HEALTHCARE UTILIZATION FOR BALANCE PROBLEMS IN COMMUNITY-DWELLING ADULTS IN THE UNITED STATES OF AMERICA

by

SHWETA KAPUR

A dissertation submitted in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY IN HUMAN MOVEMENT SCIENCE

2025

Oakland University
Rochester, Michigan

Doctoral Advisory Committee:

Daniel J. Goble, Ph.D., Chair
Kwame S. Sakyi, Ph.D., M.S.P.H., Co-Chair
Joshua Haworth, Ph.D.

To my family, my late father Mr. K.N. Kapur, my mother Mrs. Manju Kapur,
my husband Prateek, and my kids Shawn and Shiv
I could not have done this without your love and support!

ACKNOWLEDGEMENTS

This dissertation marks the culmination of an incredible educational journey for me. This journey was full of learning, growth, and discoveries, intertwined with some celebrations, and perhaps some moments of self-doubt. This remarkable journey would not have been possible without the guidance and support of numerous individuals to whom I am deeply grateful.

First and foremost, I extend my heartfelt gratitude to my PhD adviser, Dr. Daniel J. Goble, for his unwavering support and mentorship throughout this journey. I started my PhD with a clear vision of what I wanted to study. Dr. Goble saw my vision and helped me to turn it into a reality. He not only provided me with the best support, prompt responses, and mentorship when I needed help, but also gave me the freedom to carve my niche in this interdisciplinary series of projects. He was always able to sense the extent of mentorship I needed at each stage and provided just the right environment for me to thrive and flourish.

I am also immensely grateful to my co-adviser, Dr. Kwame S. Sakyi for our insightful discussions about the study designs and statistical analyses, which formed the foundation of the work presented in this dissertation. His insights and guidance have been invaluable in shaping this work and my academic growth. I appreciate every moment when he took time to address my questions and to ensure that all my doubts were cleared.

I am also thankful to Dr. Joshua Haworth for constructive feedback, thoughtful questions, and encouragement, which have enriched this research in multiple ways. The

wise suggestions provided during the proposal and manuscript preparation are much appreciated.

I am deeply grateful to my lab mates, colleagues, and friends in the School of Health Sciences at Oakland University who have shared this journey with me. Their support made this journey fulfilling and memorable.

In addition, I must thank the leadership, other faculty members, and the office staff of the School of Health Sciences, including Dean Kevin Ball, Associate Dean Kristine Thompson, Dr. John Krauss, Dr. Sara Arena, and all the other faculty members and office staff members who always celebrated every accomplishment of mine and inspired me to continue working hard.

Oakland University not only helped me gain subject matter expertise in my field during this journey but also provided me an opportunity to be a better communicator and a better educator by helping me hone my ability to communicate complex research work to a general audience in a few minutes. I'm grateful to Dean Randall and graduate school team for providing those opportunities to me.

I wish to acknowledge the financial support provided by the American Physical Therapy Association Academy of Physical Therapy Research, Oakland University School of Health Sciences, Graduate School, and Oakland University Provost Office which made this research and its dissemination at various scientific conferences possible.

Last but not least, a special thanks to my family, my mother, my husband and my kids for all their love and understanding when I was spending numerous hours day and night working on my research projects, dissertation, and conferences. I could not have done it without their love and support. Sometimes, we lose our biggest cheerleaders along

the way and that's what happened when I lost my dad in the second year of my PhD. But his blessings and love from heaven are what kept me going during that tough phase. I owe all my accomplishments to my family!

To all those who have contributed to my personal and professional growth during this journey, I thank you from the bottom of my heart. This dissertation reflects both my efforts and the invaluable contributions of those who supported me along the way.

Shweta Kapur PT, MS

PREFACE

The research work presented in this dissertation was undertaken as a part of the requirements for the Doctor of Philosophy degree in Human Movement Science, with graduate certification in Epidemiological Research (Public Health) at Oakland University. This work emerged from the integration of my prior research experiences in basic neuroscience and epidemiology, with my clinical expertise as a Physical Therapist. It reflects my passion for improving health equity and patient outcomes for individuals with balance problems.

This dissertation comprises 6 chapters that collectively address healthcare utilization for balance problems in the community-dwelling adult population of the US. While this work is my own, it is the product of many collaborations, discussions, and support from multiple mentors, and scholars. These contributions have greatly enhanced the scope and quality of this work.

I have presented portions of this research at multiple scientific conferences including the American Physical Therapy Association conferences 2023 and 2024, International Society of Gait and Posture Research Annual Meeting 2024, Midwestern Association of Graduate Schools Annual Meetings 2023 and 2024, and American Geriatric Society Annual Scientific Meeting, 2024. The feedback from the broader scientific community at these conferences has enriched the final product.

The research presented here was conducted between 2022 and 2025, under the guidance and supervision of Dr. Daniel J. Goble and Dr. Kwame S. Sakyi. I hope this

work inspires further inquiry, sparks new ideas, and contributes to the ongoing research within the field of balance problems.

ABSTRACT

HEALTHCARE UTILIZATION FOR BALANCE PROBLEMS IN COMMUNITY-DWELLING ADULTS IN THE UNITED STATES OF AMERICA

by

Shweta Kapur

Advisers: Dr. Daniel J. Goble, Ph.D. and Dr. Kwame S. Sakyi, Ph.D., M.S.P.H.

This dissertation addresses healthcare utilization for balance problems in community-dwelling adults in the United States of America. Balance problems are one of the major risk factors for falls. Falls are the leading cause of mortality and chronic disability in elderly adults. The first project (review article) presented in this dissertation explored factors associated with healthcare utilization for balance problems as guided by the Andersen Healthcare Utilization Model. This model is frequently used to examine the factors leading to the use of health services. Age, sex, race/ethnicity, BMI, and comorbidities were identified as some of the factors that pre-disposed the underutilization of healthcare services for balance problems. Socioeconomic status, health insurance, and access to primary care could enable or disable healthcare utilization. The severity of balance problems, perceived illness, and its impact on daily activities were the factors that could affect the need for care.

The second study used real-world nationally representative data from the National Health and Nutrition Examination Survey (NHANES) to investigate the associations suggested by the literature review. A total of 1834 adults who self-reported having balance problems in the past 12 months were included in this study. Outcome measure

was whether the individual ever saw a health professional for balance problems. Only 32.13% of the individuals who reported having balance problems sought healthcare services for balance problems. Older age, lack of health insurance, not seeing a healthcare provider in the past year, and not experiencing any fall(s) in the past year had a significant association with reduced healthcare utilization for balance problems. These findings can help identify populations at increased risk of underutilization.

The third study investigated the congruency between self-reported balance information and performance-based balance measures (Romberg Test of Standing Balance on Firm and Compliant Support Surfaces, RTSBFCSS), along with exploring the predictors of congruency between these balance measures. A nationally representative sample of 4939 community-dwelling adults (≥40 years) for whom self-reported balance status responses and performance-based balance examination results were available was used for this study. Of the 4939 study participants, 36.9% had evidence of balance problems on RTSBFCSS. About 7 in 10 adults with performance-based balance deficits reported no balance problems on the self-reported question. Sole reliance on self-reported information for balance screening may be inadequate. Results can help identify populations more likely to have discrepancies between balance measures.

TABLE OF CONTENTS

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DOI	Digital Object Identifier
USA	United States of America
CDC	Center for Disease Control and Prevention
BMI	Body Mass Index
DM	Diabetes Mellitus
NHANES	National Health and Nutrition Examination Survey
PSU	Primary Sampling Units
OR	Odds Ratio
95% CI	95% Confidence Interval
VIF	Variance Inflation Factor
SE	Standard Error
AOR	Adjusted Odds Ratio
STEADI	Stopping Elderly Accidents, Deaths, and Injuries
HIV	Human Immunodeficiency Viruses
RTSBFCSS	Romberg Test of Standing Balance on Firm and Compliant Support Surfaces

LIST OF PUBLICATIONS

The work done by the author during her PhD led to the following 5 peer-reviewed publications and 12 presentations at national, international, and regional scientific meetings.

Peer-reviewed publications

1. **Kapur S**, Sakyi KS, Lohia P, Goble DJ, Potential Factors Associated with Healthcare Utilization for Balance Problems in Community-Dwelling Adults within the United States: A Narrative Review. Healthcare, 2023, 11(17), 2398; DOI: https://doi.org/10.3390/healthcare11172398

2. **Kapur S**, Sakyi KS, Haworth J, Lohia P, Goble DJ: Congruence between Self-report and Performance-based Measure of Balance in Community-Dwelling Adults. (Submitted, Journal of Gerontology: Medical Sciences, under review)

3. **Kapur S**, Sakyi KS, Haworth J, Lohia P, Goble DJ: Predictors of Healthcare Utilization for Balance Problems in the US. (Submitted, under review)

Author of this dissertation also contributed to the following peer-reviewed publications during her PhD:

4. Nolff MR, **Kapur S**, Kendall BJ, Doumas M, Conner NO, Chander H, Haworth JL, Goble DJ, An initial set of reference values for the Balance Tracking System

(BTrackS) Limits of Stability protocol. Gait Posture. 2023;107:67-71. doi:10.1016/j.gaitpost.2023.09.008

5. Goble DJ, Barnes K, Lang J, **Kapur S**, Rosiek SK, Haworth JL: Developmental Normative Data for the Balance Tracking System Modified Clinical Test of Sensory Integration and Balance Protocol. Journal of Experimental Child Psychology. Accepted for publication

Conference Presentations

Platform presentations

1. Hidden Hazards: Majority of Older Adults Unaware of Clinically Detectable Balance Problems – at American Physical Therapy Association, Combined Sections Meeting 2025, Houston, Texas (Accepted)

2. Regenerative Rehabilitation, an Upcoming Frontier: Advancements in Regenerative Medicine and Implications for Physical Therapy Practice - Session Speaker at American Physical Therapy Association, Combined Sections Meeting 2025, Houston, Texas (Accepted)

3. Age as a predictor of healthcare use for balance problems in community-dwelling adults- at Michigan American Physical Therapy Association Fall 2024 Conference, Southfield, Michigan

4. Balance Problems – Thesis presentation at International Society of Gait and Posture Research (ISPGR) Annual Meeting 2024, Spain (virtual)

5. Roadblocks to managing Balance Problems- Thesis presentation at Midwestern Association of Graduate Schools Annual Meeting 2024, St. Louis, Missouri, USA

6. Factors associated with Healthcare Utilization for Balance Problems in Community-Dwelling adults in the US: A Review of the Literature- at Michigan American Physical Therapy Association Fall 2023 Conference, Grand Rapids, Michigan, USA

7. Tackling the Falls- Thesis presentation at Midwestern Association of Graduate Schools Annual Meeting 2023, Chicago, Illinois, USA

Poster Presentations

8. **Kapur S**, Thompson K: Outcomes of an Educational Module on the Impact of Regenerative Medicine on Physical Therapy. American Physical Therapy Association, Combined Sections Meeting 2025, Houston, TX (Accepted)

9. **Kapur S**, Thompson K: Doctor of Physical Therapy Students' Knowledge About Regenerative Medicine and Regenerative Rehabilitation. International

Regenerative Rehabilitation Symposium, Harvard Medical School, Boston, MA, March, 2024

10. **Kapur S**, Sakyi KS, Haworth J, Goble DJ: Healthcare Utilization for Balance Problems in the United States, American Geriatric Society Annual Scientific Meeting, May, 2024

11. Conner N, Nolff M, **Kapur S**, Goble D, Knight A, Chander H: An initial set of reference values for the balance tracking system (BTracks) limits of stability protocol based on 800 healthy young adults. American Society of Biomechanics National Conference, Knoxville, TN, August, 2023

12. Nolff MR*, **Kapur S***; Goble DJ: Normative Data for the Balance Tracking Systems (BTrackS) Limits of Stability Protocol: Results from Healthy Young Adults Between 18 and 29 Years of Age. Graduate Student Research Conference, Oakland University, MI, March 10, 2023

* Co-presenters

CHAPTER ONE

INTRODUCTION

1.1 Balance Problems and Falls

Balance is an essential function of the human body to maintain stability, both at rest and during movement. It is the ability of the body to keep its center of mass over its base of support.[1] Complex interactions between different physiological systems are necessary to accomplish balance. Sensory information from the vestibular, visual, and proprioceptive systems is sent to the brain for integration and processing.[2] Final execution occurs via the muscular system which makes the necessary postural adjustments to preserve balance.[2] Damage to any of the components underlying this complex mechanism can lead to balance problems, making the individual feel unsteady, off-balance, or dizzy.[1,3]

Balance problems are quite prevalent in adults, especially older adults.[4,5] These balance problems can result in falls, which are a major public health issue.[6] It has been reported that about 1 in every 4 adults over the age of 65 years, experience a fall every year.[7] Falls are the second leading cause of unintentional injury deaths worldwide and the leading cause of nonfatal unintentional emergency department visits in the United States (US).[8,9]

Falls cause a substantial financial burden as well. It has been reported that about $50 billion is spent on the medical management of falls and fall-related injuries every year.[10] This cost is projected to go up to a staggering $100 billion by the year 2030.[11] Hence improving healthcare utilization for balance problems and targeting timely

management of balance problems, before they result in a serious event, can result in both better patient outcomes as well as significant financial benefits.

1.2 Dissertation Overview

Community-dwelling adults are the individuals who are not institutionalized, meaning they live independently in their homes.[12,13] The work presented in this dissertation investigates the healthcare utilization for balance problems among community-dwelling adults living in the US. There are effective fall prevention interventions available,[14-17] yet the number of falls and related injuries is on the rise.[5] This led us to explore the factors preventing individuals with balance issues from seeking healthcare services for their balance problems. We also wanted to determine if all the individuals with balance problems are even aware of their condition. In the first study, an extensive literature review was conducted to examine the factors affecting healthcare utilization for balance problems. Due to the scarcity of literature directly addressing this question, the literature review was broadened to find potential factors affecting healthcare utilization for balance problems. However, these potential associations needed to be confirmed using nationally representative data. So, the second study was designed to use a nationally representative sample of community-dwelling adults with self-reported balance problems, to find the factors associated with healthcare utilization for balance problems at a population level. Following this, the third study was conceived to determine the extent of self-awareness about one's balance problem by exploring the congruency between the self-reported balance information and results of performance-based balance testing among the community-dwelling population of the US aged 40 years or more.

1.3 Organization of Dissertation

This dissertation has six chapters. **Chapter 1** presents an introduction to balance problems and falls. **Chapter 2** details the literature review of the potential factors associated with healthcare utilization for balance problems among the community-dwelling adults in the US. This review was recently published in the peer-reviewed *Healthcare Journal*.[18] **Chapter 3** contains the original research study exploring the predictors of healthcare utilization in community-dwelling adults with self-reported balance problems. This study has been submitted for publication and is currently under review for publication in the *Journal of Gerontology: Medical Sciences*. **Chapter 4** presents another original research study investigating the congruency between self-reported balance information and the results of performance-based balance testing in a nationally representative sample. This study has been submitted for publication and is currently under review for publication in the *Physical Therapy Journal*. **Chapter 5** provides a brief overview of the future directions of this research work. **Chapter 6** summaries this dissertation and contains the discussion and conclusion sections.

CHAPTER TWO

LITERATURE REVIEW: POTENTIAL FACTORS ASSOCIATED WITH HEALTHCARE UTILIZATION FOR BALANCE PROBLEMS IN COMMUNITY-DWELLING ADULTS WITHIN THE UNITED STATES

2.1 Background

Balance, the ability to maintain the body's center of mass over its base of support, is maintained by a complex set of interactions between the sensory and motor systems.[1] Injury, disease, or aging can affect these interactions and result in balance disorders.[2] Balance disorders, which are highly prevalent in the elderly,[4,5] can make the person unsteady, off-balance, or dizzy, and may result in a fall. In the United States of America (USA), falls are a leading cause of mortality and chronic disability in community-dwelling adults, especially those over 65 years of age.[6]

The Center for Disease Control and Prevention defines falls as unexpected or unintentional dropping to a lower surface (i.e. the floor), from a standing, seating, walking, or bending position.[19] A study by Penger et al. reported dizziness, which is one of the risk factors for falls, as a common complaint among adults more than 50 years old.[20,21] Since dizziness is responsive to rehabilitation, this study also called upon public health officials to raise awareness of dizziness in this population.[21]

The World Health Organization has reported that falls are the second leading cause of unintentional injury deaths worldwide.[8] Approximately 37.3 million falls occurring worldwide require medical attention each year.[8] In a study of 6785 patients by Agrawal et al., about 35% of Americans over age of 40 years had objective evidence of vestibular

dysfunction.[3] In the same study, about 32% of the individuals who reported having no symptoms of dizziness, were found to have vestibular dysfunction which correlated with an increased number of falls.[3] Screening of such individuals and early treatment may be an avenue to prevent falls.

2.1.1 Burden on Healthcare

Falls are the number one cause of nonfatal unintentional emergency department visits in the United States, according to the National Center for Injury Prevention and Control.[9] A recent cross-sectional study of fall injuries by Hoffman et al. using the data from years 2016 to 2019, reported an increase of 1.5% per year in fall-related injuries.[5] It has been estimated that there were $616.5 million in direct medical costs for fatal fall-related injuries and $30.3 billion for non-fatal injuries in 2012.[22] Given the 12-fold increase in the likelihood of falls in symptomatic patients with vestibular dysfunction, Agrawal et al. emphasized the need for screening, diagnosing, and treating patients with vestibular deficits to reduce the burden on healthcare due to fall-related injuries.[3] Early management of balance problems, both vestibular and non-vestibular, that are responsive to treatment can help reduce this ever-increasing burden of falls on healthcare.

2.1.2 Healthcare Utilization

According to the United States Department of Health and Human Services, around 70% of adults with moderate to severe balance or dizziness problems saw a healthcare specialist in 2016.[23] Since individuals with mild balance or dizziness problems might not have pronounced clinical symptoms or might even be unaware of the problem[3], it can be postulated that the number of individuals with mild balance or dizziness problems seeking healthcare services would be even lower. Lin et. al conducted a cross-sectional analysis

and reported that one in every five elderly individuals experiences dizziness or balance problems every year, but only about 50% of these individuals sought help from the healthcare system.[4] Although many studies discuss falls, their burden on healthcare and the efficacy of fall prevention programs[5,9,22], there is limited data on the factors associated with the under-utilization of healthcare services in individuals with balance problems.

