Association between Home Modification and Falls Among Older Adults: The Health and Retirement Study

by

Sheng Jie Zhu

Global Health Program
Duke Kunshan University and Duke University

Date:_____

Approved:

_____
Chenkai Wu

_____
Yunguo Liu

_____
Lijing Yan

Thesis submitted in partial
fulfillment of the requirements for the degree of
Master of Science in the Global Health Program
in the Graduate School of
Duke Kunshan University and Duke University

2023

ABSTRACT

Association between Home Modification and Falls Among Older Adults: The Health and Retirement Study

by

Sheng Jie Zhu

Global Health Program
Duke Kunshan University and Duke University

Date:_____

Approved:

_____
Chenkai Wu

_____
Yunguo Liu

_____
Lijing Yan

An abstract of a thesis submitted in partial
fulfillment of the requirements for the degree of
Master of Science in the Global Health Program
in the Graduate School of
Duke Kunshan University and Duke University

2023

Abstract

Background: The aging population is rapidly increasing, and falls are a significant threat to the health and well-being of older adults. Falls are the leading cause of injury among individuals aged 65 and older, resulting in increased healthcare costs, morbidity, and mortality. Preventing falls among older adults requires a multifaceted approach that includes education, training, research, and policy development. While studies have evaluated the effectiveness of multifactorial interventions, little attention has been paid to home modification as a fall prevention strategy. The purpose of this study is to examine the impact of home modification on the episodes of falls and fall-related injuries among retired older adults in the United States who are living independently in the community. Using data from the Health and Retirement Study (HRS), we investigated whether home modification is associated with a lower episode of falls.

Method: This study utilized data from the Health and Retirement Study (HRS) to investigate the association between home modifications and falls among community-dwelling older adults in the United States. The study included 4,620 participants aged 60 years and older who completed surveys in 2006 and 2008. The primary outcome was the occurrence of falls during the follow-up period in 2008, and the secondary outcome was injury due to a fall. The binary variable for home modification was created based on whether participants reported having any home modifications in the last two years. Covariates included demographic characteristics, lifestyle factors, and health-related

variables. Baseline demographic and health characteristics were described using means, standard deviations, counts, and proportions. Two-sample t-tests and chi-squared tests were used to compare continuous and categorical variables between participants with and without home modifications. Logistic regression models were used to assess the unadjusted and adjusted associations between home modifications and falls, adjusting for various covariates. Interaction analyses were conducted to examine the differences in associations by sex and age.

Result: This study aimed to investigate the association between home modification and falls among older adults. A total of 4,620 participants were included in the study, divided into two groups: those with and without home modification. The episodes of falls in the past two years were similar in both groups, with 25.94% in the home modification group and 25.08% in the non-home modification group. Participants with home modification had 17% lower odds of falls than those without home modification. Additionally, participants with home modification had 22% lower odds of fall-related injuries. The study found that the age category of 60-69 had the lowest episodes of falls, and female participants had a lower episode of falls than males after home modification. The presence of safety and getting around features in home modifications was also associated with a reduced episode of falls.

Conclusion: This study suggests that home modification can be an effective strategy to prevent falls and fall-related injuries among older adults living in the community. The findings are consistent with previous research and provide valuable

information for healthcare professionals and policymakers to design interventions that include home modification to reduce the burden of falls and their associated injuries in older adults.

Contents

Abstract iv

List of Tables ix

List of Figures x

1. Introduction 1

1.1 General Background 1

1.2 Risk Factors for Falls Among Older Adults 3

1.3 Outcome and Burden of Falls 5

1.4 Types of Home Modifications 6

1.5 Benefits of Home Modification for Older Adults 7

1.6 Research Gap 8

1.7 Research Aim 9

2. Methods 10

2.1 Setting and Participants 10

2.2 Inclusion criteria 11

2.3 Outcome 13

2.4 Home Modifications 13

2.5 Covariates 14

2.6 Statistical Analysis 15

3. Result 17

3.1 Sociodemographic Characteristics 17

3.2 Burden of falls and fall-related injuries 21

3.3 Association of Home Modification and Falls 22

3.4 Association of Home Modification and Fall-Related Injuries 23

3.5 Association Between Age Categories and Episodes of Fall 24
3.6 Association Between Gender and Episodes of Fall 26
3.7 Association of Special Features for Home Modification and Episodes of Fall 27
4. Discussion 29
4.1 Summary of Main Findings 29
4.2 Consistency with Previous Research 30
4.3 Study Strengths and Limitations 32
4.4 Implication for Future Research 33
5. Conclusion 36
References 37

List of Tables

Table 1. Baseline Characteristics of the Analytic Sample (N=4,620) 18

Table 2. Burden of falls between persons with and without home modification 21

Table 3. Occurrence of falls and home modification 22

Table 4. Injuries due to fall in 2008 and home modification among participants in 2006 24

Table 5. The comparison of association between age categories and incidence of fall in 2008 among participants in 2006 25

Table 6. The comparison of association between gender and incidence of fall in 2008 among participants in 2006 26

Table 7. Occurrence of fall in 2008 among participants with special safety and getting around features under the home modification & non-home modification group 28

Table 8. The comparison of association between occurrence of fall in 2008 and special safety or getting around features 28

List of Figures

Figure 1. Flow chart of inclusion criteria 12

Figure 2. Frequency distribution of falls in the participants at baseline 2006 and follow up 2008 20

Acknowledgments

I would like to take this opportunity to express my deepest gratitude to my thesis advisor Professor. Chenkai Wu, whose guidance, support, and encouragement have been invaluable throughout my research. His vast knowledge, insightful comments, and patience have been critical in shaping my research and improving the quality of my work.

I also extend my appreciation to the faculty members of the Global Health Institute for providing me with the necessary resources, opportunities, and support to pursue my research. Their feedback and suggestions have been instrumental in enhancing the quality of my work.

I would like to acknowledge the assistance and support of my family, classmates, friends, who have been a constant source of encouragement and motivation throughout this journey. Their unwavering support has helped me overcome challenges and stay focused on my goals.

Finally, I extend my heartfelt gratitude to all the participants who generously shared their time, knowledge, and experience to make this study possible. Their contributions have been invaluable in shaping my understanding of the research problem and generating new insights.

I am deeply grateful to all those who have contributed to this thesis, and I acknowledge their role in making this journey a memorable and enriching experience.

1. Introduction

1.1 General Background

Aging is a trending issue that requires global action. As stated in the latest report from the World Health Organization, by 2030, 1 in 6 people in the world will be at least 60 years old. The size of the older population will double in the next 30 years, increasing from 1 billion in 2020 to 1.4 billion in 2030 and double to 2.1 billion in 2050 [1]. The number of persons aged 80 years or older is expected to triple between 2020 and 2050, reaching 426 million [2]. The elderly population is facing a wide variety of health-related threats due to aging, such as increasing healthcare burden (ex. increasing chronic illness, the financial burden due to increasing healthcare costs), physical aging and assistance, loneliness, changing in social climate [3].

