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Review article

Neighborhood safety factors associated with older adults' health-related outcomes: A systematic literature review

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ABSTRACT

Rationale: Neighborhood safety is important for older adults' health and wellbeing, but there has not been a synthesis in the literature of what is currently known about this construct.
Objectives: This systematic literature review, following the PRISMA guidelines, focuses on identifying neighborhood safety factors associated with health-related outcomes and behaviors of older adults in the U.S.
Methods: A search was conducted in 2014 via Academic Search Complete, CINAHL, Embase, MEDLINE, SportDis, and Transportation Databases. Based on our inclusion and exclusion criteria, we identified thirty-two articles for review.
Results: Sixteen studies examined health outcomes such as health status, mental health, physical function, morbidity/mortality, and obesity; the other sixteen studies focused on health behaviors, such as physical activity and walking. Four domains of neighborhood safety were identified: overall/general neighborhood safety; crime-related safety; traffic-related safety; and proxies for safety (e.g., vandalism, graffiti). Overall/general neighborhood safety appeared most relevant to mental health and physical function. Traffic-related safety was most pertinent to physical activity, while crime-related safety was more consistently associated with mental health and walking. While all safety variables were significantly associated with mental health, no significant associations were found for obesity. We also found that specific measures or constructs of safety were not applied consistently across the examined studies, making it difficult to compare the results.
Conclusion: This review identified several important gaps in the existing studies dealing with neighborhood safety-health relationships among older adults. Further studies are needed that examine the different roles of multidimensional neighborhood safety in promoting the community health, not only in the U.S., but globally.

1. Introduction

Population aging is projected to accelerate world-wide and is recognized as a global issue (WHO, 2011). The global population aged 65 or older is expected to triple from 524 million in 2010 to 1.5 billion in 2050 (WHO, 2011). In the U.S., the population over age 50 is predicted to grow from 109 million in 2010 to 132 million in 2030 with the rapid aging of baby boomers (JCHS, 2014). Understanding the link between place and health is critical to developing effective strategies for healthy living (Satariano et al., 2012), especially for older adults who may spend significant time in their neighborhood (Gardner, 2011). Previous research has suggested the significance of direct and indirect neighborhood effects on the community health (Kawachi and Berkman, 2003; Diez Roux and Mair, 2010). Health-related problems could be systematically related to environmental differences across neighborhoods (Sampson, 2003).

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Neighborhood safety has been recognized as a key influencer of various health-related behaviors and outcomes (Loukaitou-Sideris and Eck, 2007). The older population tends to experience more difficulties in avoiding unintentional injuries (e.g., falls, crashes) or intentional injury risks (e.g., crime) (Sleet et al., 2011). Regardless of a safety problem's severity, any source of danger can increase feelings of vulnerability or fear (De Donder, Buffel, Dury, De Witte and Verte, 2013), thereby decreasing perceived control of one's environment (Downey and Van Willigen, 2005). Threats and danger have been shown to increase psychological stress, which eventually harms health (Hill et al., 2005) and discourages individual physical activities in the neighborhood (Wilcox et al., 2003).

Despite the various sources of danger known to influence health behaviors and outcomes, most previous studies have focused on only one or a few safety domains or measures. The ability to understand the different roles, or the relative importance, of different safety domains is limited. Thus, the current knowledge on the health implications of neighborhood safety remains incomplete.

In this review, we synthesize the literature that discusses the relationships between neighborhood safety and older adults' health outcomes and behaviors. This review expands the knowledge of previous literature reviews by including multiple safety domains and measures of safety and by considering a wide range of relevant health-related outcomes. Previous literature reviews have attempted to investigate various neighborhood environmental characteristics related to a specific set of health behaviors (Cauwenberg et al., 2011; Cunningham and Michael, 2004; Kerr et al., 2012) or direct health outcomes (Julien et al., 2012; Rosso et al., 2011; Yen et al., 2009), or have focused narrowly on crime-related safety (Foster and Giles-Corti, 2008). We believe this study provides a more comprehensive understanding of the health-significant roles of neighborhood safety for researchers and policy makers, which can help them examine and develop strategies to reduce safety barriers, and promote physical activity and positive health outcomes among older adults.

2. Methods

2.1. Search strategy

This systematic review was conducted in 2014, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009) (Fig. 1). Six databases were used: Academic Search Complete; CINAHL; Embase; MEDLINE; SportDis; and Transportation Databases. Combinations of various search terms were explored within titles and abstracts to identify all relevant studies. Health-related search terms included health, physical function, functional decline, mobility disability, quality of life, mental health, depression, morbidity, mortality, obesity, BMI, physical activity, walking, exercise, recreation, and cycling. Safety-related search terms included fall, injury, fear, crime, crash, traffic, safe, outdoor activity, barrier, incident, accident, neighborhood problem, neighborhood disorder, violence, noise, environmental hazard, environmental stress, and neighborhood stress. Search terms for older populations included older adult, elder, aging, senior, late life, and baby boom. The references in the identified articles were also reviewed to locate additional studies for consideration.

