



In the wake of a crisis: Caught between housing and healthcare

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ABSTRACT

Objective: To measure the association between housing insecurity and foregone medication due to cost among Medicare beneficiaries aged 65+ during the Recession.

Methods: Data came from Medicare beneficiaries aged 65+ years from the 2006–2012 waves of the Health and Retirement Study (HRS). Two-wave housing insecurity changes are evaluated as follows: (i) No insecurity, (ii) Persistent insecurity, (iii) Onset insecurity, and (iv) Onset security. We implemented a series of four weighted longitudinal General Estimating Equation (GEE) models, two minimally adjusted and two fully adjusted models, to estimate the probability of foregone medications due to cost between 2008 and 2012.

Results: Our study sample was restricted to non-proxy interviews of non-institutionalized Medicare beneficiaries aged 65+ in the 2006 wave (n = 9936) and their follow up visits (n = 8753; in 2008; n = 7464 in 2010; and n = 6594 in 2012). Results from our fully adjusted model indicated that the odds of foregone medication was 64% higher among individuals experiencing Onset insecurity versus No insecurity in 2008, and also generally larger for individuals experiencing Onset Insecurity versus Persistent Insecurity. Odds of foregone medication was also larger among females, minority versus non-Hispanic white adults, those reporting a chronic condition, those with higher medical expenditures, and those living in the South versus Northeast.

Conclusion: This study drew from nationally representative data to elucidate the disparate health and financial impacts of a crisis on Medicare beneficiaries who, despite health insurance coverage, displayed variability in foregone medication patterns. Our findings suggest that the onset of housing insecurity is most closely linked with unexpected acute economic shocks leading households with little time to adapt and forcing trade-offs in their prescription and other needs purchases. Both housing and healthcare policy implications exist from these findings including expansion of low-income housing units and rent relief post-recession as well as wider prescription drug coverage for Medicare adults.

1. Introduction

The Great Recession of 2007–2009 severely shocked the U.S. housing and financial markets (Joint Center for Housing Studies [JCHS], 2020; Kochhar & Cilluffo, 2017). Widespread unemployment precipitated insurance, income, and wealth decline among 14 million American adults, most notably among racial and ethnic minorities and persons of low socioeconomic status (SES) (Herbert & Apgar, 2010; Housing and Urban Development (HUD), 2020; Johnson, 2009; Laderman & Reid, 2009; US Bureau of Labor Statistics (BLS), 2012). Health and economic shocks during the Recession also impacted older adults (Mather, 2015). By

2007, increased financial hardship led to 1,604,719 mortgage delinquencies and 145,300 foreclosures among adults under 50 years, and also led to 634,075 mortgage delinquencies and 49,980 foreclosures among adults aged 50+. Financial hardship over the same period also resulted in 36% and 52% of “housing insecure” adults aged 50+ paying more than thirty-percent of their household income on respective rent and mortgage costs, as formally defined by the HUD (Harrell, 2011; Housing and Urban Development (HUD), 2020; Shelton, 2008).

Housing insecurity was accompanied by elevated physical and, especially, mental health conditions during the Recession, both globally and domestically (Bhat et al., 2022; Heggebo et al., 2019;

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Margerison-Zilko et al., 2016; Singh et al., 2019; Tsai, 2015). Prior research has indicated that housing-insecure adults during the Recession displayed a higher odds of poor self-rated health, anxiety, depression, hypertension, sleeping problems, and cognitive decline relative to housing-secure adults. These associations were especially prominent among housing-insecure renters, men, and racial and ethnic minorities (Ailshire, 2013; Burgard et al., 2012; Forbes & Krueger, 2019; Friedman et al., 2020; Mather, 2015; Pollack et al., 2010; Rodgers et al., 2019).

Evidence indicates that housing insecurity and poor health are linked through shifts in healthcare utilization patterns, including greater propensity to use outpatient and emergency room visits and foregone medication due to cost also known as cost-related treatment non-adherence (CRN) (Alniji et al., 2021; Caswell & Zuckerman, 2018; J. Chen et al., 2014; Currie & Tekin, 2015; Downing, 2016; Kushel et al., 2006a). As per Downing's Homeowner Distress Model, housing affordability issues during the Recession were linked to forced trade-offs between housing, food, and medical care (Downing, 2016). To our knowledge, Downing's model is the only attempt in the literature to suggest pathways—specifically stress, effect-budgeting, frustration-aggression, and trust—that mediate the relationship between housing affordability and healthcare utilization, including foregone medication due to cost.

A key component of healthcare utilization is foregone medication due to cost, which has been reported among chronically ill and older adults. Evidence indicates that foregone medication was prevalent in 25% of chronically ill adults from a National Health Interview Survey (NHIS) sample between 2014 and 2018, compared to 44.2% of chronically ill adults from the Harris Interactive Chronic Illness Panel (CIP) who lived through the 2008 Recession (Lago-Hernandez et al., 2021; Piette et al., 2011). Among older NHIS adults aged 65+ years, foregone medication reached 4.7% (1.8 million) shortly after the Recession in 2010 and 3.9% (1.8 million) in 2015, nearly half the rates among the general population aged 2+ years, which were 8.2% in 2010 (24.9 million) and 5.2% (16.4 million) in 2015 (Kennedy & Wood, 2016). Despite overall downward trends between 2004 and 2014, increased foregone medication was observed among an older HRS sample of baby boomers and the silent generation (respectively, 50–54 years and 65–69 years in 2004) who lived through the Recession (Zhang et al., 2022). Downward rates in foregone medication were also observed among both groups as they aged between 2004 and 2014 (respectively, 14.38%–10.66% and 8.05%–5.31%) (Zhang et al., 2022).

Studies show that foregone medication due to cost is generally more prevalent among lower-income adults, the uninsured, Medicaid/Medicare enrollees, and people experiencing poor physical and mental health (Kang et al., 2018; Kennedy & Wood, 2016; Lago-Hernandez et al., 2021; S. Lee et al., 2019; Piette et al., 2004a; 2004b; Soumerai et al., 2006; Zhang et al., 2022; Zivin et al., 2010). Older adults are likely to forego medication given their high prevalence of chronic diseases, out-of-pocket costs, and limited health insurance coverage, including “donut hole” drug coverage gaps for Medicare part D beneficiaries (Centers for Disease Control and Prevention (CDC), 2022; Damico et al., 2018; Federal Interagency Forum (Forum) on Aging-Related Statistics, 2020; Fong, 2019; Kaiser Family Foundation (KFF), 2021; Mather, 2015; Medicare.gov, 2021; Naci et al., 2014). Foregone medication is also especially likely among retired older adults with lower social security income and other forms of retirement income replacing labor market wages (Bakk, 2015; Ebrahimi, 2019a, 2019b; Patel et al., 2016; Piette et al., 2004b; Purcell, 2012).

Foregone medication due to cost has been linked to poor chronic disease management and self-rated health as well as increased short-term mortality (Alsten, 2020; Lago-Hernandez et al., 2021; Lu et al., 2021; Soumerai et al., 2006). One NHIS sample of chronically ill adults who forewent medication due to cost between 2000 and 2014 indicated an 8–18% higher mortality risk from diabetes (Hazard Ratio, HR: 1.18, 1.0–1.4), cardiovascular disease (HR: 1.09, 1.0–1.2), and hypertension (HR: 1.08, 0.9–1.3), compared to their counterparts who did not forego

medication due to cost (Alsten, 2020). Another NHIS sample of cancer survivor patients who experienced CRN between 2011 and 2018 were 42% more likely to experience activity limitations (OR: 1.42, 1.25–1.60) and up to 112% more likely to experience functional limitations (OR: 2.12, 1.81–2.49) compared to their treatment adherent counterparts (Lu et al., 2021).

Although previous research has examined the short-term health consequences of the Recession, little is known about foregone medication due to cost in particular and how it was impacted by housing insecurity and other socioeconomic vulnerabilities during and immediately after the Recession. Moreover, little is also known about Medicare beneficiaries aged 65+ who typically experience declines in income and annual spending post-retirement as well as high out-of-pocket costs related to intensive chronic disease medication use and donut hole health insurance coverage gaps.

The primary objective of this study was to measure the association between housing insecurity and foregone medication due to cost among Medicare beneficiaries aged 65+ during the Recession (2008–2012). Two-wave housing insecurity changes were evaluated as follows: (i) *No insecurity* (housing-insecure in neither wave), (ii) *Persistent insecurity* (housing-insecure in both waves), (iii) *Onset insecurity* (housing-insecure in the second wave only), and (iv) *Onset security* (housing-insecure in the first wave only). We hypothesized that the odds of foregone medication would be higher for individuals experiencing *Persistent housing insecurity* across two consecutive waves due to greater chronic health and financial strain. We further hypothesized this effect would be most pronounced during the peak of the recession (2008–2009) relative to other periods due to greater economic distress and harder trade-offs across competing needs for families compared to other times (Kahn & Pearlin, 2006; The National Bureau of Economic Research, 2022).

2. Methods

2.1. Data

Data came from the Health and Retirement Study (HRS). The HRS is an ongoing nationally representative panel study of non-institutionalized adults aged 50 and above and their spouses of any age. The HRS collects data on aging patterns among pre-retiree and retiree adults across four primary domains: income and wealth; health, cognition and the use of healthcare services; work and retirement; and family connections (Servais, 2010; Sonnega et al., 2014). Respondent information has been collected every two years since 1992 (Servais, 2010). Eligibility is determined from a baseline screening interview, and a respondent and their spouse are randomly selected from all age-eligible household members using a multi-stage area probability sampling design. Black and Hispanic households are oversampled at twice the rate of White households, making the HRS ideal for studying older minority populations (Heeringa & Connor, 1995). Data from HRS tracker data as well as biennial RAND HRS fat files and 2016 longitudinal files version 2 were used for this study (Bugliari et al., 2020; Servais, 2010).

