Review Article

Neighborhood Characteristics and Frailty: A Scoping Review

Heather Fritz, PhD, OTR/L,^{1,2,*} Malcolm P. Cutchin, PhD,^{1,2} Jamil Gharib, BS,² Neehar Haryadi,³ Meet Patel,³ and Nandit Patel³

¹Institute of Gerontology, ²Department of Health Care Sciences, Eugene Applebaum College of Pharmacy and Health Sciences, and ³Department of Emergency Medicine School of Medicine, Wayne State University, Detroit, Michigan.

*Address correspondence to: Heather Fritz, PhD, OTR/L, Institute of Gerontology, Wayne State University, 87 East Ferry Street, Detroit, Michigan 48202. E-mail: Heather.fritz@wayne.edu

Received: November 30, 2018; Editorial Decision Date: April 19, 2019

Decision Editor: Patricia C. Heyn, PhD

Abstract

Background and Objectives: Frailty is highly prevalent in later life and associated with early mortality and adverse health outcomes. The neighborhood has been identified as an important contributor to individual health, and neighborhood characteristics may contribute to frailty development. A scoping review was conducted of the peer-reviewed literature to better understand how physical and social neighborhood characteristics contribute to frailty.

Research Design and Methods: Following an established scoping review methodology, we searched four peer-reviewed databases for relevant studies published from January 1, 2008, to December 31, 2018. Data extracted from studies included study characteristics, operationalization of neighborhood, the conceptual model of the neighborhood–frailty relationship, operationalization of frailty, and study findings for associations among neighborhood variables and frailty indicators.

Results: A total of 522 articles were identified and 13 articles were included in the final data charting. Existing studies suggest that neighborhood characteristics are associated with frailty in later life. Few studies articulated a conceptual model identifying exact mechanisms through which neighborhood factors affected frailty. Studies designs were mostly cross-sectional. Longitudinal studies did not measure neighborhood characteristics over time. Studies varied considerably in how they operationalized the neighborhood. Frailty was most commonly assessed using a 5-point phenotype or a frailty index approach.

Discussion and Implications: Findings indicate that research on the relationship between neighborhood characteristics and frailty is an emerging area of inquiry. Additional studies are needed to more definitely explicate mechanisms through which neighborhoods contribute to, or protect older adults from, frailty.

Keywords: Pre-frail, Health, SES, Disadvantage, Phenotype

Frailty is an important geriatric syndrome affecting up to an estimated 80% of older adults, depending on the age group and population, with prevalence increasing markedly with age (Collard, Boter, Schoevers, & Oude Voshaar, 2012; Fried et al., 2001). Frailty signifies a decline in resilience to resist or recover from physical, physiological, and emotional stressors. Stressors can be diverse and include

events such as falls, acute illnesses, or loss of loved ones. Although the etiology of frailty is typically multifaceted and complex and therefore debated, there is agreement that frailty develops due to a loss of resilience or reserve across one or more domains of functioning (Bergman et al., 2007; Resnick, 2014; Whitson et al., 2016). In the context of frailty, acute stressors can trigger a cascade of negative

sequelae resulting in increased risk of death, disability, hospitalization, and institutionalization (Bandein-Roche et al., 2006; Ensrud et al., 2007; Rockwood et al., 2004). The negative consequences of frailty extend beyond the individual. Frailty is costly in terms of health care utilization as well and being considered a significant burden on caregivers and families (National Alliance for Caregiving and AARP, 2009). As such, frailty also is a significant social issue.

Frailty in later life is neither inevitable nor irreversible, however. Pre-frail older adults can regain non-frail resilience (Gill, Gahbauer, Allore, & Han, 2006). As not all older adults become frail, there is significant interest in identifying factors that contribute to frailty. Such knowledge can help inform preventative and restorative approaches to address frailty in later life. To date, the majority of research in this area has focused on individual-level factors that contribute to frailty. Studies suggest a wide range of individual-level factors that are associated with frailty development, such as chronically activated inflammatory responses, the presence of cardiometabolic conditions, obesity, autoimmune disorders, multimorbidity, depression, impaired cognitive function, older age, female gender, being African American, and low socioeconomic status (SES; Bergman et al., 2007; Espinoza & Fried, 2007; Mello, Engstrom, & Alve, 2014). Less attention has been paid to contexts that could also contribute to frailty development.

Neighborhood is a context that has been identified as an important contributor to individual health (Diez Roux & Mair, 2010; Kawachi & Berkman, 2003). For example, the quality of one's neighborhood has been linked to increased morbidity (Barber, Hickson, Kawachi, Subramanian, & Earls, 2016), mortality (Haan, Kaplan, & Camacho, 1987), and the degree to which individuals engage in a range of health behaviors including, healthy dietary intake and physical activity (Kent, Thompson, & Jalaludin, 2011). Frailty prevalence among community-dwelling older adults varies widely (Collard et al., 2012), which may have as much to do with the neighborhood environments of the individuals sampled as the characteristics of the individuals themselves. Those studies suggest a gap in our understanding of neighborhood influences on frailty development and how such environments may contribute to frailty above and beyond individual factors. Although there is a well-developed body of research about the relationship between neighborhoods and health in general, and an emerging body of research on neighborhoods and older adult health (e.g., Bierman, Lee, & Schieman, 2018; Lee & Waite, 2018; Smith, Lehning, & Kim, 2018; Spring, 2018; Wang, Chen, Shen, & Morrow-Howell, 2018), researchers have paid much less attention to the relationship between neighborhoods and frailty.

To address this gap in knowledge, we conducted a scoping review to systematically examine existing research on the relationship between the neighborhood environment and frailty. As with frailty, how best to define and operationalize neighborhood remains contested (Cutchin, Eschbach, Mair, Ju, & Goodwin, 2011). Ecological theories

(e.g., Bronfenbrenner et al., 1994), and the wider body of research about neighborhoods and health, however, suggest that is likely the synergistic effect of both neighborhood physical and social environments that impact health. Consequently, this review investigates both physical and social aspects of neighborhoods and their relationship with frailty.

Methods

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and used a rigorous scoping review method to systematically search the literature (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien 2010; Moher et al., 2009). Scoping reviews include many of the same procedures as systematic reviews. Scoping reviews, however, are a better methodological choice when the study goal is to examine the nature and extent of an emerging or heterogeneous body of research. Scoping reviews are also a preferred choice when a study goal is to identify trends and gaps in the literature in order to inform future research, and scoping reviews are most often undertaken when a body of research is small or emergent so as to inform decisions about whether or not to proceed with a systematic review. Scoping reviews include the following five steps: (i) defining the research question, (ii) identifying relevant studies, (iii) selecting studies that met the inclusion criteria, (iv) extracting and charting the data, and (v) collating, summarizing, and reporting the results.

Eligibility Criteria

To be included in the review, studies had to be primary studies published in English language peer-reviewed journals. We did not include gray literature. For inclusion, we required the primary or secondary aim of studies to be an examination of any type of relationship between a neighborhood-related variable and frailty. We included only studies that measured frailty using a validated instrument (including studies that used modified validated instruments). We excluded studies that referred to their sample as frail, yet only measured physical function, disability, or comorbidity, because these conditions are not synonymous with frailty (Fried, Ferrucci, Darer, Williamson, & Anderson, 2004). We did not exclude studies based on study design criteria because we wanted to capture the full breadth of the defined research area.

We required that included articles explicitly use the term neighborhood. Just as frailty is distinct from disability or multimorbidity, the concept of neighborhood is distinct from related concepts such as "community" or "environment" and is demonstrated as such in neighborhood research aforementioned. For that reason, we omitted related terms such as "community" in our search and excluded articles that did not explicitly state that they were measuring

at least one dimension of neighborhoods. Population-level data consistently suggest that increased odds of frailty are associated with increased age, and as such we expected that the majority of studies in our data set would include older adult samples. Because evidence also suggests that some populations, (e.g., African Americans) develop frailty at younger ages, and some medical conditions (e.g., renal failure) can also contribute to frailty development at earlier ages, we did not specify a minimum age criteria for participants.

