Falls and the Social Isolation of Older Adults in the National Health and Aging Trends Study

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Abstract

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Background: Outcomes of social isolation and falls among community-dwelling older adults can be life threatening. While an association between these two gerontological conditions is evident, the nature of that relationship is not well documented. Knowledge is needed regarding how social isolation and falling are associated.

Objectives: To report the prevalence of social isolation and the incidence of falls, and to examine the extent to which social isolation at one point in time predicts falls a year later.

Methods: This was a cross-sectional, as well as longitudinal secondary analysis of four rounds of data from the National Health and Aging Trends Study (NHATS) including a nationally representative sample of Medicare beneficiaries (round one n = 7,609). In-person interviews with annual re-interviews were conducted in participant residences. Social isolation was operationalized with a domain-inclusive construct based upon the Social Network Index and developed for this study. Falling during the previous year was self-reported.

Results: Social isolation prevalence ranged from 19.8 - 21.9%. The incidence of falls ranged from 22.4 - 26.2% across the four rounds. The predicted probability of falling increased with each increase in social isolation construct score. Even after adjusting for age, gender, and education, social isolation significantly predicted falling (*OR* = 1.08; *CI* = 1.02–1.14). Adding self-reported general health, depression, and worry about falling to the model weakened the relationship between social isolation and falls (*OR* = 1.02; *CI* = 0.96–1.08). Adding the Short Physical Performance Battery, assistive mobility device use, and activities of daily living to the model weakened the relationship further (*OR* = 0.99; *CI* = 0.94 –1.04).

Conclusions: Social isolation predicted falls in the future. This was potentially explained by the strong relationship between social isolation and physical performance. Interventions targeting both variables could have a strong impact on physical performance and future falls. In addition, "fall-prevention" interventions that specifically target social isolation could incorporate physical performance as a shorter-term and cost effective proxy outcome for falls.

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CHAPTER I: INTRODUCTION, PURPOSE & STUDY AIMS

This study is organized as three manuscripts. The first addresses the significance of social isolation and falls among older adults and offers a conceptual framework for the investigation manuscripts to follow. Manuscripts II & III address the study aims and each research paper is complete with literature review and references. National Health and Aging Trends Study data were analyzed.

There is evidence from research suggesting an association between social isolation and falls in older adults, however a clearer understanding of the association between these two constructs may lead to the development of nursing interventions and a broader implementation of relevant best practices. The purpose of this study was to explore the association between social isolation and falls over time in an older adult population. To achieve this purpose, social isolation was operationalized by a well-conceptualized, comprehensive, and domain-inclusive construct, and its exploration will address the following aims:

Study AIMS:

1. Evaluate the validity of the constructed measure of social isolation in terms of its relationship with depression in a national sample of Medicare enrollees over the age of 65.
2. Determine the prevalence of social isolation and falls at baseline and their incidence over four years in this sample.
3. Examine the extent to which social isolation predicts falls over time in this sample.

CHAPTER II: Manuscript #1

A CONCEPTUAL APPROACH TO UNDERSTANDING FALLS AMONG SOCIALLY ISOLATED OLDER ADULTS

Social isolation and falls in older community-living adults can have life altering outcomes. While evidence that supports an association between these two gerontological conditions is described below, the nature of that relationship is not well understood. This paper will examine these two concepts and report on the research literature that test the relationship between them.

The impact of social isolation and falls in the near future may be largely related to trends in aging. The population of older Americans has increased ten-fold in the last 100 years, and by 2030 it is expected that 70 million or 20% of Americans will have passed their 65th birthday (Johnson, Bulot, & Johnson, 2008). Cacioppo and Hawkley (2003) declare that the "old-old" populace, those over 85, is the fastest growing portion of the population in general. Further, the number of centenarians (those 100+ years old) is projected to swell from 65,000 in 2000, to 381,000 in 2030 (Johnson et al., 2008). The trends in aging make understanding the impact that both social isolation and falls may have on older adults very important.

Social isolation is particularly problematic for older adults due to functional limitations with changes in mobility, decreasing economic and social resources, and family structure changes with the deaths of spouses and relatives. There is a wide range of health outcomes associated with social isolation including cognitive function, depression, general health, cardiovascular disease, cancer, and mortality (Courtin & Knapp, 2015; Uchino, 2006). Additionally, social isolation has been found to impact health related behaviors and is associated

with both smoking and low physical activity (Pantell et al., 2013; Shankar, McMunn, Banks, & Steptoe, 2011). The prevalence of socially isolated older adults varies among studies from 2% to 43% (Greaves & Farbus, 2006; Iliffe et al., 2007; Kobayashi, Cloutier-Fisher, & Roth, 2009; Nicholson, 2012; Victor, Scambler, Bond, & Bowling, 2000). The variation in prevalence estimates may be due to differences in definition, measurement and/or under-reporting.

The outcomes of falls in the older adult population can be harmful in both human and financial terms. Rubenstein and Josephson (2002) reported that up to 39% of falls in older adults cause serious injuries that can restrict mobility, decrease quality of life, and increase the risk of premature death. Fall rates increase with advancing age, more so for women than men and those who have previously fallen than those who have had no falls, and falls are most common in institutional settings (Lach, 2010). Masud and Morris (2001) report the incidence of falls over a one-year period of time varies from 28% to 35% in adults over 65 years of age; and from 32% to 42% in those over 75 years of age. Falls are the leading cause of injury-related death among older adults (Haegerich et al., 2014) and account for 6% of all of their healthcare costs (Lach, 2010). The financial impact of falls is seen in an economic analysis conducted by the Centers for Disease Control and Prevention (CDC) in which the direct cost of all fall injuries in 2000 was estimated to be 1.9 billion dollars, and in 2013 this direct cost jumped to $34 billion (CDC, 2015). This number is expected to increase as the population ages and may reach $67.7 billion by 2020 (National Council on Aging, 2015). Understanding the potential impact and costs of social isolation and falls for the community-dwelling older adult population, underscores that these two gerontological conditions warrant examination.

Our understanding of the association between social isolation and falls is limited. In the research literature only two published studies that investigated the connection between these

conditions were found to measure indicators of social isolation rather than just a counting measure or a living-alone status measure (Cwikel, 1992; Faulkner, Cauley, Zmuda, Griffin, & Nevitt, 2003). Living-alone is the social isolation measure that is evident in the literature most often regarding the association between social isolation and falls (Elliott, Painter, & Hudson, 2009; Flabeau et al., 2013; Kharicha et al., 2007). Living-alone status is an interesting proxy measure for social isolation, but using this measure excludes other indicators related to social participation, and may not be a sufficient measure of isolation, because older adults are more likely to live alone and yet may continue to have connections to their social network (Lubben, 1988).

The quality of interventions available to tackle the problems of both social isolation and falls among older adults are reported in the research literature as weak, and the mechanisms of action by which social isolation impacts health are not well understood (Choi & Hector, 2012; Courtin & Knapp, 2015; Gardiner, Geldenhuys, & Gott, 2016; Gates, Fisher, Cooke, Carter, & Lamb, 2008). A clearer understanding of the association between the two gerontological conditions may lead to the development of nursing interventions and a broader implementation of relevant best practices. The objectives of this paper are to examine the conceptual clarity of social isolation and its measurement in the research literature and to explore the current evidence regarding the relationship between falls and social isolation in older adults.

Literature Review Methods

In order to study the relationship between social isolation and falls, Walker and Avant (2011) was consulted and an evidence-based, literary statement synthesis was adapted for this analysis. Published studies regarding social isolation, falls and the association between these two gerontological conditions were identified. The search included the electronic bibliographic

databases: Medline, CINAHL, PsycINFO, and Google Scholar. Search terms included social-isolation, participation, community, living-alone, alienation, network, integration, engagement, seniors, elders, older-adults, accidental, and falls. In an attempt to capture a broad and deep understanding of the current literature, an ancestry approach (examining references cited within publications) was also used.

The strategy of a statement synthesis is to identify relationships between concepts based upon literary evidence. The process involves evaluating the literature, making specific inferences, and moving to finish with more abstract inference (Walker & Avant, 2011). The steps of this analysis will first include the reasons social isolation is particularly important in older adults' lives, along with conceptual definitions of social isolation and other related social concepts. Health outcomes and risk factors of social isolation illustrate its impact, and an exploration of relevant social isolation measures precedes a discussion of falls. Second, conceptual definitions of falling is identified along with the epidemiology of the problem, including risk factors. Third, and most important to this paper, is the examination of research literature that tests the relationship between social isolation and falls. Finally, presented are conceptualized models that describe this relationship and provide a foundation for studying this complex problem in the future.

Social Isolation

It is important during assessment for health professionals to situate the older adult within a social context, because the literature clearly indicates that one's response to or interpretation of that social context can impact health positively or negatively (Tay, Tan, Diener, & Gonzalez, 2013). Health professionals may not be regularly screening for social isolation, because defining a clinically relevant level of isolation is elusive. Victor, Scambler, and Bond (2008) declared that

the precise level of engagement that defines isolation, the specification of a case-definition threshold, is not found in the literature.

Conceptual definitions

There are multiple social concepts found in the literature that are related to but should be distinguished clearly from the concept of social isolation. Therefore, it is important to explore concepts related to social isolation, specifically social network, integration, loneliness and social support.

It has been suggested that the term *social isolation* be reserved for use with social network and social integration (Nicholson, 2010). Both network and integration imply participation which is different from perceptions of isolation. At its core social isolation is the absence of contact from other people and a lack of relationships and social integration (Coyle & Dugan, 2012; Hawton et al., 2011). Nicholson (2009) offers a definition of social isolation in a concept analysis indicating that social isolation is a state in which the older adult has a minimal number of social contacts, lacks engagement with others, and lacks a sense of belonging socially. The definition utilized in this paper focuses on participation. Social isolation is a social circumstance in which the older adult has a deficiency of network contacts and a deficiency of integrating relationships with contacts.

Social network takes into account not only the number and density of social ties, but the number of different roles a person occupies, which indicates the extent to which the person is "wrapped" in their social structure (Gottlieb & Bergen, 2010). As described by Seeman (1996), social networks represent the web of intimate and formal relationships that we each maintain. For some, this web or social network becomes smaller with age (Wenger & Burholt, 2004). The

theory of socio-emotional selectivity submits that as people age, they become increasingly aware of their shorter future, and this awareness shifts their goals in favor of closer ties or bonds (Carstensen, 1995). This theory also suggests that as individuals age, personal networks increasingly consist of family (Aartsen, van Tilburg, Smits, & Knipscheer, 2004). Having family as confidants can make the individual's network more interconnected and dense, because family members tend to know each other (McPherson, Brashears, & Smith-Lovin, 2006). This interconnection leads to a smaller network for the older adult and less interest in causal or less-close contacts (Heylen, 2010). Based on this definition, participation can be thought of as a key indicator of network, and social isolation may also be viewed as a deficiency of network.

Social integration is defined in the literature as the participation of social relationships in the individual's social network, measured by their number, contact frequency, and the structure of connections (Gottlieb & Bergen, 2010; Tay et al., 2013). A greater number and more diverse ties within a social network imply greater social integration (Gottlieb & Bergen, 2010). The key to this definition is the word participation. Based on this definition, participation can be thought of as a key indicator of integration, and social isolation may be viewed as a deficiency of integration.

Loneliness has been defined as different and separate from social isolation, although these concepts are associated (Weiss, 1973). While there is not a universally agreed upon definition of loneliness (Victor et al., 2000), it has been described as a distressing feeling of social isolation that is associated with the perception of deficiency in the number or quality of the individual's social relationships (Coyle & Dugan, 2012; Weiss, 1973). Individuals can live very unsocial lives and not feel or perceive loneliness. At the same time individuals can live very social lives and still have feeling of loneliness (Coyle & Dugan, 2012). Individual expectations

of social relations are a part of loneliness, which has also been defined as a discrepancy between one's desired and one's achieved level of social relations (Dahlberg & McKee, 2014). Loneliness is based upon the *perception* that the level of interpersonal relationships one experiences is lower than that expected or desired.

Social support has been defined as both the structure of an individual's network and the functions that the network serves which lead to the perception that the individual is cared for and a member of a network of mutual obligations (Cobb, 1976; Uchino, 2006). This perception also implies self-efficacy in one's ability to participate in mutual assistance and obligations (Berkman, 1995; Lubben, 1988; Tay et al., 2013). The theory of selective optimization is relevant to the social support discussion of older adults. The assumption of this theory states that as people age and experience a decrease in cognitive and physical capacities, they are forced to select contacts that will offer social support (Heylen, 2010). Exchange theory is another theory regarding social support and reciprocity that offers further explanation of why social network tends to get smaller with increased age. The exchange theory suggests that people prefer relationships that are balanced (Aartsen et al., 2004). An older adult's decline in function makes it difficult to reciprocate support, which then may lead to a relationship ending and result in a smaller network (Aartsen et al., 2004). Gottlieb and Bergen (2010) claimed that social support is a mutual affection that is characteristic of the relationship between two parties, not a commodity that resides in the provider and passes to the recipient. Undoubtedly, this mutuality is why Lubben (1988) has indicated that the concept of social support is difficult to measure, because the measurement must also assess the need for support and show evidence of an exchange in response to need. The social support literature emphasizes the provision of help and support to older adults with physical or mental incapacity rather than a sense of isolation (Victor et al.,

2008). Therefore, social support and social isolation should be considered very different concepts. Social support and loneliness are consistent with perceptions and require evaluation of circumstances, whereas social isolation is a function of social network and integration and more consistent with participation.

Impact of social isolation on health

Psychological health. Social isolation has been associated with the cognitive well-being of older adults in literature spanning multiple decades. Bassuk et al. (1999) found that a lack of social engagement is a risk factor for cognitive impairment. These authors define engagement "as the maintenance of many social connections and a high level of participation in social activities" (p. 165). Their study was a secondary analysis of data from the Established Populations for Epidemiologic Studies of the Elderly, which provided a longitudinal design for examining cognitive function and social disengagement. With twelve years of data, at 3, 6 and 12-years of follow-up, these authors reported a significant association between cognitive decline and social disengagement measured as the number of social ties. The odds of experiencing cognitive decline were twice as great for those who reported no social ties as for those who reported five or more ties.

