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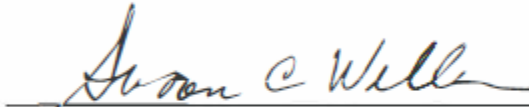
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Essays on the impact of housing insecurity and other socioeconomic factors on health-related outcomes among Medicare beneficiaries during the Great Recession

by

Monica Hernandez, MPH

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Dedication

To my family and friends who have supported me on my personal, academic, and professional journey. Thank you for your constant love and encouragement. Most importantly, to my God who has given me all that I need, including the wisdom, peace and guidance, to complete this degree.

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Essays on the impact of housing insecurity and other socioeconomic factors on health-related outcomes among Medicare beneficiaries during the Great Recession

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Monica Hernandez, PhD

The University of Texas Medical Branch, 2023

Supervisor: Neil Mehta

While previous recessions have informed much of our modern-day fiscal policy, they have informed less of relevant housing or healthcare policies focused on preventing or mitigating the effects of housing insecurity during economic crises. In this dissertation, I drew from nationally representative Health and Retirement Study (HRS) data to evaluate the role of housing insecurity on healthcare and health outcomes among Medicare beneficiaries ages 65+ during the Great Recession (2008-2012). In Paper 1, I assessed associations between housing insecurity and foregone medication due to cost. Findings indicated a greater odds of foregone medication among individuals experiencing onset versus persistent housing insecurity, suggesting that unexpected acute economic shocks leave households with little time to adapt and lead to forced trade-offs in basic needs. Guided by the disparities literature, in Paper 2, I examined racial differences in foregone medication among non-Hispanic White (NHW) and Black (NHB) beneficiaries during the 2008 Recession peak to evaluate the extent to which housing insecurity and predisposing, need-based and enabling factors within Andersen's healthcare utilization model explained the Black-White racial difference. Findings indicated statistically significant associations between race and

foregone medication that were explained with the addition of non-housing wealth. These findings suggest wealth was a stronger driver of racial disparities in foregone medication than housing insecurity during the Recession. Guided by stress-health frameworks, in Paper 3, I examined the association of housing insecurity with depressive symptoms among Medicare beneficiaries during the Recession and further assessed the extent to which Andersen's factors explained this relationship. Findings indicated that baseline housing insecurity had a positive yet insignificant effect on average depressive symptoms during 2008-2012, however, this relationship became negative and significant with the addition of baseline wealth and tenure status, suggesting the strong confounding effect of these variables on the role of housing insecurity on depression. In summary, the three papers fill important gaps in our understanding of the health effects of the Great Recession, including the extent to which housing insecurity was associated with foregone medication due to cost and depression as well as how patterns in forgone medication differed by race and other socioeconomic characteristics.

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List of Abbreviations

CES-D   Center for Epidemiological Studies Depression scale

CRN   Cost-Related Treatment Non-Adherence

GEE   Generalized Estimating Equations

HMO   Health Maintenance Organization

HRS   Health and Retirement Study

HUD   U.S. Department of Housing and Urban Development

LMM   Linear Mixed Methods

MI   Multiple Imputation

NHB   Non-Hispanic Black

NHW   Non-Hispanic White

SES   Socioeconomic Status

Chapter 1 (Overview)

INTRODUCTION

Widespread health and financial distress witnessed during the recent COVID-19 pandemic recession is not a new phenomenon. Previous recessions from the Great Depression of 1929-1939 to the 1990-1991, 2001-2003, and 2007-2009 recessions possessed varying characteristics and dynamics yet all disproportionately threatened the health and livelihood of at-risk racial/ethnic minorities and low-income populations (Airgood-Obrycki & Hermann, 2022; Bennett & Kochhar, 2019; Bertoldo et al., 2022; Hu, 2022; Whitney, 2023; Williams & Rudowitz, 2022). Despite federal housing assistance relief efforts, housing hardship or difficulty paying for housing, has been observed throughout all recessions, most notably, during the 2007-2009 housing crisis, formally known as the Great Recession of 2008 (Anderson & Gascon, 2011; Congressional Budget Office, 2015; Consumer Financial Protection Bureau, 2021; Moffitt, 2013; Peter G. Peterson Foundation, 2022).

While previous recessions have collectively informed much of my modern-day fiscal policies (e.g. labor market, tax and interest rates), they have informed less of relevant housing or healthcare policies focused on preventing and/or mitigating the effects of housing hardship among at-risk populations who often turn to emergency savings or family and friends for help during economic crises (Anthony, 2018; Consumer Financial Protection Bureau, 2021; Ingham, 2023; Sheiner, 2020). Such populations include older adults aged 65+ prone to low social security incomes and declining retirement savings along with high out-of-pocket costs and "donut hole" drug coverage gaps in which Medicare part D beneficiaries who reach a certain threshold in annual expenditures on their drug plan pay up to 25% of brand name and generic drug costs ($4,660 in 2023) (Centers for Disease Control and Prevention (CDC), 2022; Damico

et al., 2018; Ebrahimi, 2019b; Fong, 2019; Kaiser Family Foundation (KFF), 2021; Mather, 2015; Medicare.gov, 2021; Naci et al., 2014). Therefore, the overall goal of this dissertation is to inform members of the academic, policy, housing and healthcare communities on relevant research, policies and interventions to support older adults 65+ at-risk for housing hardship during economic crises. To achieve this goal, I present three papers, all drawn from nationally representative Health and Retirement Study (HRS) data, to evaluate the role of housing hardship and other socioeconomic factors on health and healthcare utilization outcomes among Medicare beneficiaries during and over the course of the Great Recession of 2008.

BACKGROUND

Understanding the Great Recession

Between 2001-2004, the U.S. Federal Reserve lowered interest rates in an effort to stimulate the economy and homeownership rates among U.S. adults (Federal Reserve Bank of St. Louis, 2020; Joint Center for Housing Studies (JCHS), 2009; United States: Financial Crisis Inquiry Commission, 2011; Weinberg, 2013). Cheap lending followed among lender financial institutions which relaxed downpayment and debt-to-income requirements on low-interest mortgage loans to at-risk homeowners with below average credit histories. However, high inflation in mid-2004 led the Reserve to raise interest rates between 2004 and 2006. As interest rates rose, homeowners were stuck with high-risk, subprime mortgage loans they could no longer afford and were forced to subsequently sell or undergo a home foreclosure. Therein began the housing bubble burst and subsequent peak of the Great Recession between 2007 to 2009 which severely shocked the U.S. housing and financial markets. Even renters whose landlord underwent a foreclosure were at risk of losing their security deposit and receiving short to no notice of eviction. Subsequent displacement left renters with few resources to turn to relative to

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their homeowner counterparts (Martin, 2010). Unemployment rates reached its highest rate in 26 years (9.7% in 2009), leaving 14.9 million adults jobless (R. W. Johnson, 2009; US Bureau of Labor Statistics (BLS), 2012). Susceptible groups such as women, racial/ethnic minorities, and persons of low socioeconomic status (SES) experienced significant declines in income, wealth, retirement savings, and health insurance coverage (Karahan & Rhee, 2020; Laderman, 2020; US Bureau of Labor Statistics (BLS), 2012). Dramatic drops in employment and housing prices between 2005 and 2008 increased foreclosures around the country, with residents in the four "sand states" (Arizona, California, Florida, and Nevada) facing the highest foreclosure rates in the country (Harrell, 2011; Herbert & Apgar, 2010; Urban Institute, 2017).

Coupled with widespread unemployment, risky lending practices targeted at increasing homeownership rates among low-income racial and ethnic minorities placed them at especially high risk of financial hardship during the Recession (Herbert & Apgar, 2010; Joint Center for Housing Studies (JCHS), 2009, p. 200; Reid & Laderman, 2009). For instance, relative to their White counterparts, Hispanic and Black borrowers were 30% more likely to receive subprime loans (Blacks: 48%, Hispanics: 47%, Whites: 17%) in 2007, possess higher loan-to-income ratios (Hispanics=2.9; Blacks=2.8; Whites=2.5) and annual percentage rates (APRs) that were respectively up to 2.5 and 3 percentage points higher than the standard rates offered on a typical 30-year fixed-rate conventional mortgage (Kochhar et al., 2009; Laderman, 2020; US Federal Reserve, 2010).

While foreclosure rates were three times higher among adults under versus over 50 years (respectively, 74.4% vs 25.6%), older adults aged 50+ still accounted for 28% (684,000) of all delinquencies or foreclosures in the country by the end of 2007 (Mackenzie, 2008; Shelton, 2008). High foreclosure rates paralleled high unemployment among older adults with evidence

indicating that nearly two-thirds of all working older adults aged 55+ lost their job in manufacturing, construction, wholesale and retail trade, education, or professional service industries (R. Johnson et al., 2008; R. W. Johnson, 2009; Joint Center for Housing Studies (JCHS), 2009). Such loss shifted older adult's spending patterns and retirement savings including the ability to supplement Social Security income and provide a financial safety net for their household members, in turn, elevating psychological distress at older ages (Ailshire, 2013; Federal Interagency Forum on Aging-Related Statistics, 2020; R. Johnson et al., 2008; R. W. Johnson, 2009; Mackenzie, 2008; Mather, 2015; Purcell, 2012). Related decisions on delaying retirement among pre-retirees or returning to the labor force among retirees (i.e. reverse retirement) were also impacted by unstable labor and financial markets during the Recession (R. Johnson et al., 2008; R. W. Johnson, 2009; Mackenzie, 2008; Mather, 2015; Zhao & Burge, 2021).

Housing insecurity during the Great Recession

As previously discussed, much is known about Recession-related income, wealth, employment losses among the general and older adult population (Alley et al., 2011; Cox et al., 2017; Houle & Keene, 2015). However, relatively less is known on Recession-related "housing insecurity", formally defined by U.S. Department of Housing and Urban Development (HUD) as spending more than 30% of monthly household income on housing costs (Harrell, 2011; Housing and Urban Development (HUD), 2020). Recession-related studies have examined other aspects of housing hardship, most notably, fluctuating housing price dynamics, foreclosures and evictions, homelessness, frequent moves, inadequate housing conditions, and/or self-reported housing affordability issues in the general population (Bhat et al., 2022; Blazer et al., 2007; Burgard et al., 2012; Cutler & Sportiche, 2022; Downing, 2016; Housing and Urban

Development (HUD), 2020; Kim & Burgard, 2022; Singh et al., 2019; Tsai, 2015; Wilkinson, 2016; Yue & Ponce, 2021). By employing the formal HUD housing insecurity definition to understand the overall impacts of housing hardship I am able to capture a wider set of households that face insecurity, rather than only those experiencing foreclosures, evictions, etc. during the Recession.

Housing insecurity and poor health

Understanding the health impacts of housing insecurity is important given evidence that housing affordability issues during the Recession accompanied a proliferation of stressors, both globally and domestically, including reduced spending on food and medical care and a broad spectrum of mental and physical health issues (Ailshire, 2013; Baker et al., 2016; Caswell & Zuckerman, 2018; Friedman et al., 2020; Kingsley et al., 2009; Mackenzie, 2008; Martin, 2010; Mather, 2015; Pollack et al., 2010; Rodgers et al., 2019; Ross & Squires, 2011). For example, nationally representative studies indicate a 45-75% higher incidence of depressive symptoms among older adults aged 50+ who experienced increased foreclosures between pre and post-Recession periods (respectively, 2005-2006 and 2010-2011) as indicated by increased default notices, auctions, and real-estate ownership (respectively, OR: 1.75; 1.14-2.67; OR:1.45; 0.96-2.19; OR: 1.62, 1.06-2.47) (Cagney et al., 2014; Mehta et al., 2015; Pruchno et al., 2017).

The literature suggests that forgone medication mediated the relationship between housing hardships and poor health during the Recession, as described in the Conceptual Frameworks section below. While specific associations between Recession-related housing insecurity (using the HUD definition) and forgone medication have yet to be examined, increased forgone medication trends among low SES adults have been well-documented during and outside the Recession. For example, findings among a 2010 National Interview and Health

Study (NHIS) sample of adults 18-64 years indicated that the likelihood of forgone medication due to cost during the Recession was three times higher among uninsured versus Medicaid insured adults (respectively, 26% vs. 9%), and up to six times higher among uninsured versus privately insured adults (respectively, 26% vs. 4%) (Center for Disease Control & Prevention (CDC), 2010; Moonesinghe et al., 2021). Similar findings from a 2017 NHIS study indicated that the odds of forgone medication due to cost, or cost-related treatment non-adherence (CRN), was highest among older adults aged 65+ with diabetes who were uninsured (AOR: 34.41, 2.14-53.65), female (AOR: 1.43, 0.84-2.45), mentally distressed (AOR: 2.33, 1.38-3.93) and obese (AOR: 3.84, 0.21- 72.02) (Chung et al., 2019; Kushel et al., 2006a; Pollack et al., 2010). In light of overall higher financial and housing hardship among racial/ethnic minorities during the Recession, few studies have examined racial differences in forgone medication patterns during the Recession especially among older adults aged 65+.

Cutting back on basic needs, including forgoing medication, is likely among older adults whose housing costs account for the largest portion of their total household expenditures. Nationally representative data indicates that, between 2005-2017, housing costs accounted for 40-46% of total household expenditures among older adults aged 50+, while healthcare, food and transportation each accounted for the next largest portions of total expenditures (respectively, between 8-16%) (Ebrahimi, 2019a). In 2017, this translated to older adults aged 50+ spending $18K-$25K on housing compared to $4.0K-4.1K on healthcare, $3.8K-$5.1K on food, and $3.6K-$7.6K on transportation (Ebrahimi, 2019a). Additional evidence from a 2018 Consumer Expenditure Survey (CE) indicates that housing insecure older adult headed households spent 31% less on healthcare and 21% less on food than their housing secure counterparts, with severely housing insecure older adult headed households spending up to 50% less on both

healthcare and food than their non-housing insecure counterparts (Joint Center for Housing Studies (JCHS), 2020). Despite this evidence, studies documenting forgone medication trends among housing insure older adults aged 65+ are largely missing from the literature. Such studies are important given that housing insecure older adults, especially Medicare beneficiaries, are very likely to forgo medication due to high out-of-pocket costs related to intensive medication use and donut hole coverage in which Medicare part D beneficiaries who reach a certain threshold in annual expenditures on their drug plan pay up to 25% of brand name and generic drug costs ($4,660 in 2023) (Medicare.gov, 2021).

Conceptual frameworks

Two theoretical frameworks, namely, Downing's Homeowner Distress Model and Andersen's Healthcare Utilization Model, may help elucidate mechanisms through which housing hardships impacted forgone medication and related mental health outcomes during the Recession (R. Andersen, 1968; Downing, 2016). As per Downing's model*,* pathways such as stress, effect-budgeting, frustration-aggression, and trust mediates the effect of homeowner financial distress on independent health-related outcomes including i) psychological and behavioral morbidities; ii) somatic morbidities and mortality; and iii) health services (Figure 11) (Downing, 2016). Of these, the stress mechanism has been the most widely cited in the literature with most studies focusing on the overall role of illness-related financial burden (stress) or perception of financial hardship (strain) on poor mental health (Hanratty et al., 2007). Nevertheless, the effect-budgeting mechanism is also well-established by evidence indicating that persons of low SES with fewer resources to budget are more likely to forgo medication and become ill especially during periods of prolonged financial hardship. Downing's model is the only attempt in the literature that I am aware of to propose a framework of mechanisms through

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which housing hardships impacted poor health during the Recession, yet it remains limited to homeowners upon which the model was initially based. Therefore, by expanding the model to both renters and homeowners, this study contributes an important understanding to the Recession-related health impacts of housing hardships among a wider U.S. population.

Relatedly, Andersen's model suggests that utilization of health care is interrelated to housing hardship and poor health via predisposing (e.g. demographics), enabling (e.g. family resources), and need-based factors (e.g. illness level), along with external environmental factors (e.g. housing and drug costs) as illustrated in Andersens' updated phase 4 model of healthcare utilization (Figure 5) (Aday et al., 1972; R. Andersen & Newman, 1973; Babitsch et al., 2012; Gelberg et al., 2000). Despite its vast application in the literature, most utilization studies have solely focused on individual rather than environmental-level factors driving utilization patterns including characteristics of the healthcare delivery system and/or the external environment (e.g. state or county-level healthcare policies) as shown in Andersen's updated phase 4 model of utilization (Figure 5) (R. M. Andersen, 1995; Gelberg et al., 2000; Heider et al., 2014; Phillips et al., 1998). Moreover, I am unaware of studies examining the relative contribution of predisposing, need-based, and enabling factors (other than health insurance coverage) driving disparities in forgone care during a time of peak economic distress. This may include a variety of factors such as out of pocket costs with coverage, renter versus homeownership status, low wealth levels and multiple chronic conditions. Therefore, applying Andersen's framework to study forgone medication patterns in the context of the Recession may help fill a literature gap in understanding the extent to which both individual and environmental-level drivers influenced disparities in forgone medication during the Recession.

THREE PAPERS

To summarize, my literature review identified a few salient research gaps in the

Recession-related health literature including a limited understanding on the extent to which i)

housing insecurity, as per the HUD definition, impacted health-related outcomes, namely

forgone medication due to cost and mental health outcomes, as well as ii) differences in forgone

medication patterns among Medicare beneficiaries aged 65+ during the Recession by

race/ethnicity & other demographic and socioeconomic characteristics. I adopted concepts from

Downing and Andersen's model to address these three gaps as described below.

Paper 1

The objective of Paper 1 was to measure the association between housing insecurity, as

per the HUD definition, and forgone medication due to cost among Medicare beneficiaries aged

65+ over the course of the Recession (2008-2012). This paper was primarily guided by

Downing's effect-budgeting mechanism, or the forced trade-offs between basic needs (i.e.,

housing and medical care) among older adults during the Recession including related evidence

indicating that persons of low SES with fewer resources to budget are more likely to forgo

medication and become ill especially during periods of prolonged financial hardship. Data came

from Medicare beneficiaries aged 65+ in the 2006 wave with non-missing covariates/exposure

variables and at least one measured outcome in any of the 2008, 2010, or 2012 waves. I

employed a series of four weighted longitudinal General Estimating Equation (GEE) models, on

both imputed and non-imputed data, to estimate the probability of forgone medications due to

cost as a function of housing insecurity changes between 2008 and 2012. Two-wave changes in

housing insecurity were defined as follows: i) No insecurity, ii) Persistent insecurity, iii) Onset

insecurity, and iv) Onset security. All models controlled for predisposing, enabling and need-

based determinants of healthcare utilization (R. M. Andersen, 1995). I hypothesized that, relative to other levels of housing insecurity, the odds of forgone medication would be generally higher for individuals experiencing *Persistent Insecurity* across two consecutive survey waves due to greater chronic health and financial strain. I further hypothesized that the odds associated with *Persistent Insecurity* would be most pronounced during the peak of the Recession (2008) compared to a few years after the Recession (respectively, 2010 and 2012) due to harder trade-offs across competing needs during periods of relatively higher economic distress and uncertainty.

Paper 2

The objective of Paper 2 was to i) identify differences in forgone medication due to cost among non-Hispanic White and Black (respectively, NHW and NHB) Medicare beneficiaries during the 2008 peak of the Great Recession and ii) evaluate predisposing, need-based and enabling factors that may help explain these differences. This paper was primarily guided by literature indicating the greater overall levels of financial hardship among minorities during the 2008 peak of the Recession as well as further exploration of other predisposing, need-based, and enabling factors (other than housing insecurity) influencing disparities in forgone medication during the Recession. Data came from NHW and NHB Medicare beneficiaries aged 65+ years in the 2006 wave who had non-missing study covariate, exposure and outcome data in the follow-up 2008 wave. I implemented six nested models to estimate the relationship between race and forgone medications due to cost in 2008. I hypothesized that the odds of forgone medication would be generally higher for NHB versus NHW adults during the peak of the Recession and that enabling factors would most explain this difference due to NHB adults' greater overall levels

of financial hardship during the Recession and subsequently lower safety net needed to prevent forced trade-offs between core health needs.

Paper 3

The objective of Paper 3 was to i) examine the association between baseline housing insecurity (2008), as per the HUD definition, and depressive symptoms among Medicare beneficiaries over the course of the Recession (2008-2012), and ii) assess the extent to which baseline predisposing, need-based and enabling covariates explained this relationship. This paper was primarily guided by literature documenting associations and pathways between housing/financial hardship and poor mental health, including Downing's stress mechanism, as well as further exploration of health-related outcomes (other than forgone medication) linked to housing insecurity during the Recession. Data came from Medicare beneficiaries aged 65+ in the 2006 wave with non-missing baseline covariates/exposure variables in 2008 and with at least one measured outcome in any of the 2008, 2010, or 2012 waves. I estimated six nested linear mixed models (LMM) to examine associations between baseline exposure & covariate variables and the number of depressive symptoms across all waves. I further assessed the roles of predisposing, need-based and enabling factors in explaining this relationship. I hypothesized that baseline housing insecurity would be associated with an increased depressive symptoms throughout the course of the Recession, and that enabling factors would explain this relationship due to neo-material pathways of material disadvantage linking poor health to housing insecurity and other indicators of financial hardship.

Chapter 2 (General Methods)

The following sections provide a brief overview of the methodology for all three dissertation papers. All papers relied on data from the Health and Retirement Study collected between 2006 and 2014. More detail can be found in each individual paper chapter (Chapters 3-5). This includes, but is not limited to, specific HRS waves used, sample inclusion and exclusion criteria and statistical analyses applied. Table 1 provides a master data dictionary containing detail on the exact variable question text and definition for each paper.

HRS DATASET

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 longitudinally every two years since 1992 and spans pre- and post-Recession time periods between 2006 and 2012 (Servais, 2010). Eligibility is determined from an initial 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). All interviews are available in English and Spanish and are based on a mixed-mode design where half the sample completes a telephone core interview, and the other half is either assigned to a face-to-face interview (FTF) with physical and biological measures or the enhanced FTF (EFTF) which includes a psychosocial questionnaire (J. Smith et al., 2017; Sonnega et al., 2014).

Data from HRS Tracker data as well as biennial RAND HRS Fat and Longitudinal files were used for this study (Bugliari et al., 2020; Servais, 2010). HRS tracker data contains cross-sectional weights, basic demographic and interview information for each respondent. RAND HRS Fat files contain raw, wave-specific HRS data for each household respondent including questions initially asked to the financial respondent only. RAND HRS Fat files are then merged to produce RAND HRS Longitudinal files containing clean and imputed variables across most HRS survey modules. RAND HRS Fat files are used for variables not found in the RAND Longitudinal files. All publicly available RAND HRS data can be accessed at the following link: https://hrsdata.isr.umich.edu/data-products/rand and HRS Tracker data can be accessed at the following link https://hrsdata.isr.umich.edu/data-products/cross-wave-tracker-file. STATA/SE version 17.0 was used for all paper analyses with SAS version 9.4 used only for initial imputation and derivation of valid inferences in Paper 1. The HRS is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.

PAPER 1 METHODS

The focus of Paper 1 in this study was to measure the association between housing insecurity, as per the HUD definition, and forgone medication due to cost among Medicare beneficiaries aged 65+ over the course of the Recession (2008-2012). I conducted analyses on both non-imputed and imputed datasets (refer to Paper 1 for more detail on the imputation method). My final analytical sample with non-missing information on all study covariate and exposure (i.e., housing insecurity) variables and at least one measured outcome (i.e., forgone medication) in the follow-up waves (2008, 2010, and 2012) was n=8,889 on the imputed dataset n=5,469 on the non-imputed dataset. Descriptive statistics were generated for all study variables

including frequency tabulations for categorical variables and mean/standard deviation and median/range values for continuous variables across 2008, 2010, and 2012 waves. I employed a series of four weighted longitudinal General Estimating Equation (GEE) models, on both imputed and non-imputed data, to estimate the probability of forgone medications due to cost as a function of housing insecurity changes between 2008 and 2012. Odds ratios and 95% confidence intervals were generated for all GEE models to estimate forgone medication as a function of housing insecurity over the course of the Recession after controlling for select predisposing, enabling and need-based determinants of healthcare utilization.

PAPER 2 METHODS

The focus of Paper 2 in this study was to i) identify differences in forgone medication due to cost among non-Hispanic White and Black Medicare beneficiaries during the 2008 peak of the Great Recession and ii) evaluate the extent to which predisposing, need-based and enabling factors help to explain these differences. My final analytical sample of respondents (n=4,635) with non-missing exposure (i.e., race/ethnicity), outcome (i.e., forgone medication) and covariate data in the follow-up 2008 wave consisted of n=4,044 NHW and n=591 NHB respondents. I initially ran descriptive analyses separately by race for all study variables, estimating the Pearson's chi-square test for categorical variables and ANOVA test for continuous variables. I then implemented six nested logistic regression models to estimate the relationship between race and forgone medications due to cost in 2008 and further assessed the roles of predisposing, need-based and enabling factors in explaining the racial difference.

PAPER 3 METHODS

The focus of Paper 3 in this study was to i) examine the association between baseline (2008) housing insecurity, as per the HUD definition, and depressive symptoms among Medicare beneficiaries over the course of the Recession (2008-2012), and ii) assess the extent to which baseline predisposing, need-based and enabling covariates explained this relationship. My final analytical sample (n=4,991) with non-missing baseline study covariates, exposure (i.e., housing insecurity) and at least one measured outcome (i.e., number of depressive symptoms) in any of the three follow-up waves between 2008 and 2012 was as follows: n=4,961 in 2008; n=4,723 in 2010; and n=4,112 in 2012. This yielded n=13,796 total person-waves of data across all three waves. Descriptive statistics were generated for all study variables including frequency tabulations for categorical variables and mean/standard deviation and median/range values for continuous variables. Main analyses were based on a linear mixed methods (LMM) approach with evaluations for repeated observations over time from the same individual. I estimated six nested linear mixed models to examine associations between baseline housing insecurity & covariate variables and the number of depressive symptoms across all waves. I further assessed the roles of predisposing, need-based and enabling factors in explaining this relationship.

Table 1. Master data dictionary

Variable	Coding scheme	Description
Forgone medication due to cost	1=Yes 0=No	Defined by the question in RAND HRS Fat files asking, "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?" Note: Forgone medication question not exclusive to those reporting a health condition. Only asked to those reporting prescription drug coverage and/or taking prescription medication.
Housing insecurity (one-wave)	0=No 1=Yes	Defined by HUD housing insecurity index identifying respondents spending at least 30% of their monthly income on housing costs. Monthly household income is based on total respondent and spouse income reported in RAND HRS Longitudinal files 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. Monthly housing costs are based on monthly rent payments (for renters, as per RAND HRS Fat files) and based on primary residence mortgages and other home loans (for homeowners, as per RAND HRS Longitudinal files).
Housing insecurity (two-wave)	0=No insecurity 1=Persistent insecurity 2=Onset insecurity 3=Onset security	Used one-wave (yes/no) housing insecurity variable at each wave above to create a two-wave variable characterizing housing insecurity changes as follows: (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).

Each two-wave category referred to the "second wave" as the current wave and the "first wave" as the wave prior.

Race/ethnicity	0=White, non-Hispanic 1=Black, non-Hispanic	Defined by two questions provided in HRS Tracker file asking, "What race do you consider yourself to be: White, Black or African American, American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander, or something else?" *and* "Do you consider yourself Hispanic or Latino?".
Age	Years (continuous)	Based on self-reported age (years) in RAND HRS Longitudinal files among adults aged 65+ years at baseline (2006).
Gender	0=Male 1=Female	Interviewer-assessed gender from HRS Tracker file.
US-born	0=Yes 1=No	Based on response provided in the in HRS Tracker file.
Education	0= No degree 1=High school grad/GED 2= Some college/Associates 3=Bachelors or higher	Based on responses of highest degree earned and years of education in RAND HRS Longitudinal files,
Census region	0=Northeast 1=Midwest 2=South 3=West	Based on responses to Cross-Wave Census Region/Division file provided in the RAND HRS Longitudinal files.
Tenure	0=Homeowner 1=Renter	Defined by the question in RAND HRS Fat files asking, "Do you [and your] [you/husband/wife/partner] own your home, rent it, or what?".

		Note: Few had another living situation (i.e., living with relatives/friend). Most "others" were institutionalized adults which were removed when model was weighted (pweight>0).
Disease status	0= Neither diabetes nor hypertension 1= Diabetes only 2= Hypertension only 3= Diabetes and hypertension	Defined by questions in RAND HRS Longitudinal files asking: "Whether or not a doctor has told respondent that s/he had [diabetes and/or hypertension] since the last interview" *or* "Whether or not a respondent has ever reported having [diabetes and/or hypertension]".
Depressive symptoms	CES-D scale (count)	Depressive symptoms were defined in the RAND HRS by the eight-item version of the Center for Epidemiologic Studies Depression (CES-D) scale asking respondents a series of eight (yes/no) questions on their depressive symptoms in the past week including feeling depressed, feeling activities were an effort, restless sleep, feeling happy, lonely, sad, getting going, and enjoying life. Responses were summed to obtain a number of depressive symptoms, for a total score ranging from 0 to 8, with higher score suggesting individuals with a greater risk of depression.
Depression status	0=Low depressive symptoms (0 to 3) 1=High depressive symptoms (4 to 8)	Applied a 4+ symptom cut-off value to responses on eight-item CES-D scale with 0 to 4 symptoms indicative of low depressive symptoms and 5 to 8 symptoms indicative of high depressive symptoms. Note: A 4+ symptom cut-off value is comparable to the 16+ symptom cut-off value validated under the longer traditional 20-item CES-D scale (Radloff, 1977).
Non-housing wealth	($ amount) 0=Q1, lowest 1=Q2	Defined as the total sum of the following self-reported components in RAND HRS Longitudinal files: o Net value of real estate

	2=Q3 3=Q4, highest	o Net value of vehicles o Net value of businesses o Net value of IRA, Keogh accounts o Net value of stocks, mutual funds, and investment trusts o Value of checking, savings, or money market accounts o Value of CD, government savings bonds, and T-bills o Net value of bonds and bond funds o Net value of all other savings Minus: o Value of other debt
Out-of-pocket medical expenditures	($ amount) 0=Q1, lowest 1=Q2 2=Q3 3=Q4, highest	Defined as the total sum of the following self-reported components in RAND HRS Longitudinal files: o Hospital costs o Nursing home costs o Doctor visits costs o Dentist costs o Outpatient surgery costs o Average monthly prescription drug costs o Home health care costs o Special facilities costs o Other
Health insurance	0=No Medicare 1=Medicare only (neither Medicaid nor HMO) 2=Medicare with Medicaid (no HMO) 3=Medicare with HMO (regardless Medicaid)	Defined by series of questions in RAND HRS Longitudinal and Fat files asking, "Are you currently covered by [Medicare/Medicaid]?" *and* "Do you receive your [Medicare/Medicaid] benefits through an HMO, that is a Health Maintenance Organization? With an HMO, the cost of a doctor's visit is typically covered in full or you pay only a small amount. All of your routine care must be provided by an HMO physician."

