Home Safety, Accessibility, and Elderly Health: Evidence from Falls

Michael D. Eriksen
Texas Tech University

Nadia Greenhalgh-Stanley
Kent State University

Gary V. Engelhardt
Syracuse University

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Abstract

We use rich longitudinal data from the Health and Retirement Study to estimate some of the health benefits to the elderly from safer, more accessible homes. We focus on the role of home safety and accessibility features on the prevention of serious, non-fatal falls for widowed individuals. The presence of such features reduces the likelihood of a fall requiring medical treatment by 20 percentage points, a substantial effect. However, we find that falls are not the type of health shock that is a main driver of housing tenure transitions among the elderly.

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1. Introduction

What are the benefits of safer homes? For the elderly, "safer" often means physically easier to navigate. Home safety and accessibility features, such as shower seats, grab bars, railings, and ramps, are designed, in general, to promote function within the residence and, in particular, to prevent falls, which often result in significant injury and medical expenditures. Indeed, Stevens et al. (2006) estimated that falls by older Americans resulted in over $19B in direct medical treatment in 2000, roughly as much as government expenditures on extensively studied programs like Section 8 rental housing, Food Stamps, and Temporary Assistance for Needy Families.[1]

In this paper, we use rich longitudinal data from the Health and Retirement Study (HRS) to estimate some of the health benefits to the elderly from safer, more accessible homes. We focus on the role of home safety and accessibility features on the prevention of serious, non-fatal falls—those requiring medical treatment—and the impact of fall reduction on residential transitions.

Our analysis is most closely related to three strands in the existing housing literature. The first has focused on the extent to which housing generates significant benefits in non-housing domains. These include impacts on child well-being and health (Green and White, 1997; Boehm and Schlottmann, 1999; Dietz and Haurin, 2003; Fortson and Sanbonmatsu, 2010; Jacob et al., forthcoming). Within this area, little attention has been given to the elderly. The second has focused on the role of health shocks in generating housing tenure transitions and spend-down of home equity at older ages. This includes the well-cited studies by Venti and Wise (1989, 1990,

[1] In their Table 2, Currie and Gahvari (2008) calculated expenditures for a large number of programs in 2002. Deflating those expenditures to real calendar-year 2000 dollars using the CPI to be consistent with the calculations in Stevens et al. (2006), there was $19.2B in expenditure for Section 8 and other assisted rental housing, $20.8B for Food Stamps, and $23.6B for TANF.

2001, 2004), as well as work by Feinstein (1993) and Megbolugbe, Sa-Aadu, and Shilling (1997), among others. The third is work by Kutty (1999, 2000), who has used the Becker-Grossman approach for the production of human and health capital to model the joint production of functionality and the demand for home safety and accessibility modifications among the elderly.[2]

A fundamental empirical challenge in identifying causal impacts on health and other outcomes is that safety features are not assigned randomly across homes. An important contribution of our analysis is that we outline the econometric problems in estimating causal impacts and then propose an instrumental variable (IV) procedure to circumvent these difficulties. Our IV approach, detailed below, can be summarized generally as follows. For older married couples, typically one spouse experiences a functional decline at a faster rate than the other, eventually leading to widowhood. Home safety and accessibility modifications are often made to accommodate the declining spouse, which then become a legacy to the surviving spouse upon widowhood. That is, surviving spouses may find themselves in residences with safety and accessibility features, independent of their own health trajectory.

We apply this logic to a sample of recently widowed homeowners 65 or older, who we can track over time in the Health and Retirement Study (HRS). We use the deceased spouse's functional status when alive, as measured by limits to Activities of Daily Living (ADLs), as an instrumental variable for the presence of home safety and accessibility features for the surviving spouse in the years after widowhood, and then estimate the impact of these features on the likelihood of a serious fall for the widow. There is a strong first-stage relationship: each additional ADL limit of the deceased spouse before death is associated with a 6 percentage point increase in

[2] There is a large literature examining falls in health services, demography, and gerontology. Gillespie et al. (2012), Wahl et al. (2009) and Heinrich et al. (2010) provide recent reviews of work in those areas.

the likelihood that the surviving spouse lives in a home with safety and accessibility features conditional upon their own health and fall history.

Based on our IV approach, we have a number of findings. First, the presence of safety and accessibility features reduces the likelihood of a serious fall for the widowed by 20 percentage points. Given the mean prevalence of falls of 11.6%, this is a substantial effect. The bulk of the effect is concentrated among men and those 75 and older. Therefore, our results suggest that housing investment in safety could significantly reduce serious falls among the elderly. Second, safety and accessibility features are associated with a substantial reduction in the likelihood of a nursing home stay. There is little evidence, however, that falls are the type of health shock that is a main driver of own-to-rent transitions among the elderly documented by Venti and Wise (1989, 1990, 2001, 2004).

We end the analysis with a description of housing investments in safety and accessibility features. Although somewhat speculative, back-of-the-envelope calculations suggest that on average each dollar of housing investment in home safety and accessibility features is associated with a 93-cent reduction in medical costs from fewer non-fatal falls.

The remainder of the paper is organized as follows. Section 2 gives basic national statistics on falls among the elderly. Section 3 describes the HRS data and the IV strategy. Section 4 discusses the estimation results for falls; section 5 discusses the results for the other outcomes. There is a brief conclusion.

2. Background on Falls

Falls are the leading cause of accidental death and non-fatal physical trauma among the elderly. They also can cause substantial psychological trauma. In Table 1, we reproduce data for calendar year 2000, which roughly coincides with the beginning of our analysis sample described below, taken from Stevens et al. (2006). The estimates in their analysis originate from a comprehensive national study of the incidence and medical treatment costs of falls for the elderly, defined as those 65 and older. The data were drawn from the 2000 National Vital Statistics System, 2001 National Electronic Injury Surveillance System, 2000 Health Care Utilization Program National Inpatient Sample, 1999 Medical Expenditure Panel Survey (MEPS), and 2000 Medicare claims data.

Columns 1-4 of the table show statistics on prevalence and cost for fatal falls. Just over ten-thousand elderly individuals died from falls in 2000 (column 1). Male, older, and widowed individuals were the most likely to die as a result of a fall. The estimated cost of medical treatment for all fatal falls was $179 million. The most common fatality was from traumatic brain injury, which occurred in 46% of the cases and was associated with a similar proportion of total cost.