2.2. Selection criteria

Selection criteria included that the articles be written in English and published in peer-reviewed journals. Articles were then subjected to further inclusion and exclusion criteria by our study team. Studies were appropriate for our review if they: (a) were empirical and quantitative; (b) included safety-related factors as independent or control variables; (c) used health-related outcome variables; and (d) included an older adult population (50 + years). Because the studies needed to be empirically based, we excluded reviews, reports, briefs, letters, and editorials. To understand the complex associations among variables, studies were excluded if they conducted only a simple bivariate correlational analysis; however, such studies were included if the bivariate analyses were conducted with a longitudinal design. Because of our focus on neighborhood-level safety, studies were excluded if safety factors were not specified as neighborhood safety (e.g., risk of falling at home) or if a composite variable was too broad because it included various other factors such as socio-economic status. Studies published before 2000 were excluded because environmental approaches to health studies were not as prevalent before 2000 (Rhodes and Nasuti, 2011). Finally, studies conducted outside the U.S. were excluded because their administrative, historical, and political settings differed significantly from those of U.S. studies, making it difficult to draw reliable syntheses and comparisons across the studies. Data availability and recording systems, especially for crimes and crashes, also varied across countries.

2.3. Identification of studies

The initial search identified 20,781 articles. After deleting duplicates and irrelevant studies by title and abstract review, 148 articles were selected as potentially relevant. After a full-text review, 62 articles were retained. After excluding 30 articles undertaken outside the U.S., 32 studies finally remained for our review (Fig. 1). Based on the inclusion and exclusion criteria specified above, two reviewers independently selected the articles. Discrepancies were resolved by reaching consensus with a third reviewer.

2.4. Data extraction

The following study characteristics were extracted from each study: first author, publication year, field of publication, study design and year, study location and setting, study participants (sample size, age, and gender), safety measures (construct and measurement types), spatial units of analysis for the safety measures, confounding variables, health-related outcome/behavior variables, statistical analyses, and associations between safety measures and outcome variables (online Appendix Supplementary Table 1). Two reviewers independently conducted data extraction and resolved disagreements by discussion with a third reviewer.

2.5. Quality assessment

The studies were assessed for a methodological quality using the assessment tool adapted from the Effective Public Health Practice Project (EPHPP, 1998), Law et al. (1998), and Wong et al. (2008). The rating score was applied on the basis of assessment criteria for study design, selection bias, data collection, confounders, and data analysis (online Appendix Supplementary Table 2). Based on total scores ranging from 0 to 8, 21 studies had scores of 6–8 in the high-quality category, and 11 reached the middle-quality category with scores of 3–5. All reviewed studies were considered qualified. High-quality studies are highlighted with boldface in Tables 2 and 3. The results of the quality assessment are provided as online Appendix Supplementary Table 3. Two researchers independently assessed the quality of each study and resolved disagreements by discussion with a third reviewer.