Only one known study has attempted to identify the factors associated with inpatient healthcare utilization resulting from falls in community-dwelling elderly individuals within the United States. In that study, Choi et al. found that certain injury characteristics and factors such as falling inside the home, falls due to loss of balance, and living alone were more likely to be associated with hospitalization following fall injuries.[24] This study also reported that almost three-quarters of the individuals experiencing falls sought treatment in outpatient settings.[24] However, this study only examined healthcare utilization in individuals who had already sustained fall-related injuries. It remains unclear to what extent including all individuals who report balance or dizziness problems would affect the analysis. Further, barriers preventing these individuals from seeking help before the condition results in a serious injury are yet unknown.

2.1.3 Objective and Significance

The objective of this study was to review the existing literature to explore the potential factors that might be associated with the utilization of healthcare services for balance problems in community-dwelling adults in the US. This information can help facilitate future research in this domain investigating the healthcare utilization for balance problems. Given the scarcity of existing studies directly discussing the healthcare utilization for balance problems before a serious balance event or fall occurs, a list of

potential factors can be useful for further studies aiming to investigate these associations with the utilization of healthcare services. The knowledge about the barriers to healthcare utilization for balance problems in community-dwelling adults can form the basis of future healthcare interventions to improve access for these patients. This approach has the potential to reduce falls when the responsible conditions are identified and treated before they result in a loss of balance or a serious fall. In addition, these findings might help in a more efficient allocation of healthcare resources. It can help in focusing the efforts on effective screening of the vulnerable individuals, on improving the access to care and on educating, those who are at higher risk for underutilization, about the effective fall prevention interventions available.

2.2 Framework

Different frameworks have been utilized in the past to analyze and understand factors associated with healthcare resource utilization. The Andersen Healthcare Utilization Model is one of the most frequently used frameworks[25], which can be used to explore and demonstrate the factors leading to the use of health services.[26]

The Andersen Healthcare Utilization Model has evolved since its conception in the 1960s, but the primary focus of this model remains unchanged, involving three categories of the factors recognized as determinants of health service utilization. These categories include predisposing factors, enabling and disabling factors, and factors affecting the need for care.[26,27]

2.3 Predisposing Factors

Predisposing factors are the factors that exist before the onset of illness and predispose an individual to be more or less likely to seek healthcare services.[27] They

include demographic factors (such as age, sex, marital status, past illness/comorbidities), social factors (education, race, occupation), and beliefs (values concerning health, attitude towards health services, etc.).[25-27]

2.3.1 Age

Falls are more common in adults over the age of 65 years.[22,28] Older adults are also responsible for higher utilization of healthcare services.[29] A study done by the CDC, USA recorded 24,190 fatal falls and 3.2 million medically treated non-fatal falls in 2012 using the data from national databases.[22] In this observational study, Burns et al. reported a higher incidence of falls and an increase in the direct medical costs related to fatal and non-fatal fall injuries with increasing age.[22] Another retrospective study looking at the utilization of ambulatory medical care services by elderly individuals was done on 123,224 patients by Bussche et al.[30] This study reported similar findings of high utilization of healthcare in the older adults, and among the older adults, those over the age of 75 years had higher utilization of healthcare compared to those between 65 to 75 years of age.[30] So, older age is associated with a higher incidence of falls as well as a higher use of healthcare services.

2.3.2 Sex

Studies from different parts of the world have explored the association between sex and the incidence of falls, and the association between sex and healthcare utilization. Women have greater loss of bone mineral density with age compared to men which increases their likelihood of experiencing fall related injuries.[31] The incidence of falls and related costs have been reported by the CDC, USA, to be higher in women compared to men.[22] The incidence of fall-related injuries has been reported to be almost twice as high in women than in men.[22,28] These findings have been confirmed in a retrospective study by

Peel et al. in Australia on 2090 patients over the age of 65 years, hospitalized with fall-related injuries over the study period of 12 months.[28] One limitation of population-based studies can be the generalization of the results to a different geographical location, given the differences in the characteristics of the study participants; so, looking at studies conducted in different parts of the globe can give an idea about the trends worldwide. Higher healthcare expenditures have been reported in women compared to men.[32] A study using historical cohort study design on cross-sectional data reported that women have also been reported to be less likely to receive preventative health screening and regular care.[29] These studies used different clinical populations but point to a similar trend that women have a higher incidence of falls and related injuries but are less likely to receive preventative health screening.

2.3.3 Race/ethnicity

Racial and ethnic inequalities have been frequently highlighted in healthcare utilization. Decreased use of outpatient medical services and increased use of the emergency room and inpatient services by Blacks and Hispanics compared to Whites and non-Hispanics respectively have been well documented in the literature.[33,34] Dark et al. conducted a study on patients with comorbid anxiety disorder and cardiometabolic syndrome and found that the odds of non-Hispanic Black respondents reporting to the emergency department and/or needing inpatient utilization were 2.39 times the odds of non-Hispanic White respondents for the same.[33] However, this study looked at the patients with comorbid anxiety disorder and cardiometabolic syndrome. Another observational study that specifically looked at the fall-related hip fractures, reported that non-Hispanic Blacks were more likely to experience longer inpatient stays and delays in care compared

to non-Hispanic Whites.[35] In another retrospective study in the US analyzing nationally representative data of patients with neurological conditions such as Parkinson's disease, multiple sclerosis, headache, cerebrovascular disease, and epilepsy, Saadi et al. reported that Blacks were 30% less likely to see an outpatient neurologist compared to Whites.[34] The same study also reported that Hispanics were 40% less likely to seek regular care compared to the non-Hispanic population.[34] Hence it can be postulated that the Black and Hispanic population might be less likely to use healthcare services for balance and dizziness problems, until the latter results in a loss of balance event or a serious fall warranting the need for emergency or inpatient services.

2.3.4 Body Mass Index (BMI)

A higher body mass index has been associated with both the increased risk of fall-related injuries and the higher utilization of healthcare services in multiple separate studies.[36-38] Some studies have reported higher risk of falling in individuals with both low and high BMI compared to those with normal BMI.[39]A study by Finkelstein et al. reported a higher probability of sustaining a fall-related injury in individuals with high BMI.[37] This study was a cross-sectional analysis done on the data for 42,304 adults representing the non-institutionalized population of the US.[37] Individuals with a BMI of 40 kg/m2 or higher had 1.79 times higher odds of sustaining a fall-related injury compared to individuals with a normal BMI.[37] One limitation of this study is that it relied on self-reported height and weight for the BMI calculation. However, high BMI is also associated with multimorbidity and a higher incidence of diabetes, which can in turn make these individuals more prone to falls and related injuries.[38] Edwards et al. used the data for 33,882 adults in Norway to look at both the annual utilization and the lifetime utilization of healthcare services.[36] This

study reported that the number of healthcare contacts increased from 3.1/ year in individuals with normal BMI to 6.1/year in individuals with class 2 and 3 obesity.[36] Even after considering the early mortality associated with high BMI, lifetime utilization was found to be higher in obese individuals.[36] However, this study explored the overall healthcare utilization and not the healthcare utilization due to fall-related injuries per se.

2.3.5 Comorbidities

The presence of multiple comorbidities has been associated with higher utilization of healthcare services.[40] Certain comorbidities also increase the risk of falls. A meta-analysis of studies from Australia, Sweden, the United Kingdom, and the United States looked at 537 participants with 1721 reported falls and found a high risk of falls in patients with Multiple Sclerosis.[41] Another review on balance and falls in Multiple Sclerosis patients by Cameron et al. in the USA reported that 50-80% of these patients have balance and gait dysfunction and more than 50% fall at least once every year.[42] Individuals with neurological disorders have been reported to have more frequent and more severe falls.[43] Recurrent and disabling falls have been commonly observed in patients with Parkinson's disease.[44,45] A study conducted by Rudzinska et al. on Parkinson's disease patients reported that these patients fell three times more frequently compared to age and sex-matched controls.[45] Homann et al. found that patients with hyperkinetic movement disorders including Huntington's disease, restless leg syndrome, and spinocerebellar ataxias had increased fall risk.[43] According to a meta-analysis of 74 studies, individuals with gait problems or those using walking aids were 2 to 3 times more likely to experience a fall.[46] Patients with Diabetes Mellitus (DM) have been reported to have higher fall risk; the increased risk of falling due to DM was much more pronounced in insulin-treated patients

compared to non- insulin-treated patients.[38] Differences in the utilization of healthcare services have been reported by a population-based study on 21,277 diabetic patients.[47] Patients with DM had higher utilization of services in women compared to men.[47] Hence, the presence of certain comorbidities can be associated with both a higher incidence of falls and a higher utilization of healthcare.

2.4 Enabling and Disabling Factors

Factors that must be available for an individual to use healthcare services have been referred to as enabling factors, and the factors that prevent an individual from using such services are disabling factors. Enabling and disabling factors include socio-economic status, place of residence, health insurance, and access to primary care health services.[25-27]

2.4.1 Socioeconomic Status

Differences in socio-economic status can result in differences in the ability to cover treatment costs and co-pays, along with the ability to take time off from work for proper evaluation and treatment. Individuals with low socioeconomic status have also described factors such as cost, transportation, poor health education, and lack of a social network as barriers to optimal healthcare utilization.[48] Several studies have reported a socioeconomic gradient in the utilization of healthcare services.[49-51] Hence individuals from low socioeconomic classes might be at a greater risk of underutilization of healthcare services for balance problems unless the problem results in a serious event. After the balance problem results in a serious event or disabling fall, these individuals might have a higher healthcare utilization as higher utilization of healthcare services has been reported after surgical procedures in socioeconomically disadvantaged groups.[50]

2.4.2 Health Insurance

The availability of health insurance and the type of insurance the individual has can determine healthcare utilization.[51,52] In different clinical populations, utilization of healthcare services has been found to be higher in individuals with public insurance compared to those with private insurance.[51,53] The odds of a hospital stay longer than three days in post knee arthroplasty patients have been reported to be 1.22 to 1.68 times more for those with public insurance compared to those with private insurance.[51] This study also reported that the individuals with public insurance had 1.40 to 1.77 times higher odds of discharge to an inpatient facility instead of home, post hospitalization compared to those with private insurance.[51] A recent study exploring healthcare spending in the US for falls reported that public insurances financed most of the healthcare spending in elderly individuals over the age of 65 years, whereas in younger individuals most of the spending involved individuals with private insurances.[54] So, while it seems reasonable to assume that individuals without insurance may be at a higher risk of underutilization of healthcare services for balance problems, more studies are needed to ascertain if the type of insurance has any association with healthcare utilization for balance problems.

2.4.3 Access to Primary Care Services

Timely access to primary care services may assist in the timely diagnosis of the balance problem and efficient management of the problem before it results in a fall. Significant potential for the reduced long-term burden on healthcare and reduced costs have been reported with increased access to primary care services.[55,56] However, a secondary analysis of data from 11 countries reported that about one in five adults experience barriers in accessing primary care services and females were more likely to

experience this.[55] Individuals residing in medically underserved areas with limited access to primary care services have been known to have worse health outcomes once they develop a condition that warrants hospitalization.[57] One might expect that those individuals who have not sought any primary care services in the past year could be less likely to seek help for balance problems.

2.5 Factors Affecting Need for Care

Factors associated with the need for care include the level or severity of illness, perceived illness, and its impact on daily activities.[25-27] These are the factors that represent the actual and perceived need for care.

2.5.1 Severity of Balance Problem

Healthcare utilization is expected to increase with the increase in the severity of the illness experienced by the individual.[58,59] However, a decrease in the use of recommended care with increasing levels of activity limitation has also been reported.[60] So, it is debatable if a more pronounced balance problem would result in an increased or decreased utilization of healthcare services.

2.5.2 Perceived Illness

Perception of the physical problem can vary with the individual. Secondary analysis of the data from a controlled trial reported that greater patient perception of fall severity in the elderly has been associated with better quality of care the patient received.[61] However, there is a scarcity of literature on the association between patients' perception of their balance problem and the utilization of healthcare services for the same. Patients perceiving their balance problem to be severe might be expected to seek help from the healthcare system compared to those who perceive their problem to be trivial or small.

2.5.3 Impact on Daily Activities

The impact of balance problems and the resulting falls can vary greatly among individuals. It can range from mild restrictions on the personal freedom to total institutionalization.[62] In a population based cross-sectional study, Taburee et al. reported falls to be one of the predictors of health-related quality of life in community-dwelling adults.[63] Recurrent fallers have also been reported to have poor physical performance and a poor quality of life compared to single fallers.[64] A more pronounced impact of the balance problems on daily activities might warrant an individual to seek help for the management of the problem.

2.6 Conclusion

To summarize, the current literature supports the existence of underutilization of healthcare services for the management of balance problems in adults, especially older adults, with balance or dizziness problems. Certain factors may be preventing these individuals from using healthcare services, and identification of such factors would aid in increasing healthcare access and reducing the incidence of falls and related injuries. There is a scarcity of literature reporting factors associated with healthcare utilization for balance problems, especially before these problems result in a serious event or fall. The potential factors identified upon the review of literature that may be associated with healthcare utilization for balance problems in community-dwelling adults have been summarized in the Figure 1.

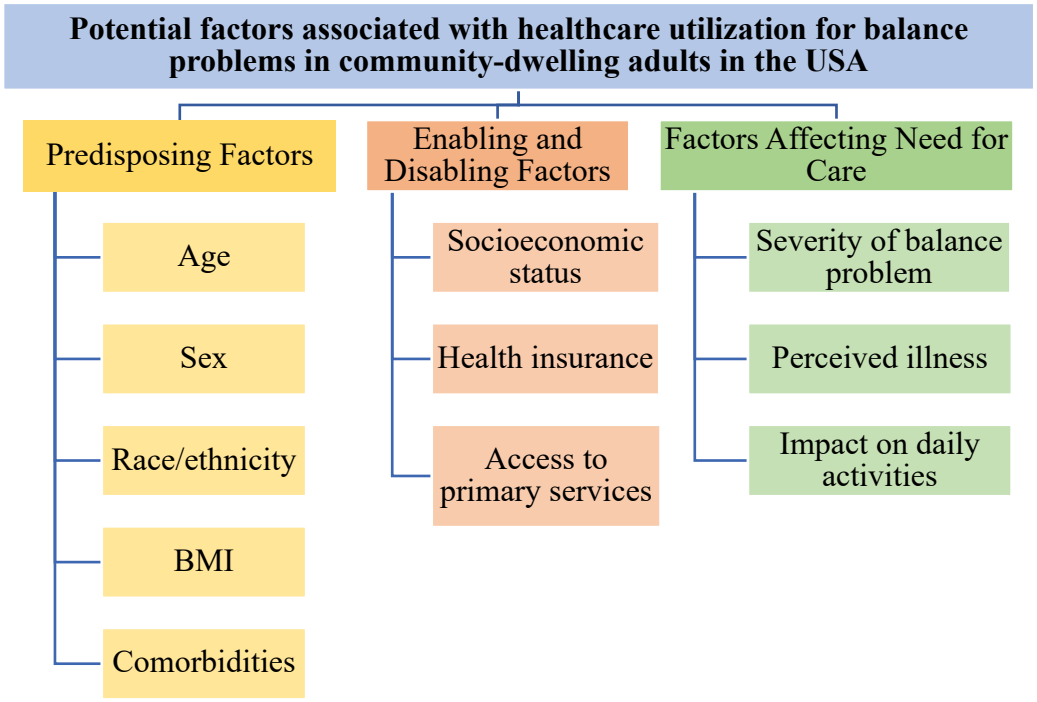

Figure 1: Potential factors identified upon literature review associated with healthcare utilization for balance problems in community-dwelling adults.

Age, sex, race/ethnicity, BMI, and comorbidities have been identified as some of the potential predisposing factors; socioeconomic status, health insurance, and access to primary care are the enabling and disabling factors; and severity of balance problem, perceived illness, and its impact on daily activities are the factors affecting need for care that may be associated with healthcare utilization for balance or dizziness problems. Further research using population-based models to confirm these associations is warranted to identify and tackle the barriers to healthcare utilization for balance problems, so that the burden of fall-related injuries can be reduced with timely intervention and management.

CHAPTER THREE

PREDICTORS OF HEALTHCARE UTILIZATION FOR SELF-REPORTED BALANCE PROBLEMS IN COMMUNITY-DWELLING ADULTS

3.1 Introduction

Balance disorders are highly prevalent in older adults.[5] These balance disorders can result in falls, which are the leading cause of mortality and morbidity in community-dwelling adults.[6] Existing literature supports the efficacy of exercise and multifactorial interventions for fall prevention in this population.[15-17,65] Despite efforts at different levels to minimize falls, the number of falls, related injuries, and its burden on the healthcare system is rising.[5,22] Given the trend of increasing falls and related injuries, despite the availability of effective fall prevention interventions, it is crucial to determine how many people with balance problems are actually utilizing these interventions. Specifically, it is important to identify the factors that prevent individuals from accessing them.

There is a scarcity of literature exploring predictors of healthcare utilization for balance problems. A recent literature review[18] used the Andersen Healthcare Utilization Model[25,27] to examine potential factors associated with the underutilization of healthcare services for managing balance problems in community-dwelling adults. This review reported factors such as age, sex, race, body mass index, and preexisting comorbidities that pre-disposed underutilization of healthcare services for balance problems. Access to a primary care provider, health insurance coverage, and socioeconomic status could enable or disable healthcare utilization. Lastly, it was posited that the occurrence of falls,

individual's perception of the balance issue, and its impact on activities of daily living can affect healthcare utilization.[18] However, further research using real-world data, such as the National Health and Nutrition Examination Survey (NHANES), is needed to confirm these potential associations.

Despite inconsistent differences between men and women on different performance-based balance tests reported in the literature,[31,66,67] there is a higher incidence of falls in women.[22] Age-related loss of bone mineral density is greater in women than men.[31] Women have also been reported to be more willing to engage in interventions to improve balance after experiencing falls[68]. This aligns with reports of higher healthcare utilization for fall-related injuries among females, especially older females compared to older men.[22] These sex differences in healthcare utilization are further evident in those with preexisting comorbidities.[47,69,70] Hence, it seems worthwhile to explore if sex is an effect modifier for the association between healthcare utilization for balance problems and other factors.