Chapter 3 (Paper 1)- In the wake of a crisis: Caught between housing and healthcare

INTRODUCTION

In a U.S. Federal Reserve effort to stimulate the economy and homeownership rates among U.S. adults between 2001-2004, lender financial institutions initiated cheap lending practices including relaxed downpayment and debt-to-income requirements on low-interest mortgage loans to at-risk homeowners with below average credit histories (Federal Reserve Bank of St. Louis, 2020; Joint Center for Housing Studies (JCHS), 2009; United States: Financial Crisis Inquiry Commission, 2011; Weinberg, 2013). However, high inflation in mid-2004 prompted the Reserve to raise interest rates between 2004 and 2006, leaving homeowners with high-risk, subprime mortgage loans they could no longer afford and forcing them to sell or undergo a home foreclosure. Therein began the housing bubble burst and subsequent peak of the Great Recession between 2007 to 2009 which severely shocked the U.S. housing and financial markets.

In response to disrupted housing and financial markets, 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; R. W. Johnson, 2009; Reid & Laderman, 2009; US Bureau of Labor Statistics (BLS), 2012). Economic shocks during the Recession impacted both younger and older adults. Increased financial hardship in 2007 led to delinquent mortgage payments and/or foreclosures among 72% of adults under 50 years (i.e. 1,604,719 delinquencies and 145,300 foreclosures) and 28% of adults aged 50+ (i.e. 634,075 delinquencies and 49,980 foreclosures) (Shelton, 2008). Increased financial hardship during the

Recession also led to housing hardship among 36% and 52% of adults aged 50+ who struggled to pay for housing, or were "housing insecure", defined by U.S. Department of Housing and Urban Development (HUD) as spending more than 30% of monthly household income on housing costs (Harrell, 2011; Housing and Urban Development (HUD), 2020).

Housing hardship during the Recession was accompanied by elevated physical and, especially, mental health conditions, both globally and domestically (Bhat et al., 2022; Heggebø et al., 2019; Margerison-Zilko et al., 2016; Singh et al., 2019; Tsai, 2015). Housing hardship and poor health during the Recession may have been linked through shifts in healthcare utilization patterns, as suggested by the literature, including greater propensity to use outpatient and emergency room visits and forgone medication due to cost, also known as cost-related treatment non-adherence (CRN) (Alnijadi et al., 2021; Caswell & Zuckerman, 2018; J. Chen et al., 2014; Currie & Tekin, 2015; Downing, 2016; Kushel et al., 2006b). Despite such evidence, Downing's Homeowner Distress Model is the only attempt in the literature that I am aware of to propose a framework of mechanisms through which housing hardship may have impacted forgone medication and poor health during the Recession (Downing, 2016). These include stress, effect-budgeting, frustration-aggression, and trust.

Few studies have applied Downing's model to study the extent to which housing hardship during the Recession led to effect-budgeting, or the forced trade-offs between basic needs (i.e., housing and medical care) among older adults. These studies are important given evidence from the 2018 Consumer Expenditure Survey (CE) indicating that households headed by housing-insecure adults aged 65+ spent 31% less on healthcare and 21% less on food than their counterparts under 65 years (Joint Center for Housing Studies, 2020). Most susceptible to such trade-offs are older low-income adults, among these the oldest old. For example, according to a

2017 HRS sample, low-income adults aged 75+ spent 48.8% of their income on housing costs

relative their 50-64 and 65-74 year old counterparts who respectively spent 47.3% and 45.8% of

their income on housing costs (Ebrahimi, 2019a). This compared to spending patterns among

older high-income adults aged 75+, 50-64, and 65-74 years from the same HRS sample who

respectively spent 41.4%, 44.2%, and 43.9% of their income on housing costs.

In line with Downing's model, persons of low SES with fewer resources to budget are

more likely to forgo medication and become ill especially during periods of prolonged financial

hardship. For instance, one study among older adult Medicare beneficiaries showed that

persistent financial hardship over the life course had more of a deleterious effect on

beneficiaries' physical and mental health outcomes than episodic financial hardship in a single

period of the life course (Kahn & Pearlin, 2006). Such findings also align with the theory of

cumulative disadvantage (CAD) positing that population-level health variation springs from

systematic differences in given characteristics overtime (e.g.: money, status, etc.) (Dannefer,

1987, 2003; O'Rand, 1996). Related literature has found that forgone medication 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., 2004b, 2004a; Soumerai et

al., 2006; Zhang et al., 2022; Zivin, Ratliff, et al., 2010). Moreover, elevated rates of forgone

medication during the peak of the Recession were observed among chronically ill older adults.

One-third (30.3%) of chronically ill adults aged 65+ from a Harris Interactive Chronic Illness

Panel (CIP) sample reported forgone medication in 2008, representing a nearly two-fold increase

(12.6%) in forgone medication rates among respondents from the year prior (Piette et al., 2011).

In this same sample, forgone medication in 2008 was even more frequent among 28.7% of

retirees, 34% of employed, and 43.2% of those seeking employment, representing relative increases of 11.4%, 14.3%, and 17.9% from the year prior (Piette et al., 2011).

Only a few Recession-related studies have focused on health impacts among Medicare beneficiaries aged 65+, as most have generally focused on older adult population aged 50+. Older adults aged 65+ are an important population to study because they are likely to forgo medication given their high prevalence of chronic diseases, out-of-pocket costs, and limited health insurance coverage, including "donut hole" drug coverage gaps in which Medicare part D beneficiaries who reach a certain threshold in annual expenditures on their drug plan pay up to 25% of brand name and generic drug costs ($4,660 in 2023) (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). Both housing insecurity and forgone medication are especially likely among retired older adults whose income is cut in half following retirement and continues to decline over time (JCHS, 2020; Purcell, 2012). Moreover, older adults who lived through the Recession were forced to delay their retirement or return to the labor force post-retirement due to decreasing housing prices and insecure retirement savings, with nationally representative survey data indicating a 25% drop (i.e. -$64,121) in median net worth among adults aged 65+ years between 2007 and 2011 (Pfeffer et al., 2013; Zhao & Burge, 2021).

While Downing's model suggests that forgone medication due to cost may mediate the relationship between housing hardship and poor health, few studies have examined the role of housing hardship on forgone medication over the course of the Recession (2008-2012). Instead, a number of studies have examined Recession-related relationships between forgone medical care due to cost and various forms of financial hardship including medical and credit card debt, net

household income, net worth and insurance status (Kalousova & Burgard, 2013, 2014; May & Cunningham, 2004). Additionally, studies examining relationships between health and housing hardship have used measures of foreclosure, evictions, or defaults as well as federal housing assistance or legal issues related to housing-finance, rather than using the HUD definition of housing insecurity which captures a wider set of households that face insecurity, rather than only those experiencing foreclosures and evictions (Alley et al., 2011; Cox et al., 2017; Houle & Keene, 2015). These studies have been mostly cross-sectional in nature, often neglecting changes in housing hardship across two or more periods of time. Related health studies have also examined other dimensions of housing hardship (e.g. housing stability, housing quality, housing safety, etc.) including self-reported housing affordability issues in the general population (Caswell & Zuckerman, 2018; Kushel et al., 2006b; Pollack et al., 2010; Rodgers et al., 2019).

Therefore, the primary objective of this study was to measure the association between housing insecurity (using the HUD definition) and forgone medication due to cost among Medicare beneficiaries aged 65+ over the course of the Recession (2008-2012). I hypothesized that, relative to other levels of housing insecurity, the odds of forgone medication would be generally higher for individuals experiencing *Persistent Insecurity* across two consecutive survey waves due to greater chronic health and financial strain. I further hypothesized that odds associated with *Persistent Insecurity* would be most pronounced during the peak of the Recession (2008) compared to a few years after the Recession (respectively, 2010 and 2012) due to harder trade-offs across competing needs during periods of relatively higher economic distress and uncertainty (The National Bureau of Economic Research, 2022).

METHODS

Dataset

Data for this analysis came from the 2006, 2008, 2010 and 2012 waves of 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 longitudinally every two years since 1992 and spans pre- and post-Recession time periods between 2006 and 2012 (Servais, 2010). Eligibility is determined from an initial 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 and Longitudinal files were used for this study (Bugliari et al., 2020; Servais, 2010).

Analytic sample

I constructed a longitudinal person-wave file from the 2008, 2010, and 2012 waves. I also used data from the 2006 wave to create the two-wave housing insecurity variable, which is described in detail below. Figure 1 shows the criteria that was used to select the eligible and analytic sample across all waves of data. My initial sample consisted of n=11,403 respondents aged 65+ who completed a 2006 interview. Following exclusions for non-Medicare beneficiaries (n=442), institutionalized (n=397) and proxy respondents (n=628), my final eligible sample

consisted of n=9,936 non-proxy, non-institutionalized Medicare beneficiaries aged 65+ in 2006.

Once RAND HRS person-level weights were applied, exclusions were made for n=584

respondents who entered institutional settings between 2008 and 2012 and n=2,494 total

respondents who died over the same time period [not shown in Figure 1]. My weighted data thus

permitted generalizability of my results to all non-institutionalized U.S. adults aged 65+ between

2008-2012 who were also non-institutionalized, non-proxy Medicare beneficiaries in 2006.

Despite relatively high follow-up interview rates in the HRS-, roughly 3-6% of surviving

respondents in my sample did not complete a follow-up interview in each wave between 2008-

2012 [not shown in Figure 1].

Therefore, my final sample of eligible respondents who completed an interview between

2008-2012 consisted of n=8,889 total unique subjects with n=8,753 respondents participating in

the 2008 wave; n=7,464 in the 2010 wave; and n=6,594 in the 2012 wave. Of these, the final

analytical sample (n=5,469 total unique subjects) with non-missing information on all study

covariate and exposure variables and at least one measured outcome in the follow-up waves was

n=4,655 respondents in 2008, n=3,907 in 2010, and n=3,308 in 2012. This yielded n=22,811

total person-waves of data across all three waves. Details on missing data are described in the

Analyses section below, which also describe respective analyses on non-imputed (n=5,469) and

imputed samples (n=8,889).

Measures

Forgone medication

Forgone medication due to cost was the main outcome variable of interest pulled from

RAND HRS files asking individuals, "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?" This question was not exclusive to respondents reporting a health condition and was only asked to those reporting prescription drug coverage and/or taking prescription medication; therefore, respondents without drug coverage yet on prescription medications were asked this question. I evaluated binary (yes/no) responses for this variable. Refer to the master data dictionary in Table 1 for more detail on the exact variable question text and definition. Because the question text asked about forgone medication "in the previous two years", the 2008 forgone medication variable ascertained forgone medication patterns between 2006 and 2008; while the 2010 variable ascertained patterns between 2008 and 2010 and the 2012 variable ascertained patterns between 2010 and 2012. (Note: In order to capture 2012 forgone medication trends, I used the 2014 forgone medication variable which asks about forgone medication "in the previous two years". This was the only 2014 variable used in the analysis).

Housing insecurity

In this study, I define housing insecurity as my primary exposure of interest according to the HUD index definition of spending more than 30% of household income on housing costs (Housing and Urban Development (HUD), 2020). I operationalized this definition by calculating the percentage of monthly household income spent on monthly housing costs: 100*(monthly housing costs/monthly household income). A small number of respondents reported an income of $0 (n=15 in 2008, n=34 in 2010 and n=25 in 2012). These individuals were coded as missing on the housing insecurity variable. 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. Refer to the master data dictionary in

Table 1 for more detail on the exact variable question text and definition.

I constructed a one-wave (yes/no) housing insecurity variable at each wave using the

30% HUD index cut-point mentioned above. I then used this construction to create a two-wave

variable using data from adjacent waves to characterize housing insecurity changes as follows:

(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). Each two-wave set referred to the "second wave"

as the current wave and the "first wave" as the wave prior. 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. Only the two-wave

variable was used in the regression analysis.

Covariates

Covariates were selected according to Andersen's 1968 healthcare utilization model,

which identifies the following three domains of utilization: i) *predisposing factors* (e.g.

demographics, social structure, and health beliefs); ii) *enabling factors* (e.g. family and

community resources); and iii) *need-based factors* (e.g. perceived and evaluated illness level) (R.

Andersen, 1968). I adapted this framework according to my data availability and variables of

interest, as guided by previous literature (Babitsch et al., 2012; Boer et al., 1997; Gelberg et al.,

2000; Heider et al., 2014; Jin et al., 2019; Kushel et al., 2006b; Phillips et al., 1998). For

example, in this analysis, *predisposing factors* were age (years), race/ethnicity (NHW/NHB),

gender (M/F), US-born status (Y/N), and census region (Northeast/ Midwest/ South/ West); *enabling factors* were tenure status (Homeowner/Renter), health insurance type (No Medicare/ Medicare only/ Medicare+Medicaid/ Medicare+HMO), non-housing wealth ($ quartiles), and out-of-pocket medical expenditures ($ quartiles); and *need-based factors* were disease (Hypertension only/ Diabetes only/ Neither/ Both) and depression (Y/N) status. Refer to the master data dictionary in Table 1 for more detail on the exact variable question text and definition.

Analyses

Missing data analysis

Table 2 indicates missing data for all study variables on the eligible, non-imputed sample. Across 2008-2012 waves, approximately 14% of respondents were missing housing insecurity information and 12-15%, were missing forgone medication information in each wave. Missingness for covariates such as health insurance and tenure status ranged between 6-15%, with missingness on other covariates such as race/ethnicity, census region, disease and depression status in less than 2% of respondents across waves. RAND HRS provided imputed values for household income, wealth and medical expenditures. Additional Appendix A, Table 2 results from the missing outcome analysis suggested that forgone medication was missing at random (MAR) due to significant associations (p<0.05) between missing forgone medication and all observed covariates. Table results also indicated that, across all waves, those with missing versus complete forgone medication data were more likely to be housing secure (74-77% vs. 73-75%), male (44-49% vs. 40-41%), renters (18-19% vs. 14%), residing in the Northeast (16-19% vs. 15%), without a Medicare HMO plan (6-9% vs. 4-5%), report both depression (16-19% vs.

12%) and diabetes & hypertension (22-25% vs. 17-20%), and be found in the lowest wealth (24-28% vs. 20-23%) and highest medical expenditure quartiles (28-31% vs. 22-26%).

Analytic overview

Descriptive statistics were generated for all study variables including frequency tabulations for categorical variables and mean/standard deviation and median/range values for continuous variables across 2008, 2010, and 2012 waves. I was unable to test for respective variable difference tests across waves due to repeated measures that are not independent overtime as well as mathematical complexity in generating a single p-value across five collapsed imputed datasets, as described in the section below. Two sets of longitudinal general estimating equations (GEE) regression analyses were performed. The first was estimated on the non-imputed model (n=5,469 unique respondents) while the second was estimated on imputed model (n=8,889 unique respondents) derived using the multiple imputation (MI) method used to impute missing values. Imputation was necessary because my data was not missing completely at random (MCAR) as previously noted, and GEE modeling assumes that the data is MCAR and thus the estimates will be biased if using non-imputed dataset. Imputed models were also considered superior to the non-imputed models due to the wider data availability on the full study sample. In the following sections, I first describe the MI approach and then the GEE regression approach. STATA/SE version 17.0 was used for non-imputed results. Dr. Xiaoying Yu assisted with the initial imputation and derivation of valid inferences using SAS version 9.4 (SAS Inc., Cary, NC) procedures, PROC MI and PROC MIANALYZE. Dr. Yu also derived GEE model results using PROC GENMOD in SAS for the imputed results.

Multiple imputations (MI)

I performed multiple imputations (MI) to handle all unit- and item-level missing data which was assumed to be missing at random (MAR) as described in the Missing Data Analysis section above. Multiple imputation assumes MAR and will be more effective if observed data is informative (i.e., there is an association). MI handled arbitrary missing data patterns in missing exposures, covariates or the outcome at any point in time. Each follow up value from the same variable was treated as a different variable, thus, the models accommodated any wave-specific processes. I 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. I 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.

GEE regression analyses

I present a series of four longitudinal general estimating equations (GEE) regression models ran separately on non-imputed and imputed models. The estimates from the five imputed datasets were combined to produce final inferential GEE population average estimates on the imputed models, as described in the MI section above. Advantages of employing GEE over repeated measures logistic regression models is that GEE models permit estimating population estimates using all waves of data and accounting for correlation among repeated measures (i.e.,

same individuals across waves). Compared to repeated logistic models, GEE can also test for significant differences across waves with the exposure*wave interaction term.

I estimated four GEE models consisting of two minimally adjusted and two fully adjusted models, one with and the other without the interaction term. For all models, I used weighted GEE with a binomial distribution, logit link function, and an exchangeable working correlation structure to model the longitudinal binary outcome, forgone medication. Model 1 includes the primary exposure (two-wave change in housing insecurity), wave, and core socio-demographic variables including current age, race/ethnicity, gender, US-born, and census region. Model 2 adds to Model 1 a one-wave lagged measure of forgone medication. Adjusting for a lagged measure of forgone medication in the previous wave is important because it is a strong confounder related to both housing insecurity and current forgone medication events. Model 3 adds to Model 2 core socio-demographic, enabling, and need-based variables including time-varying covariates (i.e. lagged forgone medication, 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 (i.e. race and ethnicity, gender, and US-born status). Model 4 is the fully adjusted model with the interaction term, adding to Model 3 interactions between housing insecurity and wave to test for differential time trends in the odds of forgone medication across the four-categories of housing insecurity. Odds ratio estimates and their 95% confidence intervals ($\alpha=0.05$) are reported. To translate the odds to a more interpretable scale, I additionally present adjusted mean probabilities of forgone 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 (i.e., at sample covariate means across all three waves of data).

Worth noting is the timing of my key exposure and outcome variables (Figure 4). For example, my 2008 model included assessment of forgone medication in 2008 and two-wave housing insecurity changes between 2006 and 2008; the 2010 model included 2010 forgone medication patterns and two-wave housing insecurity changes between 2008 and 2010; and the 2012 model included 2012 forgone medication patterns and two-wave housing insecurity changes between 2010 and 2012. Using this timing ensured temporal alignment between my 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 forgone medications occurring between 2012 and 2014. The same interpretation held for respective 2008 and 2010 interactions.

RESULTS

Non-imputed data

Descriptive results

Table 2 presents descriptive results of the non-imputed data. The mean age of the sample ranged from 76 to 79 across 2008, 2010, and 2012 waves. Overall, there was little change in the distribution of most variables across the waves. Approximately 12% of respondents experienced any level of housing insecurity in each wave. Among those experiencing insecurity, *Persistent Insecurity* was the most prevalent with approximately 6% of respondents falling into this category. There was also a slight decline over time in *Persistent Insecurity* between 2008 and 2012, from 6.2% in 2008 to 5.9% in 2012. *Onset Insecurity* and *Onset Security* each comprised 4-5% of the sample in all years. Approximately 5-6% of the sample experienced a forgone medication with a small secular decline in the prevalence of forgone medication between 2008-2012: 6.0% in 2008, 5.2% in 2010, and 4.5% in 2012.

Respondents were primarily non-Hispanic White (78%), female (58-59%), and resided in the South (40-41%). Respondents were also primarily US-born (91%), homeowners (69-71%), reported neither Medicaid nor HMO plan (58-64%), self-reported hypertension only (46-48%), and few depressive symptoms (83-85%). Respondent median out-of-pocket expenditures ranged between $1,371 to $1,680 and median non-housing wealth values ranged between $16,000 to $20,000. Appendix A, Table 1 provides exact quartile reference values for out-of-pocket expenditures and non-housing wealth variables. I also note that roughly 1% of my sample did not have Medicare between 2008-2012, and I presume that adults 65+ without Medicare are mostly ineligible for Medicare if they have insufficient work history (i.e., undocumented immigrants).

Regression results

Table 3 displays main results from the non-imputed regression models. Across all models, odds of forgone medication associated with any level of insecurity (i.e., *Persistent Insecurity, Onset Insecurity,* and *Onset Security*) between 2008-2012 were generally above 1. The overall magnitude of odds ratios was higher in non-imputed versus imputed models, described in the next section, with a statistically significant higher odds of forgone medication observed among individuals experiencing *Onset Insecurity,* relative to other insecurity categories, across all non-imputed models (1.54 < OR < 2.18). Therefore, these findings did not support my first hypothesis that *Persistent Insecurity* would display the highest odds of foregone medication relative to other housing insecurity categories.

Non-imputed results from the fully-adjusted Model 4 further indicate that, despite overall statistically insignificant wave*housing insecurity interactions in Model 4 (p=0.59), the odds ratio associated with *Onset Insecurity* in 2008 was statistically significant. The odds ratio associated with *Onset Insecurity* in 2008 was more than double than the odds ratio for *Onset*

Insecurity in 2012 (respectively, OR: 1.82 vs. 0.69), in which the odds ratio was paradoxically less than one [see Appendix A, Table 3]. Odds ratios for *Persistent Insecurity* followed overall decreases between 2008 (OR:1.00) and 2012 (OR: 0.69), with the highest odds ratio for *Persistent Insecurity* observed in 2010 (OR:1.78). Therefore, these findings did not support my second hypothesis that the odds associated with *Persistent Insecurity* would be most pronounced in 2008 relative to other years.

Additional findings from covariate odds ratios were in the overall expected direction. For instance, females, minority versus non-Hispanic white adults, those with versus without diabetes, those with higher medical expenditures, and those living in the South versus Northeast were more likely to experience a higher odds of reporting a forgone medication. Conversely, older, foreign-born adults, and those with higher non-housing wealth levels were more likely to experience a lower odds of a forgone medication relative to their younger, native-born, and less wealthy counterparts.

Imputed data

Descriptive results

As previously noted, imputed models were considered superior to the non-imputed models due to wider data availability on the full study sample. Table 4 presents descriptive results of the imputed data which were largely similar to non-imputed results in that the overall distribution of most variables was similar and relatively stable across waves. The mean age of the sample ranged from 75 to 78 across 2008, 2010, and 2012 waves. Overall levels of housing insecurity were slightly higher in imputed versus non-imputed results, with approximately 20% of respondents experienced any level of housing insecurity with *Persistent Insecurity* being the most prevalent category of housing insecurity among respondents (i.e., approximately 10%).

Onset Insecurity and *Onset Security* each comprised 5-7% of the sample in all years. Levels of

forgone medication from the imputed data were similar yet slightly higher than those from the

non-imputed data; approximately 6-7% of the imputed sample reported forgone medication with

a small secular decline in the prevalence of forgone medication between 2008-2012: 7.3% in

2008, 6.0% in 2010, and 5.5% in 2012.

Descriptive results on other covariates from imputed data were largely similar to those

from non-imputed data. For example, respondents from imputed data were primarily non-

Hispanic White (79%), female (58-59%), and resided in the South (40-41%). Respondents were

also primarily US-born (91%), self-reported hypertension only (46-49%), and few depressive

symptoms (86-87%). Slightly larger covariates differences on imputed versus non-imputed data

were observed for homeowners (81-83% vs. 69-71%) and respondents reporting neither a

Medicaid nor HMO plan (63-68% vs. 58-64).

Regression results

Findings from my non-imputed regression models were largely similar to my imputed

regression models and provided no additional support for either of my hypotheses. Table 5

shows regression results from the imputed sample. For instance, Model 1 indicates that,

compared to the reference *No Insecurity* category, all three categories with any insecurity (i.e.,

Persistent Insecurity, Onset Insecurity, and *Onset Security*) were associated with a higher odds

of forgone medication between 2008-2012, although only *Persistent Insecurity* and *Onset*

Insecurity indicated a statistically significant odds of forgone medication. While the largest odds

ratio was observed for *Onset* versus *No Insecurity* (OR: 1.37, 1.06-1.77), the overall magnitude

of odds ratio differences across housing insecurity categories were small (1.13 < OR < 1.37) and

slightly lower to those from non-imputed models (1.54 < OR < 2.18). Such patterns held across

all models including in Model 2 in which the addition of the lagged forgone medication variable did not appreciably change the odds ratios or statistical significance associated with any of the housing insecurity categories between 2008-2012. Respective mean R^2 values in Table 5 show that the inclusion of the lagged forgone medication variable increased the variance explained, with Model 1 indicating an $R^2=0.015$ and Model 2 indicating an $R^2=0.119$.

Model 3 indicates that, compared to Model 2, there was a reduction in the forgone medication odds ratios and loss of statistical significance associated with the three housing insecurity categories between 2008-2012, with odds ratios ranging between $1.00 < OR < 1.13$. Moreover, odds ratios were lower for *Persistent* versus *Onset Insecurity* (respectively, OR: 1.00, 0.89-1.12 ; OR: 1.24: 0.94-1.62) which was also observed across all Models 1-3 ($1.00 < OR < 1.13$ vs. $1.24 < OR < 1.37$). Therefore, these findings did not support my first hypothesis that *Persistent Insecurity* would display the highest odds of foregone medication relative to other housing insecurity categories.

Addition of statistically significant wave*housing insecurity interactions in Model 4 (overall p=0.04) increased the variance in Model 3 (respectively, $R^2=0.138$ vs. $R^2=0.136$). Moreover, Model 4 odds ratios for *Onset Insecurity* were statistically significant in 2008 and the multiplied interaction term indicated that the odds ratio for *Onset Insecurity* in 2008 was more than double than the odds ratio for *Onset Insecurity* in 2012 (respectively, OR: 1.64 vs. 0.61), in which the odds ratio was also paradoxically less than one [see Appendix A, Table 4]. Odds ratios for *Persistent Insecurity* followed similar overall decreases between 2008 (OR:0.99) and 2012 (OR: 0.70), with the highest odds ratio for *Persistent Insecurity* observed in 2010 (OR:1.31). Therefore, these findings did not support my second hypothesis that the odds associated with *Persistent Insecurity* would be most pronounced in 2008 relative to other years. Findings from

covariate odds ratios were in the overall expected direction and largely similar to those from non-imputed models.

Differences on the probability scale

Figure 2 is based on imputed Model 3 results and shows the overall adjusted probabilities of forgone medication between 2008-2012 for each housing insecurity category. Among those experiencing *No Insecurity*, the overall probability of forgone medications was 3.7%. Among those experiencing an *Onset Insecurity*, the overall probability was 4.6%. Those experiencing *Persistent Insecurity* had a similar probability compared to those experiencing *No Insecurity* at 3.7% and those experiencing *Onset Security* had an overall probability of 4.2%. Therefore, the magnitude of differences between these adjusted probabilities are also consistent with my main regression findings which did not provide support for my first hypothesis that *Persistent Insecurity* would display the highest odds ratios relative to other housing insecurity categories.

Additionally, Figure 3 is based on imputed Model 4 results and shows the adjusted probabilities of forgone medication for each housing insecurity category by wave (i.e., 2008, 2010, and 2012). The figure highlights that the highest overall probability of forgone medication was observed for *Onset Insecurity* with probabilities ranging from 2.37 to 6.74% between 2008 and 2012, whereas probabilities for other categories including *Persistent Insecurity* were comparably smaller ranging from 2.65 to 4.18% between 2008 and 2012. Moreover, probabilities of forgone medication in 2008 were highest for *Onset Insecurity* (i.e., 6.74%), followed by *Onset Security, No Insecurity* and *Persistent Insecurity* with the smallest probability of forgone medication in 2008 (i.e., 4.18%). Consistent with my main regression results, the figure also indicates that probability of forgone medication for *Onset Insecurity* dropped by over half between 2008 and 2012 (i.e., 6.74 to 2.37%). Taken together, these findings did not support my

first or second hypothesis on a greater odds of forgone medication for *Persistent Insecurity* that would be most pronounced in 2008.

DISCUSSION

Support for hypotheses

I assessed the association between housing insecurity changes and the odds of forgone medication due to cost among Medicare beneficiaries over the course of the Great Recession (i.e., during in 2008, shortly after in 2010 and a few years after in 2012). After controlling for Andersen's predisposing, enabling, and need-based factors, neither my multivariable regression (non-imputed/imputed) nor adjusted probability results (imputed) provided support for my hypotheses on the greater odds of forgone medication for individuals experiencing *Persistent Insecurity* in 2008. Instead, results indicated a greater odds of forgone medication for individuals experiencing *Onset* versus *Persistent Insecurity* (1.24 < OR < 1.37 vs. 1.00 < OR < 1.13) over the course of the Recession. Although I specifically assessed odds ratios in this analysis, the low prevalence of foregone medication in both non-imputed and imputed samples (5-7%) approximates risk ratio estimates, further enabling estimation of incident over prevalent foregone medication cases.

One possible explanation for the greater odds of foregone medication among adults experiencing *Onset* versus *Persistent Insecurity* is that *Onset Insecurity* may be most closely linked with unexpected acute economic shocks leading households with little time to adapt and forcing trade-offs in basic needs including housing and medical care. Moreover, my results also indicated a statistically significant greater odds of forgone medication in 2008 alone among individuals experiencing *Onset* versus *No Insecurity*. While these results did not hold for individuals experiencing *Persistent Insecurity*, it is likely that greater odds of forgone medication

in 2008 is attributed to incident economic distress and uncertainty during the peak of the Recession in 2008-2009 relative to earlier or later periods, as was initially suggested in my second hypothesis. Additional findings of a marked paradoxical inverse association in which odds ratios were less than one for both Onset & Persistent Insecurity in 2012 (OR=0.61 & 0R=0.70, respectively) aligned with results from my non-imputed models as well as repeated logistic regression models [not presented here]. The reason for this inverse relationship is unclear, however, potential explanations may 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), 2023; Moffitt, 2013).

My findings of greater forgone medication among individuals experiencing *Onset Insecurity* support Downing's *Homeowner Distress Model* positing that, under peak economic distress, adults facing incident economic hardship may be forced to re-prioritize housing costs over other basic needs, including food, transportation, and medical care, ultimately leading to poor health (Downing, 2016; JCHS, 2020). Although Downing's model was initially developed for homeowners, I developed the housing insecurity index using both rent and mortgage values, and therefore helped expand Downing's model to renters as well as homeowners. Moreover, my findings of a particularly greater odds of forgone medication in 2008, relative to other years, support findings from a National Health Interview Survey (NHIS) sample indicating that forgone medication patterns heightened during the peak of the Recession between 2008-2009, reaching 7.9% to 8.3% of the general population (i.e., 23.6 to 25.1 million adults). Despite subsequent drops in forgone medication from 8.2 to 5.2% of the general population (i.e. 24.9 to 16.4 million

adults) during the post-Recession period between 2010-2015, forgone medication did not fully return to its pre-Recession rates between 1998-2007 in which forgone medication was prevalent among 4.1% to 7.1% of the general population (i.e. 11.1 to 21 million adults) (Kennedy & Wood, 2016).

