IDENTIFICATION OF FALL RISK FACTORS AND DEVELOPMENT OF A FALLS PREDICTION MODEL FOR COMMUNITY-DWELLING OLDER ADULTS RECEIVING PUBLIC HEALTH NURSING SERVICES IN HAWAIʻI

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Dedication

To my family and grandparents who inspired me to become a Public Health Nurse.

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Abstract

Nationally, one in four seniors fall each year, with the incidence of falls increasing with age. It is estimated that there are 26 fall-related injuries per day. For older adults 65 years and older, falls are the leading cause of hospitalizations, traumatic brain injury, and the leading cause of injury Emergency Department visits. The Centers for Disease Control and Prevention estimates that in 2030, 73 million older adults will live in the United States, leading to 52 million falls and 12 million fall-related injuries annually. Fall risk factors have been identified as intrinsic or extrinsic.

The overall purpose of this study is to discover which fall risk factors (Missouri Alliance for Home Care Fall Risk Assessment Tool (MAHC-10), age, living arrangement, gender, medication number, medication type, Charlson Comorbidity Index (CCI) score, and the Age-Adjusted Charlson Comorbidity Index (ACCI) score provide the strongest indicators of falls among community-dwelling older adults in Hawaii. A fall prediction model was developed using the strongest fall indicators for community-dwelling older adults in Hawaii.

This study utilized a secondary analysis of the Hawaii Department of Health Public Health Nursing Branch fall database. The sample size was 211 community-dwelling older adults 60 years and older living in Hawaii. Data was collected for the model and included the MAHC-10 score, age, living arrangement, gender, medication number, medication type, the CCI score, and the ACCI score.

A nonparametric two-sample Wilcoxon test, a nonparametric Pearson chi-square test, a Fisher's exact test, a Cochran-Armitage test for trend, or a univariate logistic regression was performed on the independent variables. A receiver operating characteristic (ROC) curve, sensitivity, and specificity were completed for the screening tools. Multiple logistic regression

was completed to develop a prediction model for falls among Hawaii community-dwelling older adults. The statistical modeling was performed using SPSS version 25.

This study found that there were individual significant associations between community-dwelling older adult falls and the MAHC-10 total score of six or more, prior history of falls, environmental risk factors, CCI total score of two or more, the ACCI total score of six or more, depression, cancer, myocardial infarction (MI), peripheral vascular disease (PVD), and antispasmodic medication. This study also developed a parsimonious model with five variables and a c-statistic of 0.70 (95% CI= 0.61- 0.79). The variables that were included in the model were prior history of falls, MI or PVD, antispasmodic medication, depression, and environmental hazards.

This study identified significant fall risk factors and developed a parsimonious model for this sample of community-dwelling older adults in Hawaii. This information could be used in the community to identify older adults at risk for falling and provide evidence-based fall prevention interventions in the future.

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List of Abbreviations

Abbreviation	Definition
ACCI	Age-Adjusted Charlson Comorbidity Index
ADLs	Activities of Daily Living
AIC	Akaike Information Criterion
ARS	Anticholinergic Risk Scale
AUC	Area Under the Curve
CCI	Charlson Comorbidity Index
CDC	Centers for Disease Control and Prevention
CHF	Congestive Heart Failure
CI	Confidence Intervals
CINAHL	Cumulated Index to Nursing and Allied Health Literature
CIRS-G	Cumulative Illness Rating Scale for Geriatrics
CKD	Chronic Kidney Disease
CMS	Centers for Medicare and Medicaid Services
COVID-19	Coronavirus Disease of 2019
CTD	Connective Tissue Disease
CVA	Cerebral Vascular Accident
DOH	Department of Health
DTC	Dual Task Cost
ED	Emergency Department
EMS	Emergency Medical Services
FRAT	Fall Risk Assessment Tools
FRID	Fall Risk Increasing Drugs
GIC	Geriatric Index of Comorbidity
IADLs	Instrumental Activities of Daily Living
ICD	International Classification of Diseases
ICED	Index of Coexisting Diseases
IRB	Institutional Review Boards
MAHC-10	Missouri Alliance for Home Care Fall Risk Assessment Tool
MDN	Median
MFS	Morse Fall Scale
MI	Myocardial Infraction
OASIS-C	Outcome and Assessment Information Set Criteria
OR	Odds Ratios
PHN	Public Health Nurse
PHNB	Public Health Nursing Branch
PI	Primary Investigator
POMA	Tinetti Balance Assessment Tool Performance-Oriented Mobility Assessment
PUD	Peptic Ulcer Disease
PVD	Peripheral Vascular Disease
QOL	Quality of Life
ROC	Receiver Operating Characteristic
SLS	Single Leg Stance

SPPB	Short Physical Performance Battery
SS_R	Residual Sum of Squares
SSRI	Selected Serotonin Reuptake Inhibitors
STEADI	Stopping Elderly Accidents, Deaths, and Injuries
STRATIFY	St. Thomas's Risk Assessment Tool in Falling Elderly Inpatients
TBI	Traumatic Brain Injury
TCA	Tricyclic Antidepressants
TUG	Timed Up and Go Test
US	United States
VIF	Variance Inflation Factor
WHO	World Health Organization

Chapter 1. Background and Significance

Introduction

The purpose of chapter one is to describe the background and significance of older adult falls for community-dwelling older adults. The chapter presents the problem statement to guide the research and rationale for the significance of the study to nursing practice.

Successful aging-in-place is a term used in healthcare and the literature to describe how seniors can remain in their homes; however, elders have needed to move from their homes as their lives become endangered by falls. Older adult falls are relevant to the Healthy People 2030 objectives regarding reducing fatal and nonfatal injuries and fatal and nonfatal traumatic brain injuries. Also, the objectives for Healthy People 2030 stress the importance of preventing fall-related deaths among adults aged 65 years and older and reducing the rate of emergency department (ED) visits due to falls (U.S. Department of Health and Human Services, 2021).

A fall is when a person comes to rest inadvertently on the ground, floor, or other lower level (World Health Organization, 2018). Community-dwelling older adult refers to a non-institutionalized senior living in his home. In the literature, the definition of an older adult ranges, but an older adult is generally described as someone 60 years and older (Chi et al., 2019). As a population, community-dwelling older adults can be further divided into the youngest-old (65-74 years), middle-old (75-84 years), and oldest-old (85 years and older) (Lee et al., 2018).

Frailty in seniors is a condition in which the body has difficulty recovering from physiological stresses. Symptoms of frailty are exhaustion, low weight, low energy expenditure, slow gait, balance issues, and weakness. Seniors are most likely to be frail when they are of increased age, female sex, or disabled. Frail seniors are also more likely to have adverse health outcomes, which include falls, increased number of chronic diseases and pain, fewer years of education, poorer cognitive performance, frequent hospitalizations, and need assistance with activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (Lee et al., 2018; Lohman et al., 2020). Adverse outcomes include disability, hospitalizations, surgical complications, and death. Community-dwelling older adults can also be a part of minority populations, live in rural environments, and have special cultural considerations that make them unique for healthcare providers and researchers (Lee et al., 2018).

A Growing Older Adult Population

The older adult population is quickly growing globally, in the United States (US) and Hawaii. Globally, between 2015 and 2050, the proportion of the world's population over 60 years will nearly double from 12% to 22%. In 2050, it is estimated that there will be 2 billion people 60 years and older. About 80% of all older people will live in low and middle-income countries (World Health Organization, 2018).

The US Census Bureau predicts that by 2030, one in every five US residents will be 65 years and older, and by 2034, there will be 77.0 million seniors 65 years and older in the US. In 2016, there were approximately 49 million older adults 65 years and older, representing 15% of the US population. In 2060, it is estimated that 95 million older adults will represent almost 25% of the US population. The aging population and the advancement in medical care will increase life expectancy and the older adult population. The number of older adults who are 85 years and older is nearly expected to double by 2035 (6.5 million) to 2060 (19 million people) (Vespa et al., 2019).

Hawaii has seen an average growth rate for the older adult population of 3.5% annually compared to other US states. The fastest growth rates include Hawaii and Maui counties, with over 5.0% annually (Research Economic Analysis Division, 2019). About one in every four people in Hawaii will be over 60 years old in 2020. It is estimated that in 2020 there were 283,128 older adults over 65 years of age and 45,532 older adults over 85 years of age. In 2045, it is estimated that 390,719 people will be 65 years and older. Of those people, 107,159 will be 85 years and older. In Hawaii, there are more females over the age of 60 years, and the population distribution based on gender widens as age increases. Hawaii has a smaller proportion of older adults living alone, about 32.7%, compared to the US. About 11.6% of Hawaii's households are multigenerational (Hawaii Department of Health, 2019).

With the increase in the older adult population, the Centers for Disease Control and Prevention (CDC) estimates that in 2030 there will be 73 million older adults in the US. If trends continue, there could be 52 million falls and 12 million fall-related injuries annually (Centers for Disease Control and Prevention, 2021).

Significance of Older Adult Falls

National Statistics

One in four older adults fall each year, with the incidence of falls increasing with age (CDC, 2021). Falls are the leading cause of injuries for adults 65 years and older. In 2018, nationally, approximately 32,000 older adults died due to a fall, 950,000 older adults were hospitalized, and 3 million older adults were treated in the ED due to falls. Annually, older adult falls equated to $50 billion in health care spending. Fall and fall-related injuries increase with age. Women are more likely to report falling and fall-related injuries than men (Moreland et al., 2020). Men are more likely to have a fatal fall. This may be due to the circumstance of the fall, which could include falling from a higher area or drinking, leading to an increased likelihood of serious fall-related injuries (Burns & Kakara, 2018). According to Moreland (2020), the percentage of older adults who fell is higher among Caucasians and American Indian/ Alaska

Natives than African Americans and Asian/ Pacific Islanders. Fall rates are higher for older adults with poorer health status and those with difficulties with functional abilities. Older adults in rural areas report higher fall rates than in urban areas. Nationally, the death rates from older adult falls increased by 31% from 2007 to 2016 (3.0% per year) (Burns & Kakara, 2018).

Hawaii Statistics

Among Hawaii senior residents who fell during 2013-2019, there were approximately 127 deaths, 1,880 hospitalizations, 7,530 ED visits, and 8,450 Emergency Medical Services (EMS) ambulance calls yearly. That would equate to approximately 26 fall-related injuries per day (Galanis, 2021).

In 2014-2018, falls (50%) were the leading cause of fatal injuries among seniors, followed by suicides (13%) and pedestrian and car crashes (4%). Among senior-aged patients, falls caused an estimated 83% of injury-related hospitalizations. Falls are the leading cause of hospitalizations and traumatic brain injury (TBI) (87%) and the leading cause of injury ED visits (61%) in Hawaii for residents 65 years and older. In 2017-2019, falls among seniors were the leading cause of EMS-attended injuries (81%) (Galanis, 2021). The projected lifetime cost for fall injuries for Hawaii residents 65 years and older is approximately $181 million annually. Projected lifetime cost is calculated by adding the medical and work loss costs for all the older adults who died, were hospitalized, and had ED visits due to a fall (Hawaii Department of Health, 2016).

As older adults age, their fall risk also dramatically increases. For Hawaii, residents 85 years and older deaths rates caused by a fall were four times higher than residents 75 to 84 years old and 15 times higher than rates 65 to 74 years old from 2006 to 2015. Males also had a higher fall death rate than females ever year. Females had a significantly higher nonfatal fall hospitalization rate compared to males. From 2011 to 2015, 54% of fall hospitalizations were discharged to a skilled nursing facility (Hawaii Department of Health, 2016).

Epidemiology of Older Adult Falls

Risk Factors for Falls

A fall risk factor is a characteristic that increases the likelihood of an older adult falling (Stevens & Lee, 2018). As the number of risk factors increases, an older adult's fall risk also increases. Descriptive studies have been conducted to assess the risk factors for falls among older adults (Alabdullgader & Rabbani, 2021; Chidume, 2021; Ganz & Latham, 2020; Stevens & Lee, 2018). According to these studies, older adult fall risk factors are characterized as intrinsic or extrinsic.

Intrinsic fall risk factors relate to an individual's internal characteristics. Intrinsic risk factors include advance age, co-morbidities, history of falls, incontinence, visual impairment, decreased functional mobility, pain, and decreased cognitive function. A person of advance age is defined as an older adult 65 years and older. Older adults with three or more documented medical diagnoses are considered at risk for falls. Medical conditions include diabetes, hypertension, cancer, or orthostatic hypotension. Orthostatic hypotension is a form of low blood pressure when a person changes position. A prior history of falls in the past three months is also an intrinsic risk factor. The following are also intrinsic risk factors for falls. Incontinence is the inability to reach the bathroom or commode on time, including urinary frequency, urgency, and nocturia. Visual impairment, defined as having difficulty seeing, includes macular degeneration, diabetic retinopathy, and age-related changes. Impaired functional mobility includes needing help with ADLs or IADLs, gait and transfer problems, or impaired coordination. Pain affects an older adult's level of function. Cognitive impairments such as dementia, stroke, confusion, or memory deficits are examples of intrinsic risk factors (Alabdullgader & Rabbani, 2021; Chidume, 2021; Ganz & Latham, 2020; Stevens & Lee, 2018).

Extrinsic factors are related to an older adult's environment, including environmental hazards, polypharmacy, improper footwear, and improper use of assistive devices. Examples of environmental hazards are poor lighting, the presence of equipment tubing, inappropriate footwear, pets, and floor surfaces that are uneven or cluttered. Environmental hazards are estimated to play a role in about a third of older adult falls. The most hazardous areas in the home are the bathroom and stairs. This may be due to time spent in these areas, the need to transfer, and the lack of structural features, for example, grab bars (Blanchet & Edwards, 2018). Polypharmacy is described as taking four or more medications, which may include a prescription for over-the-counter medications. Medications that are highly associated with fall risk include sedatives, anti-depressants, tranquilizers, narcotics, antihypertensives, corticosteroids, anticholinergics, and hypoglycemic medications (Andersen et al., 2020). An older adult is also at risk if he does not use his assistive device correctly or all the time (Alabdullgader & Rabbani, 2021; Chidume, 2021; Ganz & Latham, 2020; Stevens & Lee, 2018).

Consequences of Falls

When an older adult falls, the consequences of the fall can vary. A fall in an older adult can have a devastating effect. The fall may result in loss of independence, chronic pain, and reduced quality of life.

Falls can result in severe injuries for older adults that range from fractures to traumatic brain injuries. Consequences can also include a loss of independence, physical function and activity, social withdrawal, fear of falling, and an overall decrease in quality of life. If an older adult falls and cannot get back up for a long time, the older adult may experience rhabdomyolysis due to muscle ischemia (Ganz & Latham, 2020).

Fractures can occur if an older adult has a fall. Hip fractures can be more severe and are associated with increased disability and mortality for older adults over 65 years. It also decreases independence and QOL (Andersen et al., 2020). Risk factors for fractures after a fall may include osteoporosis, malnutrition, sarcopenia, and fall-risk-increasing medications (Andersen et al., 2020; Han et al., 2021; Yeung et al., 2019). Malnourished older adults with hip fractures have increased in-patient mortality and other complications (Han et al., 2021).

TBI is caused by an impact on the head or body or a penetrating head injury that disrupts normal brain function. Falls are a leading cause of TBI in older adults. National rates of TBI death have increased, especially for people living in rural areas and people aged 75 years or older (Peterson & Kegler, 2020). The long-term effect of TBI for an older adult may include loss of independence and cognitive decline secondary to the trauma. TBI patients could be hospitalized, require neurosurgical intervention, and need rehabilitative therapy (Marrone et al., 2020).

The fear of falling is a debilitating phenomenon defined as an exaggerated concern about falling or a low perceived self-efficacy to avoid falls while completing ADLs. The fear of falling can harm an older adult's lifestyle by reducing activity level, leading to physical deconditioning, autonomy reduction, anxiety, social withdrawal, and overall poorer quality of life. In studies, the prevalence of the fear of falling ranges from 20%-80% for community-dwelling older adults aged 65 years and older (Ganz & Latham, 2020; Tomita et al., 2018). Both older adults who have fallen and older adults who have never experienced a fall can experience the fear of falling (Lavedán et al., 2018). The fear of falling influences older adults as well as their caregivers. Fall self-efficacy, defined as a person's belief in their ability to complete activities without falling, has been studied and has decreased their fear of falling (Soh et al., 2021).

Fall Prevention Interventions

The literature depicts many fall prevention interventions for community-dwelling older adults. Some interventions address balance concerns, environmental risk factors, medication management, and vision concerns. Multifactorial interventions address multiple fall risk factors (Ganz & Latham, 2020).

Exercise Based Interventions

Exercise-based fall prevention interventions can be individualized and home-based or in a group setting in the community. The goal is to reduce falls and improve leg strength and balance. Exercise-based fall prevention interventions include Tai Chi, walking interventions, and the Otago Exercise Program. Exercise-based fall prevention interventions may lower falls by 23% in participants compared to the control group. Exercise-based fall prevention interventions also may reduce the number of falls resulting in fractures that need medical attention (Ganz & Latham, 2020). Tai Chi is a meditative or internal martial art and mind-body exercise. Originating in China, Tai Chi has gained popularity worldwide, primarily practiced in China, the US, and South Korea. Tai Chi is usually delivered face-to-face by a Tai Chi instructor in a group setting for 60 minutes per session, thrice a week. The length of Tai Chi instruction interventions generally ranges from 12 weeks. Tai Chi improves strength balance and has been associated with decreasing fall rates in older adults (Yang et al., 2021). Limitations to exercise interventions are that some older adults may have physical limitations and cannot participate and adhere to an exercise regimen to achieve behavior change for long periods. Long-term adherence is challenging with exercise fall prevention interventions (Ganz & Latham, 2020).

The Otago Exercise Program combines walking and strength and balance exercises. This individualized exercise program is among the most popular fall-prevention interventions for community-dwelling older adults. The exercises are individually tailored to the older adult and include four physical therapist visits. The older adult receives a monthly phone call; the intervention lasts 12 months. Older adults are encouraged to exercise for 30 minutes thrice a week and walk at least twice weekly. Older adults demonstrate improvements in balance and functional ability. This fall prevention intervention is safe, effective, and cost-effective (Martins, 2018).

Environmental Interventions

Environmental interventions address home hazards and can include home safety inspections by the older adult, family member, caregiver, or a trained medical professional such as an occupational therapist or nurse (Blanchet & Edwards, 2018). It is estimated that environmental fall prevention interventions could prevent medically treated falls and avert $442 million in direct medical costs (Stevens & Lee, 2018).

Environmental interventions can be grouped into two categories: the first to address non-structural hazards and the second to address structural hazards. Nonstructural hazard interventions include installing non-skid mats, placing abrasive strips in the bath or shower, or adjusting the toilet seat level. Replacing worn-out or improper footwear is another example of an intervention that could prevent falls. Wearing the proper footwear can affect an older adult's balance, gait, and posture. Examples of proper footwear are shoes with slip-resistant soles and low heel height. Interventions to address structural hazards include installing grab bars in the bathroom, shower, or near the toilet. Grab bars should be assessed for proper placement, and sturdiness and be well anchored to the walls. Both indoor and outdoor stairs are an example of other areas that can be hazardous, and handrails in these areas can be installed to improve safety.

The presence of proper and sturdy handrails and the structural integrity of the stairs are most important when assessing this area (Blanchet & Edwards, 2018).

Medication Interventions

Medication management is a cornerstone of many fall prevention interventions. It is estimated that regularly reviewing medications could avert $418 million in direct medical costs by preventing falls (Stevens & Lee, 2018). It is recommended that older adults review their medications and identify medications that may increase fall risk or have potential interactions with their primary care provider or pharmacist annually. Medication fall prevention interventions include stopping medications that increase an older adult's risk for falls when possible, switching to safer alternatives, or reducing the medication to the lowest effective dose. Medication management reduces interactions and side effects that may lead to a fall. Over-the-counter medications and herbal supplements that cause side effects, for instance, dizziness, sedation, confusion, blurred vision, or orthostatic hypotension, should be considered (CDC, 2021).

Visual Interventions

Improving or correcting an older adult's vision is a fall prevention intervention. Part of the environmental assessment may be to increase lighting so that older adults can see better. Vision could also be improved by adequately correcting cataracts or other eye conditions and using corrective lenses (Stevens & Lee, 2018).

Multifactorial Interventions

Multifactorial interventions combine biological, behavioral, and environmental intervention types. It is unclear if multifactorial fall prevention interventions are more effective than single interventions. Some multifactorial interventions display lower rates of falls compared to the control group. Gait, balance, strength training, medication review, functional status and home safety assessment, vision assessment, and cognition assessment could all be a part of multifactorial interventions. Multifactorial interventions are time intensive, and it is suggested that due to the resource strain of multifactorial fall prevention interventions, they should be utilized for older adults who are moderately to severely at risk for falls (Ganz & Latham, 2020; Stevens & Lee, 2018).

The CDC has developed the Stopping Elderly Accidents, Deaths, and Injuries (STEADI) initiative. The STEADI provides information to screen for patients at risk for falls, assess for modifiable fall risk factors, and intervene to modify fall risk factors for older adults. The STEADI is multifactorial and includes potential interventions to address gait, strength, and balance deficits, the medication that increases the risk for falls, home hazards, and comorbidities (CDC, 2021).

Action research approaches are evolving to determine the cultural competency of fall prevention interventions and the effects of evidence-based interventions. A novel approach to addressing older adult falls is the participatory research approach that engages older adults. Community-based participatory research is also being used with public health care providers, private sector health care providers, and citizen volunteers to provide fall prevention interventions to community-dwelling older adults collectively. Public health care providers can utilize collaborative leadership using the community-based participatory research approach. Themes of enabling communication, shaping a vision, skill-building to mobilize and act, tailoring to address content, orchestrating people, and contributing information and experience are examples of how fall prevention interventions can successfully be implemented (Elliott et al., 2021).

Cost Savings of Fall Prevention Intervention Programs

For the US, it is estimated that 9,563-45,164 medically treated falls could be prevented annually if fall prevention interventions were implemented. The associated Medicare costs that could be saved are estimated at $94 million to $422 million, depending on the targeted risk, the size of the eligible population, and the effectiveness of the intervention (Stevens & Lee, 2018).

Summary: Fall Prevention Programs

The strengths of this body of work are that the effect of fall prevention interventions on the Caucasian population is well documented and the short-term effect of interventions. Improvements can be made by expanding research to reach individuals and communities in rural areas with minority populations; also, interventions can be created to have follow-up or to track client progress for the long term.

Key Problem Areas

A fundamental problem is that falls may not be well documented in the community and could be under reported. Falls may happen several weeks to months before an older adult sees a doctor or accesses health care. Knowing the true prevalence of falls in the community is a challenge. Most fall data are self-reported and subject to recall bias. If a fall did not result in an injury or the older adult did not need medical attention, an older adult may not report the fall. Also, the definition of a fall may not be well defined to older adults or vary among clinicians (Moreland et al., 2020; Oshiro et al., 2019).

Another critical problem is that falls could be caused by many factors and fall risk factors vary from individual to individual. Understanding the intrinsic and extrinsic risk factors for falls that affect community-dwelling older adults in Hawaii could help healthcare providers identify older adults at risk for falling. The literature has no agreement on a standardized fall risk assessment tool. Limited prediction models are also developed for community-dwelling older adults in Hawaii (Oshiro et al., 2019). More research is needed on fall risk factors for this population so fall prevention interventions can be implemented in Hawaii's communities.

Problem Statement

There is limited research on the risk factors for fall and fall prediction models among community-dwelling older adults in Hawaii. The purpose of this study is to discover which fall risk factors (Missouri Alliance for Home Care Fall Risk Assessment Tool (MAHC-10), age, living arrangement, gender, medication number, medication type, Charlson Comorbidity Index (CCI) score, and the Age-Adjusted Charlson Comorbidity Index (ACCI) score) provide the most vital indicators of falls among community-dwelling older adults in Hawaii. This study will develop a fall prediction model for community-dwelling older adults in Hawaii using the strongest indicators for falls.

Significance to Nursing Practice

This study has several opportunities to influence nursing practice. The goal of nurses nationally and in Hawaii is to prevent falls and injuries so older adults can have a higher quality of life and age in place for as long as possible. Understanding which fall risk factors affect Hawaii community-dwelling older adults is the first step. Validation of a fall-risk screening tool or development of a model to predict Hawaii community-dwelling older adult falls could be utilized in nursing practice to identify older adults and communities at risk for falls. Nurses can then allocate resources to develop or implement evidence-based fall prevention interventions that would address the risk factors for falls in their community.

Summary of Chapter One

This chapter has discussed the definition of a fall, and the significance of older adult falls nationally and in Hawaii. The epidemiology of older adult falls was explored through risk factors, consequences, and fall prevention interventions. In the future, the older adult population is expected to grow, which may increase fall incidence if prevention measures are not implemented to reduce community-dwelling older adult's fall risk.

Chapter 2. Review of the Literature

Introduction

Chapter two explores the literature review process and begins with fall prediction models. It also highlights the theoretical model, literature on fall risk factors and covers fall risk tools. Finally, this chapter discusses the gaps and strengths of the research, concluding with a presentation of the research questions.

Literature Review

The first objective of this literature review was to identify and analyze prediction models and report on which risk factors were most prevalently used in fall prediction models for community-dwelling older adults 60 years and older. The second objective of this literature review was to explore the different risk factors for falls and find appropriate tools and indexes to measure the selected risk factors.

Search Strategies

Studies that developed or validated fall prediction models utilizing fall risk factors to estimate an older adult's risk for a future fall were included in this search. Healthcare professionals could utilize fall prediction models to identify older adults who are more at risk for falling and focus on fall prevention interventions to decrease and prevent falls and their consequences. Databases included in the search were Medline, Cumulated Index to Nursing and Allied Health Literature (CINAHL), Academic Search Complete, Health Source: Nursing/ Academic Education, Agricola, Psychology and Behavioral Sciences Collection, Library and Information Science and Technology Abstracts. Terms for the search were fall model, older adult, and community-dwelling.

Selection of Studies

Older adults in the studies were community-dwelling and older than 60 years of age. Studies that were in hospitals or long-term care facilities were excluded. Developmental and validation studies of models were included. Studies with outcome measures of a fall or an injurious fall were included in this review. Only studies in English published between 2017-2022 were included.

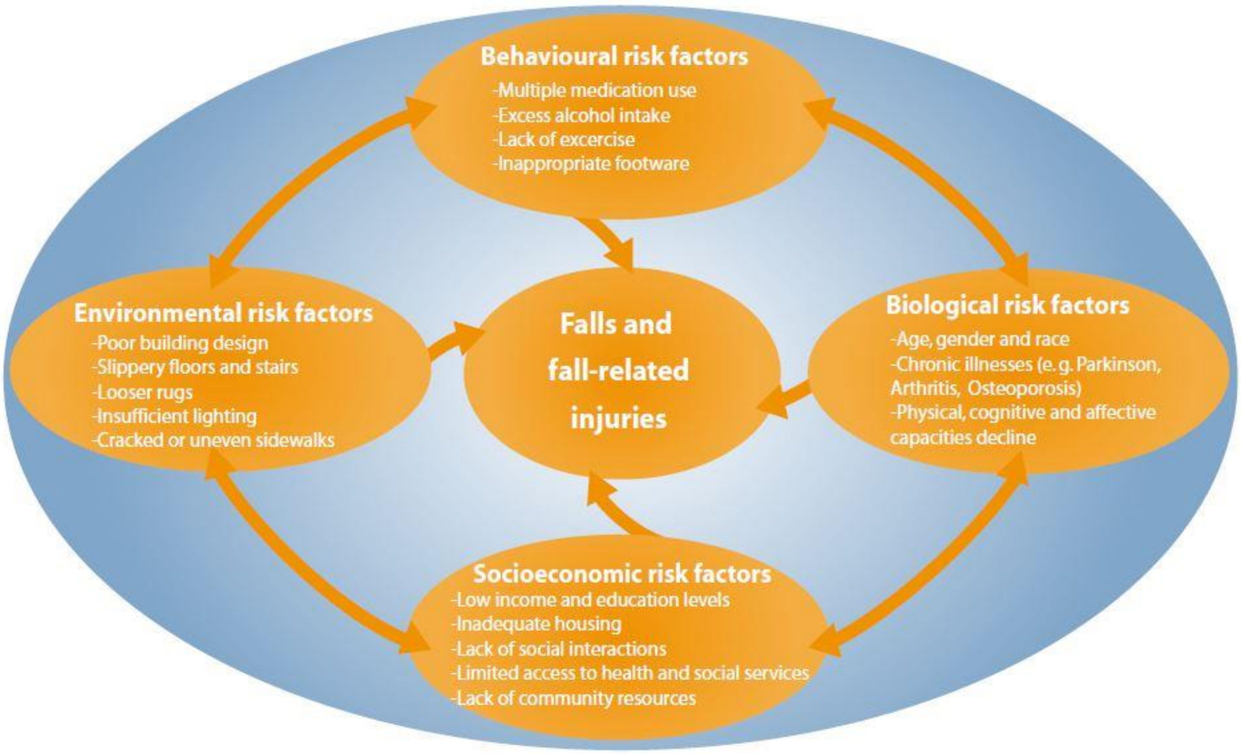
There was a total of 130 records identified with the search. Four articles were duplicates and were removed. One hundred twenty-six abstracts were screened, and 55 records were removed for the study not having a predictive model, reporting on an intervention, or reporting on a protocol or dissertation. Articles were removed if they were not written in English. Seventy-one full-text articles were assessed for eligibility. Fifty-two studies were also removed if the population included institutionalized elders or the outcome measure was not falling. Nineteen studies were included in this synthesis.

Synthesis of the Literature

Theoretical Model

The Risk Factor Model for Falls in Older Age by the World Health Organization (WHO), Figure 1, was used to analyze the types of risk factors in the studies. Falls are multifaceted, and many risk factors can explain why an older adult falls. Fall risk factors include history of falls, demographic, physical, psychological, medical, socioeconomic, environmental, and behavioral risk factors. The WHO categorizes risk factors into biological, behavioral, socioeconomic, and environmental (Qian et al., 2021).

Figure 1. The WHO Risk Factor Model for Falls in Older Age (Qian et al., 2021)



Fall Prediction Models

A total of 19 fall prediction models were found in the literature review. Four models were studied in the US, three in Japan, and two in Spain (Asai et al., 2021; Helsel et al., 2021; Ikeda et al., 2022; Lavedán et al., 2018; Makino et al., 2021; Oshiro et al., 2019; Pérez-Ros et al., 2019; Sagawa et al., 2018; Welch et al., 2021). Canada, Denmark, Finland, Hong Kong, Italy, Korea, Netherlands, Sweden, and Taiwan all had one model (Cella et al., 2020; Chen et al., 2020; Davis et al., 2017; Gade et al., 2021; Hohtari-Kivimäki et al., 2021; Kim et al., 2022; Qian et al., 2021; Trevisan et al., 2020; Van Gulick et al., 2022). One model was developed with a population from Germany and the Netherlands (Van De Loo et al., 2022). One of the US models was developed in Hawaii (Oshiro et al., 2019).

The follow-up period for falls differed from one year to 12 years. Ten of the studies followed up with their participants for one year (Asai et al., 2021; Cella et al., 2020; Chen et al., 2020; Davis et al., 2017; Gade et al., 2021; Gulick et al., 2022; Hohtari-Kivimäki et al., 2021; Loo et al., 2022; Oshiro et al., 2019; Perez-Ros et al., 2018). Two studies had a follow-up period of two years (Lavedan et al., 2018; Sagawa et al., 2018), one study followed up for three years (Ikeda et al., 2022), three studies followed up for four years (Helsel et al., 2021; Makino et al., 2021; Welch et al., 2022). There was one study each that followed up for six (Trevisan et al., 2020), ten (Qian et al., 2020) and twelve (Kim et al., 2022) years respectively. The sample size of the nineteen studies ranged from 96 individuals to 89,100 individuals. Appendix A represents the risk factors of the 19 fall prediction models categorized by the WHO Risk Factor Model for Falls in Older Age.

