The Home Environment and Disability-Related Outcomes in Aging Individuals: What Is the Empirical Evidence?

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Hans-Werner Wahl, PhD, 1 Agneta Fänge, PhD, 2 Frank Oswald, PhD, 3 Laura N. Gitlin, PhD, 4 and Susanne Iwarsson, PhD, 5

Purpose: Building on the disablement process model and the concept of person–environment fit (p-e fit), this review article examines 2 critical questions concerning the role of home environments: (a) What is the recent evidence supporting a relationship between home environments and disability-related outcomes? and (b) What is the recent evidence regarding the effects of home modifications on disability-related outcomes? Design and Methods: Using computerized and manual search, we identified relevant peer-reviewed original publications and review articles published between January 1, 1997, and August 31, 2006. For Research Question 1, 25 original investigations and for Research Question 2, 29 original investigations and 10 review articles were identified. Results: For Research Question 1, evidence for a relationship between home environments and disability-related outcomes for older adults exists but is limited by cross-sectional designs and poor research quality. For Research Question 2, evidence for a relationship between home environments and disability-related outcomes for older adults exists but is limited by cross-sectional designs and poor research quality. For Research Question 2, evidence based on randomized controlled trials shows that improving home environments enhances functional ability outcomes but not so much falls-related outcomes. Some evidence also exists that studies using a p-e fit perspective result in more supportive findings than studies that do not use this framework. Implications: Considerable evidence exists that supports the role of home environments in the disablement process, but there are also inconsistencies in findings across studies. Future research should optimize psychometric properties of home environment assessment tools and explore the role of both objective characteristics and perceived attributes of home environments to understand person–environment dynamics and their impact on disability-related outcomes in old age.

Key Words: Disablement process, Person–environment fit, Home modification, Activities of daily living, Falls, Old age, Literature review

The role of the home environment for maintaining and improving the daily function of older adults is now widely recognized in research and practice. In the field of psychology of aging, there is a long tradition of linking excessive “environmental press” (Lawton & Nahemow, 1973) with loss of functioning and disability (Scheidt & Windley, 2006; Wahl, 2001). Similarly, geriatric medicine, occupational therapy, and rehabilitation research have also emphasized the home environment as a critical objective factor supporting or undermining individual functioning (Iwarsson, 2004; Rubenstein, 1999; Stark, 2001).

Ongoing evaluation of the role of the home environment in the disablement process continues to be an important public health concern to inform interventions and health policy. This is particularly the case given that the majority of older adults live in private households with those older than 80 years spending most of their time in the home or immediate surroundings (Baltes, Maas, Wilms, Borchelt, & Little, 1999; Wahl & Gitlin, 2003). Also, older adults prefer to “age in place” as long as possible (e.g., American Association of Retired Persons [AARP], 2003). Moreover, population-based studies suggest that gains in functioning in older adults over the past few decades may be

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attributable in part to the reduction of environmental barriers (Freedman, Martin, & Schoeni, 2002; Spillman, 2004; we use the term “environmental barriers” throughout the text to refer to terms widely used in various bodies of literature such as home hazards and environmental hazards).

Given the prominence of the home environment in the everyday lives of older adults, it is surprising that systematic evaluations of the existing empirical evidence to support its impact on disablement have been rare and selective. Previous reviews targeting the home environment have only addressed the impact of home modification, mostly with respect to falls (e.g., Barras, 2005; Connell & Wolf, 1997; Gillespie et al., 2003; Gitlin, 1998; Lord, Menz, & Sherrington, 2006). To our knowledge, there has not been a comprehensive review of recent research examining the linkages between home environments and disability-related outcomes, nor has there been a comprehensive evaluation of the evidence supporting home environmental interventions and disability-related outcomes.

An examination of the extant research is important not only for research but also to inform clinical guidelines and home care and outpatient practices with functionally vulnerable older adults. For example, national organizations serving older adults have stressed the importance of modifying the home environment to maintain quality of life and enhance aging in place (AARP, 2003). Thus, in this article, we seek to synthesize the evidence to bring to the forefront the role of the home environment as a public health priority. Understanding what we know about the relationships between home environments and outcomes also provides a foundation from which to develop and refine intervention research, identify best practice guidelines, and shape policy decisions concerning programmatic and funding structures, particularly as it concerns home modification services, the cost of which is not typically covered by third-party payers.