2.2. Analytical sample

We constructed a longitudinal person-wave file from the 2008, 2010, and 2012 waves. We used data from 2006 to create the two-wave housing insecurity variable as described below. Our study sample was restricted to non-proxy interviews of non-institutionalized Medicare beneficiaries aged 65+ in the 2006 wave ($n = 9936$) and their follow up visits ($n = 8753$ respondents in 2008; $n = 7464$ in 2010; and $n = 6594$ in 2012). Appendix 1 shows the sample selection criteria using non-imputed data across all waves. Among the baseline 9936 respondents, approximately 584 respondents entered institutional settings and 2494 total respondents died between the 2008 and 2012 waves. Despite relatively high follow-up interview rates in the HRS, roughly 3–6% of

surviving respondents in our sample did not complete a follow-up interview. Approximately 14% of respondents in a wave had missing information on housing insecurity and 15% had missing information on tenure status (renter/homeowner). Missingness on foregone medications (<1%) and other covariates was low including missing race/ethnicity and the CESD in less than 2% of respondents. RAND provided imputed values for household income, wealth and medical expenditures. We performed multiple imputations (MI) to handle missing data as described below. The final analytical model included 22,811 person-waves of data with a total of 8,889 unique subjects analyzed across all three waves. .

2.3. Foregone medication

Foregone medication due to cost was the main outcome variable of interest pulled from RAND HRS files asking individuals who report taking prescription medications, "Sometimes people delay taking medication or filling prescriptions because of the cost. At any time in the previous 2 years have you ended up taking less medication than was prescribed for you because of the cost?" We evaluated binary (yes/no) responses for this variable.

2.4. Housing insecurity

The literature has broadly examined various dimensions of housing insecurity (ie: housing stability, housing quality, housing safety, etc.) most often including housing affordability issues or individuals' distress or difficulty in paying monthly housing costs (Caswell & Zuckerman, 2018; Cox et al., 2019; (JCHS), 2020; Kushel et al., 2006b; Pollack et al., 2010; Rodgers et al., 2019; Routhier, 2019; The National Low Income Housing Coalition, 2016). Also included in the literature are measures of foreclosure, evictions, or defaults as well as federal housing assistance or legal issues related to housing-finance (Alley et al., 2011; Cox et al., 2017; Houle & Keene, 2015). In this study, we define housing insecurity as our primary exposure of interest according to the HUD definition of spending more than 30% of household income on housing costs (Housing and Urban Development (HUD), 2020). We operationalized this definition by calculating the percentage of monthly household income spent on monthly housing costs: $100 \times (\text{monthly housing costs} / \text{monthly household income})$. Income values equal to \$0 were replaced with \$1. Monthly housing costs were based on information reported in the RAND HRS files on monthly rent payments for renters and primary residence mortgages and other home loans for homeowners. Monthly household income was based on information reported in the RAND HRS files on combined respondent and spouse income over the last calendar year from all sources, including earnings and wages, pensions and annuities, Social Security disability and retirement, unemployment and workers' compensation, other government transfers, household capital income, and other income.

We constructed a two-category (yes/no) housing insecurity variable at each wave using the 30% HUD cut-point. We used this construction to create a four-category variable using data from adjacent waves to characterize two-year change: (1) No insecurity (housing-insecure in neither wave), (2) Persistent insecurity (housing-insecure in both waves), (3) Onset insecurity (housing-insecure in the second wave only), and (4) Onset security (housing-insecure in first wave only).

2.5. Covariates

Covariates were selected according to Andersen's 1968 healthcare utilization model, which identifies the following three domains of utilization: (i) *predisposing factors* (ie: demographics, social structure, and health beliefs); (ii) *enabling factors* (ie: family and community resources); and (iii) *need-based factors* (ie: perceived and evaluated illness level) (Andersen, 1968). Our regression model controlled for *predisposing factors*, namely, age, race and ethnicity, gender, US-born status, tenure, and

census region; *enabling factors*, namely, health insurance type, non-housing wealth, and out-of-pocket medical expenditures; and *need-based factors*, namely, disease status and depression status. All covariates were collected from HRS tracker and RAND HRS files.

2.6. Analyses

HRS-provided sample weights were used in all analyses. We performed MI to impute all unit- and item-level missing data restricted to living, non-institutionalized beneficiaries in each wave. MI handled arbitrary missing data patterns in missing exposures, covariates or the outcome at any point in time. For the imputation models, we included all covariates in our fully adjusted regression, as described below. Each follow up value from the same variable was treated as a different variable, thus, the models accommodated any wave-specific processes. We used the fully conditional specification (FCS) method, which assumes a joint distribution for these variables (van Buuren, 2007). Five rounds of imputations were implemented to produce five datasets. Predictive mean matching method was used to impute continuous variables, logistic regression for binary variables, and discriminant function for classification variables with more than two categories. We retained only observations with positive sample weights, which removed imputed observations after death, nonrespondents for the wave (a small percentage), and respondents residing in nursing homes or otherwise found to be ineligible. Descriptive statistics were generated for all study variables including frequency tabulations for categorical variables and mean and standard deviation values for continuous variables. We used weighted general estimating equations (GEE) with a binomial distribution, logit link function, and an exchangeable working correlation structure to model the longitudinal binary outcome, foregone medication. The estimates from the five imputed data sets were combined to produce final inferential GEE population average estimates.

We present two minimally adjusted models (ie: Model 1 and 2) and two fully adjusted models (ie: Model 3 and 4). Model 1 includes housing insecurity, wave, and core socio-demographic variables including age, race/ethnicity, gender, US-born, and census region. Model 2 adds to Model 1 a one-wave lagged measure of foregone medication. Adjusting for a lagged measure of foregone medication is important because it is a strong confounder related to both housing insecurity and current foregone medication. Adjusting for this variable also allows for a better identification of incident (versus prevalent) foregone medication events.

Model 3 is the fully adjusted model excluding interactions between housing insecurity and wave. Model 4 is the fully adjusted model including respective interactions to test for differential time trends in the odds of forgone medication across the four-categories of housing insecurity. The fully adjusted model includes the primary exposure (four category change in housing insecurity), wave as a categorical variable, time-varying covariates (ie: forgone medication status in the previous wave, current age, tenure, census region, Medicare health insurance type, non-housing wealth, out-of-pocket medical expenditures, disease status and depression status), and time-fixed covariates (ie: race and ethnicity, gender, and US-born status). Odds ratio estimates and their 95% confidence intervals ($\alpha = 0.05$) are reported. To translate the odds to a more interpretable scale, we additionally present adjusted mean probabilities of foregone medication by housing insecurity category (from Model 3) and by housing insecurity category and wave (Model 4). Adjusted probabilities are presented with covariates held at their grand mean. We conducted three supplemental models to check the sensitivity of our main results by modeling "shocks" or changes to housing insecurity more directly. These were to, alternatively, condition the sample on those (i) who were secure in a lagged wave, (ii) those who were insecure in a lagged wave, and (iii) those who were insecure in two prior waves. Model (i) tests whether a shock of experiencing a housing insecure event was associated with a higher risk of foregoing medication compared to not experiencing a shock and Models (ii) and (iii).

Worth noting is the timing of our key exposure and outcome

variables. For example, housing insecurity changes in 2008 were assessed between 2006 and 2008; in 2010, changes were assessed between 2008 and 2010; and in 2012, changes were assessed between 2010 and 2012. Similarly, foregone medication was assessed in the follow-up wave to account for the time ordering issue arising from the question text asking about foregone medication “in the previous two years”. For instance, 2008 foregone medication patterns were ascertained between 2008 and 2010; while 2010 patterns were ascertained between 2010 and 2012, and 2012 patterns were ascertained between 2012 and 2014. Using this timing ensured temporal alignment between our primary exposure and outcome variables. Further interpretation of the housing insecurity*2012 interaction, for example, was based on housing insecurity events that occurred between 2010 and 2012 and foregone medications occurring between 2012 and 2014. The same interpretation held for respective 2008 and 2010 interactions. SAS version 9.4 (SAS Inc., Cary, NC) procedures, PROC MI and PROC MIANALYZE, were used to conduct the imputation and derive valid inferences using imputed datasets. PROC GENMOD was used to derive GEE model results. STATA/SE version 17.0 was used for descriptive analyses.

3. Results

3.1. Descriptive analyses

Table 1 presents descriptive results of the imputed data. Non-imputed descriptive results are indicated in Appendix 2. The mean age of the sample ranged from 75 to 78 across the 2008, 2010, and 2012 waves. Overall, there was little change in the distribution of most variables across the waves. Approximately 1 out of 5 respondents experienced some level of housing insecurity (ie: *Persistent insecurity*, *Onset insecurity*, or *Onset security*). Among those experiencing insecurity, *Persistent Insecurity* was the most prevalent with approximately 10% falling into this category. There was a slight decline over time in *Persistent Insecurity* between the 2008 and 2012 waves, from 9.9% in 2008 to 8.6% in 2012. *Onset Insecurity* and *Onset Security* each comprised 5–7% of the sample in all years. Approximately 6–7% of the sample experienced a foregone medication with a small secular decline in the prevalence of foregone medication: 7.3% in 2008, 6.0% in 2010, and 5.5% in 2012.

