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How Design of Places Promotes or Inhibits Mobility of Older Adults: Realist Synthesis of 20 Years of Research

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Abstract

Objective—The objective of this study was to determine the environmental features that best support aging in place.

Method—We conducted a realist synthesis, a theory-driven interpretive method of evidence synthesis, of 120+ articles (published 1991–2011) that attempts to explain how place may influence older adults' decisions about mobility (e.g., physical activity). We developed an initial program theory, reviewed the literature, identified outcomes, analyzed and synthesized patterns, and created a final program theory.

Results—Safety was a central mechanism, serving as one of the bridges between environmental components (e.g., connectivity, aesthetics, retail and services) and decisions about mobility. Population density, sidewalk presence, and park proximity did not emerge as key factors.

Discussion—Safety considerations are one of the most prominent influences of older adults' decisions about mobility. Street connectivity, pedestrian access and transit, and retail and services were also important. These factors are amenable to change and can help promote mobility for older adults.

Keywords

mobility; neighborhood; built environment; realist synthesis

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Introduction

The world's population is getting older and more people are living in urban areas. Estimates predict that worldwide people aged 60 years and older will double from 680 million in 2009 to 2 billion in 2050 (UN Department of Economic and Social Affairs, 2007). Aging of the population and urbanization trends go together. In developed countries, 80% of older adults already live in urban areas (UN Population Fund, 2007). In 2008, for the first time, the majority of the world's population lived in cities (UN Population Fund, 2007).

As people age, they want to "age in place" or live in their homes or communities for as long as possible. There is a growing body of research that describes how neighborhood environments, which often include built or physical (place-oriented) and social (people-oriented) components, are associated with health status and health behaviors (Heath et al., 2006; Khan et al., 2009); many of these studies focus on older adults (Yen, Michael, & Perdue, 2009) and the design features and walkability of their neighborhoods (Li, Fisher, Brownson, & Bosworth, 2005; Y. L. Michael, Green, & Farquhar, 2006; Nagel, Carlson, Bosworth, & Michael, 2008; Rodriguez, Evenson, Diez Roux, & Brines, 2009; Saelens & Papadopoulos, 2008). How environments support mobility is of particular interest because mobility encompasses critical aspects of healthy aging—moving within one's home and from one's home to other locations to maintain social ties and get services (Prohaska, Anderson, Hooker, Hughes, & Belza, 2011).

> Mobility refers to movement in all of its forms, including basic ambulation, transferring from a bed to a chair, walking for leisure and the completion of daily tasks, engaging in activities associated with work and play, exercising, driving a car, and using various forms of public transport. (Satariano et al., 2012, p. 1508)

Physical activity, one aspect of mobility, is particularly beneficial for older adults (Chodzko-Zajko et al., 2009). Walking is the most common form of physical activity in this population (McPhillips, Pellettera, Barrett-Connor, Wingard, & Criqui, 1989). The ways in which environments support or hinder physical activity, generally or specifically examining walking, have been studied extensively (Bentley, Jolley, & Kavanagh, 2010; Frank, Kerr, Rosenberg, & King, 2010; Rosso, Auchincloss, & Michael, 2011). There are several important reviews of research summarizing the positive and negative relationships between selective characteristics of neighborhoods and various outcomes for older adults (Beard & Petitot, 2010; Rosso et al., 2011; Yen et al., 2009). Much of the literature uses census or administrative data to characterize the socioeconomic composition of the neighborhood and reports that people who live in areas with higher proportions of low-income people have poorer health (Diez Roux, Borrell, Haan, Jackson, & Schultz, 2004; Hybels et al., 2006; Kubzansky et al., 2005; Lang et al., 2008). The reviews have largely focused on summaries of the statistical relationships and methodological gaps. We were interested in addressing the following question: How do characteristics of the environment (place) support mobility and what circumstances appear to facilitate or hinder mobility in older adults. Thus, we needed to use an approach that would allow examination of the processes behind how and why place is linked to mobility as well as the potential influence of personal factors.

Realist synthesis was used to assist in examining the associations found in primary studies through building theory (or theories; Pawson, 2002). In brief, realist synthesis is a theory-driven interpretive method of evidence synthesis that is based on a realist philosophy of science. Realism refers to a philosophy of science that sits, broadly speaking, between positivism ("there is a real world which we can comprehend directly through observation") and constructivism ("given that all we can know has been interpreted through human senses and the human brain, we cannot know for sure what the nature of reality is"). Realism agrees that there is a real world and that our knowledge of it is processed through human senses, brains, language, and culture. However, realism also argues that we can improve our understandings of reality because the "real world" constrains the interpretations we can reasonably make of it (Wong, Greenhalgh, Westhorp, & Pawson, 2012). Its central assumption is that of generative causation; outcomes occur because they are caused by mechanism(s) triggered under specific contexts (Astbury & Leeuw, 2010; Pawson, 2006). We have used the term *context* in this article in the realist sense of the word. When used in this way, it may refer to broad social or geographic features; features affecting the implementation of programs; the makeup of the participants in the program or the different population profiles of locations where an intervention is introduced; and the conditions in which subjects seek to enact their choices. "Context," in short, can take on a multitude of forms.