The data source for our empirical analysis below, the HRS, does not have a sufficiently large sample to study fatal falls. Therefore, we focus on non-fatal falls, national data for which appear in columns 5-8. There were an estimated 2.6 million non-fatal falls that required medical treatment in 2000 (column 5), half of which involved females who were 75 and older.[3] The estimated cost of medical treatment for all non-fatal falls was $19 billion, or an average of $7,300 per fall. Injuries to the extremities were the most common. They accounted for 54% of the cases and 61% of cost. The most common types of injury were fractures, contusions, and sprains, which combined to account for 81% and 84% of all cases and treatment costs, respectively.

[3] The data in Table 1 are for falls. In the case of fatal falls (columns 1-4), there is a one-to-one mapping of falls to individuals, as any given individual cannot die more than once from a fall. In contrast, in columns 5-8 what is measured is falls, not individuals, as an individual can have more than one non-fatal fall in a year.

3. Data and Econometric Framework

The data for our analysis come from the HRS, a stratified random sample of over 25,000 individuals 50 and older, and their spouses (regardless of age). Individuals in the study are interviewed every even-numbered calendar year until they die, at which point an "exit" interview is conducted with their next of kin to gather information on the health and economic circumstances prior to and at the time of death. The study began in 1992, and every six years (e.g., 1998, 2004, 2010, 2016, etc.), a new birth cohort of individuals in their mid-50s enters the study, refreshing the panel.

The sample we create from the HRS is a cross-section comprised of "recently" widowed homeowners, defined as respondents who were married 4 years earlier, but lost their spouse within the last 2 to 4 years and remained unmarried. The HRS only asked questions on falls and housing safety modifications to those 65 and older. Therefore, we also restrict our sample to all such widowed individuals who were older than 69 years old in order to condition on past falls and the legacy of safety modifications 4 years earlier. These restrictions result in a sample of 1,005 such "recently widowed" individuals in the HRS between 2000 and 2010.[4]

Figure 1 illustrates the HRS data sources and timing used below in the empirical strategy. As a survey administered every other year, its content maps into calendar time in two ways: individuals are asked questions about current socio-economic and health status (point-in-time), as well as behavior over the last two years or since the last wave (retrospective). Although our analysis is essentially a cross-section of widowed individuals, each observation draws upon three

[4] Specifically, 143 cases have outcomes measured in 2010 (which would correspond to wave 3 in Figure 1). These cases have the focal explanatory variable drawn from the 2008 HRS and the instruments drawn from the 2006 HRS. There are 178 cases with outcomes measured in 2008; 154 cases with outcomes measured in 2006; 196 cases with outcomes measured in 2004; 177 cases with outcomes measured in 2002; and 157 with outcomes measured in 2000.

actual waves of response in the HRS, or up to 6 calendar years for retrospective questions. Each outcome is drawn from the current wave (t) ; the focal explanatory variable is drawn from the previous wave when they first experienced widowhood $(t-2)$; and, the instrumental variable and (the majority of) the control variables are drawn from an individual and their spouse's responses two waves prior $(t-4)$.

The primary outcome of our analysis, Y, is based on a retrospective question: it is an indicator that takes on a value of one if the individual had a serious fall that required medical treatment in the last two years, i.e., between calendar years $t-2$ and t. When writing the formal econometric specification, we adopt the convention that a retrospective variable covering the time interval $(t-2,t)$ is labeled with a subscript t. Then, we model econometrically the probability of such a fall as

$$Y_{it}^{W} = \kappa + \beta D_{it-2}^{W} + \boldsymbol{\pi}\mathbf{X}_{it-k}^{W} + \gamma_t + \alpha_{it-4}^{W} + u_{it}, \qquad (1)$$

where i denotes the individual, W denotes that the variable is measured for the widowed individual, κ is a constant, and the index k runs $k=2,4$, as explained below. The term γ represents a calendar-year effect for the outcome. The term α represents a full set of dummy variables for single year of age of the widowed individual measured at $t-4$ when the spouse was still alive. The focal explanatory variable is D, a dummy variable that takes on a value of one if the widowed individual lived in a home with any of the following safety and accessibility features to help older persons or the disabled: grab bar, shower seat, railing, ramp, modification for a wheel chair, call device to get help when needed, or other such modifications.[5] Since falls between

[5] The HRS questions are H140, H141, H143 and H144. H140 states "Sometimes buildings have special features to help older persons or someone with a disability get around. Does your home have features such as a ramp, railings or modifications for a wheelchair?" This is followed up by H141: "Which special features does it have?", which includes

periods $t-2$ and t may affect housing choices measured at point-in-time t, D is drawn from period $t-2$ to avoid any reverse causality. Therefore, the primary objective is to get consistent estimates of the parameter β, which measures the impact of safety and accessibility features on *subsequent* falls, i.e., falls occurring over the next two years. The central hypothesis is that $\beta = 0$, these features have no impact on falls, versus the alternative that $\beta < 0$, these features reduce falls.

Means of selected socio-economic characteristics for this sample are shown in column 1 of Table 2. Standard deviations for continuous measures are in parentheses; medians are in square brackets. Not surprisingly, most (76%) of the widowed are women. The sample is largely comprised of whites, with less than a college degree, aged 75 or older. Mean income is just over $51,000; median income is just over $38,000. Columns 2-3 and 4-5 give similar statistics for the subgroups of those with and without serious falls and home safety and accessibility features, respectively.

The first row of panel A in Table 3 shows the frequency of having experienced any type of fall in the last two years. Almost 37% of all individuals had fallen (column 1), with the unconditional mean number of falls just under one (row 2). These statistics imply a mean of 2.6 falls, conditional on having fallen. The third row shows the mean of the primary outcome, Y^W: a serious fall in the last two years that required medical treatment. Just over 11.6% had such a fall (column 1), a far lower percentage than having experienced any fall, which indicates that many

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a possible response of "Other." H143 states "How about special features to safeguard older persons with a disability? Does your home have features such as grab bars, a shower seat, or a call device or another system to get help when needed?" This is followed up by H144: "What special features does it have to help safeguard older people or someone with a disability?", which includes "Other" as a possible response.

falls did not end up requiring medical treatment.[6] The first row of panel B shows the mean for the focal explanatory variable D^W: the presence of any home safety and accessibility feature. Just over 49% of the sample had such a feature. By far the most common features were grab bars or a shower seat (36%) and railings (20%).

A key concern with simple estimators of β in (1), such as Ordinary Least Squares (OLS), is that D might not be exogenous if there is unobserved heterogeneity in the proclivity to fall that is correlated with prior modifications. For example, those in period $t-2$ who believe they might be prone to falling in the future might modify their residences (in period $t-2$) as a preventative measure. In this case, "modifiers" are also more likely to be "fallers" along unobserved dimensions. This would induce a correlation between D and the error term u and bias upward (toward zero) estimates of β. Indeed, this can be seen in a comparison of means in Table 3. Comparing row 1 of columns 4 and 5, those with any home safety and accessibility features are 3 percentage points *more* likely to have experienced a serious fall in the subsequent two years (0.03=0.132-0.102), a correlation of the wrong sign if such features truly reduce falls.