Search Strategy

We searched four databases for relevant articles. Prior to commencing the review, our research team conducted preliminary searches and developed a list of search terms that best fit the research purpose and that were commonly used in each database. We used the advance search options in the CINAHL complete, Scopus (includes Embase and Medline), PubMed and Web of Science databases. The full search stream for each database is presented in [Table 1](#). The search terms [Neighborhood* OR Neighbourhood* AND Frail*OR Prefrail*] were applied to the “title/abstract” field in PubMed, the “title/abstract/keyword” field in Scopus, and the “keyword” field in CINAHL, and the “topic” field in the Web of Science database. We chose to include literature published in the previous 11 years to ensure the most up to date empirical evidence. Our search filters were, therefore, set to include literature published after January 1, 2008 to December 31, 2018.

Study Selection

The search resulted in obtaining 522 articles. A total of 224 duplicates were removed. Five authors (H. Fritz, J. Gharib, M. Patel, N. Haryadi, and N. Patel) independently performed the initial screening of the remaining 298 titles and abstracts based on specific inclusion criteria outlined earlier with an additional 258 articles being excluded. Specifically, the data set was split in half with J. Gharib and N. Patel both screening 149 articles and M. Patel and N. Haryadi both screening 149 articles. H. Fritz screened

all 298 articles. We conducted a full-text review of the remaining 40 articles, including a review of the reference lists. All articles were fully reviewed by a minimum of three researchers. H. Fritz reviewed all articles. J. Gharib and M. Patel provided the second review on 16 articles and M. Patel and N. Haryadi provided the second review on the remaining 16 articles. The reference review process led to the inclusion of four additional studies to the data set, for a total of 44 articles. Upon full review, 31 articles were removed because they did not include a neighborhood-related study variable or they did not use a validated measure of frailty, resulting in a final data set of $n = 13$ studies remaining (see [Figure 1](#)). The final data set was fully reviewed by an additional author (M. P. Cutchin). During the screening and full review stage, we resolved six conflicts over whether or not to include articles through consensus discussion and comparison of the article attributes to our eligibility criteria.

Data Extraction

All authors participated in extracting data from articles using a data extraction grid designed for the purposes of the study and based on the McMaster University’s Critical Review Form for Quantitative Studies ([Law et al., 1998](#)). Data points extracted for analysis included the following: (i) study characteristics (study design, sample size, recruitment source and location, and participant age), (ii) conceptual model of the neighborhood–frailty relationship, (iii) the operationalization of neighborhood, (iv) operationalization of frailty, and (v) study findings for associations among neighborhood variables and frailty indicators. Although all studies included measurement and analysis of additional individual-level variables, we extracted only study findings relating to the relationship between neighborhood variables and frailty variables. Variables were charted in a table format and H. Fritz and M. P. Cutchin synthesized the charted data. We comprehensively assessed the study design, conceptual frameworks, and variables of interest and compared similarities or differences across studies by design, conceptual frameworks used, and the operationalization of the neighborhood and frailty variables.

Table 1. Search Strategy by Database

Database	Full search strategy	Entries
Web of Science	((Topic = (Neighborhood*)) AND (Topic = (Frail* OR Prefrail*))) Limiters: Timespan: 2008–2018, Language: (English) 70	87
CINAHL	(Neighborhood* AND (Frail* OR Prefrail*)) Limiters: Published Date: 20080101-20181231; English language	38
PubMed	(Frail*[Title/Abstract] OR Prefrail*[Title/Abstract] AND Neighborhood*[Title/Abstract]) Limiters: Published in the last 11 years	271
Scopus	TITLE-ABS-KEY (Neighborhood* AND (Frail* OR Prefrail*) AND PUBYEAR >2007 Limiters: English	126

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009 flow diagram.

Neighborhood environments are complex, composed of social and physical dimensions that may operate together to protect the individual from, or exacerbate, frailty development. As such, we wanted to examine how studies defined neighborhood in terms of attributes and geographic size as well as how they conceptualized the pathways through which neighborhood characteristics contribute to frailty development. Few studies provided an explicit conceptual model, however. In the absence of an explicit model, we derived the extracted conceptual model from the description of the relationship between neighborhood features and frailty found in the introduction and background sections of the articles.

Results

Study Characteristics

The 13 studies included in this review were published between 2008 and 2018. Nine studies were cross-sectional, and four studies were longitudinal with the longest period of follow-up being 13 years (Myers, Drory, Goldbourt, & Gerber, 2014). Sample size varied considerably across the studies ranging from $n = 172$ –26,014. Studies were conducted in the Netherlands (four), the United States (four), China (two), Australia (one), England (one), and Israel (one). Mean age of study samples ranged from 54 to 85.2 years. Table 2 presents the characteristics of each study.

Conceptual Framework

Only two studies included in this review provided an explicit discussion of a conceptual or theoretical model that

guided their selection of study variables (Caldwell et al., 2017; Franse et al., 2017). We were able to infer at least a basic conceptual model from the remaining 11 studies. Of the 13 conceptual models extracted for analysis, 3 focused on neighborhood SES as contributing to frailty development through the effects that neighborhood SES has on other related health outcomes in later life (e.g., physical dysfunction or chronic disease development; Franse et al., 2017; Lang et al., 2009; Myers et al., 2014). Three studies examined neighborhood racial or ethnic homogeneity. One of those three focused exclusively on neighborhood racial or ethnic homogeneity (Aranda et al., 2011), whereas the other two studies combined racial or ethnic homogeneity with indicators of neighborhood SES (Caldwell et al., 2017; Espinoza & Hazuda, 2015). All three studies examining racial or ethnic homogeneity proposed that it could have a protective or exacerbating effect on frailty by operating through a range of social pathways (e.g., improved social cohesion, formal and informal supports, decreased social control, and increased physical disorder). Two studies conceptualized neighborhood features as contributing to frailty development through effects on physical activity among older adults (Etman et al., 2014; Yu et al., 2018).

One study proposed that the neighborhood social environment (perception of social cohesion, sense of belonging, and neighborhood security) could protect against frailty through creating a sense of safety and positive experiences, which would positively affect functioning and health (Cramm et al., 2013). The study that focused most heavily on physical neighborhood features and which included the most comprehensive list of neighborhood variables (Cramm et al., 2018), proposed that neighborhood features matter for frailty development because the absence of such features makes it difficult for older adults to create and maintain social connections. The study by Ye et al. (2018) gave equal weight to physical and social components of neighborhoods and proposed that physical and social dimensions contribute to frailty. Two studies proposed that neighborhood-level psychosocial resources or psychological stressors could contribute to or safeguard against frailty (Dent & Hoogendijk, 2014; King et al., 2017). A combined conceptual model suggests that neighborhood-level SES, racial or ethnic homogeneity, social environment, neighborhood level psychosocial stressors and resources, physical features (e.g., parks and green space, speed reducers, the number of neighborhood destinations), and neighborhood aesthetics contribute to frailty directly and indirectly through health conditions, level of physical activity, dimensions of social connectedness, social cohesion, social control, or neighborhood disorder.