Biological Risk Factors

Biological risk factors were the largest group of risk factors used by the studies. The biological risk factors used by the models were demographic, chronic illnesses and symptoms, physical capacities decline, cognitive capacities decline, and affective capacities decline. Demographics that were found to be predictors of falls in the models were age and gender. Age was studied in four models (Cella et al., 2020; Ikeda et al., 2022; Makino et al., 2021; Oshiro et al., 2019). Gender was also studied in four models (Cella et al., 2020; Chen et al., 2020; Lavedán et al., 2018; Oshiro et al., 2019).

The category of chronic illnesses and symptoms was used in 11 different studies. Comorbidities, frailty, exhaustion, and perceived unhealthiness were general risk factors to describe older adult’s health (Chen et al., 2020; Kim et al., 2022; Oshiro et al., 2019). Dizziness, low peak expiratory flow, and choking were symptoms that studies utilized (Gade et al., 2021;

Ikeda et al., 2022; Trevisan et al., 2020). Diagnoses that were identified in the models were Parkinson's Disease, obesity, low blood pressure, orthostatic hypotension, arthritis, osteoporosis, pain, visual impairment, and oral health concerns (Chen et al., 2020; Hohtari-Kivimäki et al., 2021; Ikeda et al., 2022; Makino et al., 2021; Oshiro et al., 2019; Pérez-Ros et al., 2019; Sagawa et al., 2018; Van De Loo et al., 2022).

The risk factor of physical capacity decline was used in 10 fall prediction models. Mobility and strength were assessed in the studies with different screening tools. Gait speed, stability of gait, and balance were subcategories of mobility. The most prevalent risk factor was gait speed in six studies (Asai et al., 2021; Cella et al., 2020; Makino et al., 2021; Trevisan et al., 2020; Van Gulick et al., 2022; Welch et al., 2021). Gait stability was assessed with four models (Asai et al., 2021; Cella et al., 2020; Oshiro et al., 2019; Van Gulick et al., 2022). Strength was assessed by standing from a chair without using the armrest and was used in three models (Cella et al., 2020; Ikeda et al., 2022; Welch et al., 2021). Three models used balance as a risk factor (Cella et al., 2020; Trevisan et al., 2020; Welch et al., 2021).

Mobility and strength were assessed by low mobility function, locomotion outdoors, and plantar flexor strength of the lessor toes (Chen et al., 2020; Qian et al., 2021; Van Gulick et al., 2022). Functional assessments as a subcategory included the ability to climb stairs without a handrail, and disability was assessed in one model (Ikeda et al., 2022). There were five different assessments used in the models. The Short Physical Performance Battery (SPPB) assessed balance, gait speed, and strength (Cella et al., 2020; Welch et al., 2021). The Tinetti Balance Assessment Tool Performance-Oriented Mobility Assessment (POMA) assessed balance, unsteady gait, and strength (Cella et al., 2020). The Timed Up and Go Test (TUG) assessed gait speed and strength (Asai et al., 2021; Cella et al., 2020). The Dual Task Cost (DTC) assesses gait speed, strength, and cognitive ability (Asai et al., 2021). Robotic Parameters use robotic technology to assess balance and strength (Cella et al., 2020).

Nine fall prediction models used the biological risk factor of cognitive capacity decline. Depression, cognitive function, and fear of falling were subcategories addressed in this section. Depression or depressive symptoms were addressed in three models (Gade et al., 2021; Ikeda et al., 2022; Oshiro et al., 2019). Cognitive function and a sense of coherence were used in four models (Asai et al., 2021; Davis et al., 2017; Ikeda et al., 2022; Van De Loo et al., 2022). Fear of falling was used in four models (Helsel et al., 2021; Ikeda et al., 2022; Lavedán et al., 2018; Makino et al., 2021).

One fall prediction model used the biological risk factor of affective capacity decline. The model that assessed this risk factor assessed frail older adults. The results illustrate that exhaustion and task motivation were associated with falls for older adults (Kim et al., 2022).

Behavioral Risk Factors

Behavioral risk factors were the second largest category of risk factors. Multiple use of medications and excess alcohol intake were behavioral risk factors used in eight fall prediction models. The number of medications an older adult took was used in four models (Cella et al., 2020; Makino et al., 2021; Oshiro et al., 2019; Sagawa et al., 2018). Other behavioral risk factors were types of medication and alcohol consumption (Gade et al., 2021; Qian et al., 2021). The models used psychotropic, antiepileptic, and antihistamines (Oshiro et al., 2019; Pérez-Ros et al., 2019; Van De Loo et al., 2022). Medications used to treat urinary frequency, urinary incontinence, Parkinson’s, and blood pressure were also used in models (Van De Loo et al., 2022). The fall prediction models did not address the lack of exercise and inappropriate footwear.

Socioeconomic Risk Factors

Socioeconomic risk factors used in the models were educational level and lack of social interactions. Higher education levels were associated with higher rates of falls (Gade et al., 2021; Van De Loo et al., 2022). It is rationalized in the study that higher educational status may reflect higher socioeconomic status, which could lead to higher alcohol use. Weekly alcohol consumption of more than seven units was associated with higher fall rates (Gade et al., 2021). The lack of social interactions was another socioeconomic risk factor explored in the model. Older adults who lived alone experienced a higher risk of falling (Chen et al., 2020). In the literature, low income and low educational levels are associated with a higher fall risk (Gade et al., 2021; Van De Loo et al., 2022). These fall risk models did not assess income, housing, health and social services access, or community resources.

Environmental Risk Factors

Of the 19 fall prediction models, none used environmental risk factors as an indicator in the model. Environmental risk factors include poor building design, slippery floors and stairs, loose rugs, insufficient lighting, and cracked or uneven sidewalks. One study looked at weather patterns (Qian et al., 2021).

Falls and Fall-Related Injuries

The history of falling as a risk factor was used in eight models. History of falls and fall-related injuries are associated with an increased risk of falling in older adults (Cella et al., 2020; Gade et al., 2021; Helsel et al., 2021; Ikeda et al., 2022; Pérez-Ros et al., 2019; Van De Loo et al., 2022; Van Gulick et al., 2022). Previous fall fractures were a risk factor (Pérez-Ros et al., 2019). In a study of 75,484 home care clients in New Zealand, 7,414 people sustained an injury after a fall. The most common injury of people who fell was hip fractures 4,735 (63.9%), followed by proximal humerus fractures 735 (9.9%), distal radius fractures 640 (8.6%), pelvic fractures 470 (6.3%), vertebral fracture 371 (5.0%), subdural hematoma 303 (4.1%), and subarachnoid hemorrhage 160 (2.2%) (Abey-Nesbit et al., 2021).

Risk Factors Variables

The following section reviews the literature on the variables that will be collected in this study. The variables are age, gender, living arrangement, medication number, and medication type. This section will cover medication types associated with a higher risk of falling in older adults. These include psychotropics, antidepressants, sedative-hypnotics, benzodiazepines, anticonvulsants, antispasmodics, antipsychotics, opioids, and antihypertensives.

Age

As older adults age, their risk for falls also increases. In 2018, for older adults greater than 65 years old, 27.5% reported at least one fall in the past year, and 10.2% reported at least one fall-related injury. For people aged 85 years and older, 33.8% reported at least one fall in the past year, and 13.9% reported a fall-related injury (Moreland et al., 2020). One study found by utilizing the MAHC-10 that the fall risk increased with age (Alshammari et al., 2018).

Gender

Women report higher rates of falls and fall-related injuries than men (Alabdullgader & Rabbani, 2021; Moreland et al., 2020). Older women also have more fall-related ED visits than older men. In 2018, 29.1% of women reported a fall in the past year, and 11.9% reported a fall-related injury. Compared to 25.5% of men who reported a fall in the past year and 7.9% who reported a fall-related injury (Moreland et al., 2020). Common risk factors for falls associated with men are decreased physical function, depression, and decreased cognitive function. Pain and decreased physical function are associated with fall risk in women (Kubo et al., 2021). The location of where women and men fall differs. In one study, 38.3% of men fell outside the house compared to 28.4% of women (Moreland et al., 2020).

Living Arrangement

Living arrangements may reflect the support and resources an older adult can access in the community. One study with a setting of a US homecare agency found that older adults who fell had greater odds of living alone than older adults who did not fall (Brullo et al., 2022). Living alone increases the likelihood of an older adult feeling socially isolated, whereas living with a partner protects against social isolation (Robins et al., 2018). Another study found that of older adults who have recurrent falls, African Americans were less likely than Caucasians to live alone (Okoye et al., 2021).

Medication Number

Polypharmacy is defined as taking four or more medications and is associated with an increased risk of falling. Compared to other risk factors, polypharmacy was one of the most frequently identified risk factors by people who had fallen (Alabdullgader & Rabbani, 2021). In older adults, polypharmacy described in one study as the use of four or more prescription medications daily caused a 1.5-2 times higher possibility of recurrent falls (Ming & Zecevic, 2018). Every prescription medication added to an older adult’s daily regimen increases their risk of falling 1.2 times (Fletcher et al., 2009).

The number of medications was associated with poor gait performance, overall gait decline, faster gait decline, and higher incidence of falls. For each additional medication taken, the gait decline risk increased by 12%-16%, and the fall incidence risk increased by 5%-7% (Montero-Odasso et al., 2019).

Medication Type

Reducing types of medication that could increase fall risk while weighing potential benefits could reduce falls by 39%-66% (Centers for Disease Control and Prevention, 2021). Medication management to stop medications that increase fall risk, switch to safer alternative medications, or reduce to the lowest effective medication dose is recommended by the STEADI. Certain medication classes can increase fall risk by affecting cognition and physical function (CDC, 2021).

Psychotropic Medications. Psychoactive medication use has increased over time. In a study of Medicare beneficiaries, over 50% used a psychoactive medication during the year. Over 30% used one psychoactive medication class, 15% used two psychoactive medication classes, and 9% used three or more psychoactive medication classes. Psychotropic medications affect the central nervous system and alter the psychological process of mood, emotion, perception, and behavior. Older adults taking more psychotropic medications are more likely to fall (Hanlon et al., 2009).

Antidepressants. For Medicare beneficiaries from 1996-2013, there was a 300% increase in selected serotonin reuptake inhibitors (SSRI) and antidepressant use for community-dwelling older adults (Haddad et al., 2019). A systematic literature review found that older adults who used antidepressants were 1.5 to 3 times more likely to experience recurrent falls than non-users (Ming & Zecevic, 2018). People who took SSRIs were 3.45 times more likely than non-users to fall frequently (Kerse et al., 2008). People who took Tricyclic antidepressants (TCAs) were 1.7 times more likely to recurrently fall compared to non-users (Cumming et al., 1991).

High-risk antidepressants are Paroxetine, Fluoxetine, Fluvoxamine, Nefazodone, Isocarboxazid, Phenelzine, and Tranylcypromine. Antidepressants have been found to increase an older adult's risk for falls and injuries due to potential sedation and postural disturbances. TCAs are associated with adverse effects of reduced alertness, impaired neuromuscular functioning, sedation, dizziness, postural hypotension, altered gait and balance, and confusion. All TCAs are high-risk medications for older adults (University of North Carolina, 2018).

Sedative Hypnotics. A systematic literature review found that older adults who used sedatives were more likely to experience recurrent falls than non-users (Ming & Zecevic, 2018). Three studies found that older adults who took sedatives and hypnotics were 1.8-4.5 times more likely to have recurrent falls (Askari et al., 2013; Van Strien et al., 2013; Wu et al., 2013). Older adults who used anticholinergic medication were 1.34 times more likely to have recurrent falls. All sedative-hypnotics, which are highly anticholinergic, are high-risk medications in older adults. Sedative hypnotics have increased an older adult's risk for falls and injuries due to sedation, confusion, dizziness, gait and balance problems, and weakness (University of North Carolina, 2018).

Benzodiazepines. For Medicare beneficiaries from 1996-2013, there was a 50% increase in benzodiazepine use for community-dwelling older adults (Haddad et al., 2019). Benzodiazepines are common hypnotics classified as long-acting, intermediate-acting, and short-acting. Older adults that use long-acting benzodiazepines are 1.56-2.18 more likely to have repeated falls compared to non-users (Cumming et al., 1991; Ensrud et al., 2002). Older adults who use short-acting benzodiazepines were 1.94 times more likely to have a fall compared to non-users (Van Strien et al., 2013). All benzodiazepines are fall high-risk medications for older adults. Benzodiazepines have increased an older adult's risk for falls and injuries due to sedation, confusion, dizziness, gait and balance problems, and weakness (University of North Carolina, 2018).

Anticonvulsants. For Medicare beneficiaries from 1996-2013, there was a 450% increase in anticonvulsant use for community-dwelling older adults (Haddad et al., 2019). A systematic literature review found that older adults who used anticonvulsants were more likely to experience recurrent falls than non-users (Ming & Zecevic, 2018). Older adults using anticonvulsant medications were 3.15-4.7 times more likely to experience repeated falls than non-users (Tromp et al., 1998). High risk anticonvulsant medications are Carbamazepine, Divalproex Sodium, Phenobarbital, and Phenytoin. These medications can have adverse effects of sedation and dizziness that may result in gait and balance impairment and lead to falls (University of North Carolina, 2018).

Antispasmodics. Antispasmodics concerning fall risk have not been widely studied, but clinicians should be aware of the potential adverse effects. Sedation, confusion, dizziness, gait and balance problems, and weakness are side effects of antispasmodic medications. High-risk antispasmodics include skeletal muscle relaxants such as Carisoprodol, Chlorzoxazone, and Tizanidine. Examples of gastrointestinal antispasmodics are Belladonna Alkaloids, Clidinium-Chlordiazepoxide, and Propantheline. Examples of urinary antispasmodics are Flavoxate, Oxybutynin (oral), Solifenacin, and Tolterodine (University of North Carolina, 2018).

Antipsychotics. Antipsychotics may increase an older adult's risk of falling. Adverse effects such as reduced alertness, impaired neuromuscular functioning, dizziness, sedation, postural hypotension, altered gait and balance, and extrapyramidal symptoms increase an older adult's fall risk. High-risk antipsychotics are Thioridazine, Chlorpromazine, and all antipsychotics (University of North Carolina, 2018).

Opioids. For Medicare beneficiaries from 1996 to 2013, there was a 140% increase in opioid use for community-dwelling older adults (Haddad et al., 2019). High-risk opioids are

Pentazocine and Meperidine. Opioids have been found to increase an older adult's risk for falls and injuries due to reduced alertness, impaired neuromuscular function, sedation, dizziness, impaired cognition, unsteadiness, and impaired functioning (University of North Carolina, 2018).

Antihypertensives. Older adults who used diuretics are 1.8 times more likely to experience recurrent falls than non-users. Other studies did not find any associations between falling and Diltiazem (calcium antagonist), vasodilators (nitrates), and diuretics after adjusting for confounding factors (Askari et al., 2013; Cumming et al., 1991; Lim et al., 2009). High-risk antihypertensives are all Peripheral Alpha-1 Blockers, all Centrally-Acting Medications, and Immediate Release Nifedipine. Studies are conflicting regarding the link between fall risk and antihypertensive medication. Hypotension and orthostatic hypotension are believed to contribute to fall risk, but evidence is inconsistent (University of North Carolina, 2018). Older adults who fall were 2.8 times ($p=0.03$) more likely to be prescribed non-antihypertensive cardiac medications than those who did not fall (Brullo et al., 2022).

Screening Tools

A review of the most common fall risk assessment tools (FRATs) and comorbidity indexes are also included in this section. The various screening tools will be presented, and then a rationale will be given as to the choice of screening tool that will be used for this study.

Fall Risk Tools

In the literature, there are many FRATs for older adults. A systematic literature review by De Clercq and colleagues (2021) identified 43 FRATs in older adults. Assessment tools available at no cost that were used to measure fall risk, in general, were included in the literature review. The five most used FRATs in published studies were the St. Thomas's Risk Assessment Tool in falling elderly inpatients (STRATIFY) tool with 17 articles developed in 1997, the Morse Fall

Scale (MFS) with 15 articles developed in 1989, the Hendrich II FRAT developed in 1995, the TUG developed in 1991, and the POMA developed in 1986. The MAHC-10 had two articles and was developed in 2010. The Berg Balance Scale was developed in 1989 with nine articles (De Clercq et al., 2021).

STRATIFY Tool. The STRATIFY tool is used in acute and rehabilitation services in hospital settings. The initial goal of this tool was to predict falls in elderly hospital patients utilizing information that nurses routinely collect (Hayes, 1998). The STRATIFY has also been used in the nursing home setting (Aranda-Gallardo et al., 2015; Wijnia et al., 2006). There are five questions to the STRATIFY that cover history of falls, agitation, visual impairment that impairs everyday function, need for frequent toileting, and transfer and mobility. The transfer and mobility score utilizes the Barthel index (Wijnia et al., 2006). Each clinical factor is given a score of one if yes or zero if no. Scores range from zero to five points. A score greater than or equal to two had a high sensitivity of 93%, and a score greater than or equal to three had a high specificity of 96% for predicting elderly hospital patients at risk for falling (Hayes, 1998).

Morse Fall Scale. The MFS is used in acute care hospitals and long-term care inpatient settings to assess a patient's likelihood of falling. Six questions address history of falling in the past three months, secondary diagnosis, ambulatory aids, intravenous medication therapy, gait and transferring, and mental status. The scores of the MFS range from 0-125. If older adults score 0-24 points, they are at "no risk" and can receive good basic nursing care. If older adults score 25-50 points, they are at "low risk" and can receive standard fall prevention interventions. If older adults receive greater than or equal to 51 points, they are at "high risk" and should receive high-risk fall prevention interventions. (Banez et al., 2008). The MFS was also used in the community-dwelling setting with changes to the scoring criteria. On a scale of 0-5, those scoring four or more points were "positive" for fall risk (Lin et al., 2022).

Hendrich II Scale. The Hendrich II Scale measures fall risk and is used primarily in acute care and skilled nursing settings. It has also been used in pediatrics and the home setting. For the acute care and skilled nursing settings, the scale has a sensitivity of (74.9%) and a specificity of (73.9%). The score can range from 0-16 points, with a score greater than five points considered high risk. The scale includes questions about fall-risk medications (benzodiazepines and antiepileptics), typical side effects of medications (confusion, dizziness, altered elimination, gait and mobility disturbances, and gender (Gray-Miceli, 2007). When used in patients with cardiovascular disease, an increased score on the Hendrich II scale is associated with hospital readmission and risk of death (Manemann et al., 2018).

Timed Up and Go. The TUG screening tool measures fall risk by assessing an older adult's mobility. This screening tool can be used in the inpatient and community settings. The patient starts by sitting in a standard armchair; when the clinician says go, the patient stands up from the chair, walks to a line 10 feet away on the floor, turns, walks back to the chair, and then sits down again. The TUG is scored by time in seconds to complete these tasks. If the time is greater than or equal to 12 seconds, the older adult is considered at risk for falling. The TUG is a resource in the CDC's (STEADI) initiative. Studies have used the TUG to examine the relationship between older adult heart disease and mortality. One study found that older adults with slower TUG speeds were associated with an increased risk of developing myocardial infraction (MI), congestive heart failure (CHF), and mortality in older adults (Cella et al., 2020; Giallauria, 2019). The TUG was used to measure cognitive ability via DTC in one study. Older adults were asked to complete the TUG and then asked to complete the TUG while counting aloud backward from 100. The study confirmed that slower TUG scores and DTC values were significantly associated with fall history among independently community-dwelling older adults (Asai et al., 2021).

Tinetti Balance Assessment Tool. POMA measures older adults' balance while performing activities and gait. The total score can range from 0-28 points. Minimal fall risk scores are greater than 25 points, moderate fall risk scores are between 19-23 points, and high fall risk scores are less than 19 points. The POMA highly predicts falls and fall-related injuries for community-dwelling older adults. The sensitivity for the POMA was 68%, and the specificity was 78% (Cella et al., 2020; Harada & Chiu, 1995). One study examined the relationship between POMA scores and body composition. In males, balance deficits were associated with sarcopenia. In females, fat mass was associated with balance deficits (Waters et al., 2019).

Berg Balance Scale. The Berg Balance Scale measures balance and postural stability and comprises 14 functional tasks common to everyday life. Examples of tasks are standing on one leg, turning 360 degrees, picking up an object from the floor from a standing position, transferring, and going from sitting to standing. The total score can range from 0-56 points. A score of 0-20 points is a high risk for falls, 21-40 points is a medium risk, and 41-56 is a low risk for falls. The sensitivity of the scale was 88.2%, and the specificity was 76.5% (Menezes et al., 2020). The Berg Balance Scale is correlated to the TUG and is used for the population of community-dwelling older adults (Woo-Chul et al., 2019).

Missouri Alliance for Home Care Fall Risk Assessment Tool. The MAHC-10 (Appendix B) is a standardized, multifactorial, and validated fall risk assessment tool for the home care setting. This tool was developed to be used by home health agencies to follow the Centers for Medicare and Medicaid Services' (CMS) Outcome and Assessment Information Set

Criteria (OASIS-C). Currently, only one home health care tool is validated for use (Lo et al., 2019).

The MAHC-10 measures fall risk by the ten core elements. A patient scores one point for each core element if they are older than 65, have three or more diagnoses, have a fall history within three months, or take four or more prescription medications. If the patient has incontinence, visual impairment, impaired functional mobility, environmental hazards, or cognitive impairment, they also score one point. MAHC-10 scores can range from 0-10 points. If an older adult scores four out of 10 points, he is considered high risk for falls. In the validation study, a score of four demonstrated 96.9% sensitivity and 13.3% specificity. A six out of 10 scores demonstrated 68.7% sensitivity and 46.9% specificity (Calys et al., 2013). One study found that the MAHC-10 and the POMA had a weak but significant negative relationship ($r=-0.21$, $p<0.01$) pre and post-intervention (Gallagher et al., 2013). Another study found a significant association between falling and the MAHC-10 fall risk score (Alabdullgader & Rabbani, 2021). The MAHC-10 is used in Hawaii to screen for fall risk in community-dwelling older adults.

Fall Risk Assessment Tool Summary. There were seven FRATs presented in this literature review. Utilizing the Risk Factor Model for Falls in Older Age by the WHO, a description of the types of risk factors assessed in the FRATs is presented in Appendix C. The MFS and the MAHC-10 assessed the history of falls, including biological, behavioral, and environmental fall risk factors. The STRATIFY assessed the history of falls and biological and behavioral risk factors. The Hendrich II assessed biological and behavioral fall risk. The TUG, POMA, and Berg Balance Scale assessed biological fall risk. The MFS and the MAHC-10 were the FRATs that assessed the most fall risk factors.

The Hendrich II Scale, MFS, and the STRATIFY Tool are used to assess older adults who are hospitalized or residing in long-term care and rehab facilities. The Berg Balance Scale, TUG, and the POMA are used for community-dwelling older adults. The MAHC-10 was chosen for this study because it is validated for use with community-dwelling older adults and is multifactorial, assessing the history of falls, biological, behavioral, and environmental fall risk factors.

MAHC-10 Core Element Literature

Literature on the MAHC-10 risk factors is described in this section below. There are 10 MAHC-10 core elements. This section reviews the literature on prior history of falls, incontinence, visual impairment, impaired functional mobility, environmental hazards, pain, cognitive impairment, and comorbidity. Age and polypharmacy are reviewed in their respective section.

Prior History of Falls Within Three Months. In the validation study, a prior history of falls within the past three months was significantly related to faller status ($p=<0.001$, odds ratio 2.07) (Calys et al., 2013). Generally, in the literature, a history of falls is a risk factor for falls. Studies measure the history of falls with varying time lengths, most common ranging from three months before to a year since the person had the most current fall (Cella et al., 2020; Gade et al., 2021; Ikeda et al., 2022; Makino et al., 2021; Pérez-Ros et al., 2019; Van Gulick et al., 2022).

Incontinence. Incontinence, defined by the MAHC-10, is an inability to get to the bathroom or commode on time. It includes frequency, urgency, and nocturia (Calys et al., 2013). Urinary incontinence is the involuntary leakage of urine. Incontinence may be associated with falls because older adults rush to the toilet, and they could trip or slip on a pool of urine (Gibson et al., 2021). Incontinence is associated with falls (Singh et al., 2019). One study found that an overactive bladder predicts falls in older adults with a low fall risk (Omae et al., 2021). Another potential explanation is that walking and maintaining continence are two cognitive tasks that divide an older adult's attention. This dual-tasking concept can cause gait changes and increase an older adult's fall risk (Gibson et al., 2021).

Visual Impairment. Visual impairment, as defined on the MAHC-10, includes but is not limited to macular degeneration, diabetic retinopathies, visual field loss, age-related changes, decline in visual acuity, accommodation, glare tolerance, depth perception, and night vision. Visual impairment would also include an older adult not wearing their prescribed glasses or not having the correct prescription (Calys et al., 2013). The CDC STEADI recommends asking patients about vision problems, assessing visual acuity with a Snellen eye chart, and asking patients about their use of prescription lenses (CDC, 2021). Poor vision was associated with older adult falls (Begin et al., 2021). In one study, falls were significantly higher among those with self-reported vision impairments. Declines in vision may lead to less physical activity and, therefore, a greater risk of falls (Ehrlich et al., 2019). Another study examined a questionnaire to measure visual function. The Visual Function Questionnaire 11-item Japanese Version domains were general vision, near vision, distance vision, dependency, social functioning, well-being/ distress, and role limitation. The composite score on the questionnaire was significantly associated with falls and frequent falls (greater than two falls) in one month (Niihata et al., 2018).

Impaired Functional Mobility. Impaired functional mobility defined by the MAHC-10 includes assistance with IADLS or ADLS, gait or transfer problems, arthritis, pain, fear of falling, foot problems, impaired sensation, impaired coordination, or improper use of assistive devices (Calys et al., 2013). After completing the MAHC-10 assessment, impaired functional mobility was one of the most frequently identified risk factors by people who had fallen (Brullo et al., 2022). In the validation study, functional mobility was significantly related to faller status ($p=0.03$, odds ratio 1.98) (Calys et al., 2013).

There are many fall-risk mobility screenings for older adults. The TUG and the Single Leg Stance (SLS) are commonly used examples. One study examined the ability of the TUG and SLS to identify older adults who had recurrent falls and examined the mobility screening's accuracy and cut-off values by age and sex. The TUG could identify older adults who had recent falls among women 65-74 and 75-85 years of age with an optimal cut-off score of 14.1. The SLS could identify men 65-74 years who had recent falls with an optimal cut-off score of 3.6 seconds (Beauchamp et al., 2022).

Mobility of older adults can also be measured with wearable sensors during walking. Wearable sensors are less expensive than whole-body motion analysis and other objective and quantitative fall risk assessment measures. One study found that a wearable sensor could measure gait variability, complexity, and smoothness, predicting falls in the following six months (Lockhart et al., 2021).

Environmental Hazards. Environmental hazards on the MAHC-10 include poor illumination, equipment tubing, inappropriate footwear, pets, hard-to-reach items, floor surfaces that are uneven or cluttered, or outdoor entry and exits (Calys et al., 2013). Examples from the literature on environmental risk factors for falls include slippery surfaces or spills on the floor. This can include water or urine on the floor in the home and extend to outside weather conditions such as rain, snow, or ice. Falls are common in places where older adults spend the most time, for example, kitchens, bedrooms, bathrooms, or living rooms. If an older adult cannot reach an item, they may have to use a stepstool, chair, or ladder to reach the item, which could be dangerous. Older adults may also trip on carpet edges or mats. Poor lighting is a risk factor if an older adult cannot see the path or obstacles. Lack of hand support in the bathroom and on steps or low or unsuitable seating may pose a risk. Suppose an older adult's footwear does not fit correctly or the grip is worn out, making an older adult slip. In that case, it is also dangerous if an older adult does not use or inappropriately uses their assistive device, which could also be an environmental risk factor (Keglovits et al., 2020).

A study in Portugal measured indoor and outdoor environmental hazards for older adults. Indoor hazards included poor lighting, slippery floors, loose rugs, cables, objects for climbing, steep stairs without handrails, kitchens with difficult access to items, bathrooms without handrails, showers, toilets with slippery surfaces, and beds that are not the proper height. Outdoor hazards were poor lighting, uneven surfaces (pavement, streets, sidewalks), obstacles, slippery floors, the presence of animals, and poorly fitting footwear. The presence of environmental hazards increases the likelihood of falling. The likelihood of a fall increased by 6.5% for each additional environmental hazard. Less than five environmental hazards were categorized as low risk, five environmental hazards were moderate risk, six to eight environmental hazards were high risk, and greater than eight risk factors were very high risk for falls (Pereira et al., 2021).

A national study that examined social and physical environmental fall-risk factors by racial group found that older adults with a history of falls were more likely to have lower incomes and education. Being in financial hardship increased their environmental risk factors due to their home being in disrepair and not having the financial means to fix their house or living in an area lacking sidewalks (Okoye et al., 2021).

Pain. In the validation study, pain was significantly related to faller status ($p=0.08$, odds ratio 0.76) (Calys et al., 2013). A Boston, Massachusetts, study researched the relationship between chronic pain and risk for injurious falls in community-dwelling older adults 70 years and older. The study found that pain interference and distribution were predictive of injurious falls. Pain interference is how much an older adult's pain interferes with their life. This includes general activity, housework, mood, walking, and relationships with people. According to the study, older adults who scored in the top third of the pain interference scores had a 61% greater risk of injurious falls than older adults who reported little to no pain interference. Pain distribution is identified if an older adult has pain in different locations on their body. Also, older adults with multisite pain had a 57% greater risk of injurious falls than those without pain. Pain severity did not predict injurious falls (Cai et al., 2021).

The effects of pain on a person's mental and emotional health are important. A study found an association with previous falls, pain, mild cognitive impairment, and depressive symptoms (Hirase et al., 2020). Multiple studies found that older adults with pain and depressive symptoms had a high rate of falling (Li et al., 2020; Rundell et al., 2021). Both pain and depressive symptoms independently predicted falls. Insomnia was not found to predict falls (Li et al., 2020). Older adults in pain also had slower walking speeds and lower cognitive processing speeds than non-fallers. Compared to older adults without pain, falls were associated with muscle weakness and low skeletal muscle mass (Hirase et al., 2020).

A study of Medicare beneficiaries examined the association of chronic conditions and physical performance in older adults with back pain. Lower physical performance was associated with having four or more chronic conditions: arthritis alone, arthritis combined with depression, and arthritis combined with depression and anxiety. Recurrent falls were associated with two to three and more than four chronic conditions. Older adults with arthritis, depression, and anxiety also had greater odds of falling than older adults with no or one condition (Rundell et al., 2021). Another study examined the impact of lower back and lower limb pain severity on recurrent falls in older adults. Severe lower back or lower limb pain was associated with an increased likelihood of recurrent falls in both males and females. For females, severe lower back or lower limb pain was associated with an increased likelihood of fall-related injuries (Tse et al., 2022).