In a realist review of a voluntary resettlement program (Moving to Opportunity [MTO]) that moved families from high-poverty to low-poverty neighborhoods in five U.S. cities between 1994 and 2006, Jackson et al. (2009) found that the program intervention effects on mental health were not uniform. Many adolescent males did not benefit as much as females from improvements in their mental health (outcome). Adolescent females had a greater fear of violence (mechanism) than males, and for many, the move (intervention) to a low-poverty neighborhood (context) immediately removed this threat. For many adolescent males, such a move (intervention) removed them from familiar places and their social contacts and placed them into neighborhoods (context) where they felt isolated and perceived racial discrimination (mechanisms), resulting in unchanged or deteriorated mental health.

The main goal of a realist synthesis is to look for outcome patterns in the evidence and explain the relationships underlying these patterns through the use of theory. Theory or theories are needed to help understand the relationship between an outcome, its causal mechanisms, and triggering contexts. In addition, a more specific intervention model or "program theory" is often needed to help explain how and why the intervention is designed to achieve its intended primary outcome(s). Although the method is relatively unknown among U.S. public health and biomedical researchers, it has been applied to projects in numerous subject areas in the United Kingdom, Canada, Australia, and New Zealand, including assessing threats to public health legislative interventions (Wong, Pawson, & Owen, 2011), effects of housing on mental health (Jackson et al., 2009), assessing which combination of services best supports homeless people with substance use and mental health disorders (O'Campo et al., 2009), and retention of health workers in rural areas (Dieleman, Kan, Zwanikken, & Gerretsen, 2011).

Design and Method

Identify Candidate Theories

Applying realist synthesis methods, we conducted a scoping review (Arksey & O'Malley, 2005) to identify existing theories to help understand the impact of the built environment on mobility. The conceptual framework that initially guided the database search used an ecological model (Hogue, 1984) that considers mobility to be a function of the person, the environment, and the interaction of the person with the environment. When building our initial program theory, we adapted the ecological model by encompassing elements from the International Classification of Functioning (ICF) developed by the World Health Organization (WHO; 2001) related to biology (we refer to these as individual factors), activity/actions, and participation (Figure 1; Yen & Anderson, 2012). Negative functioning at each of these three levels can be represented by physical impairments, activity limitations (or disability), and participation restrictions. For example, an older adult with diabetes may experience pain due to peripheral neuropathy (impairments in body structures) that leads to severe difficulty in walking (lower extremity limitations that affect activities) that restricts involvement in life situations (participation restriction).

Identify Studies

Based on concepts identified by our initial program theory, we proceeded to a more comprehensive literature search. Given the findings in our scoping review, we chose initially to focus on the broad outcome of mobility related to physical movement outside the person's home, including walking and transferring between outdoor spaces. Included in this broad outcome are walking for transport or leisure and general physical activity. Thus, we did not examine interventions such as shuttle services or volunteer driver programs.

We searched the PubMed and Web of Science databases for articles published between 1991 and 2011 with the key words "older adults," "physical activity," and "built environment" and for Web of Science, topic searches for "activity patterns," "activity behaviors," "traffic," "street," "crosswalk," "parks," and "urban planning." The search yielded 1,491 abstracts that we screened for relevancy and inclusion of adults aged 50 or older. One team member (I.H.Y. or J.F.F.) read the abstracts for inclusion, and two other team members (J.F.F. and a research associate) reviewed a subset of the same abstracts for quality control purposes (to determine whether the abstract indicated that the article might fit and should be reviewed further). From the initial list of abstracts, 405 articles were identified to include for further review. Of these 405 articles, 36 were removed as duplicates or articles with no data or content to contribute to the program theory; an additional 220 were removed for not addressing all of our inclusion criteria (built environment and mobility among older adults). One hundred forty-nine articles remained; however, we excluded 45 of these after reading the article and determining they were not able to make relevant contribution (e.g., a commentary or review article without data, not about older adults or no specific results for older adults). We then added 12 published and unpublished reports suggested to us by people working in the field (see next paragraph). We looked at the reference lists of these published and unpublished reports to see whether any other articles could be identified.

Eight additional articles and one report were identified from these lists. This resulted in a total of 123 articles and reports included in the synthesis.

We also conferred with 12 individuals working in both public and private agencies (city and transportation planners, public health department staff, walkability consultants, physical activity researchers, aging advocates) who do relevant research or work(ed) on related programs in the State of California, New York City, Los Angeles, Chicago, and for the entire United States. These conversations served as a way to identify gray literature to include in the synthesis and also to build a program theory. We identified two reports from work of these individuals, which were included in the synthesis (Finkelstein, Garcia, Netherland, & Walker, 2008; Lynott et al., 2009),

Based on our initial program theory, we focused on specific contexts when reviewing all articles and reports. Initially, we chose characteristics of the social environment, such as neighborhood demographic composition, high proportion of low-income people, or neighborhood social connectedness. Yet, as developing effective interventions that target the social level is challenging, we chose to focus on characteristics on which policymakers and urban planners can more actively intervene, namely, the built environment. Our goal was to try to understand how (if at all) any of these built environment contexts were related to our outcome of interest—outdoor mobility in older adults. Our hope is that policymakers and urban planners may be better able to make the necessary changes to the built environment through having a greater understanding of how and why context influences (if at all) mobility in older adults. Final contexts are shown in Table 1. The context structure, with main context (parent context) and subcontext (child context), was imported into NVivo version 8® software.

