Impact of the Design of the Built Environment on People with Dementia: An Evidence-Based Review

Gesine Marquardt, PhD; Kathrin Bueter, MA; and Tom Motzek, MSc

ABSTRACT

OBJECTIVE: In this review the impact of the design of the built environment on people with dementia in long-term care settings is systematically analyzed and summarized. Architects and designers will be provided with credible evidence on which they can confidently base their design decisions. Researchers will be able to determine which environmental aspects have been well investigated and where there are gaps in the current state of the research.

BACKGROUND: A great number of studies have established a relationship between the design of the physical environment of long-term care settings and outcomes of people with dementia. However, the methods employed are heterogeneous and the results are often conflicting. Consequently, the process of integrating the best evidence available into architectural designs may be hindered.

METHODS: A systematic literature search was conducted reviewing studies that meet certain inclusion criteria. Using an evidence-based approach, the methodical quality of the studies was rated.

RESULTS: One hundred sixty-nine studies were found. They were thematically summarized into four main categories: basic design decisions, environmental attributes, ambience, and environmental information. The effectiveness of the interventions on the behavior, cognition, function, well being, social abilities, orientation, and care outcomes on people with dementia was illustrated by matrices.

CONCLUSIONS: Results of this review indicate that, with the exception of cognition, specific design interventions are beneficial to the outcomes of people with dementia. Overall, the field of environmental design for people with dementia is well researched in many aspects and only few gaps in knowledge were identified.

KEYWORDS: Built environment, elderly, literature review, evidence-based design, outcomes

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The number of people with dementia is increasing. In 2010 it was estimated that 35.6 million people were living with dementia worldwide. This number is expected to double every 20 years, to 65.7 million in 2030 and 115.4 million in 2050 (Prince, Bryce, Albanese, Wimo, Ribeiro, & Ferri, 2013). Dementia is a syndrome due to disease of the brain; it is characterized by a progressive decline in cognitive, social, and emotional abilities. The deterioration in cognitive abilities includes impairments in memory, language, and orientation. As a result, people with dementia need assistance with numerous daily tasks and they are, as the disease progresses, in increased need of care. Dementia is associated with a high individual burden both for people affected by the disease and their caregivers (van der Linde, Stephan, Savva, Dening, & Brayne, 2012). Therefore, strategies to create appropriate living environments for people with dementia are required.

An important strategy is the adaptation of the built environment to meet the needs of persons with dementia. For more than two decades, a great number of studies examining and reviewing the relationship between people with dementia and their environment have been published. They have shown that the physical environment can have a therapeutic effect on people with dementia, helping them to improve and preserve their well being, behavior, independence, and functionality (Day & Carreon, 2000; Fleming & Purandare, 2010; Tilly & Reed, 2008). These findings were accompanied by the rise of the concept of evidence-based design (EBD). The aim of EBD is to systematically translate research findings into design practice and to expose the best available evidence in order to help architects and designers to make the right design decisions on users' behalf (Pati, 2011; Stichler, 2010a).

For more than two decades, a great number of studies examining and reviewing the relationship between people with dementia and their environment have been published.

The aim of this article is to not only review but also to rate the available evidence on environments for people with dementia in long term-care facilities using an evidence-based approach. It will provide architects and designers with credible evidence on which they can confidently base their design decisions. For researchers, this evidence-based approach will provide information on which environmental aspects have been well investigated and where there are gaps in the current state of the research.

Methods

The methods of this review, including search strategy, study selection, data abstraction, appraisal of the methodical quality, and data synthesis, are discussed below.

Search Strategy

A systematic literature search was implemented according to literature review guidelines (Centre for Reviews and Dissemination, 2009). Empirical studies published from 1980 until February 2013 were retrieved, written in English or

German, and available on the databases MEDLINE, web of science, PSYNDEX, psycINFO, academic search, EMBASE, CINAHL, and TOC Premier. The search was carried out using the keywords *dementia or Alzheimer* and *architecture or interior design or environment design or facility design or built environment or therapeutic design or environmental intervention or design intervention or physical environment.* If applicable, MeSH terms were used. In addition, reference lists of review articles were hand searched for further empirical literature.

To compare the great number of studies with their diverse methodical frameworks, a classification system is necessary.

Study Selection

For inclusion in this review studies had to meet the following criteria:

1. Quantitative or qualitative research was conducted,
2. The influence of the physical environment on people with dementia was measured,
3. Study participants were people with dementia, and
4. The participants were living in a long-term care facility.

On the basis of these inclusion criteria, titles and abstracts of articles were screened for relevance. If a clear decision on relevance could not be made, full texts were requested for a detailed analysis. Then, the full texts of articles were screened for final inclusion by two researchers. Disagreements were discussed with a third researcher until a consensus was reached.

Data Extraction

Data on study objectives, study methods, dementia diagnostic criteria, outcomes, interventions, and results were extracted from all included studies using a standardized data sheet.

Appraisal of the Methodical Quality

To compare the great number of studies with their diverse methodical frameworks a classification system is necessary. Assigning evidence levels on the basis of the study designs has been established in the field of medicine (e.g., Balshem et al., 2011) and expanded to evidence-based design (Hamilton, 2011; Pati, 2011; Stichler, 2010b). For this paper, an algorithm that guides the user through assigning hierarchical levels to research studies was used (Marquardt & Motzek, 2013). The results are in Table 1.

Based on their methodological design, the studies included in this review were assigned to a level of evidence, ranging from 1 (high) to 6 (low). Excluded from this review were studies arriving at level 1, which are systematic reviews or meta-analyses themselves. Further, professional or organizational standards and guidelines that are covered by level 4, and recommendations from manufacturers or consultants that arrive at level 6, were excluded from this review because

Table 1. Levels of Evidence for Healthcare Design

Level	Description of Quality	Included
Level 1	Systematic reviews of multiple randomized controlled trials (RCTs) or nonrandomized studies; meta-analysis of multiple experimental or quasi-experimental studies; meta-synthesis of multiple qualitative studies leading to an integrative interpretation	No
Level 2	Well-designed experimental (randomized) or quasi-experimental (nonrandomized) studies with a low attrition rate, intention to treat analysis, blinding, masked randomization, and consistent results compared to other, similar studies	Yes
Level 3a	Observational studies with a cohort design; experimental or quasi-experimental studies that did not fulfill the criteria of level 2	Yes
Level 3b	Cross-sectional studies or case-control studies; qualitative research that, based on a literature review, on a theoretical framework, reports a clear method and considers a diversity of views	Yes
Level 4	Professional standards or guidelines with studies to support recommendations	No
Level 5	Qualitative research that did not meet the criteria of level 3b	Yes
Level 6	Recommendations from manufacturers or consultants who may have a financial interest or bias	No

Source: Stichler (2010b) and Marquardt & Motzek (2013).

they do not meet the first inclusion criterion. Studies that were assigned to levels 2, 3a, 3b, and 5 were included in this review. Level 2 encompasses experimental and quasi-experimental studies fulfilling certain requirements, such as a low attrition rate, intention to treat analysis, blinding, masked randomization, and consistent results. Studies that did not fulfill these criteria, as well as studies with a cohort design, were assigned to level 3a. Studies at level 3b include qualitative research that is based on a literature review and a theoretical framework, reports a clear method, and considers a diversity of views. Cross-sectional studies and case-control studies were also assigned to level 3b. Other qualitative research that did not meet the criteria of level 3b was included in the review and assigned to level 5. Disagreements in appraising the study quality were discussed by the study authors to reach a consensus.