Operationalization of Neighborhood

Spatial dimensions of neighborhood varied across studies. Four studies defined neighborhood as U.S. census tracts, and

Table 2. Study Author, Design, and Sample Characteristics

Author, year	Design	Country	Sample size	Recruitment source	Age recruitment criteria and mean age of sample
Aranda, Ray, Snih, Ottenbacher, & Markides, 2011	Longitudinal	United States	963	Data from 2005 and 2007 waves of the Hispanic Established Populations for Epidemiologic Studies of the Elderly	≥75 (80.7)
Caldwell, Lee, & Cagney, 2017	Longitudinal	United States	1,925	Data from two waves (2005–2006; 2010–2011) of the National Social Life, Health and Aging Project	Adults between the ages 61 and 98 (66.9) years
Cramm & Nieboer, 2013	Cross-sectional	The Netherlands	945	Independently living older adults residing in four districts of Rotterdam	≥70 (77.5)
Cramm, van Dijk, & Nieboer, 2018	Cross-sectional	The Netherlands	558	Independently living older adults residing in four districts of Rotterdam	Age criteria not stated (77.1)
Dent & Hoogendijk, 2014	Cross-sectional	Australia	172	Older adults hospitalized in a subacute geriatric evaluation and management unit	≥70 (85.2)
Etman et al., 2014	Cross-sectional	The Netherlands	408	Community-dwelling persons randomly drawn from the municipal register	≥65 (75.1)
Espinoza & Hazuda, 2015	Cross-sectional	United States	394	Data from the San Antonio Longitudinal Study of Aging (1992–1996)	≥65 (69.3)
Franse et al., 2017	Cross-sectional	The Netherlands	26,014	Data from The Older Persons and Informal Caregivers Survey Minimum DataSet	≥55 (78.0)
King, Fillenbaum, & Cohen, 2017	Cross-sectional	United States	1,740	Survivors at wave 7 of the Duke Established Populations for Epidemiologic Studies of the Elderly study	≥65 to ≤105 (78)
Lang et al., 2009	Cross-sectional	England	4,818	Community-dwelling older adults drawn from the Nationally representative English Longitudinal Study of Aging	≥50 (74)
Myers et al., 2014	Longitudinal	Israel	1,151	Post-myocardial infarction patients followed up from initial hospitalization in 1992–1993 for 10–13 years	≤65 (54)
Ye, Gao, & Fu, 2018	Cross-sectional	China	2,559	Community-dwelling older adults drawn from the Shanghai Healthy City Survey (2017)	≥60 (66.12)
Yu et al., 2018	Longitudinal	China	4,000	Community-dwelling Chinese older adults participating in the Mr. and Ms. Os	≥65 (72.2)

three studies used non-standardized definitions of neighborhood space. For example, Yu et al. (2018) set neighborhood boundaries as a 300-m buffer around participants' residences, while Etman et al. (2014) used 400, 800, 1200, and 1,600 m buffers around participants' residences to operationalize various neighborhood variables. One study operationalized neighborhood based on super output areas in England, which are administrative areas that contain a minimum of 1,000 individuals and a mean of 1,500 individuals (Lang et al., 2009). In six studies, the spatial context of neighborhood was not defined or not well enough described to know the geographic scale or population average.

Studies included in this review varied in how they operationalized neighborhood. Most studies attempted to measure more than one dimension of neighborhoods. The most commonly measured dimension of neighborhood (seven studies) was SES, "deprivation," or "disadvantage" and using indices created from predominantly economic

variables (e.g., number of households receiving public assistance, unemployment rates). Five studies examined physical neighborhood features such as the aesthetic quality, degree of physical disorder, the quantity or quality of features such as green space, walking paths, infrastructure (e.g., sidewalks and street crossings), and building conditions. Four studies included measures of the neighborhood social environment (e.g., social cohesion, sense of belonging, and social participation), and two studies measured racial or ethnic heterogeneity. The studies by Cramm et al. (2018) and Etman et al. (2014) provided the most comprehensive operationalization of neighborhood and were the only studies to include measures of safety features (e.g., presence of street crossings, speed limiters, lighting), destinations, housing options, transportation, and opportunities for civic engagement. Three studies examined neighborhood aesthetics (Cramm et al., 2018; Etman et al., 2014; Ye et al., 2018). In Table 3, we provide a description of the neighborhood variables included in each study.

Operationalization of Frailty

Roughly half of the studies (six) included in this review assessed frailty using a phenotype based on the frailty criteria used in the Cardiovascular Health Study (Fried et al., 2001). The original 5-point phenotype can be used to categorize individuals as frail, pre-frail, or robust based on the presence or absence of the following five criteria: (i) unintentional weight loss of 10 pounds or more in the prior year, (ii) weakness, (iii) exhaustion, (iv) slowness, or (v) low physical activity (Fried et al., 2001). One of the five studies used a modified 4-point phenotype (Aranda et al., 2011) because physical activity had not been measured in the Hispanic Established Populations for Epidemiologic Studies of the Elderly, from which they drew their data. Three of the remaining four studies (Caldwell et al., 2017; Dent & Hoogendijk, 2014; Yu et al., 2018) included a measure of physical activity that differed from the Minnesota Leisure Time Physical Activity Questionnaire (Richardson, Leon, Jacobs, Ainsworth, & Serfass, 1994), which was the measure used in the Cardiovascular Health Study. Three of the five studies using a 5-point phenotype categorized participants into three groups using the following cutoff scores: non-frail (score = 0), pre-frail (score = 1, 2), or frail (score = 3 or more). Two studies treated frailty as a dichotomous variable of non-frail or frail, with scores of at least 3 indicating frailty.

Four studies used a frailty index (FI) approach to measure frailty. Frailty indices consist of participant self-reports about the presence or absence of conditions or deficits on a checklist. FIs are scored by dividing the number of positive responses by the total number of deficits. Scores range from 0 to 1 with higher scores indicating an increased level of frailty. One study used the 40-item FI developed by Rockwood et al. (2004), one study used the 45-item TOPICS FI (Lutonski et al., 2013) whereas another study used a 58-item FI. The study by King et al. (2017) used an FI consisting of 28 biomarkers. One study used a threshold of at least 0.25 to define frail from non-frail (Myers et al., 2014), and one study used cutoff points of robust (0–0.09), pre-frail (0.10–0.19), and frail (≥ 0.20 ; King et al., 2017). Two of the studies using a FI did not report cutoff points for categorizing individuals as robust, pre-frail, or frail (Franse et al., 2017; Lang et al., 2009). Four studies used validated scales that did not fit either the Cardiovascular Health Study or the FI approach. Table 3 presents the frailty measures and scoring criteria for all studies.

Study Findings

Study findings varied across the sample, but were largely in support of the premise that neighborhood factors contributed directly or indirectly to frailty. In some cases, even when multiple studies focused on a similar neighborhood characteristic, the effect of that characteristic on frailty development varied. For instance, the studies that

examined the effects of racial or ethnic homogeneity on frailty had mixed results. One study (Aranda et al., 2011) found that participants living in more ethnically homogeneous Mexican American neighborhoods were at 34% decreased risk for increasing frailty compared to those living in less ethnically homogeneous neighborhood. The study by Espinoza et al. also focused on Mexican Americans but found that neighborhood effects on frailty were not significant. The study by Caldwell et al. (2017) focused on African Americans and found that living in a neighborhood with a higher proportion of African Americans was associated with increased odds of developing frailty. There is stronger support for the relationship between neighborhood SES, disadvantage or deprivation and frailty. All but one study found that lower neighborhood SES and/or greater disadvantage or deprivation was associated with increased risk for frailty. The study by King et al. (2017) did not find a relationship between neighborhood disadvantage and a biomarker index measure of frailty.

Three studies focused on neighborhood physical features and walking. One study found support for the proposition that the presence of positive neighborhood features may increase walking (which in turn may protect against frailty), but did not examine a direct pathway between neighborhood characteristics and frailty (Etman et al., 2014). The study by Yu et al. (2018), however, found that green space directly and indirectly (through walking) was associated with frailty for women, but not for men. Specifically, the authors found that female residents living in areas with more than 34% green space were more likely to experience improvement in frailty status (transition from a stage of more severe to less severe frailty) over the 2-year follow-up when compared to female residents living in neighborhoods with less green space. The studies examining the relationship between social cohesion, social belonging, neighborhood security and frailty (Cramm et al., 2013), and perceived enjoyment of the neighborhood and home area and frailty (Dent & Hoogendijk, 2014), found that their selected neighborhood-level variable (or the lack of that feature) contributed to frailty development. The study by Ye et al. (2018) examined physical and social dimensions of neighborhoods and determined a greater risk of frailty for those who perceive lower neighborhood aesthetic quality, social cohesion and social participation and those living in neighborhoods collectively described as a poorer walking environment. The findings of the analyses of neighborhood and frailty variables for all studies are presented in Table 3.