Falls are an accident in which a person accidentally lands on the ground or floor or other surface below its original position. Fall-related injuries can be fatal or non-fatal [4]. There is a high episode of falls globally, falls are the most frequent cause of injury in individuals 65 years and older, resulting in 30% of community-dwelling seniors falling each year, the age-adjusted fall death is also increasing. In one-fifth of cases, medical care is necessary [4-6]. Also, in developed countries, for example, the United States, in 2014, there are an estimated 28.7% of adults who are at least 65 years old fell.

Falls are the second leading cause of unintentional injury deaths worldwide [7]. It is estimated that 684,000 deaths are due to falls, with 80% occurring in low- and middle-income countries [4]. The results of falls can lead to many detrimental health

effects on seniors, such as increased morbidity, mortality, and healthcare costs [8]. Injuries caused by falls among those 65 years of age or older cost $31 billion in 2015 and are projected to cost 74 billion in the USA by 2030 [9].

Preventing falls among seniors is crucial, and it requires a multifaceted approach that includes education, training, research, and policy development. Educating seniors on the risks and consequences of falls, as well as training them on strategies to prevent falls, such as exercises to improve balance and strength, can significantly reduce the episode of falls. Promoting research on falls can also help identify effective prevention strategies and treatments for fall-related injuries. Efficient policies are also necessary to support fall prevention initiatives in both community and clinical settings. Policies can help ensure that seniors have access to resources, such as safe living environments, proper footwear, and assistive devices, which can prevent falls. Policies can also facilitate the implementation of evidence-based fall prevention programs and promote collaboration among healthcare professionals, community organizations, and other stakeholders involved in fall prevention.

Overall, emphasizing prevention strategies through education, training, research, and policy development can go a long way in reducing the episode of falls and improving the quality of life for seniors. [4-6, 10].

1.2 Risk Factors for Falls Among Older Adults

Older adults are facing greater risk of having falls and falls related injuries [11]. Statistically speaking, falls related injuries (such as fractures and head injuries) among older adults with poorer health are about 7 times higher than people with solid health status [11, 12]. Age-related changes in the nervous system affect seniors and include vision and hearing degeneration, a decrease in proprioceptive and vibratory perception, an increase in sway, an altered gait, and impaired positional control [13]. It could be caused by issues like a physical illness, cognitive decline, medication side effects, or environmental potential harm [11]. All those age-related changes in health among older adults may facilitate the process of occurrence of falls.

Falls are a complex, multifactorial clinical syndrome that requires clinical attention. These individuals rarely have a single cause or risk factor, and their falls are frequently complex and multifaceted because of the interactions of several factors [11, 14]. Therefore, it is necessary to take a multidisciplinary approach to both prevent and treat any fall-related injuries [15].

As stated by the World Health Organization's International Classification of Functioning, Disability and Health (ICF) claim that a person's engagement and activity are influenced by both their physical limitations and the surrounding environment [16]. In general, risk factors for falls are being categorized into intrinsic and extrinsic factors [17-19]. For each of these categories, potential risk factors are presented in the following section.

Extrinsic factors frequently have an environmental focus and are shared by people who live in a similar area. Numerous external variables have been discovered, including slick floors, poor lighting, unstable, deep ground, or torn carpets, railless staircases, unsupportive or improperly situated furniture, poorly constructed bathtubs, toilets, and bathroom fixtures, debris, and pets running about on the floor [20-22]. Extrinsic factors frequently cause trips, slips, increasing the risk of falling, particularly for older individuals living in communities where there may be many risks. Environmental dangers are very common in older persons' houses, with 39% of homes having five or more hazards and 80% of homes having at least one hazard that can be identified. As a result, home evaluations and modifications intended to minimize or eliminate environmental hazards appear to be essential in programs aimed at reducing fall risk, especially because they are extrinsic in nature and thus correctable [23].

Individual-oriented intrinsic factors include health issues (such as chronic diseases), the extent of functional impairment (such as impaired activities of daily living [ADLs]), or status of being (e.g., advanced age). Muscle weakness, gait or balance problems, decreased mental health status, loss of sensation, pharmacological interactions, and a history of falls are all additional intrinsic fall risk factors [23].

1.3 Outcome and Burden of Falls

As a person gets older, they become less capable of using their hands to prevent falls and shield their hips. This leads to a higher occurrence of wrist fractures rather than hip fractures in the age group of 65 to 75 [24]. However, hip fractures become more frequent after the age of 75 [24]. Roughly 44% of falls result in minor injuries like bruises, cuts, scrapes, and sprains, while major injuries like hip and wrist fractures are much less common, occurring in around 4% to 5% of falls [25].

Data from Ontario, province of Canada showed that fall-related injuries are a significant problem for the health system in Ontario, as they are the one of the primary reasons for hospital visits (1,201 per 100,000 population) and emergency department visits (4,821 per 100,000 population) for Ontarians 65 years and over [26]. In addition, when an older adult is hospitalized due to falls, their average length of stay in the hospital is around 40% longer than the average stay for other types of hospitalizations [26]. This indicates that falls often result in serious injuries, and there is a tremendous need for community-based services to help these individuals return home after being hospitalized for a fall.

1.4 Types of Home Modifications

Home modification is the process of changing or modifying a place to facilitate daily activities, improve comfort, minimize accidents, and promote independent living. As the population of older adults grows, home modifications are becoming increasingly important in enabling individuals to remain in the home of their choice for as long as feasible. Home modifications can also assist people of all ages with health conditions, sensory or movement impairments, or cognitive disorders perform essential and envisioned daily activities, while also improving safety and well-beings [27].

Home modifications can be utilized to address unsafe places that could increase the likelihood of falling in older homes and in homes that haven't been effectively prepared for people with disabilities. Since older adult's health and functioning are dynamic, and their living environments might change over time as their houses deteriorating and maintenance become more challenging. There are many different types of home modifications, and the cost of these modifications can range from simple adaptations to expensive reconstructions. The removal of hazards from the home, such as clutter and throw rugs, the addition of special features or assistive devices, such as grab bars and ramps, the moving of furniture to make room for activities, such as sleeping on the first floor rather than the second, and the relocation of furniture to make clear pathways are all examples of home modifications [23].

1.5 Benefits of Home Modification for Older Adults

Research have revealed the impacts and numerous benefits of home modification on seniors, including links to fall prevention, the aging process, well-being, improved functioning and independence, physical health and well-being, caregiving, and economic effectiveness [28].

Firstly, number of studies have identified that with home modification such as grab bars, shower benches, and stair lifts can reduce the risk of falls and improve safety in the home for seniors [29, 30]. Secondly, modifications such as wheelchair ramps and wider doorways can make it easier for seniors to move around in their homes, and number of studies have found strong link between increasing the mobility function or self-care ability among seniors and home modifications [31, 32]. Thirdly, an Japanese study have revealed that with home modification, there was reduced chance of mortality within the home modification group compare to those without, and also, similar tendency have been observed in the progression of frailty [33]. Lastly, home modifications can improve seniors or disabled's people's overall comfort and quality of life by enabling them to live in a safer and more accessible environment. Some studies have studied the direct association between home modification and wellbeing, and results showed the quality of life have been significantly improved in the home modification group compared to the controls [34].