The number of ties in an older adults' network and the number of social activities, are important to maintaining mental function. For example, a secondary analysis of 732 older adults in a longitudinal population-based study, the Kungsholmen Project in Sweden, revealed that social interaction is relevant to preserving mental functioning (Wang et al., 2002). Social activity was measured by determining how often the older adult attended the theater, concerts or art exhibitions; traveled; played games or participated in social groups. The relative risk of dementia associated with participation versus no participation in these activities was 0.70 (95%

confidence interval 0.49, 1.01; Wang et al., 2002). The Bassuk et al. (1999) and the Wang et al. studies indicate the importance of the number of social ties and the number of social activities experienced in the lives of older adult. The cyclical nature of the relationship between these concepts is evident in the fact that mental functioning supports engaging with a number of people and activities.

While research has shown that there is an association between social isolation and depression among older adults, the nature of this relationship has not been entirely clear (Warner, 1998). Older adults identified as depressed have been found to be at risk for social isolation (Iliffe et al., 2007). In fact, in a qualitative study that placed social isolation as an adverse "circumstance" of older age, McCrae et al. (2005) suggested that depression is consistently attributed to social isolation by staff of social care services in South London, United Kingdom. The staff of this study described a circular relationship between social isolation and depression in which social isolation could exacerbate depression and depression could exacerbate social isolation. Additionally, in persons with dementia, Shub et al. (2011) found that depression mediated the outcome of social isolation. Those individuals with depression were more likely to experience social isolation than those without.

Physical health. Social isolation is a risk factor for major causes of death in older adults, such as myocardial infarction, stroke, diabetes, and cancer, and yet it is one of the least understood (Cacioppo & Hawkley, 2003; Uchino, 2006). Using data from the Health and Retirement Study, Coyle and Dugan (2012) found that those who reported social isolation (as measured with a 10-point social network index scale) had 43% higher odds of also reporting fair or poor health. Social isolation is predictive of mortality, cardiovascular disease, cancer and

infectious disease while at the same time a lack of social isolation plays a protective role against cardiovascular disease (Tay et al., 2013; Uchino, 2006).

Research suggests that the effect of social isolation on disease may be related to inflammatory makers. Social isolation in older men is associated with concentrations of C-reactive protein (CRP), an inflammatory marker for cardiovascular disease, and this biologic process may be influenced by social integration (Ford et al., 2006). That study suggested a positive association between social isolation and CRP among older adult men. The association was supported by subsequent study findings that suggested those individuals with the lowest social integration had more than twice the odds of elevated CRP concentrations compared to those with the highest social integration (Heffner et al., 2011). Both Ford et al. and Heffner et al. measured social isolation and integration with social network indexes developed for each study.

Findings from Berkman and Syme's (1979) nine-year follow-up study of Alameda County Residents are regularly cited by researchers as evidence of the importance of social networks. In terms of physical health, Berkman (1995) reported on the impact of a range of social ties and networks on all-cause mortality in these residents. Those who did not have social ties were at increased risk of dying from cerebrovascular and circulatory disease, ischemic heart disease, cancer and other diseases including gastrointestinal, respiratory and other causes of death.

Social isolation is suggested to have a mortality hazard ratio similar to smoking and greater than some other traditional clinical risk factors for mortality (Pantell et al., 2013). In the Third National Health and Nutrition Examination Survey (NHANES III), Pantell et al. suggested a low Social Network Index (SNI) score was predictive of mortality. The SNI scores were

associated with risk of mortality among men, similar to that of smoking and higher than that of high blood pressure (Pantell et al., 2013).

Health and health behavior. When studying life satisfaction among older adults, Borg, Hallberg, and Blomqvist (2006) found that social isolation was an important predictor of low perceived health. These authors suggested that older people who perceive themselves with poor psychological or physical health are disposed to accept illness as an inevitable part of aging. This perception may alter behaviors necessary to maintain health in old age and limit efforts to seek social activities (Borg et al., 2006). Health behaviors may also be influenced by others in a person's social circles. Cohen and Lemay (2007) suggested that those with higher social integration are responsive to the normative expectations of a cohesive social network to live a healthy lifestyle. Those who are less integrated may be more susceptible to negative social pressures, which may be manifested by drinking alcohol and smoking behaviors (Cohen & Lemay, 2007). Shankar et al. (2011) examined the impact of social isolation on older adults' health-related behaviors and found that being isolated was associated with both smoking and low physical activity. In that study, every standard deviation increase in social isolation was associated with a 23% increase in the odds of being physically inactive, a 32% increase of being a smoker, and a 56% increase of reporting both risk behaviors.

Risk factors. Isolation or a decrease in social network and integration may be the result of individual choice, but in many cases it is an outcome of physical conditions that reduce the individual's ability or opportunity to interact with others (Wilson, Harris, Hollis, & Mohankumar, 2011). Dimensions of social networks that may contribute social isolation include the death of a spouse, other relatives, friends, and/or close neighbors. The loss of relatives, friends, and/or close neighbors due to changes such as deteriorating health, impairment of

mobility, vision, and/or hearing, and childlessness may also contribute to social isolation. (Wenger & Burholt, 2004). Living-alone, economic deprivation, poor social skills, divorce, or moving are also risk factors for social isolation (Machielse, 2015).

Measures

According to Victor et al. (2008), there are two approaches to the measurement of social isolation: (a) counting the number of contacts within a defined period of time (single-item indicator); and (b) the calculation of isolation indexes that combine measures related to contacts, availability of family and friends and varying aspects of social contact. Counting the number of contacts as a measure of isolation is often seen in research, but the use of an isolation index that identifies multiple indicators of social isolation has been recognized as a more reliable measure of social isolation (Lubben, 1988).

An example of a single-item measure of social isolation that uses counting is the Rand Social Health Battery (Hawton et al., 2011; McDowell& Newell, 1996). 'How many times a year do you get together with friends and relatives e.g. going out together or visiting each other's homes?' The Life Space Index is another counting measure that assesses mobility based on the distance a person reports moving during the previous weeks (Baker, Bodner, & Allman, 2003) and the monthly range of contacts, using a complex scoring algorithm that produces five ordered categories of high to low contacts (Havens, Hall, Sylvestre, & Jivan, 2004). While it is not a counting indicator, living-alone status can also be described as a single-item indicator (Lubben, 1988).

Single-item indicators, such as counting the number of contacts within a defined period of time and living-alone status, are used by health services researchers, but these measures encounter problems with face validity (Lubben, 1988). Single-item indicators may not capture

enough of an individual's social network for evaluation, and Lubben has suggested that an index composed of multiple indicators is a more reliable measure of social isolation. Social isolation indexes include The Social Network Index (SNI), the Lubben Social Network Scale (LSNS) and the Lubben Social Networking Scale-6 (LSNS-6).

The SNI was developed by Berkman (1977) to assess four domains of social isolation: (a) marriage: (b) close friends and relatives: (c) church membership (d) club membership in the general adult population. However, it is interesting that an actual tool or questionnaire has never been published. Berkman (1977) has claimed that while the index has not been checked for reliability, the domains provide strong face validity. Nicholson (2010) reported that its continued use over the decades support its credibility for identifying those who are socially isolated (Ford et al., 2006; Heffner et al., 2011; Pantell et al., 2013; Shankar et al., 2011). Further, Berkman and Syme (1979) indicate that the scores on the original index are predictive of health and mortality outcomes. Each of these studies use the four domains or indicators in of the SNI varied forms.

The original Lubben Social Network Scale (LSNS) (1988) was developed specifically for clinical assessment in older adult populations and was a refinement of the Berkman-Syme Social Network Index (Lubben, 1988). The LSNS is a lengthy measure that is divided into five sections: family networks, friend networks, confidant relationships, helping others and living arrangements, with each section including 10 questions.

The Lubben Social Network Scale-6 (LSNS-6) was developed as a more concise social network assessment tool (Lubben et al., 2006). It is divided into two sections of kinship ties and non-kinship ties. Each section addresses three different levels: How many individuals do you see or hear from at least once a month? How many individuals do you feel close to such that you

could call on them for help? How many individuals do you feel at ease with that you can talk about private matters?

Synthesis/Summary of Social Isolation

The positive pole of social isolation is described by Cornwell and Waite (2009) as connectedness, and a lack of connectedness is predicitve of negative health outcomes. Pantell et al. (2013) declared that social isolation is an important risk factor for mortality and emphasized the clinical importance of understanding patients' social integration and support in order to understand their health. Further, these authors' conclusions are consistent with those of Lubben (1988), who suggested that social network assessments ought to be a regular component of a health professional's practice.

The impact of social isolation on psychological, physiological and behavioral health is evident in the literature. Much work still needs to be done to identify mechanisms of action which is beyond the scope of this paper. Research is identified in this paper as limited by a lack of conceptual clarity and the variety of social isolation measures. These multiple measures make it difficult to compare the results of studies and may impede the progress of social isolation research which in turn makes intervention development difficult. Social networks and social isolation should be measured with a multidimensional measure or index that captures the domains of marriage/partner, family and friend, church participation and club participation. This type of measure will capture variations in the nature and extent of social interaction with family, friends and others (Berkman, 1977; Lubben, 1988). A well-conceptualized, comprehensive, and domain-inclusive is particularly important to more fully understand the relationship between social isolation and falls.

Falls

There is very little research literature that indicates social isolation among older adults has been considered a risk factor for falls. However, studies do support an association between these two conditions that may affect the lives of older adults. Research literature on general risk factors for falls forms an important context for considering social factors for fall risk. A quick review of falls and fall risk factors below will lead into a review of the research literature in which the relationship between falls and the social isolation of older adults has been described.

The importance of studying falls is supported by research on health outcomes. Falls are the leading cause of injury-related death among those over 65 years of age, and the most common cause of non-fatal injuries that lead to hospitalization (Stevens, 2005). The most serious of these injuries are traumatic brain injury (TBI) and hip fractures (Stevens, 2005). Further, fractures are the most common injury from falling and include not only hip fractures, but fractures of the wrist and spine (Lach, 2010). The long-term effects of falls can be found in reduced quality of life for older people, including pain, functional decline, disability, loss of independence and leading to premature and long-term nursing home placement (Lach, 2010). Injury related to a fall accounts for 40% of factors that lead to long-term institutional care (Masud & Morris, 2001).

Conceptual Definition of a Fall

Falling is not a simple event, but a multifaceted occurrence that may lead to soft tissue injury, traumatic brain injury and fractures (Godfrey & Studenski, 2010). Fall occurrence is not always clearly appreciated by individuals and healthcare professionals, especially if there has been no resulting injury (Ambrose, Paul, & Hausdorff, 2013).

Three types of falls are identified in the literature: (a) accidental falls such as a slip on a wet floor; (b) unanticipated physiological falls such as when someone faints; (c) anticipated physiological falls which are the most common and can be anticipated by determining an individual's risk factors (Lach, 2010). Falls have been defined in multiple ways. These variations in definition likely explain some of the differences in fall rates among studies conducted in similar populations (Lamb, Jorstad-Stein, Hauer, & Becker, 2005). To standardize the definition for clinical and research efforts, the Prevention of Falls Network Europe Group defined a fall as "an unexpected event in which the participants come to rest on the ground, floor, or lower level," (Lamb et al., 2005, p. 1619). Most studies on falls require that the fall was unintentional, not caused by events such as a car accident and not the result of a syncopal or coronary event (Ambrose et al., 2013).

Risk Factors

Risk factors for falling can be categorized as intrinsic person-specific or extrinsic environmental (Ambrose et al., 2013; Stevens, 2005). In their review of the literature regarding risk factors for falls among older adults, Ambrose et al. listed *intrinsic* factors as (a) demographic including age, gender and race; (b) physiological systems including gait and balance, strength, vision and cognition; and (c) symptoms/diseases including dizziness/vertigo, cardiovascular disease, dementia and depression. Other risk factors for falling are identified as history of a previous fall, fear of falling, the use of mobility aids and deficits in activities of daily living (Stevens & Phelan, 2013). Ambrose et al. (2013) list the *extrinsic* factors as (a) home and (b) footwear. The use of sleeping medication is another extrinsic risk factor that is specifically identified in the literature as contributing to fall risk (Berry, Lee, Cai, & Dore, 2013; Mets, Volkerts, Olivier, & Verster, 2010; Stone, Ensrud, & Ancoli-Israel, 2008). The risk of falling

increases with an increase in the number of risk factors. Stevens and Phelan (2013) identified the proportion of those who fell in one year as 19% for those with one risk factor, 32% for those with two risk factors, 60% for those with three risk factors and 78% for those with four or more risk factors.

Synthesis/Summary

The continued need for falls research is evident in the impact of falls on older adult lives. New approaches to knowledge generation and intervention development are needed to temper the potentially devastating outcomes of falls. Social risk factors are important scientifically and conceptually and yet they have not been adequately considered.

Social Isolation and Falls

Research on social isolation as a fall risk factor is scarce, although the results of these few studies indicate social isolation may be a risk factor for falls in community-living older adults (see Table 1). However, only the Cwikel (1992) and Faulkner et al. (2003) studies use multiple item indicator measures of social isolation.

Table 1
Limited studies testing the relationship between falls and the social isolation of older adults.