An overall low prevalence of forgone medication in my sample (5-7%) differ from forgone medication estimates among Medicare beneficiaries in previous studies and may be attributable to differences in sample selection and methodology. For example, one study reported cost-related treatment non-adherence (CRN) among 17.7% of Medicare part D beneficiaries in 2007, among whom about one-third had reached their 75% benefit threshold (Bakk, 2015). Variability in the prevalence of forgone medication between my study and the Bakk (2015) study might be explained by the former study's assessment of forgone 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 nationally representative studies have indicated overall CRN rates of 10-15% among Medicare beneficiaries between 2005 and 2011 (i.e. 14.9% in 2005, 11.3% in 2007, 10.2% in 2009, and 10.8% in 2011), with elevated rates of CRN between 2009 and 2011 among beneficiaries with four or more chronic conditions (i.e. respectively, 14.4% vs. 17%) ((Naci et al., 2014). Slightly lower CRN estimates in my sample may be attributed to my assessment of Hispanic, non-Hispanic White and Black adults alone, excluding other races such as American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander.

To my knowledge, studies have yet to examine associations between housing insecurity changes and forgone medication trends over the course of the Recession. However, my findings of positive associations between any level of housing insecurity and forgone medication during

the Recession aligns with previous literature. For example, among a sample of Philadelphia residents, low-income adults with housing affordability issues in 2008 were 2.7 times more likely to forgo medication due to cost (Adjusted Odds Ratio, AOR: 2.68, 1.95-3.70) and 2.9 times more likely to forgo healthcare due to cost (AOR: 2.94, 2.04-4.25) than their counterparts without housing affordability issues, even after adjusting for various predisposing, enabling, and need-based factors (Pollack et al., 2010). Among the same sample of Philadelphia residents, those who underwent a home foreclosure in 2008 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 forgo medication due to cost in 2008 (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).

My findings of higher odds of forgone medication due to cost among adults with diabetes is linked to evidence of the significantly high portion of out-of-pocket costs from prescription drug spending among adults with diabetes, most often insulin or-related supplies and anti-diabetic drugs (e.g. metformin) (Centers for Medicare & Medicaid Services (CMS), 2020). A study from an HRS sample of Medicare beneficiaries aged 65 and over indicated that annual out-of-pocket prescription drug costs totaled $1,092 ($91 monthly) for patients with diabetes, compared to $1,034 for CVD patients; $887 for cancer patients; and $1,067 for lung disease patients (Fong, 2019). Findings also revealed a $243 annual incremental effect of prescription drugs for diabetic patients or an increased $243 for each additional prescription drug (Fong, 2019). High out-of-pocket costs among the chronically ill increases their risk of forgone medication, which may in turn exacerbate their disease burden, likelihood of hospitalization, and

subsequent disease-related treatment costs (Alnijadi et al., 2021; Sokol et al., 2005). Most at risk are patients with both diabetes and hypertension who often encounter comorbidities such as stroke, heart disease, and kidney disease (cdc.gov, 2020; Sokol et al., 2005).

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, I was unable to assess medication need and beliefs about medication as well as the type of medication forgone, limiting my ability to determine fluctuations in forgone medication according to medication cost. Third, my findings may be confounded by other forms of financial hardship (e.g., food insecurity, credit card and/or medical debt, etc.). Fourth, my interpretation of the interaction term on a non-linear model may be statistically misleading (Mize, 2019); however I account for this limitation by presenting adjusted probability figures showing actual probabilities of forgone medication at each wave. Finally, although I accounted for region of residence, HRS does not publicly disclose state residency information, which hinders my ability to account for state or county-level policies affecting decisions about housing, healthcare, and other related matters among beneficiaries.

Implications

To my knowledge, this is the first study to construct the housing insecurity HUD index based on HRS data and use it to evaluate variations in the odds of forgone 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 forgone medication patterns. My findings of a greater odds of forgone medication among adults experiencing *Onset Insecurity* during the peak of the Recession have housing policy implications including, but not limited to, expansion of low-income housing, eviction moratoriums and rent stabilization for at-risk renters and homeowners facing incident housing insecurity during periods of peak economic hardship (Bertoldo et al., 2022; K. L. Chen et al., 2022; Consumer Financial Protection Bureau, 2021; Hu, 2022; Liu & Eicher-Miller, 2022; The National Low Income Housing Coalition, 2016). Because housing insecurity has spillover effects on medical care, investing in housing security may be helpful in ensuring continuity of care in times of peak financial distress particularly among Medicare beneficiaries aged 65+ with limited incomes.

Additionally, findings of a generally higher odds of forgone medication among adults with any level of housing insecurity as well as chronically-ill Medicare beneficiaries underscore several healthcare policy implications. This includes greater access to Medicare Advantage plans which can now provide rental and housing assistance to chronically ill enrollees, despite out-of-network provider restrictions and pre-authorization requirements (Coleman, 2019; Porretta, 2023). Related healthcare policy implications also include wider prescription drug coverage for all Medicare adults, especially adults with diabetes who may find themselves paying out-of-pocket for long-held ADA recommended treatments not fully covered under Medicare Part D such as medications to lower blood glucose (i.e.: metformin), blood pressure (i.e.: ACE inhibitors) and cholesterol levels (i.e.: statins) ((ADA), 2005, 2020). As per ADA's current Standards of Medical Care in Diabetes report, it is important clinicians "consider costs of care and insurance coverage rules when developing treatment plans in order to reduce risk of cost

related nonadherence" ((ADA), 2020). Adopting relevant healthcare guidelines and policies to prevent forgone medication among the chronically ill may ultimately reduce $327 billion (25%) in annual healthcare dollars are attributed to diabetes, including $237 billion in medical costs and $90 billion in lost productivity ((ADA), 2018).

Figure 1. Final sample selection criteria (Non-imputed HRS 2006 and follow-up 2008, 2010, and 2012 samples)
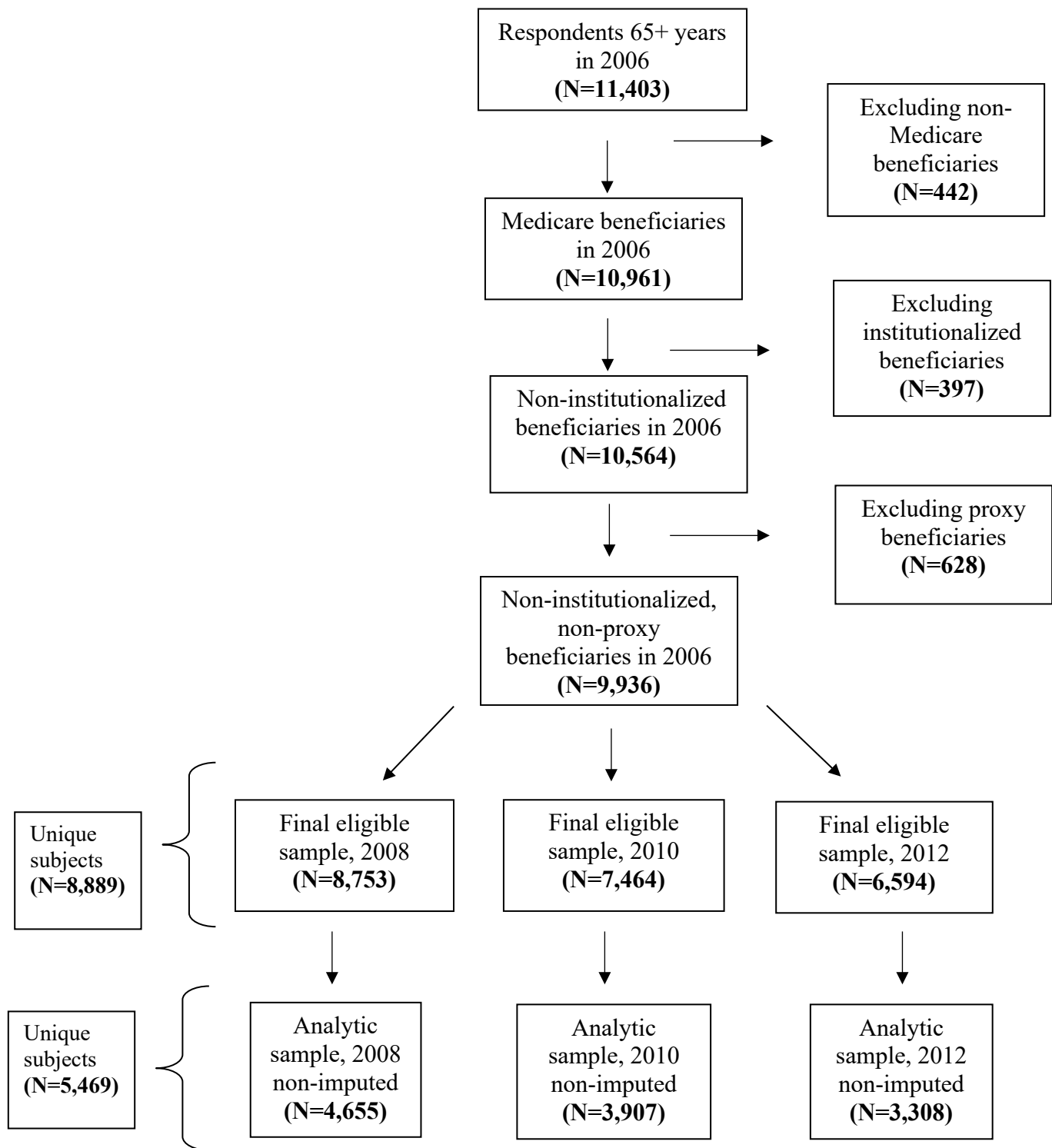
Figure 2. Adjusted probabilities of forgone medication with 95% CI by housing insecurity category, overall (based on Model 3)
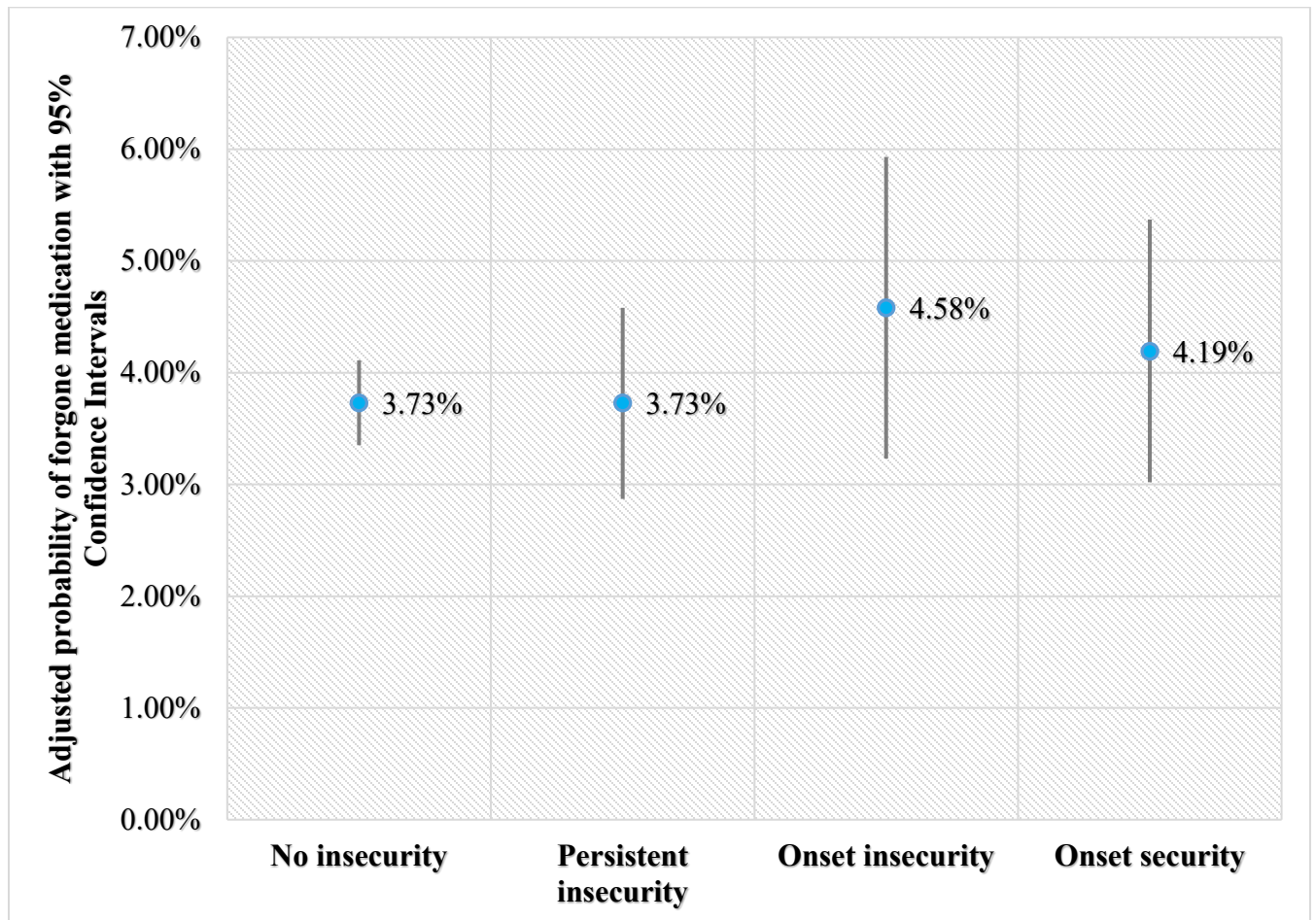
	Adj prob.	UL_adj prob.	LL_adj prob.
No insecurity	3.73%	4.11%	3.35%
Persistent insecurity	3.73%	4.58%	2.87%
Onset insecurity	4.58%	5.93%	3.23%
Onset security	4.19%	5.37%	3.02%

Figure 3. Adjusted probabilities of forgone medication with 95% CI by housing insecurity category, by wave (based on Model 4)
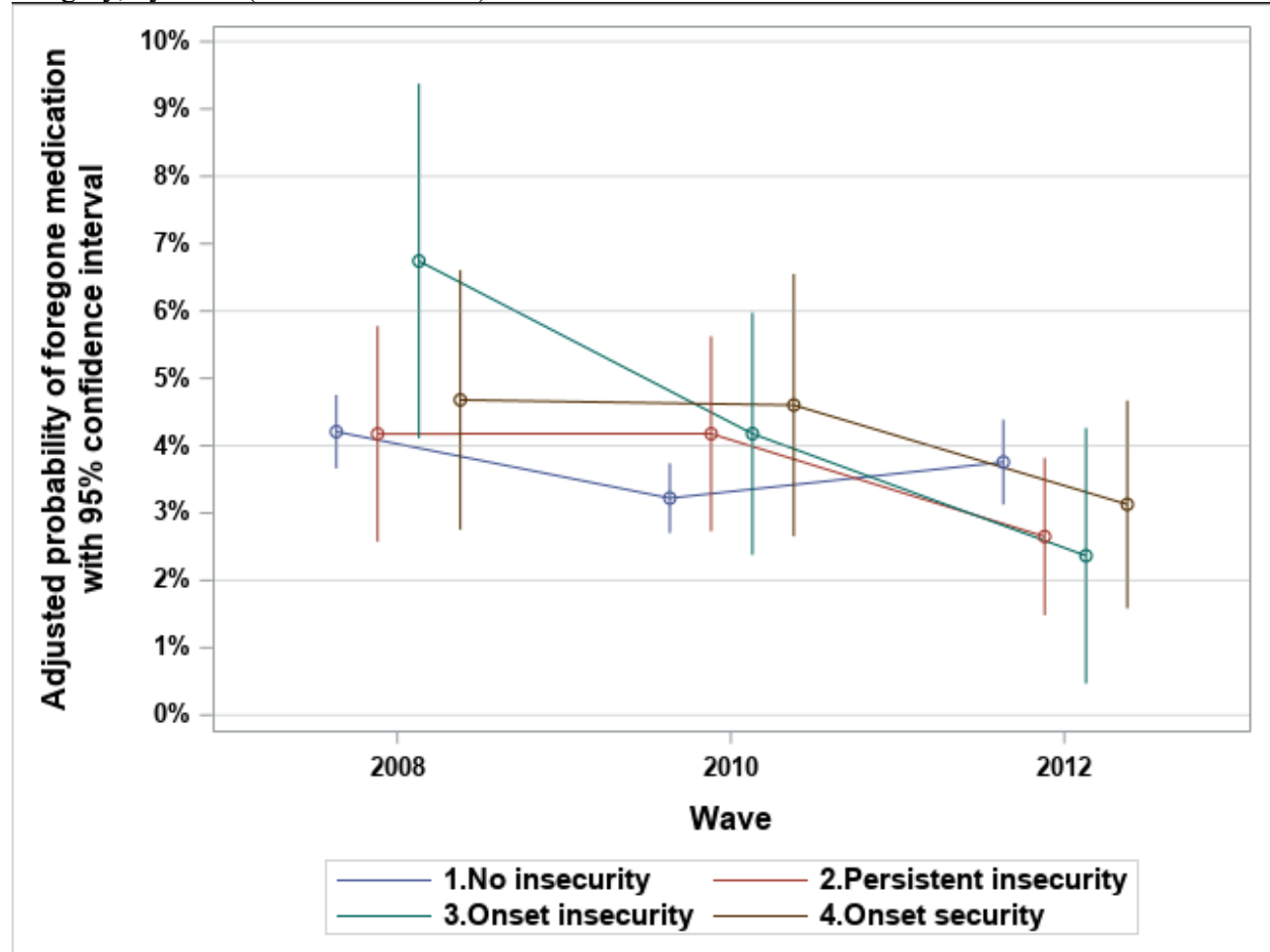
Housing insecurity	Wave	Adj prob.	LL_adj prob.	UL_adj prob.
	2008	4.21%	3.66%	4.75%
1. No insecurity	2010	3.22%	2.70%	3.74%
	2012	3.76%	3.13%	4.39%
	2008	4.18%	2.58%	5.78%
2. Persistent insecurity	2010	4.18%	2.73%	5.62%
	2012	2.65%	1.48%	3.82%
	2008	6.74%	4.11%	9.38%
3. Onset insecurity	2010	4.18%	2.38%	5.98%
	2012	2.37%	0.47%	4.27%
	2008	4.68%	2.75%	6.61%
4. Onset security	2010	4.60%	2.66%	6.55%
	2012	3.13%	1.59%	4.67%

Figure 4. Timing of key exposure and outcome variables

Table 2. Descriptive characteristics Medicare beneficiaries 65+ years (Non-imputed HRS 2006, 2008, 2010, and 2012 samples)

	Descriptive statistics [%]							
	2006 (N=9,936)		2008 (N=8,753)		2010 (N=7,464)		2012 (N=6,594)	
	N	Col %	N	Col %	N	Col %	N	Col %
Housing insecurity (one-wave)								
Missing	*1466*	*14.75*	*1256*	*14.35*	*1054*	*14.12*	*896*	*13.59*
No	7201	72.47	6414	73.28	5494	73.61	4931	74.78
Yes	1269	12.77	1083	12.37	916	12.27	767	11.63
Housing insecurity (two-wave)								
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	.	.	410	4.68	359	4.81	280	4.25
Forgone 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 status

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
Yes	1455	14.64	1131	12.92	918	12.3	856	12.98

Non-housing wealth

Missing	.	.	.	.	.	.	.	.
Q1, lowest	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, highest	2897	29.16	2578	29.45	2640	35.37	2327	35.29
Median	*19925*		*20000*		*18200*		*16000*	

Out of pocket medical expenditures

Missing	.	.	.	.	.	.	.	.
Q1, lowest	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, highest	2579	25.96	2028	23.17	1987	26.62	1712	25.96
Median	*1524*		*1371*		*1680*		*1560*	

NOTE. Refer to Figure 1 for final sample selection criteria. Appendix A, Table 1 indicates quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

Table 3. Minimally and fully adjusted models of multivariable associations predicting forgone medications due to cost (Non-imputed HRS 2008-2012 sample)

	Forgone meds due to cost [OR,95% CI]* (N=5,469)			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Housing insecurity (two-wave)				
No insecurity (Ref)				
Persistent insecurity	1.29, 0.94-1.78	1.10, 0.81-1.49	0.90, 0.66-1.23	1.00, 0.63-1.57
Onset insecurity	2.18, 1.63-2.90*	1.87, 1.38-2.53*	1.54, 1.11-2.12*	1.82, 1.18-2.83*
Onset security	1.28, 0.91-1.80	1.16, 0.81-1.66	1.01, 0.70-1.45	1.00, 0.56-1.78
Wave				
2008 (Ref)				
2010	0.95, 0.80-1.13	0.89, 0.72-0.10	0.87, 0.70-1.07	0.87, 0.68-1.12
2012	0.76, 0.62-0.94*	0.74, 0.59-0.92*	0.70, 0.56-0.88*	0.78, 0.61-1.01
Housing insecurity*Wave				
pers_insec*wave2010	.	.	.	0.92, 0.47-1.79
onset_insec*wave2010	.	.	.	0.98, 0.49-1.97
onset_sec*wave2010	.	.	.	1.10, 0.50-2.44
pers_insec*wave2012	.	.	.	0.69, 0.31-1.56
onset_insec*wave2012	.	.	.	0.38, 0.15-1.01
onset_sec*wave2012	.	.	.	0.89, 0.35-2.23
Forgone meds, lagged				
respectively 2006, 2008, and 2010	.	11.79, 9.42-14.76*	8.10, 6.38-10.28*	8.11, 6.38, 10.29*
Age				
Years	0.94, 0.93-0.96*	0.95, 0.95-0.97*	0.96, 0.94-0.97*	0.96, 0.94-0.97*
Race/ethnicity				
White, non-Hispanic (Ref)				
Black, non-Hispanic	1.97, 1.52-2.53*	1.68, 1.34-2.10*	1.17, 0.91-1.52	1.17, 0.91-1.51
Hispanic	1.80, 1.19-2.73*	1.45, 1.00-2.10	0.93, 0.62-1.38	0.94, 0.63-1.41
Gender				
Male (Ref)				
Female	1.46, 1.18-1.80*	1.30, 1.07-1.57*	1.78, 0.97-1.43	1.18, 0.97-1.43
US-born				
Yes (Ref)				
No	1.01, 0.68-1.51	1.10, 0.77-1.57	1.06, 0.74-1.53	1.05, 0.73-1.52

Tenure				
Homeowner (Ref)				
Renter	.	.	1.25, 0.99-1.58	1.27, 1.00-1.60*
Census region				
Northeast (Ref)				
Midwest	1.04, 0.75-1.46	1.07, 0.80-1.44	1.20, 0.88-1.64	1.21, 0.88-1.65
South	1.46, 1.08-1.97*	1.39, 1.06-1.81*	1.44, 1.10-1.91*	1.45, 1.10-1.92*
West	0.94, 0.64-1.38	0.93, 0.65-1.32	0.97, 0.68-1.39	0.99, 0.69-1.41
Health insurance				
Medicare only, neither Medicaid nor HMO (Ref)				
Medicare with Medicaid, no HMO	.	.	1.06, 0.70-1.59	1.05, 0.70-1.58
Medicare with HMO, regardless Medicaid	.	.	1.31, 1.06-1.61*	1.31, 1.06-1.61*
No Medicare	.	.	0.81, 0.33-1.96	0.79, 0.32-1.95
Disease status				
Neither diabetes nor hypertension (Ref)				
Diabetes only	.	.	1.13, 0.74-1.71	1.12, 0.74-1.70
Hypertension only	.	.	0.97, 0.78-1.21	0.97, 0.78-1.21
Both diabetes and hypertension	.	.	0.95, 0.72-1.25	0.95, 0.72-1.25
Depression status				
Yes	.	.	1.91, 1.52-2.39*	1.91, 1.52-2.40*
No (Ref)				
Non-housing wealth				
Q1 (Ref)				
Q2	.	.	0.71, 0.54-0.92*	0.71, 0.54-0.92*
Q3	.	.	0.58, 0.44-0.76*	0.58, 0.44-0.76*
Q4	.	.	0.31, 0.23-0.42*	0.31, 0.23-0.42*
Out of pocket medical expenditures				
Q1 (Ref)				
Q2	.	.	1.22, 0.92-1.63	1.24, 0.93-1.65
Q3	.	.	1.36, 1.02-1.82*	1.38, 1.03-1.84*
Q4	.	.	1.84, 1.38-2.46*	1.86, 1.39-2.49*

NOTE. Refer to Figure 1 for final sample selection criteria. All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance of housing insecurity variable at p<0.05. Interaction p-value (p=0.59).
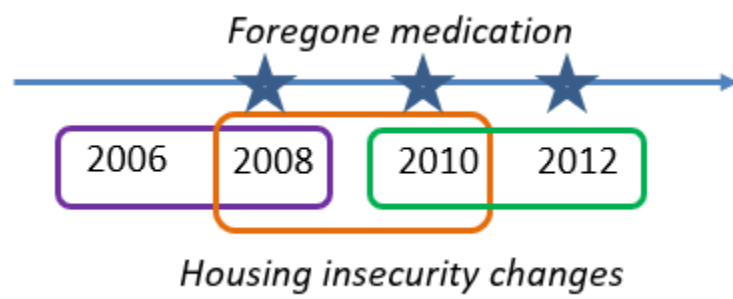
Table 4. Descriptive characteristics of Medicare beneficiaries 65+ years (Imputed HRS 2008, 2010 and 2012 sample)

	Descriptive statistics [%] (N=8,889)		
	2008 **(N=8,753)**	**2010** **(N=7,464)**	**2012** **(N=6,594)**
Housing insecurity (two-wave)			
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
Forgone 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, lowest	20.16	23.23	23.20
Q2	24.06	14.27	13.50
Q3	26.32	27.13	28.01
Q4, highest	29.45	35.37	35.29
Median	*20,000*	*18,200*	*16,000*
Out of pocket medical expenditures			
Q1, lowest	23.04	18.50	19.09
Q2	26.56	26.42	25.69
Q3	27.22	28.46	29.25
Q4, highest	23.17	26.62	25.96
Median	*1,371*	*1,680*	*1,560*

NOTE. Refer to Figure 1 for final sample selection criteria. Appendix A, Table 1 indicates quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

Table 5. Minimally and fully adjusted models of multivariable associations predicting forgone medications due to cost (Imputed HRS 2008, 2010, and 2012 sample)

	Forgone meds due to cost [OR,95% CI]* (N=8,889)			
	Model 1	Model 2	Model 3	Model 4
Housing insecurity (two-wave)				
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
Forgone meds, lagged				
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*
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 status				
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 R^2 value	0.01	0.12	0.14	0.14

NOTE. Refer to Figure 1 for final sample selection criteria. All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance of housing insecurity variable at p<0.05. Interaction p-value (p=0.04). Overall p-values should be treated as a rough guide across 5 imputed datasets; one can consider the range of p-values between one half and twice the calculated value.

Appendix A

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

Appendix A, Table 1. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables among Medicare beneficiaries 65+ years (HRS 2006, 2008, 2010, and 2012 samples)

Appendix A, Table 2. Descriptive characteristics Medicare beneficiaries 65+ years with complete versus missing forgone medication data (Non-imputed HRS 2008, 2010, and 2012 samples)

Appendix A, Table 3. Model 4 interaction results between housing insecurity * wave among Medicare beneficiaries 65+ years (Non-imputed HRS 2008, 2010, and 2012 samples)

Appendix A, Table 4. Model 4 interaction results between housing insecurity * wave among Medicare beneficiaries 65+ years (Imputed HRS 2008, 2010, and 2012 samples)

Tables

Appendix A, Table 1. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables among Medicare beneficiaries 65+ years (HRS 2006, 2008, 2010, and 2012 samples)

	Out of pocket medical expenditures [$]			
	2006 (n=9,936)	**2008** (N=8,753)	**2010** (N=7,464)	**2012** (N=6,594)
Q1	*0 to 400*	*0 to 408*	*0 to 360*	0 to 350
Q2	*402 to 1,420*	*410 to 1,350*	*365 to 1,400*	*357 to 1,340*
Q3	*1,422 to 3,500*	*1,352 to 3,200*	*1,404 to 3,610*	*1,344 to 3,440*
Q4	*3,510 to 289,210*	*3,203 to 98,000*	*3,612 to 82,336*	*3,450 to 217,725*

	Non-housing wealth [$]			
	2006 (n=9,936)	**2008** (N=8,753)	**2010** (N=7,464)	**2012** (N=6,594)
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*

*NOTE: Refer to Figure 1 for final sample selection criteria. Reference values are the same for non-imputed and imputed data as RAND HRS previously imputed wealth and medical expenditure variables.