Theoretical Perspectives

The disablement process model (DPM; Verbrugge & Jette, 1994), an often-used model, emphasizes “the main pathway” of disablement and the risk factors, referred to as extra-individual (e.g., home modifications) and intra-individual (e.g., coping styles), which influence transitions from pathology to disability. A basic assumption of the model is the role of the physical environment as an influential force on well-being, which can serve either as a risk or a protective factor. The model suggests that intervening in the environment, by either reducing risk (e.g., by removing environmental barriers) or enhancing its supportive function (e.g., by installing grab bars), may minimize disability-related outcomes. Thus, evaluating the research evidence to support these functions of the environment that are implied in the model can advance theoretical understandings of the disablement process and guide policy and treatment.

Although the DPM provides a framework for understanding the role of the environment on the disablement process, additional concepts are needed to examine the mechanisms involved in linkages between home environments and disability outcomes. Particularly helpful is the well-known competence–environmental press model (CEPM) introduced by Lawton and Nahemow (1973). Critical to the CEPM is the fundamental assumption that for each person, there are optimal combinations of environmental circumstances/conditions and personal competencies that result in the highest possible functioning for that person. The term person–environment fit (p-e fit) represents an overarching concept to address this insight (Wahl & Gitlin, 2007). One assumption we examine in our review is whether studies explicitly based on and using measures of p-e fit reveal more consistent and supportive findings compared with studies that do not. As such, the review may potentially provide validation of the importance of p-e fit in environmental studies.

Research Questions

This review article seeks to address two research issues: First, we evaluate the quality and data findings of research that targets the relationship between the home environment and disability-related outcomes for vulnerable older adults. We ask specifically, What is the recent evidence supporting a relationship between home environments and disability-related outcomes? Second, we evaluate findings from research that uses the home environment as a therapeutic modality or an intervention to influence disability-related outcomes. We ask specifically, What is the recent evidence regarding the effects of home modifications on disability-related outcomes?

For both research questions, we considered the possible inconsistency in study outcomes and whether a p-e-fit framework guiding the research
and measurement strategy is able to explain such inconsistency.

**Methods**

**Inclusion and Exclusion Criteria**

For this review, the home environment was defined as the physical setting of the house/apartment and its immediate surroundings; home modification was used to refer to any effort to improve a given physical home with the aim to address the functional needs of a person. We excluded studies that only examined assistive devices. Assistive devices are an important “external” means to cope with disability but are not necessarily part of the home environment. However, studies of home environments that included assistive devices along with home modifications were included in this review. We also included multicomponent interventions, that is, interventions that combined changes to the physical environment with other supportive efforts such as caregiver training, assistive devices, or behavioral change strategies. For Research Question 1, we excluded studies that targeted only the social environment. We considered a range of disability-related outcomes linked to activity and participation including three functional domains: mobility related, instrumental and self-care, and their associated activities. In addition, we included falls incident and accidents in the home given that they represent facets of the everyday dynamics of aging in place at home. Additionally, publications had to meet the following criteria for inclusion in the review: (a) published in peer-reviewed journals from January 1, 1997, to August 31, 2006; (b) published in English; (c) inclusion of a sample of community-dwelling individuals 18 years and older with at least 50% of individuals 50 years or older; and (d) involve quantitative analysis. We excluded all qualitative and case-oriented research because a comparative evaluation across studies could occur with somewhat comparable study approaches. We considered review papers that compiled quantitative original investigations.

**Search Methodology**

We searched numerous fields, such as geriatric and geropsychiatric medicine, rehabilitation, social and behavioral gerontology, and physical and occupational therapy research. A computerized search was conducted using Cinahl, Google, PsychInfo, PubMed, Scopus, OT Seeker, and the Cochrane Library (see Table 1 for search terms used). Additionally, we manually inspected the references cited in review articles and checked the contents of relevant journals from different academic fields. Also, 22 scholars were contacted via e-mail requesting their recent research related to the two research questions.