1.6 Research Gap

Majority of the studies have focused on the multifactorial approach for the prevention of falls among community-dwelling older adults. For example, a multicenter randomized controlled trial has evaluated the effects of a multifactorial fall prevention on fall episodes and physical functioning among seniors, results showed it had improved functional performance at 3 months for seniors who have risk for falls [35]. Another randomized controlled trial also tried to evaluate the effectiveness of a multifactorial intervention fall prevention program among older adults. After 12 months of intervention, the fall rate was 17.29% in the intervention group and 23.61% in the control group, there was a significant reduction in the number of falls at those participant's homes after intervention [36]. These aforementioned studies have approved that multifactorial intervention have strong impact on fall episodes among community-dwelling seniors who are at risk for fall. However, the impact of home modification, a strong intervention that could have significant impact on prevention for falls do not have much detailed analysis alone among community-dwelling seniors. It is anticipated that 30% of community-dwelling people aged 65 and older and 50% of those aged 85 and older will fall each year, despite estimates of fall rates varying greatly depending on the area, age, and home environments of the older population. 12% to 42% of those who fall will sustain an injury as a result of the fall [26].

Therefore, for those community-dwelling seniors, creating a safe environment for their individual physical needs may include the integration of many components for home modifications. This suggests a particular need to assess the effectiveness of home modification for those independent living community-dwelling seniors [37].

1.7 Research Aim

The purpose of the present study was to examine home modification among United States retired older adults who are living independently in the community and, more importantly, to gain an in-depth understanding of how home modification can affect older adults' physical function, ultimately, increase their quality of life. The specific aim was to examine the impact of the home modification on the episode of falls and fall-related injuries of retired elderlies in the United States based on the HRS data. In addition, we also examined whether there are gender or age differences in the association between home modification and episodes of fall. We hypothesized that there is lower episodes of fall among participants who have adopted home modification during the baseline.

2. Methods

2.1 Setting and Participants

The HRS is an ongoing biennial longitudinal cohort study began in 1992, included middle-aged and older adults (age over 50 years old) in the United States, sponsored by the National Institute of Aging and conducted by the University of Michigan (grant #NIAU01AG009740). One unique feature about HRS is the inter-professional collaboration between researchers from different disciplines (economic, psychology, epidemiology, medicine, demography), which create a more comprehensive data presentation compare to other academic research projects[38]. HRS aim to explore the role of health in the retirement decision and long term health consequences during the process of retirement by collecting relatively adequate amount of data on eligible participants' health conditions, socioeconomic status, and family structure[39]. In the initial HRS cohort baseline assessment, which was done in 1992 and 1993, a total of 12,654 respondents (7,704 households) under the age of 50 were included [40]. Baseline interviews were typically conducted in person and follow-up interviews were usually administered by telephone at two-year intervals, expect for participants who are over 80 years old or request to have face-to-face interview, by collecting information on income, jobs, asset, pension plans, health insurance, disability, cognitive function, genetic information, and health care expenditures. However, the survey mode has changed, in the beginning of 2006 [38]. Through the in-depth interviews, HRS provides enriched amount of multidisciplinary data which enable researches to utilize to answer crucial issues

that are related to the difficulties and opportunities of aging [41]. Across different waves, the overall response rates ranged between 86.8% and 89.1%.

2.2 Inclusion criteria

For this study, we used 2006 HRS as the baseline data when doing the selection of participants, because it has survey information on the status of home modification and used 2008 HRS as the follow up data after two years of home modification. 2006 HRS early release version, 1 is the first survey that included the section of home modification among the HRS series. Under the inclusion method, we first included total of 43,559 participants from 2006 HRS data. We further merged the data with 2008 HRS, who completed the follow up questionnaire after two years, left with total of 20,934 participants. We also only included participants whose age >60 years old at the time of 2006, left with 12,214 participants. We then included participants who are cognitive intact and able to answer the questions on surveys without a proxy or help and left with 11,279 participants. Also, mobility wise, we have included participants who are able to walk independently with or without other walking equipment such as walker, cane, crutches, etc., which left with 6,027 participants. In the original data, large proportion of participants have left blank for mobility section, which lead to this great reduction on sample size. Lastly, we only included participants who have survey information on home modifications and the final analytic sample included 4,620 participants **(Figure 1)**.

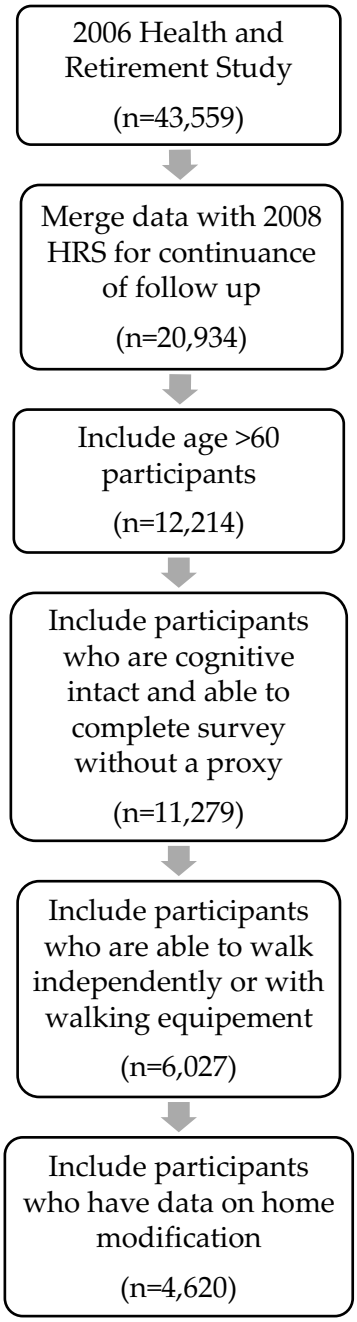


Figure 1. Flow chart of inclusion criteria

2.3 Outcome

The primary outcome of this study is the occurrence of falls during follow-up period in 2008. Falls were ascertained by asking participants whether they have fallen in the last two years (participants were answered with yes, no, don't know, or refused). Number of falls in 2008 were also analyzed. Number of falls were ascertained by asking participants in 2008 how many times they have been fallen in the last two years (participants were answered in numerical answer with number of times).

The secondary outcome of this study is the injury of due to fall during follow-up period in 2008. Injuries due to fall were ascertained by asking participants whether they have injured themselves seriously enough to need any medical treatment (participants were answered with yes, no, don't know, or refused).

2.4 Home Modifications

Respondents to the 2006 HRS Home Modifications Module were asked about whether they have house modification in last two years and special features for getting around and special safety features. Ten assistive home features were being asked to participants: ramps at the entrance, handrails at the entrance (asked if the respondent has to step up or down to get into home), an emergency call system, grab bars in the shower or tub area, a seat for the shower or tub, grab bars around the toilet, a raised or modified toilet seat, a stair glide or chair lift to go up or down stairs (asked if the respondent has living space on more than one floor), handrails in the

stairways (if the respondent has living space on more than one floor), and handrails in the hallways.