Cognitive Impairment. Cognitive impairment on the MAHC-10 includes patients with dementia, Alzheimer’s, confusion, poor judgment, impulsivity, decreased comprehension, and memory deficits. If a patient cannot adhere to the plan of care, they could be given one point on the MAHC-10 for cognitive impairment (Calys et al., 2013). Falls are significantly associated with cognitive impairment (Monachan et al., 2020; Quach et al., 2019; Zhou et al., 2022). Orientation and memory were significantly associated with falls (Zhou et al., 2022). A study found that falls are associated with people with mild cognitive impairment and lower functional status, increased time spent on the walk and dual-task tests, and increased depressive symptom scores. For people with mind Alzheimer's, falls were associated with slower time on the TUG walk test, turn-to-sit phase, and a higher visuospatial domain score (Ansai et al., 2019). A study of community-dwelling older adults found a significant interaction between social engagement and mild cognitive impairment on the rate of falls. Higher levels of social engagement were not associated with falls compared to older adults with lower social engagement. Mild cognitive impairment was associated with a 1.3 times greater falling rate (Quach et al., 2019).

Comorbidity. Comorbidity is defined as being diagnosed with two or more chronic conditions. In the US adult population, it was estimated by the National Health Interview Survey that 51.8% of adults have at least one of ten selected diagnosed chronic conditions.

Approximately 27.2% of US adults have multiple chronic conditions. The ten selected chronic conditions are arthritis, cancer, chronic obstructive pulmonary disease, coronary heart disease, current asthma, diabetes, hepatitis, hypertension, stroke, and weak or failing kidneys. Chronic conditions are associated with worse quality of life, health care outcomes, increased death, and health care costs. Chronic condition prevalence increased with age and was higher in women (28.4%) than men (25.9%). Multiple chronic conditions prevalence was higher in non-Hispanic Caucasian adults (30.6%) and lowest among non-Hispanic Asian adults (16.4%). Adults living in rural areas (34.8%) had a higher prevalence of comorbidities than adults living in urban areas (26.1%) (Boersma et al., 2020).

After completing the MAHC-10 assessment, having three or more diagnoses was one of the most frequently identified risk factors by people who had fallen. Older adults who fell were 4.5 ($p=0.03$) more likely to have Parkinson's than those who did not fall (Brullo et al., 2022). In the validation study, three or more coexisting diagnoses were significantly related to faller status ($p=0.03$, odds ratio 1.83) (Calys et al., 2013). Higher rates of fall risk factors and comorbidities are also associated with a decrease in an older adult's perceived QOL (Pérez-Ros et al., 2019). The CDC STEADI also recommends assessing for comorbidities such as osteoporosis, depression, dementia, and incontinence (CDC, 2021).

Comorbidity Measures

Multiple methods have been developed to measure comorbidity. In the literature, the most common tools are the CCI, ACCI, Cumulative Illness Rating Scale for Geriatrics (CIRS-G), Index of Coexisting Diseases (ICED), Elixhauser Comorbidity Index, and Geriatric Index of Comorbidity (GIC). A review of the comorbidity measures will be presented in this section as a rationale for which measures were chosen for this study.

Charlson Comorbidity Index. The CCI was developed in 1986 by Mary Charlson (Charlson et al., 1987). Currently, the CCI is one of the best-known comorbidity indexes to predict mortality (De Groot et al., 2003; Stavem et al., 2017; Yang et al., 2018). The initial objective of the index was to create a comorbidity index to classify and weigh comorbid condition numbers and seriousness to predict the risk of mortality. The first cohort of 559 medical patients was admitted to receiving medical services from Cornell Medical Center. The first cohort had 1-year mortality rates for the scores of "0", 12% (181); "1-2", 26% (225); "3-4", 52% (71); and "greater than 5", 85% (82). The second cohort of 685 patients was treated for primary breast cancer at Yale New Haven Hospital. The second cohort had a 10-year follow-up, and the percent of patients who died due to comorbid disease for the respective scores were "0", 8% (588); "1", 25% (54); "2", 48% (25); and "greater than 3", 59% (18) (Charlson et al., 1987).

The CCI is a weighted index considering the seriousness of comorbid disease and the overall number of comorbid diseases. The CCI assesses 19 selected conditions weighted based on their association with mortality and summed to an index on a 0-33 scale (De Groot et al., 2003; Stavem et al., 2017). Conditions assigned a weight of one are MI, CHF, PVD, cerebrovascular disease, dementia, chronic pulmonary disease, connective tissue disease (CTD), peptic ulcer disease (PUD), mild liver disease, and diabetes. Conditions assigned a weight of two are hemiplegia, moderate or severe chronic kidney disease (CKD), diabetes with end organ damage, tumors, leukemia, and lymphoma. Moderate or severe liver disease is assigned a weight of three. Metastatic solid tumors and AIDS are assigned a weight of six. The CCI was compared to the Kaplan-Feinstein method to stage comorbidity. When comparing survival curves, the CCI and Kaplan-Feinstein methods could discriminate patients at very low risk of comorbid death

(Charlson et al., 1987). The CCI reliability and predictive validity have been assessed, and it has moderate to good test-retest and interrater reliability (De Groot et al., 2003; Stavem et al., 2017).

A study of 3,159 community-dwelling older adults in the US found a CCI greater than or equal to two predicted one-year mortality. Older adults in this study were transported by ambulance after a fall and hospitalized. This study also found that respiratory diagnosis, severe brain injury, and baseline disability were predictors. In the study, 665 (21.1%) older adults died within one year. The sample was 70% female, and the median age was 84 years. About 84% of the sample had at least one comorbidity (Newgard et al., 2022).

A higher CCI indicates increased severity of the condition (Charlson et al., 1994). In a study of older adults 55 years and older with hip fractures, the mean CCI score was 2.6. The mean age of this group was 79.3, with 64.6% female and 90.6% Caucasian. About 17.2% had a history of falls (Pierrie et al., 2019).

CCI scores predicted mortality rates for community-dwelling older adults 85 years and older after five years of follow-up. The CCI had a hazard ratio of 1.199 with a 1.082-1.330 95% confidence interval. (Formiga et al., 2016). The CCI can be used to predict long-term mortality. It has excellent inter-rater reliability, and the CCI has high agreement when the health information is collected from different data sources, for example, medical charts or self-reported. The CCI has concurrent validity with the ICED, Kaplan-Feinstein, and Elixhauser Index. The CCI has been used in different settings, including community-dwelling older adults, hospitalized patients, ED patients, and cancer patients (Charlson et al., 2022).

A study compared the CCI scores from chart reviews and administrative systems. Administrative system data utilizes the International Classification of Diseases, (ICD) ninth or tenth edition codes, and a benefit of the administrative system is that data can be collected from large patient groups. Chart reviews can be time-consuming and may result in higher CCI scores than those from administrative systems. The CCI scores from chart reviews and administrative data indicated good agreement and prediction of mortality in Intensive Care Unit patients in 30 days and one year (Stavem et al., 2017).

Age-Adjusted Charlson Comorbidity Index. The ACCI Index estimates the risk from comorbid disease and a person's age to estimate the risk of death. The initial validation study was 218 patients recruited in a hospital after they received elective general surgery. The ACCI combines the CCI with the age of the person. For each decade over 40 years old, one point is added to the risk. For example, a person who is 50-59 years old would score one point, 60-69 years would score two points, and 70-79 years would score three points (Charlson et al., 1994; De Groot et al., 2003). The ACCI has often been used as a mortality predictor in oncology and post-surgery studies (Charlson et al., 2022).

A Japanese study collected data from 1,720 community-dwelling older adults 60 years and older. This study evaluated the effects of comorbidities on fragility fractures. In older men, fragility fractures were positively correlated with rheumatoid arthritis and hip fractures. In older women, fragility fractures were positively correlated with rheumatoid arthritis and antihypertensive drugs. If an older adult had an ACCI index greater than six, they had a higher fragility fracture risk than those with an ACCI index of 1-3. The ACCI index and falls were also independently and strongly associated with a higher risk of fragility fractures (Garu et al., 2021).

The ACCI was also used to assess comorbidities in a large-scale cohort study throughout China. The study explored the association between ACCI, mortality, and readmission for older adult surgical patients. Patients were categorized by their ACCI score of greater than or equal to five or less than five. Of the 3,911 older adults, the average ACCI was 4.77. Patients with an

ACCI score of five or more had an increased risk for mortality and readmission compared to those with a lower ACCI score (Zhang et al., 2022).

One study compared the CCI, ACCI, and the Elixhauser comorbidity index for a cohort of 4,508 lung cancer patients treated by surgery in Taiwan. The cohort's mean age was 64.95 years, and 56.28% of the patients were male. The overall survival was 73.94% over three years. The study demonstrated that the CCI and the ACCI scores correlated well, and 3-year mortality risk was associated with higher scores. The AACI scores had better discriminatory ability for 3-year survival when compared to the CCI and Elixhauser comorbidity index scores (Yang et al., 2018).

Cumulative Illness Rating Scale for Geriatrics. The CIRS-G is used to assess the physical impairment of seniors with an emphasis on morbidity. The scale has 14 areas grouped under body systems. For each system, a scale of 0-5 is used to rate the involvement in that system. Zero equates to no problems affecting that system. One represents a current mild problem or past significant problem in that system. Two represents moderate disability or morbidity or require first-line therapy. Three represents severe problems or constant and significant disability or hard-to-control chronic problems. Four represents extremely severe problems, immediate treatment required, organ failure, or severe functional impairment. Five scores are yielded from the CIRS-G. The total number of categories endorsed, the total score, the ratio of total score/ number of endorsed categories (yielding a severity index per category), and the number of categories at levels 3 and 4 for a given client. When categorizing conditions, for example, dementia, in the CIRS-G, it would be categorized in psychiatry and neurology. Nurses, physician assistants, nurse practitioners, and physicians may complete this scale (Miller et al., 1992). The CIRS-G has been correlated to other comorbidity measures and has concurrent validity and good interrater and test-retest reliability (De Groot et al., 2003).

Other Comorbidity Scales. The ICED uses a two-dimensional structure to measure disease severity and disability. Symptoms, signs, and laboratory tests are used for scoring through a medical chart. The ICED has concurrent and predictivity validity, good intra-rater reliability, and fair inter-rater reliability (De Groot et al., 2003). A study of hemodialysis patients found that the ICED had adequate construct validity and reliability. Severe comorbidity was associated with older age, diabetes, lower level of education, unemployed or retired status, longer duration of dialysis, and lower serum creatinine (Miskulin et al., 2001). The ICED is used to predict a patient's physical function and disability and, compared to other morbidity measures, cannot predict mortality (Soh et al., 2020).

The Elixhauser Comorbidity Index is a comorbidity measure that uses large administrative inpatient datasets as data sources. There are 30 comorbidities in the original index and 31 comorbidities in the modified weighted index. Examples of comorbidities include congestive heart failure, hypertension, paralysis, diabetes, hypothyroidism, renal failure, liver disease, obesity, weight loss, alcohol abuse, drug abuse, and depression. The range of possible scores is -19 to +89 points. A lower score indicates a lower disease burden than a higher score, which indicates a greater disease burden (Van Walraven et al., 2009). The original index was created with a study population of inpatient hospital stays from 438 hospitals in California. Nonmaternal records of patients 18 years and older who received acute care hospitalization and were not discharged to another institution were included in the initial study (Elixhauser et al., 1998). The index has been used to predict in-hospital death, hospital charges, and length of stay. The Elixhauser Comorbidity Index in community-dwelling older adults with falls was significantly higher in patients who went to acute care vs. the ED (Adams et al., 2020). A modified version of the Elixhauser Comorbidity Index and the CCI expressed that deceased patients had a higher burden of comorbidities. The Elixhauser Comorbidity Index was associated with in-hospital mortality for patients hospitalized for severe acute respiratory syndrome for coronavirus (De Giorgi et al., 2020).

The GIC utilizes 15 clinic conditions graded on a disease severity scale of 0-4 points. Conditions include heart disease, stroke, diabetes, respiratory disease, and musculoskeletal disorders. The grading scale is 0 points for an absence of disease, 1 point for asymptomatic disease, 2 points for symptomatic disease requiring medication but under satisfactory control, 3 points for symptomatic disease uncontrolled by therapy, and 4 points for life-threatening or the most severe form of the disease. The GIC accounts for the severity of the disease and the number of diseases affecting the patient. The GIC then classifies patients into four classes. Class one represents patients with one or more conditions with a disease severity grade equal to or lower than one. Class four represents patients who have two or more conditions with a disease severity of three or one or more conditions with a disease severity of four (Zekry et al., 2010). The GIC, in some studies, is better at predicting mortality among inpatients in all hospital wards, including internal medicine and geriatrics. The GIC requires a trained physician to complete scoring (Soh et al., 2020). A study that compared the CCI, Elixhauser Comorbidity Index, and the GIC found that the GIC was associated with falls. The study population was 366 hospitalized patients 60 years and older (Canaslan et al., 2022).

Comorbidity Indices Summary. Multiple methods have been developed to measure comorbidity. The most common tools in the literature are the CCI, ACCI, CIRS-G, ICED, Elixhauser Comorbidity Index, and the GIC. The CRIS-G, Elixhauser Comorbidity Index, and the GIC have data requirements that go beyond the scope of this study's data set. For example, the CIRS-G was not chosen for this study due to the minimum database required. The CRIS-G may require labs and EKGs, which our dataset will not include. The CRIS-G also recommends scoring "live" patients compared to retrospective chart reviews to increase the scale's accuracy.

The CCI and ACCI were chosen for this study. The CCI is the most extensively studied comorbidity index that predicts mortality (Charlson et al., 2022). It has been used in different settings in different countries with patients in the hospital, nursing home, ED, and community (Charlson et al., 2022; Garu et al., 2021). Elderly, oncology, and preoperative patients have been studied with the CCI. The ACCI is adapted from the CCI to account for the risk of mortality from age. The ACCI can be advantageous because it combines age and comorbidity to have one less independent variable in regression analysis (Charlson, 1994).

Gaps and Limitations in the Literature

Nineteen fall prediction models were discussed in this literature review for community-dwelling older adults aged 60 years and older. Each of the different models addressed different components and risk factors of falls. The fall prediction models have no consensus on salient factors influencing falls. Common biological risk factors include demographic, chronic illnesses and symptoms, physical and cognitive, and affective capacities decline. Common behavioral risk factors are multiple use of medications and excess alcohol intake. Socioeconomic risk factors are educational level and lack of social interactions. Although biological, behavioral, socioeconomic, and fall-related risk factors were utilized in the fall prediction models, a gap in the literature is the impact of environmental risk factors on fall prediction models. Examples of possible environmental risk factors are poor lighting, uneven or slippery ground surfaces, or lack of proper footwear. The gap in the literature could be due to difficulty in assessing environmental risk factors in the home setting. Environmental risk assessments could be self-reported in an interview or survey, or healthcare practitioners could make home visits with environmental safety assessments.

A gap in the fall risk factor literature is that research studies operationalize each risk factor differently. For example, for the history of falls, the time between a previous fall and the assessment could range from 1 month to 1 year. Specific to the risk factor of medications, most fall prediction models use the number of medications as a measure of fall risk. Certain medications were addressed in some studies, but there was limited mention of dosing in the literature. Older adult falls are multifactorial and, therefore, difficult to address.

A limitation of the literature review is that each fall prediction model utilized different community-dwelling populations, so generalizing them to a larger context would be difficult. This review identified fall prediction models from the US, Japan, Spain, Canada, Denmark, Finland, Hong Kong, Italy, Korea, Netherlands, Sweden, Taiwan, and Germany. There was also only one fall prediction model study in Hawaii.

A gap in the literature related to screening tools is that there is no consensus on the best screening methods for fall risk and comorbidity in community-dwelling older adults. The MAHC-10 is a multifactorial tool validated as a fall risk assessment tool for the home care setting. Other fall risk assessment tools explored in this literature review were the STRATIFY, MFS, Hendrich II FRAT, Berg Balance Scale, TUG, and the POMA. Comorbidity tools in consideration were the CIRS-G, ICED, Elixhauser Comorbidity Index, and the GIC. Comorbidity measures were created and validated for the inpatient and long-term care setting. Comorbidity scales for the community setting are limited. The CCI and ACCI are validated for the community setting.

A limitation of this body of research is that community-dwelling older adults can be medically fragile and difficult to recruit into research studies based on their lifestyle. They may have vision, hearing, or mobility concerns that make them unlikely to participate in written, phone, or in-person research studies. Transportation issues may play a role in older adults accessing health care. Access to community-dwelling older adults, especially in rural areas, could be limited, and community leaders can access tight-knit communities. Community leaders may need to develop rapport with a researcher before allowing contact with the older adult population.

Conclusion

This literature review explored older adult fall risk factors using the Risk Factor Model for Falls (WHO, 2021), which includes behavioral, biological, socioeconomic, and environmental risk factors. Specific to community-dwelling older adults, a fall risk factor screening tool and two co-morbidity indices were identified. Several community-dwelling fall risk models were explored, and one model was used for community-dwelling older adults living in Hawaii. Nationally, the CDC developed the CDC's STEADI initiative to help reduce fall risk among US older adults. Fall prevention resources available through the STEADI initiative assist clinicians in integrating fall prevention into routine clinical practice.

Summary of Chapter Two

There were two objectives for Chapter two. The first objective was to analyze prediction models and report on which risk factors were most prevalently used in fall prediction models for community-dwelling older adults 60 years and older. Of the 19 fall prediction models, all risk factors used were categorized through the WHO model for Risk Factors for Falls in Older Age into biological, behavioral, socioeconomic, and environmental risk factors categories. The second objective of this literature review was to explore the different risk factors for falls and find appropriate tools and indexes to measure the selected risk factors. The risk factors identified in the model were age, gender, living arrangement, medication number, medication type, and comorbidity, which were then explored in the literature. FRAT and comorbidity measures were also explored, and the MAHC-10, CCI, and ACCI were chosen for this study. The gaps and strengths were identified for this body of literature.

Chapter 3. Methodology

Introduction

The purpose of Chapter 3 is to describe the project's methodology through a description of the study design, sample, setting, measures, procedures, and analysis. The chapter will also include a plan for the human subject’s protection, ethical considerations, and a timeline for this study.

Purpose

This research study aimed to develop a fall prediction model for community-dwelling older adults in Hawaii. Decreasing fall rates may lead to fewer fall-related injuries and hospitalizations, which could assist older adults to age in place and increase QOL. This study aimed to discover which fall risk factors provide the strongest indicators of falls among community-dwelling older adults in Hawaii. The second objective was to identify the best fall risk prediction model. A prediction model specific to the population could assist healthcare providers in identifying fall prevention interventions that could benefit the community.

Theoretical Model

Multifactorial Fall-Risk Conceptual Framework

The Multifactorial fall-risk conceptual framework by Feldman and Chadhury (2008) explains falls and fall-risk factors with three dimensions that include a person’s mobility, their environment, and their behavior. The first dimension is based on the mobility of the older adult. An older adult with high mobility will be able to perform movements with minimal effort, have a good range of motion, and do a variety of movements. An older adult with low mobility may have comorbidities that affect their movement. Parkinson’s Disease, a history of stroke, respiratory issues, and musculoskeletal issues are comorbidities affecting mobility. Older adults may develop balance issues, mobility limitations, muscle weakness, and gait changes as they age.

Risk-taking behaviors increase the chances of a fall. This domain can be influenced by emotions, culture, attitudes, perceptions of one's physical abilities, medications, level of attention, and environment. Older adults who are more cautious and less likely to take risk-taking behaviors are less likely to fall. The perceived abilities of an older adult to complete tasks must be adjusted for age-related changes. If an older adult's perceived ability does not align with their actual ability, they may attempt a risk-taking behavior, which could lead to a fall. For example, if an older adult wants to change a light bulb, they could attempt the light bulb change, or if they perceive that the task is at too high a risk, they may ask for assistance from a friend or neighbor. A desire to be independent may influence an older adult's risk-taking behavior.

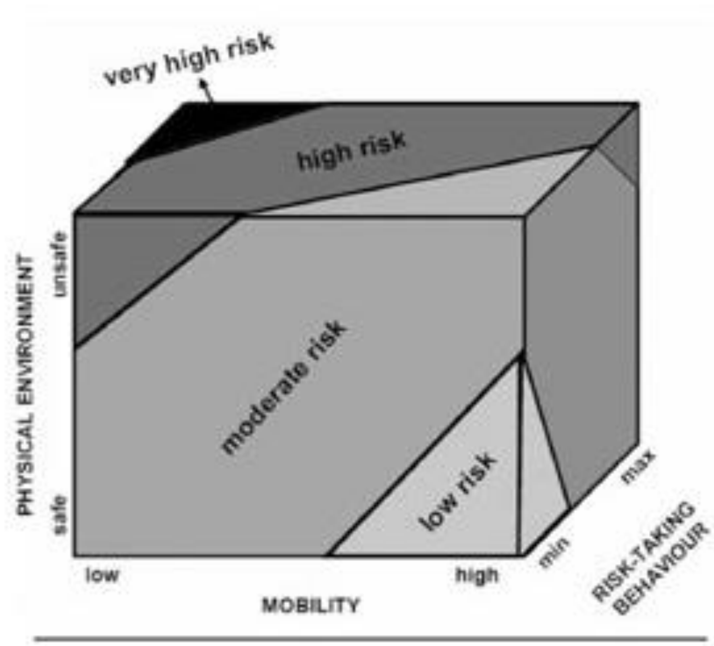
Environmental risk factors are the hazards or objects that increase fall risk in an older adult's environment. Poor Lighting, building or outdoor design, weather conditions, and conditions of walking surfaces are examples of environments that could put an older adult at risk for falling. A bathroom could have many environmental risk factors for falls, such as slippery surfaces, the absence of grab bars in the shower, or a malfunctioning bathroom light (Bégin et al., 2021).

A person with limited mobility or maximum risk-taking behavior would be at moderate risk for falls independent of the other two dimensions. Physical or psychological conditions and medications that increase the risk of falls affect a person's mobility and risk-taking behaviors.

Figure two represents the three-dimensionality of the multifactorial fall risk framework. The x-axis represents mobility (low to high), risk-taking behavior (minimum to maximum) is represented by the y-axis, and the z-axis represents the physical environment (safe to unsafe). If an older adult had high mobility, minimum risk-taking behavior, and a safe physical environment, he would be at low risk for falls. For example, an older adult living in an apartment must walk up and down the steps to go and buy groceries. If the older adult was in good physical health, was very careful, took his time, and had no environmental risk factors, walking up and down the steps could be a low-risk activity.

Conversely, if an older adult had low mobility, maximum risk-taking behavior (reckless), and an unsafe physical environment (many environmental risk factors), he would be at high risk for falls. In our older adult going out to the grocery store, for example, if the older adult had a medical condition that caused him to become dizzy or short of breath when doing physical activity, this would put the older adult at higher risk for falling. Environmentally, if the steps did not have a handrail, had poor lighting, became slippery when wet, or the person was wearing worn-out shoes, that would increase the fall risk. Behavior risk factors that could be considered include if the person was in a rush or not paying attention while walking down the steps. The multifactorial falls risk framework visually represents the complex phenomena of older adult falls (Bégin et al., 2021; Feldman & Chaudhury, 2008).

Figure 2. Multifactorial Falls Risk Conceptual Framework utilizing Mobility, Risk-Taking Behavior, and Physical Environment



Risk Factor Model for Falls

According to the Risk Factor Model for Falls by the WHO (2021), introduced in Chapter 2 and illustrated in Figure 1, older adult falls are multifaceted and are affected by the interaction between various fall risk factors. Fall risk factors can be categorized into biological, socioeconomic, behavioral, and environmental domains. Biological risk factors relate to the human body. Examples of non-modifiable biological risk factors are age, gender, and race. Biological risk factors include chronic illness (co-morbidities) and physical and cognitive decline. Behavioral risk factors are based on older adults' actions, emotions, and daily choices. Behavioral risk factors include multiple medication use, inactivity, inappropriate footwear, and excess alcohol intake. Environmental risk factors are represented by the older adult's physical conditions and surrounding environment. Examples of home hazards are slippery surfaces in the bathroom, stairs, or poor lighting. Older adults can also experience fall risk factors outside their homes in public areas, such as uneven sidewalks, poor building designs, or unfavorable weather.

Socioeconomic risk factors include social and economic status and the effect of the community on these factors. Social isolation, low income, inadequate housing, or a lack of health and social care are examples of socioeconomic risk factors.

All four risk factors affect falls and fall-related injuries. The risk factors also increase an older adult's risk of falling. For example, an older adult who lives in an area with cracked or uneven sidewalks could begin to limit their exercise because they do not feel safe in their environment. This would also decrease their potential for social interactions if they do not want to venture out into the community. In the long term, this could increase their chronic illnesses and lead to physical and cognitive decline, increasing their risk for falls and fall-related injuries (World Health Organization, 2021; Qian et al., 2021).

Research Design

The research design of this study was a retrospective secondary data analysis. This study aimed to discover which fall risk factors provide the strongest indicators of falls among community-dwelling older adults in Hawaii. A model was developed using multiple regression analysis to identify which assessment tools and fall risk factors predicted falls. This study was a secondary analysis of the Hawaii Department of Health (DOH) Public Health Nursing Branch (PHNB)'s MAHC-10 fall risk assessment data.

Measures

The following is a description of the measures used in this study. The measures are demographics, MAHC-10 score, living arrangements, number of medications, type of medications, CCI score, ACCI score, and fall.

Dependent Variable

The primary dependent variable was whether the community-dwelling older adult fell within six months of the MAHC-10 fall risk assessment completion date. Information about the fall was collected through the binary categorial variable (yes or no). Descriptive statistics about the fall included the date the older adult fell, their disposition after the fall, and related injuries. The categorical variable for disposition is defined as the patient's destination after the fall and includes home, ED, long-term care facility, hospital, and death. Injuries from a fall are categorical variables. The categories include no injury, bone fracture, strained/ torn ligament, head injury, laceration, bruising, and death. Descriptive statistics were also collected on the reported cause of the fall.

Independent Variables

There were eight independent variables in this study. Independent variables were the MAHC-10 fall risk assessment score, age, gender, living arrangement, number of medications, medication type, the CCI score, and the ACCI score.

Demographics. This study collected demographic information on older adults' age, gender, and ethnicity. Age was a continuous variable measured in years for this study. Gender was a categorical nominal variable (male or female). Ethnicity was a categorical variable and was identified as the primary ethnicity of the older adult according to the PHNB charting definition. Types of ethnicities coded in this study were American Indian, African American, Caucasian, Filipino, Hawaiian, Hispanic, Japanese, Korean, Marshallese, Micronesian, Other-Asian, Other Pacific Islander, Samoan, Tongan, and Vietnamese. Mixed ethnicity is when the older adult has two or more ethnicities and does not identify one over the others as primary.

Other ethnicity was defined as when an older adult states that they are an ethnicity not listed above.

MAHC-10. The MAHC-10 has been chosen as the fall risk assessment tool because it was multifactorial and validated for the home care setting. It is also validated for the CMS OASIS-C. The DOH PHNB is currently using the MAHC-10.

PHNs used the MAHC-10 to assess the ten types of fall risk factors. If the patient had one of the risk factors, a point is documented on the MAHC-10. There were a total of 10 potential risk factors assessed. The MAHC-10 score ranged from 0-10 points. In this study, the MAHC-10 total score was calculated manually by the PHNs and checked using the data column fields via calculations in the master data set. Two scores were used as cutoff scores. This study compared the risk for falls cut-off scores of four and six points as identified by the literature (Calys et al., 2013). The study also collected dichotomous variables of the MAHC-10 core elements, which include age over 65 years, three or more co-existing diagnoses, prior history of falls within three months, incontinence, visual impairment, impaired functional mobility, environmental hazards, polypharmacy (four or more prescription medications), pain affecting the level of function, and cognitive impairment. Categorical variables were created for MAHC-10 total score cut-off values.

Living Arrangements. Living arrangements were a categorical variable defined as whether an older adult lives alone or with others. Others included family, friends, or roommates. Clients who lived with other members of their families or had full-time or part-time caretakers who resided with them in their homes were defined as not living alone. Clients who were the only person in their household and lived alone in an owned or rented residence were defined as living alone.

Number of Medications. The number of prescription medications an older adult takes was a continuous variable.

Medication Type. Medication type was defined as if the older adult takes a type of medication classified as high risk for falls. This variable was a categorical binary variable and was answered as yes or no. Binary variables were collected for an older adult's different medication types: antidepressant, sedative-hypnotic, benzodiazepine, anticonvulsant, antispasmodic, antipsychotic, opioid, antihypertensive, and combination medications. The number of high-risk medications was assessed as a continuous variable and expressed in whole numbers representing the number of high-risk medications the older adult takes during the MAHC-10 assessment.

Charlson Comorbidity Index. The objective of the CCI was to predict the risk of death from comorbid disease. The CCI accounts for the number and seriousness of the comorbid diseases that an older adult has. The CCI was a weighted index that assigns a point for MI, congestive heart failure, PVD, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatologic disease, ulcer disease, mild liver disease, and diabetes. Two points were assigned for hemiplegia, moderate or severe renal disease, diabetes with end organ damage, tumors, leukemia, and lymphoma. Three points were assigned to moderate or severe liver disease, and six points were for metastatic solid tumors and AIDS. The total of the weighted points equals a score (Charlson et al., 1987). A score ranges from 0 to 33 points; the higher the score, the larger the comorbidity burden. The CCI scores were manually calculated and checked using calculations in the data column fields of the master data set (Appendix D). Categorical binary variables were created for all comorbidities included in the CCI and ACCI. Categorical variables were also created for CCI total score cut-off values.

The CCI has been used with different populations with moderate to good test-retest reliability and validity. Methods for data collection for the CCI were chart review and administrative data through ICD-10 codes. Chart reviews may give a higher prevalence of comorbidities than administrative data and higher predictive capacity due to the intense nature of utilizing all available medical record information. The limitations of chart reviews were that it is time-consuming and may constrict sampling from large groups compared to administrative data (Charlson et al., 1987; Stavem et al., 2017).

Age-Adjusted Charlson Comorbidity Index. The ACCI combines the effect of age and comorbidity. The ACCI was graded the same as the CCI, but zero to four points were added for age. If a person is less than 50 years old, zero points were added to the CCI score. One point was added to the CCI score if a person was 50-59 years old. If a person was 60-69 years old, two points were added; for 70-79 years, 3 points were added; and over 80 years, four points were added to the CCI score. In this study, the CCI score was added to the appropriate age points to calculate the ACCI score manually and in the master data set using calculations. The ACCI score ranges from 0-37 points. It is suggested that age may not significantly predict mortality in studies with less than five years of follow-up, and researchers should use the CCI. Also, for regression analysis, it is appropriate to separate age and the comorbidity burden of comorbidity on the dependent variable (Charlson et al., 1994). Due to the small sample size, this study considered combining variables for age and CCI. Therefore, this study collected ordinal data for the ACCI. Categorical variables were created for ACCI total score cut-off values.

Participants

The sample is comprised of community-dwelling older adults living in Hawaii (Oahu, Hawaii Island, Maui, Molokai, Lanai, and Kauai) who received PHNB services. PHNs are registered nurses that work with individuals and families to promote health and wellness. The overall purpose of PHN services is to help older adults manage their care through case management services to remain safely in their homes for as long as possible. PHNs work with frail, vulnerable elderly 60 years and older with functional limitations to provide comprehensive nursing assessments via home visits, care planning, and coordination of service delivery. Older adults are eligible for PHN services if they are over 60 years old, living at home, and have a chronic medical condition. PHNs may support older adults who have no family or caregiver available or have a caregiver in need of support. Older adults who receive PHN services may also need assistance in understanding their medical condition or need assistance finding resources in their community. PHNs also provide Memory Care Navigation.

Inclusion criteria for this study were community-dwelling individuals over 60 years old, residing in Hawaiʻi while the data was collected, and receiving PHNB case management services. For purposes of this study, eligible participants must have been enrolled in PHNB services for at least six months after an MAHC-10 fall risk assessment was completed or had fallen during the six months after the MAHC-10 fall risk assessment. Exclusion criteria included individuals younger than 60, living in a long-term care facility or a nursing home, who resided outside of Hawaiʻi during the data collection, or who did not receive PHNB case management services. Individuals discharged before six months from the MAHC-10 assessment and who did not fall during PHNB services were excluded from this study.