However, we would like to caution that a study that arrived at a lower level of evidence is not necessarily of lesser value. Not all research objectives in care environments allow for rigorous methods, such as randomized controlled trials, or large samples of participants.

Data Synthesis

To summarize the results of this review, matrices were used. Listed in the columns, interventions/exposures were summarized into thematic groups and arrayed by evidence level. In the rows, all outcome variables were assigned to one of the following seven groups:

1. **Behavior,** e.g., agitation, eating behavior, psychiatric symptoms, violence, wandering
2. **Cognition,** e.g., attention, cognitive performance

3. **Function,** e.g., activities of daily living, falls, mobility
4. **Well being,** e.g., depressive symptoms, mood, quality of life
5. **Social abilities,** e.g., engagement, social interaction
6. **Orientation,** e.g., wayfinding
7. **Care outcomes,** e.g., medication, oral intake, physical restraint use, sleep

In each field of the table, the number of icons (squares and triangles) indicates the total number of studies investigating the relationship, while the position and the shape of the icon indicates whether an impact was found. For example, a square placed on the left side of a field means that a study established a relationship between the intervention and the outcome. This can be either a positive or a negative correlation. A triangle aligned to the right, however, indicates that no effect was found.

Results

The search results of the systematic literature review are shown in Figure 1. After eliminating duplicate articles, 2,642 records were identified; 632 papers were found to fit the inclusion criteria. Of these 62 were hand searched or taken from reference lists of identified articles. After scanning full texts, 169 studies were included for further detailed analysis. The majority of these studies were conducted in the United States (n = 88). Nineteen studies were conducted in Canada, 18 in the United Kingdom, 33 in other European countries, 5 in Australia, and 6 studies in Asia. Regarding the evidence levels, 49 studies were considered to be level 2, 62 studies were categorized into level 3a, 40 studies reached level 3b, and 18 articles were evidence level 5.

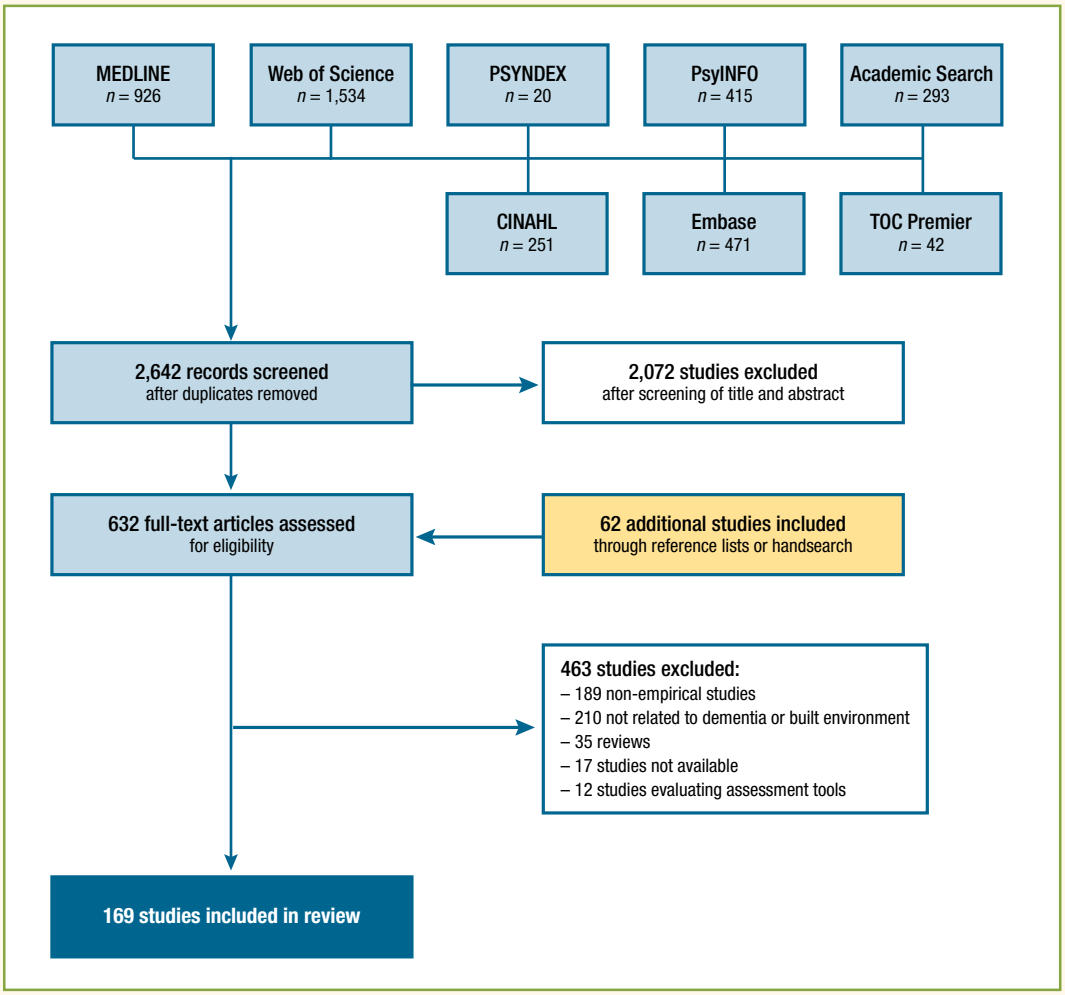
The identified studies were summarized into four main categories: Basic Design Decisions, Environmental Attributes, Ambience, and Environmental Information.

The identified studies were inductively summarized into four main categories: Basic Design Decisions, Environmental Attributes, Ambience, and Environmental Information. Studies that aimed to assess the general influence of the environment on people with dementia are not reported because it was impossible to derive precise design information. These studies either used environmental assessment tools (n = 12; such as TESS-NH) (Bicket et al., 2010); changed many or unclear characteristics of the interior design (n = 2); or were qualitative studies, which asked nursing home staff about general environmental requirements (n = 2). In addition, five studies that compared different facilities types without a clear objective are not reported.

Basic Design Decisions

This category covers the basic decisions that need to be made when designing long-term care facilities. Findings regarding special care units, small-scale environments, social density, and the building layout will be presented.

Figure 1. Search strategy.



Special Care Units

Special care units (SCUs) within nursing homes offer specialized, segregated care for cognitively impaired residents. The features of SCUs are not standardized. Besides a dementia-sensitive social and physical environment they could include dementia-trained staff, special activities, and family involvement. Nineteen studies investigating SCUs were identified.