Previous literature has explored healthcare utilization for falls and fall-related injuries[22,24], but to the authors' knowledge, there is no study exploring the factors associated with healthcare utilization for balance problems at the population level. It is both important and challenging to identify individuals for balance-related healthcare services.[16] Identifying factors that prevent or reduce the utilization of healthcare services for balance problems can guide future efforts to improve access to effective interventions for vulnerable populations.

The present study explores the factors associated with healthcare utilization for balance problems in community-dwelling adults in the United States of America. This

was an exploratory study for future hypothesis generation. New knowledge regarding the factors associated with healthcare utilization for balance problems in community-dwelling adults can form the basis of future research on healthcare interventions to improve access for these patients. This study further provides insight into age-sex, sex-falls, and sex-comorbidity interactions for healthcare utilization for balance problems.

3.1.1 Significance

Knowledge about the factors influencing healthcare utilization for balance problems in community-dwelling adults in the US can help both the researchers and regional/national organizations convene, integrate, and influence healthcare policies promoting health equity by improving access to healthcare for vulnerable populations. Timely management of balance problems, before they result in a serious event, can help improve patient outcomes and reduce the burden on the healthcare system.

3.2 Methods

This study involved a secondary analysis of the data from the National Health and Nutrition Examination Survey (NHANES), which examined a nationally representative sample of the noninstitutionalized civilian resident population of the United States. NHANES data was collected via a combination of in-home interviews and standardized health examinations conducted in mobile examination centers. NHANES used a stratified, multistage probability sampling design.

The NHANES sample was selected using a four-stage process which began with Primary Sampling Units (PSUs). PSUs were counties or small groups of contiguous counties.[71] A block or a group of blocks within a PSU containing a cluster of households were determined as segments.[71] Households were randomly chosen from these segments

and then one or more participants were selected from the households.[71] Trained interviewers administered the NHANES questionnaires in the participant's household. Additional details about the survey design, sample selection, and informed consent used by NHANES are available elsewhere.[71,72]

The analyses were carried out using demographic data and standing balance questionnaire data from NHANES 2001-02 and 2003-04 cycles. These cycles were selected for this study because they are the latest cycles of nationally representative NHANES data for the US population aged 40 years and older that administered a balance questionnaire. This questionnaire included data on balance, dizziness, or light-headedness problems. Together, these problems have been referred to as "balance problems" in this manuscript. It has been previously acknowledged that NHANES balance questionnaire data includes an over-sampling of low-income individuals, those above 60 years of age, African Americans, and Mexican Americans.[71,72] This approach ensured that these under-represented groups were well-modeled in the data.

Participants were asked "During the past 12 months, have you had dizziness, difficulty with balance or difficulty with falling?" (later referred to as the "balance status" question). The available options were yes, no, refused or don't know. Participants' response to this question was used to ascertain the presence of balance problems for this study. Participants who answered yes to this question, were further asked "Have you ever been treated by a doctor or other health professional for dizziness, a balance problem, or falling?". Similar response options of yes, no, refused or don't know were available.

3.2.1 Participants

To study healthcare utilization for balance problems in community-dwelling adults and the factors associated with it, all adult individuals, aged 40 years or more, who self-reported having balance problems in the past 12 months, were included in the study. Of the total of 21,161 participants included in NHANES 2001-02 and 2003-04 data cycles, 6785 individuals were administered the balance status question. About 1834 individuals answered yes to this question and were included in this study. The details of the inclusion of study participants have been described in Figure 2.

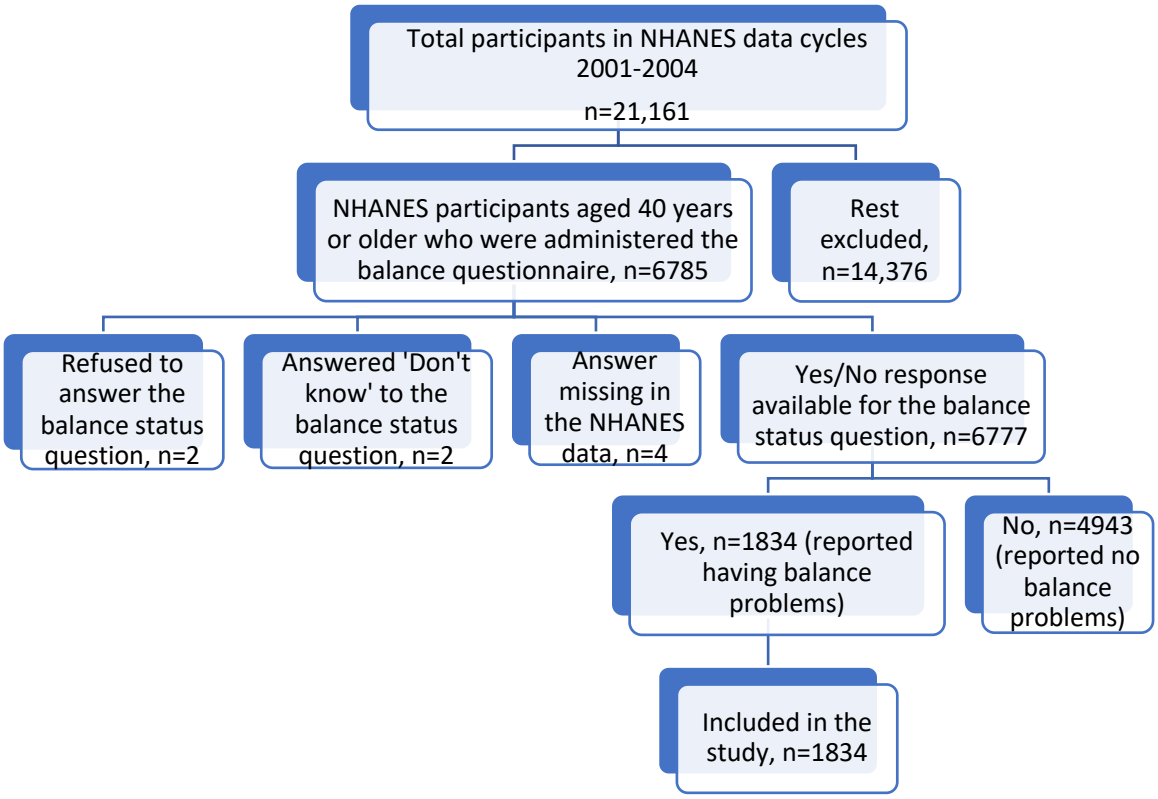

Figure 2: Flowchart detailing the inclusion criteria for study participants

3.2.2 Outcome Variable and Covariates

The outcome measure was a binary variable that assessed whether an individual ever saw a doctor or other health professional for balance problems. Predictors were drawn from the NHANES data as guided by the Andersen Health care Utilization Model, based on the literature review conducted to identify the potential factors.[18] Variables included in the model were age, sex, race, education level, marital status, annual family income, occurrence of fall(s) in the past year, number of comorbidities present (arthritis, congestive heart failure, coronary artery disease, stroke, cancer, diabetes mellitus), whether seeing a mental healthcare provider for mental health issues, general health status, whether covered by health insurance or not, whether received healthcare services over the past year or not, type of work/occupation, and average level of physical activity. Age was the only continuous variable and rest were binary or categorical variables.

3.2.3 Statistics

Data from NHANES 2001-02 and 2003-04 cycles was combined and probability weights were calculated as per the National Center for Health Statistics guidelines.[73] All analyses were adjusted using probability sampling weights with measures of frequency, central tendency, and dispersion calculated for continuous and categorical variables as appropriate. An unadjusted relative association measure (Odds ratio, OR) and 95% confidence interval (95%CI) was calculated for each association using simple logistic regression[74]. An adjusted odds ratio was calculated using binary logistic regression. The multivariable binary logistic regression model[74] was used to explore the associations between different independent variables and the outcome measure, utilization of healthcare services for balance problems. Model fitness was evaluated using the Archer-

Lemeshow goodness of fit test. The data for the outcome variable was missing for 8 participants. None of the variables included in the multivariable regression model were missing more than 5% of the data, so no imputations were made for the missing data.

Multivariable logistic regression model was constructed using a combination of statistical ($p<0.1$) and theoretical approaches based on literature review[18]. Based on the literature review,[18] age-sex interaction, sex-occurrence of fall(s) interaction, and sex-comorbidities interactions were investigated. Neither of these interactions was found to be statistically significant. We also checked for multicollinearity among the independent variables using variance inflation factor (VIF). The mean VIF was 1.61, indicating no problem of multicollinearity.

Predicted probabilities of healthcare utilization for balance problems were calculated for all the statistically significant predictor variables. For age, we calculated predicted probabilities of healthcare utilization at ten-year increments, that is, 40, 50, 60, 70, 80, and 90 years of age. To compare the relative magnitude of the associations of different explanatory variables with the outcome, the input variables were standardized or scaled. This was based on Gelman et al. recommendation that continuous variables should be divided by two times the standard deviation instead of one to match the scale of binary variables.[75] Only the continuous variables were standardized and binary variables were left as is, as proposed by literature on scaling regression inputs.[75] Standardized age variable was created by using the following equation:

$$\text{Standardized age} = [\text{Age} - (\text{Mean of age})]/\ 2(\text{Standard deviation of age})$$

The statistical analysis was conducted using the Stata version 18.0 software (StataCorp., College Station, TX). A two-tailed p-value of 0.05 was considered significant.

3.3 Results

3.3.1 Baseline Characteristics of Individuals with Self-reported Balance Problems

The baseline characteristics of the individuals who reported having balance problems have been detailed in Table 1. Of the 1834 individuals who reported having balance problems, the mean age was 60.1 years (0.5 standard error) and about 62.26% were females. With respect to race, 76.77% were Non-Hispanic Whites, with 9.37% being Non-Hispanic Blacks, 8.81% being Hispanics, and 5.05% belonging to other races. About 45.35% had more than high school education, 28.27% had high school education and 26.37% of the participants had less than high school education. Majority of the participants (58.81%) were either married or living with a partner. The annual family income was above $20,000 for 65.29% of the participants.

About 25.84% of the individuals with balance problems reported having one or more falls in the past year (Table 1). About 33.48% of the individuals who reported having balance problems had no other comorbidity. About 93.38% of individuals reported seeing a doctor or healthcare provider (for any reason) over the past year. About 36.75% of the individuals with balance problems reported that they mostly sat during the day and did not walk about much, when asked about the physical activity level. Another 46.89% reported that they stand and walk a lot during the day, but do not have to carry or lift things often. Only 4.56% reported doing heavy work or carrying heavy loads as a part of their daily activities. About 11.77% of those with balance problems were not covered by health insurance. A total of 60.27% of the individuals with balance problems reported not working at the time of this survey. About 14.49% of those with balance problems reported seeing a mental health professional in the past year.

Table 1: Baseline characteristics of the individuals who reported having balance problems

Characteristics	**Mean (Standard error)**	**Frequency (%)**
Age, years (n= 1834)	60.08 (0.46)	
Sex (n= 1834)		
Female		1091 (62.26)
Male		743 (37.74)
Race (n=1834)		
Non-Hispanics Whites		1115 (76.77)
Mexican American/other Hispanics		370 (8.81)
Non-Hispanics Blacks		283 (9.37)
Others		66 (5.05)
Education (n= 1822)		
Less than high school		693 (26.37)
High school		462 (28.27)
More than high school		667 (45.35)
Marital status (n= 1832)		
Married/living with partner		973 (58.81)
Widowed/Divorced/separated		749 (34.74)
Never married		110 (6.46)
Health insurance (n=1814)		
Yes		1617 (88.23)
No		197 (11.77)
Type of work (n=1832)		
Not working at job or business		1337 (60.27)
Working at job or business		447 (35.17)
With job or business but not working past week		33 (3.03)
Looking for work		15 (1.52)
Number of total comorbidities (n= 1834)		
0		512 (33.48)
1		687 (36.53)
2		384 (18.46)
3		179 (8.31)
4		59 (2.8)
5		11 (0.36)
6		2 (0.067)
Mental health issues/seeing mental health provider (n=1833)		
No		1615 (85.51)
Yes		218 (14.49)

Table 1 – Continued		
Characteristics	**Mean (Standard error)**	**Frequency (%)**
Seen healthcare provider in the past 1 year (n=1833)		
No		116 (6.62)
Yes		1717 (93.38)
Physical activity (n=1827)		
Sedentary (mostly sits, not walk much)		742 (36.75)
Stands/walks but no carrying/lifting		847 (46.89)
Lifts light load, climbs stairs often		179 (11.8)
Heavy work		59 (4.56)
General Health (n= 1834)		
Excellent		120 (7.46)
Very good		306 (20.23)
Good		548 (32.66)
Fair		573 (25.6)
Poor		287 (14.06)
Falls in the past year (n= 1832)		
Yes		537 (25.84)
No		1295 (74.16)

3.3.2 Healthcare Utilization for Balance Problems

Only 32.13% of the individuals (aged 40 years or more) who self-reported having balance problems sought healthcare services for balance problems (Figure 3). The results of unadjusted simple logistic regression have been detailed in Table 2. Annual family income, health insurance coverage, access to healthcare provider in the past year, and falls in the past year had statistically significant associations with healthcare utilization for balance problems. Individuals whose annual family income was more than $20,000 had 1.43 times higher odds of using healthcare for balance problems (OR 1.43; 95% CI, 1.02-2.00; p =0.04). Those without health insurance coverage had 59% reduced odds of healthcare utilization for their balance problems (OR 0.41; 95% CI, 0.26-0.63; p <0.001).

Individuals who had seen a healthcare provider in the past year were 3.26 more likely to seek healthcare services for their balance problems (OR 3.26; 95% CI, 1.56-6.78; p =0.003). Individuals with self-reported balance problems who experienced falls in the past year had 35% increased odds of using healthcare for their balance problems (OR 1.35; 95% CI, 1.05-1.73; p =0.02).

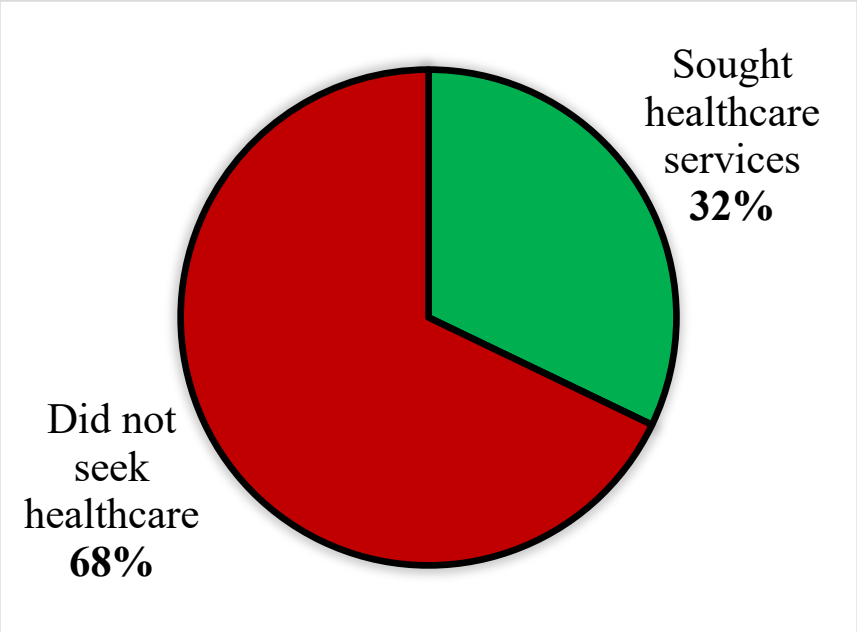

Figure 3: Proportion of individuals with balance problems who sought healthcare services for their balance problem

3.3.3 Predictors of Healthcare Utilization for Balance Problems- Results of the Adjusted Model

The multivariable logistic regression results show that age, access to healthcare provider in the past year, health insurance, and falls in the past year were all significant predictors of healthcare utilization for balance problems. For every one-year increase in age, the odds of seeking healthcare services for balance problems reduced by 2% (AOR, 0.98; 95% CI, 0.97-0.996; p =0.011). Having access to a healthcare provider in the past

year was associated with 2.45 times increased odds of using healthcare services for balance problems (AOR 2.45; 95% CI, 1.19-5.06; p =0.017). Not having health insurance coverage was associated with 48.4% decrease in the likelihood of using healthcare services for the management of balance problems (AOR 0.52; 95% CI, 0.32-0.84; p = 0.009). Falls in the past year significantly increased the odds of healthcare utilization for balance problems by 28.8% (AOR, 1.29; 95% CI, 1.03-1.61; P=0.028). The details of the adjusted odds ratios and confidence intervals have been provided in Table 3.

Table 2: Crude/unadjusted odds ratios of the relationship between healthcare utilization for balance problems and different covariates (Results of Bivariate simple logistic regression)

Covariate	**Unadjusted OR (95% CI)**	**p-value**
Age	0.997 (0.99 -1.01)	0.55
Sex		
Male	Reference	
Female	0.91 (0.69-1.20)	0.49
Race		
Non-Hispanics Whites	Reference	
Mexican American/other Hispanics	0.74 (0.49-1.12)	0.15
Non-Hispanics Blacks	1.09 (0.88- 1.36)	0.41
Others	0.63 (0.28-1.38)	0.24
Education		
Less than high school	Reference	
High school	1.09 (0.74-1.62)	0.63
More than high school	1.27 (0.94-1.73)	0.12
Marital status		
Married/living with partner	Reference	
Widowed/Divorced/separated	0.78 (0.60-1.02)	0.07
Never married	0.59 (0.24-1.43)	0.23
Annual family income		
Less than $20,000	Reference	
$20,000 or more	**1.43 (1.02-2.00)**	**0.04**

Table 2 – Continued		
Covariate	**Unadjusted OR (95% CI)**	**p-value**
Health insurance		
Yes	Reference	
No	**0.41 (0.26-0.63)**	**<0.001**
Type of work		
Not working at job or business	Reference	
Working at job or business	0.87 (0.60-1.24)	0.43
With job or business but not working past week	0.89 (0.31-2.56)	0.83
Looking for work	0.40 (0.14-1.16)	0.09
Number of total comorbidities		
0	Reference	
1	1.31 (0.96-1.78)	0.09
2	1.32 (0.90-1.93)	0.16
3	1.58 (1.01-2.46)	0.05
4	1.45 (0.68-3.07)	0.33
5	3.22 (0.71-14.70)	0.13
6	2.79 (0.17-47.08)	0.46
Seen healthcare provider in the past year		
No	Reference	
Yes	**3.26 (1.56-6.78)**	**0.003**
Physical activity		
Sedentary (mostly sits, not walk much)	Reference	
Stands/walks but no carrying/lifting	0.86 (0.66-1.13)	0.28
Lifts light load, climbs stairs often	0.91 (0.65-1.28)	0.58
Heavy work	0.71 (0.31-1.63)	0.40
General Health		
Excellent	Reference	
Very good	1.19 (0.63-2.26)	0.58
Good	1.06 (0.57-1.99)	0.84
Fair	1.07 (0.62-1.83)	0.81
Poor	1.50 (0.82-2.75)	0.18
Falls in the past year		
No	Reference	
Yes	**1.35 (1.05-1.73)**	**0.02**

*Statistically significant values are in bold.