Study	Study design	Social Isolation Measure	Sample size
Cwikel 1992	Secondary analysis	Indicators of multiple social interactions	3,494
Faulkner et al. 2003	4-year Prospective	Lubben Social Networking Scale	8,378
Kharicha et al. 2007	Secondary analysis	Living-alone	2,641
Elliott et al. 2009	4-year Prospective	Living-alone	666

Flabeau et al. 2013	Prospective observational	Less isolation at home	69
Maruf et al. 2015	Cross-sectional	Frequency of visiting family and friends	131

Two studies relevant to social isolation and falls have used social isolation indexes in their analyses (Cwikel, 1992; Faulkner et al., 2003). One was a secondary analysis of a national sample in Israel, which revealed that older adults who reported the highest levels of social interaction also reported the fewest number of falls (Cwikel, 1992). Social isolation was operationalized as a composite measure of the frequency of social interactions with family, friends and neighbors and with involvement in organized social interactions or leisure time activities. In addition, a 3-year prospective analysis of fall rates among women enrolled in the Study of Osteoporotic Fractures concluded that strong family networks may protect against the risk of falls in older community-dwelling adults, although a similar protection may not be apparent with strong friend networks (Faulkner et al., 2003). Social integration was assessed in this analysis of 8,378 women with the 10-item Lubben Social Networking Scale. The composite social measure was not significantly associated with the risk of a fall, but the study did suggest a difference between the social isolation indicators of family and friends and fall risk. This finding is consistent with socio-emotional selectivity theory, discussed earlier, that posits as people age, their goals tend to include closer ties or bonds (Carstensen, 1995) that will increasingly consist of family (Aartsen et al., 2004). The Faulkner et al. study provides relevant evidence of an association between social isolation and falls and distinguishes contact with family as having a different effect from contact with friends.

A single indicator of social isolation, living-alone, was examined as a potential health risk in a British study that sought to investigate the clinical significance of living-alone in later life and explore lone status as an epidemiological risk factor for health behaviors, health status, and service use (Kharicha et al., 2007). A total of 2601 study participants from four large medical practices in suburban London completed the Health Risk Appraisal Older People Questionnaire (HRA-O), which includes domains of functional ability, functional change, fall, vision, multiple medication use, mood, cognitive functioning and risk of social isolation. Binary logistic regression analysis was used to explore the epidemiology of "lone" status, by examining the impact of living-alone status on falls over the previous 12 months. The likelihood of having multiple falls in the last 12 months was 2.25 times greater for those who were living-alone than those who were not.

An intervention study of a fall prevention education session did suggest that living-alone as a proxy measure for social isolation was strongly associated with experiencing a fall (Elliott et al., 2009). In this study of 666 participants from senior centers, churches or clubs in a rural North Carolina County, the authors reported a strong association between living-alone and falls, but this association became weaker and non-significant when the analysis controlled for age and gender (Elliott et al., 2009).

Flabeau et al. (2013) sought to determine if a particular subgroup of patients stopped falling after a risk-based fall prevention program was implemented in a geriatric day hospital. Less isolation at home was found to be predictive of fewer falls.

Maruf, Muonwe, and Odetunde (2015) examined social risk factors for falls and reported that visiting family and friends less than twice per week was significantly associated with a

report of fall even when controlling for age, physical activity, balance, and fear of falling. Isolation in this study was measured by counting the frequency of family or friend visits.

Synthesis/summary of research testing the relationship between social isolation and falls

The studies presented here strongly suggest that there is a relationship between the social lives of older adults and falls, with more isolation associated with increased falls (Elliott et al., 2009; Flabeau et al., 2013; Kharicha et al., 2007). The Maruf et al. (2015) study, which used a counting measure, indicated that less than two visits by family or friend is associated with falls. However, other studies (Cwikel, 1992); Faulkner et al., 2003) suggest that a composite measure or index, which includes multiple indicators of older adults' social lives, may be more important for identifying concepts needed in future intervention development. Understanding more about social networks and integration may help identify components of an intervention that will decrease falls. The characteristics of networks in understanding risk of falls cannot be overlooked. Strong family connections, more than friend connections, are suggested to be protective against the risk of falls. The importance of finding ways to reduce the frequency of fall events indicates more research with such indexes is needed to understand the importance of social isolation indicators in fall risk. The need for a well-conceptualized, comprehensive, and domain-inclusive social isolation measure in such research has been presented.

Conceptual Framework

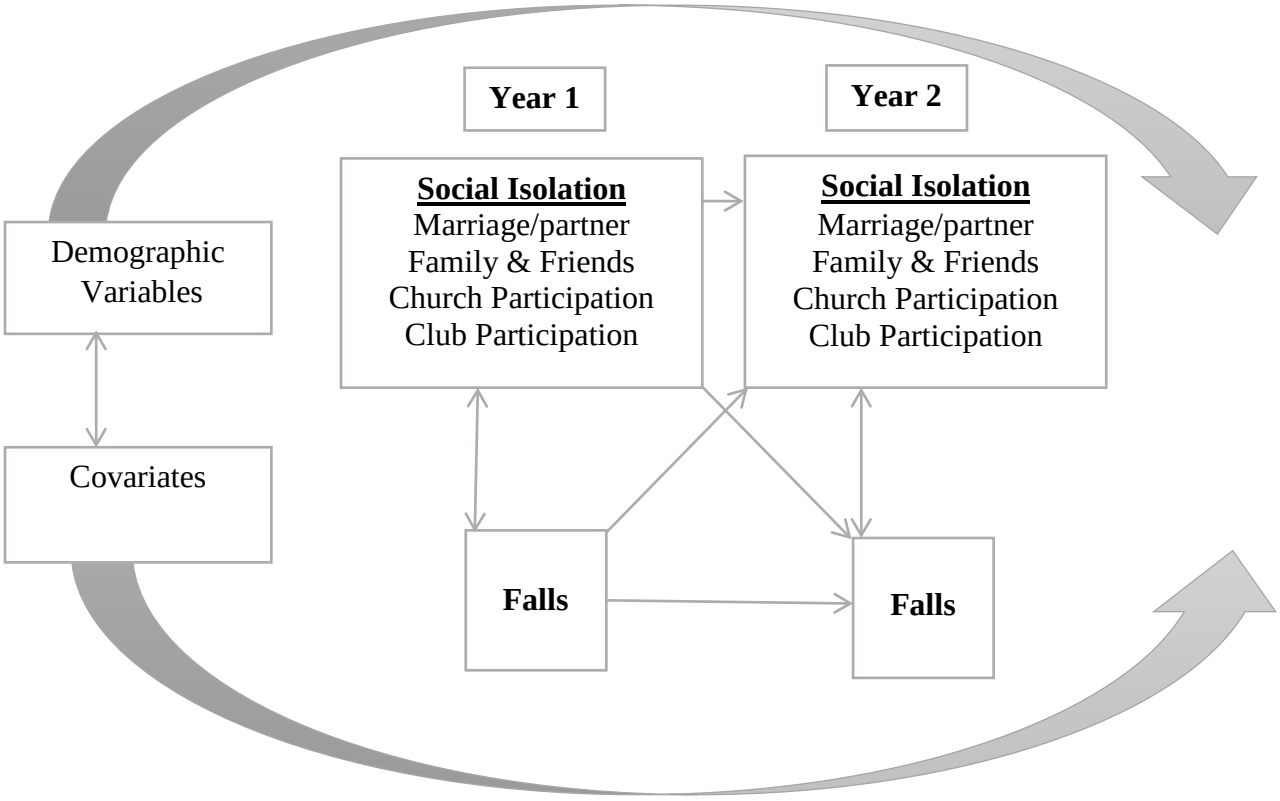
The Convoy Model of social relations and health provides a framework for conceptualizing the inter-relationship between falls and the social isolation of older adults (Antonucci, Birditt, & Akiyama, 2009). The term convoy is used in this model to describe the social connections and relationships that surround the individual and provide a protective, secure base for the maintenance of mental and physical health (Antonucci et al., 2009; Bengtson, 2009).

The Convoy Model is a unifying, conceptual framework within which attachment and close social connections can be considered. Figure 1 demonstrates the longitudinal process of how a social concept, such as isolation is inter-related with a health concept, such as falls. Social isolation includes the domains of marriage/partner, family and friends, church participation and club participation. The relationships over time are represented with one-way arrows indicating that some aspect of the association moves forward in time (see Figure 1). Two-way arrows indicate a reciprocal engagement between social relations and mental and physical health. Social connections are found in the literature as key elements of well-being and are recognized as having cumulative effects on health (Antonucci, Ajrouch, & Birditt, 2014).

Further foundation for this conceptualization is found within an *ecological model* that reflects aspects of the Convoy Model. The Ecological Model states that health and well-being are affected by the interaction among biology, behavior and environment and this interaction develops and changes during life (Gielen & Sleet, 2003). According to Bronfenbrenner (1979) there are three features of the ecology of human development or maturity. First, the individual is seen as a dynamic entity that interacts with the environment in which it resides. Second, the environment also influences the individual and requires mutual accommodation, such that the interaction between the person and environment is two-directional and characterized by reciprocity. Third, the environment is relevant in that it is not limited to the immediate setting but incorporates extended settings and the interconnections among settings. Bronfenbrenner described the ecological model topologically as nested concentric structures. These multiple levels of influence and intervention are evident in the translation of ecological models, and their use in research and intervention development received critical support by the Institute of Medicine (2001). The interpersonal or microsystem level within an ecological model is of

interest to the current conceptual framework. It reflects Bronfenbrenner's three features of ecology, with reference to how contact with people such as family members, friends and others influence individual behaviors, social norms and environment, which in turn influence health. Central to this paper is the inter-relationship between social isolation and falling. Both the Convoy Model and the Ecological Model offer a good conceptual fit and provide a foundational understanding of the relationship between social isolation and falls.

Figure 1:
Theory of the inter-relationship of Social Isolation and Falls among Older Adults over time
Adapted from a longitudinal version of the Convoy Model, (Antonucci, et al, 2009)



Summary Statement

These conceptual models provide the foundation for using index measures of social isolation in research that test the relationship between falls and socially isolated older adults.

This paper examined the paucity of conceptual clarity in the social isolation research and the resultant difficulties in comparing such studies. It will be important in future research to use a well-conceptualized, comprehensive, and domain-inclusive social isolation measure. A clearer understanding of the association between falls and the social isolation of older adults can support the development of nursing interventions and a broader implementation of relevant best practices. The current state of the literature regarding the relationship between falls and socially isolated older adults indicates that this work is still needed.

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CHAPTER III: Manuscript # 2

CREATING A SOCIAL ISOALTION CONSTRUCT

Social isolation in older community-dwelling adults can have life-altering outcomes that may profoundly impact the individual. Expanding knowledge regarding how social isolation impacts older adults is important, because socially isolated older adults are at increased risk for multiple morbidities and mortality (Berkman & Syme, 1979; Saito, Kondo, Kondo, Ojima, & Hirai, 2012; Seeman et al., 1993). Robust research that examines social isolation indicators may add to the body of knowledge that will have a positive impact on gerontological practice and policy. Unfortunately, research is limited due to a lack of conceptual clarity and the numerous approaches to the measurement of social isolation make the comparison of studies difficult and make intervention development challenging. Finding approaches to measurement that will add to the conceptual clarity of social isolation is important to future research that will contribute to the well-being of older adults.

Social isolation can also have consequences for society. The impact of this gerontological condition may be largely related to trends in aging. The population of older Americans has increased ten-fold in the last 100 years, and by 2030 it is expected that 70 million or 20% of Americans will have passed their 65th birthday (Johnson, Bulot, & Johnson, 2008). Cacioppo and Hawkley (2003) declare that the “old-old” populace, those over 85, is the fastest growing portion of the population in general. Further, the number of centenarians (those 100+ years old) is projected to swell from 65,000 in 2000, to 381,000 in 2030 (Johnson et al., 2008). In addition to the expected increase in the number of older adults, multiple other factors contribute to the problem of social isolation, such as changes in marital and childbearing patterns in the US, are expected to lead to an increasing number of older adults who do not have a spouse or a child

living with them (Cacioppo & Hawkley, 2003). The trends in aging make understanding the impact that social isolation may have on older adults very important.

The impact of social isolation on health is seen in both psychological and physiological health and health behavior. Social interaction is relevant to preserving mental functioning in older adults, and a low social network is a risk factor for cognitive impairment (Bassuk, Glass, & Berkman, 1999; DiNapoli, Wu, & Scogin, 2014; Wang, Karp, Winblad, & Fratiglioni, 2002). Being socially isolated is also consistently associated with depression (Dorfman et al., 1995; Ebner, Maura, Macdonald, Westberg, & Fischer, 2013; Iliffe et al., 2007; Lee, Hasche, Choi, Proctor, & Morrow-Howell, 2013; McCrae et al., 2005; Shub et al., 2011). The relationship between social isolation and depression has been discussed in the literature as circular. Depression in old age contributes to social isolation and social isolation contributes to depression (McCrae et al., 2005). Additionally, social isolation impacts physical health. Coyle and Dugan (2012) found that those who reported social isolation had a 43% higher odds of also reporting fair or poor health. There is a wide range of health outcomes associated with social isolation including cognitive function, depression, general health, cardiovascular disease, and cancer (Courtin & Knapp, 2015; Uchino, 2006). There is considerable evidence indicating that older adults who are socially isolated are also at increased risk for all-cause mortality (Berkman & Syme, 1979; Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). Social isolation has been found to impact health-related behaviors and is associated with both smoking and low physical activity (Pantell et al., 2013; Shankar, McMunn, Banks, & Steptoe, 2011).

Social Isolation definition

At its core social isolation is the absence of contact from other people and a lack of relationships and social integration (Coyle & Dugan, 2012; Hawton et al., 2011). Nicholson

(2009) offers a definition of social isolation in a concept analysis indicating that social isolation is a state in which the older adult has a minimal number of social contacts, lacks engagement with others, and lacks a sense of belonging socially. The definition utilized in this paper focuses on participation. Social isolation is a social circumstance in which the older adult has a deficiency of network contacts and a deficiency of integrating relationships with contacts.

The Measurement of Social Isolation

According to Victor, Scambler, and Bond (2008), there are two approaches to the measurement of social isolation: (a) counting the number of social contacts within a defined period of time; and (b) calculating indicators of isolation that combine measures related to contacts, availability of family and friends and varying aspects and types of social participation.

Counting the number of contacts has been used as a single item indicator of social isolation in the Rand Social Health Battery (Hawton et al., 2011; McDowell & Newell, 1996) and the Life Space Index (Baker, Bodner, & Allman, 2003; Havens, Hall, Sylvestre, & Jivan, 2004). While it is not a counting indicator, living-alone status is also a single-item indicator.