The outcome variable *behavior* was taken into account by 11 studies. Six studies rated as evidence levels 2 and 3a found a reduction on overall behavioral disturbances (Bellelli et al., 1998; Bianchetti, Benvenuti, Ghisla, Frisoni, & Trabucchi, 1997; Kovach & Stearns, 1994; Nobili et al., 2008), and a reduction of catastrophic reactions, such as weeping, blushing, anger, agitation, or stubbornness (Swanson, Maas, & Buckwalter, 1993). Further, less verbally agitated behavior was found in SCUs (Wilkes, Fleming, Wilkes, Cioffi, & Le Miere, 2005). Five studies mostly at level 2 found no effect on aggressive behavior (Leon &

Table 2. Basic Design Decisions

		Behavior	Cognition	Function	Well Being	Social Abilities	Orientation	Care Outcomes
Special Care Units	2	■■ ▲▲▲	■ ▲▲▲	▲▲	▲	■		■■■
	3a	■■■■ ▲	▲▲	■■ ▲▲▲		■		■■
	3b	▲		▲	■	■		■■
	5							
Small-Scale Environments	2	■■ ▲▲▲	■■■ ▲▲▲▲	■■■■■▲▲	■■■■■ ▲	■■■■ ▲	▲	■■
	3a	■ ▲	■ ▲	■■■	■■ ▲▲▲	■■■■ ▲		■
	3b	■■	■■	■	■	■■	■	■
	5	■				■■		
Low Social Density	2	■ ▲					▲	
	3a	■				■		■
	3b	■■ ▲				■■■		■
	5	■■			■	■■■		■
Building Layout	2	■					■	
	3a							
	3b	■					■■■	
	5					■		

Note: The number of icons in each field indicates the no. of studies; square icons indicate a relationship (positive or negative) was established; triangles indicate no effect was found.

Ory, 1999) and overall behavioral scores (Chafetz, 1991; Holmes et al., 1990; Mathew, Sloan, Kilby, & Flood, 1988; Wells & Jorm, 1987).

Six studies were identified dealing with the outcome *cognition***.** Only one study at level 2 observed a moderate positive impact of living in a SCU on cognition in residents (Webber, Breuer, & Lindeman, 1995), while five studies at level 2 and 3a found no effect (Bianchetti et al., 1997; Chafetz, 1991; Holmes et al., 1990; Nobili et al., 2008; Wells & Jorm, 1987).

Function was an outcome investigated by eight studies. Results of three studies at level 2 and 3a showed positive effects on basic function (Benson, Cameron, Humbach, Servino, & Gambert, 1987) and some improvements or preservation of physical capacity (Rovner, Lucas-Blaustein, Folstein, & Smith, 1990). However, no changes in functional abilities were observed by six other studies at similar levels of evidence (Bianchetti, Benvenuti, Ghisla, Frisoni, & Trabucchi 1997; Holmes, Teresi, Weiner, Monaco, Ronch, & Vickers, 1990; Mathew, Sloan, Kilby, & Flood, 1988; Nobili et al., 2008; Phillips et al., 1997; Webber, Breuer, & Lindeman, 1995).

The relationship between SCUs and *well being* was investigated by two studies meeting evidence level 2 and 3b. The latter found higher quality of life in residents living in a SCU compared with those in traditional care (Abrahamson, Clark, Perkins, & Arling, 2012), the other did not (Wells & Jorm, 1987).

Three studies compared residents' *social abilities* in SCUs with those who lived in other care homes. One study at level 3b found more social contacts (Weyerer, Schaeufele, & Hendlmeier, 2010), and two studies which arrived at evidence

levels 2 and 3a observed increased interaction among residents in SCUs (Kovach, Weisman, Chaudhury, & Calkins, 1997; Swanson, Maas, & Buckwalter, 1993).

In the context of SCUs seven studies investigated *care outcomes.* Stemming from evidence levels 2, 3a, and 3b, six studies reported a positive impact on care outcomes such as less psychotropic drug use (Bellelli et al., 1998; Bianchetti et al., 1997; Nobili et al., 2008), a decrease in physical restraint use (Bellelli et al., 1998; Nobili et al., 2008; Webber et al., 1995; Weyerer, Schaeufele, & Hendlmeier, 2010), and less tube feeding (Cadigan, Grabowski, Givens, & Mitchell, 2012). However, one study at level 3b found an increase in psychotropic drug use in SCUs (Mathew et al., 1988).

Small-scale Environments

These environments offer care for a small number of residents, varing between 5 and 15 people. Depending on their country of origin, these care concepts may be called group living, group houses, greenhouses, or domus homes (Verbeek, van Rossum, Zwakhalen, Kempen, & Hamers, 2009). Often they were described as "homelike." This term usually characterizes an environment that includes a living room, kitchen, dining room, and homelike furnishings. Involving residents in daily activities or providing individually tailored care may further complete this concept. Thirty studies investigating small-scale environments were identified.

The outcome variable *behavior* was taken into account by 10 studies. Five studies from all evidence levels reported that residents in small-scale and homelike environments were less behaviorally disturbed (Cutler & Kane, 2009; Malmberg & Zarit, 1993; Proctor, Brook, Blandford, & Billington, 1985) and less aggressive (Annerstedt, 1997). Another study at level 3b observed that a large-size unit was associated with an increased level of agitation (Sloane, Mitchell, Preisser, Phillips, Commander, & Burker, 1998). However, four other studies at levels 2 and 3a did not find any changes in behavior in small-scale units (Dean, Briggs, & Lindesay, 1993; Suzuki, Kanamori, Yasuda, & Oshiro, 2008; te Boekhorst, Depla, Lange, Pot, & Eefsting, 2009; Verbeek, Zwakhalen, van Rossum, Ambergen, Kempen, & Hamers, 2010a). One study at evidence level 2 even reported more behavioral disturbances in residents living in a small-scale environment compared with those in a traditional nursing home (Kihlgren, Bråne, Karlsson, Kuremyr, Leissner, & Norberg, 1992).

Eleven studies investigated the relationship between small-scale environments and residents' *cognition*. Six of the studies, encompassing the levels 2, 3a, and 3b, showed either an improvement or maintenance of cognitive function in small-scale units (Annerstedt, 1993; Dean, Briggs, & Lindesay, 1993; Kihlgren et al., 1992; Suzuki et al., 2008; Verbeek, Zwakhalen, van Rossum, Ambergen, Kempen, & Hamers, 2010b) or that residents were more confused in larger units (Proctor, Brook, Blandford, & Billington, 1985). However, five studies, four of them at level 2, show conflicting results. They did not find a significant effect of small-scale environments on cognition (Dettbarn-Reggentin, 2005; Reimer, Slaughter, Donaldson, Currie, & Eliasziw, 2004; Saxton, Silverman, Ricci, Keane, & Deeley, 1998; Skea & Lindesay, 1996; te Boekhorst et al., 2009).