Table 3: Significant Predictors of Healthcare Utilization for Balance Problems in the adjusted multivariable logistic regression model (n= 1745)

Covariate	Adjusted OR (95% CI)	p-value
Age	0.98 (0.97-0.996)	0.01
Falls in the past year	1.29 (1.03-1.61)	0.03
Seeing healthcare provider in past year	2.45 (1.19-5.06)	0.02
Lack of health insurance	0.52 (0.32-0.84)	< 0.01

* Archer Lemeshow Goodness of fit test for this multivariable regression; p-value = 0.65 (Variables included in the model: were age, sex, race, education level, marital status, annual family income, occurrence of fall(s) in the past year, number of comorbidities present, whether seeing a mental healthcare provider for mental health issues, general health status, whether covered by health insurance or not, whether received healthcare services over the past year or not, type of work/occupation, and average level of physical activity)

Standardization of age was performed to compare the relative magnitude of the associations of different explanatory variables with healthcare utilization for balance problems. Results of the standardized model showed that seeing a healthcare provider in the past year had the largest statistically significant influence on healthcare utilization

(AOR = 2.45; 95% CI, 1.19-5.06; p-value =0.02), followed by the impact of health insurance coverage (AOR = 0.52; 95% CI, 0.32-0.84; p-value <0.01), age (AOR 0.64; 95% CI, 0.45-0.89; p-value =0.01), and falls in the past year (AOR = 1.29; 95% CI, 1.03-1.61; p-value =0.03).

3.3.4 Predicted Probabilities of Healthcare Utilization for Balance Problems

The probability of healthcare utilization for balance problems in community-dwelling adults reduced with increasing age, as shown in Figure 4, when all the other factors were kept constant. The probability of seeking healthcare services for balance problems reduced from 0.39 for a 40-year-old with self-reported balance problems to 0.26 for an 80-year-old with similar problems. Those who reported falling in the past year had a 0.36 probability of seeking healthcare services for balance problems compared to 0.31 in those who did not experience any falls. The probability of healthcare utilization was almost twice for individuals who saw a healthcare provider in the past year compared to those who did not (0.33 vs 0.17). Lastly, the predicted probability of using healthcare for balance problems was 0.33 among those with health insurance coverage compared to only 0.21 among those who did not have insurance, keeping all the other factors constant.

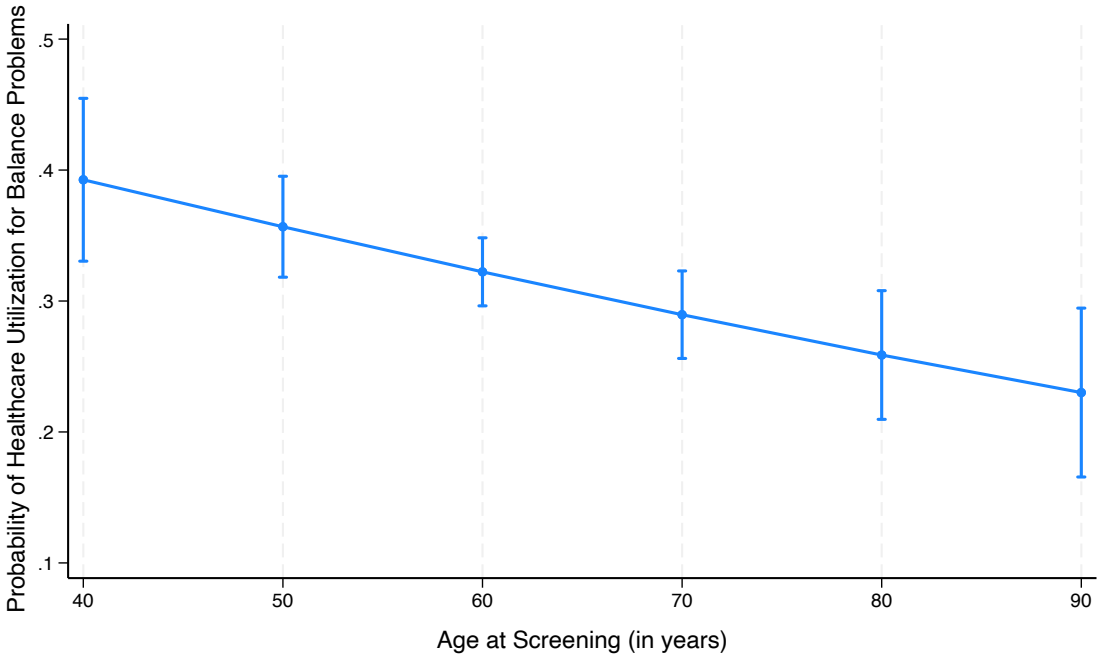

Figure 4: Predicted probability of healthcare utilization for balance problem with advancing age (with 95% confidence intervals)

3.4 Discussion

This study reports the factors associated with reduced healthcare utilization for balance problems in a nationally representative sample of community-dwelling adults with self-reported balance problems in the US. Only 32.13% of individuals with balance problems sought healthcare services to address their balance issues. Older age and lack of health insurance were statistically significant predictors of reduced healthcare utilization for balance problems. Additionally, individuals who reported not seeing any doctor/healthcare provider in the past year had reduced odds of seeking healthcare services for their balance problems. Lastly, individuals who had not experienced any falls in the past year were less likely to seek healthcare services for their balance issues, indicating that people probably tend to wait till they start falling before seeking any help.

This study reports a 2% reduction in the odds of seeking healthcare for balance problems with every one-year increase in age. The probability of seeking healthcare services for balance problems for an 80-year-old with self-reported balance problems was reduced to about two-thirds of the probability for a 40-year-old with similar problems, when all the other factors were kept constant. Older adults usually have a higher overall utilization of healthcare services compared to younger adults.[76] However, it has also been reported that older adults, though more likely to seek healthcare services for chronic problems or pre/post-surgery, are less likely to seek preventive services.[77] This aligns with the decreasing trend for healthcare utilization for balance problems with increasing age as reported by our study.

Our study also reports that community-dwelling adults with balance problems had 145% higher odds of seeking healthcare services for their balance problems if they had seen a doctor/healthcare provider (for any reason) in the past year. This finding is in alignment with the literature reporting worse health outcomes for individuals living in medically underserved areas with limited access to healthcare services.[57] Healthcare visits, particularly primary care visits increase the likelihood of preventive interventions.[78] Individuals with balance problems are likely getting referred for fall prevention interventions during their regular healthcare visits. Implementation of initiatives such as the 'Stopping Elderly Accidents, Deaths, and Injuries' (STEADI) initiative to incorporate fall risk assessment into routine clinical practice[79] would further enhance this association between healthcare utilization for balance problems and seeing a healthcare provider in the past year.

Health insurance had the second largest impact on healthcare utilization for balance problems in our study. The odds of healthcare utilization reduced by nearly 50% for the individuals with balance problems who lacked health insurance coverage. Lack of health insurance coverage is a crucial driver of the disparities seen in healthcare.[80] Health insurance coverage increases the individual's likelihood to seek preventive and clinical services.[80-82] A universal health coverage in the US could likely increase timely management of balance problems and possibly reduce the burden associated with falls and related injuries.

Participants in our study who reported fall(s) in the past year had 35% higher odds of seeking healthcare services for their balance problems. These findings imply that individuals with self-reported balance problems are less likely to seek preventive measures if they have not experienced any fall(s) in the past year. However, any fall can be debilitating and may result in serious injuries.[6,22] Hence, education regarding the availability of effective multi-factorial fall prevention interventions should be considered for those with self-reported balance problems, even if they have not experienced any falls yet. Multimodal fall prevention approaches led by physical therapists[83] and community-based interventions[84] have been reported to reduce falls and fall-related injuries, especially in community-dwelling older adults.

Though this is a statistically sound study using nationally representative data, some limitations warrant attention. This study used NHANES data from 2001-2004. Unfortunately, more recent NHANES data cycles currently available lack the balance information variables of interest. Future research can use these preliminary results on more recent data.

Access to care is an important factor that can drive healthcare utilization. While the current study included variables to account for socio-economic status and health insurance coverage, we could not look at the geographic factors such as living in a rural vs urban community, distance from the nearest hospital/healthcare provider etc. Future studies should consider including more information about the accessibility to care in their models. Perhaps a model looking at the continuum of care can be more helpful in understanding the complete picture of healthcare utilization for balance problems.

3.5 Conclusion

This study reports the underutilization of healthcare services for the management of balance problems in community-dwelling adults with self-reported balance problems. Older age, lack of health insurance, not seeing a healthcare provider in the past year, and not experiencing any falls in the past year had a significant association with reduced healthcare utilization for balance problems. These findings can help identify the populations at risk of underutilizing healthcare services for balance problems and might be useful in guiding the efforts towards increased use of effective fall prevention interventions.

CHAPTER FOUR

CONGRUENCE BETWEEN SELF-REPORT AND PERFORMANCE-BASED MEASURE OF BALANCE IN COMMUNITY-DWELLING ADULTS

4.1 Introduction

Balance disorders are highly prevalent in older adults and can result in fatal or debilitating falls. In the United States (US), falls are the leading cause of mortality and chronic disability in community-dwelling adults.[6] Additionally, the financial cost associated with medical management of fall-related injuries is estimated to reach over 100 billion dollars by the year 2030.[11]

The symptoms of balance problems vary greatly, including a generalized sense of disorientation/disequilibrium, fear of falling, staggering when walking, and acute vertigo/dizziness. Despite this disparate symptomology, and the largely subconscious nature of balance control[85], epidemiological studies on balance disorders often rely solely on self-reported measures to establish the presence or absence of balance problems.[86,87]

A variety of performance-based balance tests have been developed, and one such test is the Romberg Test of Standing Balance on Firm and Compliant Support Surfaces (RTSBFCSS). This standardized assessment tool measures balance by testing standing ability in multiple stances on various ground surfaces. This quick and easy to administer test is very similar to the modified Clinical Test of Sensory Interaction and Balance with excellent reliability and validity.[88-90]

The US Centers for Disease Control and Prevention (CDC) recommends using self-reported balance information as the first step for fall-risk screening, with

performance-based assessment advised only when self-reported balance problems exist.[79] However, several studies have demonstrated that older individuals often underestimate or overestimate their balance problems during self-report.[91,92] This incongruency between self-reported and performance-based balance in older adults might increase the probability of an individual falling[91] and minimize care-seeking for balance disorders via maladaptive self-appraisal of fall risk.[92]

The incongruence between self-reported and performance-based balance measures has been identified among several clinical populations[93-96] but has yet to be fully explored in the general population. In one of the only known studies addressing such incongruences across a nationally representative sample, close to 32% of individuals within the US over the age of 40 years were reported have balance impairment due to vestibular dysfunction and increased fall risk, despite self-reported absence of any balance issues[87]. However, this study only included patients with vestibular-related balance problems and did not examine how balance measure congruence differed by basic demographic, socioeconomic, and clinical factors.

A recent literature review overviewed the associations between various factors (e.g. age, sex, race, preexisting comorbidities, general health status, socioeconomic status, health insurance coverage) and healthcare utilization for balance problems.[18] A conceptual model based on this work (see Figure 5) suggests that the effect of age on balance metric congruence is potentially modified by sex.[18,22,97] The model also proposes that basic demographic, socioeconomic, and clinical/health status factors may influence the congruence between balance measures.

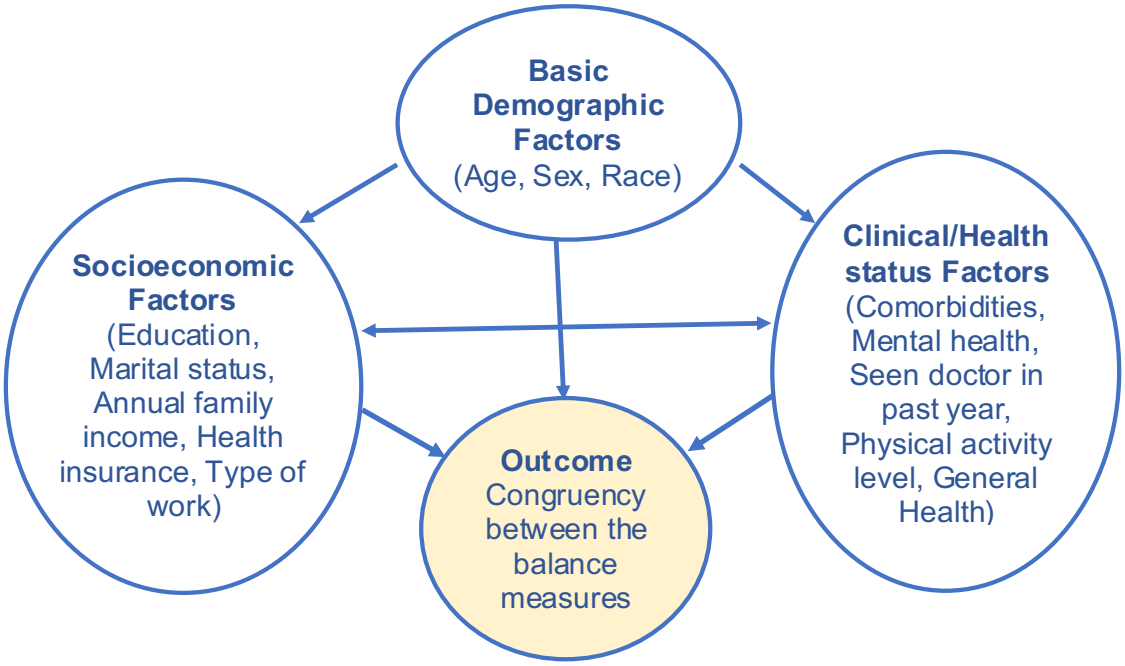

Figure 5: Conceptual model: Basic demographic, socioeconomic, and clinical/health status factors that may influence the outcome variable, the congruency between self-report and performance-based balance measure. The interactions between basic demographic factors and socioeconomic factors are proposed to be unidirectional, while interactions between socioeconomic and clinical factors are formulated as being bidirectional.

4.1.1 Purpose

This study had two objectives. Primary objective was to investigate the congruency between self-reported balance information and the results of a performance-based measure of balance (i.e. RTSBFCSS) in a nationally representative sample of community-dwelling adults. Secondary aim was to explore the factors associated with the congruency between these balance measures. Given the underutilization of healthcare services for balance problems,[18] and the reports of faulty perception of balance status,[91,92]

it was hypothesized that a high proportion of individuals over the age of 40 years would underestimate their balance problem (i.e. self-report that their balance was unimpaired but fail the RTSBFCSS). Secondary aim was exploratory and designed to provide further insight (for future hypotheses generation) into the characteristics of individuals who show congruence between self-report and performance-based balance metrics.

4.1.2 Significance

Knowledge regarding the congruency between self-report and performance-based balance measures can inform whether using self-reported information to screen for balance disorders is appropriate, or if additional balance performance measures need to be adopted to ensure that individuals with balance problems are not missed. Hence, the findings can guide efforts toward more effective screening tools for balance issues. With adequate screening, balance problems can be identified in a timely fashion and managed, resulting in better patient outcomes, improved long-term quality of life, and reduced burden on healthcare.

4.2 Methods

4.2.1 Research Design

This project was an epidemiological survey analysis that involved a secondary analysis of the National Health and Nutrition Examination Survey (NHANES) 2001-2004 data. These cycles were selected because these are the latest cycles of nationally representative NHANES data for the US population aged 40 years and older that included administration of the balance questionnaire. This study was exempt from IRB approval because NHANES data is publicly available, deidentified, and anonymous. NHANES

examined a nationally representative sample of the noninstitutionalized civilian resident population of the United States.

4.2.2 NHANES Data Collection

Demographic data, standing balance questionnaire data, and RTSBFCSS balance examination data from the NHANES 2001-2004 cycles was obtained online. NHANES data collection combined in-home interviews and standardized health examinations conducted in mobile examination centers. NHANES used a stratified, multistage probability sampling design with the sample selected using a four-stage process.[13] More details about the NHANES survey design, sample selection, and informed consent are available.[12,13]

4.2.3 Self-reported and Performance-based Balance Status Metrics

The self-reported balance component of NHANES used in this study was based on the participant's response to the question: "During the past 12 months, have you had dizziness, difficulty with balance, or difficulty with falling?".[88] The balance performance measure component of NHANES data used RTSBFCSS to identify balance deficits.[88] The RTSBFCSS was conducted on individuals above the age of 40 years who agreed to participate in the NHANES health examination component.[88] RTSBFCSS involved four standing conditions with eyes open/closed on firm and compliant surfaces. The exclusion criteria and the detailed procedure of the RTSBFCSS test have been described in Figure 6 and supplemental methods (Appendix A) respectively.

For this study, individuals were coded as having performance-based balance deficits if they did not pass any of the four test conditions of RTSBFCSS. Furthermore, participants were coded as congruent in balance measures if they correctly self-reported

the presence or absence of a balance issue as compared to their RTSBFCSS results. Participants who had a disparity between the clinical test performance and self-reported information were labeled as incongruent in balance measures.