The proposed sample size depended on the number of independent variables used in the models. The recommendation for the minimal total sample size approach is 10 cases of data for each predictor in the model (Riley et al., 2020). For example, a sample with at least 50 fall events would be appropriate if the model had five independent variables. According to the CDC, about one in four older adults fall annually (CDC, 2021). Therefore, the sample size for this data analysis was approximately 200 older adults. A convenience sample and secondary data analysis were performed using the Hawaii DOH PHNB case management falls data set and electronic health record from January 2019 to December 2022.

Procedures

Data Collection

This study was a secondary data analysis of the Hawaii DOH PHNB's electronic health record. The secondary data was extracted from the PHNB MAHC-10 fall risk assessment Excel spreadsheet, PHNB electronic health record, and Public Health Nurse (PHN) 10 database.

Data sources within the PHNB electronic health record include the MAHC-10 fall risk assessment database, the individual client records, and the PHN-10 registration database. The MAHC-10 fall risk assessment database detailed the older adult's demographics, MAHC-10 total score, MAHC-10 core elements, and fall history. The individual client record was navigated by tabs and reports on the client's medication, diagnoses, and ethnicity. The PHN-10 registration database was used to identify demographic data.

Information from the individual client record and PHN-10 registration was used to calculate the CCI and ACCI. All comorbid diseases weighted and unweighted in the CCI were inputted into the master data set and were both manually calculated and checked using calculations. For the ACCI total score, the age of the client was translated into age-adjusted points and added to the CCI score by manual calculation and calculations in the master data set.

The notes section reviewed the medication tab, point of visit tab, visit records, PHN summary, and adult/ elder profile to ensure that data was complete. The PHN-10 registration database was utilized for demographic data. The PI contacted the primary PHN for clarification if data was missing or unclear. Data was analyzed for each older adult starting from the MAHC-10 fall risk assessment date, and falls were tracked for the following six months. A convenience sample of older adult clients receiving case management services from PHNB between the time of January 2019 to December 2022 was compiled. All clients that met the inclusion criteria were included in the study.

Priori power analyses using G*power version 3.1 were conducted to determine the minimum sample size for this study. For a Wilcoxon rank sum test and a Cochran Armitage test for trend, results indicated the required sample size to achieve 95% power for detecting a medium effect (d=0.5), at a significance criterion of α= 0.05, was N= 57. For a Chi-square, results indicated the required sample size to achieve 95% power for detecting a medium effect (w=0.3), at a significance criterion of α= 0.05, was N= 145. For multiple logistic regression, results indicated the required sample size to achieve 95% power for detecting a medium effect (f^2=0.15), at a significance criterion of α= 0.05, and 5 predictor variables were N= 138. Results indicated the required sample size to achieve 95% power for detecting a medium effect (f^2=0.15), at a significance criterion of α= 0.05, and 10 predictor variables were N= 172 (Faul et al., 2009). A convenience sample was guided by Power analysis to determine the minimum number sample size needed. There were 211 records reviewed. Data collection was from January 2023 to April 2023.

Bias Control

All PHNs attend annual training on how to collect demographic data, complete the MAHC-10, review diagnosis and medications, and screen for history of falls. The annual standardized training is facilitated through the PHNB Elder Health Committee. PHNs have standardized training on home visiting and completion of the MAHC-10. During the annual renewal of MAHC-10 training, PHNs practice the instruments in a group setting and work together on hypothetical written case studies. Topics covered include the MAHC-10, definitions of a fall, fall high-risk medications, and inputting data onto the spreadsheet and in the Electronic Health Record. At the end of the training session, PHNs who do not achieve an acceptable level of performance are retrained individually by senior members of the Elder Health Committee, and all questions are answered. If PHNs have questions about elder health practice, they may ask the elder health committee representative. Being properly trained in the implementation of the screening tools mitigates interviewer bias. Collecting demographic data, fall history, the MAHC-10, and documentation are currently a part of PHNB practice. Although training on the PHNB elder health policy for home visits and documentation is updated annually, practice drift may occur. Practice drift may happen over time, where clinical practice may deviate from the policy and procedure. Practice drift is unintended in settings and may be caused by the normalization of deviance through well-intentioned actions (Harvey & Sotardi, 2017). The PI identified no practice drift issues during this study.

Dual Role of the PI

The PI held two roles. The first role was of a nursing student completing their dissertation. The second role was of a PHN for the Hawaii DOH. In the Spring of 2022, the PI met with the PHNB Branch Chief and Quality Assurance Coordinator and got approval to conduct the research at PHNB. The PI was given access to the PHNB electronic health record and senior PHNs throughout the state through the Elder Health Committee. The PI communicated the dual role with PHNB. When in the student role, the PI completed chart reviews, data analysis, and meetings with PHNB; the PI was on leave or off work hours.

Data Management

Data was managed using Microsoft Excel. A data dictionary was maintained for all variables with inclusion and exclusion criteria. All data sources were deidentified, and hard copies were kept in a locked file cabinet. The confidentiality of the participants was maintained through codes assigned to individuals and their records. All digital data was kept on the encrypted One Drive Site that PHNB uses for health data and personal information. If the research is published, the participants will not be identified in any way. Aggregated data will depict results.

Analysis

Data Cleaning

Incorrect, duplicate, or otherwise erroneous data was clarified through the electronic health record and interviewing the PHN. All efforts were made to complete the dataset. There were no excluded cases for incomplete data.

Data Analysis

Collected data was entered into SPSS version 25, and Microsoft Excel was used for analysis. Frequencies and percentages for categorical variables were expressed through descriptive analysis of the demographic data and means and standard deviations for continuous variables.

This model development study utilized the PHNB older adult individual client data. This study developed a prediction model and tested the model’s predictive performance on the same development data set.

Research Question One

Which fall risk factors provided the strongest indicators of falls among community-dwelling older adults in Hawaii? The analyzed fall risk factors included the MAHC-10, age, living arrangement, gender, medication number, medication type, CCI score, and ACCI score.

Bivariate associations between the dependent variable fall and each independent variable (MAHC-10, age, living arrangement, gender, medication number, medication type, CCI score, and ACCI score) were calculated. A nonparametric two-sample Wilcoxon test was performed for the continuous independent variables of age, number of medications, and number of high-risk medications.

A Wilcoxon rank-sum test was conducted to test the difference between the two groups on the independent variables of age, number of medications, and number of high-risk medications. In this study, the two groups were those who had fallen and those who had not fallen. The test statistic U was calculated with an equation involving the sample sizes of the two groups and the sum of ranks for group 1. If the $p<0.05$, then there was a significant difference between the two groups. The effect size was calculated by converting the z-score into the effect size estimate r. Effect size values were interpreted as less than 0.3 (small effect), 0.3- less than 0.5 (moderate effect, and greater than or equal to 0.5 (large effect). Assumptions included that the two samples were independent and that the two populations had equal variance (Field, 2018).

For the nominal categorical independent variables of gender, living arrangements, MAHC-10 total score of four, five, six, seven, and eight or more, falls high-risk medication type, CCI score of two, three, four, and five or more, and ACCI score of four, five, six, seven, and eight or more, nonparametric Pearson chi-square test or Fisher’s exact test (when there are small cell counts) was performed. Odd Ratio and its 95% confidence interval and p-values were calculated.

A Pearson's chi-square test was used to analyze the relationship between falls and the independent categorical variables. A Pearson's chi-square test compared the observed frequencies with the categories obtained by random chance. The Chi-square distribution was calculated for the degrees of freedom (r-1) (c-1). The r variable represented the number of rows, and the c variable represented the number of columns. If the observed value was bigger than the critical value (degrees of freedom), then one would say that there was a significant relationship between the two variables. It was significant if the observed chi-square was larger than the critical value. The Chi-square test statistic, degrees of freedom, and p-values were reported.

Assumptions for Pearson's chi-square test were that the data was independent. Each participant or item contributed only to one contingency table cell. Another assumption was that there were no expected values below five when using a two-by-two contingency table for two categorical variables with two categories. This assumption of expected frequencies is essential because test power will be reduced if it is not followed (Field, 2018).

The Cochran-Armitage test for trend and univariate logistic regression was performed for the ordinal categorical independent variables of the MAHC-10, CCI, and ACCI total score.

A logistic regression demonstrates how one variable changes at varied levels of the other. For the logistic regressions, association with a fall and the independent variables was calculated using odds ratios (ORs) and confidence intervals (CIs). Alternatively, it measured the association between an exposure to a variable of interest and an outcome. The OR was used to examine risk factors for falls. OR represented the change in odds from a unit change in the predictor variable. If a value is greater than one, it means that as the predictor increases, the odds of the outcome occurring increase (exposure to the associated factor increases the odds of the outcome). If a value was less than one, it meant that as the predictor increases, the odds of the outcome occurring decreased (exposure to the associated factor decreased the odds of the outcome). The CIs represented the precision and the expected range of the OR. If the width of the CI was large, it meant there was a low level of precision of the OR. If the width of the CI was small, it meant there was a high level of precision of the OR. If the CI included the number one, then the OR was not statistically significant. The expected OR could be above or below one, meaning that it is uncertain if there is an increase or decrease in the odds of a fall regarding the confidence level (Szumilas, 2010).

An alpha of 0.05 was used for this study, which meant there was a 5% false positive risk of concluding that an association existed when there was no association. If the p-value was less than or equal to 0.05, then there was a statistically significant association between the variables. If the p-value was greater than 0.05, then one cannot conclude that there was a statistically significant association between the variables. The association was not statistically significant.

Assumptions for logistic regression were independence of errors, linearity in the logit for continuous variables, absence of multicollinearity, and lack of strong influential outliers. It is recommended that there be a minimum of 10 to 20 events per covariate to address overfitting a model (Stoltzfus, 2011).

Research Question Two

Research question two was about which fall risk indicators could be used to develop a fall prediction model for community-dwelling older adults in Hawaii. Fall risk factors included the MAHC-10, age, living arrangement, gender, medication number, medication type, CCI score, and ACCI score. This section explored the receiver operating characteristic (ROC) curve, sensitivity, specificity, and multiple logistic regression.

An area under the ROC curve (AUC) was analyzed for the numerical variables of the MAHC-10, the CCI, and the ACCI total score. The C-statistic or AUC statistic was presented with a p-value and 95% confidence interval. AUC was a standard method used to assess the discriminative ability of prediction models to discriminate between diseased and non-diseased individuals or a binary event like a fall.

An AUC can range from 0.5 to 1; a higher value means the model discriminated better. An AUC value of less than 0.6 was considered poor. AUC values between 0.7 to 0.8 was acceptable. An AUC value above 0.8 was considered excellent. When adding or subtracting predictors from models, the models were the same if the AUC did not change (De Hond et al., 2022; Janssens & Martens, 2020).

The sensitivity and specificity of the tools and models were calculated. These measures examined if a screening tool or model predicted an outcome accurately. Sensitivity measures the ability of a screening tool or model to identify a person with a positive result who has the condition. Sensitivity was the number of true positives divided by the number of true positives plus the number of false negatives. Specificity measures the ability of a screening tool or model to identify a person with a negative result for a person who does not have the condition. Specificity was the number of true negatives divided by the number of true negatives plus the number of false positives (Swift et al., 2020).

A multiple logistic regression was chosen for this analysis. The independent variables were used to predict the dependent variable falls. Logistic multiple regressions allowed the dependent variables to be categorical and the independent variables to be categorical or continuous. This analysis allowed for predicting the probability of Y (falls) from the predictor variables Xs (independent variables that were chosen). Values of P(Y), the predicted value, ranged from 0-1. Values closer to 0 mean that a fall was unlikely, and values closer to 1 indicate that a fall was very likely to have occurred.

Due to the dependent variable being categorical, the data was transformed using logarithmic transformation. The categorical data was transformed into linear data through logit so that the assumption of linearity was not violated.

The maximum-likelihood estimation selected coefficients that made the observed values most likely to have occurred. Log-likelihood was used to analyze the model's fit using the sum of the observed and predicted values probabilities. Log-likelihood represented the amount of unexplained information after the model was fitted. Large log-likelihood values indicated a poorly fitting statistical model due to unexplained observations (Fields, 2018).

The R-statistic analyzed the partial correlation between the dependent and independent variables. The value ranged between -1 and 1. A negative value meant that the independent variable increased the likelihood of the outcome occurring. If the variable had a small value of R, it contributed a small amount to the model. Goodness-of-fit tests determined if predicted probabilities deviated from the observed probabilities in a way not predicted by the binomial distribution. The Hosmer-Lemeshow test was a goodness-of-fit test with a value greater than 0.05, indicating insufficient evidence to demonstrate that the model does not fit the data. The value ranged between 0 and 1, 0 representing that the predictors are bad and one representing that the model predicts the outcome variable perfectly. A p-value lower than 0.05 indicated that the predicted probabilities deviated from the observed probabilities and that there was enough evidence that the model did not fit the data. Common reasons for deviation were incorrect link function, omitted higher-order terms for variables in the model, omitted predictor that is not in the model, or overdispersion. The Hosmer-Lemeshow test was a more trustworthy test of how well the model fits the data when data has few trials per row.

The predictors were entered into the model using hierarchical regression. This method was chosen because it allows for more control by the researcher to choose the variables that remained in the model. First, the model was fit with all potential predictors. Then, predictors were systematically removed or added through informed decisions based on their contribution to the model. Predictors were removed or added from the model based on the results of the first research question. Hierarchical was chosen over the forced entry and stepwise methods.

Assumptions for logistic regression included linearity, independence of errors, lack of strongly influential outliers, and absence of multicollinearity. The assumption of linearity is applied to continuous predictors and the log of the outcome variable. If the assumption of independence of errors was violated, then overdispersion occurs. Overdispersion happened when the variance was larger than expected from the model. Overdispersion made the standard error too small, making test statistics big and falsely deemed significant. A small standard error could also influence confidence intervals by making them narrow. There may be a concern if the dispersion parameter approaches or is greater than 2. Cook's Distance was calculated to examine if there were influential outliers. Cook's distance measured the overall influence of a case on a model. Values greater than one may be concerning. Values were removed, replaced with the mean, or kept in the model. A note was made if the value was kept when reporting the results. Multicollinearity was assessed using the variance inflation factor (VIF).

Low levels of collinearity were acceptable. The VIF was a measure that a predictor had a strong linear relationship to another predictor. Generally, VIF should be less than 10. If a VIF is greater than 10, it is a cause for concern. The tolerance statistic represents (1/VIF). If the tolerance was below 0.1, that indicated a serious problem. If tolerance was below 0.2, that indicated a potential problem. Suppose there was a high collinearity level and the b coefficient's standard error increased. In that case, the size of R was limited, and it was difficult to determine the importance of predictors (Fields, 2018).

Logistic Regression Procedure

The following steps outlined the procedure for conducting a logistic regression:

1. Ran hierarchical regression to compare models and choose the most parsimonious model that best fits the data.
2. Ran final regression on the chosen model and saved diagnostic statistics.
3. Checked for bias by identifying influential cases (Cook's distance, Leverage (hat)values) and outliers (Standardized residuals, DFBeta).
4. Checked for linearity of the logit.
5. Checked for multicollinearity by rerunning as linear regression and checked collinearity statistics (Fields, 2018).

Possible Threats to Internal and External Validity

Internal validity represents the confidence that other factors or variables do not influence the construct under study. The internal validity threat of history described specific events that participants experienced throughout this study. The threat of history was especially pertinent to this study. In the Hawaii DOH PHNB's MAHC-10 fall risk assessment dataset, older adult fall status was monitored six months after completing the MAHC-10 fall risk assessment. Due to the long timeframe of the collection of data for this study, common everyday occurrences potentially affected participants' outcomes. For example, if the participant experienced adverse side effects associated with medical treatment, had changes to their caregiving structure or family, or had their activity level or personal well-being restricted by a pandemic, these factors affected internal validity.

An internal validity threat through maturation involved the participant's bodily changes. The potential impact of this threat was also high. These could include age-related biological changes, disease progressions, fatigue, hunger, or illness. This study involved a long timeframe and included elderly participants who may have experienced multiple health-related issues throughout the study. Participants may have experienced daily changes such as tiredness, hunger, or sadness. A PHN assessed client fall risk during home visits when clients were at baseline. Health records from other providers were also used for medication reconciliation and health history.

Testing could threaten internal validity if the participant became more conscious of the study's topic of interest after taking the initial measures. The participant could take steps to improve their status after the test. Suppose measures or tests are embedded in a routine. In that case, they are less likely to cause validity threats - for example, if the fall risk assessment was done when obtaining the patient's vital signs and other assessments. This study reviewed patient's charts and is an example of a method that could be a useful nonreactive measure.

Instrumentation could threaten internal validity if the means of measuring the dependent variable changed. This could be related to human researchers who observe, assess, and rate a measure. Standardization of training for researchers and experience levels of the researcher affect instrumentation. PHNs have a standardized training (overseen by the PHNB elder health committee) for older adult case management that is reviewed annually. However, the drift in each PHN technique for data collection during the one year may be possible.

The selection of participants to serve in the study can produce bias in the study's results. Scheduling, participant consent timing, or participants' geographic location could all contribute to selection bias. In this study, participants were sampled from multiple geographic locations across Hawaii at differing times of the day and types of community-dwelling structures (Flannelly et al., 2018).

External validity was the ability to generalize the research to the general population. A threat to external validity was interactions of the causal relationship with the setting. If participants were recruited from a specific setting, results may not be generalizable to other settings or the general population. Sampling bias occurs if the sample being studied does not represent the population. Sampling characteristics such as age, gender, or geographic location may limit generalizability to the population. The PHNB database sampled older adults with differing demographic characteristics from different geographic locations throughout Hawaii. The sample of older adults was also enrolled in PHNB service, which may create bias because PHNB clients were referred for various reasons and are usually medically fragile (Matthay & Glymour, 2020).

Human Subjects (IRB/ Ethical Considerations)

This was an approved exempt study by the University of Hawaii Institutional Review Board (IRB). The protocol identification number is 2022-01016. This study was a secondary data analysis of the Hawaii DOH PHNB's electronic health record and carries potential risks to the participants. Potential risks included loss of privacy. The PI took precautions to decrease the potential for the loss of privacy, as described in the data management section. There were no specific benefits to the individual client.

Summary Timeline

Data was collected from PHNB from January 2023 to April 2023. Data was analyzed from May 2023 to July 2023.

Summary of Chapter Three

This chapter described the methods for this study to discover which fall risk factors provide the strongest indicators of falls and to develop a fall prediction model for community-dwelling older adults in Hawaii. The chapter also explored relevant theoretical models, the research design, procedures, and analysis of this study.

Chapter 4. Results

Introduction

This chapter will discuss the results of this study by first describing the demographic characteristics of the cases and addressing the research question of which fall risk factors provide the strongest indicators of falls among community-dwelling older adults in Hawaii. This chapter will also discuss which fall risk indicators could be used to develop a fall prediction model for community-dwelling older adults in Hawaii. Finally, the multiple logistic regression models developed, diagnostics, and final model selection will be discussed.

Descriptive Statistics

Data was analyzed from the Hawaii Department of Health PHNB fall database, and 580 elder client charts were identified between the years 2018 to 2023. One hundred fifty-four duplicate charts were removed, and 426 charts were identified. Of those 426 charts, 215 were removed because the client was discharged before six months with no fall. A total of 211 charts were identified to fit the inclusion criteria of this study and were included in the analysis.

The mean age of participants was 78.16 years (SD= 9.04), and 117 (55.5%) were women. Table 1 describes the sample's age distribution, and Table 2 describes the ethnicity of the sample. The most common ethnicities were Caucasian at 44.1% (n=93), Asian at 32.2% (n=68), and Native Hawaiian or Other Pacific Islander at 21.3% (n=45). Ninety-seven (46.0%) of older adults lived alone.

The mean MAHC-10 total score was 6.41 (SD=1.8), and 141 (66.8%) participants had a MAHC-10 total score greater than 6 points. The mean CCI score was 3 (SD= 1.9), and the mean ACCI score was 6.2 (SD=2). The mean number of medications was 5.8 (SD=3.6), and the mean number of at-risk medications was 1.9 (SD=1.5).

Overall, 27.0% (n=57) of participants reported a fall six months after PHNB admission. Approximately 36.8% (n=21) of clients who fell did not incur a fall injury. The most common injuries were bruises 22.8% (n=13) and lacerations 19.3% (n=11). Of those community-dwelling older adults who fell, 12.28% (n=7) had a head injury, 6.00% (n=3) had a strained ligament, and 3.50% (n=2) suffered a fracture. After a fall, 66.7% (n=38) of the clients stayed home or went to the hospital 19.3% (n=11). Of the older adults who fell, 10.53% (n=6) went to the ED, and 3.51% (n=2) went to a long-term care facility (Table 3). The mean age of the older adults who fell was 79.35 (SD=8.7), and 27 (47.4%) were women. Of the older adults who fell, 27 (12.8%) lived alone. The mean MAHC-10 total score was 7.23 (SD=1.6), and 49 (86.0%) of the older adults who fell had a MAHC-10 total score greater than 6 points. The mean CCI score was 3.6 (SD= 2.1), and the mean ACCI score was 6.9 (SD=2.1). The mean number of medications that older adults who fell took was 6.1 (SD=3.6), and the mean number of at-risk medications was 2.1 (SD=1.6).

Table 1. Sample Age

Age (Years)	Total		Fall			
	N	(%)	Yes	Yes (%)	No	No (%)
60-69	45	21.33%	10	22.22%	35	77.78%
70-79	72	34.12%	21	29.17%	51	70.83%
80-89	73	34.60%	20	27.40%	53	72.60%
90-99	21	9.95%	6	28.57%	15	71.43%

Table 2. Sample Ethnicity

Ethnicity	Total		Fall			
	N	(%)	Yes	Yes (%)	No	No (%)
Asian	68	32.23%	19	27.94%	49	72.06%
Native Hawaiian or Other Pacific Islander	45	21.33%	9	20.00%	36	80.00%
Caucasian	93	44.08%	29	31.18%	64	68.82%
Other	5	2.37%	0	0.00%	5	100.00%

Table 3. Injury and Disposition of Older Adults who Fell

	N	Yes N	Yes %	No N	No %
Fall	211	57	27	154	73
Fall Injuries	57	36	63.16%	21	36.84%
Bruises		13	22.81%	44	77.19%
Laceration		11	19.30%	46	80.70%
Head Injury		7	12.29%	50	87.72%
Strained Ligament		3	5.26%	54	94.74%
Fracture		2	3.51%	55	96.49%
Fall Disposition	57	57	100%	0	0%
Home		38	66.67%	19	33.33%
Hospital		11	19.30%	46	80.70%
Emergency Department		6	10.53%	51	89.47%
Long-Term Care Facility		2	3.51%	55	96.49%

There were nine types of causes for community-dwelling older adult falls in this study. The most common was an older adult with a medical condition that caused the fall (n=11) or slip or trip (n=10). Medical conditions were dementia (n=3), syncope (n=3), dehydration (n=2), frailty (n=1), hypotension (n=1), and Parkinson's (n=1). Environmental risk factors (n=8) such as improper footwear, slippery shower, improper use of assistive devices, broken chair, pet, catheter tubing, steep steps, and a slippery driveway were mentioned as causes of the fall. Transfers (n=8), balance (n=6), and symptoms (n=4) were also causes of falls. Symptoms were weakness (n=3) and dizziness (n=1). Behavioral risk factors (n=4) such as refusing to take prescribed medication (n=2), not paying attention, and rushing were mentioned as causes of falls. Impaired mobility (n=3) and unknown causes (n=3) were additional causes.

Results of Research Question One

Research question one is: which fall risk factors provide the strongest indicators of falls among community-dwelling older adults in Hawaii? The numerical indicators in this study are age, number of medications, and number of high-risk medications. A Wilcoxon Ranked Sum test was computed for the numerical indicators. As illustrated in Table 4, the age of older adults who fell (*Median (Mdn)*=79) did not significantly differ from older adults who did not fall (*Mdn*= 77), W_s= 15,849, z=-1.21, p=0.23, r= -0.08. The number of medications older adults took who fell (Mdn=6) did not significantly differ from those who did not fall (*Mdn*=5), W_s=15852, z=-1.20, p=0.23, r= -0.08. The number of high-risk medications for older adults who fell (Mdn=2) did not significantly differ from those who did not fall (*Mdn*=2), W_s= 15950, z=-0.97, p=0.33, r=-0.07.

A Cochran-Armitage test for trend was completed to determine if the MAHC-10, CCI, and ACCI total scores and falls had a linear association, respectively. For the MAHC-10 Wald test, W(1) = 14.41, p = 0.00015. For every one-unit increase on the MAHC-10, the predicted odds changed by a factor of 1.45 with a 95% confidence interval of [1.20, 1.75]. For the CCI total score, Wald test, W(1)=7.73, p=0.01. For every one unit increase on the CCI, the predicted odds changed by a factor of 1.26 with a confidence interval of [1.07, 1.48]. The Wald test was also completed for ACCI's total score. W(1)= 8.08, p=0.004. For every one-unit increase on the ACCI, the predicted odds changed by a factor of 1.25 with a confidence interval of [1.07, 1.46]. Table 4 describes the numerical variables and the Wilcoxon and Wald Tests.

Table 4. Numerical Variables Wilcoxon and Wald Tests

			Fall		Wilcoxon Test				Wald Test			95% CI	
		Total	Yes	No	W	z-score	p-value (w-test)	Effect Size (r)	W	p-value	OR	Lower	Upper
Age	Minimum	60.00	60.00	60.00	6517.00	1.21	0.23	0.08					
	Maximum	98.00	96.00	98.00									
	Median	78.00	79.00	77.00									
	Mean	78.16	79.35	77.72									
	SD	9.04	8.72	9.14									
MAHC-10 Total Score	Minimum	1.00	3.00	1.00	7580.50	3.96	0.003	0.27	14.4	0.00015	1.45	1.20	1.75
	Maximum	10.00	10.00	10.00									
	Median	7.00	7.00	6.00									
	Mean	6.41	7.23	6.11									
	SD	9.04	1.64	1.82									
Number of Medications	Minimum	0.00	0.00	0.00	6514.00	1.20	0.23	0.08					
	Maximum	19.00	16.00	19.00									
	Median	5.00	6.00	5.00									
	Mean	5.77	6.09	5.66									
	SD	3.60	3.60	3.60									
Number of at Risk Medications	Minimum	0.00	0.00	0.00	6416.00	0.97	0.33	0.07					
	Maximum	7.00	6.00	7.00									
	Median	2.00	2.00	2.00									
	Mean	1.93	2.09	1.87									
	SD	1.56	1.62	1.54									
CCI Total Score	Minimum	0.00	0.00	0.00	7174.00	2.93	0.003	0.20	7.73	0.01	1.26	1.07	1.48
	Maximum	12.00	12.00	8.00									
	Median	3.00	3.00	2.00									
	Mean	3.00	3.61	2.77									
	SD	1.89	2.10	1.76									
ACCI Total Score	Minimum	2.00	3.00	2.00	7176.00	2.93	0.003	0.20	8.08	0.004	1.25	1.07	1.46
	Maximum	15.00	15.00	12.00									
	Median	6.00	7.00	6.00									
	Mean	6.23	6.89	5.98									
	SD	2.00	2.14	1.90									

Categorical Indicators

Categorical indicators for this study were MAHC-10 cut-off scores of six, seven, and eight or more. Categorical indicators also included MAHC-10 core elements of age 65 years and older, three or more medical diagnoses, prior history of falls, incontinence, visual impairment, impaired functional mobility, environmental hazards, poly-pharmacy, pain, and cognitive impairment. CCI scores of two or more and three or more and ACCI scores of six or more and seven or more were included. Depression, cancer, MI, PVD, MI or PVD, CHF, CVA, Dementia, COPD, CTD, PUD, Liver Disease, Hemiplegia, Moderate to Severe CKD, Hypertension, and skin ulcers were diagnoses of note for the CCI. Medication categorical indicators were high-risk medications, antidepressants, sedative-hypnotic, benzodiazepine, anticonvulsant, antipsychotic, opioids, antihypertensive, and antispasmodic medication.

Significant Indicators

The Chi-Square or Fisher's Exact tests were analyzed for all categorical variables. Significant results were found for the indicators of MAHC-10 scores of six or more, seven or more, and eight or more, prior history of falls, environmental hazards, CCI scores of two or more and three or more, ACCI scores of six or more and seven or more, depression, cancer, MI or PVD, and antispasmodic medication. Table 5 represents the results of all chi-square tests.

MAHC-10 scores of six or more, seven or more, and eight or more were found to be significant. There was a significant association between the MAHC-10 score of six or more and whether an older adult fell. $X^2(1) = 12.91$, $p < 0.001$, *phi* = 0.25. The odds ratio indicated that the odds of a person who had a MAHC-10 score of 6 or more falling was 4.13 times higher than if they had a MAHC-10 score lower than 6 with a 95% confidence interval of [1.83, 9.31]. A significant association was found between the MAHC-10 score of seven or more and whether an older adult fell. $X^2(1) = 9.29$, $p < 0.0023$, *phi* = 0.21. The odds ratio revealed that the odds of a person with a MAHC-10 score of seven or more falling was 2.67 times higher than if they had a MAHC-10 score lower than seven with a confidence interval of [1.40, 5.07]. There was also a significant association between the MAHC-10 score of eight or more and whether an older adult fell. $X^2(1) = 10.73$, $p < 0.0011$, *phi* = 0.23. The odds ratio demonstrated that the odds of a person who had a MAHC-10 score of eight or more falling was 2.85 times higher than if they had a MAHC-10 score lower than eight with a confidence interval of [1.50, 5.39].

For the MAHC-10 core elements, there was a significant association between a prior history of falls and whether an older adult fell. $X^2(1) = 15.58$, $p < 0.001$, *phi* = 0.27. According to the odds ratio, the odds of a person who had a prior history of falls and fell were 3.59 times higher than if they did not have a prior history of falls with a confidence interval of [1.87, 6.89]. There was a significant association between an environmental hazard in an older adult's home and whether an older adult fell. $X^2(1) = 8.08$, $p < 0.01$, *phi* = 0.20. The odds ratio indicated that the odds of a person who had an environmental risk factor in their home and fell was 2.82 times higher than if they did not have an environmental risk factor with a confidence interval of [1.36, 5.86].

For the CCI, there was a significant association between the CCI score of two or more and whether an older adult fell. $X^2(1) = 7.34$, $p < 0.007$, *phi* = 0.19. The odds ratio revealed that the odds of a person with a CCI score of two or more falling was 3.65 times higher than if they had a CCI score lower than two with a confidence interval of [1.36, 9.78]. A significant association was found between the CCI score of three or more and whether an older adult fell. $X^2(1) = 9.16$, $p < 0.002$, *phi* = 0.21. The odds ratio demonstrated that the odds of a person who had a CCI score of three or more falling was 2.68 times higher than if they had a CCI score lower than three with a confidence interval of [1.40, 5.13].

A significant association was found between ACCI scores of six or more and whether an older adult fell. $X^2(1) = 6.31$, $p < 0.01$, *phi* = 0.17. According to the odds ratio, a person who had an ACCI score of six or more falling was 2.41 times higher than if they had an ACCI score lower than six with a confidence interval of [1.36, 9.78]. A significant association was found between the ACCI score of seven or more and whether an older adult fell. $X^2(1) = 7.19$, $p < 0.007$, *phi* = 0.19. The odds ratio indicated that the odds of a person who had an ACCI score of seven or more falling was 2.31 times higher than if they had an ACCI score lower than seven with a confidence interval of [1.24, 4.3].