**Preparation of Data Body for the Review**

**Literature Screening and Final Inclusion Decision.**—The first screening of the literature yielded about 500 articles on environmental aspects including environmental modification/intervention and disability-related outcomes as per the screening criteria. In the case of review articles, we considered any that targeted environmental issues and disability-related outcomes. Next, we narrowed this body of work down to those that were directly relevant to the two research questions we posed. This yielded 81 original investigations and 5 review

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<th>Home modification</th>
<th>Disability-related outcomes</th>
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<tr>
<td>Accommodation</td>
<td>Home adaptation</td>
<td>Accidents</td>
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<td>Activities of daily living</td>
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<td>Functioning</td>
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<td>Built environment</td>
<td>Home hazards</td>
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<td>Environmental barriers</td>
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<td>Home</td>
<td>Home modification</td>
<td>Instrumental activities of daily living</td>
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<td>Home intervention</td>
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<td>Home repair</td>
<td>Occupation</td>
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<td>Person–environment fit</td>
<td>Housing adaptation</td>
<td>Occupational performance</td>
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articles related to Research Question 1 and 63 original investigations and 23 review articles for Research Question 2. After this identification of articles (conducted by the first author), the second author (Agneta Fänge) independently repeated this step of initial screening of all articles. A joint discussion of only a few discrepancies led to the final set of articles. The final inclusion decision yielded 25 original investigations addressing Research Question 1, but not a single meta-analytic or narrative review article. With respect to Research Question 2, 29 original investigations and 10 review articles were included. (Included studies/articles are marked with an asterisk in the reference list.)

Descriptive Analysis of the Included Literature. — We began with a descriptive analysis of the identified studies in table format with the following information extracted (the tables with all the descriptive information are available at request): first author and year of publication; kind of disability-related outcome(s); study type; type of home environment assessment (Research Question 1) or home modification, type of application (individualized vs. group), and intensity of the intervention (Research Question 2); psychometric properties of home environment assessment tool (Research Question 1); sample characteristics; narrative summary of findings (Research Questions 1 and 2). We also compiled the major findings of review articles. After a first round of condensing information into table format (Hans-Werner Wahl), an independently conducted second round by the second author resulted in a few revisions.

Assignment to Levels of Evidence. — In the next step, we considered levels of evidence of included articles, adjusting for our purpose suggestions by Sackett, Strauss, Richardson, Rosenberg, and Haynes (2000; see also Barras, 2005). We considered a hierarchy of evidence for Research Question 1, with review articles located at the highest level (Level 1a: meta-reviews; Level 1b: narrative reviews), followed by cohort studies with a longitudinal design allowing for causal inferences regarding variable relations (Level 2), case-control studies allowing for quasicausal interpretation (Level 3), and cross-sectional studies allowing for correlational interpretation (Level 4). For Research Question 2, the highest level contains systematic reviews of randomized controlled trials (RCTs; Level 1a: meta-analytic reviews; Level 1b: narrative reviews), followed by single RCTs (Level 2a) or non-randomized studies with a control condition (Level 2b), case-control studies (Level 3), and pre–post intervention studies without a control condition (Level 4). Assignment of evidence levels was conducted independently, first by the first author and then by the second author, with disagreement found for only two studies and resolved through discussion (Figure 1).

Study Quality Rating. — Each original study was rated according to a modified version of the Critical Review Form for Quantitative Papers suggested by Law and coworkers (1998; a copy of the rating form is available on request). Rating criteria included quality of description of study purpose and literature background, appropriateness of study design, preciseness of sample characterization and dropout analyses, report on psychometric properties of instruments used, appropriateness of data analytic steps, and quality of data interpretation. Ratings varied between 0 and 16 (highest quality); the majority of the rating criteria were assigned 1 point for a positive evaluation, whereas in some cases, the assignment of 0.5 points occurred (e.g., reliability information in the study = 1 point; referral to earlier published reliability information = 0.5 points; no information = 0 points). Two authors (Hans-Werner Wahl and Agneta Fänge) rated each article independently, resulting in 100% rating agreement allowing for deviations of a maximum of ±1 point. We took the mean of the ratings in all cases with deviations of ±1 point. (We generally regarded the ratings as interval scaled, that is, we report means and standard deviations as summary qualification indexes.) Thus, intrarater agreement was high for both research questions.