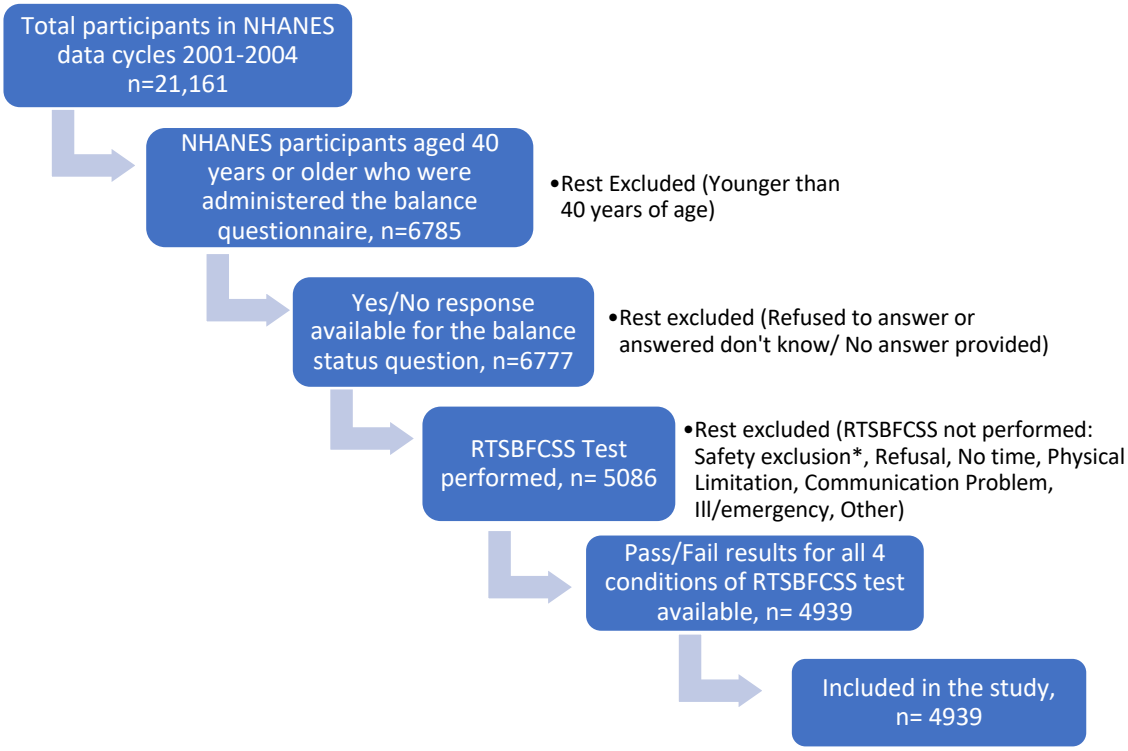

Figure 6: Flowchart depicting the inclusion criteria for study participants

* Participants were excluded for safety reasons if they could not stand unassisted, had a prosthetic device below the waist, weighed more than 275 lbs (124.7 kg), had waist circumference that was either too small or too large to accommodate a properly fitted standard-sized safety gait belt, had severe visual impairment, or any current symptoms of dizziness or lightheadedness at the time of examination.

4.2.4 Participants

Included in this study were all individuals over the age of 40 years who responded to the self-reported balance status question on the NHANES questionnaire and for whom the results of the balance examination were available (Figure 6). Participants were excluded from the study if they refused to answer the balance status question or if they answered, 'don't know'. Following this criterion, a total of 4939 individuals were included in the study.

4.2.5 Outcome Measures

First part of the study estimated the proportion of individuals who perceptually underestimated (self-reported no balance problem but failed the performance-based RTSBFCSS) or overestimated (self-reported having a balance problem but passed the RTSBFCSS) their balance problem, along with the 95% confidence intervals. For the second part of the study, the outcome variable was the presence of congruency between the self-report and performance-based balance measures (binary variable). Information used for coding all the other covariates has been detailed in Table 7.

4.2.6 Statistics

Probability sampling weights were used to obtain nationally representative statistics of the study sample. Appropriate descriptive statistics were computed for all continuous (mean and standard deviation) and categorical variables (frequency and percent).

A Chi-square test was used to explore the association between self-reported balance information and the performance on RTSBFCSS. Crude odds ratio (OR) and 95% confidence intervals (CI) were calculated using bivariate simple logistic regression.

A multivariable[74] binary logistic regression model was used to explore the predictors associated with congruency between the self-report and performance-based measures. A combined statistical ($p<0.1$) and theoretical approach was used to construct the multivariable model. Covariates included in the final model were age, sex, race, education, marital status, annual family income, health insurance, type of work, number of comorbidities, mental health issues, seeing healthcare provider in the past year, physical activity status, and general health. All covariates except age and number of comorbidities were categorical.

Adjusted OR and 95% CI were calculated to get precision of estimates. Model fitness was evaluated by the Archer-Lemeshow goodness of fit test which is the preferred test for a logistic regression model fitted using complex survey design.[98] All independent variables in the regression model were checked for multicollinearity using the variance inflation factor (VIF). The mean VIF was 1.43, indicating no problem of multicollinearity. A two-tailed p-value of 0.05 was considered significant.

We checked for age and sex interaction by adding an age-sex interaction variable in the regression model. The multivariable regression model with age-sex interaction term was also used to calculate the conditional probabilities of the outcome for each sex at ten-year increments of age, holding the other covariates constant at their means. After the age and sex interaction term was found to be statistically significant in the overall multivariable regression model, the data was stratified by sex, and multivariable logistic regression was performed for males and females separately. None of the covariates included in the model had more than 3% missing data, so no imputations were done for

the missing data. Stata version 15.1 complex (StataCorp., College Station, TX) survey design was used to conduct all the analyses.

4.3 Results

4.3.1 Baseline Characteristics

A total of 4939 adults were included in this study. The mean age of the study participants was 56.03 years (0.30 standard error), with 51.24% being females, 78.71% Non-Hispanic Whites, 9.02% Non-Hispanic Blacks, and 8.33% Hispanics. All baseline characteristics of the population are detailed in Table 4.

Table 4: Descriptive characteristics of the study population (n= 4939)

Characteristics	**Frequency (%)**	**Mean (Standard error)**
Baseline characteristics		
Age, years (n= 4939)		56.03 (0.30)
Sex (n= 4939)		
Female	2420 (51.24)	
Male	2519 (48.76)	
Race (n=4939)		
Non-Hispanics Whites	2864 (78.71)	
Mexican American/other Hispanics	1049 (8.33)	
Non-Hispanics Blacks	876 (9.02)	
Others	150 (3.95)	
Education (n= 4935)		
Less than high school	1444 (17.18)	
High school	1214 (26.23)	
More than high school	2277 (56.59)	
Marital status (n= 4935)		
Married/living with partner	3267 (70.98)	
Widowed/Divorced/separated	1386 (23.46)	
Never married	282 (5.57)	
Annual family income (n= 4810)		
Less than $20,000	1387 (19.32)	
$20,000 or more	3423 (80.68)	
Health insurance (n=4893)		
Yes	4281 (89.11)	
No	612 (10.89)	

Table 4- continued		
Characteristics	**Frequency (%)**	**Mean (Standard error)**
Type of work (n=4938)		
Not working at job or business	2512 (38.55)	
Working at job or business	2240 (56.68)	
With job or business but not working past week	133 (3.63)	
Looking for work	53 (1.14)	
Number of comorbidities (n= 4939)		0.67 (0.02)
Mental health issues/seeing mental health provider (n=4935)		
No	4619 (92.33)	
Yes	316 (7.67)	
Seen healthcare provider in the past 1 year (n=4936)		
No	605 (12.41)	
Yes	4331 (87.59)	
Physical activity (n=4932)		
Sedentary (mostly sits, not walk much)	1203 (24.74)	
Stands/walks but no carrying/lifting	2771 (53.79)	
Lifts light load, climbs stairs often	696 (16.12)	
Heavy work	262 (5.36)	
General Health (n= 4936)		
Excellent	829 (20.2)	
Very good	1319 (31.36)	
Good	1599 (30.66)	
Fair	949 (14.02)	
Poor	240 (3.75)	
Variables used to compute the outcome variable		
Self-reported balance problems (n=4939)		
No	3812 (78.79)	
Yes	1127 (21.21)	
Evidence of balance problems on clinical test (n=4939)		
No	2673 (63.09)	
Yes	2266 (36.91)	
Outcome variable		
Congruency between the balance measures (n=4939)		
Incongruent	2055 (35.84)	
Congruent	2884 (64.16)	

*The first category listed for each variable here was coded as 0 and used as the reference category for Bivariate simple and Multivariable logistic regression models.

4.3.2 Congruence between Self-reported and Performance-based Balance Measures

Among the community-dwelling US population over the age of 40 years, 21.21% self-reported having balance problems in the past year according to the self-reported questionnaire. However, on performance-based balance testing, about 36.91% of all participants were found to have evidence of balance problems. Close to 64 % (95% CI: 61.95%-66.31%) of participants were congruent in self-report and performance-based balance measures. Specifically, 11.14% (95% CI: 9.93%-12.48%) self-reported having a balance issue and failed the RTSBFCSS, while 53.02% (95% CI: 50.26%-55.76%) self-reported not having balance problems and had no evidence of performance-based deficits.

In contrast, 35.84% (95% CI: 33.69%-38.05%) of individuals showed incongruence between their self-reported balance status and the performance-based RTSBFCSS. Among these individuals, 25.78% (95% CI: 23.86%-27.79%) perceptually under-estimated their balance problems such that they reported no balance problems but failed the RTSBFCSS. The remaining 10.07% (95% CI: 8.83%-11.46%) over-estimated their balance problems (i.e. reported having balance problems but had no evidence of performance-based deficits on RTSBFCSS) (Figure 7). The differences between self-reported information and performance-based measures were statistically significant (Chi-square χ^2 (1,30) = 92.81, p-value <0.0001). Approximately 7 in 10 individuals who had evidence of balance problems on performance-based testing reported not having any balance problems on the self-reported question (Figure 8).

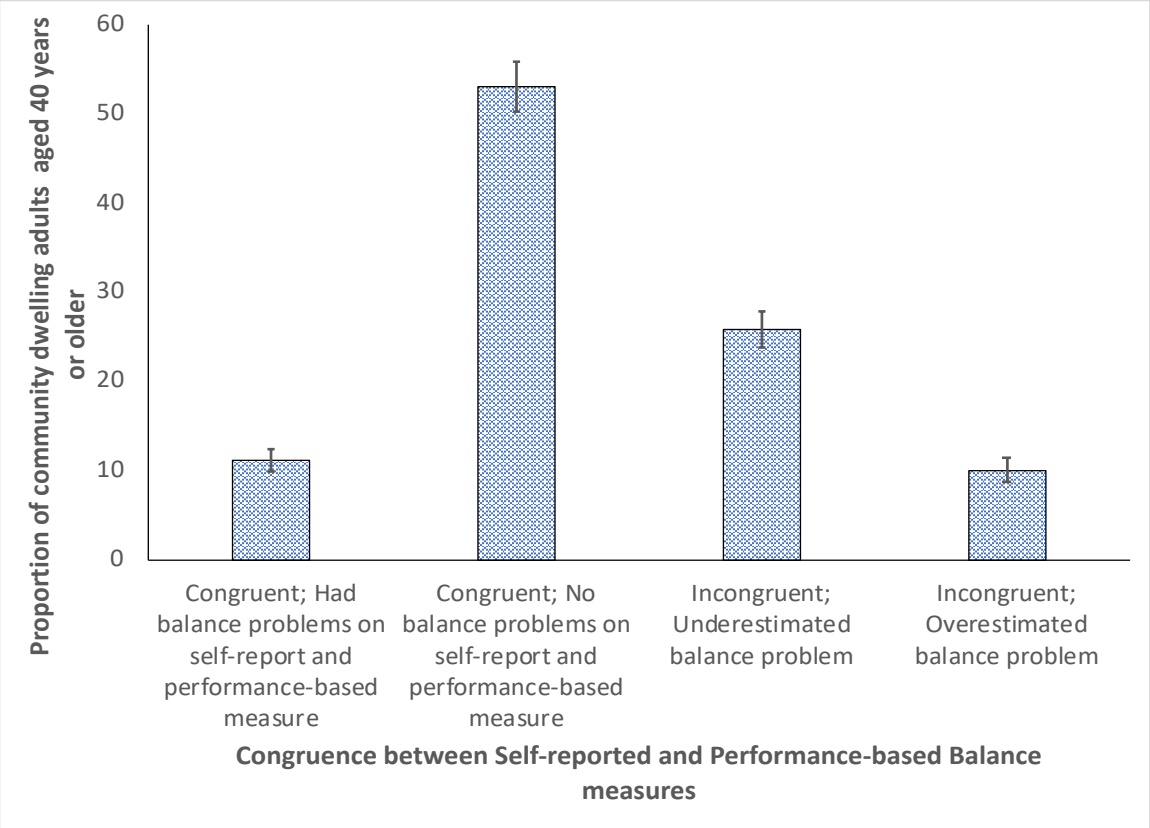

Figure 7: Bar graph showing the distribution of study participants in reference to congruent or incongruent assessment of balance problems. (n=4939)

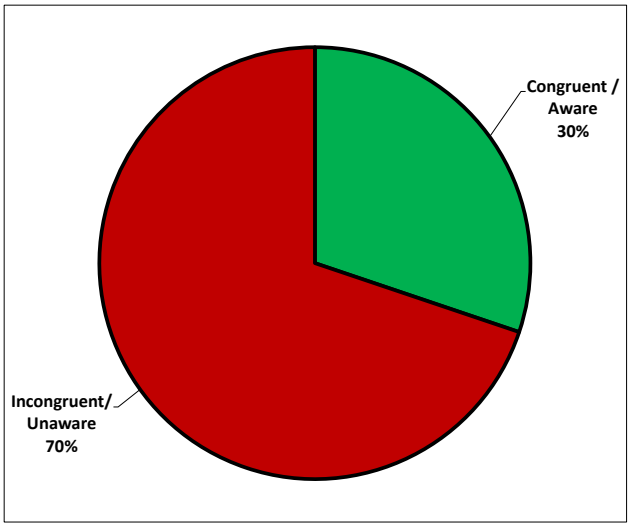

Figure 8: Pie Chart showing the self-awareness of having balance problems among individuals who had evidence of balance problems (on clinical balance test). (n=4939)

4.3.3 Association between Balance Measure Congruency and Demographic Factors

The detailed results of the unadjusted bivariate simple logistic regression models are provided in Table 5. The congruency between the self-report and performance-based balance measures was inversely related to age. In the unadjusted logistic regression analysis, an increase in age was associated with a decrease in odds of congruency among the balance measures, in the overall sample, and also for both sexes (crude OR = 0.96; 95% CI, 0.96-0.97; p-value <0.001 for all participants; crude OR = 0.97; 95% CI, 0.96-0.98; p-value <0.001for females and crude OR = 0.95; 95% CI, 0.95-0.96; p-value <0.001for males).

Non-Hispanic Blacks had statistically significantly reduced odds of congruency among the balance measures compared to non-Hispanic Whites, in the overall sample and among males, but not for females when stratified by sex (crude OR = 0.85; 95% CI, 0.72-0.996; p-value =0.045 for all participants; and crude OR = 0.75; 95% CI, 0.57-0.99; p-value =0.04 for males). Education, marital status, annual family income, type of work, number of comorbidities, seeing a healthcare provider in the past year, and general health status were some other covariates that had a significant association with congruency among the self-report and performance-based balance measures (Table 5).

The multivariable logistic regression analyses done on all participants revealed age as an independent predictor of the outcome; the odds of congruency among balance measures reduced with increase in age. The age by sex interaction was found to be statistically significant when checking for the effect modification (p-value = 0.015). The model fitness was confirmed using the Archer Lemeshow goodness of fit test for the overall model with the age and sex interaction term (p-value = 0.14; Table 6).

Table 5: Crude/unadjusted odds ratios of the relationship between congruency among the balance measures and different covariates (Results of Bivariate simple logistic regression)

Covariate	**Unadjusted OR (95% CI)**	**p-value**	**Unadjusted OR (95% CI)**	**p-value**	**Unadjusted OR (95% CI)**	**p-value**
	All Participants		**Females**		**Males**	
Age	***0.96 (0.96-0.97)***	***<0.001***	***0.97 (0.96-0.98)***	***<0.001***	***0.95 (0.95-0.96)***	***<0.001***
Sex Female Male	Reference 1.10 (0.96-1.27)	0.17				
Race Non-Hispanics Whites Mexican American/other Hispanics Non-Hispanics Blacks Others	Reference 0.86 (0.65-1.12) ***0.85 (0.72-0.996)*** ***0.70 (0.50-0.988)***	 0.25 ***0.045*** ***0.043***	 0.87 (0.66-1.15) 0.95 (0.77-1.16) 0.84 (0.54-1.31)	 0.33 0.59 0.43	 0.84 (0.60-1.17) ***0.75 (0.57-0.99)*** ***0.55 (0.33-0.90)***	 0.29 ***0.04*** ***0.02***
Education Less than high school High school More than high school	Reference ***1.43 (1.23-1.66)*** ***1.76 (1.49-2.08)***	 ***<0.001*** ***<0.001***	 ***1.32 (1.01-1.73)*** ***1.55 (1.23-1.94)***	 ***0.04*** ***<0.001***	 ***1.55 (1.15-2.11)*** ***2.01 (1.61-2.52)***	 ***0.006*** ***<0.001***
Marital status Married/living with partner Widowed/Div-orced/separated Never married	Reference ***0.75 (0.66-0.85)*** 1.09 (0.83-1.45)	 ***<0.001*** 0.51	 ***0.75 (0.63-0.89)*** 0.91 (0.59-1.40)	 ***0.001*** 0.65	 ***0.76 (0.64-0.90)*** 1.29 (0.83-2.00)	 ***0.003*** 0.25

Table-5 continued						
Covariate	**Unadjusted OR (95% CI)**	**p-value**	**Unadjusted OR (95% CI)**	**p-value**	**Unadjusted OR (95% CI)**	**p-value**
	All Participants		**Females**		**Males**	
Annual family income Less than $20,000 $20,000 or more	Reference ***1.54 (1.37-1.74)***	***<0.001***	***1.47 (1.28-1.70)***	***<0.001***	***1.62 (1.28-2.04)***	***<0.001***
Health insurance Yes No	Reference 0.96 (0.80-1.16)	0.68	1.17 (0.88-1.55)	0.28	0.79 (0.60-1.05)	0.09
Type of work Not working at job or business Working at job or business With job or business but not working past week Looking for work	Reference ***2.04 (1.72-2.41)*** ***1.91 (1.41-2.57)*** 1.29 (0.75-2.22)	***<0.001*** ***<0.001*** 0.35	***1.80 (1.44-2.25)*** ***1.95 (1.08-3.53)*** 1.19 (0.44-3.23)	***<0.001*** ***0.03*** 0.73	***2.36 (1.83-3.04)*** ***1.92 (1.10-3.35)*** 1.44 (0.64-3.26)	***<0.001*** ***0.02*** 0.37
Number of comorbidities	***0.78 (0.71-0.84)***	***<0.001***	***0.80 (0.72-0.89)***	***<0.001***	***0.75 (0.67-0.85)***	***<0.001***
Mental health issues/seeing mental health provider No Yes	Reference 0.89 (0.63-1.27)	0.52	0.85 (0.53-1.37)	0.50	0.96 (0.62-1.48)	0.86
Seen healthcare provider last year No Yes	Reference ***0.73 (0.57-0.93)***	***0.01***	0.91 (0.63-1.31)	0.60	***0.65 (0.49-0.87)***	***0.006***

Table-5 continued						
Covariate	**Unadjusted OR (95% CI)**	**p-value**	**Unadjusted OR (95% CI)**	**p-value**	**Unadjusted OR (95% CI)**	**p-value**
	All Participants		**Females**		**Males**	
Physical activity						
Sedentary (mostly sits, not walk much)	Reference					
Stands/walks but no carrying /lifting	0.88 (0.72-1.08)	0.21	0.86 (0.64-1.16)	0.31	0.90 (0.70-1.16)	0.41
Lifts light load, climbs stairs often	1.04 (0.77-1.40)	0.80	1.00 (0.68-1.47)	0.99	1.07 (0.76-1.49)	0.69
Heavy work	1.13 (0.77-1.65)	0.53	1.08 (0.50-2.31)	0.84	1.12 (0.70-1.78)	0.63
General Health						
Excellent	Reference					
Very good	***0.74 (0.60-0.92)***	***0.008***	***0.70 (050-0.98)***	***0.04***	0.80 (0.59-1.07)	0.13
Good	***0.61 (0.47-0.79)***	***<0.001***	***0.61 (0.47-0.80)***	***0.001***	***0.61 (0.43-0.87)***	***0.007***
Fair	***0.61 (0.46-0.82)***	***0.001***	***0.62 (0.42-0.90)***	***0.01***	***0.61 (0.42-0.90)***	***0.01***
Poor	***0.53 (0.34-0.81)***	***0.005***	***0.53 (0.31-0.91)***	***0.02***	0.52 (0.27-1.03)	0.06

*Statistically significant figures are in bold and italics.