Respondents were primarily non-Hispanic White (79%), female (58–59%), and resided in the South (40–41%). Respondents were also primarily US-born (91%), homeowners (81–83%), reported neither Medicaid nor HMO plan (63–68%), self-reported hypertension only (46–49%), and had little to no depressive symptoms (86–87%). Respondents displayed high overall median out-of-pocket expenditures (Q3) and non-housing wealth values (Q4), with respective values ranging between \$1392 to \$1672 for out-of-pocket expenditures, and between \$33,000 to \$45,000 for non-housing wealth. Appendix 3 provides exact quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

3.2. Regression results

Table 2 displays results from the regression models. Model 1 indicates that the three categories with some insecurity (ie: *Persistent Insecurity*, *Onset Insecurity*, and *Onset Security*) were all associated with a higher odds of foregone medication compared to the reference *No Insecurity* category. Both *Persistent Insecurity* (OR = 1.13 [95% CI: 1.04–1.23]) and *Onset Insecurity* (OR = 1.37 [95% CI: 1.06–1.77]) were associated with statistically significant odds of foregone medication. Model 2 indicates that addition of the lagged foregone medication variable did not appreciably change the odds ratios associated with the housing insecurity categories. Respective mean R² values shown in Table 2 indicate that inclusion of the lagged foregone medication variable increased the variance explained: Model 1 has an R² = 0.01 and

Model 2 has an R² = 0.12.

Model 3 indicates there was a reduction in the odds ratios associated with the three housing insecurity categories. For example, in Model 3, the odds ratio for *Persistent Insecurity* was 1.00 (95% CI: 0.89–1.12) and 1.24 (95% CI: 0.94–1.62) for *Onset Insecurity*; neither significant at the $p = 0.05$ level. Model 4 indicates that interactions as a set were statistically significant ($p = 0.04$). In this model, the odds ratio associated with the main effect of *Onset Insecurity* in 2008 was 1.64 (95% CI: 1.13–2.37) and statistically significant. The interaction between *Onset Insecurity* and the 2012 wave was also significant with an associated odds ratio of 0.37 (95% CI: 0.23–0.61), further signifying that the odds ratio associated with *Onset Insecurity* in 2012 was 0.61 in 2012 (ie: 1.64×0.37).

Odds ratios associated with the other model covariates were in the overall expected direction. For instance, females, minority versus non-Hispanic white adults, those reporting a chronic condition (ie: depression, diabetes and/or hypertension), those with higher medical expenditures, and those living in the South versus Northeast were more likely to experience a higher odds of a foregone medication. Conversely, older, foreign-born adults, and those with higher non-housing wealth levels were more likely to experience a lower odds of a foregone medication relative to their younger, native-born, and less wealthy counterparts.

3.3. Differences on the probability scale

Fig. 1a shows the predicted probabilities for each housing insecurity category based on Model 3. Among those experiencing *No Insecurity*, the probability of foregone medications was 0.037 (3.7%). Among those experiencing an *Onset Insecurity*, the probability was 0.046 (4.6%). Those experiencing *Persistent Insecurity* had a similar percentage compared to those experiencing *No Insecurity* at 0.037 or 3.7% and those experiencing *Onset Security* had a probability of 0.042 (4.2%). Fig. 1b shows the predicted probabilities by wave (2008, 2010, 2012) and housing insecurity based on Model 4 which includes the housing insecurity*wave interaction. The figure highlights that the largest difference between *No Insecurity* and *Onset Insecurity* occurred in 2008. In 2012, there was considerable overlap in the 95% confidence intervals across all the four categories. Results from the sensitivity models modeling “shocks” in housing insecurity are shown in Appendix 4 and were generally consistent with the main conclusions presented. The sensitivity models indicated that experiencing an *Onset Insecurity* event was associated with a higher probability of foregoing medications compared to *No Insecurity* and that *Persistent Insecurity* was associated with lower probabilities than *Onset Security*.

4. Discussion

We assessed the association between housing insecurity changes and the likelihood of foregone medication due to cost among Medicare beneficiaries during, shortly after, and a few years after the Great Recession. Models controlled for select predisposing, enabling, and need-based factors from Andersen’s 1960 healthcare utilization framework (Andersen, 1995). Results from our multivariable analysis indicated significant associations in the 2008 model alone, with an odds of foregone medication 64% higher among individuals who experienced *Onset insecurity* versus *No insecurity*. These results do not support our main hypothesis that *Persistent insecurity* would be most strongly associated with the likelihood of foregone medication during the peak of the Recession in 2008–2009 relative to other periods. Instead, our findings indicated that *Onset Insecurity* (vs. *No Insecurity*) was more strongly associated with foregone medications in the 2008 wave compared to the later waves, while *Persistent Insecurity* (vs. *No Insecurity*) did not follow this same pattern. *Onset Insecurity* may be most closely linked with unexpected acute economic shocks leading households with little time to adapt and forcing trade-offs in their prescription and other needs purchases. Moreover, we found a significant paradoxical inverse association between *Onset Insecurity* and foregone medications in 2012. The reason

Table 1
Descriptive characteristics of Medicare beneficiaries 65+ years (Imputed HRS 2008–2012 sample).

	2008 (n = 8,753)	2010 (n = 7,464)	2012 (n = 6,594)
	Col % or Mean (SD)	Col % or Mean (SD)	Col % or Mean (SD)
Housing insecurity (four-category)			
No insecurity	77.90	78.07	79.71
Persistent insecurity	9.89	9.01	8.64
Onset insecurity	5.75	6.00	5.44
Onset security	6.46	6.92	6.22
Foregone meds due to cost			
No	92.71	93.99	94.49
Yes	7.29	6.01	5.51
Age			
Mean, SD	75.99 (6.84)	77.64 (6.38)	78.85 (6.00)
Race/ethnicity			
White, non-Hispanic	79.16	79.09	79.05
Black, non-Hispanic	12.59	12.62	12.30
Hispanic	8.25	8.30	8.65
Gender			
Male	41.64	41.59	41.20
Female	58.36	58.41	58.80
US-born			
Yes	91.08	90.92	90.65
No	8.92	9.08	9.35
Tenure			
Homeowner	82.88	81.50	81.40
Renter	17.12	18.50	18.60
Census region			
Northeast	15.77	15.17	14.82
Midwest	25.56	26.09	26.19
South	40.57	40.43	40.51
West	18.10	18.31	18.47
Health insurance			
Medicare only, neither Medicaid nor HMO	68.03	64.89	62.91
Medicare with Medicaid, no HMO	6.72	5.87	5.67
Medicare with HMO, regardless Medicaid	24.24	28.00	30.26
No Medicare	1.01	1.24	1.16
Disease status			
Neither diabetes nor hypertension	31.39	28.58	26.63
Diabetes only	4.66	4.50	4.50
Hypertension only	46.07	47.24	48.50
Both diabetes and hypertension	17.88	19.68	20.37
Depression			
No	86.61	86.58	85.98
Yes	13.39	13.42	14.02
Non-housing wealth			
Q1	20.16	23.23	23.20
Q2	24.06	14.27	13.50
Q3	26.32	27.13	28.01
Q4	29.45	35.37	35.29
Out of pocket medical expenditures			
Q1	23.04	18.50	19.09
Q2	26.56	26.42	25.69

(continued on next page)

Table 1 (continued)

	2008 (n = 8,753)	2010 (n = 7,464)	2012 (n = 6,594)
	Col % or Mean (SD)	Col % or Mean (SD)	Col % or Mean (SD)
Q3	27.22	28.46	29.25
Q4	23.17	26.62	25.96

NOTE. Appendix, Table 3 indicates quartile reference values for out-of-pocket expenditures and non-housing wealth variables. SD: Standard deviation.

for this relationship is unclear, but it was robust to multiple specifications and covariate adjustments. Potential explanations include financial relief provided by the Affordable Care Act in late 2010–2011 including expansion of Medicaid and Medicare part D prescription coverage, in states where adopted (Anderson & Gascon, 2011; Forum on Medical and Public Health Preparedness for Catastrophic Events et al., 2014; Kaiser Family Foundation (KFF), 2021; Moffitt, 2013).

Our findings suggest support Downing's *Homeowner Distress Model* positing that, under peak economic distress, adults may be forced to reprioritize housing costs over other basic needs, including food, transportation, and medical care, ultimately leading to poor health (Downing, 2016; JCHS, 2020). Our findings also contribute to the literature on older adults aged 65+ years who are likely to undergo trade-offs during financial hardship. For example, evidence from the 2018 Consumer Expenditure Survey (CE) indicated 31% reductions in healthcare and 21% reductions in food in households headed by housing-insecure adults aged 65+ versus those under 65 years (Joint Center for Housing Studies, 2020). Such issues should not be overlooked, as housing insecurity is the most prevalent housing issue among older adults. A 2017 HRS sample indicated that adults aged 50–64 years, 65–74, and 75+ respectively spent 47.3%, 45.8%, and 48.8% of their income on housing (Ebrahimi, 2019a). Housing insecurity is more likely among older adults whose income is cut in half following retirement and continues to decline over time (JCHS, 2020; Purcell, 2012). Moreover, unlike in previous economic downturns, older adults who lived through the Recession may have been forced to delay their retirement or return to the labor force post-retirement due to decreasing housing prices and insecure retirement funds (Johnson, 2009; Lee & Ahn, 2015; Mackenzie, 2008).

Our findings support previous studies that found low-income adults with housing affordability issues are 2.9 times more likely to forego medication due to cost (Adjusted Odds Ratio, AOR: 2.68, 1.95–3.70) and 2.2 times more likely to postpone needed medications (AOR: 2.16, 1.70–2.74) than low-income adults without housing affordability issues, even after adjusting for various predisposing, enabling, and need-based factors (Kushel et al., 2006a; Pollack et al., 2010). For instance, one study found that Philadelphia adults who underwent a home foreclosure during the Recession were 3.44 times more likely to not fill a prescription due to cost than their counterparts who did not experience a home foreclosure (Pollack & Lynch, 2011). Additionally, an HRS study found that mortgage-delinquent adults aged 50+ years were 8.7 times more likely than non-mortgage delinquent adults to forego medication due to cost during the Recession (OR: 8.66, 3.72–20.16), after adjusting for age, gender, marital status, race and ethnicity, income, and unrelated debt housing (Alley et al., 2011).