Global Qualification of Findings. — Studies reporting a statistically meaningful \( p < .05 \) link between the home environment/home modification and disability-related outcomes/change in disability-related outcomes were labeled “supportive” (+), studies not supporting such a link were labeled “null” (−), and studies revealing some but not consistent support were labeled “partially supportive” (±). Partial support occurred when more than one outcome was considered in a study and support was found for at least one but not all the outcome measures. The global qualification rating of findings was again conducted independently by two authors (Hans-Werner Wahl and Agneta Fänge). When aggregated across all articles for
both research questions, there was 95% agreement. Existing discrepancies occurred in a few cases and were resolved without difficulty.

Assignment of Studies to Outcome Areas. — Finally, we organized all the work according to two broad target disability-related outcomes: functional ability-related and falls-accidents-related outcomes. Some studies addressed both target areas.

Results

Research Question 1: Relationship Between the Home Environment and Disability-Related Outcomes

Characteristics of Included Studies and Findings. — The age range of participants across studies was 18–85+ years, with most studies including those 65 years and older. Sample size of studies varied widely from $N = 51$ to $N > 10,000$. Nine of the 25 studies considered older people with limited functional capacity (e.g., wheelchair users, home health care recipients, or people with activity limitations), but no study included in this review involved individuals with dementia-related disorders. Some studies included persons without “diagnosed” functional limitations/functional loss; however, given the fact that samples included older adults, most were at risk for functional decline. The length of follow-up in longitudinal studies varied from 1 to 6 years, and confounding variables such as age, gender, and education were considered in 17 of 25 studies.

Twelve of the 25 studies (48%) reported psychometric properties of the home environment assessment that was used, mostly targeting interrater
The operationalization of the home environment ranged from assessments of 188 barriers in the home and its immediate surroundings (e.g., Iwarsson, Isacsson, & Lanke, 1998) to a small set of questions concerning housing type or floor level (Waite & Hughes, 1999). A few studies applied a complex assessment of accessibility based on p-e fit concepts (Iwarsson, 2005; Iwarsson et al., 1998; Wahl, Oswald, & Zimprich, 1999), whereas most research evaluated environmental barriers independent of person characteristics.

Nine of the 25 (36%) studies included observation, with 7 of 9 evaluating interrater reliability. Thus, most studies relied on self-reports.

Table 2 categorizes the 25 original investigations according to outcome area, level of evidence, and global qualification of findings. As shown, most studies targeted functional ability outcomes (17 of 25) and had the lowest evidence level (n = 21). Only one longitudinal study (Iwarsson, 2005) included a functional ability–related outcome and two longitudinal studies included falls–accidents–related outcomes (Bemmel et al., 2005; T. M. Gill et al., 2000).

Four of eight (50%) studies reported supportive results in the area of falls–accidents–related outcomes, whereas another four were partially supportive. The study quality rating across both outcome areas was 10.4 (SD 1.7).

**Exploration of Inconsistency in Study Findings.** — An in-depth examination of the literature on functional ability–related outcomes revealed that the studies conducted by Allen, Resnik, and Roy (2006); Hoenig, Pieper, Zolkewitz, Schenkman, and Branch (2002); Hoenig, Landermann, Shippe, and George (2003); Hoenig, Taylor, and Sloan (2003); Kutty, 2000; Meinow et al., 2005; Murphy et al., 2006; Newcomer et al., 2005; Rochette et al., 2001; Verbrugge & Madans, 1997; Wahl et al., 1999; Waite & Hughes, 1999 ±)

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**Table 2. Categorization of N = 25 Original Studies Speaking to Research Question 1, According to Level of Evidence, Outcome Area, and Global Qualification of Findings**