We attempt to circumvent this concern by using an IV approach. For older married couples, typically one spouse experiences a functional decline at a faster rate than the other. Home safety and accessibility modifications are often made to accommodate the declining spouse, which then become a legacy to the surviving spouse upon widowhood. In this case, surviving spouses may find themselves in residences with these features, independent of their own health trajectory. As shown in Figure 1, we use the deceased spouse's functional status from the last HRS interview

[6] Unfortunately, the HRS does not ask about specific injuries related to falls. Engelhardt, Eriksen, and Greenhalgh-Stanley (2013) provide similar descriptive statistics for all marital statuses in the HRS.

when alive as an instrumental variable for the later presence of home safety and accessibility features for the surviving spouse. The instrument is drawn from the first wave and measures the behavior of the deceased spouse 4-6 years prior to when the outcome data were gathered for the surviving spouse.

Specifically, let S denote the deceased spouse, then the first-stage specification is

$$D_{it-2}^{W} = \mu + \delta ADL_{it-4}^{S} + \boldsymbol{\zeta}\mathbf{X}_{it-k}^{W} + \gamma_{t-2} + \alpha_{it-4}^{W} + \nu_{it-2} . \tag{2}$$

The instrument is ADL, the number of limits to the deceased spouse's Activities of Daily Living (ADLs). The HRS collects information on five activities—bathing, eating, dressing, walking across a room, and getting in and out of bed—each designed to measure various dimensions of an individual's ability to function in his or her residential space. For each of the five tasks, the HRS records a 1 if the respondent had difficulty with that task and a zero otherwise. The scores are summed for the five tasks, so that ADL ranges from 0 (no difficulties with any of the tasks) to 5 (difficulties with all of the tasks). So, a higher value of the instrument ADL in (2), means a worse functional status.

Also included in the outcome (1) and first-stage (2) models are a set of controls $\mathbf{X}^{W}$, where

$$\boldsymbol{\zeta}\mathbf{X}_{it-k}^{W} = \sum_{k=2,4} \left(\theta_{1k} ADL_{it-k}^{W} + \theta_{2k} Mobility_{it-k}^{W} + \theta_{3k} Conditions_{it-2}^{W} + \theta_{4k} Y_{it-k}^{W} \right). \tag{3}$$

The summation in (3) represents the widowed individual's past functional, health, and fall trajectory (covering $t-2$ and $t-4$). In particular, $Mobility$ is the number of limits to five different aspects of mobility: walking several blocks, walking one block, walking across the room, climbing several flights of stairs, and climbing one flight of stairs. For each of the five tasks, the HRS records a 1 if the respondent reports having had difficulty with that task and a zero otherwise. Then the scores are summed for the five tasks, so that $Mobility$ ranges from 0 (no difficulties with any of the tasks) to 5 (difficulties with all of the tasks). So, a higher value of *Mobility* means worse physical mobility. The variable *Conditions* is a count of the number of medical conditions a doctor had ever told the widowed individual that he or she had. The eight conditions were high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis. The index ranges from 0 (the absence of all eight conditions) to 8 (the presence of all eight conditions) where, obviously, a larger index value indicates poorer health. Finally, ADL^W and Y^W measure the ADL limits and serious falls for the widowed individual. In combination, the summation in (3) represents the functional, health, and fall trajectories of the widowed individual in the years prior to the when the outcome occurred. We use these to directly control for any proclivity to fall, so that δ in the first-stage model is interpreted as the impact of the deceased spouse's functional status (when alive) on the *future* presence of safety and accessibility features for the surviving spouse, *controlling* for the surviving spouse's own functional, health, and fall trajectory.

To be valid, the instrument must satisfy three conditions. First, it must be relevant, $Cov(ADL^S_{it-4}, D^W_{it-2} \mid \mathbf{X}^W_{it-k}, \gamma_{t-2}, \alpha^W_{it-4}) \neq 0$. In principle, we believe that by the legacy effect outlined above, it is relevant. In practice, the instrument is highly correlated with the presence of home safety and accessibility features. Column 1 of Table 4 shows the first-stage estimate of δ in equation (2). Conditional on age, time, and the surviving spouse's functional, health, and fall trajectory, each additional ADL limit of the deceased spouse (when alive) is associated with a 6 percentage point increase in the likelihood that the surviving spouse subsequently lives in a home with safety and accessibility features (after widowhood). The mean incidence of such features in the sample is 49.2% (Table 3, column 1). Columns 2 and 3 of Table 4 illustrate the robustness of the baseline first-stage estimates to the addition of other control variables. In column 2, we add the socio-economic characteristics listed in Table 2. In column 3, we add a set of housing characteristics to the specification: dummy variables for whether all of the living space is on one floor; whether each floor has a bathroom; the number of floors in the structure; whether it is a multifamily structure; and dummies for physical condition (excellent, very good, good, and fair, with poor being omitted). The first-stage estimate remains essentially unchanged. We also report the Kleibergen-Paap (2006) *F*-statistic, which is an indicator of the strength of an instrumental variable and is robust to heteroscedasticity. In all three specifications we estimate the *F*-statistic to be greater than 41, indicative of a strong first-stage relationship.

To corroborate the first-stage findings, we turn in Table 5 to outcomes measured in the exit interview after the spouse's death, which occurred in period $t-2$, at the same time the information on home safety and accessibility features was gathered. In the exit interview, the surviving spouse was asked whether the death was expected or not.[7] Since the mechanism behind the legacy effect is the purposeful accommodation of the functional decline of the deceased spouse, the instrument should be correlated with anticipated or non-rapid-onset deaths, for which there would be a plausible timeframe to adjust housing features. Column 1 of the table shows estimates from a specification isomorphic to that in column 3 of Table 4, but with the dependent variable being a dummy for an expected death. Each additional ADL limit of the deceased spouse is associated with a 3.6 percentage point increase in the likelihood that the death was expected. Column 2 shows a similar result when the dependent variable measures the duration of the final illness/death: a

[7] The HRS question (WA131) is "Was the death expected at about the time it occurred, or was it unexpected?"

dummy for whether the duration was one year or more.[8] We also examined the relationship between the cause of death reported in the exit interview and the timing variables (results not shown). The two leading causes of death were cancer and heart disease. Cancer deaths were largely expected and long in duration; cardiovascular deaths were largely unexpected and short in duration. Overall, the results in Tables 4-5 are consistent with the legacy effect, whereby married couples accommodate the functional decline of the first-to-die spouse.