The results of multivariable logistic regression models, stratified by sex, have been detailed in Table 6. Males had an average of 4% reduction in the odds of congruency among the balance measures with every one-year increase in age compared to a 3% reduction in the same for females (AOR = 0.96; 95% CI, 0.95-0.96; p-value <0.001 for males; and AOR = 0.97; 95% CI, 0.96-0.98; p-value <0.001 for females). Among females, having good vs excellent health status was significantly associated with

about 29% reduction in the odds of congruency among the balance measures (AOR = 0.71; 95% CI, 0.51-0.97; p-value =0.03). On the other hand, the health status of males did not have a statistically significant association with congruency among the self-reported and performance-based balance measures. Race, education, health insurance, and being seen by a healthcare provider were significantly associated with congruency among the balance measures in males but not in females.

The predictive probabilities of the congruency between self-reported and performance-based RTSBFCSS assessment were also calculated. The margins plot shown in Figure 9 illustrates the decreasing probability of congruency among the balance measures with advancing age. It also illustrates the effect of the interaction between age and sex on the predicted probabilities of the outcome.

Table 6: Adjusted odds ratios of the relationship between congruency among the balance measures and different covariates (Results of Multivariable logistic regression model stratified by sex)

Covariate	**Adjusted OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
	Females		**Males**	
Age	***0.97 (0.96-0.98)***	***<0.001***	***0.96 (0.95-0.96)***	***<0.001***
Race				
Non-Hispanics Whites	Reference			
Mexican American/ other Hispanics	0.82 (0.69-1.08)	0.21	0.77 (0.57-1.04)	0.09
Non-Hispanics Blacks	0.86 (0.61-1.12)	0.18	***0.74 (0.56-0.99)***	***0.045***
Others	0.77 (0.49-1.22)	0.26	***0.50 (0.31-0.79)***	***0.005***
Education				
Less than high school	Reference			
High school	1.12 (0.84-1.51)	0.80	1.15 (0.81-1.62)	0.42
More than high school	1.08 (0.82-1.43)	0.60	***1.39 (1.07-1.81)***	***0.02***

Table-6 continued				
Covariate	**Adjusted OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
	Females		**Males**	
Marital status				
Married/living with partner	Reference			
Widowed/Divorced/ separated	1.08 (0.87-1.33)	0.48	0.90 (0.78-1.05)	0.17
Never married	0.93 (0.57-1.50)	0.76	1.11 (0.70-1.77)	0.65
Annual family income				
Less than $20,000	Reference			
$20,000 or more	1.13 (0.93- 1.38)	0.21	1.07 (0.87-1.32)	0.50
Type of work				
Not working at job or business	Reference			
Working at job or business	1.14 (0.88-1.49)	0.31	1.16 (0.86-1.55)	0.32
With job or business but not working past week	1.30 (060-2.81)	0.49	0.94 (054-1.65)	0.84
Looking for work	0.83 (0.27-2.56)	0.74	0.85 (0.39-1.87)	0.68
Health insurance				
Yes	Reference			
No	1.01 (0.71- 1.42)	0.97	***0.54 (0.37-0.80)***	***0.003***
Number of comorbidities	0.98 (0.86-1.11)	0.69	1.01 (0.88-1.18)	0.84
Seen healthcare provider in the past 1 year				
No	Reference			
Yes	1.10 (0.72-1.69)	0.65	***0.68 (0.47-0.99)***	***0.04***
Physical activity				
Sedentary (mostly sits, not walk much)	Reference			
Stands/walks but no carrying/lifting	0.85 (0.61-1.18)	0.32	0.94 (0.70-1.27)	0.68
Lifts light load, climbs stairs often	0.86 (0.56-1.33)	0.49	0.98 (0.67-1.44)	0.91
Heavy work	0.82 (0.32-2.14)	0.68	0.91 (0.57-1.44)	0.67

Table-6 continued				
Covariate	**Adjusted OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
	Females		**Males**	
Mental health issues/seeing mental health provider				
No	Reference			
Yes	0.78 (0.46-1.32)	0.34	0.81 (0.51-1.26)	0.34
General Health				
Excellent	Reference			
Very good	0.74 (0.51-1.06)	0.10	0.80 (0.58-1.09)	0.15
Good	***0.71 (0.51-0.97)***	***0.03***	0.77 (0.54-1.10)	0.15
Fair	0.83 (0.52-1.32)	0.41	0.95 (0.65-1.40)	0.80
Poor	0.77 (0.38-1.57)	0.46	1.02 (0.46-2.27)	0.97

*Statistically significant figures are in bold and italics.

Archer Lemeshow goodness of fit test for the overall model with the age and sex interaction term, p-value = 0.14

4.4 Discussion

This study highlights a large incongruence between self-reported and performance-based balance among community-dwelling adults, especially older adults. About 70% of the US population over the age of 40 years who had evidence of balance problems on RTSBFCSS reported not having any balance problems on the self-reported question. Assuming that the self-reported information serves as a proxy for individual's awareness/perception of their balance problem, about 7 in 10 individuals who had performance-based balance deficits were unaware of their deficits. These incongruencies may be explained using the hierarchical model of aging by Ferrucci et al., which proposed that individuals tend to maintain functioning in daily life for many years despite the presence of phenotypic changes.[99] The maintenance of daily life functions might be

impacting the self-reported balance information, while the performance-based test (RTSBFCSS) may be capturing the phenotypic changes.

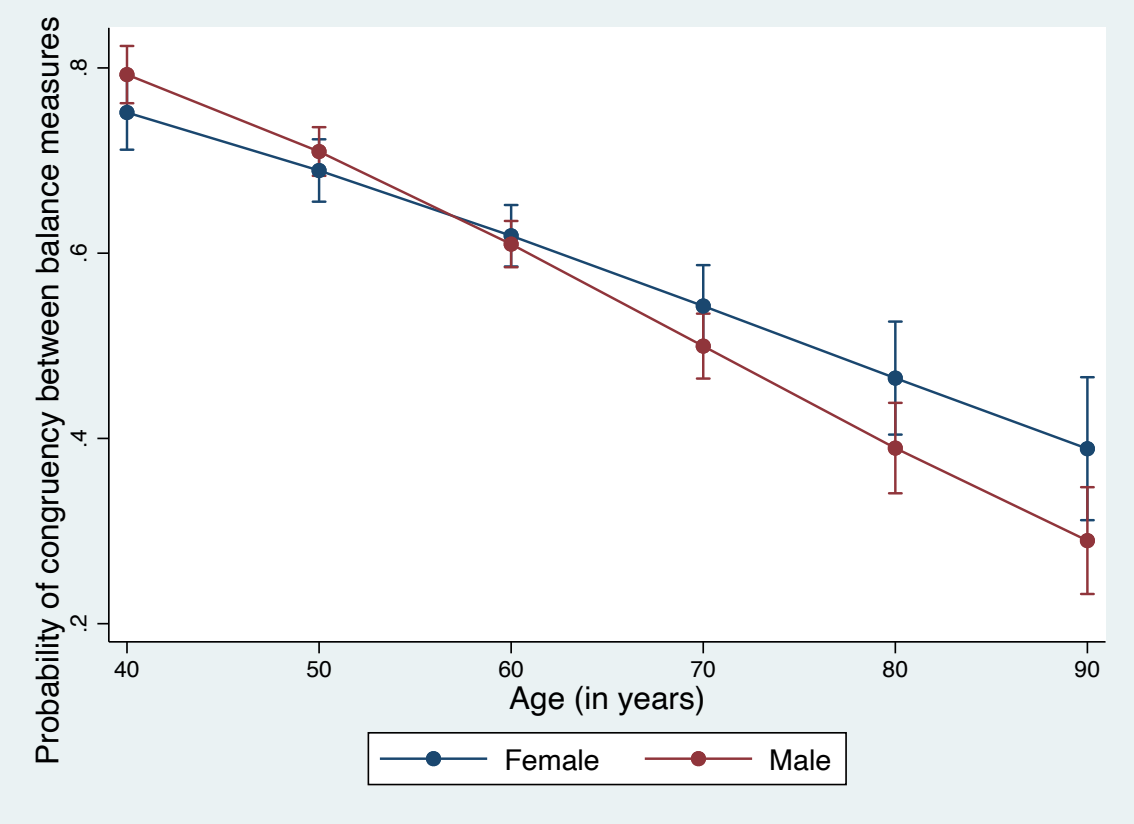

Figure 9: Marginsplot demonstrating the decreasing probability of congruency between the balance measures with advancing age and the effect of interaction between age and sex on the predicted probabilities of the outcome (n=4785). Error bars represent 95% confidence intervals.

Among females, being older and having good (vs excellent) overall health were associated with incongruency between the self-report and performance-based measures of balance problems. Among males, being older, non-Hispanic Black, having less than high school education, not having health insurance, and having seen a healthcare provider in

the past year were associated with a reduced odds of congruency between the two balance measures.

The importance and challenge of identifying individuals for fall prevention interventions have been previously discussed [16]. The results of this study suggest that relying solely on self-reported information when screening for balance problems should not be the preferred approach in clinics or for research purposes. The CDC recommended use of self-reported information as the basis of the standard approach for fall risk screening, currently used by healthcare providers across the US, might be inadequate [100,101] and can potentially leave out a large proportion of individuals who are unaware of their balance problems.

A recent study exploring the differences in self-reported information and functional performance measures within 4 domains (vision, hearing, mobility, and memory) reported discordance between the self-reported information and performance measures for all domains, including mobility [102]. A recent literature review reported that about two-thirds of hospitalized patients could not accurately identify their fall risk [103]. Previous studies have also reported that an individual's future fall risk is predicted by performance-based balance test irrespective of the patient's reported fear of falling [104] and physical activity level is more in accordance with their objective fall risk than their perceived risk[105].

The congruency between self-reported information and performance-based balance measure (RTSBFCSS) reduces with age, with a larger observed reduction seen in men compared to women. Previous studies with relatively smaller sample sizes have indicated higher chances of inaccurate perception of fall risk in older adults.[91,92]

However, to the authors' knowledge, this is the first study using nationally representative data from the US exploring the predictors of the congruency between self-reported information and performance-based balance measure (RTSBFCSS) in community-dwelling adults and demonstrating the age-sex interaction for the same. The presence of effect modification of age by sex implies that there might be a need to tailor the screening interventions to each sex for a more effective approach, especially if using self-reported information to screen for balance issues.

This study also reports that the variables having significant association with the accuracy of self-reported balance information differ by sex. In females, only general health status was found to be a statistically significant predictor of the congruency between balance measures. Whereas in males, race, education, health insurance, and being seen by a healthcare provider were statistically significant predictors of the congruency between balance measures. Previous literature also indicates that the perceptions of fall risk differ by sex. In a qualitative study, Pohl et al. showed that older men and women have distinct perceptions and strategies related to fall risk and safety[106]. Women have been reported to be more aware of their fall risk, more willing to report falls, use assistive devices and engage in fall prevention interventions, than men. [68,106] Men might underreport their fall risk due to societal expectations and attitudes towards masculinity.[103,106] An increased state of frailty and impaired physical functioning with age has been reported to be higher in women compared to men.[107] This might explain, in part, the association between overall health status and the congruency between balance measures in women, but not in men. More research is needed to determine the reasons

for basic demographic factors such as race predicting the congruency between balance measures in males, not females.

Though this study analyzed a nationally representative sample of 4939 community-dwelling individuals, several limitations warrant recognition. The analysis relied on NHANES data from 2001-2004, which is almost two decades old. Unfortunately, the later cycles of NHANES data currently available, lack the comparable variables of interest. Future studies, looking at specific predictors of the congruency between balance measures and using more recent data are warranted.

NHANES used RTSBFCSS test as the balance performance measure which has been reported to be a proven and standardized test for identifying balance problems[85], but limited data is available about the reliability and validity of this test per se. Additionally, this test is a measure of static balance and does not provide any information about the dynamic balance or the individual's ability to resist static loading or perturbations to balance. Reliance on self-reported information to determine self-awareness can introduce bias due to inaccuracies in the participant's recall, personal perceptions, or the tendency to provide socially desirable responses.

Given the exploratory nature of this study, multiple adjusted effect estimates have been reported so that the results can assist in the future hypothesis generation involving predictors of the accuracy of self-reported information for balance problems. However, this could impact the data reported in Table 2 (known as Table 2 fallacy) such that the odds ratios obtained for different covariates might be indicative of only the direct association of the covariate with the outcome and may not convey the total extent of the association. Unmeasured confounders such as psychological factors, cultural beliefs, or

stigma cannot be negated as well. The development of a population-based model for the continuum of care for balance problems in the US can assist healthcare agencies and public health organizations across the US in identifying the issues and gaps in the screening and management of balance problems.

4.5 Conclusion

The study reports that about 7 in 10 adults (aged 40 years or more) with evidence of performance-based balance deficits are unaware of their condition. This underscores the challenge of relying solely on self-reported information regarding balance issues. Older age was a significant predictor of reduced congruency between self-reported and performance-based balance measures, and the observed decline with age was larger in men than women. These findings can help identify populations at higher risk of providing incongruent self-reported information about balance issues and guide the efforts toward developing interventions for more effective screening and timely management of balance disorders.

CHAPTER FIVE

DISCUSSION

This dissertation presents several novel findings regarding healthcare utilization for balance problems by community-dwelling adults in the US. The first study, a literature review guided by the Andersen Healthcare Utilization model, reported the potential factors associated with healthcare utilization for balance problems. Possible predisposing factors for healthcare utilization related to balance issues included age, sex, race/ethnicity, BMI, and comorbidities. Socioeconomic status, health insurance coverage, and access to primary care services were the enabling or disabling factors. Additionally, the severity of balance problems, perceived illness, and its impact on daily activities influenced the need for care. Knowledge about these potential factors provided the information essential for extracting the relevant variables needed to conduct the next study.

The second study, a secondary analysis of the nationally representative data reports the factors associated with healthcare utilization for balance problems among community-dwelling adults, aged 40 years or more, with self-reported balance problems. Less than one-third of the US population with self-reported balance problems sought healthcare services for their balance issues. Age, health insurance coverage, seeing a healthcare provider in the past year, and falling were statistically significant predictors of healthcare utilization for balance problems. Of these factors, seeing a healthcare provider in the past year had the largest statistically significant influence on healthcare utilization, followed by the impact of health insurance coverage, age, and falls in the past year.

Although overall healthcare utilization has been reported to increase with age, [76] most of it is driven by the increased use of healthcare services for chronic problems and surgical interventions.[77] It has also been reported that older adults are less likely to seek preventive services, [77] which explains the decreasing healthcare utilization for balance problems with increasing age reported by this dissertation. Better access to primary care services has also been reported to improve the probability of participation in preventive interventions.[78] There is abundant literature supporting the increased use of both preventive and clinical services with health insurance coverage.[80-82] Multifactorial fall prevention interventions can reduce the risk of falls and related injuries.[83,84] Educating individuals, especially older adults, about these interventions can be beneficial, even for individuals who have not experienced any fall(s) yet. The knowledge about the predictors of healthcare utilization for balance problems can help identify the vulnerable populations at higher risk of underutilization of healthcare services and call for efforts to improve access to healthcare for better management of balance problems.

The third research study presented in this dissertation reported a lack of congruence between self-reported balance information and the results of performance-based balance testing. About 7 in every 10 individuals, aged 40 years or more, who had evidence of balance problems on the performance-based balance testing, reported having no balance problems on the self-reported question. This study also demonstrated an age-sex interaction for the congruency between self-reported and performance-based balance measures. The congruency between the balance measures reduced with age and a larger decline with age was observed in men compared to women. In women, older age and having good (as opposed to excellent) overall health had a statistically significant

association with discrepancies between self-reported and performance-based measures of balance problems. In men, older age, identifying as non-Hispanic Black, having less than a high school education, lacking health insurance, and having visited a healthcare provider in the past year were associated with lower odds of congruency between the two balance measures.