Eleven studies investigated the outcome variable *function*. Nine studies, mostly at evidence levels 2 and 3a showed a beneficial impact of small-scale environments on the performance of the activities of daily life (Annerstedt, 1997; Reimer, Slaughter, Donaldson, Currie, & Eliasziw, 2004; te Boekhorst et al., 2009; Thistleton, Warmuth, & Joseph, 2012), functional status (Dean et al., 1993; Malmberg & Zarit, 1993; Suzuki et al., 2008; Verbeek et al., 2010b), and motor function (Annerstedt, 1993) in residents. By contrast, only two studies observed no effect regarding functionality (Dettbarn-Reggentin, 2005; Saxton et al., 1998).

Well being was investigated by 12 studies. Eight of them, predominately rated evidence level 2, showed a positive impact of small-scale units on mood (Dettbarn-Reggentin, 2005; de Rooij et al., 2012), quality of life (Funaki, Kaneko, & Okamura, 2005; Kane, Lum, Cutler, Degenholtz, & Yu, 2007; Nakanishi, Nakashima, & Sawamura, 2012; Reimer et al., 2004), and a decline in depressive symptoms (Dean, Briggs, & Lindesay, 1993; Kihlgren et al., 1992). Conversely, four studies, mostly at level 3a, did not find a correlation between the small-scale environment and symptoms of depression (Skea & Lindesay, 1996; Thistleton et al., 2012) or quality of life (Samus et al., 2005; Verbeek et al., 2010a).

Fourteen studies looked at the outcome variable *social abilities*. Twelve studies at all evidence levels observed a positive effect and showed that small-scale units improved residents' social abilities (Dettbarn-Reggentin, 2005; Kihlgren et al., 1992; de Rooij et al., 2012) and communication skills (Campo & Chaudhury, 2012; Dean et al., 1993; Skea & Lindesay, 1996; Zimmerman et al., 2007). Furthermore, residents were more engaged in activities (Campo & Chaudhury, 2012; Morgan-Brown, Newton, & Ormerod, 2013; Smit, Lange, Willemse, & Pot, 2012; Smith, Mathews, & Gresham, 2010; te Boekhorst et al., 2009). Only two studies did not observe an impact on interaction behavior (McFadden & Lunsman, 2010) or social withdrawal (Reimer et al., 2004).

In a study at level 3b small-scale units were found to provide residents with better *orientation* than larger units (Marquardt & Schmieg, 2009), whereas another study at level 2 did not establish this association (Reimer et al., 2004).

Care outcomes were taken into account by four studies. Two studies at level 2 found that residents in small-scale units had lower drug use than residents in traditional nursing homes (Annerstedt, 1993; Annerstedt, 1997). Another study at level 3a showed a decline in blood pressure after residents moved to smaller sized units (Thistleton et al., 2012). Furthermore, a study at level 3b found that small-scale units can create opportunities for individualized care and attention to residents' personal needs (van Zadelhoff, Verbeek, Widdershoven, van Rossum, & Abma, 2011).

Social Density

Social density is a term describing the number of people per surface area, or, respectively, the number of people per room. The impact of social density on people with dementia has been investigated by 13 studies.

Eight studies looked at the outcome variable *behavior*. Four studies distributed over all levels of evidence found a decrease in disruptive behavior in residents who were relocated from a high to a low density unit (Morgan & Stewart, 1999; Morgan & Stewart, 1998a), a reduction of aggression (Morgan & Stewart, 1998b), and a more active and engaged behavior in residents in double versus multi-occupancy bedrooms (Hsieh, 2010). These findings are supported by two studies which found more violent behavior in units with a higher number of residents (Isaksson, Astrom, Sandman, & Karlsson, 2009; Nelson, 1995). Two studies at levels 2 and 3b could not find any impact on neuropsychiatric symptoms (Zuidema, Jonghe, Verhey, & Koopmans, 2010) or confused reaction behavior (Elmstahl, Annerstedt, & Ahlund, 1997).

One study at evidence level 5 found higher *well being* in residents having moved from shared to private bedrooms (Morgan & Stewart, 1999).

Social abilities were investigated by seven studies. One study at level 3a observed residents to be more engaged in small groups of people (Cohen-Mansfield, Thein, Dakheel-Ali, & Marx, 2010). Further it was found in a study at level 5 that residents had fewer conflicts among each other (Morgan & Stewart, 1999) and, in a study at level 3b, that they were more engaged in social interaction in double versus multi-occupancy bedrooms (Hsieh, 2010). In shared bedrooms that provided more privacy, fewer conflicts were observed in a study at level 5 (Cutler & Kane, 2002). However, three studies reported disadvantages. Two studies at levels 3b and 5 found that fewer opportunities for social interaction were provided and that the stimulation of residents was reduced (Hsieh, 2010), even causing boredom (Morgan & Stewart, 1999). Another study at level 3b stated that social withdrawal scores tend to be lower in larger facilities with more residents (Zeisel et al., 2003).

No association between social density and residents' *orientation* was found in a study rated evidence level 2 (Elmstahl et al., 1997).

Three studies found a relationship between social density and *care outcomes*. In a study at level 3a it was found that private bedrooms led to improved sleep (Morgan & Stewart, 1998b). In a qualitative study at level 5 crowding was avoided by increasing the number and size of bathrooms, which made it easier for staff to assist with toileting (Hutchinson, Leger-Krall, & Skodol Wilson, 1996). Units with a higher number of residents and a low staff–resident ratio had higher drug prescriptions than units with a lower number of residents, as was found in the study at level 3b (Zuidema, Jonghe, Verhey, & Koopmans, 2011).

Building Layout

Decisions on the building's spatial layout are among the first steps when designing care environments. This process involves choosing the size and shape of hallways and the distribution of residents' rooms as well as common spaces. Six studies investigated the impact of the building layout on people with dementia.

A negative impact from long corridors on residents' *behavior* was found in two studies. The one at evidence level 2 found that in this layout residents displayed

higher restlessness and anxiety (Elmstahl, Annerstedt, & Ahlund, 1997), while the study at level 3b additionally found more violence among residents (Isaksson, Astrom, Sandman, & Karlsson, 2009). One study at level 5 found that a central location of the nursing station and sightlines between relevant places were influential for prompting or supporting informal social interactions (Campo & Chaudhury, 2012).

Four studies established a relationship between the building's layout and the residents' *orientation*. Direct visual access to relevant places, the integration of reference points, and the implementation of several zones with a unique character were identified as helpful for resident's wayfinding abilities by all four studies mostly at level 3b (Elmstahl et al., 1997; Marquardt & Schmieg, 2009; Netten, 1989; Passini, Pigot, Rainvilee, & Tétrault, 2000). In a study at level 3b it was found that a straight circulation system supports residents to better find their way (Marquardt & Schmieg, 2009). Further supportive design features are a small number of doors and exit points (Netten, 1989), as well as the spatial proximity of communal spaces, as the study at level 2 pointed out (Elmstahl et al., 1997).

Environmental Attributes

This section encompasses all interventions and design decisions that concern the issues of lighting, noise levels, temperature, and the use of color, contrasts, and patterns in care home settings.

Lighting

The impact of lighting was examined in 28 studies, including light therapy, daylight control and the overall light level.