For the analysis, a binary variable been created for the home modification, despite of asking all the specific home modification features individually, the home modification have fall into whether the participants have ever had home modification in the last two years, with the answer yes or no, this produces a more generalized analysis of the impact of home modification on fall episodes for seniors.

2.5 Covariates

Demographic: age (in years), sex (male and female), race (white/Caucasian, black or African American, others), marital status (married, widowed, others including separated/divorced, never married and marital status unknown), and education (no formal education/grade 1-11, high school, college & post college) were included. All above were measured in 2006 data.

Lifestyle characteristics: Smoking status (current smoker, do not smoke now, including who have previously smoked and never smoked) in 2006, Alcohol use (drink alcohol and never drink alcohol) in 2006, Body Mass Index (BMI) was also calculated based on participants height and weight in 2006, as body weight (kg) divided by standing height (m) squared and categorized into underweight or normal (BMI <25 kg/m2), overweight (BMI: 25.0-29.9 kg/m2), and obese (BMI ≥30.0 kg/m2).

Baseline health conditions: Chronic conditions include hypertension, diabetes, cancer of any kind excluding skin, heart diseases, stroke, lung disease,

arthritis in 2006 were included in the baseline characteristics. For arthritis, survey respondents were asked if they ever had, or a doctor ever told them they have arthritis. For all other conditions, they were asked to report whether a doctor ever told them they have the given condition. We also included whether participants use any walking equipment for mobility as self-reported answers with yes or no.

2.6 Statistical Analysis

We described the baseline demographic and health conditions of the entire sample and by home modification using means and SDs for continuous variables and counts and proportions for categorical variables. We used a two-sample t-test and chi-squared test to compare the difference in continuous and categorical variables between participants with and without home modification, respectively. We displayed the distribution and calculated the means and SDs of number of falls in 2008 among participants with and without home modification.

We used logistic regression to assess the unadjusted and adjusted associations between the home modification at baseline and occurrence of any falls in the follow-up. We adjusted for age in years, sex (female or male), education (no formal education/grade 1-11, high school, college & post college), marital status (married, widowed, others), smoking status (current smoker, do not smoke now), race (white/Caucasian, black or African American, others), BMI, baseline medical conditions (hypertension, diabetes, cancer, heart condition, stroke, lung disease, and

arthritis), use of walking aids (yes or no), alcohol use (drink alcohol, never drink alcohol), and history of falls (yes or no).

We used logistic regression to measure the unadjusted and adjusted association between the adoption of home modifications in 2006 and injuries due to fall at follow up in 2008. The result will be adjusted for the same covariates presented above.

We further adopted interaction approach in the logistic regression model to examine whether the association between home modifications in 2006 and episodes of fall differs by sex and age (60-69, 70-79, and >80 years old), respectively.

We used chi-squared test to describe the relative frequencies and percentage of for four different groups: participants with no home modification at all, participants who have adopted both safety and getting around features, participants who only have safety features, and participants who have only getting around features in 2006 by episodes of falls in 2008.

We used logistic regression to measure the unadjusted and adjusted association between four different groups (participants with neither special safety and getting around features, participants who have adopted both safety and getting around features, participants who only have safety features, and participants who have only getting around features in 2006) at baseline and episodes of falls at follow up in 2008. The result will also be adjusted for the same covariates presented above.

All tests will be two-sided with a significance level of P <0.05. Analyses will be performed using Stata version 16.0 (StataCorp IC, College Station, TX).

3. Result

3.1 Sociodemographic Characteristics

A total of 4,620 participants were included in this study. Study sample was divided into two groups with or without home modification. The mean (SD) age for participants with home modification (N=613) and non-home modification group (N=4,007) was 72.58 (6.96) years, 72.84 (7.09) years, respectively. Among the home modification group, 286 (46.66%) were male; 531 (86.62%) were white/Caucasian and 68 (11.09%) were black or African American **(Table 1)**. For participants who have home modification, 253 (41.27%) had College & Post College education; 601 (98.04%) of them are using walking aids or other ambulatory assistive devices. For two groups, they have the similar fall episodes in the past two years, based on 2006, home modification group had 159 (25.94%) participants reported fall, and non-home modification group had 1,005 (25.08%). Also, for other baseline medical condition characteristics, such as diabetes, stroke, hypertension, cancer, heart condition, lung disease and arthritis, they all did not have significant differences between two groups **(Table 2)**.

By comparing the frequency distribution of falls in the included participants at baseline 2006 and follow up 2008, for participants who had 1 time fall episode in the past two years, we can tell that the episode of fall is higher at baseline compared to follow up **(Figure 2)**. Also, for both number of times fall in 2006 and 2008, they all showed that most participants have experienced only one time fall, twice or

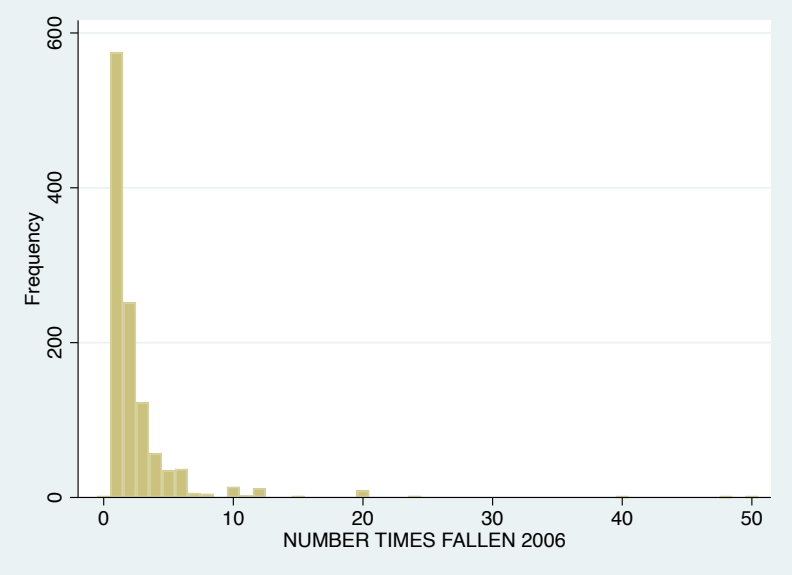
more is generally less. Since there is high episodes of one time fall among participants, we hereby categorized fall episodes into once and more than once for later analysis.