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Furthermore, the findings from 7 of 17 (41%) studies were found to be supportive and another 7 provided partially supportive evidence for a link between home environments and functional ability–related outcomes; 3 studies reported null findings.
Robison, and Tinetti (1999 [−]); Harwood, Prince, Mann, and Ebrahimi (1998 [±]); Meinow, Kareholt, and Lagergren (2005 [−]); Newcomer, Kang, LaPlante, and Kaye (2005 [±]); Verbrugge and Madans (1997 [±]); and Waite and Hughes (1999 [±]). For example, in the studies of T. M. Gill and coworkers, an overall assessment of environmental barriers in the home environment was correlated with global functional ability outcomes, and in the study of Meinow and coworkers, an overall characterization of the home environment was statistically linked with a measure of hours of help. In sum, supportive evidence was demonstrated for all studies but one (Verbrugge & Madans, 1997), which linked a specific environmental feature with a specific functional outcome. Thus, there is some supportive evidence for a link between the home environment and functional ability-related outcomes, but a link is tempered by the proximity of particular environmental features and person-based outcomes. For example, in studies linking a particular home environment such as a bathroom feature (e.g., grab bars) to an outcome (e.g., ability to bathe safely), a supportive finding appears to be more likely. Finally, with respect to falls–accidents-related outcomes, all the identified studies were at least partially supportive of a relationship with the home environment.

**Research Question 2: Relationship Between the Home Environment and Disability-Related Outcomes in Intervention Research**

**Characteristics of Included Studies and Findings.**—The age range of participants in the included studies varied from 24 to older than 80 years. Six of 29 (21%) studies included samples with individuals older than 75 years, or with mean sample ages of at least 80 years. Sample sizes ranged from N = 16 to N > 10,000. Seventeen of 29 (59%) studies targeted persons with functional loss due to age-related decline, disease, or a fall or falls-related injury, whereas 2 targeted elders with dementia-related disorders. In the remaining 12 studies, functional ability-related or falls–accidents-related outcomes were assessed, although it is unclear whether the sample had to have a functional limitation to be enrolled in the study. In 17 of the 29 (59%) studies, only the home environment was the target for intervention, whereas in 12 studies (41%), a multicomponent intervention including home modification was implemented. The type of home modifications varied widely across studies. For example, interventions included individually tailored home modification, and in some cases targeting a particular clinical population (e.g., older adults with visual impairments; Campbell et al., 2005); in other studies, a heterogeneous sample was included (e.g., Cumming et al., 1999). One study involved only bathroom adjustments (Gitlin, Miller, & Boyce, 1999), whereas in others, several housing areas were targeted (e.g., Fänge & Iwarsson, 2005). Follow-up assessments following intervention tended to be from 3 to 12 months but also varied up to 5 years. Table 3 categorizes 10 review articles and 29 original investigations by outcome area, evidence level, and global qualification of findings. In terms of the evidence, there is considerable review work on the effects of home modifications, but only for falls–accidents-related outcomes. The body of RCTs is considerable with 10 studies in the functional ability-related outcome and 13 studies in the falls–accidents-related outcome area.

Review articles report inconsistent evidence for the effect of an intervention on both types of outcomes. For example, Chang and coworkers (2004) found no substantial support for the role of a relationship between home modification and falls, whereas Gillespie and associates (2003) found substantial support at least for individuals with a falls history. Thus, the review articles suggest inconclusive findings and different outcomes.

With respect to original investigations, 7 of 13 (54%) studies found supportive and 4 (31%) reported partially supportive findings for a link between the intervention and improvements in functional ability-related outcomes, with 2 (15%) studies reporting null findings. Five of 10 (50%) RCT studies targeting functional ability were supportive and 3 (30%) were partially supportive. The findings were less favorable for falls–accidents-related outcomes. Five of 18 (28%) studies found supportive evidence for a substantial link between the intervention and a decrease in falls–accidents-related outcomes, whereas the evidence was partially supportive in 6 (33%). Seven (39%) studies reported null findings. Four of 13 (31%) RCT studies in the falls–accidents-related area were supportive, whereas another 3 (23%) reported partially supportive findings. The study quality for both target areas was a mean of 12.8 (SD 1.9) and thus higher compared with those responding to Research Question 1.