Second, the instrument must be excludable. That is, conditional on age, time, and the widowed individual's functional, health, and fall trajectories, $\mathbf{X}^W$, the deceased spouse's functional status 4-6 years prior should not have had an impact on the surviving spouse's current fall behavior, except through home safety and accessibility D^W. In a framework in which functional status and falls are produced jointly using both spouses' inputs (Kutty, 1999; 2000), this instrument surely would not be excludable for a sample of married individuals. However, there is no reason to believe that, conditional on the surviving spouse's health, functional status, and fall trajectory, the deceased spouse's functional status and fall behavior 4-6 years prior would have any *direct* bearing on the surviving spouse's current fall behavior. In our view, death insures excludability.

Third, the instrument must be exogenous, $Cov(ADL^S_{it-4}, u_{it} \mid \mathbf{X}^W_{it-k}, \gamma_t, \alpha^W_{it-4}) = 0$. Our fundamental identifying assumption is that any proclivity of the surviving spouse to fall or features of the physical landscape that would have caused both spouses to fall are accounted for by conditioning on $\mathbf{X}^W$, the widowed individual's health, functional, and fall trajectories (and, in the

[8] The HRS question (WA134) is "About how long was it between the start of the final illness and the death: was it one or two hours, less than a day, less than a week, less than a month, less than a year, or was it more than a year?" The results in column 2 are similar if the dependent variable is for a duration of one month or more.

richer specifications, the socio-economic and housing characteristics). So, we treat the instrument as conditionally independent of the error term in (1).

4. Estimation Results for Falls

The first column of panel A in Table 6 shows the OLS parameter estimate of β from equation (1). Conditional on the surviving spouse's prior health, functional status and fall trajectory, $\hat{\beta}^{OLS} = 0.005$, or the presence of home safety and accessibility features is associated with an *increase* in incidence of serious falls over the next two years of one-half of one percentage point. With a heteroscedasticity-robust standard error of 0.020 in parentheses, the null of $\beta = 0$ (no impact) cannot be rejected at conventional levels of significance.[9]

Given the concern about potential upward bias in the OLS estimate outlined above, panel B shows the IV estimate of β from (1).[10] It reverses sign, $\hat{\beta}^{IV} = -0.181$, and indicates the presence of home safety and accessibility features is associated with a decrease in the incidence of a serious fall over the next two years of 18.1 percentage points. Economically, this is a large impact, given that the mean incidence of serious falls was 11.6% (column 1 of Table 3). With a robust standard error of 0.108 in parentheses, the null of $\beta = 0$ (no impact) can be rejected in favor of the alternative that $\beta < 0$ at the 5% level of significance ($p = 0.048$). The *p*-value for the Hausman test that the OLS and IV estimates are the same is 0.078.

Columns 2 and 3 in the panel illustrate the robustness of the baseline IV estimate to the addition of other control variables. In column 2, we add the socio-economic characteristics.[11] In

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[9] The marginal effects from probit maximum likelihood estimates were similar in magnitude and significance.
[10] Its associated first-stage is shown in column 1 of Table 4.
[11] The associated first-stage is shown in column 2 of Table 4.

column 3, we add the set of housing characteristics to the specification.[12] The IV estimates remain essentially unchanged, indicating that home safety and accessibility features have statistically and economically significant impacts in reducing serious falls.

Panel C presents the marginal effects from bivariate probit estimation of β under the assumption that the errors terms in (1) and (2) are jointly normally distributed. The marginal effect in the baseline specification in column 1 indicates that safety and accessibility features reduce the likelihood of a serious fall by 17.7 percentage points. This is very close to the IV estimate in panel B. In the richest specification in column 3, the marginal effect suggests that safety and accessibility features lower the likelihood of a serious fall by 13.3 percentage points. Although somewhat smaller than the IV estimates in panel B, the two sets of estimates are not statistically different. Overall, the main results are robust to the choice of estimator.

Finally, we also examined the impact of these features on the incidence of any falls (serious or not) and the number of falls. There were no statistically meaningful impacts for these outcomes (results not shown). This is consistent with the comparison of simple means from above and suggests that safety and accessibility features do not reduce overall fall activity, but instead attenuate the severity of falls.

Table 7 and Figures 2-4 examine heterogeneity in impacts. In particular, the first two columns in the table show IV estimates of the richest specification (in column 3 of Table 6) for men and women, respectively. The fall-reduction impact is concentrated more on men than women, but the gender-specific estimates are not statistically different from each other at conventional significance levels. The full sample in Table 6 includes widowed individuals who

[12] The associated first-stage is shown in column 3 of Table 4.

both stayed in and moved from the home in which the deceased spouse died. Column 3 of Table 7 shows estimates just for the subsample of stayers, defined as widowed individuals who live in the same house after widowhood (in $t-2$) as before widowhood (in $t-4$). The advantage of limiting the sample in this manner is that the legacy effect should only work through homes in which the deceased spouse resided prior to death. The disadvantage is that in doing so, we are selecting the subsample based on a potentially endogenous variable, as mobility is one possible response to widowhood.[13] With this caveat in mind, the IV estimates for stayers in column 3 of Table 7 are nearly identical to those for the full sample in column 3 of Table 6.[14]

We explore heterogeneous effects further in Figures 2-4. The solid line in Figure 2 represents predicted serious falls by age for widowed individuals with housing with safety features, while the dashed line represents predicted serious falls for widowed individuals without such features present. The predicted values were obtained by re-estimating (1) allowing the impact of safety and accessibility features, β , to vary linearly with age.[15] The figure indicates that while the incidence of serious falls increases significantly with age for widowed individuals living without safety features, it is essentially flat or even slightly decreasing for those living in the presence of such features. Starting at approximately the age of 78, our estimates were statistically significant at the 10% level, based on standard errors obtained using the delta method. We also estimate at least a 50% reduction in serious falls due to the presence of safety features for widowed individuals over the age of 78. Figures 3 and 4 similarly illustrate differential effects of safety and

[13] We examine impacts on residential transitions directly in the next section.
[14] There are too few observations on movers to reliably estimate an effect on that subsample.
[15] Due to the additional endogenous variable through the interaction we also interact age with spouse ADLs to create an additional instrumental variable to remain identified. The Kleibergen-Paap (2006) F-statistic indicated the two instrumental variables together remained highly relevant (15.4) in the first-stage and the interaction term of age with the presence of safety features was statistically different from 0 at the 5% level.

accessibility features with years of education and the ratio of household income to the federal family-size-adjusted poverty threshold, respectively. We find the effect of modifications increasing for those with more years of education and a higher income to poverty ratio, but neither trend is statistically significant.