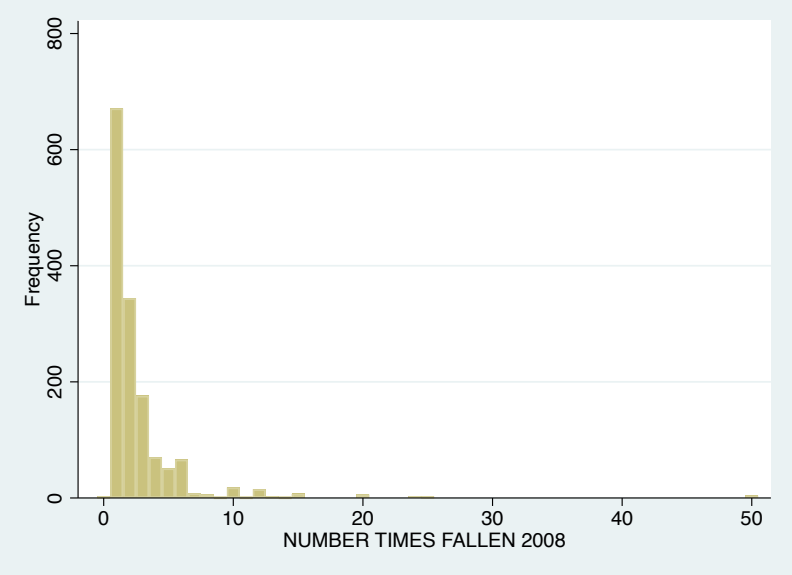
Table 1. Baseline Characteristics of the Analytic Sample (N=4,620)

Characteristics	Home modification group (N=613)	Non-home modification group (N=4,007)	p value
Age, Years (Mean ±SD)	72.58±6.96	72.84±7.09	0.3908
Gender, n (%)			0.311
Male	286 (46.66)	1,728 (45.52)	
Female	327 (53.34)	2,225 (55.53)	
Marital Status, n (%)			0.715
Married	400 (65.25)	2,557 (63.81)	
Widowed	141 (23.00)	982 (24.51)	
Others	72 (11.75)	468 (11.68)	
Race, n (%)			0.112
White/Caucasian	531 (86.62)	3,363 (83.93)	
Black or African American	68 (11.09)	493 (12.20)	
Others	14 (2.28)	151 (3.77)	
Education, n (%)			0.082
No formal education/Grades 1-11	168 (27.41)	940 (23.46)	
High School	192 (31.32)	1,377 (34.36)	
College & Post College	253 (41.27)	1,690 (42.18)	
Use of Walking Aids, n (%)			0.198
Yes	601 (98.04)	3,892 (97.13)	
No	12 (1.96)	155 (2.87)	
Fallen in past two years based on 2006, n (%)			0.649
Yes	159 (25.94)	1,005 (25.08)	
No	454 (74.06)	3,002 (74.92)	
Weight, Pounds (Mean ±SD)	178.37±95.56	178.34±95.62	0.995
Height, Feet (Mean ±SD)	5.14±0.44	5.12±0.45	0.2854
BMI, n (%)			0.016
Underweight & Normal <25	81 (13.32)	579 (14.54)	
Overweight, 25-29.9	209 (34.38)	1,119 (28.09)	
Obese & Extremely Obese, >=30	318 (52.30)	2,285 (57.37)	

Smoking Status, n (%)			0.397
Current smoker	63 (10.28)	369 (9.21)	
Do not smoke now	550 (89.72)	3,638 (90.79)	
Alcohol use, n (%)			0.086
Drink alcohol	341 (55.63)	2,080 (51.91)	
Never drink alcohol	272 (44.37)	1,927 (48.09)	
Hypertension, n (%)			0.059
Yes	349 (56.93)	2,442 (60.94)	
No	264 (43.07)	1,565 (39.06)	
Diabetes, n (%)			0.999
Yes	112 (18.27)	732 (18.27)	
No	501 (81.73)	3,275 (81.73)	
Cancer of any kind excluding skin			0.009
Yes	77 (12.56)	670 (16.72)	
No	536 (87.44)	3,337 (83.28)	
Heart Condition			0.743
Yes	153 (24.96)	1,025 (25.58)	
No	460 (75.04)	2,982 (74.42)	
Stroke			0.385
Yes	33 (5.38)	252 (6.29)	
No	580 (94.62)	3,755 (93.71)	
Lung Disease			0.900
Yes	69 (11.26)	458 (11.43)	
No	544 (88.74)	3,549 (88.57)	
Arthritis			0.409
Yes	357 (58.24)	2,404 (60.00)	
No	256 (41.76)	1,603 (40.00)	

Figure 2. Frequency distribution of falls in the participants at baseline 2006 and follow up 2008





3.2 Burden of falls and fall-related injuries

Among persons with home modification (n=613), 159 (25.94%) had falls in 2006. Of 159 persons with a history of falls in 2006, 89 (55.97%) had falls in 2008 and 59 (66.29%) of them had fallen more than once **(Table 2)**. Among persons with no home modification (n=4,007), 1006 (25.08%) had falls in 2006. Of 1,005 persons with history of falls in 2006, 581 (57.81%) had falls in 2008 and 384 (66.09%) had fallen more than once **(Table 2)**.

Table 2. Burden of falls between persons with and without home modification

	Home modification N=613	**Non-home modification N=4,007**
Had falls in 2006	159 (25.94%)	1,005 (25.08%)
Had falls in 2008	89 (55.97%)	581 (57.81%)
Once	30 (33.71%)	197 (33.91%)
More than once	59 (66.29%)	384 (66.09%)
Had no falls in 2006	454 (74.06%)	3,002 (74.92%)
Had falls in 2008	90 (19.82%)	735 (24.48%)
Once	49 (54.55%)	397 (54.01%)
More than once	41 (45.56%)	338 (45.99%)

3.3 Association of Home Modification and Falls

In the unadjusted model, persons with home modification had a lower odd of falls in the follow-up than those without home modification (odds ratio [OR] = 0.84; 95% confidence interval [CI]: 0.70-1.02; **Table 3**). The association changed minimally after the adjustment of socio-demographic and health conditions. Participants with the home modification had 17% lower odds of falls than without home modification (OR = 0.83; 95% CI: 0.68-1.01).

Table 3. Occurrence of falls and home modification

	Unadjusted OR (95% CI)	**Adjusted OR (95% CI)[a]**
Non- home modification group	Ref.	Ref.
Home modification group	0.84 (0.70-1.02)	0.83 (0.68-1.01)

Abbreviations: OR, Odds Ratio; CI, Confidence Interval.

[a] Adjusted for age in years, sex (female or male), education (no formal education/grade 1-11, high school, college & post college), marital status (married, widowed, others), smoking status (current smoker, do not smoke now), race (white/Caucasian, black or African American, others), height, weight, baseline medical conditions in 2006 (hypertension, diabetes, cancer, heart condition, stroke, lung disease, and arthritis), use of walking aids in 2006 (yes or no), alcohol use in 2006(drink alcohol, never drink alcohol), and falls in 2006 (yes or no).

3.4 Association of Home Modification and Fall-Related Injuries

In the unadjusted model, persons with home modification had lower odds of fall-related injuries in the follow-up than those without home modification (odds ratio [OR]=0.78; 95% confidence interval [CI]: 0.55-1.11; **Table 4**). The results were persisted with unadjusted model after the adjustment of socio-demographic and health conditions co-variants. Participants with home modification had 22% lower odds of fall-related injuries than those without home modification (OR = 0.78; 95%; CI: 0.54-1.12).

Table 4. Injuries due to fall in 2008 and home modification among participants in 2006

	Unadjusted OR (95% CI)	Adjusted OR (95% CI) [a]
Non- home modification group (n=1,916)	Ref.	Ref.
Home modification group (n=181)	0.78 (0.55-1.11)	0.78 (0.54-1.12)

Abbreviations: OR, Odds Ratio; CI, Confidence Interval.

