Acoustic design guidelines for dementia care facilities

Michael James HAYNE[1]; Richard FLEMING[2]

[1] Floth Sustainable Building Consultants, Australia

[2] University of Wollongong, Australia

ABSTRACT

People with dementia are particularly affected by the acoustic environment. While people with dementia might have normal hearing, they can lose the ability to interpret what they hear accurately. As such, the amount, type and variety of noise a person with dementia is exposed to needs to be carefully regulated, as over or under exposure to noise can cause confusion, illusions, frustration and agitation. This paper explores the role of noise on the ability of people with dementia to interpret and understand their surroundings. Examples are provided of acoustical design and management practices that contribute to increased levels of agitation and aggression among residents who have dementia. Guidelines are provided for the acoustic design of dementia care facilities with the ultimate aim of creating facilities that are calming and engaging for people with dementia in residential care.

Keywords: Sound, Insulation, Reverberation I-INCE Classification of Subjects Number(s): 52.2.6; 63.2

1. INTRODUCTION

It was stated by Florence Nightingale (1) that "unnecessary noise, or noise that creates an expectation in the mind, is that which hurts a patient". People with dementia are particularly affected by the acoustic environment that surrounds them. While people with dementia might have normal hearing, they can lose the ability to interpret what they hear accurately. As such, the amount, type and variety of noise a person with dementia is exposed to needs to be carefully regulated, as over or under exposure to noise can cause confusion, illusions, frustration and agitation.

2. A BRIEF OVERVIEW OF DEMENTIA

Dementia is not a single specific disease. It is an overall term used to describe a syndrome associated with more than 100 different diseases that are characterised by the impairment of brain functions, including language, memory, perception, personality and cognitive skills. Although the type and severity of symptoms and their pattern of development varies with the type of dementia, it is usually of gradual onset, progressive in nature and irreversible. Eventually, people with dementia become dependent on their care providers in most, if not all, areas of daily living (2).

Even though dementia can affect young people and is not an inevitable part of aging, it is increasingly common with age and primarily affects older people. In Australia it is expected that as the population ages, the number of people with dementia will triple, rising to around 900,000 by 2050 (2).

The course of dementia is often divided into three stages (3, 4):

1. Mild or early-stage dementia where deficits are evident in a number of areas (such as memory care and personal care) but the person can still function with minimal assistance.
2. Moderate or middle-stage dementia where the deficits become more obvious and severe and increasing levels of assistance are required to help the person maintain their functioning in the home and community.
3. Severe or late-stage dementia characterised by almost total dependence on the care and supervision by others.

[1] mhayne@floth.com.au
[2] rfleming@uow.edu.au

By the time severe or late-stage dementia is reached most people with dementia are already in residential care. Research has shown that the physical and social environments of dementia care facilities are important but often untapped resources that can have a significant impact on quality of life of people with dementia (5). Proper design of a dementia care facility can incorporate environmental modifications that help to compensate for functional deficits in persons with dementia. For example, people with dementia often have impairments such as reduced vision (6, 7) and hearing loss (8), which can compromise their ability to participate in activities requiring certain levels of noise and light for optimal engagement. Forcing people with dementia to adapt to a poorly designed environment means that the tasks of daily living cannot be successfully completed. This has resulted in many situations where people with dementia in long-term care do not perform to their maximum potential and/or exhibit what the staff consider to be "behaviour problems" (9).

There is the need for guidelines for designers of dementia care facilities to ensure that the physical environment compensates for the sensorial and perceptual deficits of people with dementia. Ideally, the environment should offer different levels of sensory stimulation, improve the attention, memory and orientation of the residents and reassure them by increasing autonomy and dignity. The design of a suitable physical environment should also be a therapeutic goal, since it may have implications for cognitive disorders and functional abilities and may have positive influences on affective disorders as well (10).

3. IMPACT OF NOISE ON PEOPLE WITH DEMENTIA

3.1 Hearing of Elderly People with Dementia

Hearing, along with eyesight, is one of the first senses to be affected by age and starts to degrade by the age of 40. High frequency pitches are the first to become less audible, with a lesser sensitivity to lower frequency sound (11). The ability to understand normal conversation is usually not affected at first, but when combined with the presence of background noise, comprehension may be decreased.

Most older people lose hearing ability and learn to compensate by a combination of lip reading, increased attention and extrapolation from the parts of sentences they can hear (11). For a person with dementia, this compensation becomes problematic, resulting in the need to minimise meaningless background noise and reverberation (12, 13).