5. Impacts on Housing Transitions

The elderly have a strong desire to live independently and age in place (AARP, 2000). Part of this stems from the familiarity, emotional, and social attachment to a residence and neighborhood (Danigelis and Fengler, 1991). Another part stems from what appear to be high psychic and economic costs of moving (Venti and Wise, 1989). Indeed, there is strikingly low housing mobility among the elderly, and what mobility there is typically is precipitated by an adverse health shock (Venti and Wise, 2001, 2004). A key question then is whether safety and accessibility features and falls are sufficiently important to alter elderly housing transitions.[16]

To examine this, panel A of Table 8 presents IV estimates of the impact of safety and accessibility features on three transition measures: having had a nursing home stay in the last two years, having moved permanent residence, and having made an own-to-rent transition. It should be emphasized that the dependent variables in Table 8 are not mutually exclusive. For example, it is not uncommon for individuals to have a nursing home stay and maintain ownership of a residence.

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[16] There have been numerous studies in the demography, medical, and gerontology literatures that suggest there are significant costs and risks to living alone for the elderly. One pathway is through physical and health risks. For example, Gurley *et al*. (1996), Tromp *et al*. (1998), and Cwikel *et al*. (1989) all document a strong relationship between living alone and the risk of falling, with Gurley *et al*. (1996) and Reuben *et al*. (1992) further linking living alone to incapacitation and death.

The dependent variable in column 1 is whether the surviving spouse had a nursing home stay between $t-2$ and t. Serious falls can lead to nursing home admissions. The results in the table generally support this view. The presence of safety and accessibility features is associated with a 10 percentage point reduction in the likelihood of a nursing home stay. With a robust standard error of 5 percentage points, this is a statistically significant effect. It is also an economically significant effect, given that the mean incidence of nursing home stays is 3.8% (column 1 of Table 3). The related IV estimate for the impact of a serious fall is shown in panel B. A serious fall is associated with a very large 46.5 percentage point increase in the likelihood of a nursing home stay. The dependent variable in column 2 is whether the surviving spouse moved permanent residences between $t-2$ and t. Safety and accessibility features are associated with lower mobility, but the estimates are too imprecise to make firm conclusions. The dependent variable in column 3 is whether the surviving spouse had transitioned from owning to renting between $t-2$ and t. Here, there appears to be little impact of safety and accessibility features on subsequent tenure transitions.

6. Summary, Implications, and Caveats

The weight of the empirical evidence suggests that home safety and accessibility features have an economically important impact on elderly health through the mitigation of serious falls. Interestingly, there is little evidence linking falls to housing tenure transitions, at least in the short run. This suggests that falls are not the type of health shock that is a main driver of tenure transitions among older homeowners.[17]

[17] This is consistent with Engelhardt and Greenhalgh-Stanley (2010), who found that the moderately adverse health shocks associated with the utilization of home health care were not important drivers of housing transitions at older ages. About 10% of Medicare home health care cases are related to the treatment of falls.

We temper our conclusions with the three important caveats. One of the drawbacks of our analysis is that we are unable to say which of the many safety and accessibility features matters the most in attenuating serious falls. For example, grab bars and shower seats are far less expensive to install than ramps. The individual features shown in panel B of Table 3 are strongly correlated with each other, resulting in substantial multicollinearity when we attempted to analyze them independently. The corresponding estimates were simply too imprecise to draw any firm conclusions about the efficacy of individual safety and accessibility features. In addition, although we believe that our identification strategy is very strong for the widowed, we are unable to provide separate estimates for the never married, married, and divorced, because a similar strategy is neither feasible (e.g., no spouse for the never married) nor plausible (e.g., joint production for the married). Finally, we only estimate short-run effects.

We close with Table 9, which is speculative and explores the possible implications of our findings for medical costs. Column 1 shows the average cost of medical treatment for non-fatal falls based on the figures in columns 5-8 of Table 1. These are for all individuals, not just the widowed.

Average medical expenditure per fall was $7,300 (in calendar year 2000 dollars). Most of this is paid for by public sources. In particular, in separate calculations from the 2010 MEPS (not shown), we found that 72% of medical costs for those 65 and older associated with trauma were paid for by Medicare and 10% by Medicaid. Only 3% of such costs were paid for out of pocket by the elderly. In contrast, housing investment in safety and accessibility modifications is almost solely privately financed. Column 2 shows average modification expenditures in the HRS of $1,700 (also in calendar year 2000 dollars), similarly calculated for all individuals.[18]

Column 3 shows the reduction in expected medical costs per dollar of housing investment, based on the IV estimate from the richest specification in Table 6 of a 21.8 percentage-point reduction in the likelihood of a fall. We make two assumptions for this calculation. First, we assume that the response of falls to features for the never married, married, and divorced is the same as that estimated for the widowed. Second, we assume one fall per person, which precludes the possibility that safety features could prevent multiple serious falls for an individual in a given time interval. Under these assumptions, our estimates imply that each dollar of housing investment is associated with a 93-cent reduction in medical costs.[19] Column 4 shows the same calculation using the age and gender group-specific IV estimates from Figure 2 and Table 7. Because falls for the older old are relatively more expensive to treat, the expected medical cost savings rise with age. Indeed, these calculations suggest that for those 75 and older, the reduction in medical costs appears to far exceed a dollar-for-dollar return.

The main takeaway from the table is that from society's point of view, housing investment in safety and accessibility for the elderly might be justified largely on the basis of the static medical cost savings alone. This ignores the money metric value of other costs: for example, the psychic costs of falls to the elderly and loved ones, the market value of formal and informal post-acute care given to those who fall, and any dynamic cost savings. A fundamental challenge, however, is that safety and accessibility may be privately underprovided if the medical cost savings accrue to public

[18] This is based on HRS questions MH203: "Did you have any out-of-pocket expenses for adding features to your home to make it easier or safer for an older person or someone with a disability to live there? This includes changes to make it easier to get around like a ramp, railings, modifications for a wheelchair and features that make it safer such as grab bars, a shower seat, or a call device to get help when needed," and the follow-up MH204, "If so, how much?"
[19] This is calculated as 0.218 multiplied by column 1, then divided by column 2.

programs like Medicare and Medicaid, and do not flow through to reductions in out-of-pocket medical costs for the elderly. Pinning down more fully the cost-benefit analysis and the long-run impacts are important avenues for future research.