Results from this HRS study further corroborated our findings of a significant association between depression and foregone medication due to cost, after adjusting for similar covariates, where mortgage-delinquent adults during the Recession were nearly 8.60 times more likely than non-mortgage delinquent adults to experience a new onset of incident depressive symptoms using a revised 8-item version of the Center for Epidemiological Studies Depression (CESD) scale (Alley et al., 2011). Furthermore, 6 out of 7 articles examined in a 2007 literature review indicated the significant role of poor mental health (e.g., depression) on the increased risk CRN among Medicare beneficiaries and people with chronic conditions (Briesacher et al., 2007). Similar

evidence was found among a 2005 HRS sample of older adults aged 65+ years, with 1–3 and ≥ 4 depressive symptoms reporting a CRN odds 1.64 and 2.25 times higher, respectively, than adults without depressive symptoms (Zivin et al., 2010).

Our findings may not be comparable to findings from other medication adherence studies because only 5–7% of our sample forewent medication due to cost. These estimates are lower than estimates from previous studies. For example, one study reported CRN among 17.7% of Medicare part D beneficiaries in 2007, among whom about one-third had reached their 75% benefit threshold (Bakk, 2015). This difference might be explained by the study's assessment of foregone medication during the 2007 pre-Recession period as well as the restriction of the sample as non-dually eligible Medicare and Medicaid beneficiaries currently taking prescription medication. Other studies have indicated CRN rates between 10 and 15% among general Medicare beneficiaries between 2005 and 2011 (14.9% in 2005, 11.3% in 2007, 10.2% in 2009, and 10.8% in 2011). Slightly lower CRN estimates in our sample may be attributed to our assessment of Hispanic, non-Hispanic White and Black adults alone, excluding other races such as American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander.

Findings from this study should be cautiously interpreted according to study limitations. First, all study variables were derived from self-reported survey data, including housing insecurity estimates calculated from self-reported income and housing costs. Such data may not include all income and financial resources (e.g.: public subsidies for housing). Second, we were unable to assess medication need and beliefs about medication as well as the type of medication foregone, limiting our ability to determine fluctuations in prescription versus non-prescription foregone medication trends. Third, our findings may be confounded by other forms of financial hardship (ie: food insecurity, credit card and/or medical debt, etc.) and additional effects of the 2010 Affordable Care Act rollout including expansion of Medicare part D prescription coverage and Medicaid in states where adopted (Forum on Medical and Public Health Preparedness for Catastrophic Events et al., 2014; Kaiser Family Foundation (KFF), 2023). Fourth, the sample was majority non-Hispanic Whites, further limiting inferences to minority populations such as Hispanics and non-Hispanic Blacks. And finally, although we accounted for region of residence, HRS does not publicly disclose state residency information, which hinders our ability to account for state or county-level policies affecting decisions about housing, healthcare, and other related matters among beneficiaries.

5. Limitations

Findings from this study should be cautiously interpreted according to study limitations. First, all study variables were derived from self-reported survey data, including housing insecurity estimates calculated from self-reported income and housing costs. Such data may not include all income and financial resources (e.g.: public subsidies for housing). Second, we were unable to assess medication need and beliefs about medication as well as the type of medication foregone, limiting our ability to determine fluctuations in prescription versus non-prescription foregone medication trends. Third, our findings may be confounded by other forms of financial hardship (ie: food insecurity, credit card and/or medical debt, etc.) Fourth, the sample was majority non-Hispanic Whites, further limiting inferences to minority

Table 2
Minimally and fully adjusted models of multivariable associations predicting foregone medications due to cost (Imputed HRS 2008–2012 sample).

	Foregone meds due to cost (OR,95% CI)*			
	Model 1	Model 2	Model 3	Model 4
Housing insecurity (four-category)				
No insecurity (Ref)				
Persistent insecurity	1.13, 1.04–1.23*	1.10, 1.00–2.21*	1.00, 0.89–1.12	0.99, 0.72–1.36
Onset insecurity	1.37, 1.06–1.77*	1.37, 1.04–1.81*	1.24, 0.94–1.62	1.64, 1.13–2.37*
Onset security	1.23, 0.91–1.66	1.24, 0.94–1.63	1.13, 0.86–1.47	1.11, 0.78–1.60
Wave				
2008 (Ref)				
2010	0.89, 0.86–0.93*	0.78, 0.74–0.83*	0.79, 0.74–0.84*	0.76, 0.70–0.82*
2012	0.89, 0.82–0.96*	0.80, 0.76–0.86*	0.79, 0.73–0.86*	0.89, 0.81–0.98*
Housing insecurity*Wave				
pers_insec*wave2010	.	.	.	1.32, 0.92–1.90
onset_insec*wave2010	.	.	.	0.80, 0.48–1.33
onset_sec*wave2010	.	.	.	1.30, 0.97–1.74
pers_insec*wave2012	.	.	.	0.71, 0.45–1.11
onset_insec*wave2012	.	.	.	0.37, 0.23–0.61*
onset_sec*wave2012	.	.	.	0.74, 0.53–1.05
Foregone meds (previous wave)				
respectively 2006, 2008, and 2010	.	11.05, 9.18–13.29*	7.05, 6.21–8.01*	7.11, 6.31–8.00*
Age				
Years	0.95, 0.94–0.96*	0.96, 0.95–0.97*	0.96, 0.95–0.97*	0.96, 0.95–0.97*
Race/ethnicity				
White, non-Hispanic (Ref)				
Black, non-Hispanic	1.81, 1.76–1.85*	1.56, 1.52–1.60*	1.17, 1.13–1.21*	1.17, 1.13–1.22*
Hispanic	1.54, 1.34–1.78*	1.47, 1.28–1.69*	1.12, 0.95–1.31	1.13, 0.96–1.31
Gender				
Male (Ref)				
Female	1.39, 1.26–1.52*	1.26, 1.14–1.39*	1.19, 1.07–1.31*	1.19, 1.07–1.31*
US-born				
Yes (Ref)				
No	0.79, 0.67–0.92*	0.78, 0.69–0.89*	0.83, 0.71–0.98*	0.83, 0.71–0.97*
Tenure				
Homeowner (Ref)				
Renter	.	.	1.07, 0.83–1.37	1.08, 0.85–1.39
Census region				
Northeast (Ref)				
Midwest	1.19, 1.03–1.38*	1.17, 1.01–1.36*	1.24, 1.04–1.47*	1.25, 1.05–1.49*
South	1.45, 1.25–1.68*	1.35, 1.17–1.55*	1.34, 1.14–1.59*	1.36, 1.15–1.61*

Table 2 (continued)

	Foregone meds due to cost (OR,95% CI)*			
	Model 1	Model 2	Model 3	Model 4
West	1.07, 0.92–1.24	1.09, 0.93–1.27	1.16, 0.98–1.37	1.17, 0.99–1.39
Health insurance				
Medicare only, neither Medicaid nor HMO (Ref)				
Medicare with Medicaid, no HMO	.	.	1.02, 0.91–1.13	1.03, 0.92–1.15
Medicare with HMO, regardless Medicaid	.	.	1.11, 1.04–1.20*	1.12, 1.04–1.20*
No Medicare	.	.	0.60, 0.32–1.12	0.59, 0.31–1.11
Disease status				
Neither diabetes nor hypertension (Ref)				
Diabetes only	.	.	1.39, 1.13–1.71*	1.38, 1.14–1.68*
Hypertension only	.	.	1.01, 0.96–1.06	1.00, 0.95–1.05
Both diabetes and hypertension	.	.	1.15, 1.05–1.25*	1.15, 1.06–1.25*
Depression				
Yes	.	.	1.91, 1.78–2.06*	1.92, 1.78–2.06*
No (Ref)				
Non-housing wealth				
Q1 (Ref)				
Q2	.	.	0.84, 0.77–0.92*	0.84, 0.77–0.92*
Q3	.	.	0.54, 0.51–0.58*	0.54, 0.51–0.58*
Q4	.	.	0.33, 0.28–0.38*	0.33, 0.28–0.39*
Out of pocket medical expenditures				
Q1 (Ref)				
Q2	.	.	1.41, 1.27–1.57*	1.43, 1.27–1.59*
Q3	.	.	1.70, 1.53–1.89*	1.72, 1.54–1.93*
Q4	.	.	2.04, 1.81–2.30*	2.06, 1.82–2.33*
Mean R² value	0.01	0.12	0.14	0.14

NOTE. All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance of housing insecurity variable at $p < 0.05$. Results based on own calculations using public-use data from the Health and Retirement Study (HRS).

populations such as Hispanics and non-Hispanic Blacks. And finally, although we accounted for region of residence, HRS does not publicly disclose state residency information, which hinders our ability to account for state or county-level policies affecting decisions about housing, healthcare, and other related matters among beneficiaries.