**Exploration of Inconsistency in Study Findings.**—Unfortunately, because many studies evaluate multicomponent-type interventions, it is difficult to determine the specific role of the home...
However, we identified six studies that solely or predominantly test a home modification approach (Brunnström, Sörensen, Alsterstad, & Sjöstrand, 2004 [+]; Gitlin, Corcoran, Winter, Boyce, & Hauck, 2001 [±]; Gitlin et al., 1999 [+]; Gitlin et al., 2003 [−]; Mann, Ottenbacher, Fraas, Tomita, & Granger, 1999 [+]; and Stark, 2004 [+]). Three of these studies (Brunnström et al., 2004; Gitlin et al., 1999; Stark, 2004) directly linked the tested home modification to an outcome, and one study (Mann et al., 1999) used a specific outcome measure of independence that was proximal to the use of home modifications. Findings from the Brunnström and associates (2004) study focused on the improvement of lighting conditions for older adults with visual impairments and found supportive evidence outcomes (i.e., higher independent functioning). In contrast, Gitlin and coworkers (2001, 2003) tested a broad home modification program and evaluated outcomes for overall functional ability (e.g., the intervention and outcome measure did not target a specific behavior), and findings were partially or not supportive. That is, it seems to be the case that the likelihood of supportive findings is higher, if the study outcome is closely linked to a specific home modification. In terms of the eight studies targeting falls outcomes and using a home modification approach (either alone or in combination with other components; Campbell et al., 2005 [+]; Cumming et al., 1999 [±]; L. Day et al., 2002 [–]; Hagsten, Svensson, & Gardulf, 2004 [±]; Mann et al., 1999 [+]; Pardessus et al., 2002 [+]; Tinetti et al., 1999 [–])

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<td>2a</td>
<td>Study based on randomized controlled trial</td>
<td>10: Brunnström et al., 2004 (+); Gill et al., 2002 (+); Gitlin et al., 2001 (±); Gitlin et al., 2003 (–); Gitlin et al., 2006 (+); Haastregt et al., 2000 (±); Hagsten, Svensson, &amp; Gardulf, 2004 (±); Mann et al., 1999 (+); Pardessus et al., 2002 (+); Tinetti et al., 1999 (–)</td>
<td>13: Campbell et al., 2005 (+); Clemson et al., 2004 (±); Close et al., 1999 (+); Cumming et al., 1999 (±); Day et al., 2002 (–); Haastregt et al., 2000 (–); Huang &amp; Acton, 2004 (–); Nikolaus &amp; Bach, 2003 (±); Pardessus et al., 2002 (–); Peel et al., 2000 (–); Steinberg et al., 2000 (±); Stevens et al., 2001 (±); Yates &amp; Dunning, 2001 (±)</td>
</tr>
<tr>
<td>2b</td>
<td>Nonrandomized clinical study</td>
<td>—</td>
<td>4: Deery, Day, &amp; Fildes, 2000 (–); Kempton, Van Beurden, Sladden, Garner, &amp; Beard, 2000 (±); Lindqvist et al., 2001 (±); Poullustrop &amp; Jeune, 2000 (±)</td>
</tr>
<tr>
<td>3</td>
<td>Observational study</td>
<td>—</td>
<td>1: Tolley &amp; Atwal, 2003 (±)</td>
</tr>
<tr>
<td>4</td>
<td>Pre–post intervention study</td>
<td>3: Fänge &amp; Iwarsson, 2005 (±); Gitlin et al., 1999 (+); Stark, 2004 (+)</td>
<td>—</td>
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that studies with less intensive home modification components (e.g., only 1-day consultation), reported null findings. This is in contrast to studies yielding supportive and partially supportive findings, in which case they tended to test more intensive environmental interventions.

Discussion

Although the home environment is widely acknowledged as the primary and preferred context for growing old (Scheidt & Windley, 2006; Wahl & Gitlin, 2007), a rigorous analysis of the evidence for a link between the home environment and the quality of life is needed to better understand its role conceptually, empirically, and practically. Our first research issue addressed the quality and findings of research on the relationship between home environments and disability-related outcomes for older adults. Our second research issue sought to determine the level of evidence for the role of the home environment as a therapeutic modality to influence disability-related outcomes. Our systematic review provides a broad platform for understanding essential relationships between persons and environments and differs from previous review efforts in several important ways. First, we used a wide search strategy that included a broad range of disciplines such as gerontology, geriatric medicine, and occupational therapy research. Second, we examined both nonintervention and intervention research on home environments and disability-related outcomes. Finally, we also evaluated the different levels of evidence that were achieved in studies and simultaneously considered two of the critical outcomes for older adults, that is, functional ability–related and falls risk– and accidents-related outcomes.