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Table 1. The Prevalence Nationally and Cost in 2000 of Fatal and Non-Fatal Falls Requiring Medical Treatment among the Elderly, by Demographic Category and Nature of the Injury

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Fatal Falls				Non-Fatal Falls			
	Cases Annually		Cost of Medical Treatment		Cases Annually		Cost of Medical Treatment	
Category	Number in Thousands	%	$ Millions	%	Number in Millions	%	$ Billions	%
Total	10.3	100	179	100	2.6	100	19	100
Age								
65-74	1.7	17	30	17	0.8	31	4	20
75-84	3.8	37	64	36	1.0	39	8	40
85 and older	4.8	47	85	47	0.8	31	8	40
Sex								
Men	4.7	46	81	45	0.8	31	5	26
65-74	1.0	21	18	20	0.3	38	1	27
75-84	1.9	40	32	40	0.3	38	2	45
85 and older	1.8	38	31	38	0.2	25	1	27
Women	5.6	54	97	55	1.8	69	14	74
65-74	0.7	13	12	12	0.5	28	3	17
75-84	1.9	34	32	33	0.7	39	6	39
85 and older	3.0	54	53	55	0.6	33	6	44
Body region of injury								
Traumatic brain injury	4.7	46	82	46	0.1	4	1	5
Lower extremity	3.3	32	60	34	0.7	27	9	48
Upper extremity	0.0	0	0	0	0.7	27	3	13
Torso	0.8	8	13	7	0.4	15	3	13
Other head or neck	0.3	3	5	3	0.5	19	2	8
Other region	0.6	6	9	5	0.1	4	2	8
Unspecified	0.6	6	10	6	0.1	4	1	4
Type of injury								
Fracture	4.3	42	78	44	0.9	35	12	61
Internal organs	2.9	28	52	29	0.1	4	1	4

Systematic/late effects	0.2	2	2	1	0.0	0	0	0
Superficial/contusions	0.0	0	0	0	0.8	31	3	17
Sprain/strain	0.0	0	0	0	0.4	15	1	6
Open wound	0.0	0	0	0	0.3	12	1	5
Dislocation	0.0	0	0	0	0.1	4	<1	1
Other type	0.1	1	1	1	<0.1	0	1	6
Unspecified	2.8	28	44	25	<0.1	0	0	1

Note: All dollar values in calendar year 2000 dollars. The data in column 1-4 are taken from Stevens et al. (2006), Table 1. The data in columns 5-8 are taken from their Table 2. The figures in subcategories in columns 2, 4, 6, and 8 may not add to 100% for that category due to rounding error.

Table 2. Sample Means for Selected Socio-Economic Characteristics, Standard Deviations in Parentheses, Medians in Brackets

	(1)	(2)	(3)	(4)	(5)
		Subsample			
Characteristics	Full Sample	With Serious Fall	Without Serious Fall	With Any Safety and Accessibility Features	Without Safety and Accessibility Features
Surviving spouse is female	0.762	0.821	0.755	0.755	0.769
Surviving spouse is white	0.889	0.949	0.881	0.895	0.883
Surviving spouse has high school degree	0.397	0.385	0.399	0.383	0.411
Surviving spouse has had some college	0.203	0.188	0.205	0.211	0.196
Surviving spouse has college degree or more	0.134	0.128	0.135	0.154	0.115
Surviving spouse's age 65-74	0.483	0.350	0.500	0.400	0.562
Surviving spouse's age 75 and older	0.517	0.650	0.500	0.600	0.438
Deceased spouse's age 65-74	0.352	0.246	0.368	0.285	0.419
Deceased spouse's age 75 and older	0.648	0.654	0.732	0.715	0.581
Family Income	51,831	40,494	53,325	51,532	52,120
	(54,131)	(23,673)	(56,782)	(52,097)	(56,077)
	[38,252]	[35,670]	[38,736]	[38,818]	[37,412]
Family Wealth	476,034	396,805	486,473	494,524	458,159
	(805,859)	(688,394)	(819,853)	(857,078)	(753,457)
	[247,487]	[222,789]	[250,443]	[246,788]	[251,823]
Number of Observations	1,005	117	888	494	511

Note: Authors' calculations based on the HRS sample of 1,005 widowed individuals described in the text. All variables are measured in wave 1, which corresponds to *t*-4. In particular, the deceased spouse's age is the age recorded in the last live interview before death.

Table 3. Sample Means for Outcome, Focal Explanatory, and Instrumental Variable, Standard Deviations in Parentheses

	(1)	(2)	(3)	(4)	(5)
		Subsample			
Variable	Full Sample	With Serious Fall	Without Serious Fall	With Any Safety and Accessibility Features	Without Safety and Accessibilit y Features
A. Outcomes					
Fallen	0.368	1.000	0.285	0.415	0.323
Number of falls	0.939	2.718	0.705	1.071	0.812
	(2.271)	(3.208)	(2.005)	(2.369)	(2.167)
Serious fall	0.116	1.000	0	0.132	0.102
Death was expected	0.610	0.628	0.608	0.620	0.600
Duration of final illness more than one year	0.250	0.190	0.258	0.260	0.241
Had a nursing home stay in the last 2 years	0.038	0.162	0.021	0.051	0.025
Moved	0.139	0.342	0.113	0.154	0.125
Own-to-rent transition	0.090	0.223	0.072	0.101	0.078
B. Focal Explanatory Variable					
Any safety and accessibility feature	0.492	0.556	0.483	1.000	0
Ramp	0.104	0.103	0.104	0.211	0
Railings	0.196	0.256	0.188	0.397	0
Modifications for a wheelchair	0.091	0.043	0.098	0.184	0
Other accessibility features	0.023	0.017	0.024	0.047	0
Grab bars or shower seat	0.364	0.419	0.356	0.735	0
Call system	0.041	0.026	0.043	0.083	0
Other safety feature	0.041	0.026	0.027	0.055	0
C. Instrumental Variable					
Number of limits to ADL of deceased spouse	1.048	0.932	1.063	1.389	0.718
	(1.593)	(1.574)	(1.596)	(1.791)	(1.294)
Number of observations	1,005	117	888	494	511

Note: Authors' calculations based on the HRS sample of 1,005 widowed individuals described in the text. Panel A shows means for outcomes used in subsequent tables. Those outcomes are measured in period *t*, with the exception of death was expected and duration of final illness, which were measured in the exit interview at *t*-2. Panel B shows means for the presence of any safety and accessibility feature used as the focal explanatory variables in the specifications below, as well as the constituent features. These features are measured in period *t-2*. Panel C shows the means of the instrument, which is measured in period *t*-4.