Measures that calculate indicators of social isolation include the Lubben Social Network Scale (LSNS), Lubben Social Networking Scale-6 (LSNS-6) and the Social Network Index (SNI). The original Lubben Social Network Scale (LSNS) was developed specifically for clinical assessment of older adult populations and was a refinement of the Berkman-Syme Social Network Index (Lubben, 1988). The Lubben Social Networking Scale-6 (LSNS-6) was developed as a more concise social network assessment tool (Lubben et al., 2006). Finally, the SNI has been used in research to assess four social domains: (a) marriage or partnership, (b) friends and relatives, (c) religious activity, and (d) voluntary association in the general adult population (Berkman & Syme, 1979). Berkman (1977) has claimed that while the SNI has not

been evaluated for reliability, the four domains provide the measure with strong face validity. Further, Berkman and Syme (1979) have indicated that the scores on the original index are predictive of health and mortality outcomes. Nicholson (2010) reported that its continued use over the decades support its credibility for identifying those who are socially isolated (Ford et al., 2006; Heffner et al., 2011; Pantell et al., 2013; Shankar et al., 2011).

Precision in measuring social isolation is needed for the comparison of studies, and for future development of social isolation interventions. Specifically, a social isolation construct that includes the indicators of social isolation for measurement is needed for research with the National Health and Aging Trends Study (NHATS) data. NHATS is a resource for the scientific study of functioning in later life. The construct developed will expand opportunities for social isolation research, including further studies using NHATS data, all of which may impact gerontological practice and policy. The purposes of this paper is to describe the development of a social isolation construct that was created using domains based upon Berkman and Syme's Social Network Index (1979), and to establish convergent validity of the measure by examining the relationship between social isolation and depression in the National Health and Aging Trends Study (NHATS).

Methods

This construct development study involved a secondary analysis of cross-sectional (baseline) data from the National Health and Aging Trends Study (NHATS) using a descriptive correlational design to examine the association between a new social isolation construct and depression in this sample of older adults.

Sample

The NHATS was designed to support the study of disability trends and dynamics in a nationally representative sample of non-nursing home Medicare beneficiaries, ages 65 years or older (Kasper & Freedman, 2015). Random subsamples from the Centers for Medicare and Medicaid Services Medicare enrollment database served as the sampling frame for NHATS (Montaquila, Freedman, Edwards, and Kasper, 2012). The NHATS study design includes baseline stratification of five-year age groups (from 65-89, and 90+), an oversampling of those over 90 years of age, and an oversampling of Black persons. NHATS round one achieved a 71% response rate, weighted for age and race (Black), with 8,245 complete cases. Included in this current study are the 7,609 community dwelling participants who were administered the sample person interview (Montaquila et al, 2012). Protocols were approved by the John Hopkins University review board, and all study participants provided written informed consent. Although the NHATS public use data are de-identified, NHATS is not on the University of Washington Human Subjects previously exempted list (SOP Public Data Set, 2015). The UW Human Subjects Research worksheet was completed to determine that secondary analysis of NHATS data does not require human subjects review, as defined by the Common Rule. (Worksheet: Human Subjects Research, 2015). On July 7, 2015, the University of Washington confirmed that this study does not meet the definition of research involving human subjects. Access to the de-identified data required registering with the NHATS website (www.nhats.org) before downloading the files. The sensitive demographic data, such as age in years, were available through an application process.

NHATS data collection involved annual in-person interviews that started in 2011. Round 1 baseline data were used for this project. The NHATS data was available in three different data

sets that are used in this analysis. (1) The sample person (SP) data contains all data on NHATS respondents collected in the Sample Person (SP) interviews. The sample person is synonymous with *participant* in this study. (2) The other person (OP) data which included data that represented a person identified based on one or more roles relative to the SP in the Round 1 SP interview. (3) The sensitive data files provide demographic data regarding the SP. The main data collection instrument was the Sample Person (SP) Interview (participant interview), which was administered in round one to all study participants living in the community or residential care settings other than nursing homes. Most SP interview data were obtained by self-report. Proxy respondents were used in instances where the participant could not respond. The inclusion criterion for this current study was participation in the NHATS study. No exclusion criteria was used. A data extract/subset of the NHATS original data set was created to include this study's demographic variables and the main variables of social isolation and depression.

Measures

The development of the *social isolation construct* was based on research by Berkman (1977), Berkman & Syme (1979), and Nicholson (2010) and was calculated using the following NHATS data items: marriage; family and friends; religious participation; and club participation. Items were recoded to ensure that a higher construct score indicated greater isolation. One point is recorded for each item that has a negative response, and the construct score is based upon the sum of those negative responses. Figure 1 depicts the relationships among the domains of the social isolation construct. With a range of 0-6, each of the indicator scores are summed to create the construct score (See Table 1). A dichotomous measure was also required, so the ordinal measure was also categorized such that a score of 4, 5, or 6 represented being socially isolated. This categorization included a medium isolation score represented by scores of 2 or 3; and a least

isolated score represented by scores of 0 or 1. Placing participants into tertiles (Pascoe et al., 2013; Reginold et al., 2013) and quartiles (Nicholson, 2010; Rutledge, Matthews, Lui, Stone, & Cauley, 2003) based upon social measure scores is often done in social network research.

Figure 1
Conceptualization of the social isolation construct

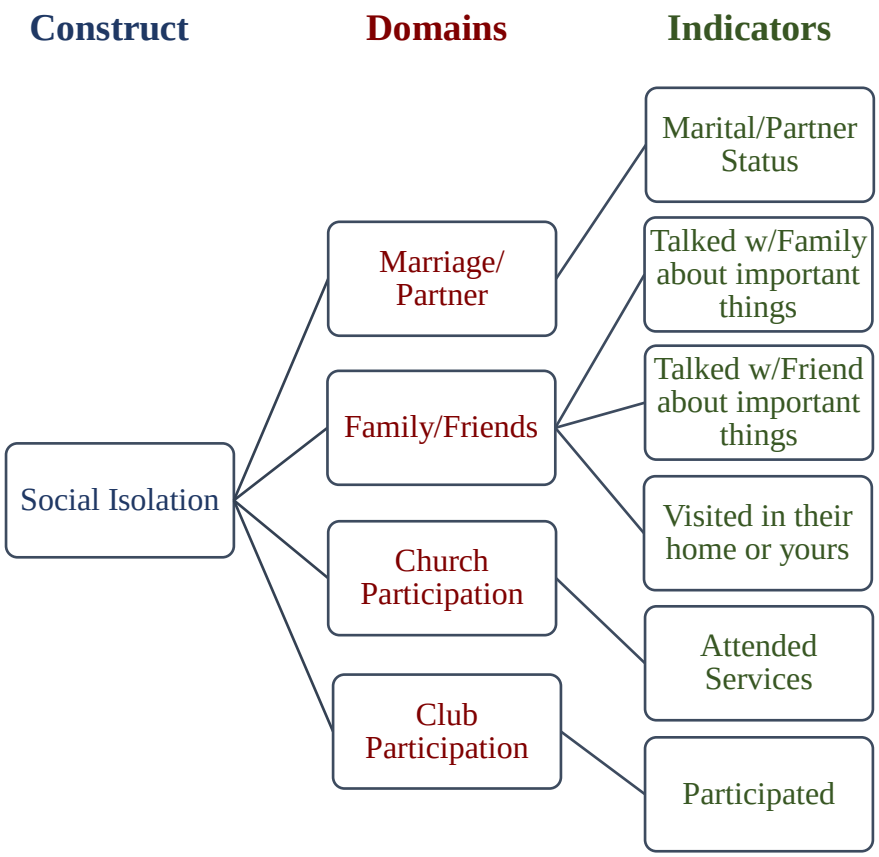


Table 1
Social Isolation Construct, Round 1 NHATS data

Domain	**Indicator Questions**	**Indicator Responses**
Marriage/Partner	Are you currently married, living with a partner, separated, divorced, widowed, or never married?	Separated; Divorced; Widowed; Never Married
Family and Friends	Looking back over the last year, who are the people you talked with most often about important things?	No family identified No friend identified
	In the last month, did you ever visit in person with friends or family not living with you either at home or theirs?	No
Church Participation	In the last month, did you ever attend religious services?	No
Club Participation	In the last month, did you ever participate in clubs, classes or other organized activities?	No

Note.
No = 1 point / Yes = 0 points
Range = 0-6
Indicator scores are summed to create the social isolation construct score
Higher score indicates more isolation

The measures in this analysis are limited to the variables that are available in the NHATS data. Loneliness was not available in the data. However, loneliness is strongly associated with depression (Holvast et al., 2015), making depression a close approximation to loneliness and useful for establishing convergent validity for the social isolation construct developed in this study. NHATS uses questions from the Physician's Health Questionnaire-2 (PHQ-2), which is a brief screening instrument for *depression* that asks about the frequency of depressed mood and anhedonia over the past 2 weeks, (Lowe et al., 2010). The PHQ-2 has demonstrated criterion

and construct validity as a brief depression screening measure (Kroenke, Spitzer, & Williams, 2003). The possible scores for the PHQ-2 range from 0-6 (See Table 2), with a higher score indicating the need for further depression assessment (Lowe, 2009). Kroenke et al. (2003) indicated that 3 and above was the optimal cutpoint for screening purposes. The reliability and validity of this measure has been documented in the general population (Kroenke et al, 2003; Lowe et al., 2010).

Table 2
Physician's Health Questionnaire-2 (PHQ-2)

Question Anchor	**Questions a & b**	**Potential Responses**
Over the last month, how often have you:	a. had little interest or pleasure in doing things? b. felt down, depressed, or hopeless?	0-Not at all 1-Several days 2-More than half the days 3-Nearly every day

Note.
Score is the sum of both a & b item responses - Range = 0-6
Scores ≥ 3 indicate the need for further depression assessment

Analysis

NHATS data, available online in SAS and STATA formats, were converted to SPSS 23 files (IBM Software), which supports analysis of complex datasets. Frequencies were examined and uncodeable response (missing; don't know; refused to answer; and inapplicable responses) were identified. Study demographic variables had from 1.1% – 14.2% uncodable responses. The social isolation construct and depression variables had 7.7% and 7.8% uncodeable responses respectively.

Statistical plan

This analysis reports with NHATS raw unweighted data and weighted data. Analytic sample weights were used to account for unequal probabilities of selection into the NHATS

sample. The weights account for differential selection of two subgroups and were adjusted for nonresponse. The subgroups were an oversampling of Black individuals and those over 90 years of age. Variance estimates were calculated using a Taylor series linearization. The computation of sample errors with this approach mathematically approximates a nonlinear statistic with a linear form, and then the variance of the nonlinear statistic is approximated by the variance of the linear function (Montaquila, Freedman, Spillman, & Kasper, 2012). Data management and statistical analysis were performed with SPSS version 23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).

The convergent validity of the social isolation construct was determined by examining the relationship between the social isolation construct and the depression scale using the unweighted data and a Pearson's (r) correlation procedure. It was expected that the Pearson's correlation would be low-moderate in strength, positive and significant.

Results

The distribution of the demographic, household and health characteristics of the sample at round one (baseline) are reported according to social isolation construct scores in Table 3. The mean age of the participants was 78.4 (SD = 8.2), and the mean age of those who were isolated was 80.6 (SD = 8.45). Females represent 59.7% of the sample and 58.2% of those who are isolated. White non-Hispanics represent 69.4% of the sample and 73% of those who are isolated. Interestingly, those with no-school through 12th grade with no diploma represent 27.2% of the sample and 37.3% of those who are isolated. Those with associate through graduate degrees represent 25.4% of the sample and only 14.4% of those who are isolated. Those who live alone represent 32.6% of the sample and 48.4% of those who are isolated. Those who report poor health represent 7.9% of the sample and 14.9% of those who are isolated. Those who score

above the cutpoint of 3 or greater for depression represent 16.0% of the sample and 23.6% of those who are isolated.

Table 3:
Distribution of Demographic, Household, and Health Characteristics According to Social Isolation R1 Status; N = 7609

Characteristics	Socially isolated [a] Yes (weighted %)	No (weighted %)	P-Value [c]
Age			< 0.001
65 – 69 years	237 (19.2)	1172 (30.4)	
70 - 74	318 (21.4)	1261 (25.9)	
75 - 79	320 (17.1)	1193 (19.6)	
80 - 84	419 (17.4)	1086 (13.9)	
85 - 89	366 (15.7)	587 (7.3)	
90 +	323 (9.2)	327 (2.9)	
Gender			0.178
Female	1217 (58.2)	3221 (56.2)	
Race/Ethnicity			
White, non-Hispanic	1181 (73.9)	4005 (83.6)	< 0.001
Black, non-Hispanic	546 (11.6)	1116 (7.3)	
Hispanic	152 (9.4)	302 (6.1)	
Other	76 (5.1)	143 (3.1)	
Education			< 0.001
No-school – 12th grade/no diploma	832 (37.3)	1215 (17.4)	
High school graduate – some college	863 (48.3)	2697 (49.2)	
Associate degree – graduate degree	251 (14.4)	1655 (33.4)	
Household			< 0.001
Lives alone	908 (48.4)	1566 (24.6)	
Overall Health Self Report			< 0.001
Excellent	151 (8.7)	787 (16.5)	
Very good	357 (19.4)	1672 (32.3)	
Good	573 (28.4)	1853 (31.3)	
Fair	581 (28.6%)	1026 (15.5)	
Poor	318 (14.9)	285 (4.4)	
Depression (PHQ-2) [b]			< 0.001
Score ≥ 3 cutpoint	493 (23.6)	725(12.0)	

Note.
[a] Social isolation construct range = 0-6, ≥ 4 = socially isolated
[b] Physician's Health Questionnaire-2 (PHQ-2) range = 0-6, ≥ 3 = depression merits more screening
[c] Significance based upon adjusted F and its degrees of freedom, (weighted sample)

Indicators of the Social Isolation Construct

Data regarding the indicators of the social isolation construct suggest that less than half of the sample were not married or living with a significant other. Four times as many participants reported not talking with friends as not talking with family members. Eight times as many participants reported visiting with friends and family in their homes or others' homes than those who don't. Less than half of the sample did not attend church services, and one and a half times as many did not participate in club or group activities as those who did. (See Table 4).