6. Conclusion

To our knowledge, this is the first study to construct the housing insecurity index in the HRS and use it to evaluate variations in the likelihood of foregone medication due to cost during, shortly after, and a few years after the Recession. This study drew from nationally representative data to elucidate the disparate health and financial impacts of a crisis on Medicare beneficiaries who, despite health insurance coverage, display variability in foregone medication patterns. Our

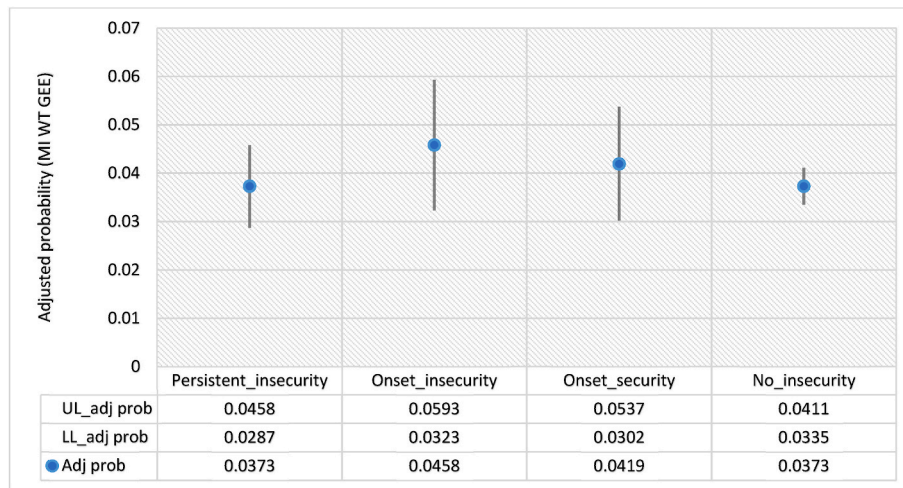


Fig. 1a. Adjusted mean probabilities of foregone medication by housing insecurity category (based on Model 3).

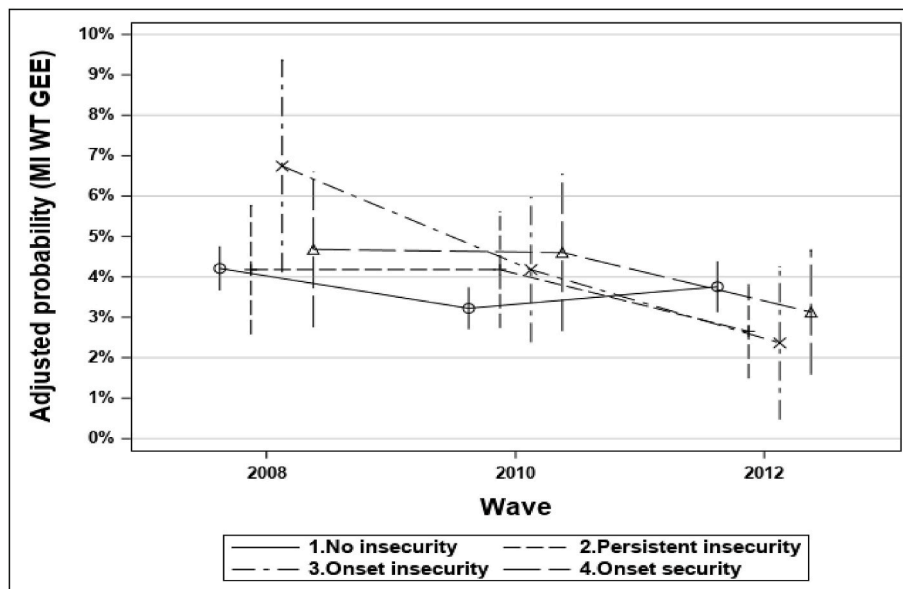


Fig. 1b. Adjusted mean probabilities of foregone medication by housing insecurity category and wave (based on Model 4).

findings also have both housing and healthcare policy implications including, but not limited to, expansion of low-income housing, eviction moratoriums and rent stabilization for at-risk adults (Bertoldo et al., 2022; K. L. Chen et al., 2022; The National Low Income Housing Coalition, 2016; Consumer Financial Protection Bureau, 2021; Hu, 2022; Liu & Eicher-Miller, 2022). Also included are recommendations for wider prescription drug coverage for all Medicare adults and greater access to Medicare Advantage plans which can now provide rental and housing assistance to chronically ill enrollees (Coleman, 2019). As suggested by Downing’s Homeowner Distress Model, investing in housing security has spillover effects on medical care and other basic needs including food and transportation (Downing, 2016). Therefore, resource transfers may be helpful in ensuring continuity of care in times of peak financial distress particularly among Medicare beneficiaries aged 65+ with limited incomes and health insurance coverage gaps (Centers for Disease Control and Prevention (CDC), 2022; Damico et al., 2018; Federal Interagency Forum (Forum) on Aging-Related Statistics, 2020; Fong, 2019; Kaiser Family Foundation (KFF), 2021; Mather, 2015; Medicare.gov, 2021; Naci et al., 2014).

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Conflict of interest

None declared.

Ethical statement

The project entirely involves the secondary analysis of de-identified and existing data sets (HRS) with regulations protecting the identity of participants as per approvals of the original studies. Names, social security numbers, addresses, and other identifiers are not contained in any of the data files we will access for this project. The authors declare no conflict of interest, financial or otherwise, with the results presented in the study.

Author statement

All authors (MH, RW, XY, NM) jointly conceptualized the research ideas and research plan. Statistical analyses were conducted by MH and XY. MH wrote an initial draft of the manuscript. All authors edited the manuscript for intellectual content. RW secured funding for this work.

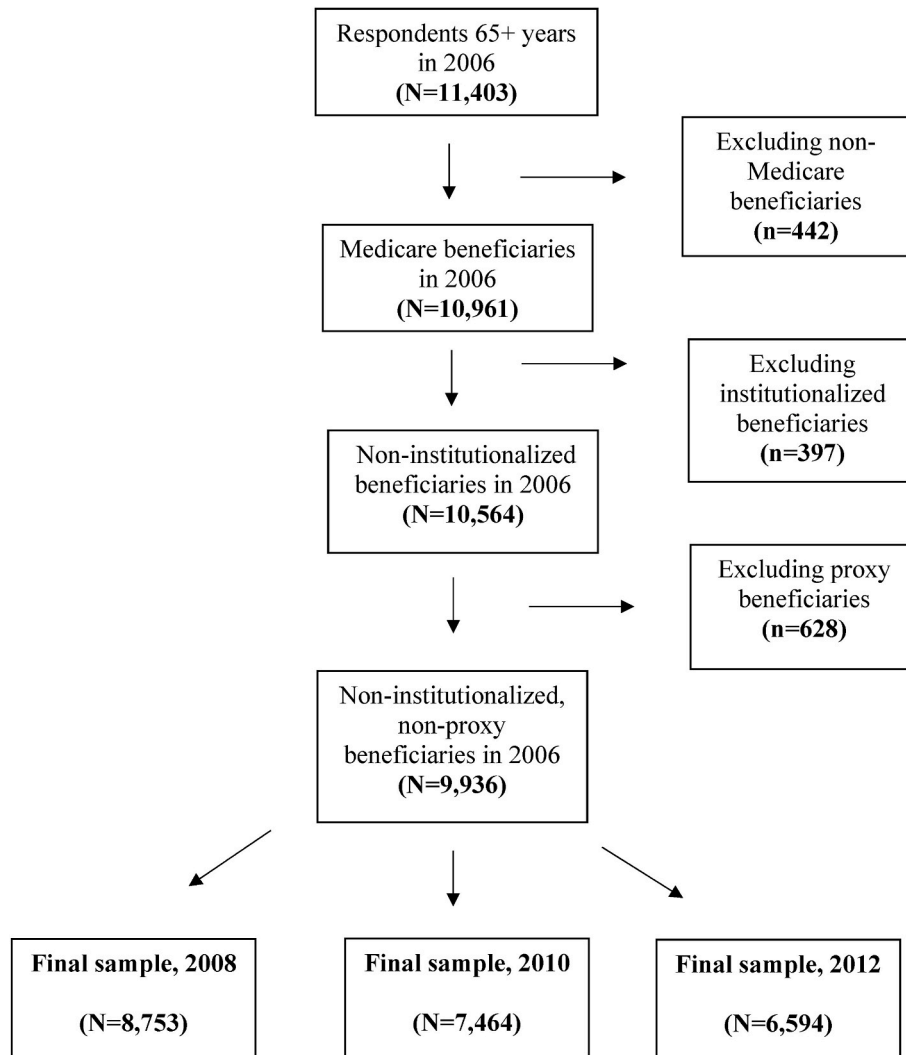
Data availability

Data will be made available on request.