Appendix A, Table 2. Descriptive characteristics Medicare beneficiaries 65+ years with complete versus missing forgone medication data (Non-imputed HRS 2008, 2010, and 2012 samples)

	Descriptive statistics [%] (N=8,889)					
	2008 (N=8,753)		**2010** (N=7,464)		**2012** (N=6,594)	
	Missing (N=1,223)	Complete (N=7,530)	Missing (N=882)	Complete (N=6,582)	Missing (N=976)	Complete (N=5,618)
Housing insecurity (one-wave)						
Missing	*11.37*	*14.83*	*11.11*	*14.52*	*12.09*	*13.85*
No	76.71	72.74	74.72	73.46	76.43	74.49
Yes	12.02	12.43	14.17	12.02	11.48	11.66
p-value	*		*			
Age						
Missing	.	.	.	.	.	.
Mean, SD	*79.38, 7.99*	*75.44, 6.48*	*80.51, 7.65*	*77.26, 6.09*	*81.17, 6.83*	*78.45, 5.75*
p-value	*		*		*	
Race/ethnicity						
Missing	*1.55*	*1.67*	*2.04*	*1.73*	*2.15*	*1.66*
White, non-Hispanic	76.45	78.66	76.08	78.50	77.56	78.30
Black, non-Hispanic	13.16	12.23	16.10	11.88	11.99	12.09
Hispanic	8.83	7.44	5.78	7.89	8.30	7.96
p-value			*			
Gender						
Missing	.	.	.	.	.	.
Male	43.91	41.27	45.92	41.01	48.77	39.89
Female	56.09	58.73	54.08	58.99	51.23	60.11
p-value			*		*	
US-born						
Missing	*0.16*	*0.11*	*0.45*	*0.06*	*0.00*	*0.07*
Yes	90.92	90.98	90.59	90.85	91.70	90.41
No	8.91	8.91	8.96	9.09	8.30	9.52
p-value			*			
Tenure						

Missing	*19.05*	*14.14*	*18.25*	*14.19*	*19.77*	*15.36*
Homeowner	61.90	72.96	62.81	71.68	61.99	70.58
Renter	19.05	14.14	18.93	14.13	18.24	14.06
p-value		*		*		*

Census region

Missing	*0.16*	*0.09*	*0.23*	*0.12*	*0.20*	*0.11*
Northeast	19.46	15.17	16.89	14.90	15.78	14.61
Midwest	21.59	26.18	24.04	26.34	24.18	26.52
South	41.86	40.29	42.74	40.08	40.37	40.49
West	16.93	18.27	16.10	18.55	19.47	18.26
p-value		*				

Health insurance

Missing	*7.60*	*5.54*	*12.59*	*7.89*	*9.12*	*7.32*
Medicare only, neither Medicaid nor HMO	59.44	65.11	57.71	60.15	58.09	58.31
Medicare with Medicaid, no HMO	8.59	5.23	5.78	4.21	5.94	4.59
Medicare with HMO, regardless Medicaid	23.22	23.13	22.22	26.62	25.51	28.69
No Medicare	1.14	0.98	1.70	1.14	1.33	1.09
p-value		*		*		*

Disease status

Missing	*0.41*	*0.12*	*0.23*	*0.14*	*0.10*	*0.05*
Neither diabetes nor hypertension	23.39	32.56	23.36	29.16	22.95	27.22
Diabetes only	5.64	4.50	3.97	4.57	4.61	4.49
Hypertension only	45.22	46.16	49.66	46.89	49.90	48.24
Both diabetes and hypertension	25.35	16.65	22.79	19.25	22.44	20.01
p-value		*		*		

Depression status

Missing	*6.95*	*1.58*	*12.70*	*3.30*	*11.68*	*3.13*
No	73.83	86.52	71.77	84.84	69.57	84.89
Yes	19.22	11.90	15.53	11.87	18.75	11.98
p-value		*		*		*

Non-housing wealth

Missing	.	.	.	.	.	.
Q1, lowest	23.63	19.60	28.34	22.55	25.72	22.77
Q2	27.88	23.44	16.55	13.96	14.34	13.35
Q3	22.73	26.91	27.32	27.10	28.59	27.91
Q4, highest	25.76	30.05	27.78	36.39	31.35	35.97
Median	*10,000*	*22,550*	*7,927*	*20,000*	*10,000*	*18,275*
p-value	*				*	
Out of pocket medical expenditure						
Missing	.	.	.	.	.	.
Q1, lowest	22.49	23.13	19.27	18.40	22.64	18.48
Q2	23.55	27.05	23.81	26.77	19.47	26.77
Q3	25.76	27.46	27.32	28.61	26.54	29.73
Q4, highest	28.21	22.35	29.59	26.22	31.35	25.03
Median	*1,575*	*1,350*	*1,800*	*1,660*	*1,757*	*1,540*
p-value	*				*	

NOTE. Refer to Figure 1 for final sample selection criteria. P-value indicates statistical significance at α=0.05 using chi-squared test for categorical variables and ANOVA test for continuous variables.

Appendix A, Table 3. Model 4 interaction results between housing insecurity * wave among Medicare beneficiaries 65+ years (Non-imputed HRS 2008, 2010, and 2012 samples)

	Odds of forgone medication [OR]* (N=5,469)		
	2008 (N=4,655)	**2010 (N=3,907)**	**2012 (N=3,308)**
No insecurity (Ref)	--	--	--
Onset insecurity	1.82*	0.92	0.69
Persistent insecurity	1.00	1.78	0.69
Onset security	1.00	1.10	0.89

NOTE. Refer to Figure 1 for final sample selection criteria. All estimates refer to Odds Ratios. Interaction p-value (p=0.59). P-value indicates statistical significance at α=0.05 using fully-adjusted GEE model (i.e., Model 4).

Appendix A, Table 4. Model 4 interaction results between housing insecurity * wave among Medicare beneficiaries 65+ years (Imputed HRS 2008, 2010, and 2012 samples)

	Odds of forgone medication [OR]* (N=8,889)		
	2008 **(N=8,753)**	**2010** **(N=7,464)**	**2012** **(N=6,594)**
No insecurity (Ref)	--	--	--
Onset insecurity	1.64*	1.31	0.61
Persistent insecurity	0.99	1.31	0.70
Onset security	1.11	1.44	0.82

NOTE. Refer to Figure 1 for final sample selection criteria. All estimates refer to Odds Ratios. Interaction p-value (p=0.04). P-value indicates statistical significance at α=0.05 using fully-adjusted GEE model (i.e., Model 4). Overall p-values should be treated as a rough guide across 5 imputed datasets; consider the range of p-values between one half and twice the calculated value.

Chapter 4 (Paper 2)-Black-White differences in forgone medication due to cost during the Recession: The role of predisposing, enabling and need-based factors

INTRODUCTION

      The Great Recession of 2007 to 2009 severely shocked the U.S. housing and financial markets (Joint Center for Housing Studies [JCHS], 2020; Kochhar & Cilluffo, 2017). Heightened unemployment (doubling from 4.4% in 2007 to 9.5% in 2010) precipitated insurance and income loss among 14 million American adults, most notably among racial and ethnic minorities and persons of low socioeconomic status (SES) (Bennett & Kochhar, 2019; Center for Disease Control & Prevention (CDC), 2010; Herbert & Apgar, 2010; Jacquez et al., 2009; R. W. Johnson, 2009; Kochhar et al., 2009; Mather, 2015; Reid & Laderman, 2009). By 2009, unemployment rates were highest among African American and Hispanic adults relative to White adults (respectively, 14.8 and 12.1% vs. 8.7%) (US Bureau of Labor Statistics (BLS), 2012).

      Coupled with widespread unemployment, risky lending or subprime practices targeted at increasing homeownership rates among low-income racial and ethnic minorities placed them at especially high risk of financial hardship during the Recession (Herbert & Apgar, 2010; Joint Center for Housing Studies (JCHS), 2009, p. 200; Reid & Laderman, 2009). For example, Hispanic and Black borrowers were 30% more likely than White borrowers to receive subprime loans (Blacks: 48%, Hispanics: 47%, Whites: 17%) including higher loan-to-income ratios than Whites (Hispanics=2.9; Blacks=2.8; Whites=2.5) and annual percentage rates (APRs) that were up to 2.5 and 3 percentage points higher for Black and Hispanic borrowers, respectively, than the typical 30-year, fixed-rate conventional mortgage rates (Kochhar et al., 2009; Reid & Laderman,

2009; US Federal Reserve, 2010), Financial illiteracy among less-educated and less-experienced minority borrowers also further hindered their understanding of the true costs associated with subprime loans (Herbert & Apgar, 2010; Reid & Laderman, 2009).

High unemployment and subprime lending among at-risk minorities was tied to declining home equity losses, higher debt-to-asset ratios and reduced retirement savings among Black and Hispanic adults during the Recession (Herbert & Apgar, 2010; Signe-Mary McKernan et al., 2013). In 2008, homeownership rates among Black and Hispanic adults were half that among White adults (respectively, 47.5 and 48.9% vs. 74.9) with a 50% reduction in median net worth among both middle-income Black and Hispanics families compared to nearly 20% among White families (respectively, B:$63,700 to $38,300; H: $85,600 to $46,000; W:$189,000 to $154,000) (Kochhar et al., 2009; Kochhar & Cilluffo, 2017). Despite these declines, upper-income White households maintained a higher-than-average median net worth of $971,500 in 2016, representing a 25% increase from its pre-Recession level. Moreover, while White-Black differences in median wealth dropped among low-income families between 2007 and 2013 (9.8 to 4.6%), they widened among middle-income families over the same time period (3.0 to 3.9%) (Kochhar & Cilluffo, 2017).

In light of overall higher financial and housing hardship among racial/ethnic minorities during the Recession, few studies have examined racial differences in forgone medication patterns during the Recession especially among older adults aged 65+. Instead, related studies have examined and reported a generally higher likelihood of cost-related treatment non-adherence (CRN), outpatient and emergency room visits among financially burdened adults including the uninsured, Medicaid/Medicare enrollees, and those with poor physical and mental health (Alnijadi et al., 2021; Caswell & Zuckerman, 2018; J. Chen et al., 2014; Clark et al.,

2016; Delavar et al., 2022; Kang et al., 2018; Kennedy & Wood, 2016; Lago-Hernandez et al., 2021; M. Lee & Salloum, 2016; S. Lee et al., 2019; Soumerai et al., 2006; Zhang et al., 2022; Zivin, Ratliff, et al., 2010). For example, findings from a 2010 National Interview and Health Study (NHIS) sample of adults 18-64 years indicated that the likelihood of forgone medication due to cost during the Recession was three times higher among uninsured versus Medicaid insured adults (respectively, 26% vs. 9%), and up to six times higher among uninsured versus privately insured adults (respectively, 26% vs. 4%) (Center for Disease Control & Prevention (CDC), 2010; Moonesinghe et al., 2021). Related findings from a 2017 NHIS study indicated that the odds of forgone medication due to cost among an older adults aged 65+ with diabetes was also more likely among uninsured adults (AOR: 34.41, 2.14-53.65), as well as females (AOR: 1.43, 0.84-2.45), mentally distressed (AOR: 2.33, 1.38-3.93) and obese adults (AOR: 3.84, 0.21-72.02) (Chung et al., 2019). This evidence corroborates Downing's model which suggest that persons with fewer resources to budget are more likely to make trade-offs between core health needs (i.e. effect-budgeting), forgoing medication and becoming ill during periods of greater financial hardship (Downing, 2016).

In light of these findings, studies of racial differences in forgone medication patterns among older adults during the Recession are important given that Medicare beneficiaries aged 65+ are especially likely to forgo medication given their high prevalence of chronic diseases, out-of-pocket costs, and limited health insurance coverage, including "donut hole" drug coverage gaps in which Medicare part D beneficiaries who reach a certain threshold in annual expenditures on their drug plan pay up to 25% of brand name and generic drug costs ($4,660 in 2023) (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). Such studies are also important given the "double jeopardy" of age and race/ethnicity that has been shown to harm the health of financially strained older adult minorities relative to their younger, non-minority counterparts (Dowd & Bengtson, 1978; Tran, Thanh V. et al., 1996).

Evidence of a generally greater likelihood of forgone medication due to cost among financially burdened adults may contribute to my understanding the related factors driving racial disparities in forgone medication patterns during the Recession. According to Andersen's 1968 framework, healthcare utilization is influenced by individual-level: i) predisposing factors including demographics, social structure and health beliefs; ii) enabling factors including family and community resources; and iii) need factors including perceived and evaluated illness level (Aday et al., 1972; R. Andersen, 1968; R. Andersen & Newman, 1973). Findings from nationally representative studies using Andersen's framework have indicated that healthcare utilization is independently associated with predisposing factors such as age, gender, and race/ethnicity; enabling factors such as income, housing and food affordability; and need-based factors such as disease severity and psychological well-being (Babitsch et al., 2012; Boer et al., 1997; Jin et al., 2019; Kushel et al., 2006a). Despite its vast application in the literature, most utilization studies have solely focused on individual rather than environmental-level factors driving utilization patterns including characteristics of the healthcare delivery system and/or the external environment (e.g. state or county-level healthcare policies) as shown in Andersen's updated phase 4 model of utilization (Figure 5) (R. M. Andersen, 1995; Gelberg et al., 2000; Heider et al., 2014; Phillips et al., 1998). Moreover, I am unaware of studies examining the relative contribution of predisposing, need-based, and enabling factors (other than health insurance) driving racial disparities in forgone care during a time of peak economic distress. Therefore,

applying Andersen's framework to study forgone medication patterns in the context of the Recession may help fill a literature gap in understanding the extent to which both individual and environmental-level drivers influenced racial disparities in forgone medication during the Recession.

In this paper I focused on non-Hispanic White and Black (respectively, NHW and NHB) Medicare beneficiaries who lived through the 2008 peak of the Great Recession to i) identify racial differences in forgone medication due to cost during this period and ii) evaluate the extent to which Andersen's predisposing, need-based and enabling factors helped explain these differences. I hypothesized that the odds of forgone medication would be generally higher for NHB versus NHW adults during the peak of the Recession and that enabling factors would most explain this difference due to NHB adults' greater overall levels of financial hardship during the Recession and subsequently lower safety net needed to prevent forced trade-offs between core health needs.

METHODS

Dataset

Data for this analysis primarily came from the 2008 wave of the Health and Retirement Study (HRS). As described below, I used information from the 2010 wave to measure forgone medication patterns in 2008. 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 longitudinally every two years since 1992 and spans pre- and post-Recession time periods

between 2006 and 2012 (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 and Longitudinal files were used for this study (Bugliari et al., 2020; Servais, 2010).

Analytic sample

Figure 6 shows the sample selection criteria that was used to select the eligible and analytic samples. My study sample was initially restricted to eligible, non-proxy interviews of non-institutionalized Medicare beneficiaries aged 65+ in 2006 (n=9,936). In this paper I further restricted eligibility criteria to NHW and NHB adults only, yielding a total eligible sample (n=9,029) of n=7,789 NHW and n=1,240 NHB respondents. Among these 9,029 individuals, I excluded n=4,394 respondents with missing study covariates and outcome data in 2008. My final analytical sample (n=4,635) consisted of n=4,044 NHW and n=591 NHB respondents. I additionally note that my data was unweighted due to a high number of exclusions, missing data, and adjustment of covariates. My results were therefore only generalizable to non-institutionalized U.S. NHB and NHW Medicare beneficiaries aged 65+ in 2006 with similar characteristics to respondents in my final analytical sample (i.e., 2008 variable characteristics). Details on missing data are described in the Analysis section below.

Measures

Forgone medication

Forgone medication due to cost was the main outcome variable of interest pulled from RAND HRS files asking individuals, "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?" This question was not exclusive to respondents reporting a health condition and was only asked to those reporting prescription drug coverage and/or taking prescription medication; therefore, respondents without drug coverage yet on prescription medications were asked this question. I evaluated binary (yes/no) responses for this variable. Refer to the master data dictionary in Table 1 for more detail on the exact variable question text and definition. In order to address the time ordering issue arising from the question text asking about forgone medication "in the previous two years", my primary outcome used the 2010 forgone medication variable to model patterns between 2008-2010. (Note: In order to capture 2008 forgone medication trends, I used the 2010 forgone medication variable which asks about forgone medication "in the previous two years". This was the only 2010 variable used in the analysis).

Race/ethnicity

Racial/ethnic status was defined by two questions provided in the HRS Tracker file asking, "What race do you consider yourself to be: White, Black or African American, American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander, or something else?" and "Do you consider yourself Hispanic or Latino?". Responses from both questions are combined to determine Hispanic versus non-Hispanic status for each respondent. Eligibility criteria is initially restricted to NHW and NHB adults for this study due to small sample sizes for Hispanic (n=743)

and other adults (n=164) including American Indian, Alaska Native, Asian, Native Hawaiian, and Pacific Islander respondents [Figure 6].

Covariates

Covariates were selected according to Andersen's 1968 healthcare utilization model, which identifies the following three domains of utilization: i) *predisposing factors* (i.e. demographics, social structure, and health beliefs); ii) *enabling factors* (i.e. family and community resources); and iii) *need-based factors* (i.e. perceived and evaluated illness level) (R. Andersen, 1968). adapted this framework according to my data availability and variables of interest, as guided by previous literature. For example, my regression model controlled for *predisposing factors*, namely, age (years), gender (M/F), US-born status (Y/N)), and census region (Northeast/ Midwest/ South/ West), baseline forgone medication; (Y/N); *enabling factors*, namely, non-housing wealth ($ quartiles), healthcare costs (i.e. health insurance type {No Medicare/ Medicare only/ Medicare+Medicaid/ Medicare+HMO}, and out-of-pocket medical expenditures {$ quartiles}), and housing factors (i.e. tenure status {Homeowner/Renter} and housing insecurity {Y/N}); and *need-based factors*, namely, disease (Hypertension only/ Diabetes only/ Neither/ Both) and depression (Y/N) status. Refer to the master data dictionary in Table 1 for more detail on the exact variable question text and definition.

Analyses

Missing data analysis

Among the eligible NHB and NHW respondents (n=9,029) in 2006, approximately 22% (n=2,230) total respondents had missing forgone medication data including 22% among NHW (n=1,742) and 23% among NHB (n=284) respondents [Appendix B, Table 5-6]. Appendix B, Table 5 shows descriptive characteristics including levels of missing data by race for all study

variables. Appendix B, Table 5 indicate that NHBs had a slightly higher percentage of missingness than NHWs on lagged forgone medication (11 vs. 10%), US-born status (0.16 vs. 0.08%), census region (11 vs 10%) depression status (15 vs. 13%), health insurance (21 vs. 15%), disease status (11 vs. 10%), and housing insecurity (25 vs. 22%). Appendix B, Table 6 results indicated that forgone medication was missing at random (MAR) due to significant associations ($p<0.05$) between missing forgone medication and all covariates except race/ethnicity and US born status. Table results also indicate that those with complete versus missing forgone medication data were more likely to report no forgone medication in the lag wave (92 vs. 55%), be female (59 vs. 56%), be homeowners (72 vs. 35%), be housing secure (72 vs. 47%), reside in the Midwest (26 vs. 13%), report hypertension only (46 vs. 27%), report few depressive symptoms (89 vs. 42%), and be found in the highest wealth (30 vs. 26%) and lowest medical expenditure quartiles (23 vs. 22%). RAND HRS provided imputed values for household income, wealth and medical expenditures (Delia Bugliari, 2020). As described in the Sensitivity Analyses section below, I performed multiple imputations (MI) to handle missing data.

Main analyses

For all study variables, I performed descriptive analyses separately by race for NHW and NHB including frequency tabulations for categorical variables and mean/standard deviation and median/range values for continuous variables. A Pearson's chi-square test for categorical variables (frequency differences) and the ANOVA test for continuous variables (mean differences) were used to test for statistically significant variable differences. I then estimated a series of nested regression models to show the confounding effects of Andersen's predisposing, enabling and need-based factors on racial disparities in forgone care. I first started with predisposing factors, then added need-based factors, and finally added enabling factors. The

order in which I included the factors was based on empirical results from the initial model which showed that enabling factors had the highest confounding effect on the relationship between race and forgone medication. Future work might consider formal mediation analyses to help determine a causal ordering between these variables, as initially posed by Andersen (R. Andersen & Newman, 1973).

Model 1 was the base model with race as the primary exposure. Model 2 added to Model 1 predisposing factors including age, gender, US-born status, and census region. Model 3 added to Model 2 need-based factors such as disease and depression status. Models 4-6 added to Model 3 enabling factors such as non-housing wealth in Model 4, healthcare factors (i.e., health insurance type and out-of-pocket medical expenditures) in Model 5, and housing factors (i.e., tenure status and housing insecurity) in the fully adjusted Model 6. All models were run on non-missing study variables, and also controlled for a lagged measure of forgone medication (measured using 2008 data) which may confound the relationship between race and follow-up forgone medication. Adjusting for this lagged measure also helped approximate incident forgone medication events. Odds ratio estimates and their 95% confidence intervals (α=0.05) are reported. STATA/SE version 17.0 was used for all analyses.

Sensitivity analyses

Additional sensitivity tests were conducted to test the robustness of my main regression results to other analytical specifications. First, I estimated logistic regression models conditioned on individuals who did not report forgone medication in 2008 to identify true incident cases in the follow-up wave. Second, I estimated logistic regression models using an imputed dataset derived from the multiple imputation (MI) method which handled arbitrary missing data patterns in missing exposures, covariates or the outcome in the 2008 wave only. All variables in

analytical model were included in the imputation model which assumed the data was missing at random (MAR) as described in the Missing Data Analysis section above. I used the fully conditional specification (FCS) method, which assumes a joint distribution for these variables (van Buuren, 2007). Linear regression method was used to impute continuous variables, logistic regression for binary variables, ordered logistic regression for ordered variables, and multinomial logistic regression for nominal variables with more than two categories. Five rounds of imputations were implemented to produce five datasets, which were combined to produce final inferential regression estimates for the sample. Results from the sensitivity analyses are discussed in the following section.

RESULTS

Descriptive results

Table 6 presents descriptive results of the non-imputed, unweighted study data with detailed variable cell counts and missing data information presented in Appendix B, Table 5. Table 6 shows that the average age of NHW respondents in my sample was 76 years compared to 74 years for NHB respondents. Forgone medication due to cost was nearly double among NHB vs NHW adults (11% vs 5%). NHB in my sample were also more likely than NHW adults to be female (65 vs. 57%), reside in the South (55 vs. 36%), be renters (31 vs. 14%), report having no HMO plan (12 vs. 2%), self-report both diabetes and hypertension (26 vs. 13%), have four or more depressive symptoms (13 vs. 10%), and display both lower median out-of-pocket expenditures ($931 vs. $1,500) and non-housing wealth values ($200 vs. $68,303). Appendix B, Table 1 provides exact quartile reference values for out-of-pocket expenditures and non-housing wealth variables. NHBs were also almost two times more likely than NHW to report housing

insecurity (25 vs. 14%). Statistically significant racial differences were detected across all study covariates except US born status.

Regression results

Table 7 displays results from the six nested logistic regression models. Statistically significant associations between race and forgone medication were observed with the inclusion of predisposing and need-based factors in Models 1-3, however, were lost following the inclusion of enabling factors in Models 4-6 (respectively, wealth, healthcare and housing factors). The odds of forgone medication was higher for NHB vs NHW adults across all models with the highest odds observed in the base Model 1 (OR: 1.80, 1.31-2.48) and the lowest odds observed with the addition of wealth in Model 4 (OR: 1.11, 0.78-1.58). These findings supported my first hypothesis of higher odds of forgone medication among NHB vs. NHW during the peak of the Recession.

My second hypothesis that enabling factors would most explain the association between race and forgone medication was also supported by several findings including a nearly 50% drop in the odds of forgone medication with the addition of wealth between Models 3 and 4 (respectively, OR: 1.60, 1.15-2.23; OR: 1.11, 0.78-1.58). In the fully adjusted Model 6, the odds of forgone medication were 16 to 39% higher among NHB vs. NHW adults, renters and housing insecure adults, respectively; however, none of these associations were statistically significant (respectively, OR:1.16, 0.81-1.66; OR: 1.39, 0.98-1.95; OR: 1.24, 0.89-1.72). Additional support for my second hypothesis came from evidence of AIC criterion values indicating that the inclusion of wealth in Model 4 from the base model increased the model fit in my sample (respectively AIC=1771 vs. AIC=1825), however, Model 6 had the best overall fit (AIC= 1760) following inclusion of additional enabling factors (i.e. healthcare and housing factors). These

results suggest the strong confounding effect of wealth on the association between race and forgone medication.

In regard to other covariates, Table 7 indicates that the odds of forgone medication were statistically higher for depressed adults and those with higher out of pocket medical expenditures (Models 3-6) and statistically lower for older (vs. younger) adults and those with higher (vs. lower) non-housing wealth (Models 4-6). For example, in the fully adjusted Model 6, odds of forgone medication was approximately two times higher for depressed versus non-depressed adults (OR: 1.91, 1.35-2.69) as well as those in the highest versus lowest quartile of out-of-pocket medical expenditures (OR: 2.06, 1.33-3.19). Odds of forgone medication also decreased by 4% among aging adults every year (OR: 0.96, 0.94-0.98). Negative stepwise associations were observed between non-housing wealth and odds of forgone medication such that odds of forgone meds were 70% lower for those in the highest vs. lowest wealth quartile in the fully adjusted Model 6 (OR: 0.28, 0.18, 0.45). Conversely, positive stepwise associations were observed between out-of-pocket medical expenditures and odds of forgone medication such that odds of forgone meds were up to two times higher for those with the highest vs. lowest medical expenditures in the fully-adjusted Model 6 (OR: 2.06, 1.33-3.19). Moreover, the odds of forgone medication were 24 to 39% higher among housing insecure adults and renters in the fully adjusted Model 6; however, none of these associations were statistically significant.

Differences on the probability scale

Figure 7 shows overall racial differences in the adjusted probabilities of forgone medication which were consistent with my main regression findings in Table 7. Adjusted probabilities are presented with covariates held at sample covariate means in 2008. As indicated in the figure, NHB adults had a consistently higher probability of forgone medication than NHW

despite diminishing racial differences across all models. For example, the largest racial differences were observed in Model 1 in which the probability of forgone medication among NHB adults was 7.50% versus 4.30% among NHW adults (Δ=3.20 percentage points). The smallest differences were observed in Model 4 in which the probability of forgone medication among NHB adults was 4.30% versus 3.90% among NHW adults (Δ=0.40 percentage points). These findings supported my first hypothesis on a higher likelihood of forgone medication among NHB versus NHW adults during the Recession. My second hypothesis that enabling factors would most explain this difference was also supported by evidence indicating that the largest racial probability difference in forgone medication between models (Δ=2.00 percentage points) occurred following the addition of wealth between Models 3 and 4 (respectively, 2.40 to 0.40).

Sensitivity results

Sensitivity results from nested incidence models as well as respective unweighted and weighted imputed models are shown in Appendix B, Tables 2-4. These results were largely similar to my main findings in Table 7, indicating robustness across different methods of analyses and contributing additional support to both my hypotheses.

For example, Appendix B, Table 2 shows results from incident models among respondents who forwent medication in 2008. Similar to my main non-incident Models 1-3 in Table 7 which controlled for the lagged occurrence of forgone medication, Models 1-3 in Appendix B, Table 2 indicated that race was also a statistically significant predictor of forgone medication which became insignificant following the addition of enabling variables in Models 4-6 (respectively, wealth, healthcare and housing factors). Also similar to my main Table 7 findings, Appendix B, Table 2 indicates that NHB were more likely than NHW adults to forgo

medication in incident Models 1-6 (1.24< OR <2.28), with an observed odds of forgone

medication in Model 6 that was 28% higher for NHB versus NHW adults (OR:1.28, 0.85-1.93)

compared to 16% higher in my main Model 6 (OR:1.16, 0.81-1.66). These findings collectively

supported both my hypotheses of greater odds of forgone medication among NHB vs. NHW

adults during the peak of the Recession that was most explained by enabling factors. Odds ratios

from age, depression, wealth and out of pocket medical expenditures in the incident Model 6

were also statistically significant and in the same direction as odds ratio from my non-incident

Model 6. Similar results between non-incident and incident models suggest that my model

predictors similarly predicted prevalent and incident forgone medication cases. Therefore,

experiencing any versus no occurrence of forgone medication between 2006 and 2008 did not

significantly alter the ORs associated with forgone medication between 2008 and 2010.

     Appendix B, Table 3 shows results from the unweighted imputed dataset. Table results

from Models 1-3 supported my first hypothesis that NHB were more likely than NHW adults to

forgo medication (1.10< OR <1.33). Nevertheless, these odds were statistically insignificant

across imputed Models 1-6 with an odds of forgone medication all under one in Models 4-6

(0.76< OR<0.82). Results indicated that the greatest drop in the association between race and

forgone medication occurred following the addition of wealth between Models 3 and 4

(respectively, OR: 1.1 vs. OR: 0.76), which further supported my second hypothesis. Odds ratios

from age, depression, wealth and out of pocket medical expenditures in the imputed Model 6

were also statistically significant and in the same direction as odds ratio from my non-imputed

main Model 6 findings shown in Table 7. However, additional findings from the imputed Model

6 indicated a significantly higher odds of forgone medication, up to three times more, among

adults with Medicare only (OR: 3.06, 0.99-9.43) or Medicare plus an HMO plan (OR: 3.42, 1.10-10.63) compared to those without any Medicare.

Appendix B, Table 4 shows results from the weighted imputed dataset. Table results from Models 1-6 provided support for my first hypothesis as the odds of forgone medication across all models were both higher and statistically different among NHB vs. NHW adults (1.10< OR <1.84). Model 6 fully adjusted estimates in Appendix B, Table 4 revealed odds of forgone medication that were up to 15% higher among NHB vs. NHW adults (OR: 1.15, 0.79- 1.67) compared to a similar 16% higher odds from my main unweighted analysis (OR:1.16, 0.81-1.66). Results also indicated that the greatest drop in the association between race and forgone medication occurred following the addition of wealth between Models 3 and 4 (respectively, OR: 1.66 vs. OR: 1.10), which further supported my second hypothesis. Different to my main findings shown in Table 7 was a significantly higher odds of forgone medication, up to three times more, among adults with a Medicare plus an HMO plan (OR: 3.45, 1.07-11.14) versus no Medicare. Statistically significant odds ratios from age, depression, wealth and out of pocket medical expenditures were also in the same direction as those observed from Model 6 across main and sensitivity analyses.

DISCUSSION

Support for hypotheses

I estimated the relationship between race and forgone medications due to cost in 2008 among NHB and NHW Medicare beneficiaries and further employed a series of nested regression models to assess the extent to which predisposing, need-based and enabling factors explained this relationship. Despite a consistently higher odds of forgone medication among NHB versus NHW adults across all models, my findings indicated statistically significant

associations between race and forgone medication that were lost with the addition of non-housing wealth in which the odds of forgone medication among NHB vs. NHW adults dropped by nearly 50% and remained generally steady with the addition of healthcare and housing factors including housing insecurity. Such findings indicated the strong confounding effect of wealth on the association between race and forgone medication and its relatively greater influence over healthcare and housing factors in explaining the racial disparities in forgone medication. In the fully adjusted Model 6, positive and negative stepwise associations were found for wealth and out of pocket medical expenditures, respectively, such that the overall odds of forgone medication was up to two times higher for adults with highest vs. lowest out of pocket medical expenditures and over 70% lower for those with highest vs. lowest non-housing wealth levels.

As previously noted, main effect estimates across all models support both my study hypotheses that the odds of forgone medication would be generally higher for older NHB versus NHW adults during the Recession and that enabling factors would most explain this difference. These findings align with fundamental cause and cumulative disadvantage (CAD) theories which suggest that racial disparities in health and healthcare are largely explained by variations in socioeconomic status (SES) over the life course. For example, under fundamental cause theory, individuals with a higher socioeconomic status are more likely to experience an overall health advantage over their lower SES counterparts due to improved healthcare affordability and access along with quicker response and recovery to health threats during widespread economic stress (Burgard & Hawkins, 2014; Clark et al., 2016; Link & Phelan, 1995; Signe-Mary McKernan et al., 2013). Relatedly, the cumulative disadvantage (CAD) theory posits that racial health disparities are rooted in systematic differences in given characteristics (e.g.: money, health, status) over the life course such that the "rich get richer and the poor get poorer" especially as

they age into midlife and their late-60's (Brown, 2016; Ferraro et al., 2006; Hayward et al., 2000; O'Rand, 1996). Evidence of CAD extends to the racial wealth disparities observed in redlining housing policies, limited educational and occupational opportunities for minorities, discrimination, and intergenerational wealth inheritance. Related racial wealth disparities have also been attributed to differences in family structure (e.g. marriage, family size, and widowhood) and financial management decisions (e.g. saving and postponing consumption) (Brown, 2016; Keister & Moller, 2000; Radha Modi & Alyasah Ali Sewell, 2022). Therefore, both fundamental cause and CAD theories support my study hypotheses that greater overall financial hardship among NHB versus NHW adults during the Recession lowered the safety net needed to prevent forced trade-offs between core health needs.