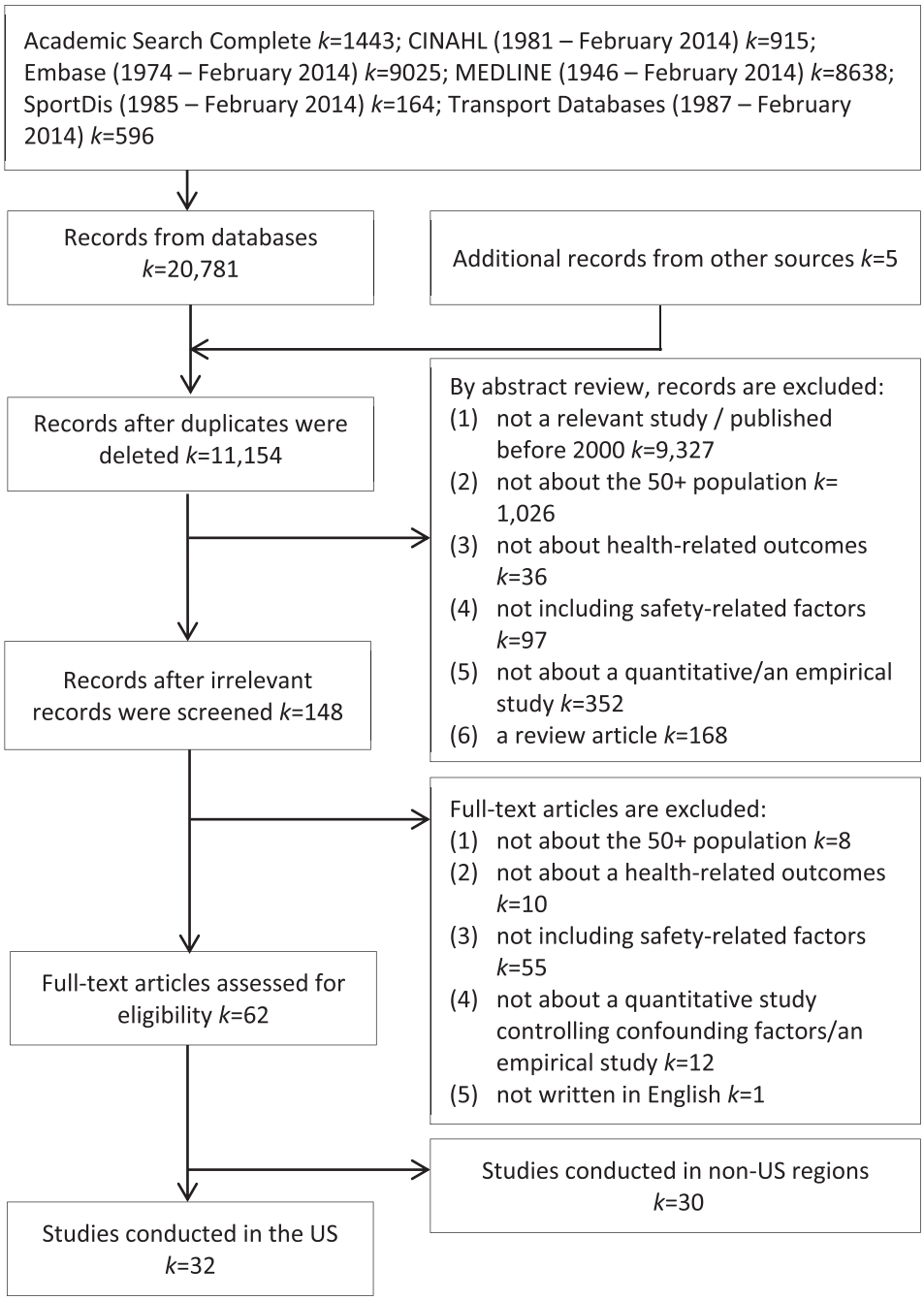

Fig. 1. Article selection process.

3. Results

3.1. Characteristics of studies included in the review

Table 1 presents the overall characteristics of the reviewed studies. Of the 32 studies, 71.9% were published between 2007 and 2013, and most were published in health or aging-related journals. The majority (71.9%) were cross-sectional. Sample sizes varied between 102 and 18,370. The largest number of studies was conducted in the western region of the U.S. Only a few studies reported being carried out in suburban (3.1%) or rural (6.3%) settings.

3.2. Variables examined in the reviewed studies

3.2.1. Neighborhood safety variables

Four domains of neighborhood safety variables were examined (Table 1): overall/general neighborhood safety ($k = 17$; 53.1% of 32); traffic-related safety ($k = 12$; 37.5%); crime-related safety ($k = 20$; 62.5%); and proxies for safety ($k = 11$; 34.4%). The overall/general neighborhood safety domain included measures related to "neighborhood safety," or safety pertaining to walking, such as "safety for walk." Traffic-related safety included "safety from traffic," "traffic volume," "heavy traffic," "traffic collision," "traffic-

Table 1
Characteristics of included studies ($k = 32$).

Study characteristics		No.	%
Publication year (January 2000–February 2014)			
2000–2006		9	28.1
2007–2013		23	71.9
Study design			
Cross-sectional		23	71.9
Longitudinal		9	28.1
Field of publication			
Health		18	56.3
Aging		13	40.6
Transportation		1	3.1
Region of study location			
Northeast		9	28.1
Midwest		5	15.6
South		7	21.9
West		10	31.2
Nationwide		6	18.8
Study setting			
General/not specified or Urban		29	90.6
Urban and suburban		1	3.1
Rural		2	6.3
Gender			
Both male and female		31	96.9
Female only		1	3.1
Sample size			
<400		6	18.8
400–4999		18	56.2
5000+		8	25
Neighborhood Safety			
Neighborhood safety measures			
Subjective measures		19	59.4
Objective measures		7	21.9
Both subjective and objective measures		6	18.7
Neighborhood Safety domains	***Number by measurement type:***		
Overall/general neighborhood safety	Subj. = 16; Both = 1	17	53.1
Traffic-related safety	Subj. = 8; Obj. = 3; Both = 1	12	37.5
Crime-related safety	Subj. = 10; Obj. = 10; Both = 1	21	62.5
Proxies for safety	Subj. = 9; Obj. = 1; Both = 1	11	34.4
Health outcomes and behaviors			
Health outcome and behavior measures			
Subjective measures		29	90.6
Objective measures		3	9.4
Health outcome domains			
Health status	Subj. = 2	2	6.3
Mental health	Subj. = 4	4	12.5
Physical function	Subj. = 6; Obj. = 1	7	21.9
Mortality/morbidity	Subj. = 1; Obj. = 1	2	6.3
Obesity	Subj. = 2	2	6.3
Health behavior domains			
Physical activity	Subj. = 6; Obj. = 1	7	21.9
Walking	Subj. = 9	9	28.1