The team divided the articles, read and highlighted text segments related to the main contexts and subcontexts using NVivo as an organizing tool, and categorized studies according to geographic location, country of origin, participant characteristics, and study design. Next, meeting every two weeks, all text segments were reviewed segment by segment, according to context, by three researchers on the analytic team (I.H.Y., J.F.F., H.T.). We used the realist synthesis context–mechanisms–outcomes (CMO) organizing principle to frame our analysis of the text segments. We wanted to create a plausible explanation of how each context might trigger (or not) one or more mechanism(s) to cause our outcome of interest (outdoor mobility). When undertaking our analysis, we anticipated that not all mechanisms would be visible and so might have to be inferred. Individual researchers reflected on how and whether any of the mechanisms we identified were plausibly and coherently able to explain the link between context and outcome as found in our included documents. This was followed by whole-team discussions about the ability of different middle-range theories to explain the data outcome patterns we identified. Through regular team discussions and rereading of specific text sections, we gradually refined our understanding of the CMO configurations we had created, specifically focusing on whether common mechanisms existed. We also used these processes to endorse, disprove, or further refine our initial program theory. This highly iterative process led us to a set of final more refined theories on mobility within the built environment among older adults.

Results

The 123 articles and reports were diverse in geographic setting, study design, and scope (Table 2). About half (52%) reported on studies conducted in the United States. Almost half (49%) took place in urban areas. Almost three fourths of the studies (70%) were published between 2006 and 2011. In describing the findings, we do not cite each of the 123 articles or reports although all of the articles contributed content to the synthesis. We provide an appendix that references the 123 articles.

Program Theory

We identified several influences of the built environment that appear to affect certain aspects of mobility in older adults (in particular, walking for transport or leisure and general physical activity). The key contexts can be grouped under the headings of aesthetics, land use, and connectivity (i.e., a quality of the street network, defined below). There appeared to be a complex interrelationship between these key contexts and differing patterns of mobility. Our "final" more refined program theory illustrates, at a broader and simplified level, the relationships between the contexts, most prominent mechanism, and the outcome we were able to best understand—namely, an older person's decision on whether to be mobile (which we subsequently refer to as "mobility decisions"; Figure 2). This outcome is different to the one for which we initially wanted to develop a program theory. We had hoped that the data we found would enable us to develop and test more comprehensive program theory—that is, one that included not only an explanation of how and why the built environment would influence an older person's decision on whether to be mobile but also further "downstream" processes that would eventually lead to actual mobility. In other words, the data we found enabled us to understand what might influence an older person's mobility decision, but not to elucidate other contextual influences and causal mechanisms leading to observed and sustained increases in mobility. As such, the focus of our review was narrowed by the data available to us, and the program theory we have developed is more modest in its scope than we had hoped. This program theory does not reflect findings from any singular study but instead was built from iterative analysis and syntheses of the data from our included studies. In the following sections, we explain how we arrived at the program theory.

Aesthetics—Authors did not have a consistent definition of aesthetics. Aesthetics were variously described by or associated with amount of litter and graffiti (Borst et al., 2009; D. King, 2008; Y. Michael, Beard, Choi, Farquhar, & Carlson, 2006); density of dwellings and buildings (Borst, Miedema, de Vries, Graham, & van Dongen, 2008; Borst and colleagues asked their participants to rate blocks by perceived attractiveness and found an inverse associate with density of buildings/dwellings); streetscapes and views (Bentley et al., 2010; Borst et al., 2008); enjoyable scenery (Eyler, Brownson, Bacak, & Housemann, 2003; A. C. King et al., 2000; Kowal & Fortier, 2007; Y. L. Michael, Green, & Farquhar, 2006; Sallis, King, Sirard, & Albright, 2007; Troped, Saunders, Pate, Reininger, & Addy, 2003); presence of trees, gardens, or vegetation (Borst et al., 2009; Borst et al., 2008; Gallagher et al., 2010; Y. L. Michael, Green, & Farquhar, 2006); architecture or historical markers (Gallagher et al., 2010; Y. L. Michael, Green, & Farquhar, 2006); and general positive aesthetic/attractive environment (Carnegie et al., 2002; Grant, Edwards, Sveistrup, Andrew,

& Egan, 2010; Humpel, Marshall, Leslie, Bauman, & Owen, 2004). To enable us to make sense of these disparate definitions, we chose to adopt a broad and inclusive definition—aesthetics was the appeal of the built environment and one's surroundings.

We noted that authors frequently reported on associations between aesthetics (as an aspect of the built environment) and mobility in older adults. A common pattern we noted was that many studies consistently found that an aesthetically pleasing environment is positively associated with increased mobility.