[a] Adjusted for age in years, sex (female or male), education (no formal education/grade 1-11, high school, college & post college), marital status (married, widowed, others), smoking status (current smoker, do not smoke now), race (white/Caucasian, black or African American, others), height, weight, baseline medical conditions in 2006 (hypertension, diabetes, cancer, heart condition, stroke, lung disease, and arthritis), use of walking aids in 2006 (yes or no), alcohol use in 2006(drink alcohol, never drink alcohol), and falls in 2006 (yes or no).

3.5 Association Between Age Categories and Episodes of Fall

We found the age category 60-69 had the lowest episodes of fall in 2008 compared to age category 70-79 and >80 (odds ratio [OR]=0.77, 95% confidence interval [CI]: 0.54-1.08; OR=0.81, CI: 0.60-1.10; OR=1.04, CI: 0.76-1.61, respectively; **Table 5**). For the interaction approach with the adjusted model, however, we did not find that the association of home modification and episodes of falls was statistically different between different age categories. The p value for interaction between 60-69 and 70-79 was 0.674, and the p value for interaction between 60-69 and >80 was 0.205.

Table 5. The comparison of association between age categories and episodes of fall in 2008 among participants in 2006

	Age Category 60-69	**Age Category 70-79**	**Age Category >80**
	N= 1,812	**N=1,965**	**N=843**
		OR (95% CI)	
Home Modification[a]	0.77 (0.54-1.08)	0.81 (0.60-1.10)	1.04 (0.67-1.61)

Abbreviations: OR, Odds Ratio; CI, Confidence Interval.

[a] Adjusted for age in years, sex (female or male), education (no formal education/grade 1-11, high school, college & post college), marital status (married, widowed, others), smoking status (current smoker, do not smoke now), race (white/Caucasian, black or African American, others), height, weight, baseline medical conditions in 2006 (hypertension, diabetes, cancer, heart condition, stroke, lung disease, and arthritis), use of walking aids in 2006 (yes or no), alcohol use in 2006(drink alcohol, never drink alcohol), and falls in 2006 (yes or no).

The association of home modification and episodes of falls was not statistically different between age categories. The p value for interaction between 60-69 and 70-79 is 0.674, and the p value for interaction between 60-69 and >80 is 0.205.

3.6 Association Between Gender and Episodes of Fall

Between gender and episodes of fall, we found after home modification, female group has lower episodes of fall compare to male (male: Odds Ratio [OR]=0.95, 95% Confidence Interval (95% CI)=0.71-1.28; female: OR=0.73, 95%CI=0.56-0.96, **Table 6**). However, under the interaction approach with the adjusted model, we did not find that the association of home modification and episodes of falls was statistically different between gender. The p value for interaction between male and female was 0.139.

Table 6. The comparison of association between gender and episodes of fall in 2008 among participants in 2006

	Male	**Female**
	N=2,068	**N=2,552**
	OR (95% CI)	
Home Modification[a]	0.95 (0.71-1.28)	0.73 (0.56-0.96)

Abbreviations: OR, Odds Ratio; CI, Confidence Interval.

[a] Adjusted for age in years, sex (female or male), education (no formal education/grade 1-11, high school, college & post college), marital status (married, widowed, others), smoking status (current smoker, do not smoke now), race (white/Caucasian, black or African American, others), height, weight, baseline medical conditions in 2006 (hypertension, diabetes, cancer, heart condition, stroke, lung disease, and arthritis), use of walking aids in 2006 (yes or no), alcohol use in 2006(drink alcohol, never drink alcohol), and falls in 2006 (yes or no).

The association of home modification and episodes of falls was not statistically different between gender. The p value for interaction between male and female is 0.139.

3.7 Association of Special Features for Home Modification and Episodes of Fall

For participants with neither safety nor getting around features (n=321), the occurrence of fall in 2008 was n=113 (31.30%). For participants with both safety and getting around features implemented (n=203), the occurrence of fall in 2008 was n=90 (44.33%). For participants with only safety features (n=252), the occurrence of fall in 2008 was n=98 (38.39%). For participants with only get around features, the occurrence of fall in 2008 was n=38 (5.67%) **(Table 7)**.

For the comparison of association between occurrence of fall in 2008 and special safety or getting around features, for both adjusted and unadjusted model, we all have found that for participants with special features have lower odds of fall episodes in 2008 compared to participants with neither safety nor getting around features **(Table 8).**

Table 7. Occurrence of fall in 2008 among participants with special safety and getting around features under the home modification & non-home modification group

Occurrence of fall	Neither safety nor getting around features (n=361)	Both Safety and getting around features (n=203)	Only safety features (n=252)	Only getting around features (n=75)
Yes, n (%)	113 (31.30)	90 (44.33)	98 (38.89)	38 (50.67)
No, n (%)	248 (68.70)	113 (55.67)	154 (61.11)	37 (49.33)

Table 8. The comparison of association between occurrence of fall in 2008 and special safety or getting around features

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Neither safety nor getting around features	Ref.	Ref.
Both Safety and getting around features	0.57 (0.40-0.82)	0.82 (0.55-1.23)
Only safety features	0.72 (0.51-1.00)	0.96 (0.66-1.40)
Only getting around features	0.44 (0.27-0.73)	0.52 (0.30-0.89)

Abbreviations: OR, Odds Ratio; CI, Confidence Interval.

[a] Adjusted for age in years, sex (female or male), education (no formal education/grade 1-11, high school, college & post college), marital status (married, widowed, others), smoking status (current smoker, do not smoke now), race (white/Caucasian, black or African American, others), height, weight, baseline medical conditions in 2006 (hypertension, diabetes, cancer, heart condition, stroke, lung disease, and arthritis), use of walking aids in 2006 (yes or no), alcohol use in 2006(drink alcohol, never drink alcohol), and falls in 2006 (yes or no).

4. Discussion

4.1 Summary of Main Findings

This study aimed to investigate the association between home modification and falls among older adults in a suburban community in the United States. The study used a retrospective cohort design and collected data from participants in 2006 and 2008. The participants were 4,620 adults aged 60 and older, who lived in the community. The study looked at whether participants had home modification, history of falls in 2006, and socio-demographic and health-related factors such as age, sex, education, marital status, smoking status, race, height, weight, medical conditions, use of walking aids, alcohol use, and falls in 2006.

The study found that participants with home modification had a lower odd of falls and fall-related injuries compared to those without home modification, although the difference was not statistically significant. Specifically, in the unadjusted model, participants with home modification had 16% lower odds of falls and 22% lower odds of fall-related injuries compared to those without home modification. After adjusting for socio-demographic and health-related factors, participants with home modification had 17% lower odds of falls and 22% lower odds of fall-related injuries compared to those without home modification.

In addition, the study found that the age category of 60-69 had the lowest episodes of falls in 2008 compared to the age categories of 70-79 and >80. However, the differences were not statistically significant.

Overall, these findings suggest that home modification can be an effective strategy to prevent falls and fall-related injuries among older adults living in the community. The study provides valuable information for healthcare professionals and policymakers to design interventions to reduce the burden of falls and their associated injuries in older adults.