Light therapy. Exposure to bright light has been studied as a non-pharmacological treatment of people with dementia. Light therapy is provided through a high-intensity light source, such as light boxes or ceiling-mounted luminaires. Overall 21 studies were identified dealing with light therapy.

Nine studies investigated the relationship between light therapy and *behavior*. Five studies, assigned to evidence levels 2 and 3a, found a positive correlation between bright light and negative behavioral outcomes, such as agitation, restlessness, or aggression (Dowling, Graf, Hubbard, & Luxenberg, 2007; Lovell, Ancoli-Israel, & Gevirtz, 1995; Riemersma-van der Lek et al., 2008; Thorpe, Middleton, Russell, & Stewart, 2000; van Hoof, Aarts, Rense, & Schoutens, 2009a). However, four studies, all of them at level 2, observed that behavior was not affected by light therapy (Barrick et al., 2010; Lyketsos, Lindell Veiel, Baker, & Steele, 1999; Ouslander et al., 2006; van Hoof, Schoutens, & Aarts, 2009b).

A positive impact of light therapy on *cognition* was observed by three studies, two at level 2 and one at level 3b (Graf et al., 2001; Nowak & Davis, 2011; Riemersma-van der Lek et al., 2008). They found residents being exposed to bright light, to be, for example, more awake, verbally competent, or, to even dis-

Table 3. Environmental Attributes

			Behavior	Cognition	Function	Well Being	Social Abilities	Orientation	Care Outcomes
LIGHTING	Light Therapy	2	■■ ▲▲▲▲	■■	■	■■ ▲▲			■■■ ■■ ▲▲▲▲
		3a	■■			▲▲			■■■
		3b		■	■	■			
		5							
	Daylight Control	2	■ ▲	▲		▲			▲
		3a							
		3b							
		5							
	Overall Light Level	2			■				■
		3a	■						■
		3b	■		■				
		5							■
Noise Level		2	▲			▲			▲▲
		3a	■				■	■	
		3b	■■■■			■	■		
		5	■						■
Room Temperature		2							
		3a							
		3b	■ ▲			■			
		5	■						
Use of Color Contrast, Patterns		2			■				■■
		3a	■		■			■	■
		3b						■	
		5	■					▲	

Note: The number of icons in each field indicates the no. of studies; square icons indicate a relationship (positive or negative) was established; triangles indicate no effect was found.

play an increase in MMSE total scores. Two studies on cognition, one at level 3b and another at level 2, showed improvements in functional performance (Nowak & Davis, 2011; Riemersma-van der Lek et al., 2008).

The outcome *well being* was measured by seven studies. Two studies, one at level 2 and another at 3b, found out that the exposure to bright light improves mood (Nowak & Davis, 2011; Riemersma-van der Lek et al., 2008). Further, a reduction of depressive symptoms was found in a study at level 2 (Dowling et al., 2007). However, three other studies at level 2 and 3a showed no results on residents' well being (Hickman et al., 2007; Lyketsos et al., 1999; Ouslander et al., 2006). Another study stated that there were no side effects of a bright light intervention (Sloane et al., 2005).

Care outcomes were investigated by 13 studies. Positive care outcomes, such as improvements in sleep or of circadian rhythms, were observed by eight studies at levels 2, 3a, and 3b (Ancoli-Israel et al., 2003; Lyketsos et al., 1999; Mishima, Hishikawa, & Okawa, 1998; Mishima et al., 1994; Satlin, Volicer, Ross, Herz, & Campbell, 1992; Sloane et al., 2007; van Hoof et al., 2009a; van Someren, Kessler, Mirmiran, & Swaab, 1997). One study at level 2 found a positive impact of bright light on the reduction of sleep disturbances in combination with melatonin intake (Riemersma-van der Lek et al., 2008). Nevertheless, four studies

at level 2 did not find any effects of bright light on sleep (Dowling et al., 2005; Dowling et al., 2008; Ouslander et al., 2006; van Hoof et al., 2009b).

Daylight control. Light interventions were used to imitate or to control naturalistic forms of light. This domain is covered by two studies at evidence level 2.

In one study, specific lighting was used to maintain a constant level of light intensity and to control the effects of natural daylight changes across the afternoon. This intervention led to improved *behavior* (La Garce, 2004). No effects on behavior, cognition, depression, or sleep were found in a study investigating the impact of a dawn–dusk light therapy, which simulates outdoor twilight transitions (Fontana et al., 2003).

Overall light level. Another lighting intervention is to increase the overall light level, which was investigated by five studies.

Two studies investigated the outcome *behavior.* One study at evidence level 3a found that increasing the lighting level at the dining table and enhancing the visual contrast of tableware resulted in decreased disruptive behavior (Koss & Gilmore, 1998). However, another study at level 3b found that brighter lighting caused more wandering (Algase, Beattie, Antonakos, Beel-Bates, & Yao, 2010).

That a higher overall light level leads to improved *function* was found in one study at evidence level 2 (Brush, Meehan, & Calkins, 2002). Lower lighting conditions were associated with more signs of negative affected mood, and thus lower *well being,* as a study at level 3b found (Garre-Olmo et al., 2012).

Three studies investigated the impact of the overall light level on *care outcomes.* An increased light level and table setting contrast (using navy blue tray liners and white plates) was found to improve oral intake, as one study at level 2 and another at level 3a found (Brush et al., 2002; Koss & Gilmore, 1998). By contrast, a study of evidence level 5 associated improvements in oral intake with lower lighting and higher noise conditions (McDaniel, Hunt, Hackes, & Pope, 2001).

Noise Level

The impact of ambient noise on people with dementia was investigated by 12 studies.

Seven studies examined the relationship between noise levels and *behavior.* Five studies at evidence levels 3b and 5 found that high levels of noise were associated with increased wandering and aggressive and disruptive behavior (Algase et al., 2010; Cohen-Mansfield & Werner, 1995; Garcia et al., 2012; Nelson, 1995) as well as agitation (Joosse, 2009). However, one of these studies pointed out that a total absence of sound might not have the desired effect either, because a pleasant level of noise might be beneficial to stimulate residents and to help them to avoid boredom (Cohen-Mansfield & Werner, 1995). Still, behavioral disturbances and violence declined when noise was avoided by a reduced volume of electronic devices, the distribution of earphones, reduced staff talking, and

fewer fast movements, as a study at level 3a found (Meyer et al., 1992). Only one study at level 2 did not find a relationship between noise levels and behavior (Ouslander et al., 2006).

The effect of noise levels on *well being* was investigated by two studies. The study at level 3b did observe a positive correlation between reduced noise and quality of life (Garcia et al., 2012), whereas the other at level 2 did not find a relationship (Ouslander et al., 2006).

Regarding *social abilities,* a study at evidence level 3a found residents to be more engaged with moderate levels of sound (Cohen-Mansfield et al., 2010), while another at level 3b observed less social interaction in residents when sound levels were high (Garre-Olmo et al., 2012).

One study at evidence level 3a observed worse *orientation* in noisy environments (Netten, 1993).