3.2 Physiological Effects

Of all the senses, hearing is the one that has the most significant impact on people with dementia in terms of quality of life. This is because dementia can worsen the effects of sensory changes by altering how the person perceives external stimuli, such as noise and light. As hearing is linked to balance this also leads to a greater risk of falls either through loss of balance or through an increase in disorientation as a result of people trying to orientate themselves in an environment that is over-stimulating and noisy.

High noise levels can lead to stress reactions such as anxiety, confusion, increased heart rate, blood pressure and fatigue from over stimulation (14, 15). Noise has also been demonstrated to delay wound healing, decrease weight gain (16) and impair immune function (17), with the effect of noise on medical and behavioural health being magnified for a person with dementia (18).

3.3 Psychological Effects

Research has indicated that persons with moderate to severe dementia may have a limited capacity to understand and interpret their environment (19, 20). It is challenging to understand and provide proper stimulation for those with dementia. Much of the research that has been conducted supports the theory that too little or too much stimulation is often the underlying source of agitation and disruptive behaviour (21, 22). The most common problematic behaviours encountered in residential aged care include complaining, cursing and verbal aggression, general restlessness, repetitive sentences, negativism, constant calls for help, wandering and trying to escape, pacing, inappropriate dressing, strange noises, hoarding, repetitive mannerisms, screaming, strange movements and hiding things (23).

An examination of case studies by Gerdner, Buckwalter and Hall (24) found that environmental noise is a likely cause for increased agitation in select individuals with dementia, suggesting a potential relationship between sound and agitation (24). Support of this relationship was subsequently found by Joosse (25), who also suggested that accumulated noise exposure could be used to predict

agitation among people with dementia in residential care.

4. ACOUSTIC DESIGN FRAMEWORK

An acoustic design framework has been formulated that is consistent with the Environmental Audit Tool (EAT). EAT is used to rate the physical environment of care facilities for people with dementia. The EAT consists of 72 items selected to exemplify a set of design principles that were first used in the development of units for the Confused and Disturbed Elderly constructed by the New South Wales Department of Health in the late 1980s and early 1990s (26, 27, 28). Originally these principles were based on expert opinion, which has subsequently been supported by strong empirical evidence over the last two decades (29, 30).

The items comprising the EAT are grouped into 10 design principles. These design principles state that the physical environment should (28):

1. Be safe and secure.
2. Be small.
3. Be simple with good visual access.
4. Have unnecessary stimulation reduced.
5. Have helpful stimuli highlighted.
6. Provide for planned wandering.
7. Be familiar.
8. Provide opportunities for a range of social interactions from private to communal.
9. Encourage links with the community.
10. Be domestic in nature, providing opportunities for engagement in the ordinary tasks of daily living.

Adopting EAT principles ensures that a salutogenic approach to the acoustic design of dementia care facilities is taken, with the design focusing on factors that influence the relationship between a person's health, stress and ability to cope. Adopting this approach, a review of the EAT design principles list has identified that the acoustic design can be beneficial to:

- Reduce unnecessary stimulation.
- Highlight helpful stimuli.
- Provide for planned wandering.
- Provide a familiar environment.
- Provide opportunities for a range of social interactions from private to communal.
- Encourage links with the community.

4.1 Reduce Unnecessary Stimulation

Often people with dementia respond on a sensory level rather than intellectually. For example, they will note the body language or tone of voice of staff rather than what they actually say (31). This sensitivity can change over time and even during the course of a day. This is because people with dementia have a reduced ability to understand their sensory environment. When this is combined with age-related deterioration in hearing, the reality is that people react to their environment rather than being supported or enabled by it (32).

If other senses are overloaded at the same time as hearing (such as sight, touch, smell and taste) the effect can be a dramatic change in the behaviour of a person with dementia. For this reason, care staff often identify mealtimes as being especially problematic (32). Researchers have identified characteristics and locations linked with high levels of sensory stimulation in environments for people

with dementia (33). In an ethnographic study of one skilled nursing facility, overstimulation was determined to be associated with loud noises (loud talking, singing and clapping, etc.), with crowding and disruptive behaviour from other residents and with frightening experiences such as scary movies and costumes (34). High stimulation (as measured by agitation levels) has been typically found to occur in elevators, corridors, nursing stations, bathing rooms, other residents' rooms and congregation areas where a number of people may be present (22, 35).

Reducing unnecessary stimulation does not mean eliminating all noise as this can lead to under-stimulation whereby the person with dementia becomes bored and exhibits problematic behaviour. Rather the focus should be on providing the right kinds of noise at the right level at the right time (18).

4.2 Highlight Helpful Stimuli

Although significant losses are associated with dementia, people with dementia retain many talents and capabilities – but these capabilities lie dormant unless they are purposely brought out. Appropriate sensory stimulation is a main avenue to awaken latent memories and abilities (36).