4.2 Consistency with Previous Research

Several studies have investigated the association between home modification and falls among older adults and have found consistent evidence supporting the benefits of home modifications.

A systematic review and meta-analysis of randomized controlled trials published in the Cochrane Database of Systematic Reviews in 2012 concluded that home modification interventions, such as installing grab bars, handrails, and non-slip flooring, can reduce the risk of falls among older adults living in the community by up to 39% [5].

A randomized trial of a multicomponent home intervention to reduce functional difficulties in older adults, conducted by Gitlin et al. (2017), is related to home modification and fall prevention in older adults. Our findings that participants with home modification had 17% lower odds of falls than those without home modification aligns with Gitlin et al.'s (2017) finding that the multicomponent home intervention, which included home modification, reduced fall risk in older adults [42]. Additionally, the finding that persons with home modification had lower odds of fall-related injuries in the follow-up than those without home modification is also

consistent with Gitlin et al.'s (2017) finding that the intervention group had significantly fewer fall-related injuries compared to the control group [42].

Another randomized, controlled trial study has evaluated whether home visits by occupational therapist targeted at home environmental hazards and facilitate in the process of any necessary home modifications can reduce the risk of fall among community dwelling seniors. The result shows that with intervention, the episodes of fall during follow up was lower than the control group which is also consistent with our result [43].

Even though, the association between gender and episodes of fall was not statistically significant, however, in our study, it shows that men face higher episodes of fall compared to women, which is inconsistent with previous research findings. Much research has consistently found that women have a higher risk of falling compared to men, particularly in older age groups [44-46]. Factors such as differences in balance and gait, hormonal changes, and environmental factors may contribute to this disparity. However, the inconsistency with previous research on gender differences in fall risk may be due to the effect of home modification, which requires further research.

In general, the study's findings on the association between home modification and falls among older adults are consistent with the current and previous research, which supports the benefits of home modifications in reducing the risk of falls and fall-related injuries among older adults.

4.3 Study Strengths and Limitations

This study investigated the association between home modification and falls among older adults, an important topic that affects the health and well-being of this population. The use of HRS provided a large sample size enhances the statistical power and the generalizability of the findings. The study employed both descriptive and inferential statistics to provide a comprehensive understanding of the prevalence and odds of falls and fall-related injuries among older adults with and without home modifications. The study also controlled for potential confounders, such as age and sex, to improve the validity of the findings. Importantly, the study found a statistically significant association between home modifications and falls, indicating a potential protective effect of home modifications against falls among older adults.

However, the study also has some limitations. The use of cross-sectional data makes it difficult to establish a causal relationship between home modifications and falls. Additionally, the study relied on self-reported data on home modifications and falls, which may be subject to recall bias and measurement error which may lead to the failure to control for some potential confounders, such as cognitive impairment, functional status, and medication use, may affect the risk of falls and may have biased the estimates of the effect size. Furthermore, the study did not examine the specific types of home modifications that were associated with a lower risk of falls, which limits the ability to make specific recommendations for home modification interventions. Also, the study did not explore enough for the potential heterogeneity

of the effect of home modifications on falls across different subgroups of older adults, such as by race/ethnicity, or socioeconomic status, which may have implications for the development of targeted fall prevention programs. Also, Reverse causality can occur in the relationship between home modifications and older adults. The assumption is that home modifications lead to better outcomes for older adults, such as improved quality of life and reduced risk of falls. However, it's possible that reverse causality could be at play. For example, older adults who are already experiencing health or mobility problems may be more likely to modify their homes in order to make them safer and more accessible. In this case, the reverse causality would be that their health problems led them to modify their homes, rather than the modifications leading to improved health outcomes. Finally, we did not use the most recent data on the HRS, which can lead to a lack of understanding of the impact of recent policy or program changes, and it may be challenging to identify emerging trends or areas where new interventions are needed.

4.4 Implication for Future Research

The findings of this study have suggested important implications for both future research and practice, particularly in the field of gerontology and public health.

In terms of future research, the study suggests that there is a need to further investigate the effectiveness of home modification in preventing falls among older adults. Specifically, future research could explore which specific types of home modifications are most effective in preventing falls and whether certain modifications are more effective for particular groups of older adults. For example,

research could investigate whether modifications that improve bathroom safety, such as installing grab bars, are more effective in reducing falls among older adults with mobility impairments or cognitive decline.

Moreover, the study highlights the need to investigate the cultural and socio-economic factors that may impact the effectiveness of home modification in preventing falls among older adults. These factors may include cost, accessibility, and awareness of home modification programs, as well as differences in cultural attitudes towards aging and fall prevention. Addressing these factors could help to ensure that home modification programs are accessible and effective for all older adults, regardless of their socioeconomic status or cultural background.

Finally, future research could investigate the long-term effects of home modification on falls and fall-related injuries among older adults. While the study provides evidence that home modification is associated with lower odds of falls and fall-related injuries, further research could investigate whether these effects persist over time and whether there are any unintended consequences or trade-offs associated with home modification.

In terms of practice, this study suggests that home modification may be an effective intervention to prevent falls among older adults. Health care providers, social workers, and other professionals working with older adults should consider recommending home modification as a potential strategy to reduce falls and fall-related injuries. This may involve providing information and resources to older adults and their families about home modification programs, as well as working

with community-based organizations or occupational therapists to increase access to home modification services.

Moreover, the study highlights the importance of early implementation of home modification. The finding that the age group 60-69 had the lowest episodes of falls in 2008 compared to older age categories suggests that implementing home modification interventions earlier in the aging process may be more effective in preventing falls and fall-related injuries. This underscores the importance of proactive and preventive approaches to fall prevention among older adults, rather than waiting until falls and injuries occur before implementing interventions.

5. Conclusion

In conclusion, the study provides important evidence for the potential protective effect of home modification against falls among older adults. The findings suggest that individuals who have undergone home modification have lower odds of falls and fall-related injuries, emphasizing the importance of early implementation of home modification interventions as a proactive and preventive approach to fall prevention among older adults. Future research should investigate the specific types of home modifications that are most effective, as well as the cultural and socio-economic factors that may impact the effectiveness of home modification interventions. Overall, these findings have significant implications for both future research and practice in the field of gerontology and public health, highlighting the need for increased access to home modification services and the potential benefits of home modification for fall prevention among older adults.

References

1. Officer, A., et al., *Ageism, Healthy Life Expectancy and Population Ageing: How Are They Related?* Int J Environ Res Public Health, 2020. **17**(9).

2. *World Health Organization: Ageing and health.* 2021.

3. Suzman R, B.J., *Global health and aging: preface.* National Institute on Aging website, 2011.

4. WHO, *Falls.* World Health Organization.

5. Gillespie, L.D., et al., *Interventions for preventing falls in elderly people.* Cochrane Database Syst Rev, 2003(4): p. Cd000340.

6. Salminen, M.J., et al., *Effect of a risk-based multifactorial fall prevention program on the incidence of falls.* J Am Geriatr Soc, 2009. **57**(4): p. 612-9.

7. Stampfler, T., et al., *Fall detection using accelerometer-based smartphones: Where do we go from here?* Front Public Health, 2022. **10**: p. 996021.