For example, in our included studies, factors generally considered to have a negative impact on aesthetics, such as litter and graffiti and density of dwellings and buildings, were associated with decreased mobility in older adults (Borst et al., 2008; D. King, 2008; Y. Michael et al., 2006). Factors considered aesthetically pleasing—presence of trees, gardens, or vegetation—correspondingly had a positive association with mobility (Carnegie et al., 2002; Eyler et al., 2003; Sallis et al., 2007; Strath, Isaacs, & Greenwald, 2010). Humpel et al. (2004) found that men with the most positive perceptions about their neighborhood's aesthetic qualities were more than 7 times more likely to be high neighborhood walkers. Y. L. Michael, Green, and Farquhar (2006) found that all study participants were more likely to walk in attractive neighborhoods: "It's a great walking neighborhood, the areas are kept clean and friendly."

Our closer examination and analysis of the data behind this pattern enable us to make the inference that the association between aesthetics and mobility decisions appeared to operate through the older adults' perceptions of safety (traffic) and security (crime). For example, Y. L. Michael, Green, and Farquhar (2006) found that "clean" and "friendly" are the antithesis of graffitied and crime-ridden, and they concluded that for older adults, maximizing the attractiveness or safety of a walking path is of utmost importance to affect decisions about mobility. However, characteristics that represent neighborhood crime and disrepair, such as vandalism, graffiti, and litter, appear to influence older adults' perceptions of security of the neighborhood; perceiving a neighborhood as insecure due to crime or other related characteristics was found to be a relatively consistent barrier to mobility decisions among older adults (Eyler et al., 2003; Finkelstein et al., 2008; Kegler, Escoffery, Alcantara, Ballard, & Glanz, 2008; Y. L. Michael, Green, & Farquhar, 2006; Satariano et al., 2010).

In summary, we observed from the included documents that there were numerous aspects of aesthetics (contexts) that were reported to be associated with changes in mobility (including walking for transport and/or leisure and general physical activity) in older adults. Our analysis of the included studies enabled us to infer that a decision not to be mobile was more likely to occur when older adults perceived that their neighborhood was unsafe or insecure and "negative" elements of aesthetics (context) acted as triggers. Conversely "positive" aspects of aesthetics triggered positive perceptions about safety, which in turn appeared to affect mobility decisions of older adults (outcome). Our inference was that the older person's perception of the safety or security of their neighborhood was one prominent mechanism causing changes in mobility decisions.

Land use—Our included documents reported that land use, including residential, commercial, and public space such as parks, influences mobility in older adults. These studies reported a heterogeneous mixture of different aspects of land use and their associations with different aspects of mobility—some of findings seemingly contradictory.

To illustrate the nature of the data we were dealing with, in one study, greater land use mix was positively associated with walking for leisure, transportation, physical activity, and meeting physical activity recommendations (Li et al., 2008). They found that older adults living in neighborhoods with higher mixed-land use, high street connectivity, better access to public transit stations, and more green and open spaces for recreation were more likely to engage in some form of neighborhood-based walking and to meet physical activity recommendations. In another study (Nagel et al., 2008), among participants who reported engaging in some amount of walking activity, the authors found that the overall number of commercial businesses, the number of likely retail walking destinations, and the percentage of high-volume and low-volume streets in the local neighborhood were associated with the total amount of time participants spent walking each week. In other research, a high number of commercial establishments and high-volume streets within a quarter-mile radius of the home was associated with increased total walking time; retail in particular was associated with likelihood of walking to places and with walking 90 or more min per week (Rodriguez et al., 2009). Finally, Kemperman & Timmermans (2009) reported that space for walking and riding bikes was associated with perceived ease of physical activity in older adults and the actual presence of parks/high park density was positively associated with active park use (Kemperman & Timmermans, 2009). From this data, it seemed reasonable for us to infer that land use is a significant built environment contextual factor that influences a range of mobility outcomes in older adults.

The relationship between land use and mobility was more complex than the relationship between aesthetics and mobility. The differing forms of land use appeared to act as a contextual influence on mobility decisions in two ways. First, land use (e.g., retail, housing mix) could give older adults a reason to want to go out. For example, Berke, Koepsell, Moudon, Hoskins, and Larson (2007) found that proximity to grocery stores at the level of the respondent's residence was associated with more walking within the neighborhood. That is, people who had stores that were close by, compared with those who did not, walked more. They also reported that clusters of destinations, such as grocery stores, restaurants, and retail (i.e., having a variety of destinations), also increased the odds of walking for older adults. This finding was echoed by other studies (Berke et al., 2007; Coogan et al., 2009; Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Gauvin et al., 2008; Satariano et al., 2010).

Second, while having a reason to be mobile was an important contextual influence on decisions about mobility, it was also related to the mechanism we had identified earlier when analyzing the data on aesthetics—namely, perception of safety and security. Berke et al. (2007) suggested that older adults balance their decisions to get out (for errands or exercise) with the risk of facing traffic during an outing. In another study, Li, Fisher, and Brownson (2005) found that both walking safety and the accessibility of physical activity facilities in neighborhoods were important considerations for older adults in their decisions

related to mobility. This is reflected in two other studies where residents of more-compact areas were more likely to view their neighborhoods as unsafe, because they felt that crowds inhibited their walking (Hollingsworth & Gray, 2010; Theis & Furner, 2011). Aesthetics (as discussed above) and land use appear as important contexts in Michael et al. (Michael, Green, and Farquhar, *Health & Place*), where they reported that among nondriving older adults, an area lacking accessible services and/or that had services located in high-crime areas was linked to decreased incentive to walk to local destinations and increased isolation.