Note: Subj. = subjective measures only; Obj. = objective measures only; Both = both subjective and objective measures.

control/calming devices," "traffic speed," and "crossing aids." Crime-related safety included "safety from crime," "crime incidents," "surveillance," and "crime watch signage." Crime incidents were specifically mentioned as murder, assault, rape, robbery, etc. We separated specific measures related to social disorders as proxies for safety, which may also provoke crime-related activities. The proxies for safety domain included vandalism, graffiti, litter and rubbish, odors, trash on the street, stray animals, lack of or poor conditions of street lights, loud noise, and abandoned buildings. Neighborhood safety was measured with a single item or multiple items. Multiple items in a single safety domain were commonly summed or averaged for statistical analyses. Multiple safety domains were also combined into composite variables, which were constructed as "neighborhood disorder" or "neighborhood problems." Some studies generated composite variables using factor analysis.

More than half of the studies relied on subjective measures alone ($k = 19$; 59.4%), while seven (21.9%) used objective measures alone. Subjective measures were mostly based on surveys from validated questionnaires, including the Neighborhood Environment Walkability Scale (NEWS) (Saelens et al., 2003) and the relevant reference (Sallis et al., 1997). Other sources of surveys included the Behavioral Risk Factor Surveillance System (BRFSS) (CDC, 2007), Ross and Mirowsky (1999), and Coulton et al. (2002). While some survey instruments relied on general questions about whether a respondent feels safe from crime, traffic, or in the neighborhood, some other instruments contained specific neighborhood conditions. Proxies for safety were also used for constructing neighborhood problems or disorders.

While subjective measures were used to measure all safety domains, objective measures were primarily used for crime- and traffic-related safety. In the crime-related safety domain, violent crime records obtained from state public safety or local police departments were generally reported as the data sources and used as

administrative-level aggregated measures (e.g., county, census tract). King (2008) used objective measures derived from walking-audits for crime safety, including the presence of security signs, neighborhood-watch signs, and surveillance, and for traffic safety, including traffic control devices, crossing aids, and posted speed limit. A study by Strath et al. (2012) included objective audit measures of street safety, and garbage or litter. The number of traffic collisions (Lee et al., 2013) and traffic volume on local streets (Strath et al., 2012) were objectively measured using the Geographic Information Systems (GIS). Of the 32 studies, six (19.4%) employed both objective and subjective measures (Clark et al., 2009; Lee et al., 2013; Michael et al., 2006; Nagel et al., 2008; Strath et al., 2012; Wilson-Genderson and Pruchno, 2013), with only three studies using both measures for capturing the same safety domain such as traffic-related safety (Lee et al., 2013), crime-related safety (Strath et al., 2012), and proxies for safety (Michael et al., 2006). Other studies used objective measures to capture one safety domain and subjective measures to capture another safety domain.

Following Julien et al. (2012), three neighborhood delimitations for measuring neighborhood safety were identified in the review: self-defined neighborhoods; administrative or municipally defined boundaries; and a certain distance buffer around each study participant's home. The majority of safety measures are subjective, and delimited by a self-defined neighborhood which depends on each respondent's perception of the neighborhood (Balfour and Kaplan, 2002; Bierman, 2009). In some studies, neighborhoods were defined by municipally defined neighborhoods (Fisher et al., 2004; Li and Fisher, 2004; Li et al., 2005a,b; Li et al., 2005a,b) or administrative units, including county (Grafova et al., 2008), census tract (Beard et al., 2009; Clark et al., 2009; Freedman et al., 2011; Freedman et al., 2008; Pruchno et al., 2012; Wilson-Genderson and Pruchno, 2013), and zip code (Wen et al., 2005). A few recent studies operationalized respondents' local neighborhood areas by using a straight-line distance buffer (Wang and Lee, 2010) or a network distance buffer around participants' homes (Lee et al., 2013; Strath et al., 2012).

3.2.2. Health outcomes and behavior variables

For health outcomes, five categories were linked with neighborhood safety: health status, mental health, physical function, morbidity/mortality, and obesity. Health-related Quality of Life (HRQOL) was also a target outcome variable, but this review contained no studies focusing on it. For health-related behaviors potentially related to neighborhood safety, two categories were identified from the reviewed articles: physical activity and walking.