For older adults diagnosed with depression, there was a significant association with falls. $X^2(1) = 11.15$, $p < 0.001$, *phi* = 0.23. The odds ratio revealed that the odds of a person who had depression and falling were 3.62 times higher than if they did not have depression with a confidence interval of [1.65, 7.93]. A significant association was found between an older adult diagnosed with cancer and whether an older adult fell. $X^2(1) = 5.51$, $p < 0.05$, *phi* = 0.16. The odds ratio demonstrated that the odds of a person who had cancer and falling was 2.67 times higher than if they did not have cancer with a confidence interval of [1.15, 6.18]. Fisher's exact test was completed, and a significant result was found for the variables MI (p=0.0055) and peripheral vascular disease (p=0.0062). MI and PVD were combined as a variable. Fisher's exact test was completed, and a significant result was found for the variable of Combo MI or PVD (p=0.0011).

Antispasmodic medication was the only high-risk medication found to have significant results. Fisher's exact test was completed, and a significant result was found for the variable of antispasmodic medication (p=0.000019).

Table 5. Categorical Indicators Chi Square Test

				Fall				Odds Ratio (unadjusted)	95% CI		
		Total N	Total %	Yes	Yes%	No	No%	OR	Lower	Upper	p-value
Demographics											
Gender	Female	117	55.45%	27	23.08%	90	76.92%	0.64	0.35	1.18	0.15
	Male	94	44.55%	30	31.91%	64	68.09%	Ref			
Lives Alone	Yes	97	45.97%	30	30.93%	67	69.07%	1.44	0.78	2.65	0.24
	No	114	54.03%	27	23.68%	87	76.32%	Ref			
Native Hawaiian or Other Pacific Islander	Yes	45	21.33%	9	20.00%	36	80.00%	0.62	0.28	1.37	0.23
	No	166	78.67%	48	28.90%	118	71.10%	Ref			
MAHC-10 Total Score											
MAHC=10 Total Score of 4 or More	≥4	200	94.79%	56	28.00%	144	72.00%	3.89	0.49	31.09	0.30
	0-3	11	5.21%	1	9.09%	10	90.91%	Ref			
MAHC=10 Total Score of 5 or More	≥5	178	84.36%	53	29.78%	125	70.22%	3.07	1.03	9.18	0.53
	0-4	33	15.64%	4	12.12%	29	87.88%	Ref			
MAHC=10 Total Score of 6 or More	≥6	141	66.82%	49	34.75%	92	65.25%	4.13	1.83	9.31	0.00033
	0-5	70	33.18%	8	11.43%	62	88.57%	Ref			
MAHC=10 Total Score of 7 or More	≥7	108	51.18%	39	36.11%	69	63.89%	2.67	1.40	5.07	0.0023
	0-6	103	48.82%	18	17.48%	85	82.52%	Ref			
MAHC=10 Total Score of 8 or More	≥8	64	30.33%	27	42.19%	37	57.81%	2.85	1.50	5.39	0.0011
	0-7	147	69.67%	30	20.41%	117	79.59%	Ref			
MAHC-10 Core Elements											
Age	>65	200	94.79%	56	28.00%	144	72.00%	3.89	0.49	31.09	0.30
	<65	11	5.21%	1	9.09%	10	90.91%	Ref			
Diagnosis	≥ 3	185	87.68%	53	28.65%	132	71.35%	2.21	0.73	6.71	0.15
	<3 Diagnoses	26	12.32%	4	15.38%	22	84.62%	Ref			
Prior History of Falls within 3 months of	Yes	101	47.87%	40	39.60%	61	60.40%	3.59	1.87	6.89	0.000079
	No	110	52.13%	17	15.45%	93	84.55%	Ref			
Incontinence	Yes	90	42.65%	28	31.11%	62	68.89%	1.43	0.78	2.64	0.25
	No	121	57.35%	29	23.97%	92	76.03%	Ref			
Visual Impairment	Yes	121	57.35%	38	31.40%	83	68.60%	1.71	0.91	3.23	0.10
	No	90	42.65%	19	21.11%	71	78.89%	Ref			
Impaired Mobility	Yes	162	76.78%	47	29.01%	115	70.99%	1.59	0.74	3.45	0.23
	No	49	23.22%	10	20.41%	39	79.59%	Ref			

		Total N	Total %	Fall Yes	Yes%	No	No%	Odds Ratio (unadjusted) OR	95% CI Lower	Upper	p-value
Environmental Hazard	Yes	138	65.40%	46	33.33%	92	66.67%	2.82	1.35	5.86	0.0045
	No	73	34.60%	11	15.07%	62	84.93%	Ref			
Polypharmacy	≥ 4	155	73.46%	44	28.39%	111	71.61%	1.31	0.64	2.67	0.45
	<4	56	26.54%	13	23.21%	43	76.79%	Ref			
Pain	Yes	92	43.60%	29	31.52%	63	68.48%	1.50	0.81	2.76	0.19
	No	119	56.40%	28	23.53%	91	76.47%	Ref			
Cognitive Impairment	Yes	109	51.66%	31	28.44%	78	71.56%	1.16	0.63	2.14	0.63
	No	102	48.34%	26	25.49%	76	74.51%	Ref			
Medications											
High-Risk Medication	≥1	167	79.15%	43	25.75%	124	74.25%	0.74	0.36	1.53	0.42
	0.00	44	20.85%	14	31.82%	30	68.18%	Ref			
Antidepressant	Yes	36	17.06%	12	33.33%	24	66.67%	1.44	0.67	3.12	0.35
	No	175	82.94%	45	25.71%	130	74.29%	Ref			
Sedative Hypnotic	Yes	1	0.47%	0	0.00%	1	100.00%	0.00	0.98	1.01	1.00
	No	210	99.53%	57	27.14%	153	72.86%	Ref			
Benzodiazepine	Yes	15	7.11%	4	26.67%	11	73.33%	0.98	0.30	3.22	1.00
	No	196	92.89%	53	27.04%	143	72.96%	Ref			
Anticonvulsant	Yes	34	16.11%	7	20.59%	27	79.41%	0.66	0.27	1.61	0.36
	No	177	83.89%	50	28.25%	127	71.75%	Ref			
Antispasmodic	Yes	9	4.27%	8	88.89%	1	11.11%	24.98	3.05	204.72	0.000019
	No	202	95.73%	49	24.26%	153	75.74%	Ref			
Antipsychotic	Yes	14	6.64%	4	28.57%	10	71.43%	1.09	0.33	3.61	1.00
	No	197	93.36%	53	26.90%	144	73.10%	Ref			
Opioids	Yes	20	9.48%	6	30.00%	14	70.00%	1.18	0.43	3.23	0.75
	No	191	90.52%	51	26.70%	140	73.30%	Ref			
Antihypertensive	Yes	144	68.25%	37	25.69%	107	74.31%	0.81	0.53	0.43	0.53
	No	67	31.75%	20	29.85%	47	70.15%	Ref			
CCI Total Score											
CCI 2 or More	≥2	166	78.67%	52	31.33%	114	68.67%	3.65	1.36	9.78	0.007
	0-1	45	21.33%	5	11.11%	40	88.89%	Ref			
CCI 3 or More	≥3	112	53.08%	40	35.71%	72	64.29%	2.68	1.40	5.13	0.0025
	0-2	99	46.92%	17	17.17%	82	82.83%	Ref			

		Fall						Odds Ratio (unadjusted)	95% CI		
		Total N	Total %	Yes	Yes%	No	No%	OR	Lower	Upper	p-value
CCI 4 or More	≥4	73	34.60%	25	34.25%	48	65.75%	1.73	0.92	3.22	0.09
	0-3	138	65.40%	32	23.19%	106	76.81%	Ref			
CCI 5 or More	≥5	39	18.48%	14	35.90%	25	64.10%	1.68	0.80	3.52	0.166
	0-4	172	81.52%	43	25.00%	129	75.00%	Ref			
ACCI Total Score											
ACCI 4 or More	≥4	195	92.42%	56	28.72%	139	71.28%	6.04	0.78	46.84	0.075
	0-3	16	7.58%	1	6.25%	15	93.75%	Ref			
ACCI 5 or More	≥5	178	84.36%	52	29.21%	126	70.79%	2.31	0.85	6.31	0.134
	0-4	33	15.64%	5	15.15%	28	84.85%	Ref			
ACCI 6 or More	≥6	134	63.51%	44	32.84%	90	67.16%	2.41	1.20	4.83	0.01
	0-5	77	36.49%	13	16.88%	64	83.12%	Ref			
ACCI 7 or More	≥7	80	37.91%	30	37.50%	50	62.50%	2.31	1.24	4.30	0.007
	0-6	131	62.09%	27	20.61%	104	79.39%	Ref			
ACCI 8 or More	≥8	45	21.33%	17	37.78%	28	62.22%	1.91	0.95	3.85	0.067
	0-7	166	78.67%	40	24.10%	126	75.90%	Ref			
Diagnoses on CCI and ACCI											
Myocardial Infraction	Yes	8	3.79%	6	75.00%	2	25.00%	8.94	1.75	45.70	0.0055
	No	203	96.21%	51	25.12%	152	74.88%	Ref			
Congestive Heart Failure	Yes	36	17.06%	8	22.22%	28	77.78%	0.73	0.31	1.72	0.48
	No	175	82.94%	49	28.00%	126	72.00%	Ref			
Peripheral Vascular Disease	Yes	16	7.58%	9	56.25%	7	43.75%	3.94	1.39	11.14	0.0062
	No	195	92.42%	48	24.62%	147	75.38%	Ref			
Combo Myocardial Infraction or Peripheral Vascular Disease	Yes	20	9.50%	12	21.10%	8	5.20%	4.87	1.87	12.65	0.0011
	No	191	90.50%	45	78.90%	146	94.80%	Ref			
Cerebrovascular accident or transient ischemic	Yes	28	13.27%	8	28.57%	20	71.43%	1.09	0.45	2.64	0.84
	No	183	86.73%	49	26.78%	134	73.22%	Ref			
Dementia	Yes	59	27.96%	21	35.59%	38	64.41%	1.78	0.93	3.41	0.08
	No	152	72.04%	36	23.68%	116	76.32%	Ref			
Chronic obstructive pulmonary disease	Yes	31	14.69%	9	29.03%	22	70.97%	1.13	0.48	2.61	0.78
	No	180	85.31%	48	26.67%	132	73.33%	Ref			
Connective Tissue Disease	Yes	5	2.37%	2	40.00%	3	60.00%	1.83	0.30	11.25	0.61
	No	206	97.63%	55	26.70%	151	73.30%	Ref			

		Total N	Total %	Fall Yes	Yes%	No	No%	Odds Ratio (unadjusted) OR	95% CI Lower	Upper	p-value
Peptic Ulcer Disease	Yes	2	0.95%	0	0.00%	2	100.00%	0.99	0.97	1.01	1.00
	No	209	99.05%	57	27.27%	152	72.73%	Ref			
Liver Disease	Yes	3	1.42%	1	33.33%	2	66.67%	1.36	0.12	15.26	1.00
	No	208	98.58%	56	26.92%	152	73.08%	Ref			
Diabetes Mellitus	Yes	67	31.75%	15	22.39%	52	77.61%	0.70	0.36	1.38	0.30
	No	144	68.25%	42	29.17%	102	70.83%	Ref			
Hemiplegia	Yes	10	4.74%	5	50.00%	5	50.00%	2.87	0.80	10.30	0.14
	No	201	95.26%	52	25.87%	149	74.13%	Ref			
Moderate to severe Chronic Kidney Disease	Yes	33	15.64%	8	24.24%	25	75.76%	0.84	0.36	1.99	0.70
	No	178	84.36%	49	27.53%	129	72.47%	Ref			
Cancer	Yes	26	12.32%	12	46.15%	14	53.85%	2.67	1.15	6.18	0.019
	No	185	87.68%	45	24.32%	140	75.68%	Ref			
Hypertension	Yes	159	75.36%	43	27.04%	116	72.96%	1.01	0.50	2.04	0.99
	No	52	24.64%	14	26.92%	38	73.08%	Ref			
Skin Ulcers	Yes	12	5.69%	3	25.00%	9	75.00%	0.90	0.23	3.43	1.00
	No	199	94.31%	54	27.14%	145	72.86%	Ref			
Depression	Yes	31	14.69%	16	51.61%	15	48.39%	3.62	1.65	7.93	0.00084
	No	180	85.31%	41	22.78%	139	77.22%	Ref			

Results of Research Question Two

The following results pertain to the second research question: Which fall risk indicators could be used to develop a fall prediction model for community-dwelling older adults in Hawaii? This section will also discuss ROC curves, sensitivity and specificity for numerical variables, multiple logistic regression models developed, model diagnostics, and selecting the final model.

Multivariate Analysis

ROC Curve, Sensitivity, and Specificity for Numerical Variables

MAHC-10 Total Score. The MAHC-10, the CCI, and the ACCI numerical variables were found to be significant, and a Receiver Operator Characteristic (ROC) curve was analyzed for each variable. Table 6 represents the ROC curves for the numerical variables. The C-statistic for the MAHC-10 Total Score was 0.68, p=0.000094 (95% CI= 0.60- 0.76). The C-statistic for the CCI Total Score was 0.63, p=0.0040 (95% CI= 0.55- 0.71). The C-statistic for the ACCI Total Score was 0.63, p=0.0040 (95% CI= 0.55- 0.71).

Table 6. Receiver Operating Characteristics Curve for the Numerical Variables

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MAHC-10	0.68	0.04	0.000094	0.60	0.76
CCI	0.63	0.04	0.0040	0.55	0.71
ACCI	0.63	0.04	0.0040	0.55	0.71

The AUC or C-statistic, sensitivity, and specificity of cutoff scores were examined to explore the most balanced cutoff score for the three indicators. For the MAHC-10, a cutoff score of 6 resulted in a maximized combined sensitivity of 0.86 and a specificity of 0.40. Figure three and Table 7 represent the ROC Curves for the MAHC-10 total score cut-off values. Table 8 and Figure four represent the MAHC-10 total score cut-off values' sensitivity and specificity values.

Figure 3. ROC Curves for the MAHC-10 Total Score Cut-off Values

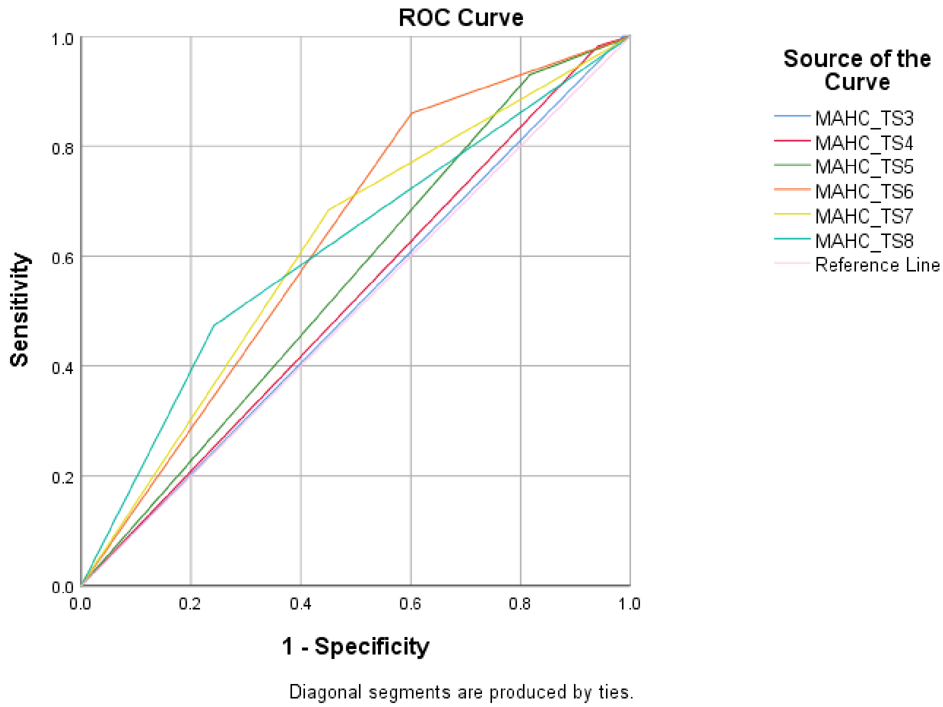


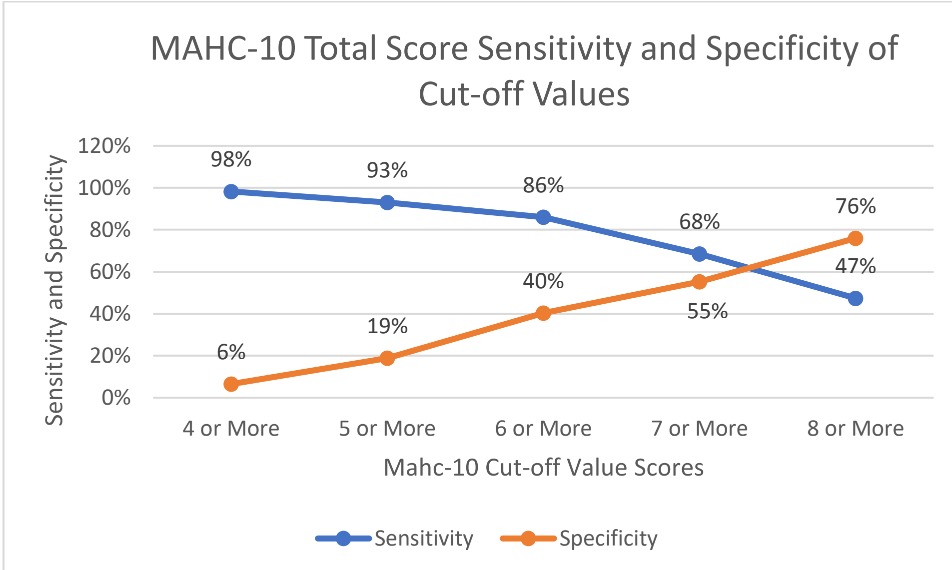
Table 7. ROC Curves Descriptions for the MAHC-10 Total Score Cut-off Values

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
MAHC_TS3	0.51	0.04	0.88	0.42	0.59
MAHC_TS4	0.52	0.04	0.65	0.43	0.61
MAHC_TS5	0.56	0.04	0.21	0.47	0.64
MAHC_TS6	0.63	0.04	0.0035	0.55	0.71
MAHC_TS7	0.62	0.04	0.01	0.53	0.70
MAHC_TS8	0.62	0.05	0.01	0.53	0.70

Table 8. Sensitivity and Specificity values for the MAHC-10 Total Score Cut-off Values

MAHC-10 Cut-off Score	Sensitivity	Specificity
4 or More	98%	6%
5 or More	93%	19%
6 or More	86%	40%
7 or More	68%	55%
8 or More	47%	76%

Figure 4. MAHC-10 Total Score Sensitivity and Specificity of Cut-off Values



CCI Total Score. The C-statistic for the CCI score greater than or equal to three was 0.62, p=0.01 (95% CI= 0.53- 0.70). For the CCI, a cutoff score greater than or equal to three resulted in a maximized combined sensitivity of 0.70 and a specificity of 0.53. Figure five and Table 9 represent the ROC Curves for the CCI total score cut-off values. Table 10 and Figure six represent the sensitivity and specificity values for the CCI total score cut-off values.

Figure 5. ROC Curve for the CCI Total Score Cut-off Scores

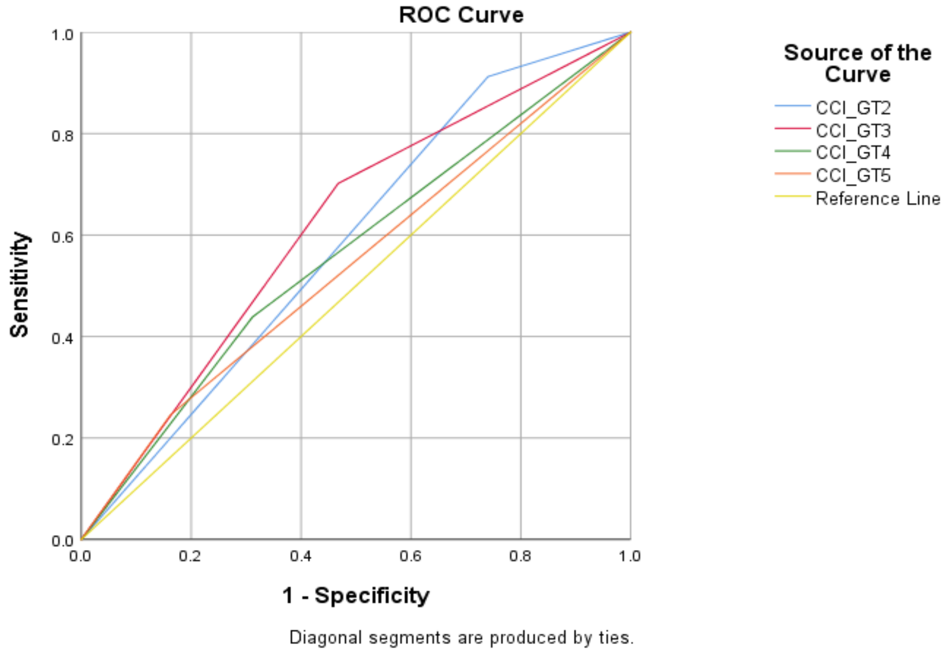


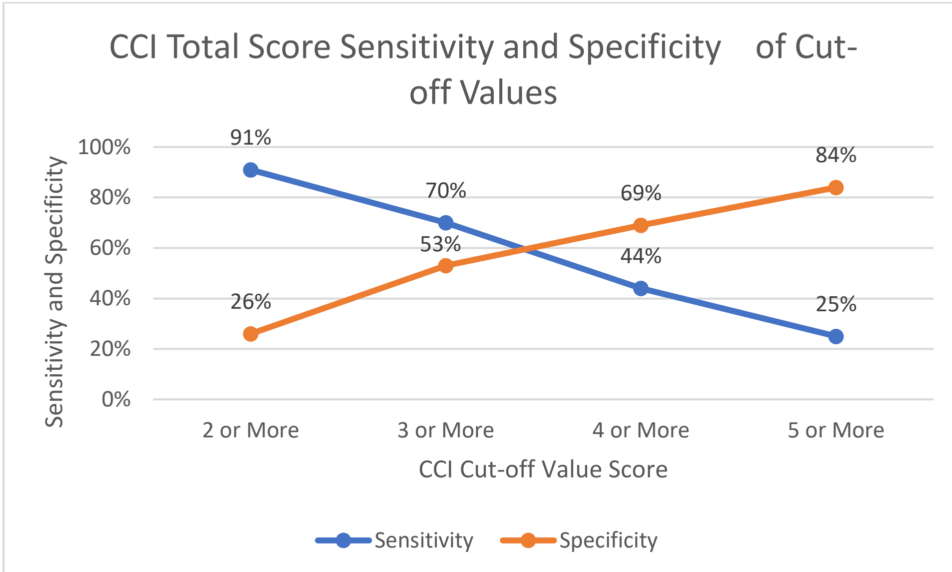
Table 9. Area Under the Curve for the CCI Cut-off Scores

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig[b]	Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
CCI_GT2	0.59	0.04	0.06	0.50	0.67
CCI_GT3	0.62	0.04	0.01	0.53	0.70
CCI_GT4	0.56	0.05	0.16	0.47	0.65
CCI_GT5	0.54	0.05	0.35	0.45	0.63

Table 10. Sensitivity and Specificity values for the CCI Total Score Cut-off Values

CCI Total Score	Sensitivity	Specificity
2 or More	91%	26%
3 or More	70%	53%
4 or More	44%	69%
5 or More	25%	84%

Figure 6. CCI Total Score Sensitivity and Specificity of Cut-off Values



ACCI Total Score. The ACCI score greater than or equal to six had a C-statistic of 0.59 (95% CI= 0.51- 0.68). The maximized combined sensitivity was 0.77 and specificity was 0.42. Figure seven and Table 11 represent the ROC Curves for the ACCI total score cut-off values. Table 12 and Figure eight represent the sensitivity and specificity values for the ACCI total score cut-off values.

Figure 7. ROC Curve for the ACCI Total Score Cut-off Scores

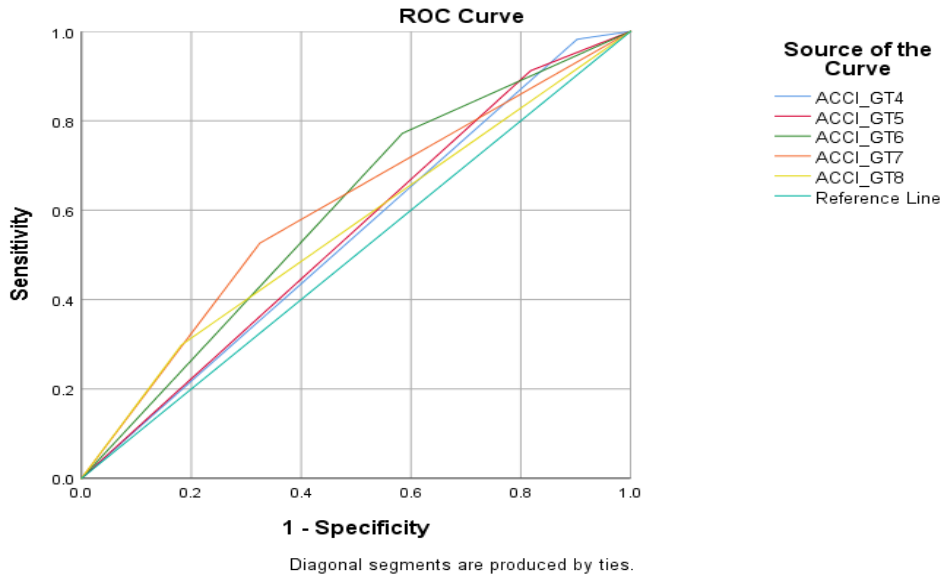


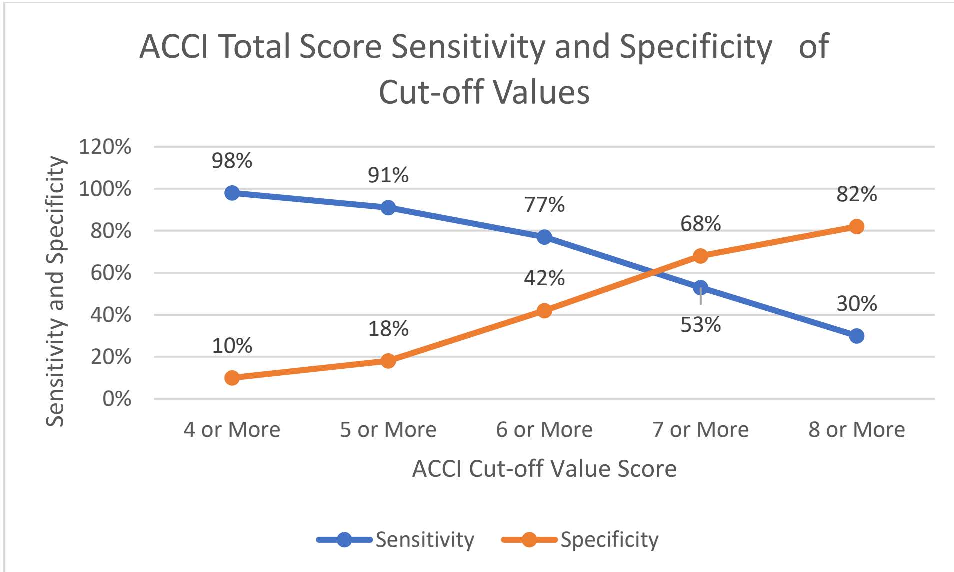
Table 11. Area Under the Curve for the ACCI Cut-off Scores

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
ACCI_GT4	0.54	0.04	0.37	0.46	0.62
ACCI_GT5	0.55	0.04	0.29	0.46	0.63
ACCI_GT6	0.59	0.04	0.04	0.51	0.68
ACCI_GT7	0.60	0.04	0.02	0.51	0.69
ACCI_GT8	0.56	0.05	0.19	0.47	0.65

Table 12. Sensitivity and Specificity values for the ACCI Total Score Cut-off Values

	Sensitivity	Specificity
4 or More	98%	10%
5 or More	91%	18%
6 or More	77%	42%
7 or More	53%	68%
8 or More	30%	82%

Figure 8. CCI Total Score Sensitivity and Specificity of Cut-off Values



Categorical variables were created for the MACH-10 total score, CCI, and ACCI based on the cut-off scores with the most balanced sensitivity and specificity scores. Cut-off scores below 70% were not chosen due to PHNB guidelines for screening tools with sensitivity scores above 70%. The cut-off score for the MAHC-10 was six. The cut-off score for the CCI was three, and the cut-off score for the ACCI was six.

Prediction Models

A total of 43 multivariate regression models were run to determine the most parsimonious model. The models were built using hierarchical analysis where predictors were entered and removed in steps based on theory and significance level based on question one. Appendix E includes all models run in this study.

Model one represents the results from the first multivariate regression model with a sample size of 211. The five variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, and depression. Predictive model one had a c-statistic of 0.63 (95% CI= 0.53- 0.72). Hosmer-Lemeshow test p-value of

0.75. Model one predictor variables were chosen due to the current recorded literature on fall risk factors and the significant results of research question one. Table 13 represents model one.

Table 13. Model 1

Logistic regression model 1 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	>=6	2.02	0.77	5.31	0.15
	<6	ref			
Hist fall	Yes	2.47	1.20	5.08	0.01
	No	ref			
Environmental Hazard	Yes	1.59	0.68	3.72	0.29
	No	ref			
Cancer Combined	Yes	1.97	0.79	4.91	0.15
	No	ref			
Depression	Yes	2.70	1.15	6.35	0.02
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.63	0.54	0.72
Overall Percentage	77.30		
Hosmer and Lemeshow	0.75		

The following models explored the difference between the CCI and ACCI. ACCI was chosen over the CCI because of better odds ratio statistics and for the theoretical ideology that being older increases one's susceptibility to falls. For example, models two and three performed similarly, with Model two using the CCI and model three using the ACCI. Models two to thirty explored the effect of race, gender, dementia, visual impairment, impaired mobility, living alone, incontinence, and medication type. There was no significant improvement when these predictors were added to the model. Also, during the analysis, nine models (3, 11, 13, 14, 15, 17, 21, 25, and 29) had significant Hosmer-Lemeshow test p-values and thus were excluded from further analyses.

Model 30 represents the results from the multivariate regression model with a sample size of 211. The 10 variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, depression, MI or PVD, antispasmodic, ACCI score greater than or equal to 6, pain, and diabetes. The final predictive model had a c-statistic of 0.73 (95% CI= 0.64- 0.82). Hosmer-Lemeshow test p-value of 0.25. Table 14 describes model 30.

Table 14. Model 30

Logistic regression model 30 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	>=6	1.65	0.57	4.83	0.36
	<6	ref			
Hist fall	Yes	3.83	1.66	8.84	0.0016
	No	ref			
Environmental Hazard	Yes	1.87	0.74	4.76	0.19
	No	ref			
Cancer	Yes	1.18	0.41	3.42	0.76
	No	ref			
Depression	Yes	2.29	0.87	6.05	0.09
	No	ref			
MI or PVD	Yes	3.70	1.14	11.99	0.03
	No	ref			
Antispasmodic	Yes	46.75	4.37	500.20	0.0015
	No	ref			
ACCI	>=6	2.03	0.83	4.96	0.12
	<6	ref			
Pain	Yes	0.66	0.30	1.44	0.30
	No	ref			
Diabetes	Yes	0.46	0.20	1.09	0.08
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.73	0.64	0.82
Overall Percentage	82.94		
Hosmer and Lemeshow	0.25		

Model 43 utilized the MAHC-10 Total Score and ACCI Total Score as numerical variables. In initial exploration, these variables did not perform as well as the categorical variables in models. There was no significant improvement when these predictors were added to the model. Table 15 describes model 43.