We were able to uncover some of the intricate relationships between land use and mobility decisions in older adults. When land use brings more services and people to a neighborhood —for example, by increasing the number of stores—it provides a contextual influence on mobility decisions by giving older adults a reason to go out. However, this does not appear to be enough on its own, as older adults appear to still wish to judge for themselves whether it is safe to be mobile. However, when land use characteristics lead to a poor perception of safety or security—as when types of stores or too many (or not enough) people create the perception of (for example) higher crime or more dangerous traffic—then land use negatively affects an older adults' decision to be mobile. Our analysis to this point indicates that once again, an older adult's perception of safety or security is *one* important mechanism causing changes in decisions about mobility.

Connectivity and street design—A number of the included studies reported on associations between connectivity and mobility. From these studies, connectivity as a concept encompassed a broad range of characteristics of the built environment. Pragmatically, we considered connectivity as being characteristic of street networks such that multiple routes serve the same destinations in a grid layout instead of cul-de-sacs. To take account of what was reported in the included studies, we expand the concept to include additional design characteristics of street networks (e.g., road length, traffic volume, and density), intersections (e.g., complexity, regulation, crossing opportunities, distances), and sidewalks (e.g., length, condition, lighting). Data from our included documents revealed that aspects of connectivity serve as important contextual influences on mobility decisions in older adults. The included studies reported both positive (Taylor, Leslie, Plotnikoff, Owen, & Spence, 2008) and negative associations (Gomez et al., 2010; Kegler et al., 2008; A. C. King et al., 2006; Li, Fisher, & Brownson, 2005; Y. L. Michael, Carlson, et al., 2006).

The perception of safety by older adults in relation to the contextual elements of connectivity provided us with one way to make sense of the positive and negative associations reported in the included studies. A study by AARP revealed that about 50% of adults aged 50 years or older reported that they cannot cross main roads close to their home safely. Half of those who reported these problems said they would walk or bicycle more if these problems were addressed (Lynott et al., 2009). Kegler et al. (2008) found that loose dogs, heavy or speeding traffic, and crime or concerns about security were barriers to physical activity in the study neighborhoods. Gomez et al. (2010) found that a high connectivity level (meaning more intersections and pedestrian crosswalks) could be associated with a perception of higher risk of traffic accidents among older adults, thus discouraging them from walking. Y. L. Michael, Green, and Farquhar (2006) reported that older adult concerns about traffic and inadequate pedestrian infrastructure limit walking and

other activities in neighborhoods by making them feel unsafe. A. C. King et al. (2006) found a significant interaction effect involving perceived safety around the concept of connectivity; participants randomized to a physical activity intervention who agreed with the statement “most drivers exceed the posted speed limits while driving in my neighborhood” showed fewer minutes per week of moderate-intensity or more vigorous physical activity relative to intervention participants who did not report speeding drivers to be as much of an issue. Another study found that perceived safety from traffic in residents’ areas with a greater number of street intersections (enabling more options for crossing of roads) was associated with a greater amount of neighborhood walking by older adults (Li, Fisher, & Brownson, 2005).

In summary, connectivity and street/intersection design characteristics that increase the perception of safety among older adults (i.e., aspects of the built environment make them feel that they can reach their destinations or use the resources in the environment around them safely, such as getting to the store near their home) positively influence mobility decisions. However, when aspects of connectivity (context) decrease perception of safety (mechanism), then connectivity tends to adversely affect decisions about mobility (outcome).

Cognitive and physical capacity—Within the included studies, we noted that cognitive and physical capacity—both perceived and actual—appeared to serve as additional contextual influences that needed to be accounted for in our program theory explaining environmental contextual influences to decisions about mobility. Although several studies in this review assessed physical capacity (Rosso et al., 2011; Wahl, 2001; Wahl & Oswald, 2010), few studies included measures of cognitive capacity or examined how it influenced the relationship between the built environment and mobility in older adults. Langlois et al. (1997) demonstrated that capacity is linked to mobility in this population; they found that older pedestrians who needed help in one or more activities of daily living were 10 times as likely as others to report difficulty crossing the street, and those with the slowest walking speeds were almost 3 times as likely to report difficulty crossing the street. Similarly, another study found that only 25% of adults with mobility disabilities (required assistance to walk 0.8 km or climb stairs) could cross the street in the time allowed by the traffic light, as compared with 100% of the older adults without disabilities (Shumway-Cook et al., 2002). Rantakokko et al. (2010) reported that among those who reported difficulties in walking, dangerous crossroads were strongly associated with risk of unmet physical activity needs. Satariano et al. (2010) examined mobility in older adults with different physical capacities and found that among adults with excellent lower-body functioning, those who lived in areas with a longer street blocks were more likely than residents of areas with shorter street blocks to walk. For adults with poor lower-body functioning, block length was not associated with walking. The authors also found that residents of areas with shorter street blocks areas were more likely to view their neighborhoods as unsafe and insecure, and that this was especially true for those with reduced lower-body functioning.

Within this smaller body of data, physical capacity (perceived or actual) appears to operate as a contextual factor that influences an older adult’s perception of safety. Older adults with less physical capacity appear to have higher “threshold” of what they perceive to be a safe

environment, whereas the reverse appears to be the case for those with better physical capacity.