A qualitative study at level 5 found that *care outcomes,* such as food and fluid intake, were higher in noisier units (McDaniel et al., 2001). No effect of reduced nighttime noise on sleep in people with dementia was found in two studies at evidence level 2. This was explained by, inter alia, the inability to reduce noise levels sufficiently (Ouslander et al., 2006; Schnelle, Alessi, Al-Samarrai, Fricker, & Ouslander, 1999).

Room Temperature

The impact of room temperature on residents was investigated by four studies, aiming at thermal comfort for residents.

Two studies, assigned to level 3b and level 5, found that a comfortable room temperature was associated with less unwanted *behavior*, such as agitated or disruptive behavior (Cohen-Mansfield & Werner, 1995; Cohen-Mansfield & Parpura-Gill, 2007). However, another study at level 3b did not observe an impact of a room's temperature or humidity on wandering behavior (Algase et al., 2010).

Uncomfortable room climate was associated with lower *well being,* here measured as quality of life (Garre-Olmo et al., 2012).

Use of Color, Contrast, and Patterns

Seven studies evaluated the use of color, contrast, and patterns in environments for people with dementia.

Painting walls and woodwork to highlight, respectively camouflage, doors led to less undesired *behavior,* as a study at evidence level 5 stated (Cooper, Mohide, & Gilbert, 1989). Further, less disruptive behavior was found to be the result of increased light intensity and enhanced visual contrast at dining tables in a study at evidence level 3a (Koss & Gilmore, 1998).

A study at level 2 observed improvements in *function* by enhancing lighting and table setting contrast (Brush et al., 2002). A study at level 3a found that whereas people with dementia seem to benefit from enhanced color contrast for tableware, lower contrast and small motifs on carpets were found to be beneficial for their walking performance (Perrit, McCune, & McCune, 2005).

Furthermore, floor patterns and dark lines or surfaces can disorient people with dementia, as a study at level 3b observed (Passini et al., 2000). In another study at level 3a, color was reported by residents as a cue for locating their room (Gibson, MacLean, Borrie, & Geiger, 2004). However, a study at level 5 did not find a relationship between color and *orientation* in people with dementia (Cooper et al., 1989).

Three studies at evidence levels 2 and 3a found that an increased table setting contrast, combined with lighting changes, improved residents' oral intake, which is a *care outcome* (Brush et al., 2002; Dunne, Neargarder, Cipolloni, & Cronin Golomb, 2004; Koss & Gilmore, 1998).

Ambience

The term *ambience* summarizes interventions that aim to create a pleasant and stimulating environment. In order to improve the behavior and well being of residents, a non-institutional character, personalization, sensory enhancement, and multi-sensory environment approach are implemented.

Non-institutional Character and Personalization

The literature suggests that a non-institutional, homelike character in long-term care facilities has positive effects on residents. Unfortunately, there is no general definition of these terms. The concept of "homelikeness" was discussed above (see "Basic Design Decisions"). Providing space for residents to individualize and personalize their surroundings was taken as an indicator for non-institutional and personalized environments. Seventeen studies on this topic were found.

Nine studies explored the correlation between non-institutional, personalized environments and *behavior*. One study at level 3b found that both staff and families identified the homelike character to be a central influencing factor on behavior in people with dementia and they appreciated the ability to respond to residents' individual needs in these environments (Garcia et al., 2012). These findings were supported by three other studies at levels 2, 3a, and 5, which found that residents in facilities with more individualized rooms and increased personalization (such as decorating each resident's room with wall decorations, ornaments, pictures, and towels) expressed fewer behavioral problems (Charras et al., 2010; Morgan & Stewart, 1999; Zeisel et al., 2003). Changing the seating arrangements and mealtime routines in dining rooms to be less institutional and more conducive to conversation resulted in improved eating behavior, as was found in two studies assigned to level 2 (Götestam & Melin, 1987; Melin & Gotestam,

Ambience summarizes interventions that aim to create a pleasant and stimulating environment.

Table 4. Ambience

		Behavior	Cognition	Function	Well Being	Social Abilities	Orientation	Care Outcomes
Non-institutional Character & Personalization	2	■■■			■	■■		
	3a	■■						
	3b	■■■			■ ▲			■■
	5	■			■■	■■■■		
Sensory Enhancement	2	■						
	3a	■■	■					■
	3b	■■■■■						
	5	■						
Multi-sensory Approach	2	■■	■	■	■			
	3a	■		▲	■■			
	3b	■						
	5							

Note: The number of icons in each field indicates the no. of studies; square icons indicate a relationship (positive or negative) was established; triangles indicate no effect was found.

1981). Moving the dining room from a central area in the facility to the living unit even led to a reduction in assaultive behavior (Negley & Manley, 1990). Another study at level 3b showed, in contrast, that a non-familiar atmosphere in the bathing area can cause problematic behavior in people with dementia (Namazi & Johnson, 1996), which stresses the importance of the non-institutional character of long-term care facilities. In addition, one study found that an unlocked door to a safe garden area is beneficial to reducing residents' agitation (Namazi & Johnson, 1992a).

Five studies investigated the effect of homelike environments on *well being.* Four studies, assigned to evidence levels 2, 3b, and 5, stated that a homelike environment and increased personalization were positively linked to improved quality of life (Charras et al., 2010; Garcia et al., 2012; Gnaedinger, Robinson, Sudbury, & Dutchak, 2007; Minde, Haynes, & Rodenburg, 1990). However, another study at level 3b did not find this association (Samus et al., 2005).

The effect of homelikeness on *social abilities* was examined by six studies. Four of them were conducted in the dining room setting. Two studies at evidence level 2 showed that changing seating arrangements resulted in increased communication (Götestam & Melin, 1987; Melin & Gotestam, 1981). The two studies at level 5 found that a homelike dining atmosphere with a small number of people eating together led to more resident-directed conversations (Roberts, 2011), and that a homelike therapeutic kitchen can become the center of activity (Marsden, Meehan, & Calkins, 2001). Two further studies at level 5 suggest that a non-institutional, homelike environment supports residents' engagement in daily activities and informal social interactions (Campo & Chaudhury, 2012; Milke, Beck, Danes, & Leask, 2009).

In the category of *care outcomes,* two studies at evidence level 3b found a relationship between a homelike environment and higher food and fluid intake (Reed, Zimmerman, Sloane, Williams, & Boustani, 2005), as well as less tube feeding (Lopez, Amella, Strumpf, Teno, & Mitchell, 2010).

Sensory Enhancement

Most design guidance states that the sensory enhancement of the physical environment through visual, auditory, tactile, and olfactory stimuli has a positive effect on mood and behavior in people with dementia. Ten studies on this topic were identified.