Health status included self-rated measures of general health status (Fillenbaum and Smyer, 1981), or frequency of any minor illnesses (e.g., headaches, indigestion, constipation). To measure mental health, measures of self-reported frequency or occurrence of depressive symptoms (Andresen et al., 1994; Derogatis et al., 1974) were used. Instruments from Guralnik et al. (1996) were commonly used to measure the level of difficulty in performing daily activities or physical tasks. This difficulty was used to indicate physical function related to older adults' degree of functional decline or mobility disability. The morbidity/mortality category included measures for survival time or experiencing serious illnesses (e.g., heart problems, diabetes, cancer, arthritis). The obesity measures were determined by Body Mass Index (BMI) based on self-reported height and weight. The physical activity category classified activity items by intensity (e.g., vigorous or moderate) and/or type (e.g., working, sport, leisure, household). Some studies (Fisher et al., 2004; Li and Fisher, 2004; Nagel et al., 2008) included walking as a physical activity domain. Walking was generally measured as the frequency or the total minutes of walking. We categorized physical activity and walking, based on the terms used in individual studies.

Subjective measures were the predominant methods used to capture health outcomes and behaviors ($k = 29$; 90.6% out of 32). Only three studies (9.4%) used objective measures, of which two dealt with health outcomes including physical disability (Beard et al., 2009) and mortality (Beard et al., 2009; Strath et al., 2012; Wen et al., 2005) The other study (Strath et al., 2012) focused on a behavioral outcome– physical activity measured from accelerometer and pedometer data.

3.3. Safety variables by health behaviors and health outcomes

Table 2 summarizes the results regarding how the four safety domains were distributed across the five health outcome and the two health behavior variables. Overall/general neighborhood safety was more commonly examined for mental health, physical function and health behaviors. Traffic-related safety and proxies for safety appeared to be most relevant to health behaviors, while crime-related safety was more frequently reported as a correlate of health outcome variables. While several health-behavior studies used various audit and GIS-based measures of traffic-related safety, none of the health-outcome studies used objective measures of traffic-related safety. No studies used direct measures of crime rate or incidents to examine health behaviors, although eight health-outcome studies used crime records to measure crime-related safety. Relatively more studies for health behaviors included proxies for safety than for health outcomes.

3.4. Variables found to be significant

Table 3 presents the significant or nonsignificant association of each safety factor with each health variable. Inconsistent roles of neighborhood safety factors were found for most health variables, while their relatively consistent roles were reported in mental health studies.

3.4.1. Health status

The review found mixed results for health status. Schieman and Meersman (2004) showed that a composite measure derived from multiple domains related to traffic, crime and proxies was significantly associated with experiencing symptoms of minor illness. However, Roh et al. (2011) found no significant association between general health status and perceived neighborhood safety.

3.4.2. Mental health

Four studies showed consistent, significant associations between mental health and neighborhood safety measures, captured as overall/general neighborhood safety, crime-related safety, and neighborhood disorder (Bierman, 2009; Cromley et al., 2012; Roh et al., 2011; Wilson-Genderson and Pruchno, 2013). The associations remained consistently significant after adjusting for other personal and neighborhood factors.

3.4.3. Physical function

The studies showed mixed results regarding physical function. Some found overall/general neighborhood safety to be related to functional decline/mobility disability (Clark et al., 2009; Latham and Clarke, 2013; Sun et al., 2012). Balfour and Kaplan (2002) found that self-reported neighborhood problems including crime, proxies for safety (noise, poor lighting) and heavy traffic, were significantly associated with the level of physical performance. However, objectively measured crime-related safety factors were found to be inconsistently associated with physical function. Pruchno et al. (2012) found a significant relationship for violent

Table 2
Neighborhood safety by health outcomes and behaviors.

Safety domains	Safety measures	Health outcomes					Health behaviors	
		HS $k = 2$	MH $k = 4$	PF $k = 7$	MM $k = 2$	OB $k = 2$	PA $k = 7$	WA $k = 9$
Overall/general neighborhood safety $k = 17$	General neighborhood safety	24	24,31	**18**,**27**,**30**			2,16,15	
	Safety for walking						**3**,**4**	**6**,**7**,9**,**10**,**14**,29,**32**
Traffic-related safety $k = 12$	General safety from traffic	5				22	2	7,21
	Traffic volume or heavy traffic		**19**	**1**				**10***
	Traffic collision							29**
	Traffic-control/calming devices						**11***,25*	
	Traffic speed						**11***,25*	**20**
	Crossing aids						**11***,25*	**20**
Crime-related safety $k = 20$	General safety from crime	5	**19**	**1**		22	25	**20**,21
	Crime incidents		**28***,31*	**13***,**17****18***,**26***	**8**,**23***	**12***	**4**	**10**,**14**
	Surveillance						**11***	
	Crime watch signage						**11***,25*	
Proxies for safety $k = 11$	Social disorders†	5	**19**	**1**			2,**4**,25*	9**,**10**,**14**,21,**32**