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APPENDIX 1. Final sample selection criteria (Non-imputed HRS 2006–2012 sample)



APPENDIX 2. Descriptive characteristics Medicare beneficiaries 65+ years (Non-imputed HRS 2006–2012 sample)

	Descriptive statistics, (N, Col%; Mean, SD)							
	2006 (n = 9936)		2008 (n = 8753)		2010 (n = 7464)		2012 (n = 6594)	
	N	Col %	N	Col %	N	Col %	N	Col %
Housing insecurity (two-category)								
Missing	1466	14.75	1256	14.35	1054	14.12	896	13.59
No insecurity	7201	72.47	6414	73.28	5494	73.61	4931	74.78
Any insecurity	1269	12.77	1083	12.37	916	12.27	767	11.63
Housing insecurity (four-category)								
Missing	9936	100	1687	19.27	1507	20.19	1317	19.97
No insecurity	.	.	5751	65.7	4853	65.02	4346	65.91
Persistent insecurity	.	.	543	6.2	435	5.83	391	5.93
Onset insecurity	.	.	362	4.14	310	4.15	260	3.94
Onset security	.	.	.	.	.	.	.	.
Foregone meds due to cost								
Missing	1017	10.24	1223	13.97	882	11.82	976	14.8
No	8359	84.13	7003	80.01	6196	83.01	5321	80.69
Yes	560	5.64	527	6.02	386	5.17	297	4.5
Age								
Mean, SD	74.53	7.21	75.99	6.84	77.64	6.38	78.85	6
Race/ethnicity								
Missing	164	1.65	145	1.66	132	1.77	114	1.73
White, non-Hispanic	7789	78.39	6858	78.35	5838	78.22	5156	78.19
Black, non-Hispanic	1240	12.48	1082	12.36	924	12.38	796	12.07
Hispanic	743	7.48	668	7.63	570	7.64	528	8.01
Gender								
Missing	.	.	.	.	.	.	.	.
Male	4162	41.89	3645	41.64	3104	41.59	2717	41.2
Female	5774	58.11	5108	58.36	4360	58.41	3877	58.8
US-born								
Missing	11	0.11	10	0.11	8	0.11	4	0.06
Yes	9062	91.2	7963	90.97	6779	90.82	5974	90.6
No	863	8.69	780	8.91	677	9.07	616	9.34
Tenure								
Missing	1495	15.05	1298	14.83	1095	14.67	1056	16.01
Homeowner	7064	71.1	6251	71.42	5272	70.63	4570	69.31
Renter	1377	13.86	1204	13.76	1097	14.7	968	14.68
Census region								
Missing	11	0.11	9	0.1	10	0.13	8	0.12
Northeast	1576	15.86	1380	15.77	1130	15.14	975	14.79
Midwest	2559	25.75	2235	25.53	1946	26.07	1726	26.18
South	4015	40.41	3546	40.51	3015	40.39	2669	40.48
West	1775	17.86	1583	18.09	1363	18.26	1216	18.44
Health insurance								
Missing	561	5.65	510	5.83	630	8.44	500	7.58
Medicare only, neither Medicaid nor HMO (Ref)	6849	68.93	5630	64.32	4468	59.86	3843	58.28
Medicare with Medicaid, no HMO	573	5.77	499	5.7	328	4.39	316	4.79
Medicare with HMO, regardless Medicaid	1953	19.66	2026	23.15	1948	26.1	1861	28.22
No Medicare	.	.	88	1.01	90	1.21	74	1.12
Disease status								
Missing	14	0.14	14	0.16	11	0.15	4	0.06
Neither diabetes nor hypertension	3437	34.59	2738	31.28	2125	28.47	1753	26.58
Diabetes only	469	4.72	408	4.66	336	4.5	297	4.5
Hypertension only	4424	44.52	4029	46.03	3524	47.21	3197	48.48
Both diabetes and hypertension	1592	16.02	1564	17.87	1468	19.67	1343	20.37
Depression								
Missing	6	0.06	204	2.33	329	4.41	290	4.4
No	8475	85.3	7418	84.75	6217	83.29	5448	82.62

(continued on next page)

(continued)

	Descriptive statistics, (N, Col%; Mean, SD)							
	2006 (n = 9936)		2008 (n = 8753)		2010 (n = 7464)		2012 (n = 6594)	
	N	Col %	N	Col %	N	Col %	N	Col %
Yes	1455	14.64	1131	12.92	918	12.3	856	12.98
Non-housing wealth								
Missing	.	.	.	.	.	.	.	.
Q1	2041	20.54	1765	20.16	1734	23.23	1530	23.2
Q2	2449	24.65	2106	24.06	1065	14.27	890	13.5
Q3	2549	25.65	2304	26.32	2025	27.13	1847	28.01
Q4	2897	29.16	2578	29.45	2640	35.37	2327	35.29
Median	19925		20000		18200		16000	
Out of pocket medical expenditures								
Missing	.	.	.	.	.	.	.	.
Q1	2261	22.76	2017	23.04	1381	18.5	1259	19.09
Q2	2514	25.3	2325	26.56	1972	26.42	1694	25.69
Q3	2582	25.99	2383	27.22	2124	28.46	1929	29.25
Q4	2579	25.96	2028	23.17	1987	26.62	1712	25.96
Median	1524		1371		1680		1560	

NOTE. Appendix 3 indicates quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

APPENDIX 3. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables (Non-imputed HRS 2006–2012 sample)

	Out of pocket medical expenditures (\$)			
	2006	2008	2010	2012
Q1	0 to 400	0 to 408	0 to 360	0 to 350
Q2	402 to 1420	410 to 1350	365 to 1400	357 to 1340
Q3	1422 to 3500	1352 to 3200	1404 to 3610	1344 to 3440
Q4	3510 to 289,210	3203 to 98,000	3612 to 82,336	3450 to 217,725
	Non-housing wealth (\$)			
	2006	2008	2008	2008
Q1	-526,000 to 10	-1.4e06 to 0	-1.4e06 to 0	-1.4e06 to 0
Q2	12 to 10,000	1 to 11,000	1 to 11,000	1 to 11,000
Q3	10,050 to 93,073	11,300 to 100,500	11,300 to 100,500	11,300 to 100,500
Q4	93,192 to 1.81e07	100,535 to 1.52e07	100,535 to 1.52e07	100,535 to 1.52e07

Appendix 4. Predicted probabilities associated with housing insecurity exposure variables from sensitivity models

	Probability	Probability based on Model 3 of Manuscript	Model Specification
Model (i)			
No Insecurity	0.0354	0.0373	Conditioned sample on having no insecurity in a lagged wave. Onset insecurity indicates an insecure status in the "current" wave.
Onset Insecurity	0.0448	0.0458	
Insecurity			
Model (ii)			
Onset Security	0.0502	0.0419	Conditioned sample on having insecurity in a lagged wave. Onset security indicates a secure status in the "current" wave and Persistent Insecurity indicates an insecure status in the "current" wave.
Persistent Insecurity	0.0428	0.0373	
Insecurity			
Model (iii)			
Onset Security	0.0342	0.0363*	Conditioned sample on having insecurity in two lagged waves. Onset security indicates a secure status in the "current" wave and Persistent Insecurity indicates an insecure status in the "current" wave.
Persistent Insecurity	0.0260	0.0320*	
Insecurity			

Note: All models adjust for covariates used in Model 3 of the main analyses. Models (i) and (ii) are estimated using 2008, 2010, and 2012 waves and Model (iii) is estimated on 2010 and 2012 waves.

* Predicted probabilities using the specification noted in Model 3, but only on the the 2010 and 2012 waves of data.