The impact on *behavior* has been investigated by nine studies. Two studies at level 3b found that a sensory enhancement of the environment has positive effects on agitation and wandering frequency in residents (Cohen-Mansfield & Werner, 1998; Yao & Algase, 2006). These studies also suggest that residents seemed to prefer the enhanced environments and spend more time in them. Another study at the same evidence level found that a soothing atmosphere reduces wandering behavior (Algase et al., 2010). However, the authors also cautioned that too much stimulation through, for example, high variations in sound levels or a high engaging quality of the environment, can result in increased wandering behavior. Two studies, one at level 2 and the other at level 5, used sensory stimuli during the bathing process to create a relaxing atmosphere. They found that increased room temperature, music (such as recorded songs of birds, the sounds of other small animals, sounds of babbling brooks), pictures, and even food are effective at reducing agitated behavior in bathrooms (Cohen-Mansfield & Parpura-Gill, 2007; Whall et al., 1997). Two other studies at levels 3a and 3b support the use of music as an intervention to reduce agitation (Cohen-Mansfield & Werner, 1995; Dunn & Riley-Doucet, 2013). Also, minimizing distraction led to reduced agitation, as a study at level 3a found (Cleary, Clamon, Price, & Shullaw, 1988). However, some studies suggest that the degree and type of sensory stimulation provided might be important in regard to the positive effect of such interventions. One study at level 3b showed that playing unwanted or interrupting pleasurable music can lead to more agitation in people with dementia (Ragneskog, Gerdner, Josefsson, & Kihlgren, 1998).

The positive effect of controlling sensory stimulation on *cognition* is supported by one study at level 3a (Namazi & Johnson, 1992b). Here, the researchers used interior partitions to reduce distractions and found residents to be more attentive under this condition.

Reducing stimulation by minimizing distractions from televisions and phones, as well as camouflaging exit doors, led to improved *care outcomes,* measured by less weight loss by residents and fewer cases of physical restraint use, as one study at level 3a found (Cleary et al., 1988).

In conclusion, it can be stated that there is sufficient evidence available to come to a consensus on the positive effect of appropriate sensory environments on agitation in people with dementia. However, study findings indicate that there is a need to control the sensory stimulation in order not to evoke the reverse effect.

Multi-Sensory Environment Approach

The aim of the multi-sensory environment approach, also known as Snoezelen, is to stimulate the primary senses. It allows the recipient to enjoy a wide range of

sensory experiences without the need for intellectual activity. It is often offered in a specifically designed room that typically is equipped with bubble tubes, fiber optics, revolving color wheel projectors, soft relaxing background music, and an oil burner for aromatic smells. The effect of multi-sensory environments on people with dementia has been investigated by seven studies.

A positive impact of multi-sensory environment sessions on *behavior* was found in four studies, which were assigned evidence levels 2, 3a, and 3b (Baker et al., 2001; Hope, Keene, Gedling, Fairburn, & Jacoby, 1998; Milev et al., 2008; Ward-Smith, Llanque, & Curran, 2009).

One of these studies, assigned level 2, also found that residents receiving Snoezelen sessions were more attentive to their environments afterward, thus improving their *cognition* (Baker et al., 2001).

Further, regarding *function,* a study at level 2 revealed improvement in motor and process scores (Collier, McPherson, Ellis-Hill, Staal, & Bucks, 2010). However, another study at level 3a could not find an effect on balance and number of falls (Klages, Zecevic, Orange, & Hobson, 2011).

Better *well being,* including improvements in mood, was found in three studies at evidence levels 2 and 3a (Baker et al., 2001; Cox, Burns, & Savage, 2004; Hope et al., 1998).

Environmental Information

Environmental information comprises mostly visual cues and physical barriers. These can support the orientation and wayfinding abilities of people with dementia. Further, wandering behavior and exit attempts can be managed.

Environmental Cues

Signs, labels, and color coding are environmental cues that can be used to communicate information to people with dementia. Thirteen studies examining their efficacy were found.

Table 5. Environmental Information

		Behavior	Cognition	Function	Well Being	Social Abilities	Orientation	Care Outcomes
Environmental Cues	2						■■	
	3a			■			■■■■■■■■■	
	3b							
	5			■				
Visual Barriers	2							
	3a	■■■■■■■ ▲						
	3b				■			
	5	■■						

Note: The number of icons in each field indicates the no. of studies; square icons indicate a relationship (positive or negative) was established; triangles indicate no effect was found.

Two studies assessed the impact of environmental cues on *function*. Residents' ability to perform activities of daily living improved when labels were placed on drawers and closet doors, objects were visible, and distracting items were removed from their workspaces, as it was found in a study at level 3a (Chard, Liu, & Mulholland, 2009). Another study at evidence level 5 found improvements in oral care when the bathroom environment was modified through pictures and colors (Connell, McConnell, & Francis, 2002).

Environmental information comprises mostly visual cues and physical barriers.

Eleven studies found positive effects of environmental cues on residents' *orientation*. Signposting seems to be an effective intervention to help residents to find their way around, as a study at level 3b found (Passini et al., 2000). However, older adults with cognitive impairments have poorer sign comprehension and experience difficulties with wayfinding signs that have icons only whereas wayfinding signs with text seem to be better understood, as a study at level 2 and another at level 3a found (Namazi & Johnson, 1991a; Scialfa et al., 2008). Also room numbers, nameplates, and color might help residents locate their bedrooms (Gibson et al., 2004). Though, one study at level 3a investigated signposting combined with verbal cues and found that signposting alone was less effective (Hanley, 1981). In four studies, three at level 3a and one at level 2, personal cues, such as written names, portrait-type photographs of residents as young adults, and personal memorabilia, were positively correlated with the residents' ability to locate their room or identify belongings (Gross et al., 2004; Namazi, Rosner, & Rechlin, 1991; Nolan, Mathews, & Harrison, 2001; Nolan, Mathews, Truesdell-Todd, & VanDorp, 2002). Furthermore, the relationship between visual access and orientation was investigated by one study at level 3a. The authors found that the frequency of toilet use increased under high visual access conditions (Namazi & Johnson, 1991b). Providing a clock and signs in a dining room led to a decrease of residents' repetitive questions for food and mealtimes in a study assigned level 3a (Nolan & Mathews, 2004).

Visual Barriers

Managing the wandering behavior of people with dementia is a challenge in long-term care facilities. Residents' attempts to leave the facility or walking into unsecure areas are a safety concern for caregivers. Visual barriers to reduce exit attempts were investigated in 11 studies.

Visual barriers tested were, for example, exit doors camouflaged through cloth barriers or with wall murals that manipulated views through window panels in the doors, and grid patterns or mirrors placed in front of doors. In nine studies at levels 3a and 5 exiting *behavior* was reduced (Dickinson & McLain-Kark, 1998; Dickinson, McLain-Kark, & Marshall-Baker, 1995; Feliciano, Vore, LeBlanc, & Baker, 2004; Namazi, Rosner, & Calkins, 1989; Roberts, 1999) and less door testing was found in four studies at level 3a (Hewawasam, 1996; Hussian & Brown, 1987; Kincaid & Peacock, 2003; Mayer & Darby, 1991). Only one study at level 3a did not find any effect (Chafetz, 1990).

The results of this review indicate that specific design interventions are effective for different outcomes of people with dementia.