Table 4: *Characteristics of the NHATS Round 1 Sample according to Social Isolation Construct Indicators*

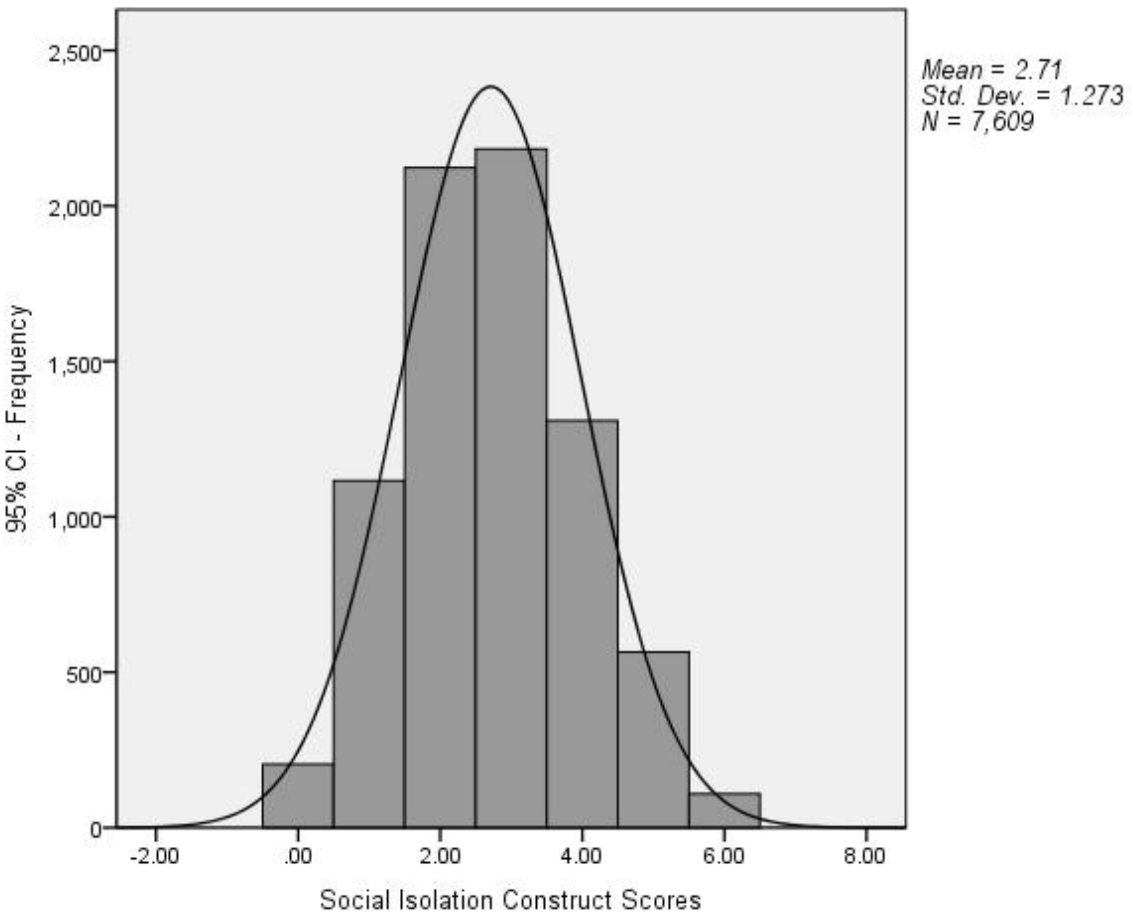
	Marital Status *n* = 7600	Family Talk *n* = 7578	Friend Talk *n* = 7578	Visit Home *n* = 7602	Attend Services *n* = 7602	Club or Group *n* = 7602
No*	43.0%	17.9%	77.6%	12.5%	43.2%	62.7%

Note.
*Each No response = 1 point, points are summed = social isolation construct score
Social isolation scores of 4, 5, or 6 = socially isolated, *n* = valid observed cases, (weighted %)

Distribution of Social Isolation Construct Scores

The distribution of the social isolation construct scores is shown in Figure 2 (with a normal distribution line superimposed). The kurtosis (*SE*) = -0.35 (0.06) and the skewness (*SE*) = 0.20 (0.03). Those who scored ≥ 4 (cutpoint) represent 21.9% (*CI* = 20.6 – 23.3) of the sample.

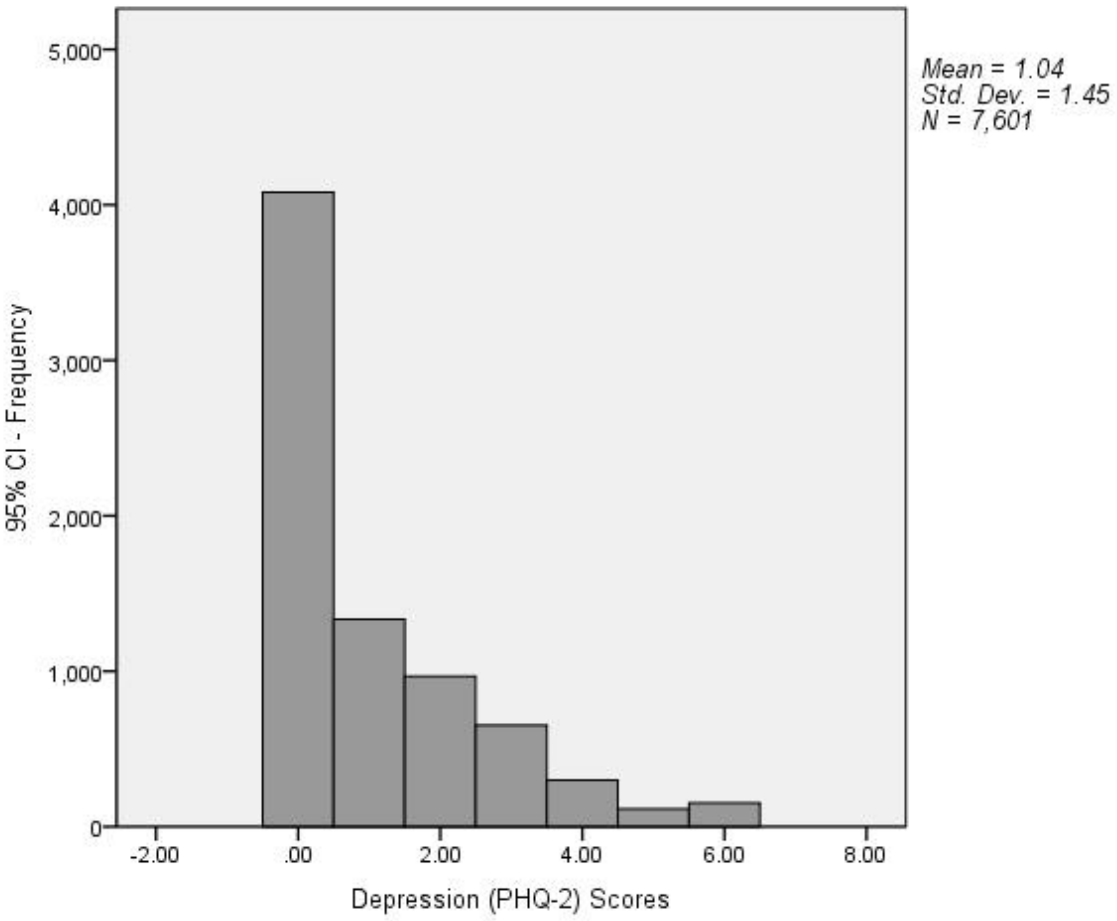
Figure 2: *Distribution of Social Isolation Scores*



Distribution of Depression Scores

The distribution of the depression scores is shown in Figure 3. The distribution is skewed to the right (*M* = 1.04; *SD* = 1.45; *Median* = 0.00; *Mode* = 0.00). The kurtosis (*SE*) was 1.72 (0.06) and the skewness (*SE*) was 1.49 (0.03). Those who scored ≥ 3 (cutpoint) represent 14.5% (*CI* = 13.4 – 15.8) of the sample. This measure asks about the frequency of depressed mood and anhedonia over the past 2 weeks. Higher scores indicate the need for further depression assessment (Lowe, 2009).

Figure 3: *Distribution of Depression Scores*



The Relationship: Social isolation construct and the depression measure (PHQ-2)

Using NHATS round one data to test the relationship between the social isolation construct and the depression scale, the unweighted Pearson's *r* was 0.23 and was significant at the 0.01 level (2-tailed). The Pearson's *r* suggests that the covariance between the social isolation construct and the depression scale was low-moderate, positive and significant.

Discussion

Relevant to older adults' health, this study was the first to examine a well-conceptualized, comprehensive, and domain-inclusive social isolation construct created with data from the

National Health and Aging Trends Study (NHATS). Measuring social isolation in this way may be particularly useful for future research and social isolation intervention development.

The Pearson's correlation between the social isolation construct and the depression measure suggests the construct's convergent validity. The interpretation of the correlations was based upon previous literature that examines the strength of the correlation for depression with social isolation. Generally, when testing the relationship between two theoretically similar constructs such as these, a higher correlation may be expected. However, analyses of psychosocial variables documented in the research literature show findings similar to this study. In Nicholson's (2010) longitudinal study, the average Spearman (*rho*) correlation at each data collection point was reported as 0.17 and statistically significant at the $p < 0.05$ level. Burnette and Myagmarjav (2013) reported a Pearson's (*r*) correlation coefficient between depression and social isolation of 0.31 that was statistically significant at the $p < 0.001$ level. Among most psychosocial variables, significant correlations are typically in the 0.20 to 0.40 range (Polit & Beck, 2012). The convergent validity in this study was demonstrated by a 0.23 Pearson's (*r*) that was significant at the .001 level, and these results support the use of this measure with the NHATS sample. This approach is consistent with other research documenting the relationship between other measures of social isolation and depression (Dorfman et al., 1995; Ebner et al., 2013; Lee et al., 2013).

The Social Network Index (SNI) has been used in research since the Alameda Study that brought the predictive validity of the measure into light (Berkman & Syme, 1979), and variations of this measure are described in many other study reports. The index has been used in psychological and behavioral research, (Bassuk et al., 1999) (Pantell et al., 2013; Shankar et al., 2011) but it is found most often in physiological research studies (Eng, Rimm, Fitzmaurice, &

Kawachi, 2002; Ford et al., 2006; Heffner et al., 2011; Loucks, Berkman, Gruenewald, & Seeman, 2005). All but one study using the SNI described the index as a measure of social networks and integration by measuring the positive responses to the domain questions. Shankar et al (2011) used the SNI to measure social isolation specifically, in a similar fashion to this current study by measuring the negative responses to the domain questions. The convergent validity analysis reported in this study along with the history of the SNI predictive validity suggest construct validity of the measure developed with the NHATS data.

The talk with family and friend indicator in this current study was given more weight (i.e., scored separately) in calculating the social isolation construct score, because family has been found to have predictive strength in falls research using the Lubben Social Network Scale (Faulkner, Cauley, Zmuda, Griffin, & Nevitt, 2003). The greater weight given to the family and friend domain for the social isolation construct is also consistent with research indicating that the number of social ties is the critical factor in social isolation (Berkman, 1977). This construct highlights the importance of social ties by considering talking with family, talking with friends and visiting in their home as part of the family and friend domain.

The strength of this study is that it builds upon the strong history of the SNI and the NHATS sample was nationally representative sample of Medicare beneficiaries ages 65 and older. Limitations are found in the fact that the frequency of contact is not available in the data set. The original SNI does measure the frequency of family and friend contact (Berkman & Syme, 1979). The subsequent use of the SNI varies widely in the extent to which indicator frequency is measured, (Bassuk et al., 1999; Eng et al., 2002; Ford et al., 2006; Heffner et al., 2011; Loucks et al., 2005; Pantell et al., 2013; Shankar et al., 2011).

While not the first study to measure social isolation, this is the first study to develop a measure for use with the NHATS data, which has strong implications for future work. The manner in which the Social isolation construct was developed using the NHATS data will make it possible to examine the strength of social isolation as a predictor of health outcomes in future research.

Conclusion

This social isolation construct is a well-conceptualized, comprehensive, and domain-inclusive social isolation measure that adds conceptual clarity and a multiple indicator measure that can be compared across studies and contribute to the development of a cohesive body of social isolation knowledge. A cohesive body of social isolation knowledge will enhance intervention development. Single item measures, such as living-alone, do not allow for research that can identify the elements of isolation and thereby promote the development of relevant social isolation interventions. The ability to conduct robust research that allows for the examination of social isolation indicators may add to the body of knowledge that will have a positive impact on gerontological practice and policy.

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CHAPTER IV: Manuscript #3

FALLS AND THE SOCIAL ISOLATION OF OLDER ADULTS: A secondary analysis of data from the National Health and Aging Trends Study (NHATS)

Social isolation and falls in older community-dwelling adults can have life-altering outcomes that may impact the individual and society. While evidence that supports an association between these two gerontological conditions is described below, the nature of that relationship is not well understood. The societal impact of social isolation and falls in the near future may be largely related to trends in aging. The population of older Americans has increased ten-fold in the last 100 years, and by 2030 it is expected that 70 million or 20% of Americans will have passed their 65th birthday (Johnson, Bulot, & Johnson, 2008). Cacioppo and Hawkley (2003) declared that the "old-old" populace, those over 85, is the fastest growing portion of the population in general. Further, the number of centenarians (those 100+ years old) is projected to swell from 65,000 in 2000 to 381,000 in 2030 (Johnson et al., 2008). There are multiple societal factors related to social isolation. The projected increase in the number of older adults, plus changes in marital and childbearing patterns in the US are expected to lead to an increasing number of older adults who live alone and do not have a spouse or a child living with them (Cacioppo & Hawkley, 2003). The preference of most individuals to "age in place" may result in a burden for family (Horner & Boldy, 2008; McDonough & Davitt, 2011).