Despite a lack of studies documenting specific wealth-related racial disparities in forgone medication among adults aged 65+ during the Recession, two studies of adults younger than 65 years indicated that socioeconomic factors explained racial disparities in forgone medication over the course of the Recession, providing additional support for both my study hypotheses. For example, one study among a National Health Interview Survey (NHIS) sample of working aged adults 18-64 years reported racial disparities in forgone medication during pre- to post-Recession periods (May 2006 to May 2010), with significantly higher rates of forgone medication among African-American versus White adults persisting throughout pre-Recession, early Recession, and Recession/post-Recession periods (respectively, 12.52 vs. 8.81% ; 14.95 vs. 9.55%; 15.24 vs. 10.72%) (Burgard & Hawkins, 2014). Socioeconomic disparities in forgone care were also found with a higher likelihood of forgo dental care during the Recession reported among adults with less than high school versus a college degree. Similar to my study, another NHIS 2006-2013 study also examined predisposing, need-based, and enabling factors (other than health insurance)

driving racial disparities in forgone care during the Recession (Travers et al., 2017). Findings indicated that racial disparities in forgone medication such that African-American versus White adults under 65 years were 14 to 23% (1.14 < OR < 1.23) more likely to forgo prescriptions throughout early to post-Recession study periods, with the highest differences observed in the early-Recession time period from December 2007 to November 2009 (OR: 1.23, 1.00-1.50).

In light of findings from the previous studies, persistent racial disparities in forgone medication pre-/post-Recession also indicate that the Recession widened a pre-existing racial disparity. For example, shortly following the Recession in 2010, the racial income disparity was 2 times higher among White versus Black adults while the racial wealth disparity (also referred to as the wealth race gap) was 6 times higher among White versus Black adults (Signe-Mary McKernan et al., 2013). Related literature also refers to the "balloon wealth gap" in the post-Recession period (2010-2013) in which White adults experienced a 2.4% median wealth increase relative to a 33.7% decrease among their African American counterparts (Kochhar & Fry, 2014). Such findings underscore the importance of applying Andersen's updated framework to assess the extent to which both individual and environmental-level factors influence racial disparities in forgone medical care, as racial disparities in forgone care may shrink or widen under varying economic contexts.

Limitations

Several study limitations are noted in this study. First, small sample sizes from my key exposure, outcome and covariates (i.e., health insurance status, out of pocket medical expenditures and wealth) may have limited my power and ability to detect statistical significance across all nested models. Second, I was unable to assess the type of medication forgone, limiting my ability to determine fluctuations in forgone medication according to medication cost

(McInerney et al., 2013). Third, due to dataset limitations, I did not adjust for other key determinants of forgone medication in this sample including health literacy/knowledge about medication (predisposing), drug concurrence/complexity (need), physician-patient relationship factors or access to local drug coverage programs (enabling), or state or county-level healthcare policies (environmental). Lastly, my cross-sectional analysis did not allow us to rule out reverse causation between forgone medication due to cost and other socioeconomic covariates, including wealth, as per studies suggesting the mediating roles of negative health shocks and early retirement in the relationship (Jensen & Li, 2014; Phillips et al., 1998).

Implications

To my knowledge, this is the first study to assess the role of predisposing, need-based, and enabling factors (other than health insurance) in explaining racial disparities in forgone care among Medicare beneficiaries during the Recession. My findings that wealth explained much of the racial disparity in forgone medication should motivate the development of policies or interventions anticipating increased forgone care during major economic crises among susceptible groups including older adult minorities with low wealth levels. Relevant policies should go beyond expanding Medicare coverage as studies have shown that racial differences in forgone medical care persist despite expanded Medicare part D coverage (Alegria et al., 2012; Bakk, 2015; Hussein et al., 2016; Levine et al., 2013). Because wealth is a key driver of racial health disparities, enhanced policy reform might address more fundamental causes of health disparities by creating additional financial opportunities for low-income minorities such as those to help build savings and investments along with promoting homeownership among minority households (Boen et al., 2020).

Utilization-related studies have largely focused on understanding the roles of income and out of pocket medical expenditures on forgone medication while neglecting the key role of accumulated wealth. Although I did not specifically examine the independent role of income on forgone medication, this literature gap along with my findings of statistically significant associations between forgone medication and other indicators of SES, including medical expenditures and wealth, should motivate future research examining the buffering and/or mediating roles of various SES indicators on racial differences in forgone medication. Future research might also evaluate the extent to which racial disparities fluctuated across various healthcare utilization domains over the course of the Recession, as per evidence of reduced prescription drug and dental/vision care spending yet increased emergency department and generic drug spending among financially strained adults during the Recession (J. Chen et al., 2014; J. Chen & Dagher, 2016; Mortensen & Chen, 2013; Sokol et al., 2005).

Figure 5. Andersen's updated phase 4 model of healthcare utilization, adapted. (Phillips et al., 1998)
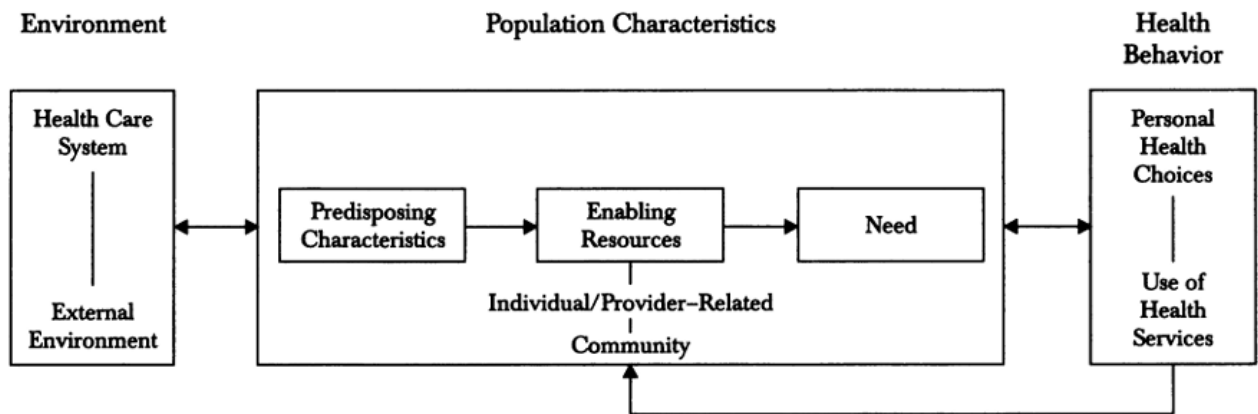
Adapted from: R. M. Andersen, 1995. "Revisiting the Behavioral Model and Access to Medical Care: Does It Matter?" *Journal of Health and Social Behavior* 36 (March): 1–10. © March 1995 by the American Sociological Association, Washington, D.C. Adapted by permission.

Figure 6. Final sample selection criteria (Non-imputed HRS baseline 2006 and follow-up 2008 samples)

Medicare beneficiaries 65+ in 2006 **(N=10,961)**

Excluding institutionalized beneficiaries in 2006 **(N=397)**

Non-institutionalized beneficiaries in 2006 **(N=10,564)**

Excluding proxy beneficiaries **(N=628)**

Non-institutionalized, non-proxy beneficiaries in 2006 **(N=9,936)**

Excluding non-NHW/NHB adults **(N=907)**

Hispanic adults (N=743)

*Other adults (N=164)

NHW adults **(N=7,789)**

Eligible NHW & NHB sample in 2006 **(N=9,029)**

NHB adults **(N=1,240)**

Excluding *missing 2008 study variables: **(N=4,394)**

Missing covariates (N=2,716)

Missing foregone medication (N=2,026)

Final analytical 2008 sample **(N=4,635)**

Final NHW sample **(N=4,044)**

Final NHB sample **(N=591)**

NOTES: "Other" race includes American Indian, Alaska Native, Asian, Native Hawaiian, and Pacific Islander. Missing variables not mutually exclusive.

Figure 7. Adjusted probability of forgone medication across all models, by race (based on Table 7 findings)
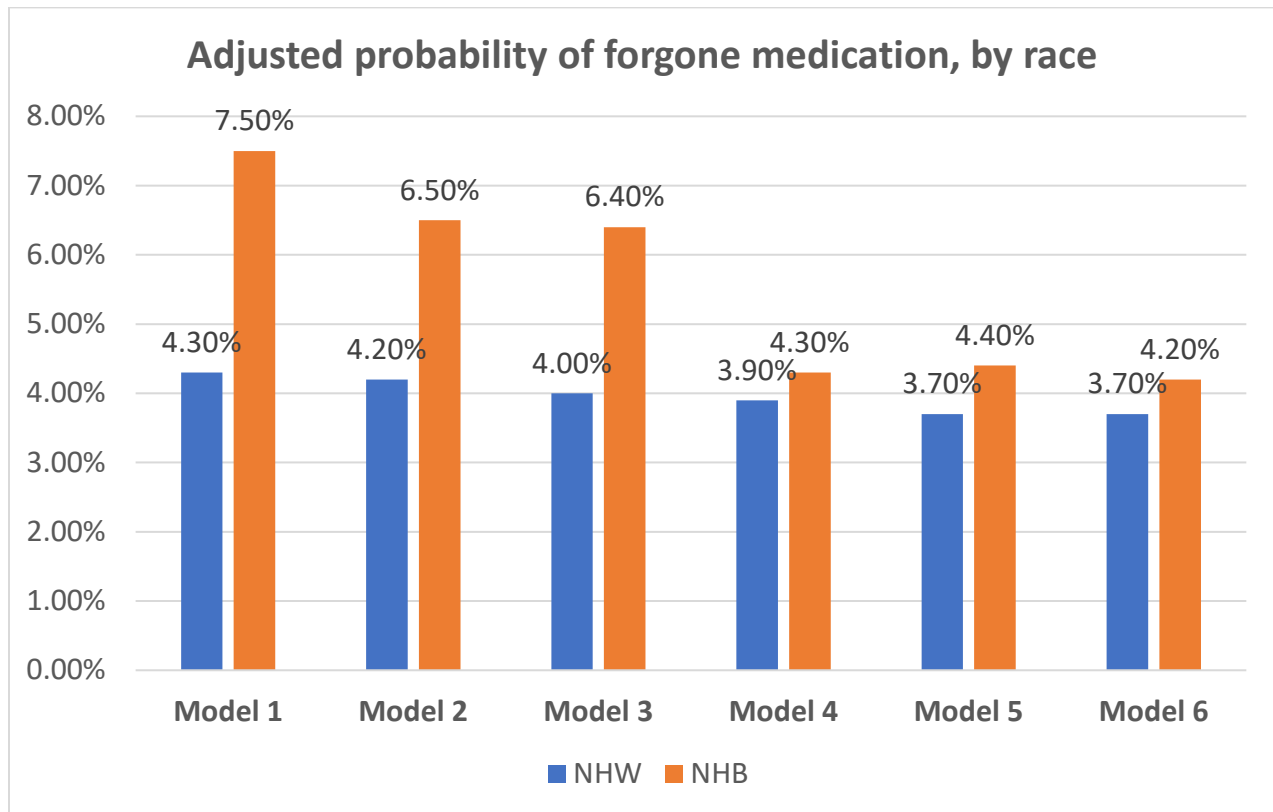
Table 6. Descriptive characteristics of NHW and NHB Medicare beneficiaries 65+ years (Unweighted, non-imputed HRS 2008 sample)

	Descriptive statistics [%] (N=4,635)	
	NHW **(N=4,044)**	**NHB** **(N=591)**
Forgone meds (2008)*		
Yes	5.07	10.49
No	94.93	89.51
Forgone meds, lagged (2006)*		
Yes	4.60	9.98
No	95.40	90.02
Age*		
Mean (SD)	*76.12 (6.54)*	*74.40 (5.79)*
Gender*		
Male	42.98	35.19
Female	57.02	64.81
US-born		
Yes	95.62	96.11
No	4.38	3.89
Census region*		
Northeast	17.71	15.91
Midwest	30.49	22.84
South	35.81	55.16
West	16.00	6.09
Disease status*		
Neither diabetes nor hypertension	34.79	17.26
Diabetes only	4.10	3.55
Hypertension only	47.87	53.64
Both diabetes and hypertension	13.23	25.55
Depression*		
Yes	9.79	13.37
No	90.21	86.63

Non-housing wealth*		
Q1, lowest	9.47	45.35
Q2	17.51	32.15
Q3	30.59	15.91
Q4, highest	42.43	6.60
Median ($)	*68,303*	*200*
Out of pocket medical expenditures*		
Q1, lowest	16.89	34.69
Q2	28.83	26.23
Q3	30.22	23.35
Q4, highest	24.06	15.74
Median ($)	*1,500*	*931*
Health insurance*		
No Medicare	0.74	1.86
Medicare only (neither Medicaid nor HMO)	74.23	56.85
Medicare with Medicaid (no HMO)	2.32	12.35
Medicare with HMO (regardless Medicaid)	22.70	28.93
Tenure*		
Homeowner	86.08	68.70
Renter	13.92	31.30
Housing insecurity*		
None	85.78	74.96
Any	14.22	25.04

NOTE. Refer to Figure 6 for final sample selection criteria. P-value indicates statistical significance at α=0.05 using chi-squared test for categorical variables and ANOVA test for continuous variables. Appendix B, Table 1 indicates quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

Table 7. Nested logistic regression models of race/ethnicity on forgone medication due to cost (Unweighted, non-imputed HRS 2008 sample)

	Forgone meds due to cost, 2008 [OR, 95%CI]* (N=4,635)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Race/ethnicity						
NHW (Ref)						
NHB	1.80 (1.31, 2.48)*	1.60 (1.15, 2.22)*	1.60 (1.15, 2.23)*	1.11 (0.78, 1.58)	1.18 (0.83, 1.69)	1.16 (0.81, 1.66)
Forgone meds, lagged (2006)						
No (Ref)						
Yes	11.57 (8.53, 15.69)*	10.70 (7.85, 14.58)*	9.97 (7.27, 13.67)*	8.03 (5.81, 11.08)*	7.19 (5.17, 10.00)*	6.98 (5.01, 9.73)*
Age						
Years		0.96 (0.94, 0.98)*	0.96 (0.94, 0.98)*	0.96 (0.94, 0.98)*	0.96 (0.94, 0.98)*	0.96 (0.94, 0.98)*
Gender						
Male (Ref)						
Female		1.14 (0.87, 1.50)	1.11 (0.84, 1.46)	1.07 (0.82, 1.41)	1.09 (0.83, 1.44)	1.07 (0.81, 1.41)
US-born						
Yes (Ref)						
No		0.95 (0.49, 1.83)	0.88 (0.45, 1.71)	0.95 (0.49, 1.87)	0.90 (0.46, 1.78)	0.86 (0.43, 1.71)
Census region						
Northeast (Ref)						
Midwest		0.95 (0.63, 1.43)	0.95 (0.63, 1.43)	1.00 (0.66, 1.51)	1.09 (0.71, 1.66)	1.12 (0.73, 1.71)
South		1.15 (0.79, 1.68)	1.14 (0.78, 1.66)	1.14 (0.78, 1.67)	1.21 (0.82, 1.78)	1.28 (0.87, 1.90)
West		0.76 (0.46, 1.25)	0.75 (0.46, 1.25)	0.85 (0.51, 1.42)	0.81 (0.48, 1.35)	0.79 (0.47, 1.33)

Disease status				
Neither diabetes nor hypertension (Ref)				
Diabetes only	1.18 (0.62, 2.27)	1.14 (0.59, 2.19)	1.10 (0.57, 2.13)	1.09 (0.56, 2.11)
Hypertension only	1.01 (0.75, 1.37)	0.99 (0.72, 1.34)	0.93 (0.68, 1.28)	0.92 (0.67, 1.26)
Both diabetes and hypertension	0.90 (0.60, 1.35)	0.83 (0.55, 1.24)	0.75 (0.49, 1.13)	0.74 (0.49, 1.12)
Depression status				
Yes	2.15 (1.54, 3.00)*	1.87 (1.33, 2.63)*	1.91 (1.36, 2.69)*	1.91 (1.35, 2.69)*
No (Ref)				
Non-housing wealth				
Q1 (Ref)				
Q2		0.80 (0.56, 1.14)	0.77 (0.54, 1.10)	0.81 (0.56, 1.16)
Q3		0.54 (0.37, 0.79)*	0.51 (0.34, 0.75)*	0.56 (0.38, 0.84)*
Q4		0.27 (0.18, 0.43)*	0.25 (0.16, 0.39)*	0.28 (0.18, 0.45)*
Health insurance				
No Medicare (Ref)				
Medicare only (neither Medicaid nor HMO)			1.16 (0.36, 3.69)	1.33 (0.41, 4.31)
Medicare with Medicaid			1.13 (0.31, 4.12)	1.21 (0.33, 4.49)

(no HMO)						
Medicare with HMO (regardless Medicaid)					1.71 (0.53, 5.49)	1.95 (0.59, 6.39)
Out of pocket medical expenditures						
Q1 (Ref)						
Q2					1.18 (0.76, 1.82)	1.21 (0.78, 1.88)
Q3					1.70 (1.11, 2.61)*	1.78 (1.16, 2.72)*
Q4					1.98 (1.29, 3.06)*	2.06 (1.33, 3.19)*
Tenure						
Homeowner (Ref)						
Renter						1.39 (0.98, 1.95)
Housing insecurity						
No (Ref)						
Yes						1.24 (0.89, 1.72)
AIC value	1825.33	1815.89	1805.12	1771.11	1762.74	1760.39

NOTE: All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance at p<0.05 within model.

Appendix B

Black-White Differences in forgone medication due to cost during the Recession: The role of predisposing, enabling and need-based factors

Appendix B, Table 1. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables among Medicare beneficiaries 65+ years (HRS 2008 sample)

Appendix B, Table 2. Nested models predicting incidence of forgone medication due to cost among Medicare beneficiaries 65+ years (Unweighted, non-imputed HRS 2008 sample)

Appendix B, Table 3. Nested models predicting likelihood of forgone medication due to cost among Medicare beneficiaries 65+ years (Unweighted, imputed HRS 2008 sample)

Appendix B, Table 4. Nested models predicting likelihood of forgone medication due to cost among Medicare beneficiaries 65+ years (Weighted, imputed HRS 2008 sample)

Appendix B, Table 5. Descriptive characteristics of NHW and NHB Medicare beneficiaries 65+ years with missing information (Unweighted, non-imputed HRS 2008 sample)

Appendix B, Table 6. Descriptive characteristics Medicare beneficiaries 65+ years with missing versus complete forgone medication outcome data (Unweighted, non-imputed HRS 2008 sample)

Tables

Appendix B, Table 1. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables among Medicare beneficiaries 65+ years (HRS 2008 sample)

	Out of pocket medical expenditures [$] **(n=9,936)**	**Non-housing wealth [$]** **(n=9,936)**
NHW (n=7,789)		
Q1	*0 to 408*	*-1.4e06 to 0*
Q2	*410 to 1,350*	*1 to 11,000*
Q3	*1,352 to 3,200*	*11,002 to 100,100*
Q4	*3,203 to 471,640*	*100,535 to 1.52e07*
NHB (n=1,240)		
Q1	*0 to 408*	*-79,028 to 0*
Q2	*428 to 1,350*	*1 to 11,000*
Q3	*1,352 to 3,200*	*12,000 to 100,500*
Q4	*3,224 to 84,623*	*101,000 to 371,800*

*NOTE: Refer to Figure 6 for final sample selection criteria. Reference values are based on imputed RAND HRS data.

Appendix B, Table 2. Nested models predicting incidence of forgone medication due to cost among Medicare beneficiaries 65+ years (Unweighted, non-imputed HRS 2008 sample)

Forgone meds due to cost, 2008	Main effect [OR, 95% CI]* (N=4,390)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Race/ethnicity						
NHW (Ref)						
NHB	2.28 (1.59, 3.25)*	1.99 (1.38, 2.86)*	1.93 (1.33, 2.81)*	1.24 (0.83, 1.86)	1.32 (0.87, 1.98)	1.28 (0.85, 1.93)
Age						
Years		0.95 (0.93, 0.98)*	0.95 (0.93, 0.98)*	0.95 (0.93, 0.98)*	0.95 (0.93, 0.98)*	0.95 (0.93, 0.98)*
Gender						
Male (Ref)						
Female		1.22 (0.89, 1.66)	1.17 (0.86, 1.60)	1.13 (0.82, 1.54)	1.14 (0.83, 1.55)	1.12 (0.82, 1.53)
US-born						
Yes (Ref)						
No		0.80 (0.34, 1.84)	0.77 (0.33, 1.78)	0.85 (0.37, 1.98)	0.83 (0.36, 1.93)	0.82 (0.35, 1.91)
Census region						
Northeast (Ref)						
Midwest		1.19 (0.74, 1.91)	1.18 (0.73, 1.90)	1.26 (0.78, 2.03)	1.36 (0.84, 2.22)	1.41 (0.86, 2.29)
South		1.31 (0.84, 2.06)	1.30 (0.83, 2.04)	1.32 (0.84, 2.08)	1.38 (0.87, 2.18)	1.46 (0.92, 2.31)
West		0.84 (0.45, 1.54)	0.84 (0.45, 1.54)	0.97 (0.52, 1.79)	0.91 (0.49, 1.70)	0.90 (0.49, 1.68)
Disease status						
Neither diabetes nor hypertension (Ref)						

Diabetes only	1.14 (0.53, 2.44)	1.06 (0.49, 2.30)	1.03 (0.48, 2.23)	1.03 (0.48, 2.23)
Hypertension only	1.02 (0.72, 1.44)	0.97 (0.68, 1.37)	0.91 (0.64, 1.29)	0.89 (0.63, 1.27)
Both diabetes and hypertension	0.98 (0.61, 1.57)	0.86 (0.53, 1.38)	0.76 (0.47, 1.22)	0.75 (0.46, 1.21)
Depression status				
Yes	2.03 (1.36, 3.03)*	1.78 (1.18, 2.67)*	1.77 (1.18, 2.67)*	1.75 (1.16, 2.64)*
No (Ref)				
Non-housing wealth				
Q1 (Ref)				
Q2		0.81 (0.53, 1.23)	0.80 (0.52, 1.22)	0.82 (0.54, 1.26)
Q3		0.50 (0.32, 0.78)*	0.49 (0.31, 0.77)*	0.53 (0.33, 0.84)*
Q4		0.27 (0.16, 0.44)*	0.26 (0.16, 0.42)*	0.28 (0.17, 0.47)*
Health insurance				
No Medicare (Ref)				
Medicare only (neither Medicaid nor HMO)			1.02 (0.23, 4.51)	1.10 (0.25, 4.83)
Medicare with Medicaid (no HMO)			1.55 (0.32, 7.60)	1.51 (0.31, 7.37)
Medicare with HMO (regardless Medicaid)			1.52 (0.34, 6.80)	1.64 (0.37, 7.30)

Out of pocket medical expenditures						
Q1 (Ref)						
Q2					1.21 (0.75, 1.96)	1.24 (0.77, 2.01)
Q3					1.77 (1.11, 2.83)*	1.84 (1.15, 2.96)*
Q4					2.16 (1.33 (3.51)*	2.24 (1.37, 3.65)*
Tenure						
Homeowner (Ref)						
Renter						1.40 (0.94, 2.08)
Housing insecurity						
No (Ref)						
Yes						1.19 (0.81, 1.76)
AIC value	1501.28	1492.64	1490.08	1461.89	1456.99	1456.63

NOTE: All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance at p<0.05 within model.

Appendix B, Table 3. Nested models predicting likelihood of forgone medication due to cost among Medicare beneficiaries 65+ years (Unweighted, imputed HRS 2008 sample)

Forgone meds due to cost, 2008	Main effect [OR, 95%CI]* (N=5,975)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Race/ethnicity						
NHW (Ref)						
NHB	1.33 (0.99, 1.78)	1.17 (0.87, 1.57)	1.10 (0.81, 1.49)	0.76 (0.55, 1.05)	0.83 (0.60, 1.14)	0.82 (0.59, 1.13)
Forgone meds, lagged (2006)						
No (Ref)						
Yes	12.34 (9.49, 16.03)*	11.39 (8.72, 14.86)*	10.56 (8.05, 13.84)*	8.52 (6.46, 11.23)*	7.85 (5.91, 10.42)*	7.71 (5.79, 10.25)*
Age						
Years		0.96 (0.94, 0.98)*	0.96 (0.94, 0.98)*	0.96 (0.95, 0.98)*	0.96 (0.94, 0.98)*	0.96 (0.94, 0.98)*
Gender						
Male (Ref)						
Female		1.10 (0.87, 1.39)	1.07 (0.84, 1.36)	1.06 (0.84, 1.35)	1.04 (0.82, 1.33)	1.03 (0.81, 1.32)
US-born						
Yes (Ref)						
No		0.98 (0.57, 1.69)	0.95 (0.55, 1.65)	1.04 (0.60, 1.81)	0.97 (0.56, 1.69)	0.96 (0.55, 1.68)
Census region						
Northeast (Ref)						
Midwest		0.76 (0.52, 1.09)	0.77 (0.53, 1.11)	0.82 (0.57, 1.19)	0.84 (0.57, 1.23)	0.85 (0.58, 1.24)
South		1.11 (0.80, 1.53)	1.13 (0.81, 1.56)	1.12 (0.81, 1.56)	1.14 (0.81, 1.60)	1.18 (0.84, 1.66)

West	0.63 (0.41, 0.97)*	0.65 (0.42, 1.01)	0.72 (0.46, 1.12)	0.72 (0.46, 1.12)	0.71 (0.45, 1.12)
Disease status					
Neither diabetes nor hypertension (Ref)					
Diabetes only		0.95 (0.51, 1.77)	0.93 (0.49, 1.73)	0.88 (0.46, 1.65)	0.87 (0.46, 1.63)
Hypertension only		1.09 (0.83, 1.43)	1.06 (0.81, 1.40)	0.95 (0.72, 1.25)	0.94 (0.71, 1.25)
Both diabetes and hypertension		1.26 (0.90, 1.78)	1.16 (0.82, 1.64)	0.98 (0.69, 1.40)	0.97 (0.68, 1.39)
Depression status					
Yes		2.09 (1.56, 2.78)*	1.85 (1.38, 2.48)*	1.97 (1.47, 2.65)*	1.97 (1.46, 2.64)*
No (Ref)					
Non-housing wealth					
Q1 (Ref)					
Q2			0.82 (0.61, 1.12)	0.78 (0.57, 1.06)	0.80 (0.58, 1.09)
Q3			0.55 (0.39, 0.76)*	0.50 (0.36, 0.70)*	0.52 (0.37, 0.74)*
Q4			0.23 (0.15, 0.34)*	0.20 (0.13, 0.30)*	0.21 (0.14, 0.32)*
Health insurance					
No Medicare (Ref)					
Medicare only (neither Medicaid nor HMO)				3.00 (0.98, 9.22)	3.06 (0.99, 9.43)*

Medicare with Medicaid (no HMO)					2.42 (0.69, 8.50)	2.35 (0.67, 8.30)
Medicare with HMO (regardless Medicaid)					3.37 (1.09, 10.45)*	3.42 (1.10, 10.63)*
Out of pocket medical expenditures						
Q1 (Ref)						
Q2					1.31 (0.88, 1.96)	1.13 (0.88, 1.97)
Q3					2.11 (1.44, 3.10)*	2.14 (0.46, 3.14)*
Q4					1.95 (1.32, 2.90)*	1.97 (1.33, 2.92)*
Tenure						
Homeowner (Ref)						
Renter						1.26 (0.92, 1.73)
Housing insecurity						
None (Ref)						
Any						1.02 (0.78, 1.34)
AIC value	2364.63	2344.30	2327.44	2267.32	2249.54	2251.40

NOTE: All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance at p<0.05 within model.

Appendix B, Table 4. Nested models predicting likelihood of forgone medication due to cost among Medicare beneficiaries 65+ years (Weighted, imputed HRS 2008 sample)

Forgone meds due to cost, 2008	Main effect [OR,95% CI]* (N=4,390)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Race/ethnicity						
NHW (Ref)						
NHB	1.84 (1.29, 2.63)*	1.65 (1.17, 2.34)*	1.66 (1.16, 2.37)*	1.10 (0.75, 1.60)	1.16 (0.80, 1.67)	1.15 (0.79, 1.67)
Forgone meds, lagged (2006)						
No (Ref)						
Yes	12.66 (9.19, 17.43)*	11.71 (8.52, 16.09)*	10.91 (8.00, 14.87)*	8.31 (6.03, 11.44)*	7.57 (5.43, 10.54)*	7.39 (5.26, 10.38)*
Age						
Years		0.95 (0.93, 0.98)*	0.95 (0.93, 0.98)*	0.96 (0.93, 0.98)*	0.96 (0.93, 0.98)*	0.95 (0.93, 0.98)*
Gender						
Male (Ref)						
Female		1.27 (0.96, 1.68)	1.23 (0.92, 1.64)	1.20 (0.89, 1.61)	1.21 (0.89, 1.64)	1.19 (0.87, 1.63)
US-born						
Yes (Ref)						
No		1.13 (0.53, 2.41)	1.06 (0.50, 2.25)	1.18 (0.57, 2.44)	1.14 (0.54, 2.41)	1.12 (0.53, 2.34)
Census region						
Northeast (Ref)						
Midwest		1.05 (0.74, 1.48)	1.05 (0.73, 1.51)	1.12 (0.77, 1.63)	1.25 (0.84, 1.86)	1.28 (0.86, 1.90)
South		1.17 (0.78, 1.76)	1.16 (0.77, 1.75)	1.17 (0.77, 1.78)	1.28 (0.83, 1.98)	1.36 (0.89, 2.07)

	Model 1	Model 2	Model 3	Model 4	Model 5
West	0.77 (0.46, 1.30)	0.78 (0.47, 1.29)	0.90 (0.52, 1.55)	0.87 (0.49, 1.55)	0.86 (0.48, 1.52)
Disease status					
Neither diabetes nor hypertension (Ref)					
Diabetes only		0.90 (0.42, 1.89)	0.85 (0.42, 1.73)	0.84 (0.43, 1.68)	0.83 (0.42, 1.61)
Hypertension only		1.08 (0.79, 1.47)	1.03 (0.76, 1.41)	0.99 (0.73, 1.33)	0.97 (0.72, 1.32)
Both diabetes and hypertension		0.91 (0.58, 1.42)	0.83 (0.53, 1.29)	0.77 (0.50, 1.19)	0.76 (0.50, 1.18)
Depression status					
Yes		2.12 (1.53, 2.95)*	1.84 (1.29, 2.61)*	1.89 (1.35, 2.64)*	1.86 (1.33, 2.60)*
No (Ref)					
Non-housing wealth					
Q1 (Ref)					
Q2			0.69 (0.46, 1.03)	0.67 (0.45, 1.01)*	0.71 (0.47, 1.06)
Q3			0.47 (0.27, 0.81)*	0.45 (0.26, 0.76)*	0.49 (0.29, 0.84)*
Q4			0.24 (0.15, 0.36)*	0.22 (0.14, 0.34)*	0.25 (0.16, 0.39)*
Health insurance					
No Medicare (Ref)					
Medicare only (neither Medicaid nor HMO)				1.96 (0.58, 6.59)	2.21 (0.66, 7.44)

Medicare with Medicaid (no HMO)	1.91 (0.47, 7.74)	2.01 (0.51, 8.00)
Medicare with HMO (regardless Medicaid)	3.08 (0.96, 9.91)	3.45 (1.07, 11.14)*
Out of pocket medical expenditures		
Q1 (Ref)		
Q2	1.24 (0.72, 2.12)	1.27 (0.74, 2.19)
Q3	1.78 (1.04, 3.06)*	1.85 (1.06, 3.20)*
Q4	1.90 (1.10, 3.27)*	1.96 (1.14, 3.35)*
Tenure		
Homeowner (Ref)		
Renter		1.35 (0.91, 2.02)
Housing insecurity		
None (Ref)		
Any		1.21 (0.80, 1.82)

NOTE: All estimates include Odds Ratio and 95% CI. Asterisk (*) indicates statistical significance at p<0.05 within model.