Positive effects of unobtrusive safety features on *well being* of people with dementia were found in one study at a level 3b. Here, facilities which provided camouflaged and silent electronic door locks tended to have fewer depressed residents (Zeisel et al., 2003).

Discussion

The results of this review indicate that specific design interventions are associated with different outcomes of people with dementia. Matrices were generated to visualize these intervention–outcome relationships and to help designers and architects to transfer the research findings into design practice. They can use the matrices to get an overview of the literature and to make design decisions according to the concept of evidence-based design.

Basic Design Decisions

Evidence shows that providing segregated care in SCUs has a positive impact on residents' behavior, their social abilities and care outcomes. By contrast, cognition and function do not seem to be influenced by the type of care provided. The reason may be found in the fact that the term "special care unit" is not standardized. While offering segregated care for people with dementia is always a feature of an SCU, spatial characteristics can vary. The impact of small-scale environments on residents with dementia provides a deeper insight: results indicate mainly positive effects on all outcomes investigated. Strong evidence was found for improved social abilities, functionality, and well being. But in the fields of behavior, cognition, and orientation the results are conflicting. Still, there is strong evidence that small-scale care environments lead to positive outcomes for people with dementia and they should be implemented whenever possible. This is further supported by findings, showing that a low social density is positively associated with residents' behavior, social abilities, and care outcomes. However, some studies also pointed out that a low density could cause a decrease of social contact. Therefore, efforts should be made for residents to regulate the degree to which they wish to interact with other residents and staff. When designing a building's spatial layout, research findings need to be incorporated. The research studies analyzed in this review show some associations with behavior and functionality, while a relationship between the spatial layout and the residents' orientation abilities has been established. Supportive spatial features include a straight circulation system, visual access to relevant places, and the integration of meaningful reference points.

In order to create a pleasant environment that positively affects the outcomes of residents with dementia, an informed design of environmental attributes is necessary.

Environmental Attributes

In order to create a pleasant environment that positively affects the outcomes of residents with dementia, an informed design of environmental attributes such as lighting, acoustics, room temperature, and the use of colors, contrast, and patterns is necessary. Among these environmental attributes, the impact of light on

the outcomes of people with dementia has been investigated the most. However, the results are conflicting. Drawing from the evidence, it can be stated that bright light therapy has a positive impact on sleep. Associations with improved behavior and well being also have been established, but have not been confirmed by all studies. Also, there may be a positive correlation between bright light therapy and cognition. Lighting sources that simulate daylight were tested by very few studies and did not yield the desired results. Adequate general lighting, however, may lead to decreased disruptive behavior. A higher luminance level to improve vision, for example at the dining table, might be effective for residents' functional abilities and oral intake. Therefore, providing sufficient lighting should be one of the key architectural efforts in care environments for people with dementia. The same can be stated for good acoustics as well. There is strong evidence showing a relationship between high noise levels and unwanted behavior, while pleasant sounds were found to be positively stimulating. A comfortable room climate may further contribute to improved behavior and well being in residents. As visual impairments are frequently found in older adults and are therefore also found in people with dementia, they need to be considered in design. The evidence shows that residents benefit from the informed application of colors, including a strong color contrast. However, caution is necessary when using patterns and dark lines on flooring, which may be found confusing and even cause falls.

Ambience

Offering residents an environment that does not have an institutional design but has a homelike appearance and allows for individual transformations has positive effects on behavior, well being, social abilities, and care outcomes. Among other results, residents were found to display fewer behavioral disturbances, experience a higher quality of life, and interact more with each other and staff. However, most of these studies included interventions in addition to the appearance of the environment, such as changed care routines. Therefore, the effects observed may also result from a combination of environmental and organizational interventions. Still, a homelike, personalized environment provides the frame for less institutional care routines and thus is beneficial for people with dementia in care homes. For example, studies suggest that a homelike dining atmosphere, which is characterized by residents dining on the unit in a small group and in a dining room with familiar mealtime routines such as residents serving themselves, results in improved eating behavior and more communication. Further, the environment needs to provide sensory stimulation through visual, auditory, tactile, and olfactory stimuli. Evidence shows that unwanted behavior, especially agitation, can be reduced and care outcomes will be improved. However, it is necessary to control the degree of sensory stimulation in order not to trigger any reverse effects through overstimulation. Using multi-sensory environments for Snoezelen sessions further contributes positive impacts on residents' behavior and mood.

Offering residents an environment that does not have an institutional design but has a homelike appearance and allows for individual transformations has positive effects on behavior, well being, social abilities, and care outcomes.

Environmental Information

Visual cues can support the ability of people with dementia to orient themselves. Effective cues were identified to be signposting, room numbers, and colors. However, the type and the design of the cues are of great importance. Signs, for instance, should contain icons and text. The personalization of cues has been found to be especially supportive. Nameplates, portrait-type photographs, or personal memorabilia can be placed outside of rooms to help residents locate their room. Visual barriers, such as camouflaged doors or door knobs, are effective to reduce the attempts of people with dementia to leave the facility and may even increase their well being.

Strengths and Limitations

This review summarizes the broad spectrum of research in the field of design for people with dementia. Because a wide range of studies with very different methodical approaches was found, it was necessary to provide some guidance on the studies' credibility. In the approach chosen here, this was done by assessing the studies' quality through rating their study design. The results were visualized using matrices that offer an overview of the intervention–outcome relationships and their evidence level. In this way, architects and designers are guided in developing designs that are based on current, systematically acquired, and appraised evidence. However, this review also has some limitations. Because of the wide range of heterogeneous methodical approaches and study qualities, the appraisal of the studies' quality focused mainly on the study design. This way, not all aspects which determine the methodological quality of a study, and thus the credibility of its outcome, can be questioned. However, the study design itself can be seen as an indicator of the methodical quality of a study.

Conclusion

Results of this review paper show the impact the characteristics of the built environment in care homes have on residents with dementia. Only the outcome cognition seems not to be affected by the built environment. However, a progressive cognitive decline is a key characteristic of dementia. Thus, tracing back changes in the resident with dementia's cognition to environmental characteristics may provide a methodological challenge. Through the evidence-based approach that takes the methodological quality of the studies reviewed into account, it also shows how well researched the specific intervention–outcomes relationships are. By visualizing these relationships through matrices it becomes evident that the field of dementia design is well researched in many aspects. However, there are also some gaps that are either the result of conflicting study outcomes (such as whether daylight control has an impact on outcomes of people with dementia), or that represent less researched aspects (such as the use of a sensory environment). The matrices provided in this article contribute to exposing these shortcomings, which need further research studies. Further, the results of this review could be used to create planning recommendations and design guidelines. For this process, the expertise of dementia design experts from all professional groups involved needs to be included.

Implications for Practice

- A large body of literature, consisting of 169 research studies that have been reviewed, supports a strong relationship between the design of the built environment and outcomes of people with dementia.
- Specific design interventions in long-term care environments are effective to different outcomes of people with dementia, including their behavior, function, well being, social abilities, orientation, and care outcomes.
- The cognition of people with dementia seems not to be affected by environmental design interventions.

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