Table 15. Model 43

Logistic regression model 30 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS		1.39	1.14	1.69	0.001
ACCI TS		1.17	0.99	1.37	0.059

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.54	0.45	0.64
Overall Percentage	73.0		
Hosmer and Lemeshow	0.72		

Model Diagnostics. Model diagnostics were investigated; model 30 results indicated there was no multicollinearity between two or more variables. All variance inflation factors (VIF) were below 10, and the tolerance statistics were above 0.1. There were no DFB or Cook's distance values greater than 1. There was a concern with the Leverage statistic. Analysis of the Leverage statistic resulted in eight cases that were above the 0.01 value. The expected average leverage value is (k+1)/N. The variable k represents the number of predictors, and N represents the sample size. For this model, .052 was the expected average leverage value. Cases were investigated when values were three times the average. For this model, that value would be a value of 0.01. The two cases with the highest Leverage statistic were excluded from the following models. The linearity of the logit was not checked because all variables in the models were categorical.

Model 31 represents the results from the multivariate regression model with the unstable variable antispasmodic medication and a sample size of 209. The 10 variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, depression, MI and PVD, Antispasmodic medication, ACCI score greater than or equal to 6, pain, and diabetes. This predictive model demonstrated a c-statistic of 0.73 (95% CI= 0.64- 0.82). Hosmer-Lemeshow test p-value of 0.34. Table 16 describes model 31.

Table 16. Model 31

Logistic regression model 31 (N=209)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	>=6	1.24	0.41	3.70	0.70
	<6	ref			
Hist fall	Yes	4.11	1.75	9.65	0.0012
	No	ref			
Environmental Hazard	Yes	2.31	0.87	6.15	0.09
	No	ref			
Cancer	Yes	1.07	0.36	3.12	0.91
	No	ref			
Depression	Yes	2.23	0.84	5.95	0.11
	No	ref			
MI or PVD	Yes	3.60	1.10	11.80	0.03
	No	ref			
Antispasmodic	Yes	4854184159.07	0.00		1.00
	No	ref			
ACCI	>=6	2.37	0.94	5.95	0.07
	<6	ref			
Pain	Yes	0.64	0.29	1.42	0.27
	No	ref			
Diabetes	Yes	0.48	0.20	1.14	0.09
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.73	0.64	0.82
Overall Percentage	83.30		
Hosmer and Lemeshow	0.34		

When the two outlier cases were excluded from the regression model, one of the cases was the only case that did not have a fall and took antispasmodic medication. Thus, excluding this case from the model made the antispasmodic medication variable unstable. To build the next model, the antispasmodic medication variable was excluded. Model 34 represents the multivariate regression model results with a sample size of 209. The 10 variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, depression, MI or PVD, ACCI score greater than or equal to 6, pain, diabetes, and four or more diagnoses as defined by the MAHC-10 fall risk assessment. The final predictive model had a c-statistic of 0.70 (95% CI= 0.61- 0.79). Hosmer-Lemeshow test p-value of 0.07.

The odds for falling were increased by a factor of 4.55 (95% CI= 1.50-13.77) if a client had a history of MI or PVD and 3.73 (95% CI=1.64-8.50) if a client had a history of falling within three months. The odds of falling were decreased by a factor of 0.43 (95% CI= .018-1.0) if a client had diabetes. Model 34 is represented by Table 17.

Table 17. Model 34

Logistic regression model 34 (N=209)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	Upper	p-value
MAHC_TS	>=6	1.15	0.38	3.51	0.81
	<6	ref			
Hist fall	Yes	3.73	1.64	8.50	0.0017
	No	ref			
Environmental Hazard	Yes	2.54	0.96	6.68	0.06
	No	ref			
Cancer	Yes	1.38	0.50	3.75	0.53
	No	ref			
Depression	Yes	2.08	0.81	5.34	0.13
	No	ref			
MI or PVD	Yes	4.55	1.50	13.77	0.01
	No	ref			
ACCI	>=6	2.01	0.83	4.86	0.12
	<6	ref			
Pain	Yes	0.89	0.42	1.90	0.76
	No	ref			
Diabetes	Yes	0.43	0.18	1.00	0.05
	No	ref			
Diagnosis >=4	Yes	2.16	0.59	7.93	0.25
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	80.86		
Hosmer and Lemeshow	0.07		

Parsimonious Model. A model with five variables was created to achieve the most parsimonious model with a sample size of 211 clients (Table 18, Model 42). Eight models (models 35-42) were built, and predictor variables were excluded if the predictor was not contributing to the prediction of a client falling. In the final model, the predictors of a history of falls, MI or PVD, antispasmodic medication, and depression made significant contributions to the model. Environmental Hazards were added to the model to reach an AUC of 0.70. The MAHC-10 score of 6 or more was excluded from the final model because the AUC score remained unchanged when that predictor variable was excluded.

The final predictive model had a c-statistic of 0.70 (95% CI= 0.61- 0.79) and a Hosmer-Lemeshow test p-value of 0.15. For model 42, the sensitivity of the model was 45.6% and a specificity of 94.8%. The odds for falling were increased by a factor of 4.32 (95% CI= 2.01- 9.28) for a client who had a history of falls within the past three months, increased by a factor of 4.49 (95% CI= 1.47- 13.72) for a client that had a history of MI or PVD, increased by a factor of 33.82 (95% CI= 3.50- 326.39) for a client that had a history of taking antispasmodic medication, increased by a factor of 2.59 (95% CI= 1.06- 6.35) for a client with a history of depression, and increased by a factor of 2.05 (95% CI= 0.91- 4.61) for a client with a history of environmental hazards.

Model diagnostics were investigated; model 42 had no multicollinearity between two or more variables. All variance inflation factors (VIF) were below 10, and the tolerance statistics were above 0.1. There were no DFB values greater than 1. One case had a Cook's distance value of 1.04. This case was an older adult who took antispasmodic medication and did not have a fall. There was a concern with the Leverage statistic. The expected average leverage value is (k+1)/N. The variable k represents the number of predictors, and N represents the sample size. For this model, .028 was the expected average leverage value. Cases should be investigated when values are three times the average. For this model, that value would be 0.0853. Twelve cases were above the 0.0853 value. The cases are described as follows. Three cases fell and took antispasmodic medication and two fell and did not take antispasmodic medication. Three older adults did not fall and did not take antispasmodic medication. One older adult took an antispasmodic medication and did not fall. The linearity of the logit was not checked because all variables in the models were categorical.

Table 18. Model 42

Logistic regression model 42 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	Upper	p-value
Hist fall	Yes	4.32	2.01	9.28	0.00018
	No	ref			
MI or PVD	Yes	4.49	1.47	13.72	0.008
	No	ref			
Antispasmodic	Yes	33.82	3.50	326.39	0.002
	No	ref			
Depression	Yes	2.59	1.06	6.35	0.037
	No	ref			
Environmental Hazard	Yes	2.05	0.91	4.61	0.083
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.702	0.613	0.79
Overall Percentage	81.50		
Hosmer and Lemeshow	0.150		

A ROC curve graph of five models was created to illustrate the AUC in Figure 9. Table 19 represents the models of the AUC statistics in more detail. Model 30 had the largest c-statistic of 0.73 (95% CI= 0.64- 0.82); this model had 10 predictor variables. Model 39 had a c-statistic of 0.70 (95% CI= 0.61- 0.80) with six variables and Model 42 had a c-statistic of 0.702 (95% CI= 0.61- 0.79) with five predictor variables (history of fall, MI or PVD, antispasmodic, depression, and environmental hazard). Model 36 had a c-statistic of 0.622 (95% CI= 0.53- 0.71) with five predictor variables, and Model 40 had a c-statistic of 0.699 (95% CI= 0.61- 0.79) with six predictor variables. Model 42 was chosen as the most parsimonious model with the highest c-statistic and as few predictor variables as possible.

Figure 9. ROC Curves for Five Models

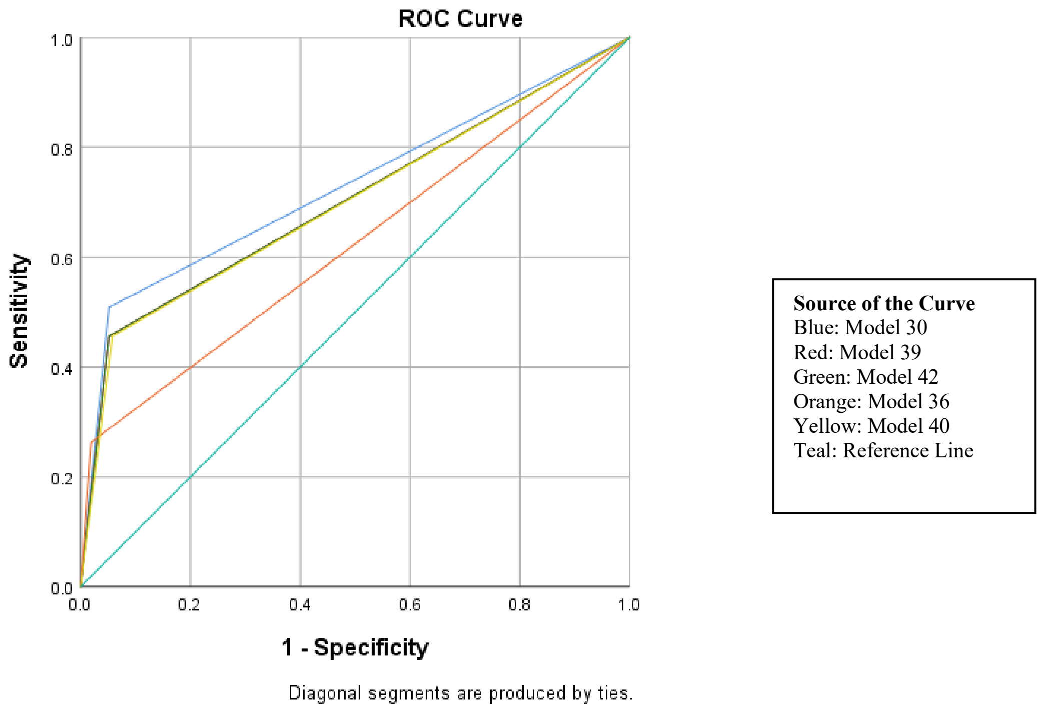


Table 19. Area Under the Curve for Five Models

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Model 30	0.728	0.044	3.55E-7	0.642	0.815
Model 39	0.702	0.045	0.000007	0.613	0.791
Model 42	0.702	0.045	0.000007	0.613	0.791
Model 36	0.622	0.047	0.007	0.530	0.714
Model 40	0.699	0.045	0.000009	0.610	0.788

Summary of Chapter Four

This chapter presented the sample's demographic characteristics and reported on which numerical and categorical risk factors provided the strongest indicators of falls among community-dwelling older adults in Hawaii. Significant associations between the MAHC-10 total score of six or more and whether an older adult fell were discovered. Core elements of the MAHC-10 that were found to have a significant association with older adult falls were prior history of falls and environmental risk factors. The CCI total score of two or more and the ACCI total score of six or more had a significant association with older adult falls. Comorbidities of depression, cancer, MI, and PVD were also significantly associated with older adult falls. The high-risk fall medication that was found to have a significant association with falling was antispasmodic medication. This study did not find the indicators of age, gender, number of medications, or number of high-risk medications significantly associated with older adult falls. This chapter then utilized the fall risk factors to develop cut-off scores for the MAHC-10, CCI, and ACCI using ROC Curve analysis and sensitivity and specificity calculations. Finally, a parsimonious fall prediction model was developed using multiple logistic regression.

Chapter 5. Discussion and Conclusions

Introduction

Chapter five explores and interprets the key findings of this study and will compare the results to the current community-dwelling older adult fall literature. This chapter will also discuss the contribution to the literature, limitations, and strengths of this research. Through reviewing this information, practice and future research recommendations will be presented.

Summary of Key Findings for Research Question One

The first research question was: Which fall risk factors provide the strongest indicators of falls among community-dwelling older adults in Hawaii? This study found significant associations between the MAHC-10 total score of six or more and whether an older adult fell. Core elements of the MAHC-10 that were found to have a significant association with older adult falls were prior history of falls and environmental risk factors. The CCI total score of two or more and the ACCI total score of six or more had a significant association with older adult falls. Comorbidities of depression, cancer, MI, and PVD were also significantly associated with older adult falls. The high-risk fall medication that was found to have a significant association with falling was antispasmodic medication. This study did not find the indicators of age, gender, number of medications, or number of high-risk medications significantly associated with older adult falls.

Interpretation of Findings for Research Question One

MAHC-10

This study found a significant association between the MAHC-10 score of six or more and whether an older adult fell. $X^2(1) = 12.91$, $p < 0.001$, *phi* = 0.25. According to the odds ratio, a person who had a MAHC-10 score of 6 or more falling was 4.13 times higher than if they had a

MAHC-10 score lower than six with a confidence interval of [1.83, 9.31]. The MAHC-10 cutoff score of six resulted in a maximized combined sensitivity of 86.0% and a specificity of 40.0%. A MAHC-10 cutoff score of four had a 98.0% sensitivity and a 6.0% specificity. In this study, the AUC for the MAHC-10 Total Score was 0.68, p=0.00015 (95% CI= 0.60- 0.76). The MAHC-10 in this study performed similarly to other studies. A MAHC-10 score of six or more has better accuracy in predicting falls than a score of 4 or more. A score of six or more maximized sensitivity and specificity.

Similar results were documented by three other researchers. A study in Saudi Arabia of 269 older adults found that the MAHC-10 had a significant association (p=0.043) with falling. Approximately 34.6% (93 participants) were considered at high risk for falls. Participants who were categorized as at-risk with a score of four or more were at three times greater risk than those in the no-risk group (aOR: 3.07, 95% CI: 1.03-9.10; P=0.043) (Alabdullgader & Rabbani, 2021). In the validation study, a score of 4 demonstrated 96.9% sensitivity and 13.3%. A score of six demonstrated 68.7% sensitivity and 46.9% specificity (Calys et al., 2013). A study utilizing the OASIS dataset of 59,006 home healthcare patients in New York found the AUC of the MAHC-10 to be 0.6 (95% CI= 0.59-0.62) (Lo et al., 2019).

The MAHC-10 results in this study and the literature were similar. This may be due to the MAHC-10 being a multifactorial fall risk assessment. A total of ten variables were assessed for fall risk. PHNs during home visits, have the opportunity and ability to assess all ten variables to get a wholistic view of the client. The MAHC-10 is also an easy-to-use fall risk assessment tool. PHNs also have multiple opportunities through home visits, telephone calls, and medical record reviews in the following six months to assess an older adult for falls.

Prior History of Falls

In this study, there was a significant association between a prior history of falls and whether an older adult fell. $X^2(1) = 15.58$, $p < 0.001$, *phi* = 0.27. The odds ratio indicated that the odds of a person who had a prior history of falls and fell was 3.59 times higher than if they did not have a prior history of falls with a confidence interval of [1.87, 6.89].

These findings are similar to the findings in other studies. In the validation study, a prior history of falls within the past three months was significantly related to older adults who had fell status (p=<0.001, odds ratio 2.07)(Calys et al., 2013). Previous history of falls is commonly reported to be a significant predictor of future falls (Manlapaz et al., 2019). One study found that of those older adults who were considered at high risk for falling by the MAHC-10 with a score of four or more, 68.8% (64 participants) had a history of a fall in the previous year (P<0.001) (Alabdullgader & Rabbani, 2021). A study in Norway with community-dwelling older adults examined gait speed. A gait speed slower than 1.0 meters per second is a strong predictor of older adult falls. There were 108 older adults in this study that found that low gait speed was significantly associated with a history of multiple falls (OR=3.70, 95% CI [1.18, 11.65]) (Kyrdalen et al., 2019). A study of community-dwelling older adults with knee osteoarthritis found through logistic regression analysis that previous history of falls was a risk factor for falls [OR, 6.85; P=0.019]. Previous falls were defined as falling within a year before the survey (Amano & Tamari, 2022).

Studies measure the history of falls with varying time lengths, most common ranging from three months to a year before the person had the most current fall (Alabdullgader & Rabbani, 2021; Cella et al., 2020; Ikeda et al., 2022; Makino et al., 2021; Pérez-Ros et al., 2019; Van Gulick et al., 2022). This study defines a history of falls as an older adult falling in the three months before a MAHC-10 assessment. The PHNB population served is medically fragile and has many intrinsic risk factors that affect their fall risk. About 87.68% (n=185) of older adults had three or more medical diagnoses. For example, hypertension, dementia, and connective tissue disease would be difficult to manage in three months. Thus, intrinsic and extrinsic risk factors may continue to persist without intervention leading to a history of falls being a prominent risk factor in this study and in older adult fall literature.

Environmental Risk Factor

This study had a significant association between an environmental hazard in an older adult's home and whether an older adult fell. $X^2(1) = 8.08$, $p < 0.01$, *phi* = 0.20. The odds ratio revealed that the odds of a person who had an environmental risk factor in their home and fell was 2.82 times higher than if they did not have an environmental risk factor in their home with a confidence interval of [1.36, 5.86].

This is similar to four other studies in the literature. A study in Saudi Arabia found similar results: environmental risk factors (aOR: 2.79, 95% CI: 1.24-6.28; P= 0.013) were associated with fall risk for older adults. Environmental risk factors significantly related to falls were high door sills, uneven floor surfaces, and poor lighting. There was no significant association between falling and footwear and pets (Alabdullgader & Rabbani, 2021). A study examining the history of falls and environmental hazards in Saudi Arabia found a significant association utilizing Chi-square analysis. The study reported that 103 (81.7%) out of 126 older adults with a history of falls also had an environmental hazard. The total sample size of 357 older adults participated in the study (Alshammari et al., 2018).

A study in Portugal measured the indoor and outdoor environmental hazards of older adults. Indoor hazards included poor lighting, slippery floors, loose rugs, cables, objects for climbing, steep stairs without handrails, kitchens with difficult access to items, bathrooms without handrails, showers, toilets with slippery surfaces, and beds that are not the proper height. Outdoor hazards were poor lighting, uneven surfaces (pavement, streets, sidewalks), obstacles, slippery floors, the presence of animals, and poorly fitting footwear. The presence of environmental hazards increases the likelihood of falling. The likelihood of a fall increased by 6.5% for each additional environmental hazard. Less than five environmental hazards were categorized as low risk, five environmental hazards were moderate risk, six to eight environmental hazards were high risk, and greater than eight risk factors were very high risk for falls (Pereira et al., 2021).

Another study found a significant difference between the environmental risk factors of older adults who had fallen and older adults who had not fallen. Specifically, hazards relating to flooring, carpeting, the bathroom, access to the home and rooms. Weather conditions of rain, hot temperatures, and humidity were also significant environmental risk factors (Qian et al., 2021). The results of this study and other studies in the literature agree that there is a significant association between environmental hazards in an older adult's home and older adult falls. The environmental fall risk factors in the literature are similar to those found in PHNB client's home. Common environmental risk factors are slippery and uneven floors, poor lighting, loose rugs, pets, and outdoor hazards.

CCI and ACCI

This study found that CCI scores of two or more and three or more were significant. There was a significant association between the CCI score of two or more and whether an older adult fell. $X^2(1) = 7.34$, $p< 0.007$, *phi* = 0.19. The odds ratio demonstrated that the odds of a person with a CCI score of two or more falling was 3.65 times higher than if they had a CCI score lower than two with a confidence interval of [1.36, 9.78]. In this study, a CCI cutoff score of two or more had a sensitivity of 91.0% and a specificity of 26.0%. A significant association was found between the CCI score of three or more and whether an older adult fell. $X^2(1) = 9.16$, $p < 0.002$, *phi* = 0.21. According to the odds ratio, a person who had a CCI score of three or more falling was 2.68 times higher than if they had a CCI score lower than three with a confidence interval of [1.40, 5.13]. A CCI cutoff score of three or more had a 70.0% sensitivity and a 53.0% specificity.

In this study, ACCI scores of six or more and seven or more were found to be significant. There was a significant association between the six or more ACCI score and whether an older adult fell. $X^2(1) = 6.31$, $p < 0.01$, *phi* = 0.17. The odds ratio indicated that the odds of a person who had an ACCI score of six or more falling was 2.41 times higher than if they had an ACCI score lower than six with a confidence interval of [1.36, 9.78]. The ACCI total score cut-off value of six or more had a 77.0% sensitivity and a 42.0% specificity.

This is similar to other studies in the literature. A US multicenter longitudinal cohort study of 206,612 patients who suffered from fall-related injuries and received treatment at the ED found that an older adult was 2.79 times more likely to have a fall and a revisit to the ED if the older adult had a CCI score of three or more (95% CI 2.68 to 2.90). The CCI score was the strongest independent association of older adults who fell and had a revisit at the ED (Cox et al., 2022). Another study, through a secondary analysis of a cohort study in the Northwestern United States, examined 3,159 older adults who had fallen and required emergency services. A predictive model for mortality was developed using four predictors. Having any of the four predictors of CCI total score of two or more, respiratory diagnosis, serious brain injury, and baseline disability predicted 30-day mortality with a 96.6% sensitivity and 21.4% specificity.

The model predicted one-year mortality with a 91.6% sensitivity and a 23.8% specificity (Newgard et al., 2022).

Falls are the most common cause of TBI in older adults. A study estimated the risk of TBI associated with opioid use among older adult Medicare beneficiaries. This study found that participants with CCI total scores of two or more were significantly higher opioid users than non-opioid users (43.7% vs. 82.7%, $P < 0.001$) (Herrera et al., 2021). Fractures are another complication of falls and were studied by a Japanese study that collected data from 1,720 community-dwelling older adults 60 years and older. This study evaluated the effects of comorbidities on fragility fractures. In older men, fragility fractures were positively correlated with rheumatoid arthritis and hip fractures. In older women, fragility fractures were positively correlated with rheumatoid arthritis and antihypertensive drugs. If an older adult had an ACCI index greater than six, they had a higher fragility fracture risk than those with an ACCI index of 1-3. The ACCI index and falls were also independently and strongly associated with a higher risk of fragility fractures (Garu., 2021). The sample of older adults is recruited form all major islands except Niihau from across the state of Hawaii. This study and other studies in the literature find that having a CCI score of two or more, a CCI score of three or more, and an ACCI score of six or more are significantly related to older adults falling, respectively. The literature also indicates that having a greater number of comorbidities, CCI, and ACCI scores are associated with falls and complications of falls.

Depression

This study found a significant association between an older adult diagnosed with depression and whether an older adult fell. $X^2(1) = 11.15$, $p < 0.001$, *phi* = 0.23. The odds ratio revealed that the odds of a person who had depression and falling were 3.62 times higher than if they did not have depression with a confidence interval of [1.65, 7.93].

These findings are consistent with the existing literature. Multiple studies have found that older adults who have fallen are more likely to have depression than older adults who have not fallen (Lipardo et al., 2020; Qian et al., 2021). A US study with 1,356 home-bound elders found that older adults with depression and anxiety were at increased risk for falls (OR=1.269, p=0.042) compared to those without that health condition (Zhao et al., 2019).

A study of Medicare beneficiaries examined the association of chronic conditions and physical performance in older adults with back pain. Lower physical performance was associated with having four or more chronic conditions: arthritis alone, arthritis combined with depression, and arthritis combined with depression and anxiety. Recurrent falls were associated with two to three and more than four chronic conditions. Older adults with arthritis, depression, and anxiety also had greater odds of falling than older adults with no or one condition (Rundell et al., 2021).

Higher depressive symptoms increased the odds of recurrent falling (OR=1.09 and 95% CI 1.07-1.11) in a study of 5,227 older adults in Latin America and Caribbean cities. This study also explored that depressive symptoms significantly mediate between polyvictimization and recurrent falling. A history of polyvictimizations is associated with mental health consequences like depression. Polyvictimization is defined as two or more types of abuse. Types of abuse represented in this study were caregiver neglect, emotional, physical, financial, or sexual abuse. Recurrent falls were defined as more than two falls in the past 12 months (Reyes-Ortiz et al., 2021).

The odds ratio in this study for depression was higher than in the literature. This may be due to many of PHNB's older adult clients residing in rural areas. The lack of socialization, access to health care, and access to community socialization programs could play a role. Many PHNB older adult clients do not have family living in Hawaii. Also, data was collected during and after the Coronavirus Disease of 2019 (COVID-19) pandemic, which could have affected the mental health of older adults. This study and other studies in the literature find that depression is significantly related to older adults falling.

Cancer

This study found a significant association between an older adult diagnosed with cancer and whether an older adult falls. $X^2(1) = 5.51$, $p < 0.05$, *phi* = 0.16. The odds ratio demonstrated that the odds of a person who had cancer and falling was 2.67 times higher than if they did not have cancer with a confidence interval of [1.15, 6.18].

Cancer as a fall risk factor has been well-studied in the literature (Bluethmann et al., 2020; Magnuson et al., 2019; Qian et al., 2021; Sattar, 2018). A history of cancer and falls could limit mobility for older adults. A study of US community-dwelling older adults with cancer history found that a history of multiple falls was associated with lower gait speed scores in all participants ($P < 0.05$). Also, older adults with a history of cancer and a history of falls were three times more likely to use mobility devices (OR= 2.97; 95% CI= 2.4-3.68; $P < 0.001$) (Bluethmann et al., 2020).

To explore the circumstances of falls among those with cancer, a study in Canada recruited community-dwelling older adults with a history of cancer and falls. This study found that falls most commonly occurred indoors and during the day. The most common location of falls was in the living room and bathroom. Falls in the bathroom were more likely to be injurious. Falls on staircases, sidewalks, and while walking were also common. A person's physical sensations before a fall were weakness, dizziness, and difficulty balancing. Peripheral neuropathy and cancer-related pain, which are cancer-related symptoms, were not commonly reported in this study (Sattar, 2018).

Studies have suggested that older adults with cancer have an increased risk of falling due to the effects that the cancer has on the person and the toxicities of cancer treatments (Sattar, 2018). Cancer and cancer treatments can increase the risk of a fall-related injury due to bone loss from bone malignancies or bone metastases and interference with blood supply due to radiation therapy. Fatigue and chemotherapy-induced peripheral neuropathy can also increase a person's fall susceptibility (Magnuson et al., 2019). Falls can also impact cancer treatments (Sattar, 2018).

In this study, there was a 12.32% (n=26) rate of cancer in the sample of older adults. Of those older adults who had cancer, 46.15% (n=12) had a fall in six months. During PHN home visits, older adults with cancer may have symptoms or side effects from the treatment and medication. If in hospice, an older adult may also have more environmental hazards like tubing or assistive devices to aid with weakness or tiredness. This study and other studies find a significant association with having a history of cancer and older adults falling.

MI or PVD

This study used Fisher's exact test and found a significant association between the variables of a fall and MI (p=0.006). Falls and peripheral vascular disease (p=0.02) were also significantly associated. When combined, Fisher's exact test was completed, and a significant association was found between fall and the variable of Combo MI or PVD (p=0.001).

This study's findings are similar to the literature; one study found that older adults with slower TUG speeds were associated with an increased risk of developing MI, CHF, and mortality in older adults (Cella et al., 2020; Giallauria, 2019). A study of 2,404 Medicare beneficiaries who reported at least one fall found that having a history of MI increased their odds of having bathroom modifications (OR= 1.43, 95% CI= 1.06, 1.94, $p=0.020$). A study of 3,014 men found that men with PVD had more falls ($p=0.09$). Men with PVD also had a higher risk for hip fracture (OR 1.70; 95% CI 0.91-2.11, $p \leq 0.05$) (Bokrantz et al., 2022).

In this study, 9.50% (n=20) of older adults had MI or PVD, and of those older adults, 21.10% (n=12) had a fall. PHNs notice that clients with MI or PVD have physical and functional limitations due to their condition. Older adults with MI or PVD may also have more home modifications in the bathroom to help stabilize balance, assist with ADL modifications, and assist caregivers. For example, older adults with PVD, who have a history of falls may have lower physical function or have a history of MI (Bokrantz et al., 2022). This study and other studies in the literature find a significant association between MI, PVD, and older adult falls.

Antispasmodic Medication

Antispasmodic medication was the only high-risk medication found to have significant results. Fisher's exact test was completed, and a significant association was found between the variables of a fall and antispasmodic medication ($p=0.000$).

There is literature on fall-risk-increasing drugs (FRID) and polypharmacy increasing the susceptibility of older adults to falls. Literature on specifically antispasmodic medication is limited. A study using the National Ambulatory Medical Care Survey sampled 239,016,482 ambulatory care visits of older adults 65 years and older to explore if an injurious fall was associated with being prescribed a new FRID. Of the patients who experienced an injurious fall, approximately 4.4% continued taking antispasmodic medication. Antidepressants and antispasmodic medication were frequently prescribed FRID for the injurious fall group during the visit. Antispasmodic medications relax the skeletal muscles, are highly anticholinergic, and have depressive side effects, for example, dizziness, drowsiness, and hypotension (Elliott et al., 2022; Fick et al., 2019).

Antispasmodic medications are highly anticholinergic (UNC, 2018). Taking anticholinergic medication has been associated with falls. A study examining the relationship between medications with anticholinergic properties and hip fractures in elderly patients found that medications with moderate (OR: 1.97, 95% CI: 1.9-3.27) or high (OR: 1.83, 95% CI: 1.13-2.96) Anticholinergic Risk Scale (ARS) scores increased the probability of a fracture from a fall. ARS score represents the risk associated with patients developing an adverse event when taking anticholinergic medication (Machado-Duque et al., 2018).

There was a small sample of nine out of 211 older adults who took antispasmodic medications in this study. This variable was unbalanced, with eight older adults falling and one older adult not falling. Although the results of this study align with the fall literature, the reservations about the sample size of older adults who took antispasmodic medications should be noted.

Non-significant Results

This study did not find the indicators of age, gender, number of medications, or number of high-risk medications significantly associated with older adult falls. Among fall literature for age, it is commonly presented that older age is found to be a predictor of falls (Cella et al., 2020; Chen et al., 2020; Qian et al., 2021; Tornero-Quiñones et al., 2020; Van Gulick et al., 2022). Findings indicated that there was no difference between the age of older adults who had a fall and did not have a fall is an uncommon result (Asai et al., 2021; Kim et al., 2022). A possible explanation for this study's result could be that the sample comprised community-dwelling older adults receiving PHNB services. PHNB older adults tend to be referred to PHNB due to their medical fragility. Thus, the younger older adults are also medically fragile. Also, PHNB community-dwelling older adults who are unsafe in their homes may be placed in long-term facilities. Thus, these reasons could potentially skew this study's results.

Similar to the findings in this study, gender was not found to have a significant association with falls (Asai et al., 2021; Cella et al., 2020; Qian et al., 2021; Tornero-Quiñones et al., 2020). Literature on gender and falls is mixed. Other studies have found that females have a higher rate of falling than males (Alabdullgader & Rabbani, 2021; Chen et al., 2020; Ikeda et al., 2022; Moreland et al., 2020; Van Gulick et al., 2022). Older women also have more fall-related ED visits than older men (Moreland et al., 2020). This study had a small sample size of 211, with 57 (27.01%) older adults that fell. There were 27 (47.37%) females and 30 (52.63%) males that fell. This is a small sample size given that the literature states that the environments and psychology of falling for each gender are different which may have contributed to the non-significant results.