Appendix B, Table 5. Descriptive characteristics of NHW and NHB Medicare beneficiaries 65+ years with missing information (Unweighted, non-imputed HRS 2008 sample)

	Descriptive statistics [N, Col%] (N=9,936)			
	NHW **(N=7,789)**		**NHB** **(N=1,240)**	
Forgone meds (2008)				
Missing	*1,742*	*22.36*	*284*	*22.90*
Yes	356	4.57	109	8.79
No	5,691	73.06	847	68.31
Forgone meds, lagged (2006)				
Missing	*793*	*10.18*	*136*	*10.97*
Yes	386	4.96	109	8.79
No	6,610	84.86	995	80.24
Age				
Missing	*781*	*10.03*	*132*	*10.65*
Mean (SD)	*76.45*	*6.99*	*75.26*	*6.80*
Gender				
Missing	*-*	*-*	*-*	*-*
Male	3,358	43.11	441	35.56
Female	4,431	56.89	799	64.44
US-born				
Missing	*6*	*0.08*	*2*	*0.16*
Yes	7,447	95.61	1,177	94.92
No	336	4.31	61	4.92
Census region				
Missing	*784*	*10.07*	*132*	*10.65*
Northeast	1,170	15.02	160	12.90
Midwest	2,010	25.81	237	19.11
South	2,606	33.46	646	52.10
West	1,219	15.65	65	5.24
Disease status				
Missing	*794*	*10.19*	*134*	*10.81*
Neither diabetes nor hypertension	2,359	30.29	187	15.08
Diabetes only	309	3.97	43	3.47
Hypertension only	3,271	42.00	552	44.52

Both diabetes and hypertension	1,056	13.56	324	10.81
Depression status				
Missing	*996*	*12.79*	*185*	*14.92*
Yes	813	10.44	173	13.95
No	5,980	76.77	882	71.13
Non-housing wealth				
Missing	-	-	-	-
Q1, lowest	932	13.30	540	48.74
Q2	1,499	21.39	364	32.85
Q3	2,071	29.55	147	13.27
Q4, highest	2,506	35.76	57	5.14
Median ($)	*41,000*		*20*	
Out of pocket medical expenditures				
Missing	-	-	-	-
Q1, lowest	1,295	18.48	385	34.75
Q2	1,883	26.87	266	24.01
Q3	2,020	28.82	253	22.83
Q4, highest	1,810	25.83	204	18.41
Median ($)	*1,560*		*960*	
Health insurance				
Missing	*1,153*	*14.80*	*255*	*20.56*
No Medicare	61	0.78	17	1.37
Medicare only (neither Medicaid nor HMO)	4,865	62.46	546	44.03
Medicare with Medicaid (no HMO)	214	2.75	141	11.37
Medicare with HMO (regardless Medicaid)	1,496	19.21	281	22.66
Tenure				
Missing	*1,906*	*24.47*	*266*	*21.45*
Homeowner	5,096	65.43	703	56.69
Renter	787	10.10	271	21.85
Housing insecurity				

Missing	*1,712*	*21.98*	*314*	*25.32*
None	5,297	68.01	725	58.47
Any	780	10.01	201	16.21

NOTE. Refer to Figure 6 for final sample selection criteria. Appendix B, Table 1 indicates quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

Appendix B, Table 6. Descriptive characteristics Medicare beneficiaries 65+ years with missing versus complete forgone medication outcome data (Unweighted, non-imputed HRS 2008 sample)

	Descriptive statistics [N, Col%] (N=9,936)			
	Missing (N=2,230)		Complete (N=7,706)	
Race/ethnicity				
Missing	*204*	*9.15*	*703*	*9.12*
NHW	1,742	78.12	6,047	78.47
NHB	284	12.74	956	12.41
Forgone meds, lagged (2006)*				
Missing	*909*	*40.76*	*108*	*1.40*
Yes	87	3.90	473	6.14
No	1,234	55.34	7,125	92.46
Age*				
Missing	*901*	*40.40*	*99*	*1.28*
Mean (SD)	*79.85*	*8.16*	*75.51*	*6.52*
Gender*				
Missing	*-*	*-*	*-*	*-*
Male	985	44.17	3,177	41.23
Female	1,245	55.83	4,529	58.77
US-born				
Missing	*3*	*0.13*	*8*	*0.10*
Yes	2,048	91.84	7,014	91.02
No	179	8.03	684	8.88
Census region*				
Missing	*903*	*40.49*	*106*	*1.38*
Northeast	253	11.35	1,157	15.01
Midwest	296	13.27	1,994	25.88
South	552	24.75	3,062	39.74
West	226	10.13	1,387	18.00
Disease status*				
Missing	*909*	*40.76*	*109*	*1.41*
Neither diabetes nor hypertension	309	13.86	2,474	32.10
Diabetes only	72	3.23	341	4.43
Hypertension only	611	27.40	3,511	45.56

Both diabetes and hypertension	329	14.75	1,271	16.49
Depression status*				
Missing	*1,045*	*46.86*	*258*	*3.35*
Yes	249	11.17	908	11.78
No	936	41.97	6,540	84.87
Non-housing wealth*				
Missing	-	-	-	-
Q1, lowest	319	24.00	1,507	19.81
Q2	372	27.99	1,784	23.45
Q3	295	22.20	2,037	26.78
Q4, highest	343	25.81	2,279	29.96
Median ($)	*10,000*		*22,000*	
Out of pocket medical expenditures*				
Missing	-	-	-	-
Q1, lowest	293	22.05	1,769	23.25
Q2	294	22.12	2,040	26.82
Q3	326	24.53	2,074	27.26
Q4, highest	416	31.30	1,724	22.66
Median ($)	*1,690*		*1,350*	
Health insurance*				
Missing	*1,015*	*45.52*	*538*	*6.98*
No Medicare	16	0.72	76	0.99
Medicare only (neither Medicaid nor HMO)	773	34.66	4,924	63.90
Medicare with Medicaid (no HMO)	123	5.52	411	5.33
Medicare with HMO (regardless Medicaid)	303	13.59	1,757	22.80
Tenure*				
Missing	*1,194*	*53.54*	*1,211*	*15.72*
Homeowner	791	35.47	5,517	71.59
Renter	245	10.99	978	12.69

Housing insecurity*

Missing	*1,044*	*46.82*	*1,221*	*15.84*
No	1,038	46.55	5,545	71.96
Any	148	6.64	940	12.20

NOTE. Refer to Figure 6 for final sample selection criteria. P-value indicates statistical significance at α=0.05 using chi-squared test for categorical variables and ANOVA test for continuous variables.

Chapter 5 (Paper 3)- Evaluating the relationship between housing insecurity and depressive symptoms among Medicare beneficiaries over the course of the Recession: The role of predisposing, enabling and need-based factors

INTRODUCTION

The Great Recession of 2007 to 2009 severely shocked the U.S. housing and financial market. Heightened unemployment (doubling from 4.4% in 2007 to 9.5% in 2010) precipitated insurance and income loss among 14 million American adults most notably among racial and ethnic minorities and persons of low socioeconomic status (SES) (Bennett & Kochhar, 2019; Center for Disease Control & Prevention (CDC), 2010; Herbert & Apgar, 2010; Jacquez et al., 2009; R. W. Johnson, 2009; Kochhar et al., 2009; Mather, 2015; Reid & Laderman, 2009; US Bureau of Labor Statistics (BLS), 2012). Increased financial hardship during the Recession also led to housing hardship among 36% and 52% of adults aged 50+ who struggled to pay for housing, or were "housing insecure", defined by U.S. Department of Housing and Urban Development (HUD) as spending more than 30% of monthly household income on housing costs (Harrell, 2011; Housing and Urban Development (HUD), 2020).

Housing hardship during the Recession was accompanied by elevated physical and, especially, mental health conditions, both globally and domestically (Bhat et al., 2022; Heggebø et al., 2019; Margerison-Zilko et al., 2016; Singh et al., 2019; Tsai, 2015). Prior research has indicated that adults facing housing hardship during the Recession displayed a higher odds of poor self-rated health, anxiety, depression, hypertension, sleeping problems, and cognitive decline relative to their counterparts without hardship. These associations were especially prominent among 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). Nationally representative studies indicate a 45-75% higher incidence of depressive symptoms between pre and post-Recession periods (respectively, 2005-2006 and 2010-2011) among older adults aged 50+ experiencing increased foreclosures including heightened default notices, auctions, and real-estate ownership holdings (respectively, OR: 1.75; 1.14-2.67; OR:1.45; 0.96- 2.19; OR: 1.62, 1.06-2.47) (Cagney et al., 2014; Mehta et al., 2015; Pruchno et al., 2017).

Despite such evidence, Downing's Homeowner Distress Model is the only attempt in the literature that I am aware of to propose a framework of mechanisms through which housing hardship impacted poor health during the Recession (Figure 11) (Downing, 2016). These include stress, effect-budgeting, frustration-aggression, and trust. Of these, the stress mechanism has been the most widely cited in the literature with most studies focusing on the overall role of illness-related financial burden (stress) or perception of financial hardship (strain) on poor mental health (Hanratty et al., 2007). For example, although there is a potential for reverse causation, studies have indicated positive associations between financial strain and/or stress and poor mental health including depression and anxiety as well as other markers of poor physical health including early disability, chronic conditions, terminal cancer, and mortality among older adult women and racial/ethnic minorities (Blazer et al., 2007; Kahn & Pearlin, 2006; Lincoln, 2007; Shippee et al., 2012; Sun et al., 2009). Additionally, while highly useful, Downing's model remains limited to homeowners upon which the model was initially based. Therefore, by adapting the model to both renters and homeowners, this study contributes an important understanding to the Recession-related health impacts of housing hardships among a wider U.S. population.

Relatedly, *psychosocial* and *neo-material* pathways have surfaced in the literature to help explain associations between overall financial hardship and poor health among adults with varying SES levels, also known as the social health gradient (Adamson et al., 2006; Cambois & Jusot, 2011; Kahn & Pearlin, 2006; Krieger et al., 2005; Macleod et al., 2005; Skalická et al., 2009). For example, the *psychosocial* pathway is explained by stress associated with perceptions of social disadvantage, in turn, increasing the risk of unhealthy behaviors and cumulative biological health burden, making it more difficult for the body to readjust to prior health levels overtime (also referred to as allostatic load) (Gruenewald et al., 2012; McEwen, 1998). Conversely, the *neo-material* pathway is explained by direct material disadvantage and health damaging exposures leading to inadequate access to material resources such as medical care, housing and food. While both pathways can help explain the social health gradient, in this study I primarily rely on the *neo-material* pathway to understand the extent to which housing insecurity led to differential poor mental health outcomes among older adults over the course of the Recession.

Studies documenting associations and related pathways between financial stress/strain and poor mental health are well-established in the extant literature. Less established, however, are studies evaluating the particular role of housing insecurity, as per the HUD definition, on depression among older adults over the course of the Recession (2008-2012) (Housing and Urban Development (HUD), 2020). Instead, a number of studies have examined poor mental health linked to various forms of financial stress/strain including perceived income inadequacy and unmet basic need as well as economic status tied to unemployment, out of pocket medical expenses and medical and credit card debt (Kalousova & Burgard, 2013, 2014; May & Cunningham, 2004; Zimmerman & Katon, 2005). Rather than examining housing insecurity,

studies on poor mental health have also turned to other housing-related financial stressors including foreclosure, evictions, or defaults as well as federal housing assistance or legal issues related to housing-finance. Related health studies have also examined other dimensions of housing (e.g. housing stability, housing quality, housing safety, etc.) including individuals' distress or difficulty in paying monthly housing costs (Caswell & Zuckerman, 2018; Kushel et al., 2006b; Pollack et al., 2010; Rodgers et al., 2019).

Additionally, only a few Recession-related studies have focused on the overall health impacts of financial or housing hardships among Medicare beneficiaries aged 65+, as most have generally focused on older adult population aged 50+. Older adults aged 65+ are an important population to study because, in line with neo-material pathways of material disadvantage, they have fewer resources to budget and are therefore more likely to forgo medication due to cost and experience poorer health outcomes than working-aged adults under 65 years. Supporting evidence indicates that adults aged 65+ are likely to forgo medication due to cost given their high out-of-pocket costs and limited health insurance coverage, including "donut hole" drug coverage gaps in which Medicare part D beneficiaries who reach a certain threshold in annual expenditures on their drug plan pay up to 25% of brand name and generic drug costs ($4,660 in 2023) (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). Both housing insecurity and forgone medication are especially likely among retired older adults whose income is cut in half following retirement and continues to decline over time (JCHS, 2020; Purcell, 2012). Moreover, older adults who lived through the Recession were forced to delay their retirement or return to the labor force post-retirement due to decreasing housing prices and

insecure retirement savings, with nationally representative survey data indicating a 25% drop

(i.e. -$64,121) in median net worth among adults aged 65+ years between 2007 and 2011

(Pfeffer et al., 2013; Zhao & Burge, 2021).

Therefore, the primary objective of this study was to i) examine the association between

baseline (2008) housing insecurity and depressive symptoms among Medicare beneficiaries over

the course of the Recession (2008-2012), and ii) assess the extent to which baseline predisposing,

need-based and enabling covariates explained this relationship. I hypothesized that baseline

housing insecurity would be associated with an increased depressive symptoms throughout the

course of the Recession, and that enabling factors would explain this relationship due to neo-

material pathways of material disadvantage linking housing insecurity to poor health and other

indicators of financial hardship.

METHODS

Dataset

Data for this analysis primarily came from the 2008, 2010 and 2012 waves of 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

longitudinally every two years since 1992 and spans pre- and post-Recession time periods

between 2006 and 2012 (Servais, 2010). Eligibility is determined from an initial 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 and Longitudinal files were used for this study (Bugliari et al., 2020; Servais, 2010).

Analytic sample

I constructed a longitudinal person-wave file from the 2008, 2010, and 2012 waves. Figure 8 shows the criteria that was used to select the eligible and analytic samples across all waves of data. Consistent with previous papers, my initial sample consisted of n=9,936 non-proxy, non-institutionalized Medicare beneficiaries aged 65+ in 2006. Once RAND HRS person-level weights were applied, exclusions were made for n=584 respondents who entered institutional settings and n=2,494 total respondents who died between 2008 and 2012 [not shown in Figure 8]. My weighted data thus permitted generalizability of my results to all non-institutionalized U.S. adults aged 65+ between 2008-2012 who were also non-institutionalized, non-proxy Medicare beneficiaries in 2006. Despite relatively high follow-up interview rates in the HRS-, roughly 3-6% of surviving respondents in my sample did not complete a follow-up interview in each wave between 2008-2012 [not shown in Figure 8]. Therefore, my final sample of eligible respondents between 2008-2012 consisted of n=8,889 total unique subjects with n=8,753 respondents participating in the 2008 wave; n=7,464 in the 2010 wave; and n=6,594 in the 2012 wave.

Among eligible respondents, exclusions were further made for respondents missing baseline covariates (n=3,919) and exposure variables (n=990) in 2008. Therefore, the final analytical sample (n=4,991) with non-missing study covariate/exposures and at least one measured outcome in any of the three follow-up waves between 2008 and 2012 was as follows:

n=4,961 in 2008; n=4,723 in 2010; and n=4,112 in 2012. This yielded n=13,796 total person-waves of data across all three waves. Details on missing data are described in the Analyses section below.

Measures

Depressive symptoms

Depressive symptoms were the main outcome of interest defined in the RAND HRS by the eight-item version of the Center for Epidemiologic Studies Depression (CES-D) scale. The scale has been widely applied as a screening tool for depression across different population subgroups including Black and White adults over 64 years with varying education levels (Asebedo & Wilmarth, 2017; Radloff, 1977; Zivin, Llewellyn, et al., 2010). Respondents are asked to answer a series of eight (yes/no) questions on their depressive symptoms in the past week including feeling depressed, feeling activities were an effort, restless sleep, feeling happy, lonely, sad, getting going, and enjoying life. In this study I obtain a total score ranging from 0 to 8 based on the number of endorsed depressive symptoms, with higher scores indicating individuals with a higher number of depressive symptoms.

Housing insecurity

In this study, I define housing insecurity as my primary exposure of interest according to the HUD index definition of spending more than 30% of household income on housing costs (Housing and Urban Development (HUD), 2020). I operationalized this definition by calculating the percentage of monthly household income spent on monthly housing costs: 100*(monthly housing costs/monthly household income). A small number of respondents reported an income of $0 (n=15 in 2008, n=34 in 2010 and n=25 in 2012). These individuals were coded as missing

on the housing insecurity variable. 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 wages and non-wage earnings (e.g. job or military reserve earnings), pensions and annuities, Social Security disability and retirement, unemployment and workers' compensation, other government transfers, household capital income, and other income. Refer to the master data dictionary in Table 1 for more detail on the exact variable question text and definition. I constructed a one-wave (yes/no) housing insecurity variable in 2008 using the 30% HUD index cut-point mentioned above.

Covariates

Covariates were selected according to Andersen's 1968 healthcare utilization model, which identifies the following three domains of utilization: i) *predisposing factors* (e.g. demographics, social structure, and health beliefs); ii) *enabling factors* (e.g. family and community resources); and iii) *need-based factors* (e.g. perceived and evaluated illness level) (R. Andersen, 1968). I adapted this framework according to my data availability and variables of interest, as guided by previous literature (Babitsch et al., 2012; Boer et al., 1997; Gelberg et al., 2000; Heider et al., 2014; Jin et al., 2019; Kushel et al., 2006b; Phillips et al., 1998). For example, my regression model controlled for *predisposing factors*, namely, education (No degree/ High school,GED/ Some college,Associate's/ Bachelor's or higher), race/ethnicity (NHW/NHB), age (years), gender (M/F), US-born status (Y/N), census region (Northeast/Midwest/South/West), and forgone medication due to cost (Y/N); *enabling factors*, namely, non-housing wealth ($ quartiles), healthcare factors (i.e. health insurance type {No

Medicare/ Medicare only/ Medicare+Medicaid/ Medicare+HMO}, and out-of-pocket medical

expenditures {$ quartiles}), and housing factors (i.e. tenure status {Homeowner/Renter}); and

need-based factors, namely, disease status (Hypertension only/ Diabetes only/ Neither/ Both).

The data dictionary in Table 1 shows the question text and definitions of all study covariates,

including outcome and exposure variables.

Analyses

Missing data analysis

Among the n=9,936 eligible respondents in 2006, approximately 14% of respondents

(n=1,256) had missing baseline housing insecurity data; 4% (n=823) had missing depressive

symptom data in any wave; and between 6-15% had missing data on other baseline covariates

such as health insurance, forgone medication and tenure status, respectively [not shown in Figure

8]. RAND provided imputed values for household income, wealth and medical expenditures

(Delia Bugliari, 2020). I did not impute missing data, rather, employed a linear mixed model

based on likelihood-based estimation which assumes that data is missing at random (MAR).

Additional Appendix C, Table 3 results from the missing outcome analysis suggested that

number of depressive symptoms were missing at random (MAR) due to significant associations

(p<0.05) between missing depressive symptoms and all observed covariates excluding only

housing insecurity. Appendix C, Table 3 results also indicated that, across all waves, those with

missing versus complete depressive symptoms data were more likely to be housing secure (73-

74% vs. 71-73%), non-White (30-33% vs. 20%), male (44-50% vs. 41%), US born (10-14% vs.

9%), have no degree (42-50% vs. 21-24%), be without a Medicare/Medicaid HMO plan (9-15%

vs. 5%), report both diabetes & hypertension (18-24 vs. 16-18%), and be found in the lowest

wealth (24-31% vs. 20-23%) and highest medical expenditure quartiles (32-40% vs. 23-26%).

Main analyses

Descriptive statistics were generated for all study variables including frequency tabulations for categorical variables and mean/standard deviation and median/range values for continuous variables. Main analyses were based on a linear mixed methods (LMM) approach with evaluations for repeated observations over time from the same individual. I applied the LMM random intercept model which is equivalent to cluster at the individual level such that repeated observations from several waves were clustered within the same individual. The LMM approach is a likelihood-based method and assumes data is MAR for longitudinal data which thus made imputation unnecessary. That is, given the same observed covariates and history of the outcome, the missingness for the current wave is random. Thus, LMM was preferred over the alternate Generalized Estimating Equations (GEE) approach because my data was MAR, as previously noted, and GEE modeling assumes that the data is missing completely at random (MCAR).

I estimated six nested linear mixed models to examine associations between baseline exposure & covariate variables and depressive symptoms in 2008, 2010 and 2012 as per related life-course Stress Process studies indicating the effects of earlier financial stressors on poor mental health outcomes in later life (Kahn & Pearlin, 2006). Baseline wave exposure and covariate variables were also selected in order to assess on the impact of baseline factors on subsequent trajectories and further minimize the effect of reverse causation, as per studies indicating the potential for reverse causality between poor mental health and indicators of financial hardship (Kang et al., 2018). I estimated a series of nested regression models show the confounding effects of Andersen's predisposing, enabling and need-based factors on the

relationship between housing insecurity and depressive symptom trajectories. I first started with predisposing factors, then added need-based factors, and finally added enabling factors. The order in which I included the factors was based on empirical results from the initial model which showed that enabling factors had the highest confounding effect on the relationship between housing insecurity and depressive symptoms. Future work might consider formal mediation analyses to help determine a causal ordering between these variables, as initially posed by Andersen (R. Andersen & Newman, 1973).

Model 1 was the minimally-adjusted model with baseline housing insecurity as the primary exposure. Model 2 added to Model 1 predisposing factors such as baseline education, age, gender, US-born status, census region, and forgone medication. Model 3 added to Model 2 need-based factors such as disease status. Models 4-6 added to Model 3 enabling factors such as healthcare factors (e.g., health insurance type and out-of-pocket medical expenditures) in Model 4, non-housing wealth in Model 5, and housing factors (e.g., tenure status) in the fully adjusted Model 6. All models were run on non-missing study variables.

One additional sensitivity test was conducted in this study controlling for lagged depressive symptoms in 2006 along with predisposing, need-based and enabling covariates, as described above. Controlling for lagged depressive symptoms is important because it is an important confounder related to both future housing insecurity and depressive symptoms. Results from all analyses are discussed in the following section. Coefficient estimates (β) and their 95% confidence intervals (α=0.05) are reported. STATA/SE version 17.0 was used for all analyses.

RESULTS

Descriptive results

Table 8 shows baseline descriptive statistics from my study sample in 2008. The average age of my sample was 76 years with 16% of respondents reporting housing insecurity. Respondents reported a mean and median of one out of eight depressive symptoms, with nearly 50% reporting no depressive symptoms. Most respondents in my sample were female (58%), non-Hispanic White (81%), US born (93%), resided in the South (39%) and reported having up to a high school/GED degree (39%). Respondents also mostly reported having been diagnosed with hypertension (48%), having Medicare only (70%), being homeowners (83%). Respondent median out-of-pocket expenditures totaled $1,392 while median non-housing wealth values totaled $40,000. Appendix C, Table 1 provides exact quartile reference values for out-of-pocket expenditures and non-housing wealth variables.

Table 9 presents additional descriptive statistics across all waves by depressive symptom level (low vs. high). For descriptive purposes only, I dichotomize my primary outcome (CES-D score) only using a 4+ symptom cut-off value (i.e. low: 0-3 vs. high: 4-8) that is comparable to the 16+ symptom cut-off value validated under the longer traditional 20-item CES-D scale (Radloff, 1977). Across 2008-2012 waves, statistically significant differences were observed between level of depressive symptoms and all study covariates except housing insecurity in which significance was observed in the 2010 wave only. Net statistical significance, housing insecure respondents were more likely to report high versus low depressive symptoms (13-18% vs. 12-16%) across all waves, displaying an average of 1.33 to 1.41 depressive symptoms versus 1.24 to 1.33 across all waves [not shown]. High versus low depressive symptoms were also more likely among non-White (29-30% vs. 17%), female (68-69% vs. 56-57%) and foreign-born (12-14% vs. 7%) respondents as well as those with no degree (33-35% vs. 17-19%), renters (25-28%

vs. 13-16%), with no Medicare/Medicaid HMO (10-12% vs. 4%), with diabetes only (5-8% vs. 4%), who forwent medication due to cost (13-16% vs. 5%), and who were found in the lowest wealth quartiles (30-32% vs. 15-17%).

Regression results

Table 10, and respective Figure 9 coefficient plot, displays estimates from the nested mixed regression models. Associations between baseline housing insecurity and depressive symptoms between 2008-2012 were generally positive yet close to zero and insignificant across all models except Models 5 and 6 (respectively, β: -0.03, -0.14 to 0.08; β: -0.13, -0.24 to -0.01). For example, a positive coefficient was observed with the inclusion of baseline predisposing and need-based factors in Models 1-3 as well as with the inclusion of baseline healthcare factors (e.g. out of pocket medical expenditures and health insurance) in Model 4, however, became negative following the inclusion of baseline wealth and tenure status in Models 5-6 and statistically significant in Model 6 only. Therefore, these findings did not support my first hypothesis that baseline housing insecurity would be associated with increased depressive symptoms throughout the course of the Recession.

In light of overall insignificant and close to zero associations, my second hypothesis that enabling factors would most explain the relationship between baseline insecurity and depressive symptoms became irrelevant. Nevertheless, main effect findings in Table 10 indicated that tenure status was a strong confounder in this association given a 0.10-point decrease in the association between baseline housing insecurity and average depressive symptoms following the addition of baseline tenure status between Models 5 and 6 (respectively, β: -0.03, -0.14 to 0.08; β: -0.13, -0.24 to -0.01). Additional AIC criterion values indicated that, relative to the minimally-adjusted Model 1 (AIC=51539), the inclusion of baseline wealth and tenure status variables in Models 5-6

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increased the model fit in my sample (respectively, AIC=50925 and AIC=50895) with the best

overall fit following inclusion of the baseline tenure status variable in the fully adjusted Model 6.

Therefore, these results suggest the strong confounding effects of wealth and tenure status on the

association between housing insecurity and depressive symptoms.

In regard to other covariates, Table 10 indicates consistently significant associations

between baseline predisposing, need-based, & enabling covariates and depressive symptoms

between 2008-2012 across all models. For example, relative to their counterparts, positive

associations with depressive symptoms were observed among Hispanics, females, aging adults,

those who forwent medication, those with both diabetes and hypertension, and renters. On the

other hand, relative to their counterparts, negative associations with depressive symptoms were

observed among those with at least a bachelor's degree and high wealth levels. Among these,

respondents with at least a bachelor's degree versus no degree at baseline experienced the

greatest overall average decrease in depressive symptoms ($-0.74 < \beta < -0.57$), while respondents

who forwent medication due to cost at baseline experienced the greatest overall average increase

in depressive symptoms ($0.87 < \beta < 0.99$).

Average marginal effect differences

Figure 10 shows the average marginal effect differences in depressive symptoms by

housing insecurity category. Marginal effects are presented with covariates held at the 2008

baseline covariate mean value. The mean number of depressive symptoms was higher among

individuals with any versus no housing insecurity in Models 1-4, (1.32-1.40 vs. 1.31-1.33)

however, became lower among individuals with any versus no housing insecurity following the

inclusion of baseline wealth and tenure status in Models 5-6 (1.21-1.29 vs. 1.32-1.33). Therefore,

these findings were consistent with my main regression findings which did not support my first

hypothesis that baseline housing insecurity would be associated with increased depressive symptoms throughout the course of the Recession. Similar to main findings, my second hypothesis became irrelevant due to overall insignificant and close to zero associations, however Figure 10 findings also indicated the strong confounding effects of tenure status with evidence showing that, across all models, the largest difference in mean depressive symptoms (Δ=0.09) across housing insecurity categories occurred following the addition of tenure status between Models 5 and 6 (respectively, -0.03 to -0.12), and was most notable among those with any insecurity.

Sensitivity results

Sensitivity analyses shown in Appendix C, Table 2 indicate that controlling for lagged 2006 depressive symptoms did not significantly alter my main findings or support for study hypotheses. For example, sensitivity results indicate that baseline housing insecurity was generally positively associated with average depressive symptoms across all models ($0.00 < \beta < 0.04$). Statistical significance was only observed following the addition of tenure status in the fully-adjusted Model 6 in which there was also a slight negative association between baseline housing insecurity and average depressive symptoms (β: -0.03, -0.13 to 0.06). Similar to my main findings, the best overall model fit was also observed following the addition of tenure status in the fully-adjusted Model 6 (AIC=48973). Also similar to my main findings, across all models, respondents with at least a bachelor's degree versus no degree at baseline experienced the greatest overall average decrease in depressive symptoms ($-0.25 < \beta < -0.21$), while respondents who forwent medication due to cost at baseline experienced the greatest overall average increase in depressive symptoms ($0.41 < \beta < 0.45$). Lastly, in order to account for the skewed outcome and verify the robustness of my main findings, I conducted an additional

sensitivity test in which I logged the outcome using a GEE with Poisson and found the RR<1 in the final fully-adjusted model [not shown in Appendix C]. This finding is consistent with my main LMM model findings in which the OR<1 in the final fully-adjusted model.

DISCUSSION

Support for hypotheses

In this study I examined the association between baseline housing insecurity and depressive symptoms among Medicare beneficiaries over the course of the Recession and employed a series of nested regression models to assess the extent to which other baseline predisposing, need-based and enabling factors explained this relationship. In general, baseline housing insecurity had positive yet insignificant associations with average depressive symptoms during 2008-2012, however, this relationship became negative and significant with the addition of baseline wealth and tenure status. These findings did not support my first hypothesis that baseline housing insecurity would be associated with increased depressive symptoms throughout the course of the Recession. One possible explanation for the observed inverse relationship between housing insecurity and depressive symptoms in the fully-adjusted model may be attributed to federal emergency housing assistance and the 2010 Affordable Care Act which expanded access to mental and behavioral health services among Medicaid adults (Anderson & Gascon, 2011; Forum on Medical and Public Health Preparedness for Catastrophic Events et al., 2014; Kaiser Family Foundation (KFF), 2023; Moffitt, 2013).