Note:Results of studies with high methodological quality are highlighted in **boldface**. For references, see online Appendix Supplementary Table 1. Reference 24 (Roh et al., 2011) examined two health outcomes in separate models. HS = health status. MH = mental health. MM = morbidity/mortality. OB = obesity. PA = physical activity. PF = physical function. WA = walking. †Measures of social disorders include vandalism, graffiti, trash and litter, street lighting, unattended dogs, alcohol or drug use, loud noises, and abandoned buildings.
*Objective measure. **Both objective and subjective measures. No asterisks = subjective measure.

Table 3
Associations between safety variables and health variables.

Health variables	Safety variables	Associations between safety variables and health variables	
		Significant	Nonsignificant
Health Outcomes			
Health status	Overall/general neighborhood safety		24
	Neighborhood problems (T/C/P)	5	
Mental health	Overall/general neighborhood safety	31, 24	
	Crime-related safety	**28***, 31*	
	Neighborhood disorder (T/C/P)	**19**	
Physical function	Overall/general neighborhood safety	**18**,**27**,**30**	
	Traffic-related safety	**1**	
	Crime-related safety	**1**,**26***,***17***	**13***,**18***
	Neighborhood problems (T/C/P)	**1**	
Mortality/morbidity	Crime-related safety	**8**,**23***	8
Obesity	Crime-related safety		**12***,22
	Traffic-related safety		22
Health Behaviors			
Physical activity	Overall/general neighborhood safety	2,**3**,16,15	**4**,25
	Traffic-related safety	2,**11***,25*	
	Crime-related safety	**11***,25*	25
	Proxies for safety		25*
	Neighborhood problems (C/P)		4
Walking	Overall/general neighborhood safety	**6**,**7**	9**,**10**
	Traffic-related safety	**10***, 29*	**7**,**20**,21
	Crime-related safety	**20**,21	
	Proxies for safety	9*	9*, 21
	Safety concern† (S/T)	29	
	Neighborhood disorder (S/P)	**32**	
	Neighborhood problems (C/P)	**10**,***14***	

Note: Neighborhood disorder and problems are composite measures. Results of studies with high methodological quality are highlighted in **boldface**. The studies with counterintuitive findings are highlighted in *italics*. For references, see online Appendix Supplementary Table 1. C = crime-related safety. P = proxies for safety. S = overall/general neighborhood safety. T = traffic-related safety. †Injury concern was also included to measure the safety concern.
*Objective measure. **Both objective and subjective measures. No asterisks = subjective measure.

crime, but other studies found no relationship when using crime reports from the city's newspaper (Clark et al., 2009) or a composite measure comprising crime and a segregation index (Freedman et al., 2008). Beard et al. (2009) found a negative association between high crime rates and physical disability.

3.4.4. Mortality

The studies showed mixed results regarding mortality. Freedman et al. (2011) found that an objective composite measure of crime and segregation was related to self-reported chronic conditions. The frequency of personally experienced victimization was significant, while a perceived composite measure of violent crimes was not significant in predicting mortality measured as survival time (Wen et al., 2005).

3.4.5. Obesity

None of the three studies that examined obesity outcomes found significant relationships with neighborhood safety. Objectively measured crime and segregation (Grafova et al., 2008) and perceived safety from crime and traffic (Eisenstein et al., 2011) showed nonsignificant relationships with obesity.

3.4.6. Physical activity

As did the results of Foster and Giles-Corti (2008), our review found unclear associations between safety and physical activity. Most studies found at least one significant safety correlate of physical activity; however, one study (Fisher et al., 2004) found none. Associations of traffic-related safety were the most consistently significant (King, 2008; Strath et al., 2012; Wilcox et al., 2003), while results for other safety domains were mixed. In the Strath et al. (2012) study, objective measure of social crime was significantly related to physical activity, but perceived safety from crime was not. Within the overall/general neighborhood safety dimension, perceptions of neighborhood safety were shown as significant correlates of physical activity (Li and Fisher, 2004; Shores et al., 2009; Tucker-Seeley et al., 2009; Wilcox et al., 2003); however, perceived safety for walking was not (Fisher et al., 2004; Strath et al., 2012). While aggregated measures of safety dimensions—referred to as neighborhood disorder or neighborhood problems—were significantly correlated with health outcomes (Bierman, 2009; Schieman and Meersman, 2004), a composite variable of neighborhood problems was not significantly correlated with physical activity (Fisher et al., 2004).