References

- Ailshire, J. A. (2013). Linked lives in the Great recession: Personal and family mortgage delinquency and financial stress and older adult health and well-being. In *Population association of America*. <https://paa2013.princeton.edu/papers/132440>.
- Alley, D. E., Lloyd, J., Pagán, J. A., Pollack, C. E., Shardell, M., & Cannuscio, C. (2011). Mortgage delinquency and changes in access to health resources and depressive symptoms in a nationally representative cohort of Americans older than 50 years. *American Journal of Public Health, 101*(12). <https://doi.org/10.2105/AJPH.2011.300245>
- Alnijadi, A. A., Yuan, J., Wu, J., Li, M., & Lu, Z. K. (2021). Cost-related medication nonadherence (CRN) on healthcare utilization and patient-reported outcomes: Considerations in managing medicare beneficiaries on antidepressants. *Frontiers in Pharmacology, 12*, Article 764697. <https://doi.org/10.3389/fphar.2021.764697>
- Alsten, S. C. V. (2020). Cost-related nonadherence and mortality in patients with chronic disease: A multiyear investigation, national health interview survey, 2000–2014. *Preventing Chronic Disease, 17*. <https://doi.org/10.5888/pcd17.200244>
- Andersen, R. (1968). A behavioral model of families' use of health services. *A Behavioral Model of Families' Use of Health Services, 25*. <https://www.cabdirect.org/cabdirect/abstract/19702701913>.
- Andersen, R. M. (1995). Revisiting the Behavioral Model and Access to Medical Care: Does it Matter? *Journal of Health and Social Behavior, 36*(1), 1–10. JSTOR <https://doi.org/10.2307/2137284>. JSTOR.
- Anderson, R. G., & Gascon, C. S. (2011). *A closer look: Assistance programs in the wake of the crisis*. St. Louis: Federal Reserve Bank of. <https://www.stlouisfed.org/publications/regional-economist/january-2011/a-closer-look-brassistance-programs-in-the-wake-of-the-crisis>.
- Bakk, L. (2015). Medicare Part D coverage gap: Race, gender, and cost-related medication nonadherence. *Social Work in Public Health, 30*(6). <https://doi.org/10.1080/19371918.2015.1052607>
- Bertoldo, J., Wolfson, J. A., Sundermeier, S. M., Edwards, J., Gibson, D., Agarwal, S., & Labrique, A. (2022). Food insecurity and delayed or forgone medical care during the COVID-19 pandemic. *American Journal of Public Health, 112*(5), 776–785. <https://doi.org/10.2105/AJPH.2022.306724>
- Bhat, A. C., Almeida, D. M., Fenelon, A., & Santos-Lozada, A. R. (2022). A longitudinal analysis of the relationship between housing insecurity and physical health among midlife and aging adults in the United States. *SSM - Population Health, 18*, Article 101128. <https://doi.org/10.1016/j.ssmph.2022.101128>
- Briesacher, B. A., Gurwitz, J. H., & Soumerai, S. B. (2007). Patients at-risk for cost-related medication nonadherence: A review of the literature. *Journal of General Internal Medicine, 22*(6). <https://doi.org/10.1007/s11606-007-0180-x>
- Bugliari, D., Carroll, J., Hayden, O., Hayes, J., Hurd, M., Karabatakis, A., Main, R., Marks, J., McCullough, C., Meijer, E., Moldoff, M., Pantoja, P., Rohwedder, S., & StClair, P. (2020). *RAND HRS longitudinal file 2018 (V2)*. RAND center for the study of aging. <https://hrsdata.isr.umich.edu/data-products/rand-hrs-longitudinal-file-2018>.
- Burgard, S. A., Seefeldt, K. S., & Zelter, S. (2012). Housing instability and health: Findings from the Michigan recession and recovery study. *Social Science & Medicine, 75*(12), 2215–2224. <https://doi.org/10.1016/j.socscimed.2012.08.020>
- van Buuren, S. (2007). Multiple imputation of discrete and continuous data by fully conditional specification. *Statistical Methods in Medical Research, 16*(3), 219–242. <https://doi.org/10.1177/0962280206074463>
- Caswell, K. J., & Zuckerman, S. (2018). Food insecurity, housing hardship, and medical care utilization. https://www.urban.org/sites/default/files/publication/98701/2001896_foodinsecurity_housinghardship_medicalcareutilization_finalized.pdf.
- Centers for Disease Control and Prevention (CDC). (2022). Health and economic costs of chronic diseases. <https://www.cdc.gov/chronicdisease/about/costs/index.htm>.
- Chen, K. L., Miake-Lye, I. M., Begashaw, M. M., Zimmerman, F. J., Larkin, J., McGrath, E. L., & Shekelle, P. G. (2022). Association of promoting housing affordability and stability with improved health outcomes: A systematic review. *JAMA Network Open, 5*(11), Article e2239860. <https://doi.org/10.1001/jamanetworkopen.2022.39860>
- Chen, J., Vargas-Bustamante, A., Mortensen, K., & Thomas, S. B. (2014). Using quantile regression to examine health care expenditures during the Great Recession. *Health Services Research, 49*(2), 705–730. <https://doi.org/10.1111/1475-6773.12113>
- Coleman, K. (2019). *Implementing supplemental benefits for chronically ill enrollees*. April 24. U.S. Dept. of Health & Human Services Guidance Portal <https://www.hhs.gov/guidance/document/implementing-supplemental-benefits-chronically-ill-enrollees>.
- Consumer Financial Protection Bureau. (2021). Housing insecurity and the COVID-19 pandemic. March <https://www.consumerfinance.gov/data-research/research-reports/housing-insecurity-and-the-covid-19-pandemic/>.
- Cox, R., Henwood, B., Rodnyansky, S., Rice, E., & Wenzel, S. (2019). Road map to a unified measure of housing insecurity. *Citiescape: A Journal of Policy Development and Research, 21*(2), 93–128. <https://www.proquest.com/openview/a65988445c3cbcd056337f3181eb26ff/1?pq-origsite=gscholar&cbl=316218>.
- Cox, R., Rodnyansky, S., Henwood, B., & Wenzel, S. (2017). Measuring population estimates of housing insecurity in the United States: A comprehensive approach, 1–CESR-Schaeffer Working Paper No. 2017-012 <https://doi.org/10.2139/ssrn.3086243>.
- Currie, J., & Tekin, E. (2015). Is there a link between foreclosure and health? *American economic journal. Economic Policy, 7*(1), 63–94. <https://doi.org/10.1257/pol.20120325>
- Damico, A., Cubanski, J., & Neuman, T. (2018). *Closing the Medicare Part D coverage gap: Trends, recent changes, and what's ahead*. Kaiser Family Foundation (KFF). <https://www.kff.org/medicare/issue-brief/closing-the-medicare-part-d-coverage-gap-trends-recent-changes-and-whats-ahead/>.
- Downing, J. (2016). The health effects of the foreclosure crisis and unaffordable housing: A systematic review and explanation of evidence. *Social Science & Medicine, 162*. <https://doi.org/10.1016/j.socscimed.2016.06.014>
- Ebrahimi, Z. (2019a). How do retirees' spending patterns change over time?. In *Employee benefit research Institute (EBRI)* (492nd ed.) https://www.ebri.org/docs/default-source/ebri-issue-brief/ebri_ib_492_spendingovertime-3oct19.pdf?sfvrsn=9f503c2f_10#:~:text=On%20average%2C%20across%20all%20observed,an%20average%20of%20%2436%2C000%20vs.
- Ebrahimi, Z. (2019b). *Spending Patterns of older households (EBRI issue brief, No. 480)*. Employee Benefit Research Institute (EBRI). <https://www.ebri.org/content/spending-patterns-of-older-households>.
- Federal Interagency Forum (Forum) on Aging-Related Statistics. (2020). *Older Americans 2020: Key Indicators of well-being* (aging stats). Federal interagency Forum on aging-related statistics. <https://agingstats.gov/>.
- Fong, J. H. (2019). Out-of-pocket health spending among Medicare beneficiaries: Which chronic diseases are most costly? *PLoS One, 14*(9). <https://doi.org/10.1371/journal.pone.0222539>
- Forbes, M. K., & Krueger, R. F. (2019). The Great recession and mental health in the United States. *Clinical Psychological Science: A Journal of the Association for Psychological Science, 7*(5), 900–913. <https://doi.org/10.1177/2167702619859337>
- Forum on Medical and Public Health Preparedness for Catastrophic Events, Board on Health Sciences Policy, Board on Health Care Services, & Institute of Medicine. (2014). Key features of the affordable care Act by year. In *The impacts of the affordable care Act on preparedness resources and programs: Workshop summary*. National Academies Press (US). <https://www.ncbi.nlm.nih.gov/books/NBK241401/?report=classic>.
- Friedman, E. M., Houle, J. N., Cagney, K. A., Slaughter, M. E., & Shih, R. A. (2020). The foreclosure crisis, community change, and the cognitive health of older adults. *The Journals of Gerontology: Series B, 75*. <https://doi.org/10.1093/geronb/gbaa047>
- Harrell, R. (2011). *State housing profiles: Housing conditions and affordability for the older population*. Public Policy Institute. https://assets.aarp.org/rgcenter/ppi/liv-com/AARP_Housing2011_Full.pdf.
- Heeringa, S., & Connor, J. (1995). *Technical Description of the Health and retirement study sample design (technical description of the health and retirement study sample design)*. Institute for Social Research, University of Michigan. <https://hrs.isr.umich.edu/publications/biblio/5310>.
- Heggebo, K., Tøge, A. G., Dahl, E., & Berg, J. E. (2019). Socioeconomic inequalities in housing during the Great recession: A scoping review of the research literature. *Scandinavian Journal of Public Health, 47*(6), 635–654. <https://doi.org/10.1177/1403494818801637>
- Herbert, C., & Apgar, W. (2010). Report to congress on the root causes of the foreclosure crisis. US department of housing and urban development (HUD): Office of policy development and research. SSRN *Electronic Journal*. <https://doi.org/10.2139/ssrn.1582496>
- Houle, J. N., & Keene, D. E. (2015). Getting sick and falling behind: Health and the risk of mortgage default and home foreclosure. <https://doi.org/10.1136/jech-2014-204637>.
- Housing and Urban Development (HUD). (2020). *Glossary of terms to affordable housing—HUD*. HUD Archives. <https://archives.hud.gov/local/nv/goodstories/2006-04-06glos.cfm>.
- Hu, B. (2022). Older renters of color have experienced high rates of housing insecurity during the pandemic. *Housing perspectives | joint center for housing studies*. <https://www.jchs.harvard.edu/blog/older-renters-color-have-experienced-high-rates-housing-insecurity-during-pandemic>.
- JCHS, J. C. for H. S. (2020). *The state of the Nation's housing 2020*. Harvard University. https://www.jchs.harvard.edu/sites/default/files/reports/files/Harvard_JCHS_The_State_of_the_Nations_Housing_2020_Report.pdf.
- Johnson, R. W. (2009). *Rising senior Unemployment and the Need to Work at older ages (the retirement policy program)*. Urban Institute. <https://www.urban.org/sites/default/files/publication/30676/411964-Rising-Senior-Unemployment-and-the-Need-to-Work-at-Older-Ages.PDF>.
- Joint Center for Housing Studies. (2020). *The state of the Nation's housing 2020*. Harvard University. https://www.jchs.harvard.edu/sites/default/files/reports/files/Harvard_JCHS_The_State_of_the_Nations_Housing_2020_Report.pdf.
- Joint Center for Housing Studies (JCHS). (2019). *Housing America's older adults 2019*. Harvard University. <https://www.jchs.harvard.edu/housing-americas-older-adults-2019>.
- Kahn, J. R., & Pearlman, L. I. (2006). Financial strain over the life course and health among older adults. *Journal of Health and Social Behavior, 47*(1), 17–31. <https://doi.org/10.1177/002214650604700102>
- Kaiser Family Foundation (KFF). (2021). *An overview of the Medicare Part D prescription drug benefit*. October 13. Kaiser Family Foundation <https://www.kff.org/medicare/fact-sheet/an-overview-of-the-medicare-part-d-prescription-drug-benefit/>.
- Kaiser Family Foundation (KFF). (2023). Status of state Medicaid expansion decisions. February 16 <https://www.kff.org/medicaid/issue-brief/status-of-state-medicicaid-expansion-decisions-interactive-map/>.
- Kang, H., Lobo, J. M., Kim, S., & Sohn, M.-W. (2018). Cost-related medication non-adherence among U.S. adults with diabetes. *Diabetes Research and Clinical Practice, 143*. <https://doi.org/10.1016/j.diabres.2018.06.016>
- Kennedy, J., & Wood, E. G. (2016). Medication costs and adherence of treatment before and after the affordable care Act: 1999–2015. *American Journal of Public Health, 106*(10). <https://doi.org/10.2105/AJPH.2016.303269>
- Kochhar, R., & Cilluffo, A. (2017). *How wealth inequality has changed in the U.S. since the Great Recession, by race, ethnicity and income*. Pew Research Center. <https://www.pewresearch.org/fact-tank/2017/11/01/how-wealth-inequality-has-changed-in-the-u-s-since-the-great-recession-by-race-ethnicity-and-income/>.