Sources that have been identified as providing helpful stimulation to people with dementia in residential care include (37):

- The sounds of nature such as bird song, wind rustling through the trees and water features. In outdoor areas the planting of bamboo can be used so that residents can hear the plants move and scrape against each other in the wind.
- Familiar music or sounds from their youth that can help facilitate recall. Use music to draw people to therapeutic/ recreational programming but provide noise-free areas for residents to avoid music if it is distressing
- Sounds that act as sensory prompts. Examples include a clock chiming every hour so that a person is aware of the time of day and the sound of a kettle whistling to indicate that the kettle is on the stove and has finished boiling the water. It is important that any sound used as helpful stimuli is not too loud, as loud noise has been found to cause distress and agitation in people with dementia.

4.3 Provide for Planned Wandering

Wandering is quite common for people with dementia and may be due to a number of reasons including (but not limited to) disorientation in a changed environment, loss of memory, excess energy, search for the past, expressing boredom, confusing night with day, continuing a habit such as long walks, agitation, discomfort or pain, belief they have a job to do and an inability to differentiate between dreams and reality (38).

It is common to incorporate a wandering path into the design of a dementia care facility to enable wandering to take place safely (30). The wandering path should take people past areas of interest in the expectation that these will provide the person with an alternative to repetitive wandering. Examples of these types of areas include gardens and areas from which they can safely observe various activities, such as children playing, without being over-stimulated. As noted by Brawley (39), gardens are a lovely and interesting way to provide a source of sensory stimulation and avoid monotony – a virtual symphony of sight, sound, colour, fragrance, birds and small animals.

4.4 Provide a Familiar Environment

Many people who enter dementia care facilities come from quiet homes where none of the noises frequently encountered in dementia care facilities exist (40). It is also known that people with dementia are able to recall their distant past more easily than their recent past (30). As such, the acoustic environment must be designed to be as familiar as possible to the resident in their early adulthood. For this to occur, unfamiliar sources of noise need to be controlled and the acoustic environment designed to recreate a home-like environment as closely as possible.

4.5 Provide Opportunities for a Range of Social Interactions from Private to Communal

People with dementia require a range of opportunities for social interaction. Spaces are required where a person can sit alone quietly or intimately with one or two friends as well as in larger groups (30). There needs to be areas where residents, friends and family can have a quiet conversation without

being overheard or subject to distracting levels of intruding noise and reverberation.

4.6 Encourage Links with the Community

Dementia care facilities need to provide amenities that encourage visitors, so that links with friends and family are not broken (30). These types of amenities may include café areas, function rooms and children's play areas. As all of these areas may contain noisy activities, it is important to ensure that their acoustic design is consistent with the requirements of the facility to ensure that noise impacts upon the residents are minimised.

5. PRINCIPLES OF ACOUSTIC DESIGN

It is clear that applying the acoustic design framework to achieve a salutogenic approach consistent with EAT principles in each functional space of a dementia care facility will involve at the most basic level managing noise from external and internal sources to achieve the appropriate acoustic environment and controlling reverberation.

5.1 Controlling Noise from External and Internal Sources

The acoustic design needs to control unwanted airborne and impact-generated noise while facilitating the use of beneficial sounds. Loud noises, as well as persistent intermittent noise (e.g. tap dripping) can trigger worry, unpleasant memories, cause annoyance and/or agitation (18). Examples of sources that can potentially generate unwanted noise that should be considered during the planning and design stages of a dementia care facility are summarised in Table 1.

Table 1 – Examples of sources that can potentially generate unwanted noise

Source	Examples of Unwanted Noise Generators
External activities	Road traffic, rail traffic, aircraft, vehicle activities in car parks, loading docks and service areas, industrial processes, amplified and unamplified entertainment, crowds of people, dogs barking, construction activities, grounds maintenance activities such as lawn mowing and use of leaf blowers
Mechanical plant and services	Air-conditioning systems, air supply and exhaust systems, pumps, air compressors, lifts, wastewater and stormwater flow, hydraulic pipework
Impact generated	Footfalls or objects being dropped on hard flooring such as tiles and timber, washing machines, tumble dryers, doors closing, water hammer
Residential activities	Televisions, radios, loud music, loud conversations and vocalisations by residents and visitors, laughter, ice machines, spa baths, medical equipment, clatter of dishes and cutlery, windows opening and closing
Communication systems	Landline phones, mobile phones, paging systems, intercom systems, call bells
Safety systems	Medical emergency alarms, fire alarms, wander-guard systems
Staff operations	Photocopiers, paper tearing, opening and closing ring binders, staff using telephones, vacuum cleaners, floor polishers, pill crushers, staff talking to each other, trolley wheels, dish washing machines, food preparation, footfalls on hard floors and stairs

5.2 Controlling Reverberation

Controlling reverberation throughout the dementia care facility is important to ensure speech intelligibility is achieved (remembering that many older residents require hearing aids), reduce the impact of intruding noise from internal and external sources and achieve privacy. The recommended reverberation times for different spaces in a dementia care facility are presented in Table 2.