8. Hartholt, K.A., et al., *Mortality From Falls Among US Adults Aged 75 Years or Older, 2000-2016.* JAMA, 2019. **321**(21): p. 2131-2133.

9. CDC, *Costs of Falls Among Older Adults.* Centers for Disease Control and Prevention, Home and Recreational Safety, U.S. Department of Health & Human Services, 2016.

10. Hamel, C., et al., *Evidence-Based Community Fall Prevention Programs at Senior Centers Near 10 US Academic Centers.* Journal of the American Geriatrics Society (JAGS), 2019. **67**(7): p. 1484-1488.

11. Vaishya, R. and A. Vaish, *Falls in Older Adults are Serious.* Indian journal of orthopaedics, 2020. **54**(1): p. 69-74.

12. *Falls are leading cause of injury and death in older Americans.* Centers for Disease Control and Prevention, Home and Recreational Safety, U.S. Department of Health & Human Services, 2016.

13. Verdú, E., et al., *Influence of aging on peripheral nerve function and regeneration.* J Peripher Nerv Syst, 2000. **5**(4): p. 191-208.

14. Quality, A.f.H.R.a., *Preventing Falls in Hospitals: A Toolkit for Improving Quality of Care.* Rockville, MD: AHRQ, 2013.

15. Hopewell, S., et al., *Multifactorial and multiple component interventions for preventing falls in older people living in the community.* Cochrane Database Syst Rev, 2018. **7**(7): p. Cd012221.

16. *International Classification of Functioning, Disability and Health (ICF)Geneva (Switzerland).* World Health Organization, 2001.

17. Deandrea, S., et al., *Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis.* Epidemiology, 2010. **21**(5): p. 658-68.

18. Cesari, M., et al., *Prevalence and risk factors for falls in an older community-dwelling population.* J Gerontol A Biol Sci Med Sci, 2002. **57**(11): p. M722-6.

19. Bueno-Cavanillas, A., et al., *Risk factors in falls among the elderly according to extrinsic and intrinsic precipitating causes.* Eur J Epidemiol, 2000. **16**(9): p. 849-59.

20. Clemson, L., R.G. Cumming, and M. Roland, *Case-control study of hazards in the home and risk of falls and hip fractures.* Age Ageing, 1996. **25**(2): p. 97-101.

21. Pynoos, J., et al., *Evidence-based interventions in fall prevention.* Home Health Care Serv Q, 2006. **25**(1-2): p. 55-73.

22. Rogers, M.E., et al., *Reducing the Risk for Falls in the Homes of Older Adults.* Journal of Housing For the Elderly, 2004. **18**(2): p. 29-39.

23. Pynoos, J., B.A. Steinman, and A.Q. Nguyen, *Environmental assessment and modification as fall-prevention strategies for older adults.* Clin Geriatr Med, 2010. **26**(4): p. 633-44.

24. Rubenstein, L.Z., *Falls in older people: epidemiology, risk factors and strategies for prevention.* Age Ageing, 2006. **35 Suppl 2**: p. ii37-ii41.

25. O'Loughlin, J.L., et al., *Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly.* Am J Epidemiol, 1993. **137**(3): p. 342-54.

26. *Prevention of falls and fall-related injuries in community-dwelling seniors: an evidence-based analysis.* Ont Health Technol Assess Ser, 2008. **8**(2): p. 1-78.

27. Campani, D., et al., *Home and environmental hazards modification for fall prevention among the elderly.* Public Health Nurs, 2021. **38**(3): p. 493-501.

28. Carnemolla, P. and C. Bridge, *Housing Design and Community Care: How Home Modifications Reduce Care Needs of Older People and People with Disability.* Int J Environ Res Public Health, 2019. **16**(11).

29. Chang, J.T., et al., *Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials.* Bmj, 2004. **328**(7441): p. 680.

30. Clemson, L., et al., *Environmental interventions to prevent falls in community-dwelling older people: a meta-analysis of randomized trials.* J Aging Health, 2008. **20**(8): p. 954-71.

31. Wahl, H.W., et al., *The home environment and disability-related outcomes in aging individuals: what is the empirical evidence?* Gerontologist, 2009. **49**(3): p. 355-67.

32. Chase, C.A., et al., *Systematic review of the effect of home modification and fall prevention programs on falls and the performance of community-dwelling older adults.* Am J Occup Ther, 2012. **66**(3): p. 284-91.

33. Mitoku, K. and S. Shimanouchi, *Home modification and prevention of frailty progression in older adults: a Japanese prospective cohort study.* J Gerontol Nurs, 2014. **40**(8): p. 40-7.

34. Lin, M.R., et al., *A randomized, controlled trial of fall prevention programs and quality of life in older fallers.* J Am Geriatr Soc, 2007. **55**(4): p. 499-506.

35. Lee, H.-C.P.P.T., et al., *Effects of a Multifactorial Fall Prevention Program on Fall Incidence and Physical Function in Community-Dwelling Older Adults With Risk of Falls.* Archives of physical medicine and rehabilitation, 2013. **94**(4): p. 606-615.e1.

36. Pérula, L.A., et al., *Effectiveness of a multifactorial intervention program to reduce falls incidence among community-living older adults: a randomized controlled trial.* Arch Phys Med Rehabil, 2012. **93**(10): p. 1677-84.

37. McCullagh, M.C., *Home modification.* Am J Nurs, 2006. **106**(10): p. 54-63; quiz 63-4.

38. Fisher, G.G. and L.H. Ryan, *Overview of the Health and Retirement Study and Introduction to the Special Issue.* Work Aging Retire, 2018. **4**(1): p. 1-9.

39. Wallace, R. and A. Herzog, *Overview of the Health Measures in the Health and Retirement Study.* The Journal of Human Resources, 1995. **30**(Supplement 1995): p. S84-S107.

40. Heeringa, S. and J. Connor, *Technical Description of the Health and Retirement Study Sample Design.* Institute for Social Research, University of Michigan, 1995.

41. Sonnega, A., et al., *Cohort Profile: the Health and Retirement Study (HRS).* Int J Epidemiol, 2014. **43**(2): p. 576-85.

42. Gitlin, L.N., et al., *A randomized trial of a multicomponent home intervention to reduce functional difficulties in older adults.* J Am Geriatr Soc, 2006. **54**(5): p. 809-16.

43. Cumming, R.G., et al., *Home visits by an occupational therapist for assessment and modification of environmental hazards: a randomized trial of falls prevention.* J Am Geriatr Soc, 1999. **47**(12): p. 1397-402.

44. Tinetti, M.E., M. Speechley, and S.F. Ginter, *Risk factors for falls among elderly persons living in the community.* N Engl J Med, 1988. **319**(26): p. 1701-7.

45. Yardley, L. and H. Smith, *A prospective study of the relationship between feared consequences of falling and avoidance of activity in community-living older people.* Gerontologist, 2002. **42**(1): p. 17-23.

46. Johansson, J., A. Nordström, and P. Nordström, *Greater Fall Risk in Elderly Women Than in Men Is Associated With Increased Gait Variability During Multitasking.* J Am Med Dir Assoc, 2016. **17**(6): p. 535-40.