Given previous discussions in the literature on the importance and challenge of improving access to fall prevention interventions and management of balance problems,[16] the findings of this dissertation provide some novel and vital information. Relying solely on the self-reported information for screening of balance problems can potentially leave out about 70% of the population who demonstrate evidence of balance problems on performance-based testing but reported not having any balance issues. This finding is in agreement with previous literature which also discussed that the CDC-recommended use of only self-reported information as the first step of the fall risk screening algorithm can be inadequate.[100,101]

The sex-related variations in the predictors of the congruency between the balance measures reported by this dissertation can be explained partly by the differences in the perceptions of fall risk among men and women.[106] Better awareness of the fall risk, increased willingness to report falls, and enhanced engagement in the active management of balance problems have been reported in women compared to men.[68,106] Previous literature also reports that men tend to underreport their fall risk due to attitudes toward masculinity and differences in the expectations of society for men compared to women.[107] To summarize, the findings of the third study presented in this dissertation indicate that the sole reliance on self-reported information for balance screening can

potentially be inadequate. Results can also help identify populations more likely to have discrepancies between balance measures.

Although the studies presented in this dissertation use nationally representative data on thousands of community-dwelling participants, some limitations warrant attention. Studies used the data from 2001-2004 data cycles. Unfortunately, the later cycles of data available lacked the variables of our interest. Future research can use our findings to explore recent data, as it becomes available. Reliance on self-reported information can also introduce bias related to recall and individual perceptions. In future, creating a population-based model for the continuum of care for balance problems can help healthcare agencies and public health organizations identify challenges and gaps in the screening and management of these issues.

CHAPTER SIX

CONCLUSION AND FUTURE DIRECTIONS

The studies elaborated in this Ph.D. dissertation present new information regarding healthcare utilization for balance problems in community-dwelling adults, aged 40 years or more. About 7 in 10 adults with evidence of performance-based balance deficits are unaware of their condition. These findings can help identify the populations at risk of underutilizing healthcare services for balance problems. Results can also assist in identifying the populations at higher risk of providing incongruent self-reported information about balance issues. This information can be used to develop a population-based model for the continuum of care for balance problems in the US (Figure 10).

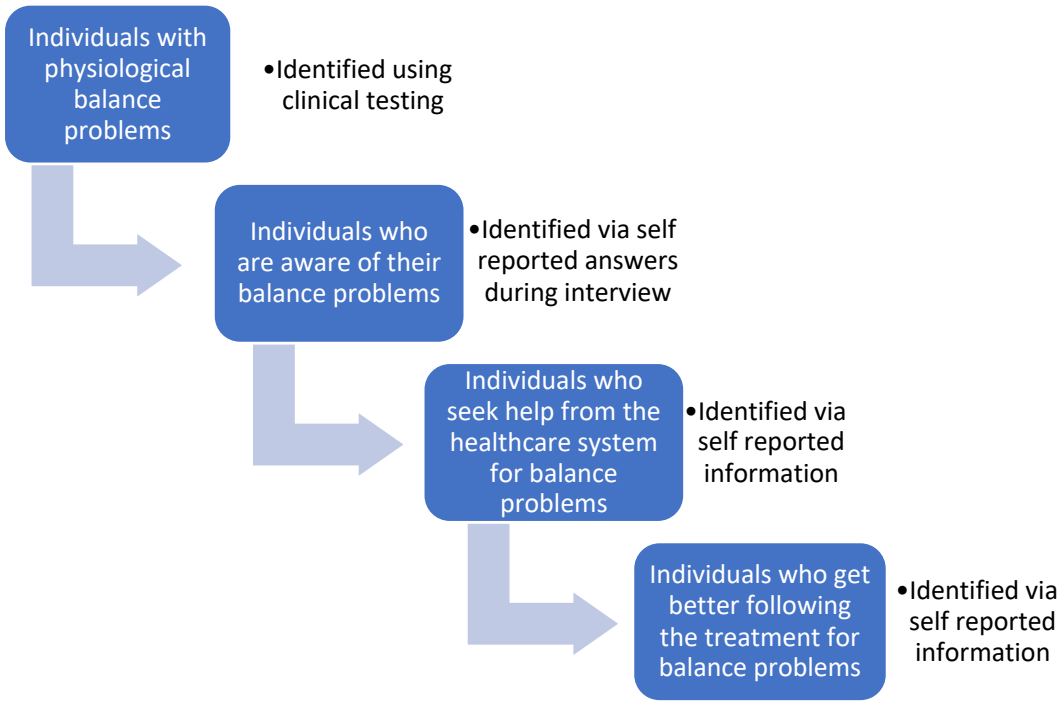

Figure 10: Outline for developing a population-based model for the continuum of care for balance problems in the United States

This population-based model will help identify the proportion of the population with balance problems at different stages. It begins with identifying individuals who have a physiological balance issue. The next stage focuses on determining the proportion of these individuals who are aware of their condition. It then examines the subset of individuals who seek help from the healthcare system. Finally, the model evaluates those who experience improvement as a result of utilizing healthcare services. Models such as the one described here have been successfully used for certain infectious diseases like HIV and Hepatitis C, but it has not been used for balance problems yet. This continuum of care model can assist healthcare agencies and public health organizations across the US to identify the issues and gaps in care and improve the management of balance problems. Ultimately, it can facilitate improvement in patient outcomes and reduce the burden of falls and fall-related injuries on the healthcare system.

To conclude, the research work presented in this dissertation advances our understanding of the factors associated with healthcare utilization for balance problems among the community dwelling adult population of the US. It also lays a foundation for future research and meaningful implementation of performance-based testing to improve the initial screening for balance problems. By helping with the identification of vulnerable populations, this work can also assist in improving the access to healthcare for timely management of balance problems.

APPENDICES

APPENDIX A

SUPPLEMENTAL MATERIAL

Table 7: Table detailing the criterion used for coding different covariates

Covariate	**Criterion**
Age	Age at the time of screening interview (in years)
Sex	Biological sex
Race	Using the combined information about race and ethnicity. All Hispanic particpants were grouped as Mexican American/ Hispanics. Non- Hispanic participants were categorized, based on self-reported race as Non- Hispanic Black, Non- Hispanic White and Others (which included non- Hispanics Multiracials)
Number of comorbidities	Comorbidities included: Arthritis, Congestive Heart failure, Coronary Artery disease, Stroke, Cancer, Diabetes Mellitus
Presence of mental health issues	Proxy used: Seen mental health provider in the past year

Table-7 continued	
Covariate	**Criterion**
Health insurance	Whether covered by health insurance or some other kind of health care plan, including health insurance obtained through employment or purchased directly as well as government programs like Medicare and Medicaid
Seeing healthcare provider in the past year	Seeing a doctor or other health care professional about one's health at a doctor's office, a clinic, hospital emergency room, at home or some other place
General Health Status	Self-reported answer to the question: How would say you general health is?
Physical Activity	Average level of physical activity during the daily activities of a typical day (including work, housework, going to and attending classes etc.)
Type of work	Self-reported information about current job/business, specifically type of work done in the week preceding the interview

Table-7 continued	
Covariate	**Criterion**
Annual Family income	U.S. Bureau of the Census Current Population Survey definition of "family" was used to group household members into one or more families. Family was defined as: "a group of two people or more (one of whom is the householder) related by birth, marriage, or adoption and residing together"
Education	Highest grade or level of school completed or the highest degree
Marital status	Based on information obtained during NHANES household interview

SUPPLEMENTAL METHODS

RTSBFCSS Procedure Details

The four RTSBFCSS conditions included standing with feet together with eyes open on firm surface (condition 1), eyes closed on firm surface (condition 2), eyes open on foam surface (condition 3) and eyes closed on foam surface (condition 4). The test duration was 15 seconds each for conditions 1 and 2, and 30 seconds each for conditions 3 and 4. The test was terminated early if the individual failed a condition. The failure was defined as movement of the participant's feet or arms from the test starting position,

opening of eyes during conditions 2 and 4, or any intervention needed from the examining staff to stop the participant from falling. It was noted for each test condition whether the participant passed the test or not. Each participant was offered one additional trial if they did not pass the first trial.

APPENDIX B

COPYRIGHT LETTERS FOR PERMISSION TO REPRODUCE

OAKLAND UNIVERSITY
Powered by Google

Shweta Kapur <skapur2@oakland.edu>

Re: MDPI Contact Form: Permission to use my published article in my PhD dissertation

healthcare <healthcare@mdpi.com> Mon, Jun 17, 2024 at 9:33 PM
To: Shweta Kapur <skapur2@oakland.edu>

Dear Mr./Ms. Kapur,

Thank you very much for your inquiry.

For all articles published in MDPI journals, copyright is retained by the authors. Articles are licensed under an open access Creative Commons CC BY 4.0 license, meaning that anyone may download and read the paper for free. In addition, the article may be reused and quoted provided that the original published version is cited. These conditions allow for maximum use and exposure of the work, while ensuring that the authors receive proper credit.

No special permission is required to reuse all or part of article published by MDPI, including figures and tables. For articles published under an open access Creative Common CC BY license, any part of the article may be reused without permission provided that the original article is clearly cited. Reuse of an article does not imply endorsement by the authors or MDPI.

Please do not hesitate to let us know if you have any further questions.

Kind regards,
Healthcare Editorial Office

News: Healthcare has received its new IF: 2.8

More information please see: https://www.mdpi.com/journal/healthcare/

Please follow us on Twitter for more information: https://twitter.com/HealthcareMDPI_

Topic Advisory Panel is open for application in Healthcare. Welcome to join us: https://www.mdpi.com/journal/healthcare/topical_advisory_panel_application

Welcome to read Editor's Choice Articles: https://www.mdpi.com/journal/healthcare/editors_choice

Special Issue Mentor Program: https://www.mdpi.com/journal/healthcare/announcements/5128

We are currently looking for qualified individuals to apply for Editorial Board Member: https://www.mdpi.com/journal/healthcare/editors

Healthcare Top 20 Cited Papers in 2022, please see: https://www.mdpi.com/journal/healthcare/announcements/6778

MDPI Branch Office, Beijing
Poly Metropolitan
Floor 9-11, Building 2, Courtyard 4, Guanyinan North Street, Tongzhou District, 101101 Beijing, China
Tel.: +86 10 6954 3724
--
MDPI
Healthcare Editorial Office
St. Alban-Anlage 66, 4052 Basel, Switzerland
E-Mail: healthcare@mdpi.com
http://www.mdpi.com/journal/healthcare/

Per Healthcare Journal website

“Articles published in Healthcare will be Open-Access articles distributed under the terms and conditions of the Creative Commons Attribution License (CC BY). The copyright is retained by the author(s). MDPI will insert the following note at the end of the published text:

REFERENCES

1. Shumway-Cook A WM. *Motor Control: Theory and Practical Applications.* Lippincott, Williams & Wilkins; 2001.

2. Vestibular Disorders Association MAW, and F. Owen Black, and Matthew Crowson,. The human balance system. VeDA. Accessed Oct 27, 2022, https://vestibular.org/article/what-is-vestibular/the-human-balance-system/the-human-balance-system-how-do-we-maintain-our-balance/

3. Agrawal Y CJ, Della Santina CC, Schubert MC, Minor LB. Disorders of Balance and Vestibular Function in US Adults : Data From the National Health and Nutrition Examination Survey, 2001-2004 . . doi:doi:10.1001/archinternmed.2009.66

4. Lin HW, Bhattacharyya N. Balance disorders in the elderly: epidemiology and functional impact. *Laryngoscope*. Aug 2012;122(8):1858-61. doi:10.1002/lary.23376

5. Hoffman G, Franco N, Perloff J, Lynn J, Okoye S, Min L. Incidence of and County Variation in Fall Injuries in US Residents Aged 65 Years or Older, 2016-2019. *JAMA Netw Open*. 02 01 2022;5(2):e2148007. doi:10.1001/jamanetworkopen.2021.48007

6. Bergen G, Stevens MR, Burns ER. Falls and Fall Injuries Among Adults Aged ≥65 Years - United States, 2014. *MMWR Morb Mortal Wkly Rep*. Sep 23 2016;65(37):993-998. doi:10.15585/mmwr.mm6537a2

7. Kakara R BG, Burns E, Stevens M. . Nonfatal and Fatal Falls Among Adults Aged ≥65 Years — United States, 2020–2021. *MMWR Morb Mortal Wkly Rep*. 2023;(72):938–943. doi:http://dx.doi.org/10.15585/mmwr.mm7235a1

8. Organization WH. Falls. WHO. Accessed Oct 20, 2022. https://www.who.int/news-room/fact-sheets/detail/falls

9. National Center for Injury Prevention and Control C. 10 Leading Causes of Nonfatal Unintentional Emergency Department Visits, United States. **CDC**. Accessed Oct 27, 2022, https://wisqars.cdc.gov/cgi-bin/broker.exe

10. Florence CS, Bergen G, Atherly A, Burns E, Stevens J, Drake C. Medical Costs of Fatal and Nonfatal Falls in Older Adults. *J Am Geriatr Soc*. Apr 2018;66(4):693-698. doi:10.1111/jgs.15304

11. Houry D, Florence C, Baldwin G, Stevens J, McClure R. The CDC Injury Center's response to the growing public health problem of falls among older adults. *Am J Lifestyle Med*. 2016;10(1):74-7. doi:10.1177/1559827615600137

12. NHANES. NHANES 2003-2004 Overview. CDC; 2004.

13. NHANES. NHANES 2001-2002 Overview. Center for Disease Control and Prevention. Accessed Sep 20, 2023, https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/overview.aspx?BeginYear=2001

14. Grossman DC, Curry SJ, Owens DK, et al. Interventions to Prevent Falls in Community-Dwelling Older Adults: US Preventive Services Task Force Recommendation Statement. *JAMA*. Apr 24 2018;319(16):1696-1704. doi:10.1001/jama.2018.3097

15. Guirguis-Blake JM, Michael YL, Perdue LA, Coppola EL, Beil TL. Interventions to Prevent Falls in Older Adults: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA*. Apr 24 2018;319(16):1705-1716. doi:10.1001/jama.2017.21962

16. Guirguis-Blake JM, Perdue LA, Coppola EL, Bean SI. Interventions to Prevent Falls in Older Adults: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA*. Jul 02 2024;332(1):58-69. doi:10.1001/jama.2024.4166

17. Reuben DB, Gazarian P, Alexander N, et al. The Strategies to Reduce Injuries and Develop Confidence in Elders Intervention: Falls Risk Factor Assessment and Management, Patient Engagement, and Nurse Co-management. *J Am Geriatr Soc*. Dec 2017;65(12):2733-2739. doi:10.1111/jgs.15121

18. Kapur S, Sakyi KS, Lohia P, Goble DJ. Potential Factors Associated with Healthcare Utilization for Balance Problems in Community-Dwelling Adults within the United States: A Narrative Review. *Healthcare (Basel)*. Aug 26 2023;11(17)doi:10.3390/healthcare11172398

19. NHANES. National Health and Nutrition Examination Survey. Center for Disease Control, USA. Accessed Nov 29, 2022. https://wwwn.cdc.gov/Nchs/Nhanes/limited_access/BAQ_K_R.htm

20. Aggarwal NT, Bennett DA, Bienias JL, Mendes de Leon CF, Morris MC, Evans DA. The prevalence of dizziness and its association with functional disability in a biracial community population. *J Gerontol A Biol Sci Med Sci*. May 2000;55(5):M288-92. doi:10.1093/gerona/55.5.m288

21. Penger M, Strobl R, Grill E. Country-specific and individual determinants of dizziness in Europe: results from the Survey of Health Ageing and Retirement in Europe (SHARE). *Public Health*. Aug 2017;149:1-10. doi:10.1016/j.puhe.2017.04.002

22. Burns ER, Stevens JA, Lee R. The direct costs of fatal and non-fatal falls among older adults - United States. *J Safety Res*. 09 2016;58:99-103. doi:10.1016/j.jsr.2016.05.001

23. US. Healthy People 2030. Office of Disease Prevention and Health Promotion, US Department of Health and Human services. Accessed October 20, 2022. https://health.gov/healthypeople/objectives-and-data/browse-objectives/sensory-or-communication-disorders/increase-proportion-adults-dizziness-or-balance-problems-who-have-been-referred-specialist-hoscd-11/data

24. Choi NG, Choi BY, DiNitto DM, Marti CN, Kunik ME. Fall-related emergency department visits and hospitalizations among community-dwelling older adults: examination of health problems and injury characteristics. *BMC Geriatr*. Nov 11 2019;19(1):303. doi:10.1186/s12877-019-1329-2

25. Phillips KA, Morrison KR, Andersen R, Aday LA. Understanding the context of healthcare utilization: assessing environmental and provider-related variables in the behavioral model of utilization. *Health Serv Res*. Aug 1998;33(3 Pt 1):571-96.

26. Andersen RM. Revisiting the behavioral model and access to medical care: does it matter? *J Health Soc Behav*. Mar 1995;36(1):1-10.

27. Andersen R, Newman JF. Societal and individual determinants of medical care utilization in the United States. *Milbank Mem Fund Q Health Soc*. 1973;51(1):95-124.