Discussion

We conducted a scoping review of existing research on the relationship between neighborhood and frailty. Studies included in this review measured both physical and/or social dimensions of neighborhoods in relation to frailty status. The majority of studies found support (either directly or

Table 3. Additional Study Details

Author, year	Conceptual model	Operationalization of neighborhood	Operationalization of frailty	Study findings
1. Aranda et al., 2011	Neighborhoods with a high density of Mexican American (MA) is health protective of MA frailty because ethnic density is associated with higher levels of social cohesion, instrumental and emotional supports, intact family structures, normative socialization and social regulation, high labor force participation, residential stability, and home ownership	<ul style="list-style-type: none"> Measured % of MA at the census tract level. Tracts coded as either a high or low ethnically dense tract (high = >60% MA; low = ≤60% MA) 	Modified 4-point phenotype based on Cardiovascular Health Study (Fried et al., 2001); the physical activity component of the phenotype was not measured; three levels of frailty (non, pre, and frail)	<ul style="list-style-type: none"> Those in high-density MA tracts had a 34% decreased risk for a negative change in frailty status compared to those living in low-density MA tracts
2. Caldwell et al., 2017	Draws on social control theory; racial or ethnic density, SES disadvantage, and residential instability lead to breakdowns in physical order and social cohesion, which lead to frailty	<ul style="list-style-type: none"> Census tract level (2000 U.S. Census) Neighborhood racial or ethnic density: % non Hispanic African American and % Hispanic SES disadvantage: proportion of individuals living below federal poverty line; number of households receiving public assistance; population 25+ with HS diploma; number of unemployed age 16+ Residential instability: number of residents who moved in past year; number of unoccupied dwellings Physical disorder: two interviewer rated questions about upkeep of participant's and street's buildings Social cohesion: participant responses to 5 Likert-type items about social cohesion in the neighborhood 	<p>Five-point phenotype based on Cardiovascular Health Study (Fried et al., 2001)</p> <p>Three levels of frailty (non, pre, and frail)</p>	<ul style="list-style-type: none"> Living in higher density African American neighborhoods was marginally associated with higher odds of frailty when compared to those in lower density African American tracts Greater physical disorder and greater residential instability were associated with higher odds of frailty; greater social cohesion was associated with lower odds of frailty

Table 3. Continued

Author, year	Conceptual model	Operationalization of neighborhood	Operationalization of frailty	Study findings
3. Cramm et al., 2018	Determining neighborhood characteristics that are desired by frail older people can be used to reflect the kinds of neighborhood characteristics that support aging in place for frail older people	<ul style="list-style-type: none"> • Neighborhood areas not defined • Neighborhood characteristics: self-report survey of 24 items based on WHO's Global Age Friendly Cities guide: outdoor spaces and buildings, transportation, housing, social participation, respect and social approval, civic participation, communication and information, and community support and health services. • Participants rated how much they missed neighborhood characteristics on a 1–5 point scale ranging from 1 (<i>not missed at all</i>) to 5 (<i>extremely missed</i>) 	<p>Tilburg Frailty Indicator to assess physical, social, and psychological dimensions of frailty</p> <p>Score range 1–15 with scores ≥ 5 indicating frailty</p>	<ul style="list-style-type: none"> • Frailty leads to greater recognition of the lack of neighborhood characteristics needed to age in place in seven of the eight domains identified by the WHO: outdoor spaces and buildings, transportation, housing, social participation, respect and social approval, communication and information, and community support and health services • Frail older people reported more difficulties in all of these domains with respect to aging in place, compared with older people who were not frail
4. Cramm et al., 2013	Supportive neighborhood characteristics, such as social cohesion, sense of belonging, and a sense of safety, could increase social support and access to resources that positively affect the physical, social, and psychological functioning of older people	<ul style="list-style-type: none"> • Neighborhood areas not defined • Neighborhood social environment: Measured using the Neighborhood Social Cohesion and Sense of Belonging Scale • Perceived neighborhood security: measured using 4 items: "the neighborhood is quiet and peaceful," "the neighborhood is spacious and roomy," "the neighborhood is safe," and "the neighborhood is orderly with good public security" • Neighborhood areas not defined • Enjoyment of home/neighborhood: measured using 4 items from the Older People's Quality of Life questionnaire (I feel safe where I live; The local shops, services and facilities are good overall; I get pleasure from my home; I find my neighborhood friendly) 	<p>TFI to assess physical, social, and psychological factors</p> <p>Score range 1–15 with scores ≥ 5 indicating frailty</p>	<ul style="list-style-type: none"> • Feeling secure in the neighborhood, social cohesion, and having a sense of belonging to the neighborhood were associated with lower rates of frailty
5. Dent & Hoogendijk, 2014	Authors suggest psychosocial resources (including enjoyment of home/neighborhood) act as a safeguard against frailty	<ul style="list-style-type: none"> • Neighborhood areas not defined • Enjoyment of home/neighborhood: measured using 4 items from the Older People's Quality of Life questionnaire (I feel safe where I live; The local shops, services and facilities are good overall; I get pleasure from my home; I find my neighborhood friendly) 	<p>Five-point phenotype based on Cardiovascular Health Study (Fried et al., 2001)</p>	<ul style="list-style-type: none"> • Higher levels of frailty $\times$ lower enjoyment of the home and neighborhood scores were associated with an increased risk for mortality, discharge to higher level care and 1-month emergency re-hospitalization

Table 3. Continued

Author, year	Conceptual model	Operationalization of neighborhood	Operationalization of frailty	Study findings
6. Etman et al., 2014	Area characteristics matter because if the area is pleasant and supportive, it will foster transportation walking among older adults; in turn, increase walking would protect against frailty development	<ul style="list-style-type: none"> • Neighborhood areas of 400, 800, 1200, and 1600 m around participants' residence were created using ArcGIS. • Area characteristics inventoried using google maps: the number of street segments, walking paths, and parks. • All other neighborhood characteristics were measured using street audits • Aesthetics: absence of dog waste, graffiti, litter, presence of trees, gardens, other greenspace, water, and parks, and maintenance of the streets, sidewalks, and benches • Functional features: presence of a sidewalk of at least 2 m wide at the left and right side of street, presence of curb cuts, benches, and waste bins, absence of sidewalk obstacles, and flatness of walking surface • Safety: presence of street crossings, speed limiters, lighting, ability to clearly see persons on the street, bicycle lanes, and speed limits • Destinations: bus stop, supermarket, bakery, vegetable store, butcher, other shops, shopping center, hairdresser, café, ATM, sport facility, community center, pharmacy, letter box, and nursing home 	<p>Identification of Seniors at Risk of Functional Loss (ISAR) scale</p> <p>The ISAR is scored from 0–5 point with scores of ≥ 2 suggesting frailty</p>	<ul style="list-style-type: none"> • The total average walking time was lower for frail compared to non-frail persons. • Frail persons had more destinations in their residential area within a buffer up to 1200 m, and more functional features within a buffer up to 800 m compared to non-frail persons • A 1-point increase in the aesthetics score (range 1–22) within 800 and 1200 m, an increase of one functional feature (range 1–14) per street within 400 m, and an increase of one destination (range 1–∞) within 400 and 800 m were each positively associated with increased transportation walking
7. Espinoza & Hazuda, 2015	Following the model of Aranda et al. (2011) earlier and testing the relationships across three types of neighborhoods	<ul style="list-style-type: none"> • Neighborhood measured at the census tract level • Neighborhood SES and assimilation to the broader society among MAs measured across three distinct levels: low-income almost exclusively MA census tracts (barrio); middle income, ethnically balanced tracts (transitional); and high income, mostly European American neighborhoods (suburbs) 	<p>Five-point phenotype based on Cardiovascular Health Study (Fried et al., 2001)</p> <p>Three levels of frailty (non, pre, and frail)</p>	<ul style="list-style-type: none"> • Neighborhood differences in frailty were not significant