With respect to Research Question 1, we conclude that evidence does exist for a relationship between the home environment and disability-related outcomes. The majority of studies identified provide supportive or at least partially supportive evidence. Findings are mostly at a low level of evidence, that is, they are based on cross-sectional studies, and do not allow for causal interpretations. However, of note are the three longitudinal studies and the one case-control study that were reviewed, all revealed partially supportive findings. This suggests some support for a causal effect of the home environment warranting additional research in this area. Of concern is that not a single study was identified that included dementia-related disorders, with most research with this clinical population being conducted in institutional settings (e.g., K. Day, Carreon, & Stump, 2000). Further, study quality is limited even for those studies revealing supportive evidence. Most importantly, evidence for the psychometric quality of home environmental assessments used in studies is only available in less than half of the studies.

For Research Question 2, overall, there is evidence that improving the home environment reduces disability-related outcomes. Again, the majority of studies provide supportive or at least partially supportive evidence; however, the evidence varies based on the specific outcome considered, that is, functional ability–related versus falls–accident-related outcomes. Only a few of the studies reviewed that targeted falls–accident-related outcomes were found to be supportive of the role of the home environment. In contrast, more than half of the intervention studies reviewed that targeted functional ability–related outcomes revealed supportive results. Given that most studies followed an RCT design, study quality in both target areas was higher compared with those addressing Research Question 1. Thus, our findings tentatively underscore the role of home environmental interventions in supporting functional abilities–related outcomes, but the evidence is less convincing for falls–accident-related outcomes. This is in line with the meta-review of Chang and coworkers (2004), which questions the role of a home environment improvement approach as a single intervention strategy for reducing fall risk. Some evidence suggests, however, that improvement of the home environment is particularly important for older people with a history of falls (Gillespie et al., 2003). A recent review article, published after our search period, arrived at a similar conclusion (Lord et al., 2006).

The question remains as to why there is more supportive evidence for the impact of environments on functional ability–related compared with the falls–accident-related outcomes? One explanation may be that the link between functional ability and the home environment is more proximal. Functional ability is an ongoing behavior and in constant interaction with the physical environment. In contrast, falls and accidents are rather seldom events that represent a confluence of multiple risk factors, only one of which may be the environment. Previous research confirms that the most effective fall reduction interventions are multicomponent including, for example, balance and muscle strengthening exercise, and medication review.
and adjustments. Also, the risk factors for falls are manifold and include depression, polypharmacy and specific medications, and cognitive impairment (e.g., Lord et al., 2006), which all are relatively independent of the physical home environment. This is not to say that the physical home environment is not a risk factor for falls—accidents-related outcomes. However, it seems that the role the physical environments plays for falls—accidents-related outcomes is not very strong and more under random variation as compared with functional ability-related outcomes.

Another derivation from this review is that studies that target one aspect of the home environment (e.g., improving the bathing room) and a disability area closely related to this aspect (independence in bathing) have a higher impact than more diffuse interventions and study outcomes. Furthermore, our review also underscores that the intensity and skillfulness of the home modification intervention appears to play a role such that the more intense and skilled interventions result in greater improvements.

Our main conclusion is that there is emerging support for the role of the environment as a driving force of disability-related outcomes, as envisioned in the DPM (Verbrugge & Jette, 1994). In addition, as has been argued by models such as the CEPM of aging (Lawton & Nahemow, 1973) and the p-e fit idea (Iwarsson & Ståhl, 2003; Wahl & Gitlin, 2007), our review offers support for p-e fit assumption; that is, environmental barriers independent of person-based competencies have only a limited influence on disability-related outcomes. Instead, the role of the environment is better understood and is more apparent when considered in conjunction with the coexisting functional capacity of the person. Recent evidence with very old community-dwelling people from European countries highlights the advantages of this simultaneous dual consideration of the person and environment (Oswald et al., 2007).