- Kushel, M. B., Gupta, R., Gee, L., & Haas, J. S. (2006a). Housing instability and food insecurity as barriers to health care among low-income Americans. *Journal of General Internal Medicine*, 21(1), 71–77. <https://doi.org/10.1111/j.1525-1497.2005.00278.x>. PubMed.
- Kushel, M. B., Gupta, R., Gee, L., & Haas, J. S. (2006b). Housing instability and food insecurity as barriers to health care among low-income Americans. *Journal of General Internal Medicine*, 21(1), 71–77. <https://doi.org/10.1111/j.1525-1497.2005.00278.x>. PubMed.
- Laderman, Elizabeth, & Reid, Carolina. The untold costs of subprime lending: examining the links among higher-priced lending, foreclosures and race in California, No 2009-09. <https://EconPapers.repec.org/RePEc:fip:fedfcw:2009-09>.
- Lago-Hernandez, C., Nguyen, N. H., Khara, R., Loomba, R., Asrani, S. K., & Singh, S. (2021). Cost-related nonadherence to medications among US adults with chronic liver diseases. *Mayo Clinic Proceedings*, 96(10), 2639–2650. <https://doi.org/10.1016/j.mayocp.2021.02.026>
- Lee, S.-J., & Ahn, M. (2015). Housing affordability challenges for U.S. Baby boomers resulting from the 2009 recession. *Housing and Society*, 40, 85–109. <https://doi.org/10.1080/08882746.2013.11430610>
- Lee, S., Jiang, L., Dowdy, D., Hong, Y. A., & Ory, M. G. (2019). Attitudes, beliefs, and cost-related medication nonadherence among adults aged 65 or older with chronic diseases. *Preventing Chronic Disease*, 15. <https://doi.org/10.5888/pcd15.180190external>
- Liu, Y., & Eicher-Miller, H. A. (2022). Cost-attributed medical care disruptions are a concern among US adults with food insecurity during the COVID-19 pandemic. *American Journal of Public Health*, 112(6), 823–825. <https://doi.org/10.2105/AJPH.2022.306851>
- Lu, Z. K., Xiong, X., Brown, J., Horras, A., Yuan, J., & Li, M. (2021). Impact of cost-related medication nonadherence on economic burdens, productivity loss, and functional abilities: Management of cancer survivors in medicare. *Frontiers in Pharmacology*, 12, Article 706289. <https://doi.org/10.3389/fphar.2021.706289>
- Mackenzie, S. (2008). The impact of the financial crisis on older Americans. http://www.aarp.org/money/budgeting-saving/info-12-2008/i19_crisis.html.
- Margerison-Zilko, C., Goldman-Mellor, S., Falconi, A., & Downing, J. (2016). Health impacts of the Great recession: A critical review. *Current Epidemiology Reports*, 3(1), 81–91. <https://doi.org/10.1007/s40471-016-0068-6>
- Mather, M. (2015). *Effects of the Great Recession on older Americans' Health and well-being* (Today's Research on Aging). <https://www.prb.org/todays-research-aging-great-recession-2/>.
- Medicare.gov. (2021). Costs in the coverage gap. <https://www.medicare.gov/drug-coverage-part-d/costs-for-medicare-drug-coverage/costs-in-the-coverage-gap>.
- Moffitt, R. A. (2013). The Great Recession and the Social Safety Net. *The Annals of the American Academy of Political and Social Science*, 650(1), 143–166. <https://doi.org/10.1177/0002716213499532>
- Naci, H., Soumerai, S. B., Ross-Degnan, D., Zhang, F., Briesacher, B. A., Gurwitz, J. H., & Madden, J. M. (2014). Medication affordability gains following Medicare Part D are eroding among elderly with multiple chronic conditions. *Health Affairs*, 33(8). <https://doi.org/10.1377/hlthaff.2013.1067>
- Patel, M. R., Piette, J. D., Resnicow, K. R., Kowalski-Dobson, T., & Heisler, M. (2016). Social Determinants of Health, Cost-related Nonadherence, and Cost-reducing Behaviors Among Adults With Diabetes: Findings From the National Health Interview Survey. *Medical Care*, 54(8). <https://doi.org/10.1097/MLR.0000000000000565>
- Piette, J. D., Heisler, M., & Wagner, T. H. (2004a). Cost-related medication underuse among chronically ill adults: The treatments people forgo, how often, and who is at risk. *American Journal of Public Health*, 94(10). <https://doi.org/10.2105/ajph.94.10.1782>
- Piette, J. D., Heisler, M., & Wagner, T. H. (2004b). Problems paying out-of-pocket medication costs among older adults with diabetes. *Diabetes Care*, 27(2). <https://doi.org/10.2337/diacare.27.2.384>
- Piette, J. D., Rosland, A. M., Silveira, M. J., Hayward, R., & McHorney, C. A. (2011). Medication cost problems among chronically ill adults in the US: Did the financial crisis make a bad situation even worse? *Patient Preference and Adherence*, 5, 187–194. <https://doi.org/10.2147/PPA.S17363>
- Pollack, C. E., Griffin, B. A., & Lynch, J. (2010). Housing affordability and health among homeowners and renters. *American Journal of Preventive Medicine*, 39(6). <https://doi.org/10.1016/j.amepre.2010.08.002>
- Pollack, C. E., & Lynch, J. (2011). Health Status of People Undergoing Foreclosure in the Philadelphia Region. <https://doi.org/10.2105/AJPH.2009.161380>.
- Purcell, P. J. (2012). *Income Replacement Ratios in the Health and Retirement Study* (Social Security Bulletin, Vol. 72). Office of Research, Evaluation, and Statistics, Office of Retirement and Disability Policy, Social Security Administration Division of Policy Evaluation. <https://www.ssa.gov/policy/docs/ssb/v72n3/v72n3p37.html>.
- Rodgers, J., Briesacher, B. A., Wallace, R. B., Kawachi, I., Baum, C. F., & Kim, D. (2019). County-level housing affordability in relation to risk factors for cardiovascular disease among middle-aged adults: The National Longitudinal Survey of Youths 1979. *Health & Place*, 59, Article 102194. <https://doi.org/10.1016/j.healthplace.2019.102194>
- Routhier, G. (2019). Beyond Worst Case Needs: Measuring the Breadth and Severity of Housing Insecurity Among Urban Renters. *Housing Policy Debate*, 29(2), 235–249. <https://doi.org/10.1080/10511482.2018.1509228>
- Servais, M. (2010). *Overview of HRS public data files for cross-sectional and longitudinal analysis*. Institute for Social Research, University of Michigan. <https://hrs.isr.umich.edu/publications/biblio/5835>.
- Shelton, A. (2008). A First Look at Older Americans and the Mortgage Crisis. https://assets.aarp.org/rgcenter/econ/i9_mortgage.pdf.
- Singh, A., Daniel, L., Baker, E., & Bentley, R. (2019). Housing Disadvantage and Poor Mental Health: A Systematic Review. *American Journal of Preventive Medicine*, 57(2), 262–272. <https://doi.org/10.1016/j.amepre.2019.03.018>
- Sonnega, A., Faul, J. D., Ofstedal, M., Langa, K. M., Phillips, J. W., & Weir, D. R. (2014). Cohort Profile: The Health and Retirement Study (HRS). *International Journal of Epidemiology*, 43(2). <https://doi.org/10.1093/ije/dyu067>
- Soumerai, S. B., Pierre-Jacques, M., Zhang, F., Ross-Degnan, D., Adams, A. S., Gurwitz, J., Adler, G., & Safran, D. G. (2006). Cost-related medication nonadherence among elderly and disabled medicare beneficiaries: A national survey 1 year before the medicare drug benefit. *Archives of Internal Medicine*, 166(17), 1829–1835. <https://doi.org/10.1001/archinte.166.17.1829>
- The National Bureau of Economic Research. (2022). *The NBER's business cycle dating procedure: Frequently asked questions*. NBER. <https://www.nber.org/research/business-cycle-dating>.
- The National Low Income Housing Coalition. (2016). *The Gap: The Affordable Housing Gap Analysis 2016* (A Shortage of Affordable Homes 2020). <https://spotlighntonpoverty.org/news/the-gap-the-affordable-housing-gap-analysis-2016/>.
- Tsai, A. C. (2015). Home Foreclosure, Health, and Mental Health: A Systematic Review of Individual, Aggregate, and Contextual Associations. *PLoS One*, 10(4), Article e0123182. <https://doi.org/10.1371/journal.pone.0123182>
- US Bureau of Labor Statistics (BLS). (2012). The Recession of 2007–2009: BLS Spotlight on Statistics. <https://www.bls.gov/spotlight/2012/recession/>.
- Zhang, J., Bhaumik, D., & Meltzer, D. (2022). Decreasing rates of cost-related medication non-adherence by age advancement among American generational cohorts 2004–2014: A longitudinal study. *BMJ Open*, 12(5), Article e051480. <https://doi.org/10.1136/bmjopen-2021-051480>
- Zivin, K., Ratliff, S., Heisler, M. M., Langa, K. M., & Piette, J. D. (2010). Factors influencing cost-related nonadherence to medication in older adults: A conceptually based approach. *Value in Health: The Journal of the International Society for Pharmacoeconomics and Outcomes Research*, 13(4). <https://doi.org/10.1111/j.1524-4733.2009.00679.x>