Table 4. First-Stage Estimates of the Impact of the Mobility and Fall Behavior of the Deceased Spouse on the Incidence of Home Safety and Accessibility Features for Widowed Individuals, Robust Standard Errors in Parentheses

	(1)	(2)	(3)
Instrumental Variable	Dependent Variable: Dummy if Home Safety or Accessibility Features		
Number of limits to ADL of deceased spouse	0.060	0.065	0.066
	(0.009)	(0.010)	(0.010)
Kleibergen-Paap F-statistic	41.1	42.9	43.7
Controls			
Calendar year and age effects	Yes	Yes	Yes
Surviving spouse's health, functional status and fall trajectory	Yes	Yes	Yes
Socio-economic characteristics	No	Yes	Yes
Housing structural characteristics	No	No	Yes

Note*:* Each column in the table represents a different specification of the first-stage model. Only the OLS estimates and heteroscedasticity-robust standard error are shown for the instrumental variable. The Kleibergen-Paap F-statistic indicates the strength of the instrumental variable, robust to heteroscedasticity. The other control variables used in each model are listed at the bottom of the table, but their estimates and standard errors are not shown. All estimates are OLS estimates; probit maximum likelihood estimates were very similar.

Table 5. Reduced-Form Estimates of the Relationship between Limits to Activities of Daily Living of the Deceased Spouse and Speed of the Subsequent Death, Robust Standard Errors in Parentheses

	(1)	(2)
	Dependent Variable:	
Instrumental Variable	Death was Expected	Duration of Final Illness More than One Year
Number of limits to ADL of deceased spouse	0.036	0.034
	(0.010)	(0.010)

Note*:* Each column in the table represents a different reduced-form specification. Only the OLS estimates and heteroscedasticity-robust standard error are shown for the instrumental variables. The other control variables used in each model are those listed in column 3 of Table 4 that include calendar-year and age effects, surviving spouse's health, functional status and fall trajectory, housing structural characteristics, and socio-economic characteristics., but their estimates and standard errors are not shown. All estimates are OLS estimates; probit maximum likelihood estimates were very similar.

Table 6. Ordinary Least Squares, Instrumental Variable, and Bivariate Probit Estimates of the Effect of Home Safety or Accessibility Features on the Incidence of Serious Falls for Widowed Individuals, Robust Standard Errors in Parentheses

	(1)	(2)	(3)
	Dependent Variable: Dummy if Serious Fall in Last Two Years		
Explanatory Variable			
A. OLS Estimates			
Dummy if home safety or accessibility features	0.005	0.004	-0.002
	(0.020)	(0.020)	(0.020)
B. IV Estimates			
Dummy if home safety or accessibility features	-0.181	-0.201	-0.218
	(0.108)	(0.100)	(0.101)
p-value for Hausman test	0.078	0.036	0.020
C. Bivariate Probit Marginal Effects			
Dummy if home safety or accessibility features	-0.177	-0.135	-0.133
	(0.092)	(0.055)	(0.057)
Controls			
Calendar year and age effects	Yes	Yes	Yes
Surviving spouse's health, functional status and fall trajectory	Yes	Yes	Yes
Socio-economic characteristics	No	Yes	Yes
Housing structural characteristics	No	No	Yes

Note*:* Each cell in the table shows the parameter estimate of beta in equation (1.1) in the text from a separate regression using the sample of 1,005 observations described in the text. Panel A presents OLS estimates with heteroscedasticity-robust standard errors; probit maximum likelihood estimates were similar. Panel B shows the associated IV estimates using the first-stage regressions shown in Table 4, with heteroscedasticity-robust standard errors. The p-value for the Hausman test is the exact level of significance for the test of the null hypothesis that the OLS and IV estimates are equal. Panel C shows the marginal effects from bivariate probit maximum likelihood estimates.

Table 7. Instrumental Variable Estimates of the Prevalence of Home Safety or Accessibility Features on the Incidence of Serious Falls for Widowed Individuals, by Sex and for the Subsample of Stayers, Robust Standard Errors in Parentheses

	(1)	(2)	(3)
	Dependent Variable: Dummy if Serious Fall in Last Two Years		
Explanatory Variable	Men	Women	Stayers
Dummy if home safety or accessibility features	-0.465	-0.149	-0.198
	(0.249)	(0.134)	(0.110)
Number of Observations	241	764	889

Note*:* Each cell in the table shows the IV parameter estimate of beta in equation (1.1) in the text from a separate regression using the subsample observations described in the column heading, using the richest set of controls shown in column 3 of Table 6 that include calendar-year and age effects, surviving spouse's health, functional status and fall trajectory, housing structural characteristics, and socio-economic characteristics. All standard errors are heteroscedasticity-robust.

Table 8. Instrumental Variable Estimates of the Impact of Home Safety or Accessibility Features and Serious Falls on the Housing Transitions of Widowed Individuals, Robust Standard Errors in Parentheses

	(1)	(2)	(3)
	Dependent Variable:		
Explanatory Variable	Had a Nursing Home Stay in the Last 2 Years	Moved	Own-to-Rent Transition
A. Impact of Features			
Dummy if home safety or accessibility features	-0.101	-0.090	-0.0008
	(0.051)	(0.104)	(0.085)
B. Impact of a Serious Fall			
Dummy if had a serious fall	0.465	0.415	-0.004
	(0.290)	(0.475)	(0.392)

Note*:* For panel A, each cell shows IV estimates of the impact of home safety and accessibility features on the respective dependent variable shown in the column heading on the sample of 1,005 observations described in the text. All specifications control for calendar-year and age effects, surviving spouse's health, functional status and fall trajectory, housing structural characteristics, and socio-economic characteristics. The associated first-stage regression in panel A is in column 3 of Table 4. Likewise, for panel B, each cell shows the IV estimates of the impact of a serious fall on the respective dependent variable. The first-stage regression for panel B is not shown in other tables. All standard errors are heteroscedasticity-robust.