Further, the DPM points to extra-individual factors and intra-individual factors (Verbrugge & Jette, 1994), affecting the main pathway toward disability. Most of the quantitative research we reviewed addresses only risk factors and extra-individual factors, and thus, we also concentrated on these factors. However, it may be that intra-individual factors such as coping with home environments or attitudes toward home modification contribute to the relationship between home environments and disability-related outcomes and to the explanation of variation in the efficiency of intervention programs (e.g., Gitlin et al., 2001; Stark, 2001). Future research is needed to examine the perceived environment via constructs such as usability (Fänge & Iwarsson, 2005), housing-related control (Oswald, Wahl, Martin, & Mollenkopf, 2003; Oswald et al., 2006), or other constructs such as readiness to modify the home or personal control. Moreover, assistive devices (e.g., Löfqvist, Nygren, Brandt, Oswald, & Iwarsson, 2007) and the social environment (Haak, Dahlin-Ivanoff, Fänge, Sixsmith, & Iwarsson, 2007) need to be carefully considered as well. They may have an important part in the dynamics of autonomy. Such research would contribute to a broader and fuller understanding of how the environment operates in conjunction with other factors including their prediction and mediation roles. As was argued in the original DPM publication, it would also be important to include a wider range of quality-of-life indicators as outcomes than hitherto considered (Verbrugge & Jette, 1994; see also Oswald et al., 2007).

There remain critical methodological challenges for future research in the home environment field. Currently, the methodological soundness of more than half of the studies related to Research Question 1 was questionable primarily due to the lack of information provided on the reliability and validity of the home assessment procedure utilized. A pronounced limitation is that there is not a generally acknowledged measure and there is still a temptation to “quickly” invent a measure of the home environment for a study. There are few psychometrically sound tools and it is challenging to derive valid and reliable home measurement tools. However, the “Housing Enabler,” one of the few instruments that assesses environments based on person competencies, demonstrates the possibility and utility of a p-e fit assessment approach (e.g., Iwarsson, Nygren, & Slaug, 2005). The Home Environmental Assessment Protocol has also been shown to have strong interrater agreement, reliability, and validity, but it is limited to use with dementia populations living at home and assesses the environment from a global patient perspective (Gitlin et al., 2003). Given the fact that psychometrically sound instruments are essential for examining the role of home environments, this review indicates that tool development should be one of the priorities of this area of inquiry.

Several limitations of our review should be noted. First, every review article is confronted with
the file drawer problem. That is, results with unfavorable findings may not have been published, thus forging the "true" evidence situation. Although our search process was thorough, we may have missed important work, but we assume that such possible cases would not change the tendencies found. Moreover, comparing rather heterogeneous research as we have done has disadvantages. Such heterogeneity, particularly in terms of the home assessment methods used, prevents the application of a meta-analytic approach. Also, the term outcome, which we applied to the dependent variables of both Research Questions 1 and 2, may be questioned regarding Question 1 because here we addressed nonintervention and mostly cross-sectional research. Additionally, multicomponent interventions including home modification are frequently not reporting on the "pure" effect of the latter. Also, studies based on a qualitative research approach were not considered in our review, but they may contribute much to the understanding of the underlying mechanisms and should be considered in future reviews (e.g., Haak, Dahlin-Ivanoff, Fänge, Sixsmith, & Iwarsson, 2007; Stark, 2001).

Based on the results of our literature review, we arrive at the following recommendations for future research in the field:

- High-quality research, particularly longitudinal research and RCT research, is needed. Because practically no major longitudinal aging study explicitly considers the home environment, this rich resource for primary and secondary data analysis does not infuse p-e research. We would thus urge ongoing longitudinal studies that address functioning in old age to include psychometrically tested home environment assessments.

- There is a need to obtain conceptual clarity and definitions that can drive development of adequate home environment measurement tools. A related point is that home environment measures used in studies need to be more comparable and have proven validity, reliability, and sensitivity to detect changes over time.

- Stronger consideration of the p-e fit concept is needed to guide studies in this area and the measurement of the environment. Measuring environmental barriers without consideration of the person and the fit with the person appears to have only limited potential to explain variance in disability-related outcomes. This represents both a conceptual and a methodological challenge.

- There is a need to consider and measure both the objective and perceived home environment to grasp the full picture of person-environment dynamics and their impact on disability-related outcomes. Combined quantitative and qualitative methodologies may best serve this need.

References

Asterisks indicate the references that have been part of the literature analysis.


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