Preexisting Theory

When analyzing data available from included documents reporting contextual elements of the built environment in older adults, we found that aesthetics, land use, connectivity, and physical capacity were the major contextual influences related to decisions about mobility. Moreover, our "final" refined program theory suggests that perception of safety, determined by subjective or objective assessments by the older adult, is one important mechanism through which aesthetics, land use, and connectivity cause changes in mobility decisions. Although suggestive, due to the more limited data available, the inferences we were able to make about the relationship between physical capacity and decisions about mobility and perceptions of safety and security are less definitive.

We wanted to explore the coherence of our "final" refined program theory in relationship to existing substantive theories in the health literature. As is often the case in realist reviews, we undertook additional searching. We found that existing health behavior theory provides additional support for the main mechanism (perception of safety), which we inferred was operating within our "final" refined program theory. The bioecological model takes into consideration how people and environments change over time (Bronfenbrenner & Morris, 2006) and how these changes are reflected in changing processes. Walking occurs if the environmental context is suitable. In older adults, fast cars, heavy traffic, and hard to cross streets will be environmental barriers that inhibit walking. Conversely, pleasant scenery, easy to cross streets, and sidewalks may encourage walking. Thus, environmental and personal contexts influence an older adult's perception of safety and affect decisions about walking behavior.

In terms of changing personal factors, as adults age and their physical abilities diminish (i.e., reduced mental and physical acuity), they may perceive more danger and feel more limited, thus negatively affecting their ability or desire to walk. Our included studies do seem to support this change in "threshold" in older adults (see *Cognitive and physical capacity* above). To illustrate, an older adult, in particular, might view a short traffic signal as particularly dangerous or noisy traffic as distracting. Because she knows she will not have adequate time to cross the street or because the noise makes her nervous to be out, she may choose not to walk (Rantakokko et al., 2009).

Discussion

We conducted a realist synthesis of research articles and other literature that described how different contextual elements of the built environment influence decisions about mobility of older adults. Three interrelated contexts (aesthetics, land use, and connectivity) emerged as key influences on mobility decisions. They influenced mobility decisions mainly through the mechanism of the perception of safety, both subjective (e.g., perceptions) and objective measures (e.g., speed limits, numbers of lanes of traffic, condition of sidewalks) of older adults.

This review was limited to studies of built environment features, as contrasted with social environment (e.g., socioeconomic status of the people in the neighborhood, social capital). Policies that promote aesthetics, land use (e.g., mixed use), and connectivity can also influence the socioeconomic composition of an area and possibly social capital (e.g., if there are pleasant public gathering spaces, neighbors might venture out more and get to know each other, which could in turn support feelings of safety leading to more neighborhood walking). Another limitation to the scope was that although mobility is a broad concept, it is not a PUBMED MeSH key word, so articles cannot be identified with it as a search term. We used a public health perspective to define and classify variables across studies, but how these variables may be grouped may vary between disciplines.

The majority of the studies (72%) that were identified were cross-sectional. In the refined program theory, we show how key contextual elements of the built environment are related to decisions about mobility and highlight the centrality of perception of safety (labeled as “Safety” in Figure 2) as one prominent mechanism. Note the feedback loops in the figure showing the complex and dynamic nature of decisions about mobility. Aethetics can influence perceptions of safety and security, which can support the inclination to walk. Because most of the studies were cross-sectional, they were not reporting these patterns over time (e.g., that environment with aesthetic features *led to* feelings of security). It might be possible that people who are inclined to walk or exercise choose environments with certain characteristics. Perhaps the greater limitation associated with the cross-sectional studies is the lack of information they provide about how to implement strategies to increase safety or security.

Most of the studies were conducted in urban or suburban areas. Although rural areas have distinct features, the contexts with relevance to mobility that were highlighted in these studies were similar to those highlighted in the urban and suburban studies, for example, sidewalks (presence/absence), public transit, and proximity of destinations. Although we can have some certainty about the relevance and transferability of the perception of safety mechanism in older adults living in urban and suburban areas, the same cannot necessarily be said within a more rural context. Thus, the literature would benefit from more studies, with the goal of providing data to further test and refine our understanding of the perceived safety mechanism and/or to elicit other mechanisms, including (for example) how cognitive capacity affects the patterns that emerged from these 123 articles and reports. In addition, this collection of studies did not focus on different experiences by economic status or ethnicity. As such, questions remain about the transferability of the mechanism of perception of safety under these different contexts. Future work should be carried out in racially and ethnically diverse and economically heterogeneous settings to elucidate the relevance of this mechanism under different economic and ethnic contextual influences. Although we believe that the program theory we have developed is supported by the data within the included studies, the issues raised above do indicate that further program theory refinement in both the depth and breadth is still needed.

The scope of our “final” program theory has necessarily had to be more modest. We had initially set out to try to develop a program theory that would provide an understanding of all the processes needed to lead to greater mobility in older adults. However, limitations

imposed by the nature of the included studies necessitated a further focusing of our review on the contextual influences and underlying mechanism that predominantly related to an older adult's decisions around whether (or not) to be mobile. Further processes "downstream" of this point remain to be fully elucidated and would also constitute an area for future research.