The impact of social isolation on the health of older adults is seen in both psychological and physical health. There is a wide range of health outcomes associated with social isolation including cognitive function, depression, general health, cardiovascular disease, cancer, and mortality (Courtin & Knapp, 2015; Uchino, 2006). Social interaction is important for preserving

mental functioning in older adults, and a low social network is a risk factor for cognitive impairment (Bassuk, Glass, & Berkman, 1999; DiNapoli, Wu, & Scogin, 2014; Wang, Karp, Winblad, & Fratiglioni, 2002). Being socially isolated is also associated with depression (Iliffe et al., 2007; McCrae et al., 2005; Shub et al., 2011), and those who have fewer social contacts curtail activities due to a fear or *worry about falling* (Howland et al., 1998). Coyle and Dugan (2012) found that those who reported social isolation had a 43% higher odds of also reporting fair or poor health. Individuals who are *depressed* and individuals who report *poor health* may participate less often in healthy activities or more often in risk-taking behavior which may then lead to further decrease in health or accidents. Additionally, social isolation has been found to impact health-related behaviors and is associated with both smoking and low physical activity (Pantell et al., 2013; Shankar, McMunn, Banks, & Steptoe, 2011).

The outcomes of falls in the older adult population can be devastating in both human and financial terms. Rubenstein and Josephson (2002) reported that up to 39% of falls in older adults cause serious injuries that can restrict mobility, decrease quality of life, and increase the risk of premature death. The risk of falling is closely associated with *gait, balance, strength, the use of a mobility device and deficits in activities of daily living* (Steven & Phelan, 2013). Falls are the leading cause of injury-related death among older adults (Haegerich et al., 2014) and account for 6% of all of their healthcare costs (Lach, 2010). To further punctuate the financial impact of falls, an economic analysis conducted by the Centers for Disease Control and Prevention (CDC) estimated the direct cost of all fall injuries in 2000 to be 1.9 billion dollars, and in 2013 this direct cost jumped to $34 billion (CDC, 2015). This number is expected to increase as the population ages and may reach $67.7 billion by 2020 (National Council on Aging, 2015). Understanding the potential impact and costs of social isolation and falls for the community-

dwelling older adult population, underscores that these two gerontological conditions warrant examination.

The problem is a lack of conceptual clarity regarding social isolation and an abundance of social isolation measures, both of which limit our understanding of the relationship between social isolation and falls and make comparing studies difficult. In the research literature only two published studies that investigated the connection between these conditions measured indicators of social isolation rather than just living-alone status (Cwikel, 1992; Faulkner, Cauley, Zmuda, Griffin, & Nevitt, 2003). Both studies reported a significant relationship between social isolation and falls but do not identify a temporal element of the relationship. The Cwikel study used indicators that measure social interactions and organized social interactions. The Faulkner et al. study used the Lubben (LSNS) assessment of gerontological social integration (Lubben, 1988). Faulkner et al. suggested strong family networks may protect against the risk of falls in older community-dwelling adults, although it also found that strong friend networks may not offer similar protection. Living-alone is the social isolation measure that is evident most often in the literature regarding the association between social isolation and falls (Elliott, Painter, & Hudson, 2009; Flabeau et al., 2013; Kharicha et al., 2007). While living-alone status makes for an interesting proxy measure for social isolation, using this measure excludes indicators of social participation and may not be a sufficient measure of isolation, because older adults are more likely to live alone and may continue to have connections to their social network (Lubben, 1988). The evidence regarding the importance of family versus friends (Faulkner et al. 2003) in predicting a fall indicates that social isolation should be measured in falls research with a multidimensional measure that captures variations in the nature and extent of social interaction with family, friends and others.

A clearer understanding of the association between these two gerontological conditions is needed to support the development of fall prevention interventions and a broader implementation of relevant best practices. The objectives of this study were to: (1) report the incidence of falls and prevalence of social isolation; and (2) examine the extent to which social isolation at one point in time predicts falls a year later in a nationally representative sample of older adults.

Methods

This was a cross-sectional, as well as longitudinal secondary analysis. Data from the National Health and Aging Trends Study (NHATS) round one (2011), round two (2012), round three (2013), and round four (2014) were analyzed (http://www.nhats.org/). NHATS is a resource for the scientific study of functioning in later life and is conducted by the Johns Hopkins University Bloomberg School of Public Health, with funding from the National Institute on Aging. It was designed to support the study of disability trends and dynamics in a national sample of non-nursing home Medicare beneficiaries, ages 65 years or older (About NHATS, 2015).

Sample

Random subsamples from the Centers for Medicare and Medicaid Services' Medicare enrollment database served as the sampling frame for NHATS (Montaquila, Freedman, Edwards, & Kasper, 2012). A three-stage sampling plan included selection of: (1) 95 primary sampling units (PSUs—individual counties or groups of counties) from the contiguous United States (i.e., excluding Alaska, Hawaii, and Puerto Rico); (2) 655 secondary sampling units (SSUs -- ZIP codes or ZIP code fragments within sampled PSUs); and (3) beneficiaries who were age 65 and older as of September 30, 2010. Protocols were approved by the Johns Hopkins University institutional review board, and all study participants provided written informed consent. The

Human Subjects Division, University of Washington confirmed that this current secondary analysis of NHATS data does not meet the definition of research involving human subjects. Face-to-face annual interviews were conducted by trained personnel. The sample person interviews for each year were conducted with the same participants from the previous year. Thus, the participants age over the four years and the sample is smaller each year**.** The sample person is synonymous with *participant* in this study. If the sample person (SP) could not respond, a proxy was used. Reasons for proxy use in NHATS are dementia or cognitive impairment reported by proxy, SP is too ill, speech or hearing impairment, language barrier, or the SP is temporarily unavailable. NHATS round one achieved a 71% weighted response rate with 8,245 complete cases; the round two weighted response rate was 85.3% with 7,075 complete cases; the round three weighted response rate was 87.4% with 5,799 complete cases; and the round four weighted response rate was 89.5% with 4,737 completed cases (Kasper & Freeman, 20015). Participants who resided in the community and were administered the sample person interview were included in the first round of this study (n = 7,609). These individuals resided in their own homes or in a group home that was not a nursing home. Starting in round two, and as a small number of participants transitioned into nursing homes, the *sample person interview* was also administered to these same participants, such that round two n = 6,056 (includes 64 [1.06%] nursing home residents); round three n = 4,884 (includes 81 [1.66%] nursing home residents); and round four n = 4,037 (includes 96 [2.38%] nursing home residents). Inclusion criteria for this current analysis was participation in the NHATS study and a completed sample person interview in the data base. No exclusion criteria were used.

Measures

Outcome variable. Several questions regarding falling were included in the interviews, and the possible responses were yes/no. The questions were asked after the participants were given the following definition of falling, "By falling down, we mean any fall, slip, or trip in which you lose your balance and land on the floor or ground or at a lower level." The outcome variable for this study was assessed by asking participants if they had experienced a fall in the last 12 months. Participants were also asked if they worried about falling last month, and the possible responses were yes/no.

Independent variable. Social isolation is the independent variable in this study and was operationalized as a comprehensive, and domain-inclusive construct (See Figure 1). The construct was based upon the Social Network Index (SNI) used by Berkman and Syme (1979) and Nicholson (2010). The indicators include marriage/partner status, talked with family, talked with friends, visited in family or friend's homes or own, attended religious services, and participated in club/community activities. Table 1 contains the social isolation construct with indicator questions and response options.

Figure 1
Conceptualization of the social isolation construct

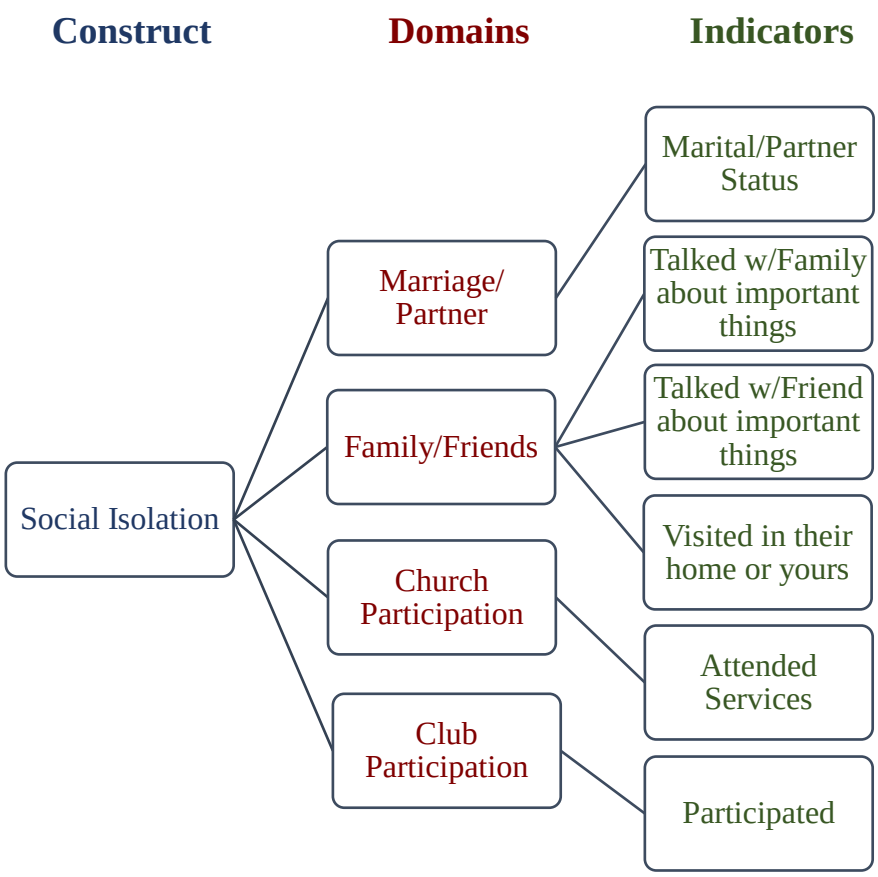

Table 1
Social Isolation Construct

Domain	Indicator Questions	Indicator Responses
Marriage/Partner	Are you currently married, living with a partner, separated, divorced, widowed, or never married?	Separated; Divorced; Widowed; Never Married
Family and Friends	Looking back over the last year, who are the people you talked with most often about important things?	No family identified No friend identified
	In the last month, did you ever visit in person with friends or family not living with you either at home or theirs?	No
Church Participation	In the last month, did you ever attend religious services?	No
Club Participation	In the last month, did you ever participate in clubs, classes or other organized activities?	No

Note.
No = 1 point / Yes = 0 points
Range = 0-6
Indicator scores are summed to create the social isolation construct score
Higher score indicates more isolation

Previous research has found that family and friend contact differs in the predictability of falls (Faulkner et al., 2003), and being able to identify the type of contact may be important to future research. The greater weight given to the family and friend domain for this social isolation construct is theoretically appropriate, because research indicates that the extent to which one has family and friend social ties is the critical factor in evaluating social isolation (Berkman, 1977). To measure social isolation, one score is recorded for a negative response to each indicator. The possible range of scores is 0 – 6. A higher score indicates more social isolation. The ordinal

measure was categorized such that a score of 4, 5, or 6 represented being socially isolated. This categorization included a medium isolation score represented by scores of 2 or 3; and a least isolated score represented by scores of 0 or 1. Placing participants into tertiles (Pascoe et al., 2013; Reginold et al., 2013) and quartiles (Nicholson, 2010; Rutledge, Matthews, Lui, Stone, & Cauley, 2003) based upon social measure scores is often done in social network research when comparing those who are and are not engaged in a social network.

Demographic variables. Age, sex, self-identified race and ethnicity and education, as reported in the baseline interview in 2011 are included as demographic variables. Race and ethnicity were categorized into white, non-Hispanic; black non-Hispanic; other non-Hispanic including American Indian/Asian/Native Hawaiian/Pacific Islander; or Hispanic. Nine education levels were collapsed into three: No-school – 12th grade/no diploma, High school graduate – some college, and Associate degree – graduate degree.

Covariates. Selected for this study are variables available in the NHATS database that are associated with or predictive of falls are included in this study (Ambrose, Paul, & Hausdorff, 2013; Berry, Lee, Cai, & Dore, 2013; Mets, Volkerts, Olivier, & Verster, 2010; Stevens & Phelan, 2013; Stone, Ensrud, & Ancoli-Israel, 2008; Tinetti, Gordon, Sogolow, Lapin, & Bradley, 2006). Variables available in the NHATS database that are associated with social isolation are also included in this study (Bassuk et al., 1999; Coyle & Dugan, 2012; DiNapoli et al., 2014; Iliffe et al., 2007; McCrae et al., 2005; Pantell et al., 2013; Seeman, 2000; Shankar et al., 2011; Shub et al., 2011; Wang et al., 2002).

Behavioral covariates. Living-alone or with others was a household characteristic asked of participants and is included as a measure in this study, because this is the most frequently reported study measure of social isolation related to falls. The use of sleep medicines was

assessed and was reported in this study as yes or no. Cigarette smoking was assessed by asking participants if they smoke now. The possible answers were yes/no. Sensory impairment was assessed by asking if a hearing device was used in the last month and if glasses or contacts are needed to see things at a distance. The possible answers were yes/no. Activities of daily living scores were assessed with questions regarding help needed for dressing, eating, bathing, and toileting. Higher scores indicated more help was needed. (Fillenbaum & Smyer, 1981; Katz, 1983). Instrumental activities of daily living scores were assessed with questions regarding help needed for performing laundry, shopping, cooking hot meals, handling bills and banking, keeping track of medications, and driving. Higher scores indicated more help was needed (Lawton & Brody, 1969).