28. Peel NM, Kassulke DJ, McClure RJ. Population based study of hospitalised fall related injuries in older people. *Inj Prev*. Dec 2002;8(4):280-3. doi:10.1136/ip.8.4.280

29. Jacobs MM, Ellis C. Heterogeneity among women with stroke: health, demographic and healthcare utilization differentials. *BMC Womens Health*. 04 17 2021;21(1):160. doi:10.1186/s12905-021-01305-5

30. van den Bussche H, Kaduszkiewicz H, Schäfer I, et al. Overutilization of ambulatory medical care in the elderly German population?--An empirical study based on national insurance claims data and a review of foreign studies. *BMC Health Serv Res*. Apr 14 2016;16:129. doi:10.1186/s12913-016-1357-y

31. Daly RM, Rosengren BE, Alwis G, Ahlborg HG, Sernbo I, Karlsson MK. Gender specific age-related changes in bone density, muscle strength and functional performance in the elderly: a-10 year prospective population-based study. *BMC Geriatr*. Jul 06 2013;13:71. doi:10.1186/1471-2318-13-71

32. Williams JS, Bishu K, Dismuke CE, Egede LE. Sex differences in healthcare expenditures among adults with diabetes: evidence from the medical expenditure panel survey, 2002-2011. *BMC Health Serv Res*. 04 11 2017;17(1):259. doi:10.1186/s12913-017-2178-3

33. Dark T, Rust G, Sehres G, Harman JS. Racial Disparities in Healthcare Utilization Among Individuals with Cardiometabolic Risk Factors and Comorbid Anxiety Disorder. *J Racial Ethn Health Disparities*. 12 2020;7(6):1234-1240. doi:10.1007/s40615-020-00748-0

34. Saadi A, Himmelstein DU, Woolhandler S, Mejia NI. Racial disparities in neurologic health care access and utilization in the United States. *Neurology*. Jun 13 2017;88(24):2268-2275. doi:10.1212/WNL.0000000000004025

35. Jarman MP, Sokas C, Dalton MK, et al. The impact of delayed management of fall-related hip fracture management on health outcomes for African American older adults. *J Trauma Acute Care Surg*. Jun 01 2021;90(6):942-950. doi:10.1097/TA.0000000000003149

36. Edwards CH, Aas E, Kinge JM. Body mass index and lifetime healthcare utilization. *BMC Health Serv Res*. Oct 15 2019;19(1):696. doi:10.1186/s12913-019-4577-0

37. Finkelstein EA, Chen H, Prabhu M, Trogdon JG, Corso PS. The relationship between obesity and injuries among U.S. adults. *Am J Health Promot*. 2007;21(5):460-8. doi:10.4278/0890-1171-21.5.460

38. Yang Y, Hu X, Zhang Q, Zou R. Diabetes mellitus and risk of falls in older adults: a systematic review and meta-analysis. *Age Ageing*. 11 2016;45(6):761-767. doi:10.1093/ageing/afw140

39. Trevisan C, Crippa A, Ek S, et al. Nutritional Status, Body Mass Index, and the Risk of Falls in Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis. *J Am Med Dir Assoc*. May 2019;20(5):569-582.e7. doi:10.1016/j.jamda.2018.10.027

40. van den Bussche H, Schön G, Kolonko T, et al. Patterns of ambulatory medical care utilization in elderly patients with special reference to chronic diseases and multimorbidity--results from a claims data based observational study in Germany. *BMC Geriatr*. Sep 13 2011;11:54. doi:10.1186/1471-2318-11-54

41. Nilsagård Y, Gunn H, Freeman J, et al. Falls in people with MS--an individual data meta-analysis from studies from Australia, Sweden, United Kingdom and the United States. *Mult Scler*. Jan 2015;21(1):92-100. doi:10.1177/1352458514538884

42. Cameron MH, Nilsagard Y. Balance, gait, and falls in multiple sclerosis. *Handb Clin Neurol*. 2018;159:237-250. doi:10.1016/B978-0-444-63916-5.00015-X

43. Homann CN, Homann B, Ivanic G, Urbanic-Purkart T. Accidental Falls in Patients with Hyperkinetic Movement Disorders: A Systematic Review. *Tremor Other Hyperkinet Mov (N Y)*. 2022;12:30. doi:10.5334/tohm.709

44. Bloem BR, Grimbergen YA, Cramer M, Willemsen M, Zwinderman AH. Prospective assessment of falls in Parkinson's disease. *J Neurol*. Nov 2001;248(11):950-8. doi:10.1007/s004150170047

45. Rudzińska M, Bukowczan S, Stożek J, et al. The incidence and risk factors of falls in Parkinson disease: prospective study. *Neurol Neurochir Pol*. 2013 Sep-Oct 2013;47(5):431-7. doi:10.5114/ninp.2013.38223

46. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology*. Sep 2010;21(5):658-68. doi:10.1097/EDE.0b013e3181e89905

47. Shalev V, Chodick G, Heymann AD, Kokia E. Gender differences in healthcare utilization and medical indicators among patients with diabetes. *Public Health*. Jan 2005;119(1):45-9. doi:10.1016/j.puhe.2004.03.004

48. Minejima E, Wong-Beringer A. Impact of Socioeconomic Status and Race on Sepsis Epidemiology and Outcomes. *J Appl Lab Med*. Jan 12 2021;6(1):194-209. doi:10.1093/jalm/jfaa151

49. Frølich A, Ghith N, Schiøtz M, Jacobsen R, Stockmarr A. Multimorbidity, healthcare utilization and socioeconomic status: A register-based study in Denmark. *PLoS One*. 2019;14(8):e0214183. doi:10.1371/journal.pone.0214183

50. Grits D, Emara AK, Klika AK, Murray TG, McLaughlin JP, Piuzzi NS. Neighborhood Socioeconomic Disadvantage Associated With Increased Healthcare Utilization After Total Hip Arthroplasty. *J Arthroplasty*. Oct 2022;37(10):1980-1986.e2. doi:10.1016/j.arth.2022.04.041

51. Singh JA, Cleveland JD. Socioeconomic status and healthcare access are associated with healthcare utilization after knee arthroplasty: A U.S. national cohort study. *Joint Bone Spine*. Mar 2020;87(2):157-162. doi:10.1016/j.jbspin.2019.11.007

52. Freeman JD, Kadiyala S, Bell JF, Martin DP. The causal effect of health insurance on utilization and outcomes in adults: a systematic review of US studies. *Med Care*. Oct 2008;46(10):1023-32. doi:10.1097/MLR.0b013e318185c913

53. Cooper JN, Koppera S, Boss EF, Lind MN. Differences in Tonsillectomy Utilization by Race/Ethnicity, Type of Health Insurance, and Rurality. *Acad Pediatr*. Aug 2021;21(6):1031-1036. doi:10.1016/j.acap.2020.11.007

54. Dieleman JL, Cao J, Chapin A, et al. US Health Care Spending by Payer and Health Condition, 1996-2016. *JAMA*. Mar 03 2020;323(9):863-884. doi:10.1001/jama.2020.0734

55. Corscadden L, Levesque JF, Lewis V, Strumpf E, Breton M, Russell G. Factors associated with multiple barriers to access to primary care: an international analysis. *Int J Equity Health*. Feb 20 2018;17(1):28. doi:10.1186/s12939-018-0740-1

56. Glass DP, Kanter MH, Jacobsen SJ, Minardi PM. The impact of improving access to primary care. *J Eval Clin Pract*. Dec 2017;23(6):1451-1458. doi:10.1111/jep.12821

57. Goodwin AJ, Nadig NR, McElligott JT, Simpson KN, Ford DW. Where You Live Matters: The Impact of Place of Residence on Severe Sepsis Incidence and Mortality. *Chest*. Oct 2016;150(4):829-836. doi:10.1016/j.chest.2016.07.004

58. Murimi-Worstell IB, Lin DH, Kan H, et al. Healthcare Utilization and Costs of Systemic Lupus Erythematosus by Disease Severity in the United States. *J Rheumatol*. Mar 2021;48(3):385-393. doi:10.3899/jrheum.191187

59. Kobelt G, Thompson A, Berg J, et al. New insights into the burden and costs of multiple sclerosis in Europe. *Mult Scler*. Jul 2017;23(8):1123-1136. doi:10.1177/1352458517694432

60. Na L, Hennessy S, Bogner HR, et al. Disability stage and receipt of recommended care among elderly medicare beneficiaries. *Disabil Health J*. Jan 2017;10(1):48-57. doi:10.1016/j.dhjo.2016.09.007

61. Min LC, Reuben DB, Keeler E, et al. Is patient-perceived severity of a geriatric condition related to better quality of care? *Med Care*. Jan 2011;49(1):101-7. doi:10.1097/MLR.0b013e3181f53523

62. Scuccato R. [Falls in the elderly.]. *Recenti Prog Med*. 2018;109(7):401-404. doi:10.1701/2955.29711

63. Taburee W, Sirilak S, Khotcharrat R, et al. Health-Related Problems and Drivers of Health-Related Quality of Life Among Community-Dwelling Older Adults. *J Prim Care Community Health*. 2020;11:2150132720913724. doi:10.1177/2150132720913724

64. Boyé ND, Mattace-Raso FU, Van Lieshout EM, Hartholt KA, Van Beeck EF, Van der Cammen TJ. Physical performance and quality of life in single and recurrent fallers: data from the Improving Medication Prescribing to Reduce Risk of Falls study. *Geriatr Gerontol Int*. Mar 2015;15(3):350-5. doi:10.1111/ggi.12287

65. Grossman DC, Curry SJ, Owens DK, et al. Interventions to Prevent Falls in Community-Dwelling Older Adults: US Preventive Services Task Force Recommendation Statement. *JAMA*. Apr 24 2018;319(16):1696-1704. doi:10.1001/jama.2018.3097

66. Slater LV, Vriner M, Schuyten K, Zapalo P, Hart JM. Sex Differences in Y-Balance Performance in Elite Figure Skaters. *J Strength Cond Res*. May 2020;34(5):1416-1421. doi:10.1519/JSC.0000000000002542

67. Khobkhun F, Thanakamchokchai J. Biological sex-related differences in whole-body coordination during standing turns in healthy young adults. *Sci Rep*. Dec 13 2023;13(1):22112. doi:10.1038/s41598-023-49201-2

68. Stevens JA, Ballesteros MF, Mack KA, Rudd RA, DeCaro E, Adler G. Gender differences in seeking care for falls in the aged Medicare population. *Am J Prev Med*. Jul 2012;43(1):59-62. doi:10.1016/j.amepre.2012.03.008

69. Arsenault-Lapierre G, Bui T, Godard-Sebillotte C, et al. Sex Differences in Healthcare Utilization in Persons Living with Dementia Between 2000 and 2017: A Population-Based Study in Quebec, Canada. *J Aging Health*. Mar 30 2024:8982643241242512. doi:10.1177/08982643241242512

70. Sikka N, DeLong A, Kamano J, et al. Sex differences in health status, healthcare utilization, and costs among individuals with elevated blood pressure: the LARK study

from Western Kenya. *BMC Public Health*. May 19 2021;21(1):948. doi:10.1186/s12889-021-10995-3

71. NHANES. NHANES 2001-2002 Overview. Center for Disease Control and Prevention. Accessed Sep 20, 2023, https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/overview.aspx?BeginYear=2001

72. NHANES. NHANES 2003-2004 Overview. CDC.

73. CDC. NHANES: weighting. National Center for Health Statistics.

74. Hidalgo B, Goodman M. Multivariate or multivariable regression? *Am J Public Health*. Jan 2013;103(1):39-40. doi:10.2105/AJPH.2012.300897

75. Gelman A. Scaling regression inputs by dividing by two standard deviations. *Stat Med*. Jul 10 2008;27(15):2865-73. doi:10.1002/sim.3107

76. Foley KT, Luz CC. Retooling the Health Care Workforce for an Aging America: A Current Perspective. *The Gerontologist*. 2020;61(4):487-496. doi:10.1093/geront/gnaa163

77. Americans IoMUCotFHCWfO. *Retooling for an Aging America: Building the Health Care Workforce*. 2008.

78. Hostetter J, Schwarz N, Klug M, Wynne J, Basson MD. Primary care visits increase utilization of evidence-based preventative health measures. *BMC Fam Pract*. Jul 28 2020;21(1):151. doi:10.1186/s12875-020-01216-8

79. CDC. Preventing Falls in Older Patients. National Center for Injury Prevention and Control. Accessed Sep 11, 2024, 2024. https://www.cdc.gov/steadi/media/pdfs/steadi-pocketguide-508.pdf

80. Magge H, Cabral HJ, Kazis LE, Sommers BD. Prevalence and predictors of underinsurance among low-income adults. *J Gen Intern Med*. Sep 2013;28(9):1136-42. doi:10.1007/s11606-013-2354-z

81. Fox JB, Shaw FE, Office of Health System Collaboration OotADfPCDC. Relationship of income and health care coverage to receipt of recommended clinical preventive services by adults - United States, 2011-2012. *MMWR Morb Mortal Wkly Rep*. Aug 8 2014;63(31):666-70.

82. Okoro CA, Zhao G, Fox JB, Eke PI, Greenlund KJ, Town M. Surveillance for Health Care Access and Health Services Use, Adults Aged 18-64 Years - Behavioral Risk Factor Surveillance System, United States, 2014. *MMWR Surveill Summ*. Feb 24 2017;66(7):1-42. doi:10.15585/mmwr.ss6607a1

83. Arena SK, Wilson CM, Boright L, Peterson E. Impact of the HOP-UP-PT program on older adults at risk to fall: a randomized controlled trial. *BMC Geriatr*. Oct 1 2021;21(1):520. doi:10.1186/s12877-021-02450-0

84. Ytterstad B. The Harstad injury prevention study: community based prevention of fall-fractures in the elderly evaluated by means of a hospital based injury recording system in Norway. *J Epidemiol Community Health*. Oct 1996;50(5):551-8. doi:10.1136/jech.50.5.551

85. NHANES. Balance procedure manual. US CDC. 2022. https://wwwn.cdc.gov/nchs/data/nhanes/1999-2000/manuals/ba.pdf

86. Mitchell MB, Bhattacharyya N. Balance Disorder Trends in US Adults 2008-2016: Epidemiology and Functional Impact. *OTO Open*. 2023;7(2):e58. doi:10.1002/oto2.58

87. Agrawal Y CJ, Della Santina CC, Schubert MC, Minor LB. Disorders of Balance and Vestibular Function in US Adults : Data From the National Health and Nutrition Examination Survey, 2001-2004 . . 2009;doi:doi:10.1001/archinternmed.2009.66

88. CDC. NHANES Balance procedure manuals. May 2001. Accessed Sep 21, 2023. https://wwwn.cdc.gov/nchs/data/nhanes/1999-2000/manuals/ba.pdf

89. Horn LB, Rice T, Stoskus JL, Lambert KH, Dannenbaum E, Scherer MR. Measurement Characteristics and Clinical Utility of the Clinical Test of Sensory Interaction on Balance (CTSIB) and Modified CTSIB in Individuals With Vestibular Dysfunction. *Arch Phys Med Rehabil*. Sep 2015;96(9):1747-8. doi:10.1016/j.apmr.2015.04.003

90. Whitney SL, Poole JL, Cass SP. A review of balance instruments for older adults. *Am J Occup Ther*. Sep 1998;52(8):666-71. doi:10.5014/ajot.52.8.666

91. Delbaere K, Close JC, Brodaty H, Sachdev P, Lord SR. Determinants of disparities between perceived and physiological risk of falling among elderly people: cohort study. *BMJ*. Aug 18 2010;341:c4165. doi:10.1136/bmj.

92. Thiamwong L, Huang HJ, Ng BP, et al. Shifting Maladaptive Fall Risk Appraisal in Older Adults through an in-Home Physio-fEedback and Exercise pRogram (PEER): A Pilot Study. *Clin Gerontol*. 2020;43(4):378-390. doi:10.1080/07317115.2019.1692120

93. Velayutham SG, Chandra SR, Bharath S, Shankar RG. Quantitative Balance and Gait Measurement in Patients with Frontotemporal Dementia and Alzheimer Diseases: A Pilot Study. *Indian J Psychol Med*. 2017;39(2):176-182. doi:10.4103/0253-7176.203132

94. Cattaneo D, Gervasoni E, Anastasi D, et al. Prevalence and patterns of subclinical motor and cognitive impairments in non-disabled individuals with early multiple

sclerosis: A multicenter cross-sectional study. *Ann Phys Rehabil Med*. Jan 2022;65(1):101491. doi:10.1016/j.rehab.2021.101491

95. Erez O, Gordon CR, Sever J, Sadeh A, Mintz M. Balance dysfunction in childhood anxiety: findings and theoretical approach. *J Anxiety Disord*. 2004;18(3):341-56. doi:10.1016/S0887-6185(02)00291-8

96. Hale EA, Hickman R, Dowd H, Varathan D, Liu G, Louis ED. Subtle Cerebellar Features in Relatives of Essential Tremor Cases. *Front Neurol*. 2020;11:605. doi:10.3389/fneur.2020.00605

97. Kakara R, Bergen G, Burns E. Understanding the Association of Older Adult Fall Risk Factors by Age and Sex Through Factor Analysis. *J Appl Gerontol*. Jul 2023;42(7):1662-1671. doi:10.1177/07334648231154881

98. Archer KJ, Lemeshow S. Goodness-of-fit Test for a Logistic Regression Model Fitted using Survey Sample Data. *The Stata Journal*. 2006;6(1):97-105. doi:10.1177/1536867x0600600106

99. Ferrucci L, Levine ME, Kuo PL, Simonsick EM. Time and the Metrics of Aging. *Circ Res*. Sep 14 2018;123(7):740-744. doi:10.1161/CIRCRESAHA.118.312816

100. Nithman RW, Vincenzo JL. How steady is the STEADI? Inferential analysis of the CDC fall risk toolkit. *Arch Gerontol Geriatr*. 2019;83:185-194. doi:10.1016/j.archger.2019.02.018

101. Song W, Latham NK, Liu L, et al. Improved accuracy and efficiency of primary care fall risk screening of older adults using a machine learning approach. *J Am Geriatr Soc*. Apr 2024;72(4):1145-1154. doi:10.1111/jgs.18776

102. Twardzik E, Schrack JA, Freedman VA, Reed NS, Ehrlich JR, Martinez-Amezcua P. An Incomplete Model of Disability: Discrepancies Between Performance-Based and Self-Reported Measures of Functioning. *J Gerontol A Biol Sci Med Sci*. Apr 1 2024;79(4)doi:10.1093/gerona/glad271

103. Dabkowski E, Cooper S, Duncan JR, Missen K. Adult Inpatients' Perceptions of Their Fall Risk: A Scoping Review. *Healthcare (Basel)*. May 27 2022;10(6)doi:10.3390/healthcare10060995

104. Garbin AJ, Fisher BE. The Interplay Between Fear of Falling, Balance Performance, and Future Falls: Data From the National Health and Aging Trends Study. *J Geriatr Phys Ther*. 2023 Apr-Jun 01 2023;46(2):110-115. doi:10.1519/JPT.0000000000000324

105. Jansen CP, Klenk J, Nerz C, et al. Association between everyday walking activity, objective and perceived risk of falling in older adults. *Age Ageing*. Sep 11 2021;50(5):1586-1592. doi:10.1093/ageing/afab037

106. Pohl P, Sandlund M, Ahlgren C, Bergvall-Kåreborn B, Lundin-Olsson L, Melander Wikman A. Fall risk awareness and safety precautions taken by older community-dwelling women and men--a qualitative study using focus group discussions. *PLoS One*. 2015;10(3):e0119630. doi:10.1371/journal.pone.0119630

107. Ye L, Elstgeest LEM, Zhang X, Alhambra-Borrás T, Tan SS, Raat H. Factors associated with physical, psychological and social frailty among community-dwelling older persons in Europe: a cross-sectional study of Urban Health Centres Europe (UHCE). *BMC Geriatr*. Jul 12 2021;21(1):422. doi:10.1186/s12877-021-02364-x