The findings from this realist synthesis and the program theory that emerged have important implications for city and transportation planning and decision makers nationally and internationally with regard to understanding how to support aspects of mobility for older adults. A key message is that when older adults make decisions about mobility, they need to perceive that it is safe for them to be more mobile. Our review has highlighted that that there are elements of the built environment that can be modified to encourage more positive decisions about mobility—namely, aesthetics, land use, and connectivity.

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Appendix

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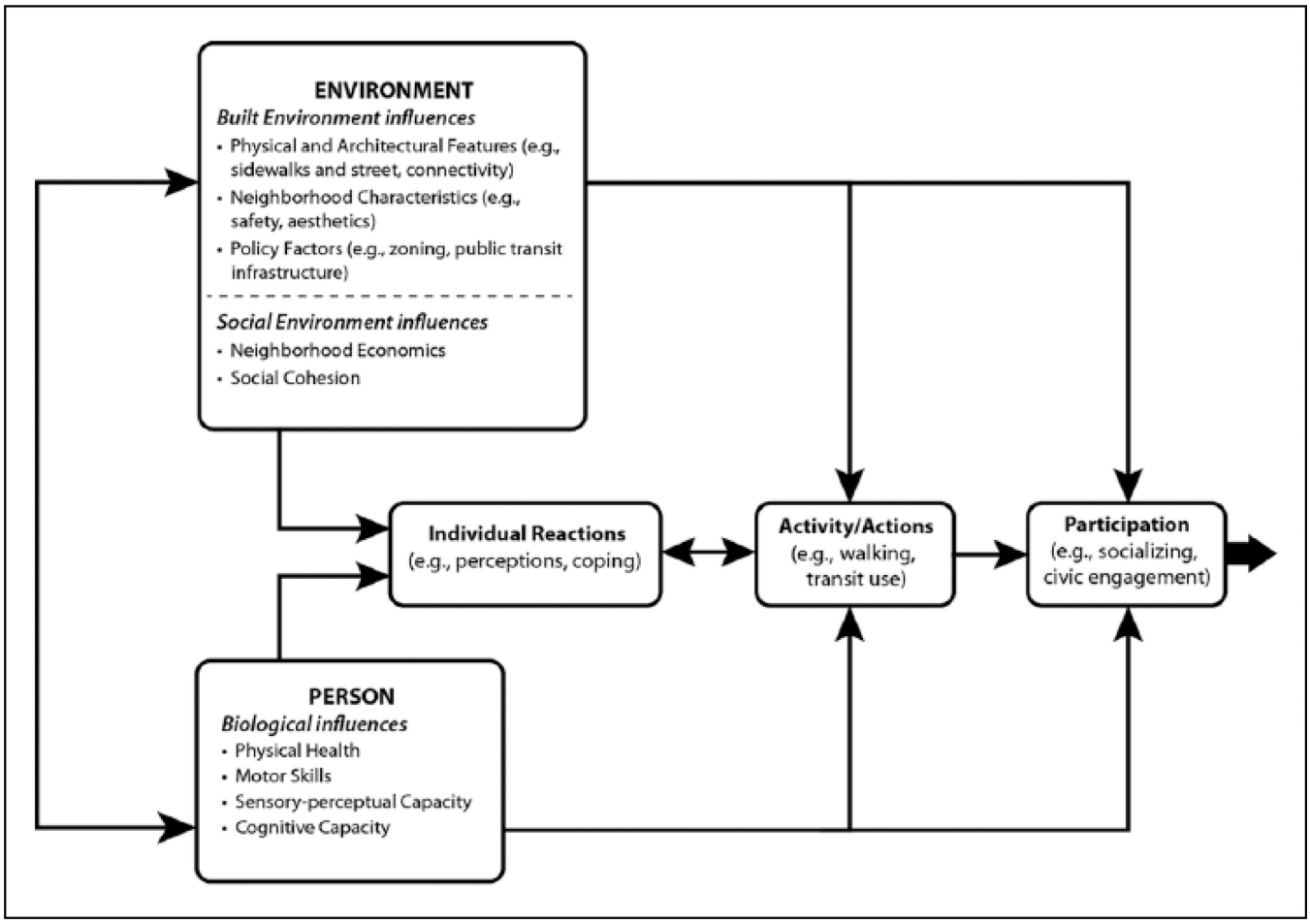

Figure 1.
Initial program theory: Contextual influences that promote mobility in older adults.