Table 3. Continued

Author, year	Conceptual model	Operationalization of neighborhood	Operationalization of frailty	Study findings
8. Franse et al., 2017	Neighborhood SES contributes to frailty directly as well as indirectly through increased risk of multimorbidity	<ul style="list-style-type: none"> Dutch neighborhood “areas” not described well enough to know geographic scale or population average Neighborhood SES: based on the education level, income, and labor market position of persons living in each area code 	45-item TOPICS-FI Score range of 0–1 with higher scores indicating more frailty	<ul style="list-style-type: none"> Neighborhood SES was significantly associated with frailty. Persons living in more deprived neighborhoods had higher frailty scores compared to those living in the least deprived neighborhoods The number of comorbidities mediated the association between neighborhood SES and other frailty components, attenuations ranged between 20% and 90% There was no statistically significant association between Duke FI score and neighborhood disadvantage
9. King et al., 2017	Psychological resilience literature as basis to suggest that individuals are based in social systems, including neighborhood level stressors, that may also have an effect on frailty	<ul style="list-style-type: none"> Census tract level (1990 U.S. census) Neighborhood disadvantage Z score created from percentage of blacks, families with below poverty-level, households on public assistance, female-headed households, residents younger than 18 years, and unemployed male civilians aged 16 years and older 	Cumulative impairment lab test-based FI (the Duke FI), which consists of 28 biomarkers Score range of 0–1 with greater scores indicating greater frailty	<ul style="list-style-type: none"> Greater neighborhood deprivation was independently associated with greater individual frailty
10. Lang et al., 2009	Individual SES and neighborhood deprivation have been associated with various health outcomes but not frailty	<ul style="list-style-type: none"> Neighborhood measured at the super output area, an administrative area that contains a minimum of 1,000 individuals and a mean of 1,500 individuals Neighborhood deprivation: using the Index of Multiple Deprivation (2004), which is based on seven dimensions of deprivation: income; employment; health; education, skills, and training; barriers to housing and services; living environment; and crime Deprivation scores summarized into quartiles to protect individuals from disclosure 	58-item FI covering sensory and functional impairments, comorbidities, self-rated health, low mood or depression Score range of 0–1 with greater scores indicating greater frailty	<ul style="list-style-type: none"> Greater neighborhood deprivation was independently associated with greater individual frailty
11. Myers et al., 2014	Individual and neighborhood SES has been associated with adverse cardiovascular outcomes, and the same factors may be associated with frailty development post myocardial infarction	<ul style="list-style-type: none"> Neighborhood areas not defined Neighborhood SES: measured using an index developed by the Israel Central Bureau of Statistics, summarizing socioeconomic measures from 1995 National Census 	Rockwood 40-item FI of accumulation of deficits Score range of 0–1 with greater scores indicating greater frailty	<ul style="list-style-type: none"> Neighborhood SES was predictive of frailty development Being in the lower vs. upper neighborhood SES tertile was associated with 60% increased odds of frailty development

Table 3. *Continued*

Author, year	Conceptual model	Operationalization of neighborhood	Operationalization of frailty	Study findings
12. Ye et al., 2018	Frailty reflects an interaction among individual factors and a range of environmental elements	<ul style="list-style-type: none"> Neighborhood areas not defined. Physical neighborhood environment derived from individual ratings of neighborhood aesthetic (5-item questionnaire) and walking environment (7-item scale) Social neighborhood environment derived from individual responses on a 4-item social cohesion scale and an 8-item social participation scale Individual scores within a neighborhood averaged to determine neighborhood scores on the four measures 	<p>The FRAIL is a 5-item scale (fatigue, resistance, ambulation, illness, and weight loss) based on the Cardiovascular Health Study and the FI</p> <p>Three levels of frailty (non, pre, and frail)</p>	<ul style="list-style-type: none"> Individual level ratings of aesthetic quality, social cohesion, and social participation along with neighborhood level walking environment were inversely related to odds ratios of frailty (greater risk of frailty for those who perceive lower neighborhood aesthetic quality, social cohesion and social participation and those living in neighborhoods collectively described as a poorer walking environment) Green space directly effects frailty and indirectly effects frailty through physical activity Participants living in neighborhoods with more than 34.1 % green space (the highest quartile) at baseline were more likely to experience improvements in frailty at the 2-year follow-up than those living in neighborhoods with 0% to 4.5% green space When men and women were analyzed separately, the association between green space and frailty remained significant for men but not women
13. Yu et al., 2018	Green space fosters walking and social contact which could contribute to health and protect against frailty	<ul style="list-style-type: none"> Neighborhood as a 300 m radial buffer around each participant's residence (neighborhood unique to each older adult) Neighborhood green space: quantified using the Normalized Difference Vegetation Index, an indicator of live vegetation coverage estimated from spectral information in IKONOS satellite images 	<p>Five-point phenotype based on Cardiovascular Health Study (Fried et al., 2001)</p> <p>Three levels of frailty (non, pre, and frail)</p>	

Notes: The 5-point frailty phenotype is operationalized as the presence of the following five criteria: (1) unintentional weight loss of 10 pounds or more in the prior year, (2) weakness, (3) exhaustion, (4) slowness, or (5) low physical activity. Individuals are scored according to the following: non-frail (score = 0), pre-frail (score = 1, 2), or frail (score = 3 or more). Score ranges refer to the score range for the entire instrument. Unless otherwise stated, all findings represent fully adjusted models. Only the studies by Cramm et al., 2013, 2018, Franse et al., 2017, and King et al., 2017 used multilevel models to account for nested/hierarchical study design. FI = frailty index, ISAR = Identification of seniors at risk, MA = Mexican American, SES = socioeconomic status, TFI = Tilburg Frailty Indicator.

indirectly) for the relationship between selected neighborhood variables and frailty status.

Study Characteristics

A positive aspect of the studies included in this review was the use of relatively large sample sizes, and as such, studies appear to be appropriately powered. Yet the majority of studies were cross-sectional designs; only four used a longitudinal design. In the longitudinal studies, participant-level factors were measured at more than one time, but neighborhood variables were not assessed longitudinally. Neighborhoods change in ways that could affect hypothesized neighborhood-level pathways to frailty. For example, in some American cities the economic crisis of 2008 was associated with rapid deterioration of housing stock and physical infrastructure as well as resident turnover and social change in neighborhoods. Those changes have the potential to disrupt social networks, trust, perceived safety, aesthetic enjoyment, and use of the neighborhood environment (Fritz, Cutchin, & Cummins, 2018), which the studies reviewed here suggest could affect the progression to frailty. Conversely, neighborhood gentrification can have both negative and positive effects on older adult health (Smith et al., 2018) although the consequences for frailty per se appear to be not yet known. Because we lack knowledge about how people and neighborhoods change together over time, future longitudinal research that queries the effect of neighborhood-level changes over time could contribute new and much-needed insight about neighborhood conditions as a causal factor for frailty and frailty progression.