Table 9. Static Comparison of Medical Costs from Falls and Housing Investment in Safety and Accessibility Modifications, by Demographic Category in Thousands of $2000

	(1)	(2)	(3)	(4)
Category	Average Cost of Medical Treatment (in thousands)	Average Housing Investment in Safety and Accessibility Modifications (in thousands)	Reduction in Expected Medical Cost per Dollar of Housing Investment using IV Estimate in Table 6	Reduction in Expected Medical Cost per Dollar of Housing Investment using IV Estimates in Table 7
Total	7.3	1.7	0.93	0.93
Age				
65-74	5.0	1.9	0.57	-0.11
75-84	8.0	1.7	1.03	1.81
85 and older	10.0	1.7	1.28	2.26
Sex				
Men	6.3	1.8	0.76	1.63
Women	7.8	1.9	0.89	0.61

Note: All dollar values are in thousands of real calendar year 2000 dollars. The data in column 1 are for all individual 65 and older, and the quotient of columns 5 and 7 in Table 1, taken from Stevens et al. (2006). The data in column 2 are the authors' calculations for all individuals 65 and older from the HRS, using the respondent-level analysis weights to make them comparable to the national data on medical cost in column 1. Column 3 uses the IV estimate from column 3 of Table 7 of a 21.8 percentage-point reduction in falls to calculate the expected cost. Column 4 uses the IV estimates for each category from Table 7 to calculate the expected cost, where the estimate for 75 and older from Table 7 was applied to medical costs for both the 75-84 and 85 and older groups.

Figure 1. HRS Variables and Timing

HRS Wave	1	1	2	2	3	3
Question Type	Retro-spective	Point-in-time	Retro-spective	Point-in-time	Retro-spective	Point-in-time
Calendar Time	(t-6,t-4)	t-4	(t-4,t-2)	t-2	(t-2,t)	t
Marital Status		Married		Widow		Widow
Death			Spouse Dies			
Outcome (Widow)					Serious Fall	
Focal Variable				Safety & Access		
Instrument (Spouse)		ADLs				
Key Controls (Widow)	Serious Fall	ADLs, Health	Serious Fall	ADLs, Health		
Other Controls		Demog/ Housing				

Figure 2. Predicted Probability of a Serious Fall of Widows in the Next 2 years with and without the Presence of Housing Safety Features, by Age

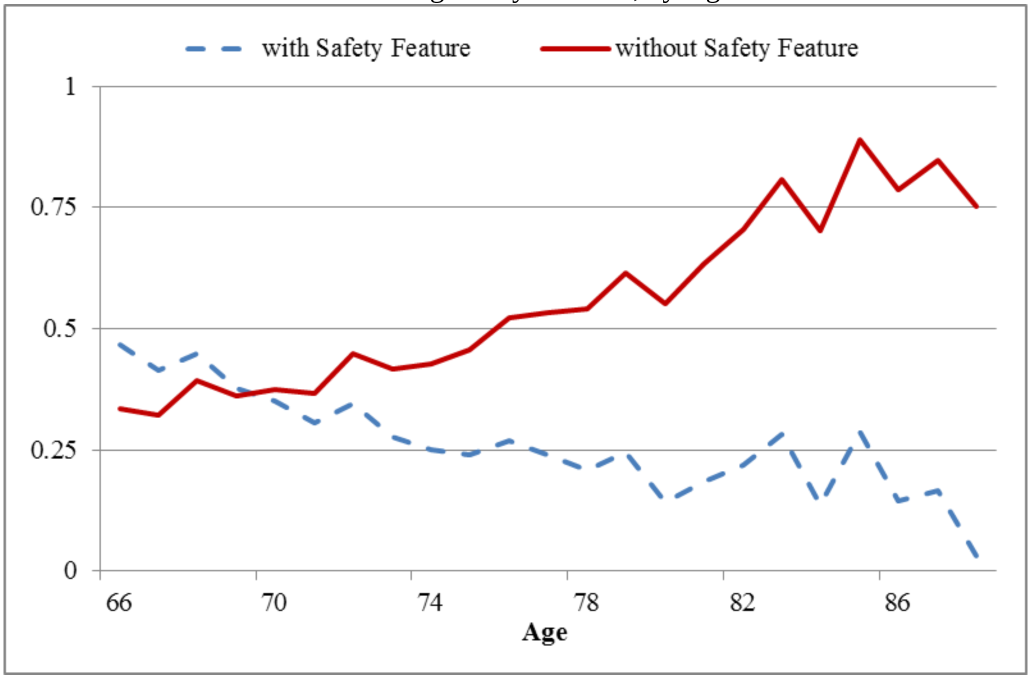

Figure 3. Predicted Probability of a Serious Fall of Widows in the Next 2 years with and without the Presence of Housing Safety Features, by Years of Education

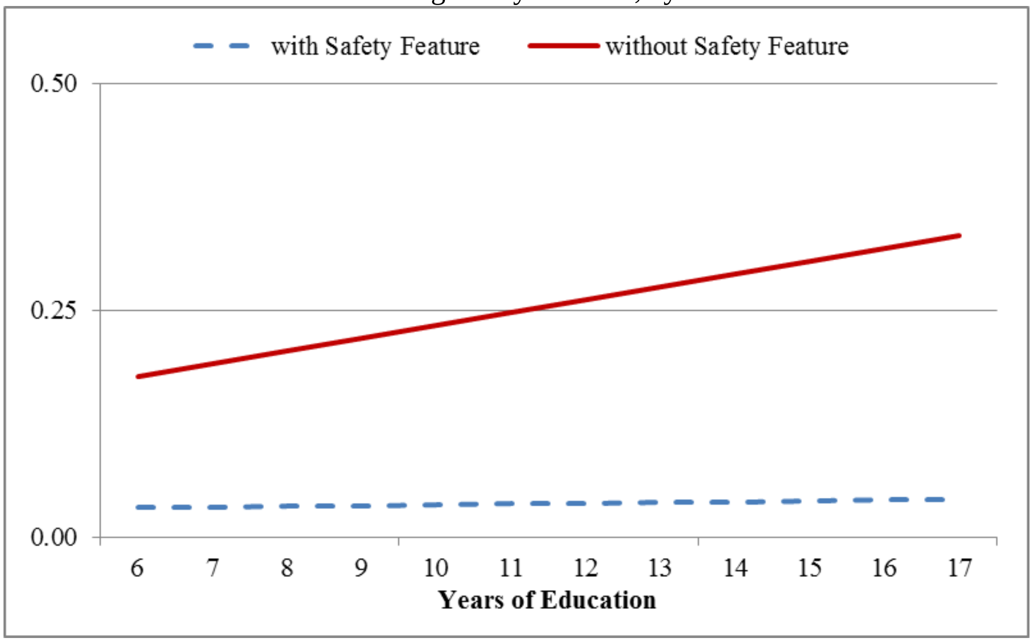

Figure 4. Predicted Probability of a Serious Fall of Widows in the Next 2 years with and without the Presence of Housing Safety Features, by Income-to-Poverty Threshold