Physical function covariates. The use of assistive-mobility devices was assessed by asking if in the last month a device (cane; scooter; walker; and/or wheelchair) was used. The possible answers were yes/no. Physical activity was assessed with two questions that asked participants if they ever go walking and if they ever spend time doing a vigorous activity that increases their breathing and heart rate. The possible answers were yes/no. The Short Physical Performance Battery (SPPB) was used to measure physical performance. This assessment consists of balance stands, gait speed, and chair stands. Balance stands describe the participants' foot placement while holding the stand for 10 seconds. Foot placements include the side by side stand, the semi-tandem stand; and the tandem stand. If the participants are unable to hold the stand for a 10 seconds, the more challenging stand is not administered. Values for balance scores were summed based upon one score for a 10 second side-by-side stand and a semi-tandem stand. Two points were added to the score if the participants held the tandem stand for 10 seconds for a possible four points for balance stands. Gait speed was measured in meters per

second over a 3-meter course with the faster of two trials added to the score. Chair stands were assessed with the participants instructed to rise from a chair and return to a seated position five times while keeping their arms folded over their chest. The times were recorded. Scores ranged from 0 – 4, with 0 indicating an inability to complete the test and four indicating the highest performance. The total SPPB score was the sum of the balance stand score, the gait speed score and the chair stands score.

Health and comorbidity covariates. Participants self-reported their general health condition and rated it as excellent, very good, good, fair, or poor with a higher score indicating poorer health. Also, participants were asked if they had been told by their healthcare professional that they had a broken bone, broken hip, heart attack, heart disease, arthritis, osteoporosis, diabetes, stroke, cancer, and/or dementia. The possible answers were yes/no. Depression was identified with the Patient Health Questionnaire-2 (PHQ-2) which is an ultra-brief screening instrument for depression (Lowe, et al. 2010). The items are anchored by the question, "Over the last month, how often have you …" and include: a) had little interest or pleasure in doing things and b) felt down, depressed, or hopeless. The PHQ-2 has demonstrated criterion and construct validity as a brief depression screening measure (Kroenke, Spitzer, & Williams, 2003). The ordinal response options are rated from *not at all* to *nearly every day*. The depression score is the sum of both items. The possible scores for the PHQ-2 range from 0-6, with a higher score indicating the need for further depression assessment (Lowe, 2009). Kroenke et al. (2003) indicated that 3 and above was the optimal cutpoint for screening purposes. The reliability and validity of this measure has been documented in the general population (Kroenke et al, 2003; Lowe et al., 2010).

Data Analysis

This paper reports with NHATS raw unweighted data and weighted data. Analytic sample weights were used in this analysis and had been developed to account for unequal probabilities of selection into the NHATS sample. The weights account for differential selection of two subgroups and were adjusted for nonresponse. The subgroups were an oversampling of Black individuals and those over the age of 90. Variance estimates were calculated using a Taylor series linearization. The computation of sample errors with this approach mathematically approximates a nonlinear statistic by a linear form, and then the variance of the nonlinear statistic is approximated by the variance of the linear function (Montaquila, Freedman, Spillman, & Kasper, 2012). Data management and statistical analysis were performed with SPSS version 23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).

The demographic, household, behavioral and health characteristics of study participants from round one data were compared according to fall status in round one using chi-square and independent t-test analysis. (Table 1). Testing the relationship over time between the social isolation construct and falls was accomplished using logistic regression. The social isolation construct score in round one was placed in the model one as the independent variable. Whether the individual reported a fall in round two was placed in the model one as the dependent variable. Falls are a risk factor for nursing home placement (Lach, 2010), so the 64 participants who were residing in a nursing home in round two were not removed from the sample. For this reason, the nursing home participants in rounds three and four also remain in the sample for subsequent analysis. Pearson's *r* correlations of all the study variables were examined with round one data. Two selection criteria were used to determine adjustment covariates for the logistic regression models three and four. Variables with relationships that were significantly correlated with *p*

values at the 0.01 level (2-tailed) with both falling and social isolation, and also demonstrated a Pearson correlation coefficient strength with the social isolation construct ≥ 0.10 were considered for model testing. In social science research correlation coefficient r = 0.10 - 0.29 is considered low to moderate and r = 0.30 - 0.49 is considered moderate to substantial (De Vaus, 2002).

In model two, demographic variables were added to model one simultaneously. In model three, self-report variables were added to the model two simultaneously. In model four, the physical performance and function variables were added to model three simultaneously (See Table 2).

Table 2
Steps used for testing Falls BY Social Isolation Construct Model

Model one	Falls Round 2 BY Social Isolation Construct Round 1
Model two	Falls Round 2 BY Social Isolation Construct Round 1, Age, Gender & Education
Model three	Falls Round 2 BY Social Isolation Construct Round 1, Age, Gender, Education, General health, Depression, & Worry about falling
Model four	Falls Round 2 BY Social Isolation Construct Round 1, Age, Gender, Education, General health, Depression, Worry about falling, SPPB, Assistive-mobility device, & ADLs

Note.
Covariates added to the model as independent variables were all from Round 1 data
Assistive-mobility device = cane, walker, scooter and/or wheelchair
SPPB = Short Physical Performance Battery
ADL = Activities of daily living

Results

The mean age of the participants in round one was 78.4 (SD=8.19), in round two it was 79.2 (SD=8.04), in round three it was 79.9 (SD=7.80), and in round four it was 80.6 (SD=7.68). The characteristics of study participants are presented in Table 3 according to 2011 round one fall status. As expected the mean age in round one was higher for those who fell that for those

who didn't and those in the older age groups were more likely to fall. Females represented 56.5% of the sample and 63.5% of those who fell. Interestingly white, non-Hispanic was the only Race/Ethnicity group percentage of fallers (83.4%) that was greater than the groups representation in the sample (81.3%). Those who live-alone represent 29.4% of the sample and 32.6% of those who fell. Those who use sleep medicine represent 29.1% of the sample 38.2% of those who fell. Those who use visual correction represent 60.8% of the sample and 65.8% of those who fell. As expected those who need help with activities of daily living (ADL) represent only 10.6% of the sample and 19.9% of those who fell. Similarly, those who need instrumental activities of daily living (IADL) help represent 53.1% of the sample and 61% of those who fell. As expected those who worry about falling represent 24.8% of the sample and 44.8% of those who fell. Those who use an assistive mobility device represent 21.0% of the sample and 35% of those who fell. Those who take walks, as expected represent 62.9% of the sample and 53% of those who fell. Those who perform a vigorous activity, as expected represent 40.3% of the sample and 33.9% of those who fell. As expected the Short Physical Performance Battery mean score was less (6.57, SD = 4.02) for those who fell than for those who did not (8.14, SD = 3.6). Those who report poor health represent 5.6% of the sample and 9.9% of those who fell. As expected those who reported a comorbidity were represented as having fallen in a greater percentage than were represented in the sample. Finally, as expected the mean depression score was higher for those who fell (1.35, SD = 1.60) that for those did not fall (0.84, SD = 1.29).

Table 3
Distribution of Demographic, Household, Behavioral and Health Characteristics of Participants According to Fall Status at NHATS Round 1 (2011), N=7,609

Characteristics	Fall in the last year? Yes (weighted %)	No (weighted %)	*P*-Value [a,b]
Age *M*= 78.4, *SD* = 8.19	*Mean*=78.56 (*SD*=8.11)	*Mean*=77.15 (*SD*=7.71)	< 0.001[a]
65 – 69 years	259 (25.9)	1026 (29.1)	< 0.001[b]
70 - 74	286 (23.0)	1163 (26.4)	
75 - 79	305 (19.5)	1065 (19.2)	
80 - 84	305 (15.1)	1001 (13.9)	
85 - 89	233 (11.2)	572 (7.7)	
90 +	162 (5.3)	388 (3.6)	
Female	997 (63.5)	2946 (54.4)	< 0.001 [b]
Race/Ethnicity			
White, non-Hispanic	1115 (83.4)	3473 (80.7)	0.016 [b]
Black, non-Hispanic	295 (7.3)	1206 (8.6)	
Hispanic	96 (7.0)	306 (6.7)	
Other	31 (2.3)	167 (4.0)	
Education			0.055 [b]
No-school – 12th grade/no diploma	412 (21.0)	1338 (20.7)	
High school graduate – some college	743 (50.9)	2452 (48.8)	
Associate degree – graduate degree	382 (28.7)	1359 (30.5)	
Lives alone	523 (32.6)	1665 (28.4)	0.009 [b]
Sleep medicine used	554 (38.2)	1,319 (26.5)	< 0.001 [b]
Smokes now	117 (16.7)	415 (16.1)	0.747 [b]
Hearing device used in last month	219 (12.1)	631 (11.0)	0.525 [b]
Visual correction used in last month	1012 (65.8)	3105 (59.3)	< 0.001 [b]
ADL help needed	367 (19.9)	564(7.9)	< 0.001 [b]
IADL help needed	958 (61.0)	2716 (50.8)	< 0.001 [b]
Worry about falling	717 (44.8)	1100 (19.0)	< 0.001 [b]

Table 3
Distribution of Demographic, Household, Behavioral and Health Characteristics of Participants According to Fall Status at NHATS Round 1 (2011), N=7,609

Characteristics	Fall in the last year? Yes (weighted %)	No (weighted %)	*P*-Value [a,b]
Assistive-mobility devices used (cane; scooter; walker; and/or wheelchair)	657 (35.3%)	1190 (16.9%)	< 0.001 [b]
Ever go for a walk	790 (53.8%)	3235 (65.6%)	< 0.001 [b]
Vigorous activity [c]	461 (33.9%)	1931 (42.1%)	< 0.001 [b]
SPPB Score *M* = 7.51, *SD* = 3.91	*Mean*=6.57 (*SD*=4.02)	*Mean*=8.14 (*SD*=3.63)	< 0.001[a]
Overall Health Self Report			< 0.001 [b]
Excellent	138 (10.9)	740 (17.0)	
Very good	372 (27.4)	1516 (31.7)	
Good	466 (29.1)	1713 (31.4)	
Fair	395 (22.8)	966 (15.6)	
Poor	178 (9.9)	275 (4.3)	
Heart disease	483 (28.8)	1231 (21.9)	< 0.001 [b]
Arthritis	1011 (63.8)	2649 (48.8)	< 0.001 [b]
Osteoporosis	406 (27.8)	940 (18.4)	< 0.001 [b]
Diabetes	444 (27.9)	1212 (21.6)	< 0.001 [b]
Stroke	230 (12.7)	496 (8.0)	0.002 [b]
Alzheimer's or other dementia	127 (6.2)	213 (2.8)	< 0.001 [b]
Depression (PHQ-2) *M* = 1.04, *SD* =1.45	*Mean*=1.35 (*SD* =1.60)	*Mean*=0.84 (*SD*=1.29)	< 0.001[a]

Note.
Frequencies reported with unweighted data - % reported with weighted data
[a] Continuous variable significance based upon t-test for equality of means, (unweighted data)
[b] Categorical variable significance based upon adjusted F and its degrees of freedom, (weighted sample)

Table 3
Distribution of Demographic, Household, Behavioral and Health Characteristics of Participants According to Fall Status at NHATS Round 1 (2011), N=7,609

	Fall in the last year?		
Characteristics	Yes (weighted %)	No (weighted %)	*P*-Value [a,b]

[c] Vigorous = In the last month, did you ever spend time on vigorous activities that increased your heart rate and made you breathe harder? This includes things like working out, swimming, running or biking, or playing a sport.
SPPB = Short Physical Performance Battery – Possible scores = 1-12
Heart disease: Asked as 2 separate questions regarding heart attack and heart disease; For the purpose of this analysis they were combined into Heart disease
Depression (PHQ-2) = Patient Health Questionnaire-2 – Possible scores = 0 - 6

Round one (2011) social isolation construct score frequencies are broken out in Figure 2. Social isolation was operationalized for each participant using with this construct (un-weighted $M = 2.71$; $SD = 1.27$ and a weighted $M = 2.56$; $SE = 0.02$). A Score of 4, 5, or 6 represents being socially isolated.

Figure 2
NHATS Round One Distribution of Social Isolation Construct Scores
N = 7,609

Note: NHATS = National Health and Aging Trends Study, Scores =

The prevalence of social isolation among the NHATS sample was calculated for each of the four rounds with unweighted data and weighted data (See Table 4). Socially isolated was defined with a cutpoint of 4 or greater (See Methods). The correlation between the social isolation construct and age was positive, low-moderate in strength (r = 0.25) and significant at the 0.01 level (2-tailed), so the observed prevalence was estimated controlling for age. This prevalence calculation includes the nursing home participants in the 2012 (round 2), 2013 (round 3), and 2014 (round 4) samples. A calculation which excluded the nursing home participants was conducted, and the weighted results were not appreciably altered.

Table 4
Prevalence of Social Isolation by NHATS Round

	Socially Isolated					
Round	Mean Age (SD)	Observed Frequency	Observed Prevalence	N	Weighted Prevalence	Confidence Interval
1	78.4 (8.19)	1983	26.1%	7609	21.9%	(20.6 – 23.3)
2	79.2 (8.04)	1501	23.8%	6619	19.8%	(18.5 – 21.1)
3	79.9 (7.80)	1231	23.4%	5483	20.1%	(18.6 – 21.7)
4	80.6 (7.68)	1050	24.7%	4526	21.1%	(19.6 – 22.6)

Note. Socially Isolated = Construct score of 4, 5, or 6
NHATS = National Health and Aging Trends Study
Observed prevalence estimated controlling for age
Round 1 baseline exclusion criteria = no nursing home participants
Round 2 = 64 nursing home participants
Round 3 = 81 nursing home participants
Round 4 = 96 nursing home participants

The incidence of at least one fall event in the previous year was calculated with unweighted data and weighted data for each of the four NHATS rounds (Table 5). Participants who fell in the current year and during any of the previous study years are reported for rounds two, three and four. No history of fall data before the round one interview are available. The mean age of the sample increased from 78.4 to 80.6 years over the four years of the study, and as expected the incidence of falling also increases.