We also need to note that although the majority of studies included in this review found support for the association between neighborhood characteristics and frailty, there are other plausible explanations for those relationships. In particular, it is possible that concentrations of frail populations are more explanatory of poor neighborhood environments. For example, self-selection bias is a well-understood problem in neighborhoods and health research (Diez Roux & Mair, 2010). Individuals with similar characteristics and risks for frailty may “select into” particular types of neighborhoods (Wolch, 1979). For example, “service oriented ghettos” are a phenomenon in which social and health care and low-income housing options are centralized in inner city locations (Dear & Wolch, 2014). Although examinations of the geographical clustering of frail individuals around health service cores are lacking, frailty is consistently associated with lower levels of formal education and lower SES (Espinoza, Jung, & Hazuda, 2012; Szanton, Seplaki, Thorpe, Allen, & Fried, 2010). Pre-frail or frail older adults may, therefore, have fewer economic resources and as such may have few options but to live in poorer quality neighborhoods. Because of such processes and patterns of urban residential location, it would be difficult to say if frailty is a reflection of the people who reside in an area or the area characteristics.

In addition, we note that few studies were able to control for potentially important variables such as time of residence in the neighborhood. Temporality can play both a protective or exacerbating role in frailty development. More time in a neighborhood—even a relatively poor quality neighborhood—can improve one’s familiarity and connections with the neighborhood environment and people, and therefore enhance supports and quality of life. However, from a stressor exposure perspective, more time in a poor-quality neighborhood could increase the detrimental exposures that can exacerbate frailty development.

Conceptual Frameworks

Few studies provided rich conceptual or theoretical bases to support detailed hypothesis about causal pathways through which neighborhoods contribute to frailty. For example, neighborhood SES was the most commonly queried neighborhood-level variable. Authors suggested that neighborhood SES influenced frailty through contributing to adverse health outcomes such as physical disability or multimorbidity. Because not all people who have a physical disability or multimorbidity become frail, however, more conceptual clarity about the causal pathways and mediators is needed. Given the developing nature of this body of work, especially the conceptual thinking about how neighborhoods are related to frailty and its development, and acknowledging the heterogeneity of study designs (conceptual operationalization, variables, and analytical approaches) included in this review, we conclude that it would be premature to propose a conceptual model that defines an a priori conceptual framework or a post hoc framework of empirical findings. Yet we can suggest that this emerging research area is providing some strong clues that multiple neighborhood dimensions are related to frailty and its development and that further conceptual development is warranted.

It is also important to note that only one study (Cramm et al., 2018) queried residents about their perceptions of what neighborhood features were missing and that would be important to aging and frailty. This innovative view suggests that frailty status and dependence might drive the relationship with one’s neighborhood and what factors are considered most important to quality of life. This finding is supported by previous research among individuals with physical and cognitive disabilities, which suggests that perceptions of neighborhood quality and the perceived value of neighborhood characteristics differ depending on one’s capacities (e.g., Emerson, Hatton, Robertson, & Baines, 2014). Future research assessing perceptions of neighborhoods by frailty status could suggest additional dimensions of neighborhood life to be conceptualized and measured, including those that contribute to frailty as well as those important for supporting individuals at different stages of frailty development.

Operationalization of Neighborhood

Operationalization of the neighborhood construct varied across studies, and six of the studies did not define their neighborhood areas well enough for readers to know what the relevant geography was, either in terms areal size or population parameters. The unit of analysis—and therefore the reliability and validity of measures derived—are an important dimension of this and other neighborhoods and health research (Cutchin et al., 2011; Diez Roux & Mair, 2010). As with the majority of the broader neighborhoods and health research, however, attention to these intertwined conceptual, measurement, and inferential issues is lacking in these studies on neighborhoods and frailty. It is also interesting to note that in three studies, study participants effectively defined their neighborhood (Cramm et al., 2013; Dent & Hoogendijk, 2014; Ye et al., 2018) as they rated neighborhood dimensions based on their own perceptions. Neighborhood effects on frailty are always in addition to individual effects—exposure to neighborhood dimensions depends on an individual's location and patterns of activity. Thus, in addition to objective and subjective measures of neighborhood environments, mixed methods approaches that incorporate multiple perspectives on neighborhood space, such as the combination of geographical information systems approaches and qualitative interviews (Hand, Rudman, Huot, Gilliland, & Pack, 2018), may be useful to expanding the understanding of how neighborhoods effect frailty.

Another interesting finding is that socioeconomic disadvantage or deprivation was the most commonly measured neighborhood characteristic. All studies examining neighborhood disadvantage or deprivation used indices, and those indices varied in terms of the variables that were used to comprise the index. Thus, although all but one study found support for the premise that worse neighborhood socioeconomic conditions contribute to frailty, the study approaches also are not yet consistent enough in measures representing such conditions to provide evidence of replication of findings. As this research area grows and national-level data sets become more harmonized, we expect this need can and will be addressed. We also note the possibility that the inconsistent findings regarding the relationship between neighborhood ethnic homogeneity and frailty is an artifact of the correlation of lower SES and ethnic minority status; in effect, neighborhood SES may mask the effect of neighborhood minority concentration in some studies.

The other variables measured (e.g., ethnic homogeneity, social cohesion, safety, neighborhood satisfaction) tended to mirror the wider neighborhoods and health research field. Given the number of studies that have examined physical neighborhood characteristic and health more broadly we find it notable that only three studies (Etman et al., 2014; Ye et al., 2018; Yu et al., 2018) operationalized neighborhood in terms of physical environmental features. It is also important to note that although most studies included in this review measured more than one

neighborhood-level characteristic, the majority of studies reflected a very narrow view of neighborhood ecology. The exceptions to this are the studies by Cramm et al. (2018), Etman et al. (2014) and Ye et al. (2018), whose selection of neighborhood-level variables reflects a more holistic interpretation of a neighborhood's potential influence on frailty. Moreover, only five studies (Cramm et al., 2013, 2018; Franse et al., 2017; King et al., 2017; and Ye et al., 2018) used a multilevel modeling approach to address the nested, hierarchical nature of individual and neighborhood-level variables and partition the effects of neighborhood-level variables from individual-level effects. Therefore, future research on neighborhoods and frailty will be stronger after more carefully contending with key issues of the unit of analysis, more consistent measurement approaches, the physical environment of neighborhoods, and more appropriate analytical strategies.

Frailty Operationalization

The majority of studies included in this review assessed frailty using either a 5-point phenotype model based on the Cardiovascular Health Study, or an index approach. This finding is not surprising considering that those two approaches are the most popular modes of frailty assessment (Dent, Kowal, & Hoogendijk, 2016). Only one of the five studies using the phenotype approach followed the original Cardiovascular Health Study approach for measuring each of the five criteria. A recent review of the use of the frailty phenotype suggests that more often than not, studies modify how they measure at least one of the five criteria, with the activity and weight components being modified most often (Theou et al., 2015). Although the original phenotype criteria are highly predictive of adverse health outcomes and mortality, variations of the phenotype have not been systematically validated and there is a danger in accepting proxy phenotypes at face value. The results of future studies of neighborhoods and frailty may be more convincing if validated phenotype measures are followed.

The selection of frailty measures in neighborhoods and frailty research is also important because it should reflect how researchers conceptualize frailty and how they hypothesize that neighborhood factors affect frailty over time. A phenotype measurement approach assesses physical components of frailty, whereas an index approach assesses physical as well as psychosocial contributors to frailty development. In addition, an index approach accommodates variability in the constituent parts so that the measure can be adapted across settings while still remaining highly predictive of mortality and adverse health event (Rockwood, 2016). Neighborhood ecosystems are complex and include social and physical elements that likely work together to affect frailty. From a theoretical standpoint, an index approach may allow for better conceptualization of how both physical and social neighborhood elements transact to affect psychosocial and physical dimensions of frailty.

Because conceptual models and measurement issues are often interrelated, future studies should be more explicit about both their conceptualizations of how neighborhoods affect frailty and how their choice of frailty assessment aligns best with those hypothesized pathways.