In light of overall insignificant and close to zero associations across models, my second hypothesis that enabling factors would most explain the relationship between baseline insecurity and depressive symptoms became irrelevant. Nevertheless, main effect findings indicated that tenure status was a strong confounder in this relationship given that the largest change in the

association between baseline housing insecurity and depressive symptoms occurred between models excluding versus including the tenure status variable in which the coefficient decreased by 0.10 points, respectively. Moreover, respondents with at least a bachelor's degree versus no degree at baseline experienced the greatest overall average decrease in number of symptoms ($-0.74 < \beta < -0.57$), while respondents who forwent medication due to cost at baseline experienced the greatest overall average increase in symptoms ($0.87 < \beta < 0.99$). These results were largely similar yet slightly more attenuated than my sensitivity analyses, further suggesting that lagged depressive symptoms in 2006 did not strongly confound the relationship between housing insecurity and depressive symptoms over the course of the Recession.

In this study I did not find strong evidence in favor of my first hypothesis that housing insecurity was positively associated with depressive symptoms over the course of the Recession due to largely insignificant and close-to-zero associations. My findings are also inconsistent with other studies which have found positive associations between housing hardship and poor mental health with one study among an HRS sample of older adults aged 50+ indicating a 2.20 times higher (OR: 2.20, 1.23-3.93) odds of depression among those who reported any versus no difficulty with housing payments during the Recession, even after controlling for age, gender, race/ethnicity, partnership status, education and employment status (Ailshire, 2013). Similar findings were found among a sample of mostly middle to older aged adults aged 30-84 years from the Midlife in the United States (MIDUS) study in which the odds of reporting clinically depressive symptoms in the last year was 30% higher (OR: 1.30, 1.18-1.48) among adults reporting any housing-related hardship (i.e. falling behind on mortgage/rent payments, being threatened by a foreclosure/eviction, moving in with relatives to save money, etc.), even after controlling for baseline depressive symptoms and various sociodemographic factors including

age, gender, race/ ethnicity, education, employment, marital status, income, and financial status (Forbes & Krueger, 2019).

Several factors may help explain why my study findings are not comparable to those from previous studies. For instance, the Ailshire (2013) study was based on interviews from HRS respondents aged 50+, a majority White and college-educated, who completed the internet-based survey between March-August 2009. Therefore, the Ailshire (2013) study was based on cross-sectional versus longitudinal data (i.e., 2009 vs. 2008-2012) of HRS respondents displaying different sociodemographic characteristics to my study sample despite reporting similar sample sizes near five-thousand respondents. Rather than using the full 8-item CES-D scale, the Ailshire (2013) study also assessed depression using a single yes/no question from the CES-D scale asking if respondents felt depressed much of the time during the past week, and did not adjust for other key predictors of depression included in my analyses such as baseline depression, wealth and tenure status.

Moreover, in contrast to my study, the Forbes (2019) study used the World Health Organization's Composite International Diagnostic Interview Short Form (CIDI-SF) to measure whether clinically significant depressive symptoms were present or absent among respondents in the last year. The Forbes (2019) study also created a composite measure of housing-related hardship impacts (i.e., falling behind on mortgage/rent payments, being threatened by a foreclosure/eviction, moving in with relatives to save money, etc.), rather than examining the unique effects of falling behind on mortgage/rent payments synonymous to experiencing housing insecurity in my study. Lastly, despite controlling for baseline depression, the Forbes (2019) study used linear regression to estimate associations between baseline housing hardship in 2008 and post-Recession depressive symptoms between 2012-2013. In contrast, my study used linear

mixed models to estimate associations between baseline housing insecurity in 2008 and depressive symptoms over the course of the Recession between 2008-2012. Differences in sample selection, variable definitions, and methodology may help explain the variability between my study findings and those from previous studies, however further research is needed to fully explain these differences.

Although I did not specifically examine if the association between housing insecurity and depression differed by tenure status, my findings suggested the strong confounding effects of tenure status on the association between housing insecurity and depressive symptoms. Further interaction tests would be needed to test the extent to which baseline tenure status buffers this association. Moreover, my findings of a significantly greater likelihood of depressive symptoms among renters versus homeowners over the course of the Recession supports literature indicating renters' greater susceptibility to financial and housing distress over the course of the Recession. For example, evidence from a study of middle-aged adults from the National Longitudinal Survey of Youths 1979 (NLSY79) indicated that a one percentage point increase in the county-average proportion in total household income spent on housing costs increased the odds of high depressive symptoms (CES-D>7) by 20% among renters and by 14% among homeowners (respectively, OR: 1.20, 0.92-1.56; OR: 1.14, 0.94-1.39) even after accounting for individual (i.e. age, gender, urban/rural, cost of living, etc.), county (i.e. median property value, poverty rate, % Black, etc.), and state-level covariates (i.e. state-level economic activity index) (Rodgers et al., 2019). Similar results were found in a study of non-institutionalized middle-aged adults from the Michigan Recession and Recovery Study (MRRS) in which renters who were behind on rent payments had a 3.7 times greater odds (OR: 3.66, 1.15-11.7) of meeting major/minor depressive criteria, as per validated Diagnostic and Statistical Manual Fourth Edition (DSM-IV) guidelines,

compared to a 3.13 greater odds (OR: 3.13, 0.76-12.9) among homeowners who were behind on

mortgage payments even after adjusting for key demographic and socioeconomic covariates (i.e.

age, sex, race, partnership status, educational attainment, 2008 income-to-needs ratio, and earlier

health problems) (Burgard et al., 2012).

As posited by Rodgers et al. (2019), mental health disparities by tenure status may be tied

to renters' high uncertainty & anxiety regarding unforeseen rent increases during economic crises

compared to homeowners with fixed-rate mortgages who face lower anxiety on the burden of

future housing costs. Greater susceptibility to poor mental health among low-income renters over

the course of the Recession is also supported with evidence of a 17% increase in the number of

extremely low-income households earning <30% of the Area Median Income (AMI) per

affordable rental unit between 2007 and 2010 along with evidence from an American

Association of Retired Persons (AARP) report indicating that, during the Recession, 52% of

older adult renters versus 36% of older adult homeowners paid at least thirty-percent of their

household income on housing costs, while 28% of older adult renters versus 15% of older adult

homeowners paid at least fifty-percent of their household income on housing costs (Harrell,

2011; Housing and Urban Development (HUD), 2020; True-Funk, 2018).

Along with evidence of greater susceptibility to financial and housing distress among

low-income renters over the course of the Recession, my findings of significantly higher

depressive symptoms associated with indicators of low SES (i.e. education, health insurance,

medical expenditures, wealth) generally aligns with extant literature on positive associations

between forgone medication due to cost and poor mental health as well as my hypotheses on

neo-material pathways of material disadvantage explaining relationships between financial stress

and poor health (R. Andersen, 1968; Brenner, 1987; Chung et al., 2019; Glonti et al., 2015; S.

Lee et al., 2019; Mehta et al., 2015; Pruchno et al., 2017; Zivin, Ratliff, et al., 2010).

Furthermore, 6 out of 7 articles examined in a 2007 literature review have indicated significant

reverse associations between poor mental health (e.g., depression) and increased risk of cost-

related treatment non-adherence (CRN), or forgone medication due to cost, 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, Ratliff, et al., 2010).

Limitations

My findings should be interpreted in light of a few study limitations. First, baseline

housing insecurity estimates were self-derived and calculated from self-reported income and

housing costs. Such data may not include all income and financial resources (e.g.: public

subsidies for housing). Additionally, because I measured the binary form of this variable, I was

unable to assess variations in the housing insecurity index on a scale of 0 to 100, potentially

indicating the nuanced effects of spending thirty versus fifty percent of annual household income

on housing costs, for example. Second, I was not easily able to compare my findings to other

studies due to differences in instruments used to measure depressive symptoms in the literature

(i.e. 7 & 11-item CES-D scale, DSM-IV, CIDI-SF, etc) (Bergmans & Wegryn-Jones, 2020;

Cagney et al., 2014; Mehta et al., 2015; Pruchno et al., 2017; Rodgers et al., 2019). Third, my

findings may be confounded by other forms of financial hardship which I did not control for,

such as food insecurity, credit card and/or medical debt, etc., as well as other factors alleviating

or augmenting housing insecurity and/or depression such as marital status and co-habitation with

adult children (Ailshire, 2013; Bergmans & Wegryn-Jones, 2020; Guerra & Eboreime, 2021;

Mather, 2015). Moreover, due to dataset limitations, I did not adjust for other housing factors such as housing price as per studies indicating inverse associations between housing value and depression among both renters & homeowners during the Recession (Cutler & Sportiche, 2022; Mather, 2015; Yue & Ponce, 2021). And finally, statistical model fitting issues such as non-convergence errors may have limited my ability to ensure valid estimates and statistical significance in fully-adjusted models. However, in light of these model fitting issues, similar findings between my main and sensitivity analyses increase the validity and robustness of my main findings and do not alter my final study conclusions.

Implications

Findings from this study have key research and policy implications. For example, my findings that tenure status largely explained the relationship between housing insecurity and depressive symptoms, along with general evidence of greater housing hardship among older adult renters during the Recession, should inform future housing policies leading to wider expansion of low-income housing, eviction moratoriums and rent stabilization for older adult renters during periods of high economic distress (Bertoldo et al., 2022; K. L. Chen et al., 2022; Consumer Financial Protection Bureau, 2021; Hu, 2022; Liu & Eicher-Miller, 2022; The National Low Income Housing Coalition, 2016). Related research could employ formal mediation analyses to evaluate pathways through which housing insecurity among renters & homeowners precipitates a cascade of other housing hardships leading to depression, including multiple moves and/or homelessness (Baker et al., 2016; Ferreira et al., 2010; Kim & Burgard, 2022).

Moreover, my findings of decreased depressive symptoms among adults with high wealth levels should also motivate future research examining the extent to which wealth and savings

losses influenced depressive symptoms & retirement decisions among both retirees and pre-retirees over the course the Recession (R. Johnson et al., 2008; R. W. Johnson, 2009; Mackenzie, 2008; Mather, 2015; Piette et al., 2004a; True-Funk, 2018; Zhao & Burge, 2021).

My findings of increased depressive symptoms among adults with low education levels should encourage adoption of low-cost mental health interventions (e.g. self-guided internet-based cognitive bibliotherapy) for low SES adults as well as related interventions to encourage the provision of instrumental, informational, appraisal or emotional support from family and friends of low SES adults during economic crises (Gualano et al., 2017; House, 2002; Karyotaki et al., 2017, 2018; Pearlin et al., 1981; K. P. Smith & Christakis, 2008; Zunzunegui et al., 2003). Additional findings that respondents who forwent medication at baseline experienced the greatest overall increase in depressive symptoms over the course of the Recession may also inform future healthcare recommendations including wider prescription drug coverage for all Medicare adults. Because investing in housing security has spillover effects on healthcare and other basic needs including food and transportation, healthcare recommendations may also expand access to Medicare Advantage plans which can now provide rental and housing assistance to chronically ill enrollees, despite out-of-network provider restrictions and pre-authorization requirements (Coleman, 2019; Porretta, 2023).

Figure 8. Final sample selection criteria (Non-imputed HRS 2006 and follow-up 2008, 2010, and 2012 samples)
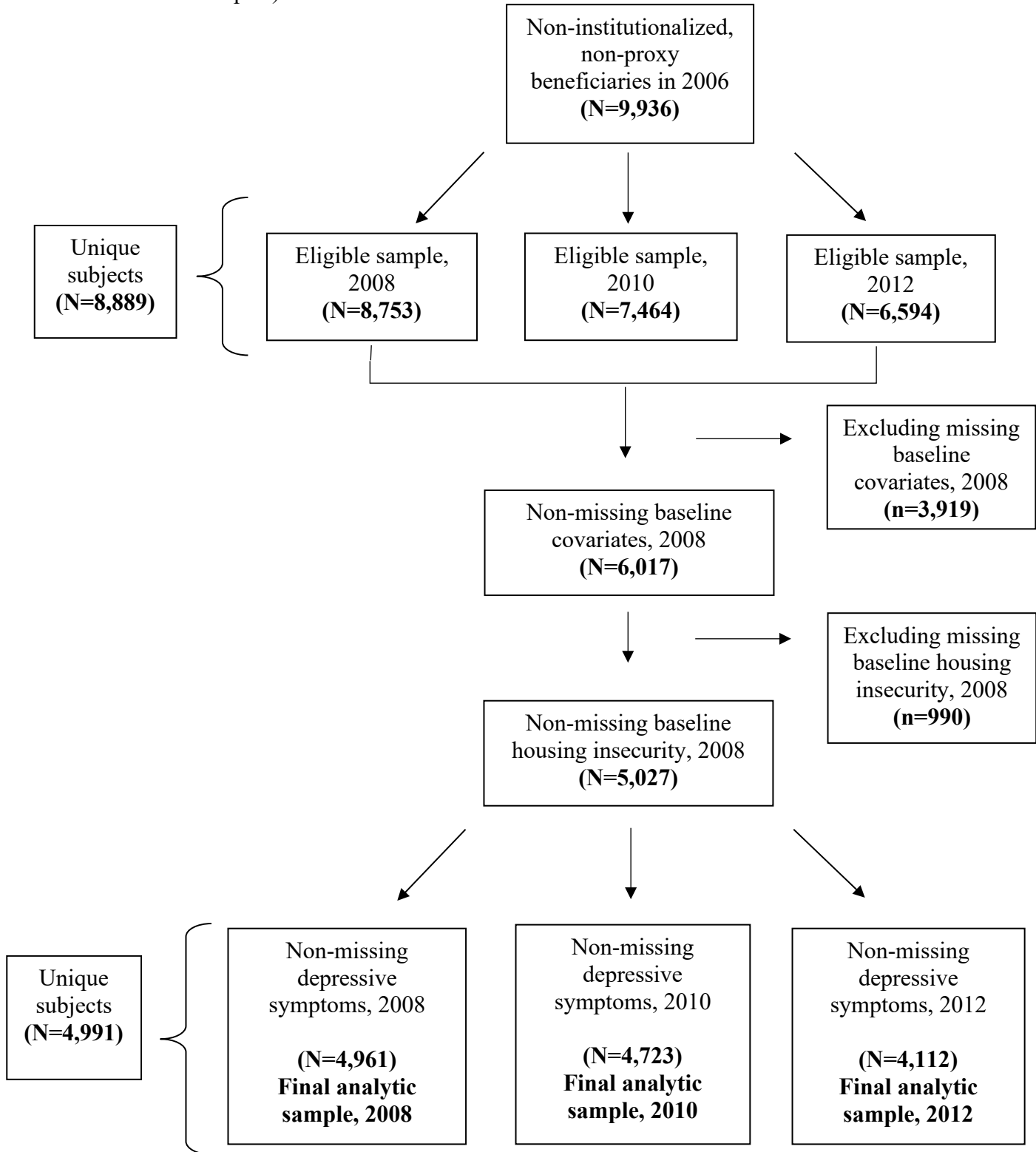
Figure 9. Coefficient plot and 95% confidence intervals for nested linear mixed regression models of baseline housing insecurity on number of depressive symptoms over time (based on Table 10)
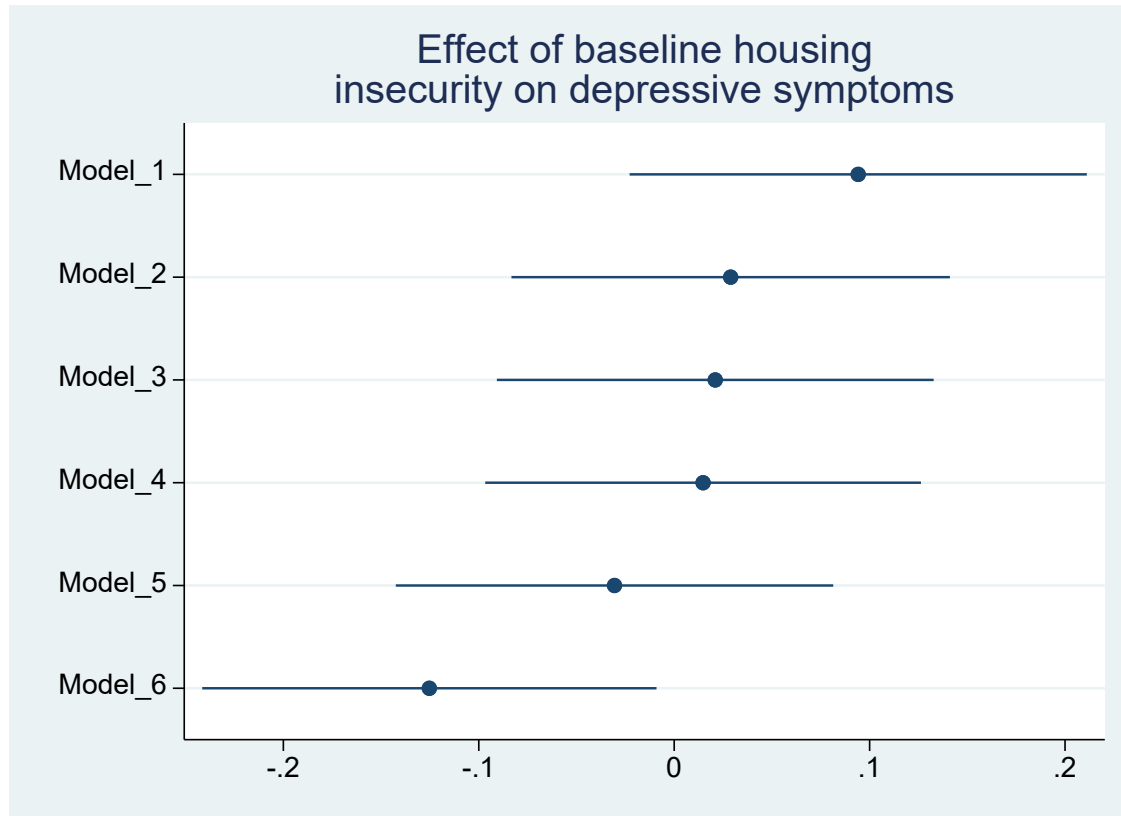
Figure 10. Average marginal effect differences in depressive symptoms by housing insecurity category (based on Table 10)
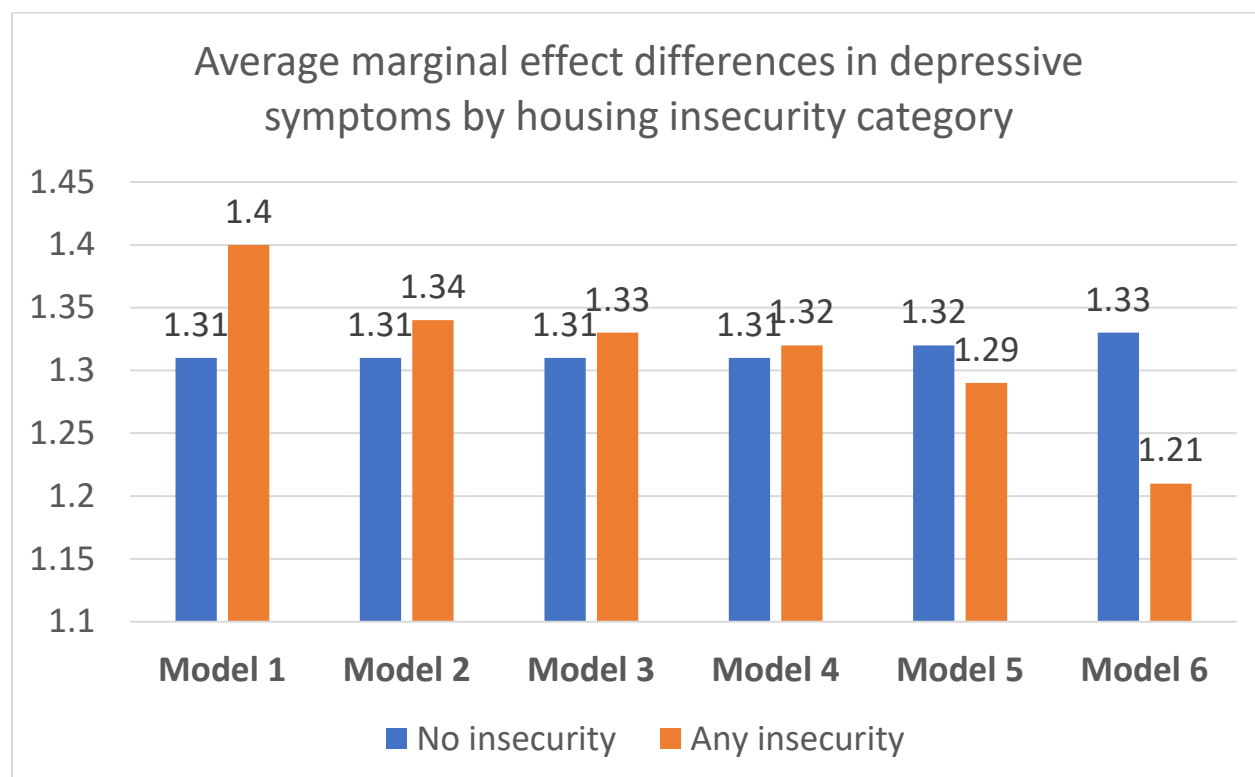
Figure 11. Downing's homeowner distress model
(Downing, 2016)
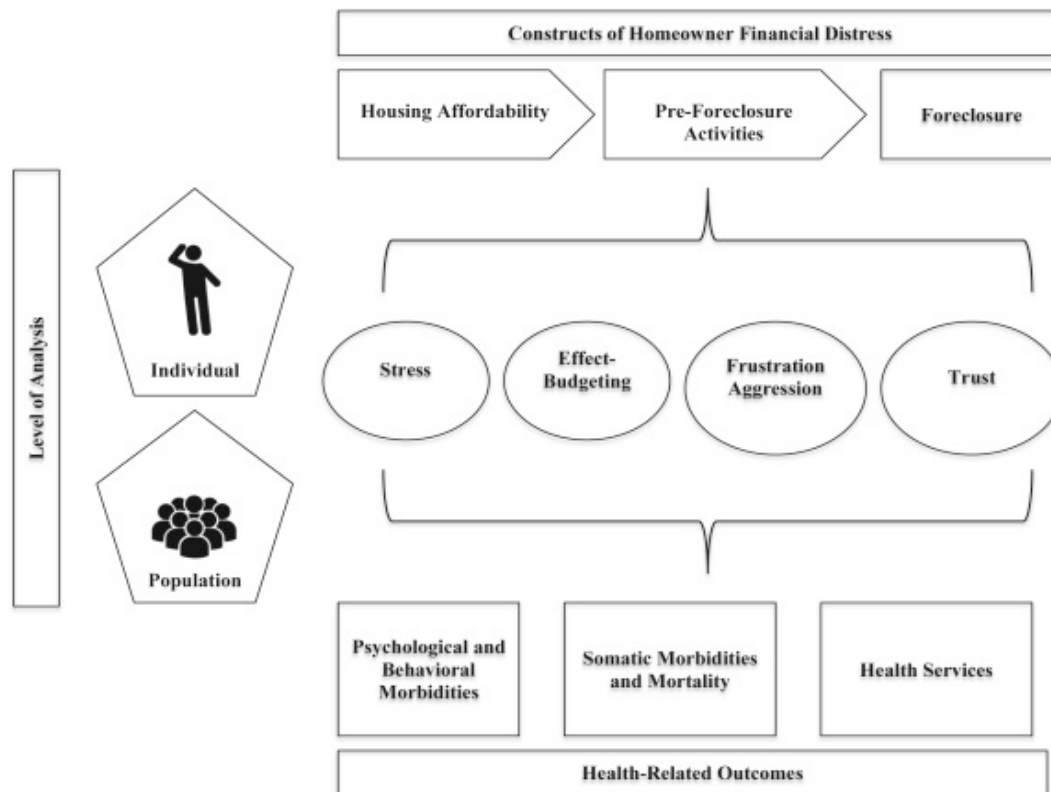
Table 8. Descriptive characteristics of Medicare beneficiaries 65+ years (HRS 2008 baseline sample)

	Descriptive statistics [N, %] (N=4,961)	
	N	**%**
Housing insecurity		
No	4,173	84.12
Yes	788	15.88
Depressive symptoms		
Mean, SD	*1.25*	*1.76*
Median, Range	*1*	*0-8*
Education		
No degree	1,025	20.66
High school/GED	1,955	39.41
Some college/Associates	1,007	20.30
Bachelor's or higher	974	19.63
Race/ethnicity		
Non-Hispanic White	4,040	81.44
Non-Hispanic Black	591	11.91
Hispanic	330	6.65
Gender		
Male	2,079	41.91
Female	2,882	58.09
US-born		
Yes	4,589	92.50
No	372	7.50
Age (years)		
Mean, SD	*75.81*	*6.47*
Median, Range	*75*	*66-106*
Census region		
Northeast	848	17.09
Midwest	1,374	27.70
South	1,933	38.96
West	806	16.25

Forgone meds

Yes	296	5.97
No	4,665	94.03

Disease status

Neither diabetes nor hypertension	1,600	32.25
Diabetes only	213	4.29
Hypertension only	2,379	47.95
Both diabetes and hypertension	769	15.50

Out of pocket medical expenditures

Q1	1,038	20.92
Q2	1,399	28.20
Q3	1,407	28.36
Q4	1,117	22.52
Median ($), Range	*1,392*	*0-98,000*

Health insurance

No Medicare	46	0.93
Medicare only (neither Medicaid nor HMO)	3,457	69.68
Medicare with Medicaid (no HMO)	247	4.98
Medicare with HMO (regardless Medicaid)	1,211	24.41

Non-housing wealth

Q1	803	16.19
Q2	1,011	20.38
Q3	1,372	27.66
Q4	1,775	35.78
Median ($), Range	*40,000*	*-1.4e06-1.52e07*

Tenure

Homeowner	4,113	82.91
Renter	848	17.09

Table 9. Descriptive characteristics of Medicare beneficiaries 65+ years by low versus high depressive symptoms, respectively, 0-3 vs. 4+ symptoms (HRS 2008, 2010, and 2012 samples)

	Descriptive statistics [%] (N=5,027)					
	2008 **(N=4,961)**		**2010** **(N=4,723)**		**2012** **(N=4,112)**	
	Low (N=4,410)	High (N=551)	Low (N=4,156)	High (N=567)	Low (N=3,590)	High (N=522)
Housing insecurity (one-wave)						
No	84.38	82.03	88.04	84.43	87.95	87.42
Yes	15.62	17.97	11.96	15.57	12.05	12.58
p-value				*		
Age						
Mean, SD	*75.80, 6.44*	*75.93, 6.72*	*75.44, 6.24*	*75.79, 6.28*	*74.92, 5.95*	*75.26, 5.89*
p-value						
Race/ethnicity						
White, non-Hispanic	82.70	71.32	82.92	70.37	83.23	70.11
Black, non-Hispanic	11.61	14.34	11.60	14.99	11.23	13.22
Hispanic	5.69	14.34	5.49	14.64	5.54	16.67
p-value		*		*		*
Gender						
Male	43.27	31.03	43.65	31.22	43.30	31.80
Female	56.73	68.97	56.35	68.78	56.80	68.20
p-value		*		*		*
US-born						
Yes	93.20	86.93	93.41	85.89	93.01	87.55
No	6.80	13.07	6.59	14.11	6.99	12.45
p-value		*		*		*
Education						
No degree	19.14	32.85	18.19	34.04	17.24	35.06
High school/GED	39.41	39.38	39.85	36.33	39.94	34.67
Some college/Associates	20.82	16.15	20.98	17.81	21.70	17.43
Bachelor's or higher	20.63	11.62	20.98	11.82	21.11	12.84

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p-value	*		*		*
Tenure					
Homeowner	84.31	71.69	84.82	73.37	86.02	74.52
Renter	15.69	28.31	15.18	26.63	13.98	25.48
p-value	*		*		*	
Census region					
Northeast	17.14	16.70	16.43	18.17	16.77	16.48
Midwest	28.12	24.32	28.73	20.63	28.66	22.80
South	38.57	42.11	38.98	41.62	38.61	41.57
West	16.17	16.88	15.86	19.58	15.96	19.16
p-value			*		*	
Health insurance					
Medicare only, neither Medicaid nor HMO	70.32	64.61	71.01	60.85	71.14	63.60
Medicare with Medicaid, no HMO	4.29	10.53	3.87	11.82	3.68	10.15
Medicare with HMO, regardless Medicaid	24.58	23.05	24.18	26.63	24.32	25.10
No Medicare	0.82	1.81	0.94	0.71	0.86	1.15
p-value	*		*		*	
Disease status					
Neither diabetes nor hypertension	32.81	27.77	33.11	27.16	34.01	27.20
Diabetes only	4.20	5.08	4.11	5.82	3.73	8.24
Hypertension only	48.10	46.82	48.20	45.50		
Both diabetes and hypertension	14.90	20.33	14.58	21.52	48.11	43.49
p-value	*		*		*	
Forgone meds due to cost					
No	94.90	87.11	95.36	84.30	95.13	87.16
Yes	5.10	12.89	4.64	15.70	4.87	12.84
p-value	*		*		*	
Non-housing wealth					
Q1, lowest	14.47	29.95	16.51	32.45	16.69	31.03
Q2	19.64	26.32	11.69	17.28	10.58	16.67

Q3	28.59	20.15	28.03	22.93	28.55	24.71
Q4, highest	37.30	23.59	43.77	27.34	44.18	27.59
Median	*47,000*	*5,000*	*40,000*	*4,400*	*40,000*	*5,000*
p-value		*		*		*

Out of pocket medical expenditure

Q1, lowest	20.73	22.50	16.39	19.05	17.35	22.80
Q2	28.32	27.22	27.91	24.87	26.60	20.11
Q3	28.66	25.95	30.56	25.75	30.11	28.16
Q4, highest	22.29	24.32	25.14	30.34	25.93	28.93
Median	*1,393*	*1,360*	*1,680*	*1,980*	*1,600*	*1,623*
p-value			*		*	

NOTE. Refer to Figure 8 for final sample selection criteria. P-value indicates statistical significance at α=0.05 using chi-squared test for categorical variables and ANOVA test for continuous variables.