This study found that medication number and the number of high-risk medications taken were not significantly associated with falls. Two studies had similar findings, and the sample size of the two studies was 100 and 537 participants, respectively (Asai et al., 2021; Cella et al., 2020). A sample size of 211 was used in this study and may be attributed to the insignificant result regarding falls and medication number and type. Also, of note, when PHNs do home visits, it may take some time to build rapport with clients. Some clients refuse to allow PHNs to view their medications. Over time, PHNs may develop trust to assist clients with their medication management. Some clients also refuse to take any of their prescribed medications. PHNs may request the medication list from the Primary Care Provider, but some clients do not have a medical home in the case of homeless individuals or elders who have not seen a doctor in years.

At the time of PHN intake, the client would have zero medications. The goal of the PHN would be to build rapport, educate the client on the benefits of having a medical home, and assist the client in finding a Primary Care Provider. The process of building rapport may take more than six months in some cases and would be longer than the period for this study. This differs from the fall literature, stating a significant difference between the number of medications older adults who have fallen and those who have not taken (Qian et al., 2021). In the literature, polypharmacy is associated with falls, and taking more medications increases an older adult's risk for falls. Taking psychotropic, antidepressants, sedatives, benzodiazepines, anticonvulsants, antispasmodics, antipsychotics, opioids, or antihypertensives could increase an older adult's risk for falls (Haddad et al., 2019; CDC, 2021; UNC, 2018).

Summary of Key Findings for Research Question Two

The second research question was: Which fall risk indicators could be used to develop a fall prediction model for community-dwelling older adults in Hawaii? This study ran 43 multivariate regression models using hierarchical analysis. Model 30 used 10 variables in the model. The 10 variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, depression, MI and PVD, antispasmodic, ACCI score greater than or equal to 6, pain, and diabetes. The final predictive model had a c-statistic of 0.73 (95% CI= 0.64- 0.82). Hosmer-Lemeshow test p-value of 0.25. Model diagnostics for model 30 were investigated, and there were no concerning results for multicollinearity between two or more variables. VIF was below 10, the tolerance statistics were above 0.1, and no DFB or Cook's distance values exceeded 1. There was a concern with 8 cases having a Leverage statistic greater than 0.01. The two cases with the highest Leverage statistic were excluded from the following models.

Model 31 represents the results from the multivariate regression model with the unstable variable Antispasmodic medication and a sample size of 209. The 10 variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, depression, MI and PVD, Antispasmodic medication, ACCI score greater than or equal to 6, pain, and diabetes. This predictive model had a c-statistic of 0.73 (95% CI= 0.64-0.82). Hosmer-Lemeshow test p-value of 0.34.

Model 34 represents the final multivariate regression model results with a sample size of 209. The 10 variables in this model included MAHC-10 total score greater than or equal to 6, history of falls, environmental risk factors, cancer, depression, MI and PVD, ACCI score greater than or equal to 6, pain, diabetes, and four or more diagnoses. The final predictive model had a c-statistic of 0.70 (95% CI= 0.61- 0.79). Hosmer-Lemeshow test p-value of 0.07.

Model 42, with five variables, was created to achieve the most parsimonious model with a sample size of 21 older adults. In the final model, the predictors of a history of falls, MI or PVD, antispasmodic medication, and depression made significant contributions to the model. Environmental Hazards were added to the model to reach an AUC of 0.70.

Interpretation of Findings for Research Question Two

Model 42 was the most parsimonious, using the least number of predictors and achieving an AUC of 0.70. The predictors of a history of falls, MI or PVD, antispasmodic medication, and depression made significant contributions to the model. Environmental hazards were added to the model to increase the AUC.

The final predictive model had a c-statistic of 0.70 (95% CI= 0.61- 0.79) and a Hosmer-Lemeshow test p-value of 0.15. For model 42, the sensitivity of the model was 0.46 and a specificity of 0.95. The odds for falling were increased by a factor of 4.32 (95% CI= 2.01-9.28) for a client who had a history of falls within the past three months, increased by a factor of 4.49 (95% CI= 1.47- 13.72) for a client that had a history of MI or PVD, increased by a factor of 33.82 (95% CI= 3.50- 326.39) for a client that had a history of taking antispasmodic medication, increased by a factor of 2.59 (95% CI= 1.06- 6.35) for a client with a history of depression, and increased by a factor of 2.05 (95% CI= 0.91- 4.61) for a client with a history of environmental hazards.

Most of the risk factors chosen for the final model in this study were used in other models to predict falls in the literature and were found to have a significant association with older adult falls in question one of this study. History of falling as a risk factor was used in eight models and is associated with an increased risk of falling in older adults (Cella et al., 2020; Gade et al., 2021; Helsel et al., 2021; Ikeda et al., 2022; Pérez-Ros et al., 2019; Van de Loo et al., 2022; Van Gulick et al., 2022). Depression or depressive symptoms were addressed in three models (Gade et al., 2021; Ikeda et al., 2022; Oshiro et al., 2019). In the literature, medications used to treat urinary frequency, urinary incontinence, and Parkinson's were also used in models to predict falls and recurrent falls (Van de Loo et al., 2022).

Fall prediction models found that the risk for falls increased as comorbidities increased. The CCI was also used in fall risk prediction models (Oshiro et al., 2019). To this author's knowledge, no models used MI or PVD diagnoses specifically. Comorbidities, frailty, exhaustion, and perceived unhealthiness were general risk factors used in prediction models to describe older adults' health (Chen et al., 2020; Kim et al., 2022; Oshiro et al., 2019).

This study utilized the environmental risk factor as the last predictor due to the desire to expand the model past the biological risk factors based on the WHO Risk Factor Model for Falls in Older Age. Environmental risk factor as a predictor was also found to have a significant association with falls in research question one of this study. To this author's knowledge, environmental risk factors have not been used in fall prediction models. No environmental risk factors were found to be useful in the prediction models in the literature. Environmental risk factors include poor building design, slippery floors and stairs, loose rugs, insufficient lighting, and cracked or uneven sidewalks. One study examined weather patterns, but the results were insignificant (Qian et al., 2021). The ability to climb stairs without a handrail was used in a predictive model (Ikeda et al., 2022). This may represent an older adult's mobility and strength more than an environmental risk factor.

Although the final model developed had an acceptable AUC statistic of 0.7 and specificity of 0.95, the sensitivity of the model was 0.46 which is concerning for clinical applications. The antispasmodic medication variable was unbalanced as evidenced by the large confidence interval. For antispasmodic medication, the unadjusted odds ratio was 24.98 compared to the adjusted odds ratio in model 42 of 33.82. This reflects that the data may be skewed causing the model to be unstable and affecting the applicability of the model to clinical practice.

Comparing Results

In this study, Model 42 and the MAHC-10 Total Score were the best methods found for predicting older adult falls in this sample. Model 42 used five predictors: history of falls, MI or PVD, antispasmodic medications, depression, and environmental hazards, and was the most parsimonious model in this study. Model 42 used the least number of predictors and achieved an AUC of 0.70. The final predictive model had a c-statistic of 0.70 (95% CI= 0.61- 0.79) and a Hosmer-Lemeshow test p-value of 0.15. For model 42, the sensitivity of the model was 0.46 and a specificity of 0.95.

The MAHC-10 Total Score is based on 10 core elements, and evidence-based literature, and is calculated by PHNs currently in practice. The MAHC-10 Total Score did have an AUC of 0.68, p=0.00009 (95% CI= 0.60- 0.76). For the MAHC-10, a cutoff score of 6 resulted in a maximized combined sensitivity of 0.86 and a specificity of 0.40. Notably, some components of the MAHC-10 were found to have a strong association with falls in this specific sample. These specific components were used in Model 42.

Due to model 42 being unstable due to skewed data from the antispasmodic medication predictor, it may be pertinent to use the MAHC-10 Total Score to predict falls for PHNB older adult-carried cases until more research can be done. The difference in AUC between Model 42 and the MAHC-10 Total score is 0.2 which is a small increase in AUC considering Model 42 uses 5 predictors compared to 1 predictor by the MAHC-10 Total Score.

Knowledge Contribution

Overall, this study contributed to the literature by studying a unique sample of community-dwelling older adults who lived in Hawaii. Data was obtained from the Hawaii Department of Health Public Health Nursing Branch. The mean age of participants was 78.16 years (SD= 9.04), and 117 (55.5%) were women. The most common ethnicities were Caucasian at 44.1% (n=93), Asian at 32.2% (n=68), and Native Hawaiian or Other Pacific Islander at 21.3% (n=45). Ninety-seven (46.0%) of older adults lived alone.

In this study, 27.0% (n=57) of participants reported a fall six months after PHNB admission. Approximately 36.8% (n=21) of clients who fell did not have a fall injury. The most common injuries were bruises 22.8% (n=13) and lacerations 19.3% (n=11). The most common dispositions of clients after a fall were home at 66.7% (n=38) and the hospital at 19.3% (n=11).

This study aimed to understand the risk factors significantly associated with Hawaii community-dwelling older adult falls. The MAHC-10 total score of six or more, the CCI total score of two or more, the CCI total score of three or more, and the ACCI total score of six or more had a significant association with older adult falls. Other significant predictors associated with older adult falls were prior history of falls, environmental risk factors, depression, cancer, MI, PVD, and antispasmodic medication. For this sample, age, gender, number of medications, and number of high-risk medications were not significantly associated with older adult falls.

The MAHC-10 performed similarly to other studies predicting falls for this sample of Hawaii community-dwelling older adults. The mean MAHC-10 total score was 6.41 (SD=1.8). A MAHC-10 score of six or more has better accuracy in predicting falls than a score of 4 or more. In this study, 141 (66.8%) participants had a MAHC-10 total score greater than 6 points. The mean MAHC-10 total score of those who fell was 7.23 (SD=1.6), and 49 (86.0%) of those who fell had a MAHC-10 total score greater than 6 points. According to the odds ratio, a person who had a MAHC-10 score of 6 or more falling was 4.13 times higher than if they had a MAHC-10 score lower than 6 with a confidence interval of [1.83, 9.31]. The MAHC-10 cutoff score of 6 resulted in a maximized combined sensitivity of 86.0% and a specificity of 40.0%.

Assessing this sample of Hawaii community-dwelling older adults with CCI and ACCI contributed to the literature to assist researchers in gaining a better understanding of comorbidities for this population. The comorbidities with the highest incidence in this sample were hypertension 159 (73.36%), diabetes 67 (31.75%), and dementia 59 (27.96%). The mean CCI score was 3 for all older adults (SD= 1.9). For older adults who had fallen, the CCI score was 3.6 (SD= 2.1). CCI scores of two or more and three or more were found to be significant. The odds ratio revealed that the odds of a person with a CCI score of two or more falling was

3.65 times higher than if they had a CCI score lower than two with a confidence interval of [1.36, 9.78]. The odds ratio demonstrated that the odds of a person who had a CCI score of three or more falling was 2.68 times higher than if they had a CCI score lower than three with a confidence interval of [1.40, 5.13].

In this study, the mean ACCI score was 6.2 (SD=2) for all participants, and the mean ACCI score was 6.9 (SD=2.1) for older adults who fell. ACCI scores of six or more and seven or more were found to be significant. According to the odds ratio, a person who had an ACCI score of six or more falling was 2.41 times higher than if they had an ACCI score lower than six with a confidence interval of [1.36, 9.78]. The odds ratio indicated that the odds of a person who had an ACCI score of seven or more falling was 2.31 times higher than if they had an ACCI score lower than seven with a confidence interval of [1.24, 4.3].

A parsimonious model was developed with five variables with a sample size of 211 Hawaii community-dwelling older adults. In the final model, the predictors of a history of falls, MI or PVD, antispasmodic medication, and depression made significant contributions to the model. Environmental Hazards were added to the model to reach an AUC of 0.70.

Limitations of the Study

This study had several limitations. This study's fall follow-up period was six months from the initial MAHC-10 assessment. A longer timeframe may provide greater insight into community-dwelling older adult falls. This study and other studies on community-dwelling older adult falls are subject to recall bias and the potential for underreporting falls. This study reported falls to PHNs during home visits and points of contact like telephone calls or reviewing the client’s medical records.

Another limitation of this study is that variables do not represent all fall-related risk factors. According to the WHO Risk Factor Model for Falls, fall risk has four dimensions. Most of the variables in this study were categorized into the biological dimension. This study only assessed environmental risk factors using one general variable. In this study, variables were selected due to being identified as viable options with data collection methods in the PHNB clinical setting. Multiple PHNs assessed all variables in clinical practice. Although PHNs were trained by PHNB annual standardized training and performed assessments according to written Standard Operating Procedures, some random measurement errors cannot be excluded due to practice drift. Older adult clients also received fall prevention interventions for their needs while receiving PHN services. Other fall prevention interventions may have been accessible to clients through their Primary Care providers, community agencies, and statewide fall prevention campaigns.

A limitation of this study is the small sample size involving community-dwelling older adults living in Hawaii who receive PHNB services. Results may not generalize to other populations or represent all community-dwelling older adults. This study also lacked strong statistical power to detect associations due to small numbers within groups, making some variables unstable. Sample size availability affected model development, resulting in model instability when two cases were excluded during model diagnostics. This study used the Fishers test and combined variables as in MI and PVD to account for the small sample size.

Strengths

The strengths of this study are that there was no missing data. During the data collection phase, if data was not accessible initially, the electronic health record or hard chart was accessed.

For these records, PHNs were able to verify the data accuracy. The data in this study provides new information on older adult risk factors and fall history for a unique community population.

This study also provides insight into how the MAHC-10, CCI, and ACCI preforms for community-dwelling older adults in Hawaii. The MAHC-10, CCI, and ACCI sensitivity, specificity, and AUC were calculated for this sample. Cut-off scores were also investigated and the optimal cut-off scores were identified for this sample.

The sample of community-dwelling older adults that PHNB provides services to are medically fragile and live in rural areas. This study was a statewide sample of community-dwelling older adults from Hawaii, Honolulu, Kauai, and Maui counties. The inclusion of neighbor islands was important to represent the state of Hawaii as a whole. This study also included 21.3% (n=45) of Native Hawaiians and Pacific Islanders (NHPI). The NHPI population is one of the fastest-growing populations in the US and is understudied (Phillips et al., 2022; Tomioka et al., 2019; Walter et al., 2022).

Future Recommendations

The following are recommendations to improve clinical practice and for future research. The first recommendation is to increase the sample size for model development for future studies. For this current study, a sample size of 400 with potentially 100 cases of older adult falls would be beneficial. In this study, 27.0% (n=57) of participants reported a fall six months after PHNB admission (Riley et al., 2020).

The results and model developed with this sample could also be cross-validated with a different sample of community-dwelling older adults. Other fall models could be developed and fall risk factors could be identified for sub-populations of community-dwelling older adults living in Hawaii. The Asian or NHPI, frequent fallers, or community-dwelling older adults living alone or with dementia populations could be studied in the future.

Variables about fall risk for community-dwelling older adults living in Hawaii could be expanded. Additional socioeconomic, behavioral, environmental, and biological risk factors can be included in future studies. Additional socioeconomic variables could be specific to this study, including financial, educational, or health literacy variables. Behavioral variables could include alcohol consumption, exercise frequency, medication compliance, medication dosage, and frequency, or use of a walking aid. More specifics on environmental risk factors about where the fall occurred, poor lighting, slippery floors, or uneven surfaces would be beneficial. The variable of antispasmodic medication could be further examined for this specific population.

Future research could involve other assessments and exploring the relationship of different factors with older adult falls to identify community-dwelling older adults at risk for falls. The association between depression, cognitive impairment, fear of falling, and falls could assist researchers and clinicians in understanding more about the psychological aspects of falling. Potential scales include the Geriatric Depression Scale, Mini-Cong, FES-I, and Icon-FES (Hirase et al., 2020; Kubo et al., 2021; Monachan et al., 2020; Quach et al., 2019; Soh, 2021). Additional variables on mobility, gait speed, stability, balance, and strength may be considered. Tools for consideration in future research and clinical practice are in the CDC STEADI Older Adult Fall Prevention clinical resources. These tools are the TUG, the 30-Second Chair Stand Test, and the 4-Stage Balance Test (Asai et al., 2021; Cella et al., 2020; Makino et al., 2021; Trevisan et al., 2020; Van Gulick et al., 2022; Welch et al., 2021). Frailty would also be a variable for consideration. In the literature, the poor performance of models may be due to frailty in the sample that is greater than the average community-dwelling population (Ikeda et al., 2022). Future research and clinical practice could improve by increasing the types of variables collected to increase the understanding of fall risk factors.

Future studies for Hawaii community-dwelling older adults should increase the timeframe for fall follow-up to at least one year. Studies could follow clients over an extended period and account for older adults who have frequent falls. Future studies could be created to understand risk factors for recurrent and isolated Hawaii community-dwelling older adults who fall (Pérez-Ros et al., 2019). In clinical practice, a fall calendar would decrease clients' recall bias risk.

Future research and clinical practice would also benefit from studying the effectiveness of evidence-based fall prevention interventions. Fall prevention interventions like A Matter of Balance, Stepping On, Tai Chi, or the Otago Exercise Program are common evidence-based fall prevention that can be used in rural areas (Ganz & Latham, 2020; Martins, 2018; Yang et al., 2021). Future research should study the effectiveness of the CDC STEADI with this population (CDC, 2021). Research on fall prevention interventions to examine outcomes of falls, fear of falling, or mobility and strength over a period for older adults living in Hawaii would assist in finding the most appropriate intervention for Hawaii's unique older adult population.

Summary of Chapter Five

Chapter Five discussed the key findings of this study and provided interpretations of the results. This chapter also discussed this study's contribution to further the literature on falls and community-dwelling older adults living in Hawaii. This study contributed to the literature by providing insight into this unique sample of community-dwelling older adults living in Hawaii. This study also identified risk factors that are significantly associated with falls. The MAHC-10 total score of six or more, the CCI total score of two or more, the CCI total score of three or more, and the ACCI total score of six or more, prior history of falls, environmental risk factors, depression, cancer, MI, PVD, and antispasmodic medication were found to be significantly associated with falls. Information was gathered on the MAHC-10, CCI, and ACCI performance for this unique sample. A parsimonious model with an AUC of 0.70 was developed with five variables with the predictors of a history of falls, MI or PVD, antispasmodic medication, depression, and environmental hazards. Lastly, the limitations, strengths, and future recommendations for research and clinical practice were explored in this final chapter.

Appendix A

Risk Factors of the Fall Prediction Models Categorized by the WHO Risk Factor Model for Falls in Older Age

Risk Factor Type	Risk Factor (Number of Studies)	Study
Biological	Age (4)	(Cella, et al., 2020) (Ikeda, et al., 2022) (Makino, et al., 2021) (Oshiro, et al., 2019)
	Gender (4)	(Cella, et al., 2020) (Chen, et al., 2020) (Lavedan, et al., 2018 (Oshiro, et al., 2019)
	Chronic Illnesses & Symptoms (11)	(Chen, et al., 2020) (Gade, et al., 2021) (Hohtari-Kivimaki, et al., 2021) (Ikeda, et al., 2022) (Kim, et al., 2022) (Makino, et al., 2021) (Oshiro, et al., 2019) (Perez-Ros, et al., 2018) (Sagawa, et al., 2018) (Trevisan, et al., 2020) (Van De Loo, et al., 2022)
	Physical Capacities Decline (10)	(Asai, et al., 2018) (Cella, et al., 2020) (Chen, et al., 2020) (Ikeda, et al., 2022) (Makino, et al., 2021) (Oshiro, et al., 2019) (Qian, et al., 2021) (Trevisan, et al., 2020) (Van Gulick, et al., 2022) (Welch, et al., 2022)
	Cognitive Capacities Decline (9) (Depression)	(Asai, et al., 2018) (Davis, et al., 2017) (Gade, et al., 2021) (Helsel, et al., 2021) (Ikeda, et al., 2022) (Lavedan, et al., 2018) (Makino, et al., 2021) (Oshiro, et al., 2019) (Van De Loo, et al., 2022)
	Affective Capacities Decline (1)	(Kim, et al., 2022)

	(Exhaustion and motivation)	
Behavioral	Multiple Medication Use (6)	(Cella, et al., 2020) (Makino, et al., 2021) (Oshiro, et al., 2019) (Perez-Ros, et al., 2018) (Sagawa, et al., 2018) (Van De Loo, et al., 2022)
	Excess Alcohol Intake (2)	(Gade, et al., 2021) (Qian, et al., 2021)
Socioeconomic	Education Levels (2)	(Gade, et al., 2021) (Van De Loo, et al., 2022)
	Lack of Social Interactions (1)	(Chen, et al., 2020)
Environmental	None	
Falls and Fall-Related Injuries	History of Falls (8)	(Cella, et al., 2020) (Gade, et al., 2021) (Helsel, et al., 2021) (Ikeda, et al., 2022) (Makino, et al., 2021) (Perez-Ros, et al., 2018) (Van De Loo, et al., 2022) (Van Gulick et al., 2022)

Appendix B

Missouri Alliance for Home Care Fall Risk Assessment Tool (MAHC-10)

Missouri Alliance for HOME CARE

Home Care Fall Reduction Initiative

MAHC 10 - Fall Risk Assessment Tool

Click here to review the Validation Study of the Missouri Alliance for Home Care's fall risk assessment tool.

Conduct a fall risk assessment on each patient at start of care and re-certification.

Patient Name:____________________

(Circle one) SOC or Re-certification Date:__________

Required Core Elements **Assess one point for each core element "yes".** *Information may be gathered from medical record, assessment and if applicable, the patient/caregiver. Beyond protocols listed below, scoring should be based on your clinical judgment.*	**Points**
Age 65+	
Diagnosis (3 or more co-existing) Includes only documented medical diagnosis	
Prior history of falls within 3 months An unintentional change in position resulting in coming to rest on the ground or at a lower level	
Incontinence Inability to make it to the bathroom or commode in timely manner Includes frequency, urgency, and/or nocturia.	
Visual impairment Includes but not limited to, macular degeneration, diabetic retinopathies, visual field loss, age related changes, decline in visual acuity, accommodation, glare tolerance, depth perception, and night vision or not wearing prescribed glasses or having the correct prescription.	
Impaired functional mobility May include patients who need help with IADLS or ADLS or have gait or transfer problems, arthritis, pain, fear of falling, foot problems, impaired sensation, impaired coordination or improper use of assistive devices.	
Environmental hazards May include but not limited to, poor illumination, equipment tubing, inappropriate footwear, pets, hard to reach items, floor surfaces that are uneven or cluttered, or outdoor entry and exits.	
Poly Pharmacy (4 or more prescriptions – any type) All PRESCRIPTIONS including prescriptions for OTC meds. Drugs highly associated with fall risk include but not limited to, sedatives, anti-depressants, tranquilizers, narcotics, antihypertensives, cardiac meds, corticosteroids, anti-anxiety drugs, anticholinergic drugs, and hypoglycemic drugs.	
Pain affecting level of function Pain often affects an individual's desire or ability to move or pain can be a factor in depression or compliance with safety recommendations.	
Cognitive impairment Could include patients with dementia, Alzheimer's or stroke patients or patients who are confused, use poor judgment, have decreased comprehension, impulsivity, memory deficits. Consider patients ability to adhere to the plan of care.	
A score of 4 or more is considered at risk for falling **Total**	

Clinician's signature____________________

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Appendix C

Types of Risk Factors Assessed by Fall Risk Assessment Tools

Fall Risk Assessment Tool	History of Falls	Biological Risk Factors	Behavioral Risk Factors	Environmental Risk Factors	Socioeconomic Risk Factors
Berg Balance Scale		X			
Hendrich II Scale		X	X		
MAHC-10	X	X	X	X	
Morse Fall Scale (MFS)	X	X	X	X	
STRATIFY Tool	X	X	X		
Timed Up and Go (TUG)		X			
Tinetti Balance Assessment Tool (POMA)		X			

Appendix D

Charlson Comorbidity Index

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Charlson Comorbidity Index

Chart review version

Components of classical Charlson Comorbidity Index[1]

1. Has the patient had a myocardial infarction? (MI)
   ___ No

   ___ Yes

Criteria: Myocardial infarction includes patients with one or more definite or probable myocardial infarction. These patients should have been hospitalized for chest pain or an equivalent clinical event and have had electrocardiographic and/ or enzyme changes. Patients with electrocardiographic changes alone who have no clinical history are not designated as having had an infarction.

2. Has the patient been hospitalized or treated for heart failure? (CHF)
   ___ No

   ___ Yes

Criteria: Congestive heart failure includes patients who have had exertional or paroxysmal nocturnal dyspnea and who have responded symptomatically (or on physical examination) to digitalis, diuretics, or afterload reducing agents. It does not include patients who are on one of those medications but who have had no response and no evidence of improvement of physical signs with treatment.

3. Does the patient have peripheral vascular disease? (PVD)
   ___ No

   ___ Yes

[1] Charlson, ME, Ales, KA, Pompei, P, MacKenzie, CR. A new method of classification of prognostic comorbidity for longitudinal studies: development and validation. J Chron Disease. 1987; 40(5): 373–383.

Criteria: Peripheral vascular includes patients with intermittent claudication or those who had a bypass for arterial insufficiency, those with gangrene or acute arterial insufficiency, and those with a treated or untreated thoracic or abdominal aneurysm (6 cm or more).

4. Has the patient had a CVA or transient ischemic disease? (CVA)
   ___ No

   ___ Yes

Criteria: Cerebrovascular disease includes patients with a history of a cerebrovascular accident with minor or no residua, and patients who have had transient ischemic attacks.
If the CVA resulted in hemiplegia, code only hemiplegia.

5. Does the patient have hemiplegia? (PLEGIA)
   ___ No

   ___ Yes

Criteria: This includes patients with a hemiplegia or paraplegia, whether it occurred as a result of a cerebrovascular accident or other condition.

6. Does the patient have asthma, chronic lung disease, chronic bronchitis or emphysema? (COPD)
   ___ No

   ___ Yes

Criteria: Pulmonary disease includes patients with asthma, chronic bronchitis, emphysema, and other chronic lung disease who have ongoing symptoms such as dyspnea or cough, with mild or moderate activity. This includes patients who are dyspneic with slight activity, with or without treatment and those who are dyspneic with moderate activity despite treatment, as well as patients who are dyspneic at rest, despite treatment, those who require constant oxygen, those with CO_2 retention and those with a baseline PO_2 below 50 torr.

7. Does the patient have diabetes that requires treatment? (DM)
   ___ No

___ Yes

Criteria: Diabetes includes all patients with diabetes treated with insulin or oral hypoglycemic, but not diet alone. Diabetes during pregnancy alone is not counted.

7a. Does the patient have end organ damage from diabetes? (DMENDORGAN)

___ No

___ Yes

Criteria: This includes patients with retinopathy, neuropathy, or nephropathy attributable to diabetes.

8. Does the patient have moderate or severe renal disease? (RENAL)

___ No

___ Yes

Criteria: Moderate renal insufficiency includes patients with a serum creatinine >3 mg/dl. Severe renal disease includes patients on dialysis, those who had a transplant, and those with uremia.

9. Does the patient have a chronic liver disease? (MILDLIVER)

___ No

___ Yes

Criteria: Mild liver disease consists of chronic hepatitis (B or C) or cirrhosis without portal hypertension.

9a. Does the patient have moderate to severe liver disease? (SEVERELIVER)

___ No

___ Yes

Criteria: Moderate liver disease consists of cirrhosis with portal hypertension, but without bleeding. Severe liver disease consists of patients with ascites, chronic jaundice, portal hypertension or a history of variceal bleeding or those who have had liver transplant.

10. Has the patient had gastric or peptic ulcers? (ULCER)

___ No

___ Yes

Criteria: Peptic ulcer disease includes patients who have required treatment for ulcer disease, including those who have bled from ulcers.

11. Has the patient had cancer (other than basal cell skin cancer)? (CANCER)

___ No

___ Yes

If yes, which:

___ Lymphoma?

___ Leukemia?

___ Solid tumor (which?)___________________________

Criteria: Lymphoma includes patients with Hodgkins, lymphosarcoma, Waldenstrom's macroglobulinemia, myeloma, and other lymphomas. Leukemia includes patients with acute and chronic myelogenous leukemia, acute and chronic lymphocytic leukemia, and polycythemia vera. Solid tumor consists of patients with solid tumors without documented metastases, including breast, colon, lung, prostate, and a variety of other tumors.

11a. Has the patient had a metastatic solid tumor? (METASTASES)

___ Breast

___ Colon

___ Prostate

___ Lung

___ Melanoma

___ Other _________________

Criteria: Metastatic cancer includes patients with metastatic solid tumors, including breast, lung, colon and other tumors.

12. Does the patient have Alzheimer's, dementia from any etiology or any serious cognitive impairment? (DEMENTIA)

___ No

___ Yes

Criteria: Dementia includes patients with moderate to severe chronic cognitive deficit resulting in impaired function from any cause.

13. Does the patient have any rheumatic or connective tissue disease? (RHEUMATIC)

___ No

___ Yes

Criteria: Rheumatologic disease includes patients with systemic lupus erythematous, polymyositis, mixed connective tissue disease, rheumatoid arthritis, polymyositis, polymyalgia rheumatica, vasculitis, sarcoidosis, Sjogrens syndrome or any other systemicvasculitis

14. Does the patient have HIV or AIDS? (HIV)

___ No

___ Yes

Criteria: Acquired immune deficiency syndrome includes patients with definite or probable AIDS, i.e. AIDS related complex, and those who are HIV positive and asymptomatic.

Additional components of Charlson Comorbidity Index adapted to predict cost[2]

15. Does the patient have hypertension? (HBP)

___ No

___ Yes

Criteria: Hypertension includes patients who have systolic pressures >140 mm Hg and/ or diastolic pressures >90 mm Hg if without diabetes or renal disease, as well as controlled hypertensives; or patients with diabetes or renal disease who have systolic pressures >140 mm Hg or diastolic pressures >80 mm Hg.

16. Has the patient had decubitus ulcers, peripheral skin ulcers or repeated episodes of cellulitis? (SKINULCER)

___ No

___ Yes

Criteria: Partial thickness loss of skin over legs or back with open ulcers or two or more episodes of cellulitis requiring treatment with antibiotics, regardless of etiology.

17. Does the patient have depression? (DEPRESSION)

___ No

___ Yes

Criteria: Patients who are currently receiving treatment for depression, whether pharmacologic or psychotherapy, or cognitive behavioral therapy, or notes indicating that the patient has probable or definite depression.

18. Is the patient on warfarin or coumadin? (WARFARIN)

___ No

___ Yes

[2] Charlson, ME, Charlson RE, Briggs, W, Hollenberg, J. Can disease management target patients most likely to generate high costs? The impact of comorbidity. J Gen Intern Med. 2007; 22(4): 464-469.

Conditions that are not assigned weights

- Angina includes patients with chronic exertional angina, those who had coronary artery bypass graft, and those initially admitted with unstable angina.
- Arrhythmia includes patients with chronic atrial fibrillation or flutter, sick sinus syndrome, or ventricular arrhythmias requiring chronic treatment.
- Valvular disease includes patients with hemodynamically significant aortic stenosis and/or insufficiency, those with significant mitral stenosis and/or insufficiency, and those with prosthetic aortic or mitral valves, asymmetric septal hypertrophy requiring treatment, or tricuspid insufficiency.
- Other neurologic conditions includes patients with Parkinson’s disease, uncontrolled seizures, or syncope without an identified cause or treatment.
- Other endocrine includes patients with hypopituitarism, adrenal insufficiency, and recurrent acidosis.
- Inflammatory bowel disease includes patients with ulcerative colitis or regional enteritis.
- Gastrointestinal bleeding includes those who have had bleeding requiring transfusions from causes other than ulcer disease.
- Coagulopathy includes patients with a circulating anticoagulant, or other coagulopathy.

