however, it is evident that both a lack of wireless broadband access or devices at home and unfamiliarity with computer training could be barriers among older adults.[67,68] Ensuring resource (e.g. Internet access, devices) and digital literacy training to bridge and close the digital divide between older and younger adults should be also a policy priority along with the continued availability of essential food to vulnerable communities.

Limitations

Several limitations exist in the current study. We examined *self-reported* health outcomes (i.e. COVID-19 infection and perceived health status), which could suffer from underreporting due to stigma and unawareness. It is possible that the respondents' acquaintances may have died from causes other than COVID-19. With regard to the COVID-19 infection and death of respondents' acquaintances variables, the study questions did not specify whether the acquaintances were friends, relatives, neighbors, or a wider range of social networks, which warrant greater distinction in future investigation.

In addition, non-finance−driven food insecurity was measured by a single question without information on why food-insecure adults were unable to buy food even though they had money. Possible reasons − which we could not discern − include respondent's mobility constraints such as functional impairments and transportation limitations and social distancing policies such as the lockdown and the grocery stores' altered hours. We acknowledge that the differences between 'financial' and 'non-financial' barriers are not always clear-cut and that certain non-financial barriers could in theory be attenuated through financial means (e.g. spending more to order food delivery if allowed). However, we had to restrict our definitions of 'financial' and 'non-financial' barriers to the subjective interpretation of our respondents. We were unable to specify geographical residence of respondents. Thus, we acknowledge that a fuller understanding of geographic effects (e.g. food deserts) is necessary in the future research. Our sample consists of US households with older adults and therefore does not generalize to other countries or age groups.

Conclusions

Our results indicate that non-finance−driven food insecurity during the pandemic is significantly associated with poorer health and higher likelihood of COVID-19 infection both within respondents' households and among their acquaintances even after adjusting for potential confounders. Food insecurity caused by both non-financial barriers and financial constraints was associated with twice the likelihood of knowing someone who died from COVID-19. Our findings reveal an urgent need to promote policies, procedures, and research to protect vulnerable older adults from food insecurity and to reduce disparities in health outcomes during and after the pandemic.

Author statements

Ethical approval

Not required. We used the public data of the Health and Retirement Study (HRS) which was reviewed by the University of Michigan's IRB.

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Competing interests

None declared.

Author contributions

Shinae L. Choi: Conceptualization, Formal analysis, Writing — original draft preparation, reviewing, revising, and editing. Fei Men: Conceptualization, Writing — original draft preparation, reviewing, revising, and editing.

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