3.4.7. Walking

Unlike the findings for physical activity, traffic-related safety was not found to be consistently associated with walking. Perceived crime safety was consistently significant although it was examined in only two studies. Objective measures of traffic volume and collision were significantly associated with walking (Lee et al., 2013; Nagel et al., 2008), while perceived traffic-safety measures were not (Li et al., 2005b; Satariano et al., 2010; Wang and Lee, 2010). Overall/general neighborhood safety and proxies for safety were also found to be inconsistently correlated with walking. The studies (Nagel et al.,2008; Mendes de Leon et al., 2009) found a significant relationship between walking and perceived neighborhood problems measured with various proxies for safety. Michael and Carlson (2009) showed an increased perception of neighborhood problems for the walking intervention group. Wang and Lee (2010) found no relationship with lighting conditions. In the Michael et al. (2006) study, objectively measured graffiti and vandalism were significant predictors of walking, but subjectively measured graffiti and vandalism were not.

4. Discussion

This systematic review examined multiple dimensions of neighborhood safety shown to be linked with various health-related outcomes and behaviors among older adults. Our review's scope was restricted to studies conducted in the U.S., where car-dependent landscapes are prevalent, and crimes and traffic accidents are more numerous than in most other high-income nations. In the urban U.S. context, environmental risk factors work against health-related behaviors and health promotion. Physical activity in the U.S. tends to be geared toward leisure or recreation and often occurs in neighborhood streets, compared to other countries where physical activity involves more transportation and utilitarian functions. Mental health may be more easily influenced by environmental risk factors, compared to other health outcomes, such as physical health. Our findings showed that associations of traffic-related safety with physical activity were consistently significant, while crime-related safety was consistently significant for walking. In the review, the safety measures were significantly associated with mental health, but none were significantly associated with obesity. Our systematic review also provides a comprehensive examination of the current knowledge on this topic.

4.1. Lack of neighborhood safety and health measures

A number of health studies of older adults have investigated diverse aspects of neighborhood safety. However, empirical evidence is still inefficient or unavailable for establishing solid links between specific neighborhood safety factors and health-related outcomes. While several qualitative studies (Gallagher et al., 2010; Lees et al., 2007; Lockett et al., 2005) have revealed that fall hazards caused by poor sidewalk conditions were a main concern for older adults, there was limited quantitative evidence on the roles of fall-related risk factors, suggesting the need for additional studies. As noted previously, we find no studies of HRQOL. However, a study conducted outside the U.S. (Parra et al., 2010) using the Short-Form survey found significant evidence supporting the association between neighborhood safety and HRQOL. More research on HRQOL would help establish solid relationships between neighborhood safety concerns and health-related outcomes.

4.1.1. Multidimensional safety measures

The roles of multi-dimensional safety measures require further attention in future studies dealing with correlates or determinants of relevant health-related outcomes. In this review, most studies examined one or two safety domains; only a few (Balfour and Kaplan, 2002; Nagel et al., 2008; Strath et al., 2012; Wang and Lee, 2010) included three or more. While our review may be insufficient to clearly distinguish among multiple neighborhood safety factors within each health category, our findings suggest that health-related outcomes may be associated differentially with various domains of neighborhood safety.

4.2. Lack of measurement clarity

Our review showed inconsistent patterns of associations between neighborhood safety and health, which may be partly attributable to the lack of clear guidelines for or consensus on defining the constructs/domains and measuring the variables. The same domain of neighborhood safety was differently constructed across the studies. In the review, the constructs were simply addressed as neighborhood safety or represented as part of the neighborhood environmental characteristics, but crime-related safety was often considered part of a social environmental construct. In addition, the same construct was sometimes captured by different safety domains. One study (Clark et al., 2009) used perceived safety from crime to assess overall neighborhood safety. Health-outcome studies measured neighborhood disorders or problems with traffic, crime, and proxies for safety, while health-behavior studies used crime-related safety and proxies for safety to measure neighborhood disorders or problems. Moreover, the specific instruments used to assess each domain of neighborhood safety differed across the studies. For crime-related safety, although older adults may be more fearful of crime incidents and at greater risk for property crimes (e.g., burglary, theft) (Foster et al., 2013), only violent crime incidents or perceived safety from crime were found to be significant in our review.