Conclusions

We conducted a scoping review of studies examining the relationship between neighborhood characteristics and frailty. Findings suggest additional research is warranted. Studies included in this review suggested frailty or increases in frailty are associated with social and physical characteristics of neighborhoods where older adults live. The small number of studies and high heterogeneity among studies regarding overall design and the measurement of both neighborhood and frailty variables limits the ability to draw meaningful inferences from this emerging body of work. We suggest that future studies of the neighborhood and frailty relationship be more explicit in their conceptualization of how exactly neighborhood factors work alone or together to affect frailty. We noted the need for longitudinal designs and multilevel models including measurement of change in neighborhood variables, along with tests of mediation of neighborhood effects by various social and individual factors.

Limitations

This scoping review has limitations that must be noted. We opted to restrict our search to the previous 10 years to present the most up to date research about the relationship between neighborhoods and frailty. It is possible that expanding the search could have yielded a different data set and inferences. In addition, although we note several methodological issues with the study of neighborhoods and frailty across the studies included in our data set, we did not conduct a formal assessment of the risk for bias in the reports analyzed.

Implications

Frailty is a significant health issue in later life as well as a significant social issue. Frailty is not inevitable, however, and efforts should be taken to attenuate the risk of frailty development. Research on the relationship between neighborhood characteristics and frailty is an emerging area. From a public health perspective, intervening at the neighborhood level where older adults spend most of their time may hold promise for reducing frailty risk and better supporting aging in place. A better understanding of how neighborhoods affect frailty is a necessary precursor to conceptualizing neighborhood-level frailty prevention interventions and designing policies regarding the creation of more frailty-preventing neighborhood environments.

Results of this scoping review suggest that neighborhoods can contribute to frailty while also suggesting conceptual and methodological issues that should be addressed to enhance future studies.

Funding

This work was supported by a grant from the Michigan Health Endowment Fund: R1707-141644.

Conflict of Interest

The authors have no conflict of interest to report. The work presented does not require ethics board approval.

References

- * indicates article analyzed as part of the scoping review.
- *Aranda, M. P., Ray, L. A., Snihi, S. A., Ottenbacher, K. J., & Markides, K. S. (2011). The protective effect of neighborhood composition on increasing frailty among older Mexican Americans: a barrio advantage? *Journal of Aging and Health*, 23, 1189–1217. doi:10.1177/0898264311421961
- Arksey, H. & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology*, 8, 19–31. doi:10.1080/1364557032000119616
- Bandeem-Roche, K., Xue, Q. L., Ferrucci, L., Walston, J., Guralnik, J. M., Chaves, P., . . . Fried, L. P. (2006). Phenotype of frailty: Characterization in the women's health and aging studies. *Journal of Gerontology, Series A: Biological Sciences and Medical Sciences*, 61, 262–266. doi:10.1093/gerona/61.3.262
- Barber, S., Hickson, D. A., Kawachi, I., Subramanian, S. V., & Earls, F. (2016). Neighborhood disadvantage and cumulative biological risk among a socioeconomically diverse sample of African American adults: An examination in the Jackson Heart Study. *Journal of Racial and Ethnic Health Disparities*, 3, 444–456. doi:10.1007/s40615-015-0157-0
- Bergman, H., Ferrucci, L., Guralnik, J., Hogan, D. B., Hummel, S., Karunanathan, S., & Wolfson, C. (2007). Frailty: An emerging research and clinical paradigm—issues and controversies. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 62, 731–737. doi:10.1093/gerona/62.7.731
- Bierman, A., Lee, Y., & Schieman, S. (2018). Neighborhood disorder and sleep problems in older adults: Subjective social power as mediator and moderator. *Gerontologist*, 58, 170–180. doi:10.1093/geront/gnx049
- Bronfenbrenner, U., Husen, T., & Postlethwaite, T. N. (1994). International encyclopedia of education. *Ecological models of human development*, 3, 37–43.
- *Caldwell, J. T., Lee, H., & Cagney, K. A. (2017). Disablement in context: Neighborhood characteristics and their association with frailty onset among older adults. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences*. 1–10. doi:10.1093/geronb/gbx123
- Collard, R. M., Boter, H., Schoevers, R. A., & Oude Voshaar, R. C. (2012). Prevalence of frailty in community-dwelling older persons: A systematic review.

- Journal of the American Geriatrics Society*, 60, 1487–1492. doi:10.1111/j.1532-5415.2012.04054.x
- *Cramm, J. M., van Dijk, H. M., & Nieboer, A. P. (2018). The creation of age-friendly environments is especially important to frail older people. *Ageing & Society*, 38, 700–720. doi:10.1017/S0144686X16001240
- *Cramm, J. M. & Nieboer, A. P. (2013). Relationships between frailty, neighborhood security, social cohesion and sense of belonging among community-dwelling older people. *Geriatrics & Gerontology International*, 13, 759–763. doi:10.1111/j.1447-0594.2012.00967.x
- Cutchin, M. P., Eschbach, K., Mair, C. A., Ju, H., & Goodwin, J. S. (2011). The socio-spatial neighborhood estimation method: An approach to operationalizing the neighborhood concept. *Health & Place*, 17, 1113–1121. doi:10.1016/j.healthplace.2011.05.011
- Dear, M. J., & Wolch, J. R. (2014). *Landscapes of despair: From deinstitutionalization to homelessness*. Princeton: Princeton University Press.
- *Dent, E. & Hoogendijk, E. O. (2014). Psychosocial factors modify the association of frailty with adverse outcomes: A prospective study of hospitalised older people. *BMC Geriatrics*, 14, 108. doi:10.1186/1471-2318-14-108
- Dent, E., Kowal, P., & Hoogendijk, E. O. (2016). Frailty measurement in research and clinical practice: A review. *European Journal of Internal Medicine*, 31, 3–10. doi:10.1016/j.ejim.2016.03.007
- Diez Roux, A. V. & Mair, C. (2010). Neighborhoods and health. *Annals of the New York Academy of Sciences*, 1186, 125–145. doi:10.1111/j.1749-6632.2009.05333.x
- Emerson, E., Hatton, C., Robertson, J., & Baines, S. (2014). Perceptions of neighbourhood quality, social and civic participation and the self rated health of British adults with intellectual disability: Cross sectional study. *BMC Public Health*, 14, 1252. doi:10.1186/1471-2458-14-1252
- Ensrud, K. E., Ewing, S. K., Taylor, B. C., Fink, H. A., Stone, K. L., Cauley, J. A., ... Cawthon, P. M.; Study of Osteoporotic Fractures Research Group. (2007). Frailty and risk of falls, fracture, and mortality in older women: The study of osteoporotic fractures. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 62, 744–751. doi:10.1093/gerona/62.7.744
- Espinoza, S. E., & Fried, L. P. (2007). Risk factors for frailty in the older adult. *Clinical Geriatrics*, 15, 37.
- *Espinoza, S. E. & Hazuda, H. P. (2015). Frailty prevalence and neighborhood residence in older Mexican Americans: The San Antonio Longitudinal Study of Aging. *Journal of the American Geriatrics Society*, 63, 106–111. doi:10.1111/jgs.13202
- Espinoza, S. E., Jung, I., & Hazuda, H. (2012). Frailty transitions in the San Antonio Longitudinal Study of Aging. *Journal of the American Geriatrics Society*, 60, 652–660. doi:10.1111/j.1532-5415.2011.03882.x
- *Etman, A., Kamphuis, C. B., Prins, R. G., Burdorf, A., Pierik, F. H., & van Lenthe, F. J. (2014). Characteristics of residential areas and transportation walking among frail and non-frail Dutch elderly: Does the size of the area matter? *International Journal of Health Geographics*, 13, 7. doi:10.1186/1476-072X-13-7
- *Franse, C. B., van Grieken, A., Qin, L., Melis, R. J. F., Rietjens, J. A. C., & Raat, H. (2017). Socioeconomic inequalities in frailty and frailty components among community-dwelling older citizens. *PloS One*, 12, e0187946. doi:10.1371/journal.pone.0187946
- Fried, L. P., Ferrucci, L., Darer, J., Williamson, J. D., & Anderson, G. (2004). Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 59, 255–263. doi:10.1093/gerona/59.3.M255
- Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., ... McBurnie, M. A.; Cardiovascular Health Study Collaborative Research Group. (2001). Frailty in older adults: Evidence for a phenotype. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 56, M146–M156. doi:10.1093/gerona/56.3.M146
- Fritz, H., Cutchin, M. P., & Cummins, E. R. (2018). Loss of trust in the neighborhood: The experience of older African Americans in Detroit. *The Journals of Gerontology: Series B*, 73, e108–e119.
- Gill, T. M., Gahbauer, E. A., Allore, H. G., & Han, L. (2006). Transitions between frailty states among community-living older persons. *Archives of Internal Medicine*, 166, 418–423. doi:10.1001/archinte.166.4.418
- Haan, M., Kaplan, G. A., & Camacho, T. (1987). Poverty and health. Prospective evidence from the Alameda County Study. *American Journal of Epidemiology*, 125, 989–998. doi:10.1093/oxfordjournals.aje.a114637
- Hand, C. L., Rudman, D. L., Huot, S., Gilliland, J. A., & Pack, R. L. (2018). Toward understanding person-place transactions in neighborhoods: A qualitative-participatory geospatial approach. *Gerontologist*, 58, 89–100. doi:10.1093/geront/gnx064
- Kawachi, I., & Berkman, L. F. (Eds.). (2003). *Neighborhoods and health*. New York: Oxford University Press.
- Kent, J., Thompson, S., & Jalaludin, B. (2011). *Healthy built environments: a review of the literature*. Healthy Built Environments Program. Sydney: City Futures Research Centre, University of New South Wales.
- *King, K. E., Fillenbaum, G. G., & Cohen, H. J. (2017). A cumulative deficit laboratory test-based frailty index: Personal and neighborhood associations. *Journal of the American Geriatrics Society*, 65, 1981–1987. doi:10.1111/jgs.14983
- *Lang, I. A., Hubbard, R. E., Andrew, M. K., Llewellyn, D. J., Melzer, D., & Rockwood, K. (2009). Neighborhood deprivation, individual socioeconomic status, and frailty in older adults. *Journal of the American Geriatrics Society*, 57, 1776–1780. doi:10.1111/j.1532-5415.2009.02480.x
- Law, M., Stewart, D., Pollock, N., Letts, L., Bosch, J., & Westmorland, M. (1998). *Guidelines for Critical Review Form-Quantitative Studies*. Retrieved from: <https://srs-mcmaster.ca/wp-content/uploads/2015/05/Guidelines-for-Critical-Review-Form-Quantitative-Studies.pdf>. Accessed 17 May, 2019.
- Lee, H. & Waite, L. J. (2018). Cognition in context: The role of objective and subjective measures of neighborhood and household in cognitive functioning in later life. *Gerontologist*, 58, 159–169. doi:10.1093/geront/gnx050
- Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: Advancing the methodology. *Implementation Science*, 5, 69. doi:10.1186/1748-5908-5-69
- Lutonski, J. E., Baars, M. A., van Kempen, J. A., Buurman, B. M., den Elzen, W. P., Jansen, A. P., ... Melis, R. J. (2013). Validation