Table 10. Nested linear mixed regression models of baseline housing insecurity on number of depressive symptoms over time (HRS 2008, 2010, 2012 sample)

	Number of Depressive symptoms [β, 95%CI]* (N=4,991)					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Housing insecurity						
No (Ref)						
Yes	0.09 (-0.02, 0.21)	0.03 (-0.08, 0.14)	0.02 (-0.09, 0.13)	0.01 (-0.10, 0.13)	-0.03 (-0.14, 0.08)	-0.13 (-0.24, -0.01)*
Wave						
2008 (Ref)						
2010	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*
2012	0.14 (0.10, 0.19)*	0.14 (0.09, 0.19)*	0.14 (0.09, 0.19)*	0.14 (0.09, 0.20)*	0.15 (0.10, 0.20)*	0.15 (0.10, 0.20)*
Education						
No degree (Ref)						
High school/GED		-0.45 (-0.56, -0.33)*	-0.44 (-0.55, -0.32)*	-0.40 (-0.52, -0.29)*	-0.35 (-0.46, -0.23)*	-0.35 (-0.47, -0.23)*
Some college/Associates		-0.56 (-0.69, -0.43)*	-0.54 (-0.67, -0.41)*	-0.51 (-0.64, -0.37)*	-0.43 (-0.56, -0.30)*	-0.43 (-0.57, -0.30)*
Bachelor's or higher		-0.74 (-0.88, -0.61)*	-0.71 (-0.85, -0.58)*	-0.69 (-0.83, -0.56)*	-0.58 (-0.72, -0.44)*	-0.57 (-0.72, -0.43)*
Race/ethnicity						
Non-Hispanic White (Ref)						
Non-Hispanic Black		0.12 (-0.01, 0.25)	0.08 (-0.05, 0.21)	0.06 (-0.07, 0.19)	-0.07 (-0.21, 0.06)	-0.09 (-0.22, 0.05)
Hispanic		0.59 (0.40, 0.78)*	0.54 (0.35, 0.73)*	0.49 (0.29, 0.68)*	0.36 (0.16, 0.55)*	0.37 (0.18, 0.57)*

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Gender

Male (Ref)

Female	0.35 (0.26, 0.43)*	0.36 (0.28, 0.45)*	0.35 (0.27, 0.43)*	0.24 (0.26, 0.42)*	0.32 (0.24, 0.41)*

US-born

Yes (Ref)

No	-0.17 (-0.34, 0.01)	-0.17 (-0.34, 0.01)	-0.13 (-0.31, 0.04)	-0.14 (-0.32, 0.03)	-0.12 (-0.29, 0.05)

Age

Years	0.02 (0.01, 0.02)*	0.02 (0.01, 0.02)*	0.02 (0.01, 0.02)*	0.02 (0.01, 0.03)*	0.02 (0.01, 0.02)*

Census region

Northeast (Ref)

Midwest	-0.05 (-0.17, 0.08)	-0.05 (-0.18, 0.07)	-0.05 (-0.18, 0.07)	-0.04 (-0.17, 0.09)	-0.01 (-0.14, 0.11)
South	0.05 (-0.07, 0.17)	0.04 (-0.07, 0.16)	0.03 (-0.08, 0.15)	0.03 (-0.09, 0.15)	0.07 (-0.05, 0.19)
West	0.10 (-0.05, 0.24)	0.11 (-0.04, 0.25)	0.10 (-0.04, 0.24)	0.13 (-0.01, 0.28)	0.15 (0.01, 0.29)*

Forgone meds

Yes	0.99 (0.82, 1.16)*	0.99 (0.81, 1.16)*	0.96 (0.79, 1.13)*	0.89 (0.72, 1.06)*	0.87 (0.70, 1.05)*

No (Ref)

Disease status

Neither diabetes (Ref) nor hypertension

Diabetes only		0.41 (0.21, 0.62)*	0.38 (0.18, 0.59)*	0.36 (0.15, 0.57)*	0.37 (0.16, 0.57)*
Hypertension only		0.11 (0.12, 0.20)*	0.09 (-0.00, 0.18)	0.08 (-0.02, 0.17)	0.07 (-0.02, 0.16)
Both diabetes and hypertension		0.38 (0.26, 0.51)*	0.34 (0.21, 0.46)*	0.30 (0.17, 0.43)*	0.29 (0.16, 0.41)*

Out of pocket medical expenditures						
Q1 (Ref)						
Q2			0.07 (-0.05, 0.19)	0.09 (-0.03, 0.21)	0.10 (-0.02, 0.22)	
Q3			0.06 (-0.06, 0.18)	0.10 (-0.02, 0.22)	0.11 (-0.01, 0.24)	
Q4			0.26 (0.14, 0.39)*	0.30 (0.17, 0.43)*	0.31 (0.19, 0.44)*	
Health insurance						
No Medicare (Ref)						
Medicare only			-0.06 (-0.48, 0.36)	0.01 (-0.41, 0.44)	0.09 (-0.34, 0.51)	
Medicare with Medicaid			0.54 (0.08, 1.00)*	0.50 (0.04, 0.96)*	0.49 (0.03, 0.95)*	
Medicare with HMO			-0.07 (-0.50, 0.36)	-0.02 (0.45, 0.40)	0.05 (-0.38, 0.47)	
Non-housing wealth						
Q1 (Ref)						
Q2					-0.24 (-0.38, -0.11)*	-0.21 (-0.35, -0.07)*
Q3					-0.42 (-0.56, -0.28)*	-0.35 (-0.49, -0.21)*
Q4					-0.48 (-0.63, -0.34)*	-0.41 (-0.56, -0.27)*
Tenure						
Homeowner (Ref)						
Renter						0.35 (0.23, 0.47)*
AIC value	51539	51042	51004	50966	50925	50895

NOTE: All estimates include coefficient estimates (β) and 95% CI. Asterisk (*) indicates statistical significance at p<0.05 within model.

Appendix C

Evaluating the relationship between housing insecurity and depressive symptoms among Medicare beneficiaries during the Recession: The role of predisposing, enabling and need-based factors

Appendix C, Table 1. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables among Medicare beneficiaries 65+ years (HRS 2008 sample)

Appendix C, Table 2. Nested models of baseline housing insecurity on number of depressive symptoms over time, controlling for lagged 2006 depressive symptoms (HRS 2008-2012 sample)

Appendix C, Table 3. Descriptive characteristics of Medicare beneficiaries 65+ years with complete versus missing number of depressive symptoms data (HRS 2008, 2010, and 2012 samples)

Tables

Appendix C, Table 1. Quartile reference values for out-of-pocket expenditures and non-housing wealth variables among Medicare beneficiaries 65+ years (HRS 2008 sample)

	Out of pocket medical expenditures ($) (N=8,753)	Non-housing wealth ($) (N=8,753)
Quartiles		
Q1	*0 to 408*	*-1.4e06 to 0*
Q2	*410 to 1,350*	*1 to 11,000*
Q3	*1,352 to 3,200*	*11,300 to 100,500*
Q4	*3,203 to 98,000*	*100,535 to 1.52e07*

*NOTE: Refer to Figure 8 for final sample selection criteria. Reference values are based on imputed RAND HRS data.

Appendix C, Table 2. Nested models of baseline housing insecurity on number of depressive symptoms over time, controlling for lagged 2006 depressive symptoms (HRS 2008-2012 sample)

	Depressive symptoms [β, 95%CI]* (N=4,991)					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Housing insecurity						
No (Ref)						
Yes	0.04 (-0.05, 0.13)	0.02 (-0.07, 0.11)	0.01 (-0.08, 0.10)	0.02 (-0.07, 0.11)	0.00 (-0.09, 0.10)	-0.03 (-0.13, 0.06)
Wave						
2008 (Ref)						
2010	0.07 (0.02, 0.12)*	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*	0.07 (0.03, 0.12)*	0.08 (0.03, 0.12)*	0.08 (0.03, 0.12)*
2012	0.14 (0.09, 0.19)*	0.15 (0.10, 0.20)*	0.15 (0.10, 0.20)*	0.15 (0.10, 0.20)*	0.15 (0.10, 0.20)*	0.15 (0.10, 0.20)*
Education						
No degree (Ref)						
High school/GED		-0.15 (-0.24, -0.05)*	-0.14 (-0.24, -0.05)*	-0.15 (-0.25, -0.06)*	-0.13 (-0.23, -0.04)*	-0.13 (-0.23, -0.04)*
Some college/Associates		-0.20 (-0.31, -0.10)*	-0.19 (-0.30, -0.08)*	-0.21 (-0.32, -0.10)*	-0.18 (-0.29, -0.07)*	-0.18 (-0.30, -0.07)*
Bachelor's or higher		-0.24 (-0.35, -0.12)*	-0.22 (-0.34, -0.11)*	-0.25 (-0.36, -0.13)*	-0.21 (-0.33, -0.09)*	-0.21 (-0.33, -0.09)*
Race/ethnicity						
Non-Hispanic White (Ref)						
Non-Hispanic Black		0.00 (-0.11, 0.11)	-0.02 (-0.13, 0.09)	-0.00 (-0.11, 0.11)	-0.05 (-0.16, 0.07)	-0.05 (-0.16, 0.06)
Hispanic		0.36 (0.21, 0.52)*	0.34 (0.18, 0.49)*	0.36 (0.20, 0.51)*	0.31 (0.15, 0.47)*	0.32 (-0.16, 0.48)*
Gender						
Male (Ref)						
Female		0.13 (0.06, 0.20)*	0.15 (0.08, 0.21)*	0.14 (0.07, 0.21)*	0.14 (0.07, 0.21)*	0.13 (0.07, 0.20)*

US-born

Yes (Ref)

No	-0.03 (-0.17, 0.11)	-0.03 (-0.17, 0.11)	-0.02 (-0.17, 0.12)	-0.03 (-0.17, 0.11)	-0.02 (-0.16, 0.12)

Age

Years	0.01 (0.00, 0.02)*	0.01 (0.01, 0.02)*	0.01 (0.00, 0.02)*	0.01 (0.01, 0.02)*	0.01 (0.00, 0.01)*

Census region

Northeast (Ref)

Midwest	-0.04 (-0.14, 0.06)	-0.04 (-0.15, 0.06)	-0.05 (-0.17, 0.12)	-0.05 (-0.15, 0.06)	-0.04 (-0.14, 0.06)
South	-0.01 (-0.11, 0.08)	-0.02 (-0.11, 0.08)	-0.02 (-0.12, 0.07)	-0.03 (-0.12, 0.07)	-0.01 (-0.11, 0.09)
West	0.05 (-0.07, 0.17)	0.05 (-0.06, 0.17)	0.05 (-0.06, 0.17)	0.06 (-0.05, 0.18)	0.07 (-0.05, 0.19)

Forgone meds

Yes	0.45 (0.30, 0.59)*	0.45 (0.30, 0.59)*	0.43 (0.29, 0.58)*	0.41 (0.27, 0.56)*	0.41 (0.27, 0.55)*

No (Ref)

Disease status

Neither diabetes (Ref) nor hypertension

Diabetes only		0.22 (0.06, 0.39)*	0.21 (0.04, 0.38)*	0.20 (0.03, 0.37)*	0.20 (0.04, 0.37)*
Hypertension only		0.03 (-0.05, 0.10)	0.01 (-0.06, 0.09)	0.01 (-0.07, 0.09)	0.01 (-0.07, 0.08)
Both diabetes and hypertension		0.21 (0.11, 0.31)*	0.18 (0.08, 0.29)*	0.17 (0.07, 0.28)*	0.17 (0.06, 0.27)*

Out of pocket medical expenditures

Q1 (Ref)

Q2			0.07 (-0.03, 0.17)	0.08 (-0.02, 0.18)	0.08 (-0.02, 0.18)
Q3			0.08 (-0.02, 0.18)	0.09 (-0.01, 0.19)	0.10 (-0.00, 0.20)
Q4			0.18 (0.08, 0.29)*	0.19 (0.09, 0.30)*	0.20 (0.09, 0.31)*

Health insurance					
No Medicare (Ref)					
Medicare only			0.03 (-0.32, 0.38)		0.08 (-0.27, 0.43)
Medicare with Medicaid			0.09 (-0.29, 0.47)		0.08 (-0.30, 0.46)
Medicare with HMO			-0.01 (-0.36, 0.35)		0.04 (-0.31, 0.39)
Non-housing wealth					
Q1 (Ref)					
Q2			-0.07 (-0.18, 0.04)		-0.06 (-0.17, 0.06)
Q3			-0.14 (-0.26, -0.03)*		-0.12 (-0.23, 0.00)
Q4			-0.16 (-0.28, -0.04)*		-0.13 (-0.25, -0.01)*
Tenure					
Homeowner (Ref)					
Renter					0.14 (0.04, 0.24)*
AIC value	49108	48997	48982	48981	48979	48973

NOTE: All estimates include coefficient estimates (β) and 95% CI. Asterisk (*) indicates statistical significance at p<0.05 within model.

Appendix C, Table 3. Descriptive characteristics of Medicare beneficiaries 65+ years with complete versus missing number of depressive symptoms data (HRS 2008, 2010, and 2012 samples)

	Descriptive statistics [%] (N=8,889)					
	2008 (N=8,753)		**2010 (N=7,464)**		**2012 (N=6,594)**	
	Missing (N=204)	Complete (N=8,549)	Missing (N=329)	Complete (N=7,135)	Missing (N=290)	Complete (N=6,304)
Housing insecurity (one-wave)						
Missing	*15.20*	*14.33*	*16.72*	*16.09*	*18.62*	*16.78*
No	74.02	73.26	73.25	71.56	72.76	71.15
Yes	10.78	12.41	10.03	12.35	8.62	12.07
p-value						
Age						
Missing	-	-	-	-	-	-
Mean, SD	*80.24, 8.25*	*75.89, 6.78*	*80.30, 8.16*	*75.05, 6.20*	*79.86, 7.34*	*74.53, 5.84*
p-value		*		*		*
Race/ethnicity						
Missing	*2.45*	*1.64*	*1.52*	*1.78*	*2.07*	*1.71*
White, non-Hispanic	66.67	78.63	68.69	78.65	65.17	78.79
Black, non-Hispanic	18.63	12.21	13.98	12.31	20.69	11.68
Hispanic	12.25	7.52	15.81	7.26	12.07	7.82
p-value		*		*		*
Gender						
Missing	-	-	-	-	-	-
Male	49.51	41.46	45.29	41.42	44.48	41.05
Female	50.49	58.54	54.71	58.58	55.52	58.95
p-value		*				
US-born						
Missing	*0.98*	*0.09*	*0.00*	*0.01*	*0.00*	*0.06*
Yes	88.73	91.03	85.71	91.06	85.52	90.83
No	10.29	8.88	14.29	8.83	14.48	9.11
p-value		*		*		*

Education

Missing	*0.00*	*0.01*	*0.00*	*0.01*	*0.00*	*0.02*
No degree	50.00	23.79	41.95	21.93	42.07	21.22
High school/GED	28.92	37.88	31.31	38.36	30.34	38.40
Some college/Associates	11.76	19.64	14.89	20.46	13.10	20.67
Bachelor's or higher	9.31	18.68	11.85	19.23	14.48	19.69
p-value		*		*		*

Tenure

Missing	*29.41*	*14.48*	*28.27*	*14.69*	*21.38*	*14.69*
Homeowner	59.31	71.70	59.27	73.03	65.17	73.87
Renter	11.27	13.81	12.46	12.28	13.45	11.44
p-value		*		*		*

Census region

Missing	*0.00*	*0.11*	*5.47*	*1.14*	*7.24*	*1.36*
Northeast	9.80	15.91	15.50	14.87	13.10	14.78
Midwest	21.57	25.63	20.67	25.96	24.48	25.84
South	45.59	40.39	36.17	40.10	37.24	39.75
West	23.04	17.97	22.19	17.94	17.93	18.26
p-value		*		*		*

Health insurance

Missing	*9.31*	*5.74*	*16.72*	*6.01*	*19.31*	*5.79*
Medicare only, neither Medicaid nor HMO	52.45	64.60	52.58	64.99	52.76	65.18
Medicare with Medicaid, no HMO	14.71	5.49	11.25	4.78	8.62	4.65
Medicare with HMO, regardless Medicaid	23.04	23.15	17.93	23.27	17.93	23.43
No Medicare	0.49	1.02	1.52	0.95	1.38	0.95
p-value		*		*		*

Disease status

Missing	*0.00*	*0.16*	*5.78*	*1.15*	*7.24*	*1.40*
Neither diabetes nor hypertension	26.96	31.38	28.88	32.40	27.93	33.01
Diabetes only	5.88	4.63	4.56	4.41	3.79	4.49
Hypertension only	43.14	46.10	43.16	45.68	43.45	45.24
Both diabetes and hypertension	24.02	17.72	17.63	16.36	17.59	15.86

p-value			*			*
Forgone meds due to cost						
Missing	*41.67*	*13.31*	*2.13*	*0.49*	*8.62*	*1.95*
No	55.88	80.58	89.67	92.45	84.83	90.99
Yes	2.45	6.11	8.21	7.06	6.55	7.06
p-value		*		*		*
Non-housing wealth						
Missing	.	.	.	.	.	.
Q1, lowest	23.53	20.08	31.31	22.86	27.24	23.02
Q2	28.43	23.96	15.81	14.20	22.41	13.09
Q3	28.92	26.26	25.84	27.19	23.45	28.22
Q4, highest	19.12	29.70	27.05	35.75	26.90	35.60
Median	*10,000*	*20,300*	*6,000*	*20,000*	*4,000*	*18,000*
p-value		*		*		*
Out of pocket medical expenditure						
Missing	.	.	.	.	.	.
Q1, lowest	25.00	23.00	20.67	18.40	21.38	18.99
Q2	19.61	26.73	18.84	26.77	17.59	26.06
Q3	22.55	27.34	20.36	28.83	29.31	29.25
Q4, highest	32.84	22.94	40.12	26.00	31.72	25.70
Median	*1,710*	*1,368*	*2,320*	*1,664*	*1,965*	*1,553*
p-value		*		*		*

NOTE. *Refer to Figure 8 for final sample selection criteria. P-value indicates statistical significance at α=0.05 using chi-squared test for categorical variables and ANOVA test for continuous variables.*

Chapter 6 (Summary & Conclusions)

SUMMARY OF KEY FINDINGS

In this dissertation I present three papers, all drawn from nationally representative HRS data, evaluating the role of housing insecurity and other socioeconomic factors on health and healthcare utilization outcomes among Medicare beneficiaries during and over the course of the Great Recession of 2008. Specifically, in Paper 1 of this study I assessed the association between housing insecurity, as per the HUD definition, and forgone medication due to cost among Medicare beneficiaries aged 65+ over the course of the Recession (2008-2012). This paper was primarily guided by Downing's effect-budgeting mechanism, or the forced trade-offs between basic needs (i.e., housing and medical care) among older adults during the Recession including related evidence indicating that persons of low SES with fewer resources to budget are more likely to forgo medication and become ill especially during periods of prolonged financial hardship. Main findings indicated a greater odds of forgone medication for individuals experiencing Onset versus Persistent Insecurity over the course of the Recession with a statistically significant greater odds of forgone medication in 2008 among individuals experiencing Onset versus No Insecurity. My findings corroborate findings from the literature and lend support to Downing's Homeowner Distress Model positing that, under peak economic distress, adults may be forced to re-prioritize housing costs over other basic needs, including food, transportation, and medical care, ultimately leading to poor health (Downing, 2016; JCHS, 2020). My findings also suggest that the onset of housing 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. My findings of a greater odds of foregone medication in 2008 among individuals experiencing onset insecurity have overall

housing policy implications for at-risk homeowners and renters during peak economic crises including expansion of low-income housing units, eviction moratoriums and rent stabilization. Additionally, my findings of a higher overall odds of foregone medication among adults with any level of housing insecurity as well as chronically-ill Medicare beneficiaries with high donut hole coverage gaps, such as those with diabetes, underscore healthcare policy implications such as wider prescription drug coverage and greater access to Medicare Advantage plans for at-risk adults during periods of widespread economic hardship (Coleman, 2019).

In Paper 1, I also found that, in contrast to housing insecurity, race/ethnicity was consistently associated with forgone medication such that NHB adults were significantly more likely than NHW adults to forgo medication over the course of the Recession. Along with these findings, Paper 2 was primarily based on literature indicating the greater overall levels of financial hardship among minorities during the 2008 peak of the Recession as well as further exploration of other predisposing, need-based, and enabling factors (other than housing insecurity) influencing disparities in forgone medication during the Recession.

In Paper 2 of this study, I sought to identify racial differences in forgone medication due to cost among NHW and NHB Medicare beneficiaries during the 2008 peak of the Great Recession and further evaluate the extent to which predisposing, need-based and enabling factors would help explain these differences. Findings indicated statistically significant associations between race and forgone medication that were lost with the addition of non-housing wealth in which the odds of forgone medication among NHB vs. NHW adults dropped by nearly 50% and remained generally steady with the addition of healthcare and housing factors including housing insecurity. Moreover, odds of forgone medication were over 70% lower for those with highest vs. lowest non-housing wealth levels. These findings indicate that, despite health insurance

coverage and levels of housing insecurity, racial wealth disparities may have accounted for

Black-White differences in Medicare beneficiaries' ability to pay for and adhere to needed

medications during the Recession. My findings of the wealth race gap are supported by the

fundamental cause and cumulative disadvantage (CAD) theories which suggest that racial

disparities in health and healthcare are largely explained by SES variations over the life course.

Given evidence of racial differences in forgone medical care that persist despite expanded

Medicare part D coverage, enhanced policy reform might address more fundamental causes of

health disparities by creating additional financial opportunities for low-income minorities such as

those to help build savings and investments along with promoting homeownership among

minority households (Boen et al., 2020).

In Paper 3, I examined the association between baseline (2008) housing insecurity, as per

the HUD definition, and depressive symptoms among Medicare beneficiaries over the course of

the Recession (2008-2012). I further assessed the extent to which predisposing, need-based, and

enabling factors explained this relationship. This paper was primarily guided by literature

documenting associations and pathways between housing/financial hardship and poor mental

health, including Downing's stress mechanism, as well as further exploration of health-related

outcomes (other than forgone medication) linked to housing insecurity during the Recession.

Main findings indicated that baseline housing insecurity had positive yet insignificant

associations with average depressive symptoms during 2008-2012, however, this relationship

became negative and significant with the addition of baseline wealth and tenure status.

Moreover, the greatest overall decrease in depressive symptoms was observed among

respondents with at least a bachelor's degree while the greatest overall increase in depressive

symptoms was observed among respondents who forwent medication due to cost. Along with

evidence of greater susceptibility to financial and housing distress among low-income renters over the course of the Recession, my findings of significantly higher depressive symptoms associated with indicators of low SES (i.e. education, health insurance, medical expenditures, wealth) generally aligns with extant literature on positive associations between forgone medication due to cost and poor mental health as well as my hypotheses on neo-material pathways of material disadvantage explaining relationships between financial stress and poor health (R. Andersen, 1968; Brenner, 1987; Chung et al., 2019; Glonti et al., 2015; S. Lee et al., 2019; Mehta et al., 2015; Pruchno et al., 2017; Zivin, Ratliff, et al., 2010). Given findings of increased depressive symptoms among adults with low education levels, key policy implications from this paper include the adoption of low-cost mental health interventions (e.g. self-guided internet-based cognitive bibliotherapy) as well as related interventions encouraging social support from family and friends who may be able to provide low SES adults with instrumental, informational, appraisal or emotional support (Gualano et al., 2017; House, 2002; Karyotaki et al., 2017, 2018; Pearlin et al., 1981; K. P. Smith & Christakis, 2008; Zunzunegui et al., 2003).

CONCLUSIONS

In conclusion, this study applied concepts from Downing and Andersen's model to reveal the extent to which housing insecurity and related predisposing, need-based and enabling factors adversely affected older adult healthcare utilization and mental health outcomes during and over the course of the Recession. Overall study findings helped fill important literature gaps in the Recession-related health literature including the extent to which i) housing insecurity, as per the HUD definition, impacted forgone medication due to cost and mental health outcomes, as well as ii) differences in forgone medication patterns among Medicare beneficiaries aged 65+ during the Recession by race/ethnicity & other demographic and socioeconomic characteristics. Key study

findings indicated that onset housing insecurity and wealth were key predictors of foregone medication while tenure status was a key predictor of depressive symptoms over the course of the Recession.

Along with filling important literature gaps, to my knowledge, this is the first study to adapt Downing's model to study the impact of housing insecurity on health-related outcomes among both renters and homeowners. This is also the first study that I am aware of to construct the housing insecurity HUD index based on HRS data and use it to evaluate variations in the likelihood of forgone medication due to cost over the course of the Recession, given that related studies have been mostly cross-sectional, often neglecting changes in housing hardship across two or more periods of time. By employing the formal HUD housing insecurity definition in this study, I was thus able to capture a wider set of older at-risk Medicare beneficiaries aged 65+ facing insecurity, rather than only those experiencing foreclosures, evictions, etc. over the course of the Recession.

This study also demonstrated the role of other key factors such as tenure status, education, and forgone medication on depressive symptoms among beneficiaries throughout the Recession. Although forgone medication and depressive symptoms were evaluated as separate outcomes in this dissertation, net of other factors, my Paper 1 findings indicated the predictive role of onset housing insecurity on forgone medication while Paper 3 findings indicated the predictive role of forgone medication on depressive symptoms. Together, these findings suggest that forgone medication may be one mediating factor on the pathway between housing insecurity and depression among older adults which can be analyzed in future work.

Formal mediation tests examining this pathway among aging older adults are well-warranted given further literature on Pearlin's "stress proliferation process" whereby stressors in

late life can both persist and proliferate from stressors in early life across various life domains (Pearlin, 1989; Pearlin et al., 2005). Also according to Pearlin's general "stress process" theory, psychosocial resources mediate relationships between stress and health yet can be depleted under stressful conditions, in turn, leading to poor health behaviors and/or exacerbate health outcomes (Israel & Schurman, 1990; Pearlin, 1989; Taylor & Broffman, 2011). However, as per the "structural amplification hypothesis", psychosocial resources may also moderate the relationship between stress and health; both absorbing and buffering the cumulative effects of stress on poor health outcomes (Figure 12) (Koltai & Stuckler, 2019; Pearlin, 1999; Pudrovska et al., 2005). Therefore, future work might also examine the mediating and moderating influence of psychosocial resources on the relationship between housing insecurity and poor mental health among aging older adults.

Overall findings from this study have key health implications for the roughly 20 million housing insecure renters and 16.7 million housing insecure homeowners today (Joint Center for Housing Studies (JCHS), 2020). This includes approximately 39% of older-adult headed households struggling to pay for their housing costs as well as the 43% of older adult homeowners with mortgage debt (Federal Interagency Forum (Forum) on Aging-Related Statistics, 2020; Joint Center for Housing Studies (JCHS), 2016, 2019, 2020; Purcell, 2012). Therefore, it is critical that members of the academic, policy, housing and healthcare communities adopt relevant research, policies and interventions to enhance medication adherence and mental health among millions of susceptible older adults including renters and those with low wealth levels. Such efforts have the potential to not provide a safety net for at-risk older adults during economic crises, but also contribute to lower annual national health expenditures associated with a growing chronic disease burden, treatment costs and

hospitalizations among older adults susceptible to financial and housing distress (American

Diabetes Association (ADA), 2018; Center for Disease Control & Prevention (CDC), 2020;

Heidenreich et al., 2011; Kirkland et al., 2018; Sokol et al., 2005).

Figure 12: Stress proliferation example
(Pearlin, 1999)

Leonard I. Pearlin

FIGURE 19.1. The stress process model.
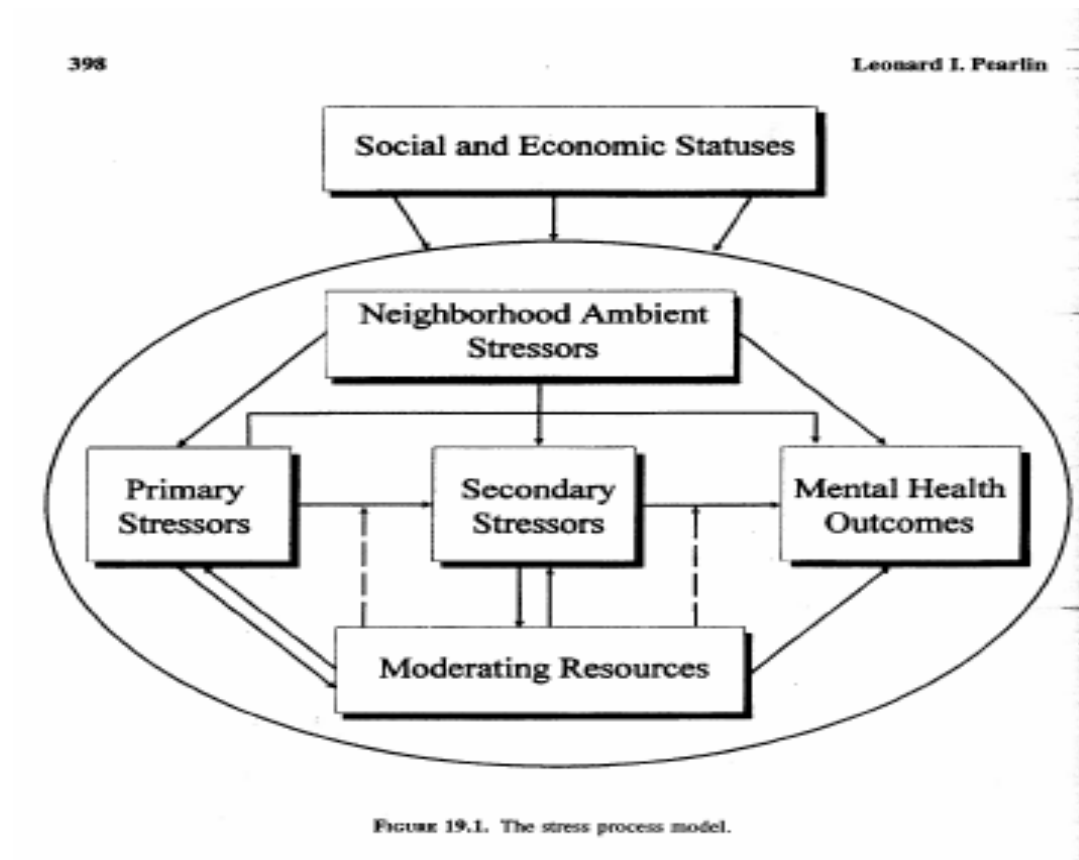
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Publications

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2. Hernandez, M., Cantu, P., Markides, K. The effect of financial strain on the health outcomes of older Mexican-origin adults: Findings from the Hispanic Established Population for the Epidemiological Study of the Elderly (H-EPESE). International Journal of Aging and Human Development. [Revise and resubmit].

3. Li, C., Aguilar, E., Arthur, P., Peniche, J., Gutierrez, M., Hernandez, M., Wong, R. Assigning Lifetime Occupation Domains for Older Mexicans: MHAS-O*NET Linkage Protocol. Journal Salud Pública de México Special Issue of the 7th Annual Seminar/Workshop MHAS-ENASEM 2022.

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