Another contributor to the inconsistent results could be limitations of the neighborhood safety measurements used, which are supported by previous calls for more precise measurements and definitions of neighborhood (Foster and Giles-Corti, 2008; Mair et al., 2008). The urban planning and transportation literature (Austin et al., 2002; Ewing and Dumbaugh, 2009) examining the built environmental correlates of neighborhood safety found a significant number of physical environmental factors related to perceived safety, including housing quality, roadway design, and street condition. Given such evidence, it is possible that subjective measures of safety may be endogenously associated with outcome

variables; therefore, using subjective measures alone may lead to biased results. There is a need for studies that investigate the direct and indirect effects of environmental factors on older adults' health (Satariano et al., 2012), using both subjective and objective measures.

Our review found that neighborhoods were not captured clearly or consistently across the reviewed studies. To reduce the discrepancy in self-defined neighborhood boundaries which likely varied by individual respondents, surveys often provide instructions for the defining neighborhoods; however, it is unclear to what extent the instructions actually reduce the discrepancy. Although there is an emerging trend toward using GIS techniques to create objectively defined neighborhood boundaries around individual study participants, only a few recent studies (Lee et al., 2013; Strath et al., 2012) utilized such individualized boundaries. In addition, none of the studies in the review included objective measures of crime-related safety at the street level, which may contain various risk factors such as lighting conditions and visual surveillance. It appears that the nature and strength of associations between health and neighborhood safety may vary depending on how neighborhoods are measured. Therefore, more studies are needed to identify effective ways to measure the neighborhood (e.g. boundaries, units, definitions, perceived vs. objectively measured) so that neighborhood effects on older adults' health can be studied optimally.

4.3. Complex interactions among variables

Another consideration for future research is related to the complex interplay among neighborhood safety, health outcomes, and health behaviors. People with poor health may feel more vulnerable to neighborhood safety problems, and have greater concerns about potential risk factors (e.g., fear of crime, fall risks). This, in turn, may affect older adults' outdoor activities related to preventing or managing various health problems, including obesity, depression, and chronic disease. Increased physical activity that enhances self-efficacy and physical strength (Bandura, 1998) may reduce fear and perceived safety concerns (Morris et al. (2008). In addition, many other studies have shown that health outcomes have been used as independent or mediating variables to predict health-related behaviors, and vice versa. Therefore, studies are needed that simultaneously examine both health outcomes and behaviors in relation to neighborhood safety.

4.4. Limitations of this review

This review has several limitations. First, it was not feasible to explode search terms in the database search engines due to the relatively broad nature of the search terms needed to cover both neighborhood safety and health outcomes/behaviors. However, the search was undertaken using various search terms and electronic databases in different disciplines to reduce the risk of omitting important articles. Second, our review included only peer-reviewed journal articles published in English since 2000. This restriction regarding publication type does not meet some criteria (e.g., publication status, publication bias) on the Assessment of Multiple Systematic Reviews (AMSTAR) checklist for assessing the quality of systematic reviews (see Shea et al., 2007). This restriction may also lead to publication bias. However, because the review's focus was on statistical and empirical evidence that clearly addressed the association between neighborhood safety and health, gray literature such as reports and newsletters should be considered exclusion criteria. The mixed results of neighborhood safety on health in this review indicate that the review may not have a particular issue regarding publication bias. Third, this review only included studies conducted in the U.S. and published in English since 2000. However, focusing only on U.S. studies enabled more contextual homogeneity and clearer interpretation of findings. For example, in a relatively safe country, such as Japan, neighborhood safety factors may not be an issue for older adults' health behaviors/outcomes (Tsunoda et al., 2012).

4.5. Conclusions and implications

Despite the limitations, this review revealed differences in the specific domains of safety influencing health outcomes and behaviors as well as identified gaps in the existing literature on this topic. This review has significant implications for injury control and safety promotion. While the articles in this systematic review were limited to those conducted in the U.S., local context and cultural norms are important considerations in global implications for understanding the relationship between environmental safety and health. For example, while in some areas of the world, sidewalks are less prevalent (WHO, 2013), walking is still a common mode of transportation due to lack of affordable alternatives. Additionally, with the global emphasis on "Exercise is Medicine" (Lobelo et al., 2014), walking is becoming an important worldwide lifestyle factor in promoting health and preventing disease. It behooves the World Health Organization (WHO) to consider global policies on injury prevention and safety promotion as has been done for traffic safety and childhood safety (WHO, 2004). It is important that diverse aspects of neighborhood safety be considered when establishing health interventions, which should be integrated with housing, transportation, and urban planning policies. Well-maintained/designed streets with traffic calming, good visibility that enables natural surveillance, street lights in good condition, and renovation of abandoned buildings can reduce safety concerns regarding the risks of traffic, crime, and fall injuries. More active attention to our surrounding can induce policy changes that significantly affect health among older adults. As the amount of health literature containing reliable/valid measures of neighborhood safety increases, future studies should ascertain the role of multi-dimensional neighborhood safety in pursuit of healthy living.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2016.07.024.

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