- of a frailty index from the older persons and informal caregivers survey minimum data set. *Journal of the American Geriatrics Society*, **61**, 1625–1627. doi:10.1111/jgs.12430
- Mello, A. d. e. C., Engstrom, E. M., & Alves, L. C. (2014). Health-related and socio-demographic factors associated with frailty in the elderly: A systematic literature review. *Cadernos de Saude Publica*, **30**, 1143–1168.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of Internal Medicine*, **151**, 264–269.
- *Myers, V., Drory, Y., Goldbourt, U., & Gerber, Y. (2014). Multilevel socioeconomic status and incidence of frailty post myocardial infarction. *International Journal of Cardiology*, **170**, 338–343. doi:10.1016/j.ijcard.2013.11.009
- National Alliance for Caregiving and AARP (2009). Caregiving in the US: 2009. Retrieved from http://www.caregiving.org/data/Caregiving_in_the_US_2009_full_report.pdf Accessed October 2, 2018.
- Resnick, B. (2014). Resilience in older adults. *Topics in Geriatric Rehabilitation*, **30**, 155–163.
- Richardson, M. T., Leon, A. S., Jacobs, D. R., Jr, Ainsworth, B. E., & Serfass, R. (1994). Comprehensive evaluation of the Minnesota Leisure Time Physical Activity Questionnaire. *Journal of Clinical Epidemiology*, **47**, 271–281.
- Rockwood, K. (2016). Conceptual models of frailty: Accumulation of deficits. *Canadian Journal of Cardiology*, **32**, 1046–1050. doi:10.1016/j.cjca.2016.03.020
- Rockwood, K., Howlett, S. E., MacKnight, C., Beattie, B. L., Bergman, H., Hébert, R., . . . McDowell, I. (2004). Prevalence, attributes, and outcomes of fitness and frailty in community-dwelling older adults: report from the Canadian study of health and aging. *Journals of Gerontology, Series A: Biological sciences and Medical Sciences*, **59**, 1310–1317.
- Smith, R. J., Lehning, A. J., & Kim, K. (2018). Aging in place in gentrifying neighborhoods: Implications for physical and mental health. *Gerontologist*, **58**, 26–35. doi:10.1093/geront/gnx105
- Spring, A. (2018). Short-and long-term impacts of neighborhood built environment on self-rated health of older adults. *Gerontologist*, **58**, 36–46. doi:10.1093/geront/gnx119
- Szanton, S. L., Seplaki, C. L., Thorpe, R. J., Jr, Allen, J. K., & Fried, L. P. (2010). Socioeconomic status is associated with frailty: The women's health and aging studies. *Journal of Epidemiology and Community Health*, **64**, 63–67. doi:10.1136/jech.2008.078428
- Theou, O., Cann, L., Blodgett, J., Wallace, L. M., Brothers, T. D., & Rockwood, K. (2015). Modifications to the frailty phenotype criteria: systematic review of the current literature and investigation of 262 frailty phenotypes in the survey of health, ageing, and retirement in Europe. *Ageing Research Reviews*, **21**, 78–94. doi:10.1016/j.arr.2015.04.001
- Wang, Y., Chen, Y. C., Shen, H. W., & Morrow-Howell, N. (2018). Neighborhood and depressive symptoms: A comparison of rural and urban Chinese older adults. *Gerontologist*, **58**, 68–78. doi:10.1093/geront/gnx063
- Whitson, H. E., Duan-Porter, W., Schmader, K. E., Morey, M. C., Cohen, H. J., & Colón-Emeric, C. S. (2016). Physical resilience in older adults: Systematic review and development of an emerging construct. *Journal of Gerontology, Series A: Biological Sciences and Medical Sciences*, **71**, 489–495. doi:10.1093/gerona/glv202
- Wolch, J. R. (1979). Residential location and the provision of human services: some directions for geographic research. *The Professional Geographer*, **31**, 271–277. doi:10.1111/j.0033-0124.1979.00271.x
- *Ye, B., Gao, J., & Fu, H. (2018). Associations between lifestyle, physical and social environments and frailty among Chinese older people: A multilevel analysis. *BMC Geriatrics*, **18**, 314. doi:10.1186/s12877-018-0982-1
- *Yu, R., Wang, D., Leung, J., Lau, K., Kwok, T., & Woo, J. (2018). Is neighborhood green space associated with less frailty? Evidence from the Mr. and Ms. Os (Hong Kong) study. *Journal of the American Medical Directors Association*, **19**, 528–534. doi:10.1016/j.jamda.2017.12.015