Charlson Comorbidity Index

Scoring

Condition	Variable name	Points	Notes
Myocardial infarction	MI	1	
Congestive heart failure	CHF	1	
Peripheral vascular disease or bypass	PVD	1	
Cerebrovascular disease or transient ischemic disease	CVA	1	CVA only
Hemiplegia	PLEGIA	2	If hemiplegia, do not count CVA separately
Pulmonary disease/ asthma	COPD	1	
Diabetes	DM	1	DM only
Diabetes with end organ damage	DMENDORGAN	2	If end organ damage, do not count DM separately
Renal disease	RENAL	2	
Mild liver disease	MILDLIVER	2	
Severe liver disease	SEVERELIVER	3	
Gastric or peptic ulcer	ULCER	1	
Cancer (lymphoma, leukemia, solid tumor)	CANCER	2	Nonmetastatic cancer only
Metastatic solid tumor	METASTASES	6	If Metastatic, do not count cancer separately
Dementia or Alzheimer’s	DEMENTIA	1	
Rheumatic or connective tissue disease	RHEUMATIC	1	
HIV or AIDS	HIV	6	
Hypertension	HBP	1	

Skin ulcers/ cellulitis	SKIN ULCER	2	
Depression	DEPRESSION	1	
Warfarin	WARFARIN	1	

Appendix E

Logistic Regression Models

Logistic regression model 1 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.02	0.77	5.31	0.15
	<6	ref			
Hist fall	Yes	2.47	1.20	5.08	0.01
	No	ref			
Environmental Hazard	Yes	1.59	0.68	3.72	0.29
	No	ref			
Cancer Combined	Yes	1.97	0.79	4.91	0.15
	No	ref			
Depression	Yes	2.70	1.15	6.35	0.02
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.63	0.54	0.72
Overall Percentage	77.30		
Hosmer and Lemeshow	0.75		

Logistic regression model 2 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.89	0.72	4.99	0.20
	<6	ref			
Hist fall	Yes	2.47	1.19	5.09	0.01
	No	ref			
Environmental Hazard	Yes	1.51	0.64	3.55	0.35
	No	ref			
Cancer Combined	Yes	1.62	0.62	4.21	0.32
	No	ref			
Depression	Yes	2.49	1.05	5.92	0.04
	No	ref			
CCI	≥3	1.63	0.78	3.42	0.19
	<3	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.63	0.53	0.72
Overall Percentage	76.80		
Hosmer and Lemeshow	0.44		

Logistic regression model 3 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.84	0.69	4.90	0.22
	<6	ref			
Hist fall	Yes	2.52	1.22	5.19	0.01
	No	ref			
Environmental Hazard	Yes	1.65	0.70	3.91	0.25
	No	ref			
Cancer Combined	Yes	1.64	0.64	4.20	0.30
	No	ref			
Depression	Yes	2.53	1.06	6.00	0.04
	No	ref			
ACCI	≥6	1.76	0.81	3.79	0.15
	<6	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.63	0.53	0.72
Overall Percentage	76.80		
Hosmer and Lemeshow	0.04		

Logistic regression model 4 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.64	0.60	4.47	0.34
	<6	ref			
Hist fall	Yes	2.84	1.33	6.08	0.01
	No	ref			
Environmental Hazard	Yes	1.78	0.73	4.32	0.21
	No	ref			
Cancer Combined	Yes	1.83	0.72	4.64	0.20
	No	ref			
Depression	Yes	2.57	1.07	6.13	0.03
	No	ref			
MI or PVD	Yes	4.75	1.66	13.62	0.00
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.67	0.58	0.76
Overall Percentage	79.60		
Hosmer and Lemeshow	0.20		

Logistic regression model 5 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.01	0.76	5.32	0.16
	<6	ref			
Hist fall	Yes	2.48	1.20	5.13	0.01
	No	ref			
Environmental Hazard	Yes	1.60	0.68	3.76	0.28
	No	ref			
Cancer Combined	Yes	1.92	0.77	4.78	0.16
	No	ref			
Depression	Yes	2.72	1.16	6.38	0.02
	No	ref			
Native Hawaiian & Pacific Islander	Yes	0.61	0.25	1.47	0.27
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.63	0.53	0.72
Overall Percentage	76.80		
Hosmer and Lemeshow	0.73		

Logistic regression model 6 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.87	0.70	5.01	0.21
	<6	ref			
Hist fall	Yes	2.51	1.21	5.19	0.01
	No	ref			
Environmental Hazard	Yes	1.86	0.77	4.51	0.17
	No	ref			
Cancer Combined	Yes	1.78	0.71	4.48	0.22
	No	ref			
Depression	Yes	3.27	1.35	7.92	0.01
	No	ref			
Age	Yes	1.04	1.00	1.08	0.06
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.62	0.53	0.71
Overall Percentage	75.80		
Hosmer and Lemeshow	0.06		

Logistic regression model 7 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.10	0.79	5.54	0.14
	<6	ref			
Hist fall	Yes	2.46	1.19	5.07	0.01
	No	ref			
Environmental Hazard	Yes	1.53	0.65	3.59	0.33
	No	ref			
Cancer Combined	Yes	1.84	0.73	4.63	0.20
	No	ref			
Depression	Yes	2.87	1.20	6.86	0.02
	No	ref			
Gender	Female	1.58	0.80	3.10	0.18
	Male	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.62	0.53	0.71
Overall Percentage	77.30		
Hosmer and Lemeshow	0.22		

Logistic regression model 8 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.69	0.62	4.65	0.31
	<6	ref			
Hist fall	Yes	3.35	1.50	7.45	0.00
	No	ref			
Environmental Hazard	Yes	1.53	0.64	3.68	0.34
	No	ref			
Cancer Combined	Yes	1.57	0.59	4.19	0.37
	No	ref			
Depression	Yes	2.80	1.15	6.81	0.02
	No	ref			
Antispasmodic	Yes	32.95	3.59	302.69	0.00
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.67	0.57	0.76
Overall Percentage	80.10		
Hosmer and Lemeshow	0.42		

Logistic regression model 9 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.42	0.50	4.00	0.51
	<6	ref			
Hist fall	Yes	3.74	1.63	8.61	0.00
	No	ref			
Environmental Hazard	Yes	1.71	0.69	4.23	0.24
	No	ref			
Cancer Combined	Yes	1.56	0.57	4.23	0.39
	No	ref			
Depression	Yes	2.54	1.03	6.28	0.04
	No	ref			
MI or PVD	Yes	4.24	1.37	13.10	0.01
	No	ref			
Antispasmodic	Yes	30.55	3.13	298.47	0.00
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	81.50		
Hosmer and Lemeshow	0.09		

Logistic regression model 10 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.39	0.49	3.95	0.53
	<6	ref			
Hist fall	Yes	3.72	1.62	8.55	0.00
	No	ref			
Environmental Hazard	Yes	1.67	0.67	4.17	0.27
	No	ref			
Cancer Combined	Yes	1.45	0.51	4.12	0.49
	No	ref			
Depression	Yes	2.45	0.98	6.14	0.06
	No	ref			
MI or PVD	Yes	3.93	1.21	12.72	0.02
	No	ref			
Antispasmodic	Yes	29.52	3.04	286.47	0.00
	No	ref			
CCI	≥3	1.20	0.53	2.73	0.66
	<3				

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	81.50		
Hosmer and Lemeshow	0.08		

Logistic regression model 11 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.36	0.48	3.86	0.57
	<6	ref			
Hist fall	Yes	3.76	1.64	8.62	0.00
	No	ref			
Environmental Hazard	Yes	1.74	0.70	4.34	0.23
	No	ref			
Cancer Combined	Yes	1.34	0.48	3.74	0.57
	No	ref			
Depression	Yes	2.37	0.95	5.93	0.06
	No	ref			
MI or PVD	Yes	3.61	1.14	11.46	0.03
	No	ref			
Antispasmodic	Yes	34.02	3.37	343.36	0.00
	No	ref			
ACCI	≥6	1.61	0.69	3.74	0.27
	<6	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.79
Overall Percentage	82.00		
Hosmer and Lemeshow	0.02		

Logistic regression model 12 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.11	0.38	3.24	0.85
	<6	ref			
Hist fall	Yes	4.45	1.87	10.61	0.00
	No	ref			
Environmental Hazard	Yes	1.81	0.72	4.51	0.20
	No	ref			
Cancer Combined	Yes	1.47	0.52	4.16	0.46
	No	ref			
Depression	Yes	2.37	0.93	6.05	0.07
	No	ref			
MI or PVD	Yes	4.12	1.27	13.37	0.02
	No	ref			
Antispasmodic	Yes	35.60	3.30	383.96	0.00
	No	ref			
ACCI	≥6	1.47	0.63	3.46	0.38
	<6	ref			
Dementia	Yes	2.18	0.97	4.92	0.06
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.78
Overall Percentage	80.60		
Hosmer and Lemeshow	0.33		

Logistic regression model 13 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.51	0.51	4.48	0.45
	<6	ref			
Hist fall	Yes	3.81	1.66	8.76	0.00
	No	ref			
Environmental Hazard	Yes	1.76	0.71	4.38	0.23
	No	ref			
Cancer Combined	Yes	1.35	0.48	3.77	0.57
	No	ref			
Depression	Yes	2.38	0.95	5.97	0.07
	No	ref			
MI or PVD	Yes	3.93	1.20	12.84	0.02
	No	ref			
Antispasmodic	Yes	37.98	3.63	397.38	0.00
	No	ref			
ACCI	≥6	1.62	0.70	3.75	0.26
	<6	ref			
Visual Impairment	Yes	0.74	0.34	1.66	0.47
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	81.50		
Hosmer and Lemeshow	0.03		

Logistic regression model 14 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.39	0.48	3.96	0.54
	<6	ref			
Hist fall	Yes	3.78	1.64	8.72	0.00
	No	ref			
Environmental Hazard	Yes	1.70	0.68	4.28	0.26
	No	ref			
Cancer Combined	Yes	1.25	0.44	3.53	0.67
	No	ref			
Depression	Yes	2.51	0.99	6.37	0.05
	No	ref			
MI or PVD	Yes	3.62	1.14	11.48	0.03
	No	ref			
Antispasmodic	Yes	36.17	3.64	359.07	0.00
	No	ref			
ACCI	≥6	1.60	0.68	3.72	0.28
	<6	ref			
Gender	Female	1.64	0.80	3.38	0.18
	Male	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	82.00		
Hosmer and Lemeshow	0.01		

Logistic regression model 15 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.05	0.35	3.20	0.93
	<6	ref			
Hist fall	Yes	4.39	1.85	10.41	0.00
	No	ref			
Environmental Hazard	Yes	1.85	0.73	4.68	0.20
	No	ref			
Cancer Combined	Yes	1.38	0.49	3.90	0.54
	No	ref			
Depression	Yes	2.18	0.86	5.52	0.10
	No	ref			
MI or PVD	Yes	3.47	1.08	11.10	0.04
	No	ref			
Antispasmodic	Yes	46.47	4.09	528.33	0.00
	No	ref			
ACCI	≥6	1.53	0.65	3.58	0.33
	<6	ref			
Diagnosis	Yes	2.78	0.66	11.66	0.16
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.79
Overall Percentage	82.00		
Hosmer and Lemeshow	0.01		

Logistic regression model 16 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.53	0.52	4.45	0.44
	<6	ref			
Hist fall	Yes	1.81	0.72	4.55	0.20
	No	ref			
Environmental Hazard	Yes	1.81	0.72	4.55	0.20
	No	ref			
Cancer Combined	Yes	1.36	0.48	3.80	0.56
	No	ref			
Depression	Yes	2.69	1.04	6.93	0.04
	No	ref			
MI or PVD	Yes	3.56	1.12	11.30	0.03
	No	ref			
Antispasmodic	Yes	36.01	3.64	356.17	0.00
	No	ref			
ACCI	≥6	1.58	0.68	3.67	0.29
	<6	ref			
Pain	Yes	0.63	0.29	1.38	0.25
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	81.50		
Hosmer and Lemeshow	0.07		

Logistic regression model 17 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.73	0.56	5.42	0.34
	<6	ref			
Hist fall	Yes	3.95	1.70	9.15	0.00
	No	ref			
Environmental Hazard	Yes	1.74	0.69	4.40	0.24
	No	ref			
Cancer Combined	Yes	1.34	0.48	3.76	0.58
	No	ref			
Depression	Yes	2.73	1.06	7.05	0.04
	No	ref			
MI or PVD	Yes	3.52	1.11	11.21	0.03
	No	ref			
Antispasmodic	Yes	38.31	3.81	385.02	0.00
	No	ref			
ACCI	≥6	1.65	0.70	3.88	0.25
	<6	ref			
Pain	Yes	0.66	0.30	1.45	0.30
	No	ref			
Impaired Mobility	Yes	1.42	0.51	3.99	0.50
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.72	0.64	0.81
Overall Percentage	82.90		
Hosmer and Lemeshow	0.03		

Logistic regression model 18 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.83	0.61	5.50	0.28
	<6	ref			
Hist fall	Yes	3.86	1.65	9.06	0.00
	No	ref			
Environmental Hazard	Yes	1.65	0.65	4.17	0.29
	No	ref			
Cancer Combined	Yes	1.12	0.39	3.26	0.83
	No	ref			
Depression	Yes	2.90	1.10	7.61	0.03
	No	ref			
MI or PVD	Yes	3.40	1.05	10.98	0.04
	No	ref			
Antispasmodic	Yes	46.87	4.78	459.48	0.00
	No	ref			
ACCI	≥6	1.69	0.72	3.99	0.23
	<6	ref			
Pain	Yes	0.60	0.27	1.33	0.21
	No	ref			
Lives Alone	Yes	2.23	1.05	4.75	0.04
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	81.50		
Hosmer and Lemeshow	0.09		

Logistic regression model 19 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.75	0.57	5.40	0.33
	<6	ref			
Hist fall	Yes	3.96	1.70	9.21	0.00
	No	ref			
Environmental Hazard	Yes	1.82	0.73	4.57	0.20
	No	ref			
Cancer Combined	Yes	1.36	0.48	3.83	0.56
	No	ref			
Depression	Yes	2.68	1.04	6.93	0.04
	No	ref			
MI or PVD	Yes	3.45	1.08	10.97	0.04
	No	ref			
Antispasmodic	Yes	39.96	3.95	404.05	0.00
	No	ref			
ACCI	≥6	1.55	0.66	3.61	0.31
	<6	ref			
Pain	Yes	0.62	0.28	1.35	0.23
	No	ref			
Incontinence	Yes	0.74	0.34	1.61	0.45
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.80
Overall Percentage	81.50		
Hosmer and Lemeshow	0.23		

Logistic regression model 20 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.69	0.54	5.25	0.36
	<6	ref			
Hist fall	Yes	4.07	1.76	9.39	0.00
	No	ref			
Environmental Hazard	Yes	1.82	0.73	4.53	0.20
	No	ref			
Depression	Yes	2.74	1.06	7.06	0.04
	No	ref			
MI or PVD	Yes	3.47	1.09	11.02	0.03
	No	ref			
Antispasmodic	Yes	39.94	4.01	397.77	0.00
	No	ref			
ACCI	≥6	1.74	0.76	4.00	0.19
	<6	ref			
Pain	Yes	0.66	0.30	1.46	0.31
	No	ref			
Impaired Mobility	Yes	0.70	0.25	1.94	0.49
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.63	0.80
Overall Percentage	82.50		
Hosmer and Lemeshow	0.13		

Logistic regression model 21 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.61	0.52	4.98	0.41
	<6	ref			
Hist fall	Yes	3.82	1.66	8.79	0.00
	No	ref			
Environmental Hazard	Yes	1.67	0.67	4.18	0.27
	No	ref			
Cancer Combined	Yes	1.32	0.47	3.70	0.59
	No	ref			
Depression	Yes	2.45	0.98	6.16	0.06
	No	ref			
MI or PVD	Yes	3.56	1.12	11.33	0.03
	No	ref			
Antispasmodic	Yes	37.24	3.62	382.91	0.00
	No	ref			
ACCI	≥6	1.69	0.72	3.95	0.23
	<6	ref			
Impaired Mobility	Yes	0.64	0.23	1.77	0.39
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.63	0.80
Overall Percentage	82.50		
Hosmer and Lemeshow	0.05		

Logistic regression model 22 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.37	0.42	4.41	0.60
	<6	ref			
Hist fall	Yes	4.70	1.97	11.26	0.00
	No	ref			
Environmental Hazard	Yes	1.88	0.75	4.67	0.18
	No	ref			
Depression	Yes	2.66	1.01	7.01	0.05
	No	ref			
MI or PVD	Yes	3.87	1.19	12.57	0.02
	No	ref			
Antispasmodic	Yes	40.40	3.87	422.30	0.00
	No	ref			
ACCI	≥6	1.64	0.71	3.79	0.25
	<6	ref			
Pain	Yes	0.74	0.33	1.68	0.48
	No	ref			
Impaired Mobility	Yes	0.71	0.25	2.01	0.52
	No	ref			
Dementia	Yes	1.97	0.86	4.49	0.11
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.63	0.80
Overall Percentage	81.52		
Hosmer and Lemeshow	0.16		

Logistic regression model 23 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.86	0.58	6.00	0.30
	<6	ref			
Hist fall	Yes	4.10	1.77	9.47	0.00
	No	ref			
Environmental Hazard	Yes	1.83	0.74	4.55	0.19
	No	ref			
Depression	Yes	2.73	1.05	7.09	0.04
	No	ref			
MI or PVD	Yes	3.74	1.14	12.21	0.03
	No	ref			
Antispasmodic	Yes	43.68	4.25	448.64	0.00
	No	ref			
ACCI	≥6	1.74	0.76	4.00	0.19
	<6	ref			
Pain	Yes	0.68	0.31	1.50	0.34
	No	ref			
Impaired Mobility	Yes	0.69	0.25	1.93	0.48
	No	ref			
Visual Impairment	Yes	0.77	0.34	1.72	0.52
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	82.00		
Hosmer and Lemeshow	0.23		

Logistic regression model 24 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.77	0.56	5.53	0.33
	<6	ref			
Hist fall	Yes	4.06	1.75	9.40	0.00
	No	ref			
Environmental Hazard	Yes	1.73	0.69	4.35	0.25
	No	ref			
Depression	Yes	2.87	1.10	7.50	0.03
	No	ref			
MI or PVD	Yes	3.51	1.11	11.14	0.03
	No	ref			
Antispasmodic	Yes	42.87	4.28	429.77	0.00
	No	ref			
ACCI	≥6	1.73	0.75	4.00	0.20
	<6	ref			
Pain	Yes	0.70	0.32	1.56	0.39
	No	ref			
Impaired Mobility	Yes	0.64	0.22	1.82	0.40
	No	ref			
Gender	Female	1.67	0.81	3.46	0.17
	Male	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	82.00		
Hosmer and Lemeshow	0.06		

Logistic regression model 25 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.30	0.39	4.35	0.67
	<6	ref			
Hist fall	Yes	4.64	1.95	11.06	0.00
	No	ref			
Environmental Hazard	Yes	1.93	0.76	4.90	0.16
	No	ref			
Depression	Yes	2.49	0.96	6.48	0.06
	No	ref			
MI or PVD	Yes	3.33	1.04	10.65	0.04
	No	ref			
Antispasmodic	Yes	52.75	4.65	598.72	0.00
	No	ref			
ACCI	≥6	1.67	0.72	3.87	0.23
	<6	ref			
Pain	Yes	0.69	0.31	1.51	0.35
	No	ref			
Impaired Mobility	Yes	0.73	0.26	2.05	0.56
	No	ref			
Diagnosis	Yes	2.53	0.60	10.71	0.21
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	82.50		
Hosmer and Lemeshow	0.01		

Logistic regression model 26 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.11	0.66	6.78	0.21
	<6	ref			
Hist fall	Yes	3.96	1.70	9.25	0.00
	No	ref			
Environmental Hazard	Yes	1.59	0.63	3.99	0.33
	No	ref			
Depression	Yes	2.99	1.13	7.88	0.03
	No	ref			
MI or PVD	Yes	3.36	1.04	10.86	0.04
	No	ref			
Antispasmodic	Yes	51.64	5.22	511.13	0.00
	No	ref			
ACCI	≥6	1.82	0.78	4.23	0.17
	<6	ref			
Pain	Yes	0.62	0.28	1.40	0.25
	No	ref			
Impaired Mobility	Yes	0.66	0.23	1.88	0.44
	No	ref			
Lives Alone	Yes	2.29	1.08	4.85	0.03
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	82.00		
Hosmer and Lemeshow	0.41		

Logistic regression model 27 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.90	0.59	6.14	0.29
	<6	ref			
Hist fall	Yes	4.11	1.77	9.53	0.00
	No	ref			
Environmental Hazard	Yes	1.83	0.74	4.57	0.19
	No	ref			
Depression	Yes	2.72	1.06	7.03	0.04
	No	ref			
MI or PVD	Yes	3.37	1.06	10.73	0.04
	No	ref			
Antispasmodic	Yes	43.85	4.33	444.46	0.00
	No	ref			
ACCI	≥6	1.70	0.74	3.93	0.21
	<6	ref			
Pain	Yes	0.65	0.29	1.43	0.28
	No	ref			
Impaired Mobility	Yes	0.72	0.26	2.00	0.52
	No	ref			
Incontinence	Yes	0.75	0.35	1.64	0.48
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	82.00		
Hosmer and Lemeshow	0.29		

Logistic regression model 28 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.87	0.60	5.86	0.28
	<6	ref			
Hist fall	Yes	3.92	1.70	9.02	0.00
	No	ref			
Environmental Hazard	Yes	1.83	0.73	4.61	0.20
	No	ref			
Depression	Yes	2.33	0.88	6.17	0.09
	No	ref			
MI or PVD	Yes	3.66	1.13	11.87	0.03
	No	ref			
Antispasmodic	Yes	51.79	4.73	566.91	0.00
	No	ref			
ACCI	≥6	2.22	0.92	5.31	0.07
	<6	ref			
Pain	Yes	0.69	0.31	1.54	0.36
	No	ref			
Impaired Mobility	Yes	0.68	0.24	1.94	0.47
	No	ref			
Diabetes	Yes	0.45	0.19	1.05	0.07
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.73	0.64	0.82
Overall Percentage	82.90		
Hosmer and Lemeshow	0.30		

Logistic regression model 29 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.75	0.56	5.49	0.34
	<6	ref			
Hist fall	Yes	4.14	1.79	9.57	0.00
	No	ref			
Environmental Hazard	Yes	1.67	0.66	4.22	0.28
	No	ref			
Depression	Yes	2.78	1.06	7.30	0.04
	No	ref			
MI or PVD	Yes	3.29	1.04	10.45	0.04
	No	ref			
Antispasmodic	Yes	48.29	4.70	496.35	0.00
	No	ref			
ACCI	≥6	1.92	0.82	4.51	0.13
	<6	ref			
Pain	Yes	0.75	0.33	1.68	0.48
	No	ref			
Impaired Mobility	Yes	0.63	0.22	1.81	0.39
	No	ref			
Med Type	Yes	0.52	0.21	1.26	0.15
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.72	0.63	0.81
Overall Percentage	82.50		
Hosmer and Lemeshow	0.00		

Logistic regression model 30 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.65	0.57	4.83	0.36
	<6	ref			
Hist fall	Yes	3.83	1.66	8.84	0.00
	No	ref			
Environmental Hazard	Yes	1.87	0.74	4.76	0.19
	No	ref			
Cancer	Yes	1.18	0.41	3.42	0.76
	No	ref			
Depression	Yes	2.29	0.87	6.05	0.09
	No	ref			
MI or PVD	Yes	3.70	1.14	11.99	0.03
	No	ref			
Antispasmodic	Yes	46.75	4.37	500.20	0.00
	No	ref			
ACCI	≥6	2.03	0.83	4.96	0.12
	<6	ref			
Pain	Yes	0.66	0.30	1.44	0.30
	No	ref			
Diabetes	Yes	0.46	0.20	1.09	0.08
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.73	0.64	0.82
Overall Percentage	82.94		
Hosmer and Lemeshow	0.25		

Logistic regression model 31 (N=209)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.24	0.41	3.70	0.70
	<6	ref			
Hist fall	Yes	4.11	1.75	9.65	0.00
	No	ref			
Environmental Hazard	Yes	2.31	0.87	6.15	0.09
	No	ref			
Cancer	Yes	1.07	0.36	3.12	0.91
	No	ref			
Depression	Yes	2.23	0.84	5.95	0.11
	No	ref			
MI or PVD	Yes	3.60	1.10	11.80	0.03
	No	ref			
Antispasmodic	Yes	4854184159.07	0.00		1.00
	No	ref			
ACCI	≥6	2.37	0.94	5.95	0.07
	<6	ref			
Pain	Yes	0.64	0.29	1.42	0.27
	No	ref			
Diabetes	Yes	0.48	0.20	1.14	0.09
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.73	0.64	0.82
Overall Percentage	83.30		
Hosmer and Lemeshow	0.34		

Logistic regression model 32 (N=209)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.42	0.49	4.12	0.52
	<6	ref			
Hist fall	Yes	3.27	1.49	7.17	0.00
	No	ref			
Environmental Hazard	Yes	2.41	0.93	6.28	0.07
	No	ref			
Cancer	Yes	1.37	0.51	3.71	0.53
	No	ref			
Depression	Yes	2.23	0.88	5.65	0.09
	No	ref			
MI or PVD	Yes	4.68	1.55	14.09	0.01
	No	ref			
ACCI	≥6	2.03	0.84	4.90	0.11
	<6	ref			
Pain	Yes	0.85	0.40	1.80	0.67
	No	ref			
Diabetes	Yes	0.47	0.20	1.09	0.08
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.71	0.62	0.80
Overall Percentage	81.82		
Hosmer and Lemeshow	0.01		

Logistic regression model 33 (N=209)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.57	0.51	4.90	0.43
	<6	ref			
Hist fall	Yes	3.30	1.50	7.25	0.00
	No	ref			
Environmental Hazard	Yes	2.33	0.89	6.11	0.08
	No	ref			
Cancer	Yes	1.34	0.49	3.66	0.56
	No	ref			
Depression	Yes	2.27	0.89	5.77	0.09
	No	ref			
MI or PVD	Yes	4.61	1.53	13.89	0.01
	No	ref			
ACCI	≥6	2.10	0.86	5.14	0.10
	<6	ref			
Pain	Yes	0.88	0.41	1.88	0.74
	No	ref			
Diabetes	Yes	0.47	0.20	1.08	0.08
	No	ref			
Impaired Mobility	Yes	0.76	0.28	2.09	0.59
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	81.34		
Hosmer and Lemeshow	0.04		

Logistic regression model 34 (N=209)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.15	0.38	3.51	0.81
	<6	ref			
Hist fall	Yes	3.73	1.64	8.50	0.00
	No	ref			
Environmental Hazard	Yes	2.54	0.96	6.68	0.06
	No	ref			
Cancer	Yes	1.38	0.50	3.75	0.53
	No	ref			
Depression	Yes	2.08	0.81	5.34	0.13
	No	ref			
MI or PVD	Yes	4.55	1.50	13.77	0.01
	No	ref			
ACCI	≥6	2.01	0.83	4.86	0.12
	<6	ref			
Pain	Yes	0.89	0.42	1.90	0.76
	No	ref			
Diabetes	Yes	0.43	0.18	1.00	0.05
	No	ref			
Diagnosis	Yes	2.16	0.59	7.93	0.25
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.70	0.61	0.79
Overall Percentage	80.86		
Hosmer and Lemeshow	0.07		

Logistic regression model 35 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.001	0.796	5.032	0.140
	<6	ref			
Hist fall	Yes	3.887	1.745	8.657	0.001
	No	ref			
MI or PVD	Yes	4.322	1.440	12.972	0.00904
	No	ref			
Antispasmodic	Yes	33.066	3.545	308.400	0.002134
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.62	0.530	0.714
Overall Percentage	78.70		
Hosmer and Lemeshow	0.37		

Logistic regression model 36 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.193	0.867	5.545	0.097
	<6	ref			
Hist fall	Yes	3.785	1.694	8.457	0.001174
	No	ref			
MI or PVD	Yes	4.692	1.519	14.490	0.007
	No	ref			
Antispasmodic	Yes	39.317	3.923	394.006	0.002
	No	ref			
Diabetes	Yes	0.500	0.226	1.106	0.087
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.62	0.530	0.714
Overall Percentage	78.70		
Hosmer and Lemeshow	0.38		

Logistic regression model 37 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.862	0.729	4.757	0.194
	<6	ref			
Hist fall	Yes	3.676	1.619	8.347	0.002
	No	ref			
MI or PVD	Yes	3.911	1.288	11.873	0.016
	No	ref			
Antispasmodic	Yes	32.493	3.422	308.499	0.002
	No	ref			
Depression	Yes	2.769	1.145	6.698	0.023817
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Upper Bound
Area Under the Curve	0.69	0.610	0.788
Overall Percentage	81.00		
Hosmer and Lemeshow	0.34		

Logistic regression model 38 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.791	0.701	4.578	0.223
	<6	ref			
Hist fall	Yes	3.658	1.620	8.256	0.002
	No	ref			
MI or PVD	Yes	3.276	1.053	10.192	0.040
	No	ref			
Antispasmodic	Yes	35.138	3.664	336.943	0.002
	No	ref			
Depression	Yes	2.568	1.047	6.303	0.039
	No	ref			
ACCI	≥6	1.704	0.755	3.847	0.199
	<6	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.69	0.604	0.783
Overall Percentage	81.00		
Hosmer and Lemeshow	0.05		

Logistic regression model 39 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.376	0.487	3.892	0.547
	<6	ref			
Hist fall	Yes	3.890	1.693	8.934	0.001367
	No	ref			
MI or PVD	Yes	4.250	1.376	13.133	0.012
	No	ref			
Antispasmodic	Yes	31.819	3.312	305.641	0.003
	No	ref			
Depression	Yes	2.577	1.050	6.327	0.039
	No	ref			
Environmental Hazard	Yes	1.821	0.744	4.456	0.189
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.70	0.613	0.791
Overall Percentage	81.5		
Hosmer and Lemeshow	0.19		

Logistic regression model 40 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	1.849	0.725	4.714	0.198
	<6	ref			
Hist fall	Yes	3.545	1.561	8.051	0.002
	No	ref			
MI or PVD	Yes	3.940	1.295	11.988	0.016
	No	ref			
Antispasmodic	Yes	30.914	3.178	300.715	0.003115
	No	ref			
Depression	Yes	2.698	1.105	6.589	0.029
	No	ref			
Cancer	Yes	1.717	0.640	4.606	0.283
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.69	0.610	0.788
Overall Percentage	81.00		
Hosmer and Lemeshow	0.13		

Logistic regression model 41 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
MAHC_TS	≥6	2.123	0.807	5.582	0.127
	<6	ref			
Hist fall	Yes	3.836	1.677	8.775	0.001
	No	ref			
MI or PVD	Yes	3.833	1.261	11.651	0.018
	No	ref			
Antispasmodic	Yes	35.447	3.767	333.557	0.002
	No	ref			
Depression	Yes	3.120	1.253	7.768	0.015
	No	ref			
Pain	Yes	0.646	0.300	1.393	0.265
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.69	0.610	0.788
Overall Percentage	81.00		
Hosmer and Lemeshow	0.09		

Logistic regression model 42 (N=211)

Predictor Variable		Odds ratio (adjusted) OR	95% CI Lower	95% CI Upper	p-value
Hist fall	Yes	4.32	2.01	9.28	0.000
	No	ref			
MI or PVD	Yes	4.49	1.47	13.72	0.008
	No	ref			
Antispasmodic	Yes	33.82	3.50	326.39	0.002
	No	ref			
Depression	Yes	2.59	1.06	6.35	0.037
	No	ref			
Environmental Hazard	Yes	2.05	0.91	4.61	0.083
	No	ref			

		Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Area Under the Curve	0.70	0.613	0.79
Overall Percentage	81.50		
Hosmer and Lemeshow	0.15		

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