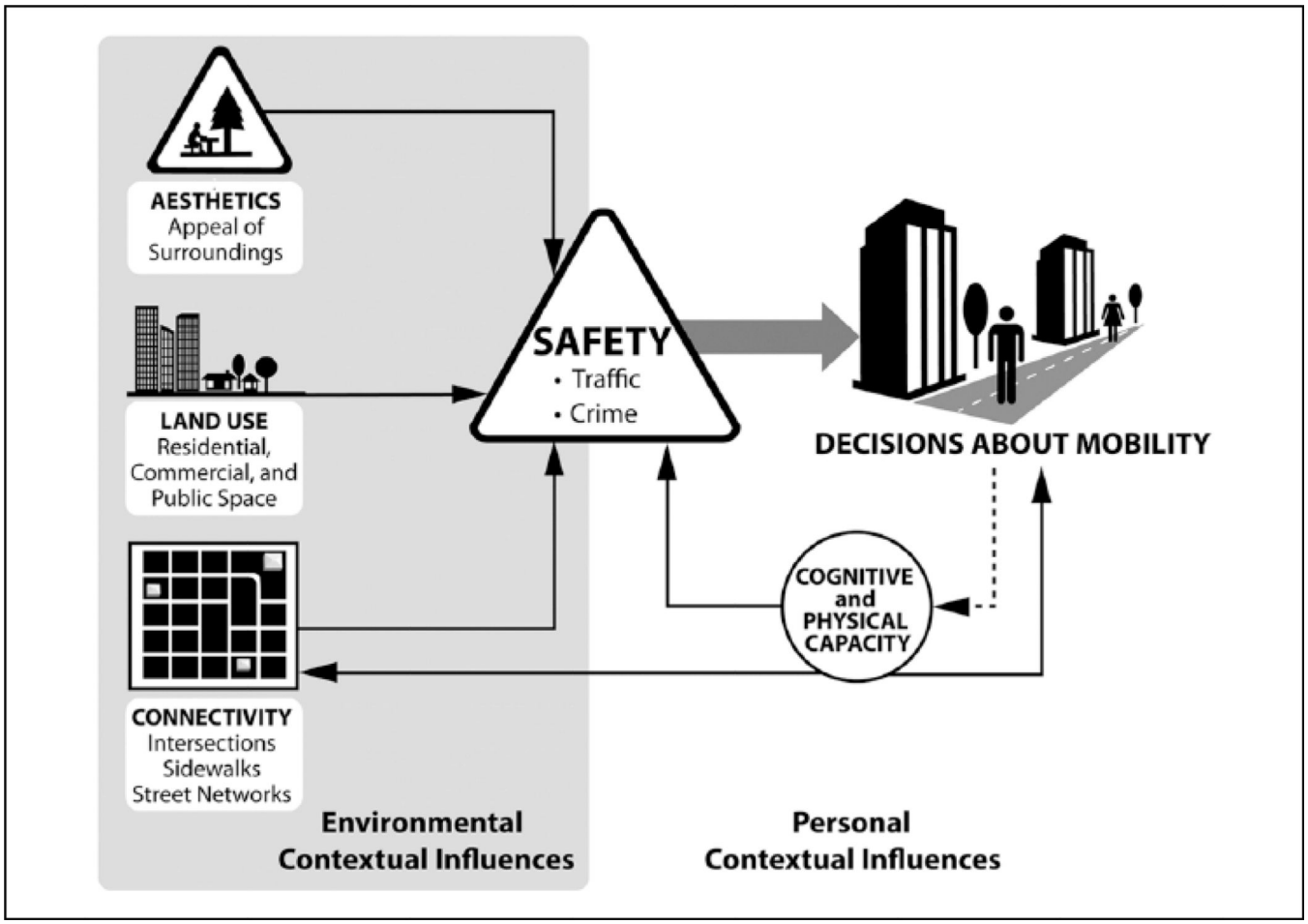

Figure 2.
Refined program theory on mobility in older adults.

Table 1

Themes

Sidewalks

- Well-maintained (and linked to walking)
- Poorly maintained

Streets and Roads

- Poor street conditions
- Traffic-calming measures
- Presence of bike lanes

Neighborhood land composition

- Land use mix (residential and commercial)
- Primarily residential
- Space designated for physical activity (trails, bike paths, walking paths)

Connectivity—Length of street blocks and number of intersections
Residential Density—population density
Safety—Neighborhood safety (crosswalks, lights, crime, vandalism, etc.)
Transportation—Lack of other forms of transportation (car, public)
Destinations

- Retail destinations within walking
- Park/open or green space within walking
- Services within walking distance
- Facilities—recreation centers

Aesthetics—The appeal of the built environment and one's surroundings

Note. "Parent Themes" are given in bold face and "Child Themes" are bulleted.

Table 2

Description of the Articles and Reports Included in the Realist Synthesis (n = 123).

	Articles *n* (%)
Country where study occurred	
The United States	64 (52)
Canada	11 (9)
Australia	8 (7)
The United Kingdom	9 (7)
The Netherlands	6 (5)
Colombia	3 (2)
No specific country	8 (7)
Other	13 (11)
Neighborhood type	
Urban	60 (49)
Rural	3 (2)
Urban and rural	15 (12)
Suburban	6 (5)
Multiple (national studies; urban, suburban, and exurban)	35 (28)
Unknown/not stated	4 (3)
Number of neighborhoods in study	
1	26 (21)
2–10	32 (25)
11–100	14 (11)
101 or more	9 (7)
NA/unknown	42 (34)
Year article/report was published	
1991–1999	7 (6)
2000–2005	26 (21)
2006–2011	87 (70)
Unpublished	3 (2)
Study design[a]	
Cross-sectional	89 (72)
Longitudinal	9 (7)
Qualitative	8 (7)
Multimethod or NA	17 (14)

[a]Most studies included data from surveys, or a combination of surveys and other methods (e.g., census/administrative data; 71 studies); the remainder of the studies included observational, interview, or focus group data (27); or solely secondary data compiled from existing databases.