Table 5
Incidence of a Fall Reported by Round, and Those Who Fell in Any Previous NHATS Round

Falls					
Round	Observed Frequency (Incidence)	Those who fell in the current & any previous round	N	Weighted Incidence	Confidence Interval
1	1550 (22.9%)	No history reported	6765	22.4%	21.2 – 23.7
2	1278 (24.1%)	629 (49.2%)	5298	23.8%	22.5 – 25.1
3	1129 (26.3%)	736 (65.2%)	4295	25.3%	23.9 – 26.7
4	959 (27.1%)	727 (75.8%)	3545	26.2%	24.6 – 27.8

In the model one logistic regression results the intercept was significantly different from zero, indicating that the log-odds of falling (holding the predictor constant at zero) was -1.04, which was significantly different from zero, b = -1.40, (SE = 0.08), t = -17.84(56), p <.001. In this regression model, social isolation was significantly predictive of falling, b = .10, (SE = 0.03), t = 3.86(56), p <.001, OR= 1.1 (CI = 1.05 – 1.17). The observed (unweighted data) and predicted weighted probabilities of each social isolation level (score) in round one on falls in round two are presented in Table 6. For example, participants with a social isolation score of 6 had a 30.5% predicted probability of falling compared to a 19.7% predicted probability of falling for participants with a social isolation score of 0.

Table 6
Observed and LOGISTIC Regression Predicted Probabilities of Falling R2 BY Social Isolation Construct R1 Scores

Social Isolation Construct Score R1	Observed Probability of a Fall R2	Predicted probability of a Fall R2 / logistic regression
0	23.5%	19.7%
1	20.9%	21.4%
2	21.7%	23.1%
3	26.9%	24.9%
4	24.3%	26.8%
5	30.3%	28.8%
6	33.3%	30.5%

Note. R1 = 2011 Round; R2 = 2012 Round

The Pearson's *r* correlation coefficient between falls and the social isolation construct in round one was weak ($r = 0.05$), positive and significant at the 0.01 level (2-tailed). Among all the study variables, the range of significant correlations indicated little to moderate correlations with coefficients ranging from 0.03 to (-0.42). The covariates that were considered for adjustment variables in the logistic regression models were all significantly correlated with social isolation at the 0.01 level (2-tailed). The strongest of these correlations was a negative, moderate relationship between the Short Physical Performance Battery (SPPB) and the social isolation construct ($r = -0.42$). The other covariates' correlation with social isolation demonstrated the following coefficients: General Health Self-report $r = 0.281$, Depression $r = 0.231$. Worry about falling $r = 0.144$, Assistive-mobility device $r = 0.283$, Activities of Daily Living (ADL) $r = 0.292$. The general health self-report was included to represent co-morbidities in the sample.

To examine the extent to which social isolation in round one predicted a fall in round two in this nationally representative sample, a series of logistic regression models were analyzed (see Table 7). Model one includes the study's primary variables. Falls in round two is the dependent variable and the social isolation construct in round one is the independent variable. Model two includes simultaneously adding the demographic variables of age, gender, and education as

independent variables to model one social isolation. Model three includes simultaneously adding self-health report, the depression measure, and worry about falls to model two. Model four includes simultaneously adding the SPPB, assistive-mobility devices used, and ADLs to model three.

Table 7
LOGISTIC Regression Models:
Falls Round2 BY Social Isolation Construct Round 1 and Covariates Round 1

	Model 1[a] N=5,298	Model 2[b] N=5250	Model 3[c] N=5239	Model 4[d] N=4608
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
Intercept	0.25 (0.21-0.29)	0.11 (0.08-0.17)	0.06 (0.04-0.10)	0.13 (0.07-0.23)
SI Construct	1.11 (1.05-1.17)	1.08 (1.02-1.14)	1.02 (0.96-1.08)	0.99 (0.94-1.04)
Age		1.13 (1.06-1.20)	1.11 (1.04-1.18)	1.04 (0.98-1.12)
Gender		1.36 (1.14-1.62)	1.25 (1.04-1.50)	1.20 (0.99-1.46)
Education		1.00 (0.97-1.04)	1.03 (0.99-1.08)	1.02 (0.98-1.07)
General health [e]			1.15 (1.07-1.23)	1.07 (0.99-1.17)
Depression [f]			1.12 (1.06-1.92)	1.11 (1.04-1.19)
Worry about falls [g]			1.65 (1.39-1.97)	1.48 (1.20-1.82)
SPPB [h]				0.97 (0.94-1.00)
Assistive mobility device [i]				1.35 (1.02-1.76)

Table 7
LOGISTIC Regression Models:
Falls Round2 BY Social Isolation Construct Round 1 and Covariates Round 1

	Model 1[a] N=5,298	Model 2[b] N=5250	Model 3[c] N=5239	Model 4[d] N=4608
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
ADL [j]				1.06 (0.94-1.19)

Note.
CI = Confidence Interval, SI = Social Isolation
[a] Model 1 = Falls Round 2 & Social Isolation Construct Round 1
[b] Model 2 = Falls Round 2 & Social Isolation Construct Round 1, Age, Gender & Education
[c] Model 3 = Falls Round 2 & Social Isolation Construct Round 1, Age, Gender, Education, General health, Depression, & Worry about falling
[d] Model 4 = Falls Round 2 & Social Isolation Construct Round 1, Age, Gender, Education, General health, Depression, Worry about falling, SPPB, Assistive-mobility device, & ADLs
[e] General health self-report (Higher score = increased poor health)
[f] PHQ-2 = Patient Health Questionnaire-2 (Higher score = more depression)
[g]In the last month did you worry about falling?
[h]NHATS-SPPB = Short Physical Performance Battery (Higher score = better performance)
[i]In the last month, have you used a cane, walker, wheelchair, or scooter?
[j]Activities of Daily Living – (Domains of dressing, eating, bathing, toileting; Higher score = more help needed)

The social isolation construct remained significantly associated with falls in model two after adjusting for age, gender and education. This relationship was weakened by the self-reported covariates of health, depression and worrying about falls in model three. Further, when adjusted for physical performance covariates (SPPB, the use of an assistive-mobility device, and ADLs) the relationship is additionally weakened.

Discussion

This study examined the relationship between socially isolated older adults and falls over time in a nationally representative sample of adults 65 years of age and older. This study used a comprehensive and domain-inclusive social isolation construct that specifically expands on the

Social Network Index dimensions of Berkman and Syme (1979), and it was the first to examine this measure as a predictor of falls. Other studies have used various multiple indicator measures of social isolation as predictors of falls, but specific domains of the SNI have not been examined as predictive of falls. Cwikel (1992) used indicators that measure social interactions with organized social interactions and found that those who report the highest levels of social interaction report the fewest falls. Faulkner et al (2003) reported that the use of the Lubbens Social Network Scale (Lubben, 1988) did not predict falls; however, the indicators from the Lubbens Social Network Scale regarding family did significantly predict falls. This current study is not only the first to use this construct, but it is the first to investigate a multiple indicator measure of social isolation and falls with a nationally representative sample of Medicare recipients. Other studies that have examined multiple dimensions of social factors predicting falls included a nationally representative sample in Israel (Cwikel, 1992) and a sample of non-Black women from Baltimore, MD; Portland, ME; Minneapolis, MN; and Pittsburgh, PA (Faulkner et al., 2003).

The prevalence of social isolation among the participants in this study ranged over the rounds from 21.23% - 24.05%. This range is in the center of previously reported social isolation prevalence, from 2% – 43% (Greaves & Farbus, 2006; Iliffe et al., 2007; Kobayashi, Cloutier-Fisher, & Roth, 2009; Nicholson, 2012; Taylor, Herbers, Talisman, & Morrow-Howell, 2016; Victor, Scambler, Bond, & Bowling, 2000). The large variation in previous prevalence reports may have been due to differences in definition of social isolation, measurement and/or under-reporting. Social isolation decreased with age, which may indicate that contact with family, friends, or caregivers also increase with age. Consistent with the exchange theory, this may

indicate that as social networks decrease in size their density increases to compensate maintaining a steady level of social integration (Aartsen et al., 2004).

The incidence of falls among the participants in this study, who had a mean age of 78, ranged over the rounds from 22.4% - 26.2%, which is consistent with previous research. The incidence of falls among samples of community dwelling older adult with similar ages report similar rates of falls (Cwikel, 1992; Durbin, Kharrazi, Graber, & Mielenz, 2016; Maruf, Muonwe, & Odetunde, 2015). As expected, falling increased with age over the four years. A clinically important result identified in the fall incidence data is the identification of a high rate of recurrent falls. In round two of this study, 49.2% of those reporting a fall had reported a fall in round one. Among those who fell from 2012 to 2014, the ratio of those who also fell in any previous study year increased from 49.2% to 75.8%. Recurrent falls are an important risk factor for falling and for serious falls-related injury (Deandrea et al., 2010; Rubenstein, 2006; Ward et al., 2015).

This study identifies an important temporal relationship between social isolation and falls. Social isolation in year one predicted a fall in year two. The relationship remained significance when adjusted for age, gender and education. Clinically, it is important to note the positive correlation between the social isolation scores and the probability of falling. The observed probability of falling and the linear predictability of falling increased with each increase in the social isolation construct scores. While no causal relationship has been established here general health, depression, worry about falls, SPPB scores, and assistive-mobility device use in part explain that relationship. Social isolation, general health, depression, worry about falls, SPPB scores, and assistive-mobility device use were all predictive of falling in the logistic regression models.

The social isolation construct at baseline remained significantly associated with falls in round two after adjusting for age, gender and education. However, this relationship was weakened by the self-report covariates of self-reported health, depression and worrying about falls in model three. The variation between social isolation and falls is in part explained by the variation of these variables with social isolation. General health was predictive of falls in model three, but was not significant in model four. Socially isolated adults are 43% more likely to report poor health (Coyle & Dugan, 2012). Self-efficacy and self-care capacity may influence the reporting of poor health, and the use of poor health practices may lead to poor health consequences. Socially isolated older people may just resign themselves to the fact that to them ageing means lower self-care capacity and poor health and thus refrain from preventive actions or health promoting activities (Borg, Hallberg, & Blomqvist, 2006).

Depression was significantly predictive of falls in both model three and four. The relationship between social isolation and depression has been discussed in previous research as circular in which social isolation could exacerbate depression and depression could exacerbate social isolation (McCrae et al., 2005). This circular relationship makes defining the mechanism of action for the association of both concepts with falling difficult. Worry about falling was also significantly predictive of falling in both model three and four. Worry about falling has also been associated with future falls (McKee et al., 2002), and accounts for much of the variance in model three. Those who have fewer social contacts curtail activities due to a fear or worry about falling (Howland et al., 1998). Worry about falling may lead to a decreased participation in healthy behaviors and a decreased opportunity to participate in social activities.

When the physical function covariates of the Short Performance Physical Battery (SPPB), assistive-mobility device use, and ADLs are added to the model the relationship between social

isolation and falls is additionally weakened. The SPPB was predictive of falling in model four and the strongest correlation with social isolation in this study. The SPPB has been identified in previous research as an indicator of lower extremity strength that is associated with falls among older adults (Veronese et al., 2014), and physical activity has been associated with perceived social identity (Chen & Lin, 2016). The physical activity involved with visiting friends, going to church and participating with a club require a level of physical function that helps maintain physical health. Finding a level of engagement with community that is personalized can support the maintenance of an individualized level of physical functioning as the individual ages.

While the use of an assistive-mobility device accounts for much of the variance in model four, previous NHATS research has found that the incidence of falls is not associated with assistive-mobility device use (Gell, et al., 2015). In this current study the use of an assistive-mobility device is predictive of falls, and this differing result may be explained by the inclusion of the social isolation construct variable in the models. Similarly, Cwikel (1992) reported that the significance of the relationship between social isolation and falls was explained by variance in mobility level. The Activities of daily living (ADL) variable was not predictive of falls in model four. However, ADLs have been found to have a substantive relationship with falls among older adults, and the ability to perform the activities has been associated with physical frailty (Mamikonian-Zarpas & Lagana, 2015).

The findings in this study have implications for future research on social isolation and falls, given the relationship between the two is weakened by physical performance and function. The mechanism of action is not well understood, but it is possible that interventions targeting physical performance can decrease the likelihood of falls. The substantial relationship between social isolation and physical performance would indicate that interventions targeting both

variables, could have an even stronger impact on physical performance and future falls. In addition, "fall-prevention" interventions that specifically target social isolation could incorporate physical performance as a shorter-term and cost effective proxy outcome for falls. Current research suggests that developing strategies or interventions that are aimed to build not only social embeddedness but also the treatment of chronic health conditions is needed to combat social isolation (Victor & Bowling, 2012). This is a strong indicator of the connection between physical function/health and isolation. Further, investigators are calling for more research that will link risk factors of isolation and evidence of how those risk factors impact health. More research is needed to find the covariates through which the mechanism of action can be known. What is/are the lever(s) to this mechanism of action?

This study also offers evidence to support the use a comprehensive, and domain-inclusive construct as a social isolation measure in future falls research. While living-alone is suggested to be predictive of falls among older adults (Elliott et al., 2009; Flabeau et al., 2013; Kharicha et al., 2007), it is not considered to be a good measure of social isolation (Lubben 1988). Although living-alone is important to identify as a risk factor for falls, it does not add to the body of knowledge that will inform future intervention development. Additionally, the operationalization of social isolation with this construct measure may be useful for future researchers studying other gerontological health outcomes.

The large nationally representative sample from the NHATS is a strength of this study. A limitation of this study is found in the lack of fall history data. A baseline question regarding whether or not a participant had ever fallen in the past would have provided a fuller picture of fall assessment. The data offers information that only includes the previous year. Without this

information only the distribution of falls over the four years was available for analysis, and also the report of the recurrent falls reported here does not have a truly historical context.

In conclusion, the results of this study suggest that being socially isolated is a risk factor for falls, and this relationship is explained in part by the strong relationship between social isolation and physical performance. The recognition of the relationships among falls, social isolation and physical performance offers a new way to approach fall and social isolation intervention studies.

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