Table 2 – Recommended reverberation times for different spaces (from 41)

Type of Occupancy/Activity	Recommended Reverberation Time (s)
Sleeping areas	0.5
Common Areas	<1.0
Toilets and bathrooms	Minimised as far as practical
Kitchen and service areas	Minimised as far as practical
Staff work areas	0.6 to 0.8
Corridors and lobbies	0.6 to 0.8

6. ACOUSTIC DESIGN GUIDELINES

Reference has been made to dementia care facility publications (18, 29, 31, 32, 37, 42) along with personal experience to prepare guidelines for the acoustic design of dementia care facilities.

6.1 Overall Facility Layout

Generally, dementia care facilities should be located away from major external noise sources as listed in Table 1. If this cannot be accomplished, bedrooms, activity areas and social spaces should be located so that they are screened from intruding noise sources.

The facility should be designed so that areas can be closed off to minimise noise impacts associated with cleaning and maintenance activities. For example, doors fitted to a hallway that provides access to the bedrooms enables that area to be closed off while residents are at dinner for vacuuming. Acoustic absorption should be incorporated into the ceilings of hallways, circulation areas, staff work areas and entry foyers to reduce reverberation and increase the level of privacy.

Bedrooms should not open directly onto the dining room, activity areas or large social spaces, as it is impossible to achieve the required level of acoustic separation between these areas and the bedrooms without the use of acoustic doors. As the residents will generally be older, they will not have the physical strength to be able to open and close a heavy acoustic door fitted with acoustic seals. A better arrangement is to have the bedrooms off a small dead-end corridor that leads directly to the dining room/activity area that is considered to be the "heart" of the facility.

In all instances where hard flooring such as tiles or timber is located over a noise-sensitive space an acoustic underlay should be used to reduce the impact sound transmission generated from footfall noise, movement of furniture and items being dropped on the floor. As a minimum, the acoustic underlay should achieve a 15-rating point improvement over the base floor without any floor coverings.

The design of the fire alarm system also needs to be carefully considered, as fire alarm testing can cause distress and anxiety to people with dementia (18). The fire alarm design should consider the choice, distribution and location of audible devices. Input should be obtained from the local fire authority involved in the planning of the test procedures to ensure that the test procedures are as sensitive as possible to the needs of people with dementia.

6.2 External Building Envelope

The external building envelope (walls, glazing, doors, floors and roof/ceiling) need to be designed so that intruding noise from external sources is not readily discernable to the residents. In addition to achieving the recommended design sound levels presented in Table 3, transient peak emergence needs to be controlled so that noise from regularly occurring transient sources are within 5dBA of the long-term average background level.

6.3 Bedrooms

The bedroom is a significant place for a person with dementia as it is often the only defensible personal space the resident has access to. In this personal space the person with dementia needs to be able to adjust their television or radio to a level where they can hear it comfortably. As many older people with dementia also suffer from hearing loss, this means that the noise level within the bedroom can be of the order of 80dBA. To ensure that noise transfer from and into bedrooms does not cause

nuisance to other residents and staff, it is critical that the walls, floor, ceiling and doors separating bedrooms from other internal spaces are designed and constructed to achieve adequate sound attenuation.

Table 3 – Recommended design sound levels for different spaces (from 41)

Type of Occupancy/Activity	Recommended Design Sound level, L_{Aeq} (dBA)
Sleeping areas	35
Common Areas	40
Toilets and bathrooms	45
Kitchen and service areas	45
Staff work areas	40
Corridors and lobbies	40

Bedrooms should be situated away from high-noise areas such as kitchens, utility rooms, administration zones and services rooms. If bedrooms must be located adjacent to these areas, the dividing wall, floor or ceiling should incorporate discontinuous construction. The recommended acoustical performance requirements are presented in Table 4. These performances are presented in terms of the weighted sound reduction index (R_w) and the sound transmission class (STC), which are considered to be equivalent to each other for this application. All services penetrations through these constructions would need to be acoustically treated to ensure that the overall acoustical performance of the dividing wall, floor or ceiling is not compromised.

Table 4 - Minimum recommended acoustic performances/construction for bedrooms

Dividing Wall, Floor or Ceiling that Separates Bedroom from…	Minimum Recommended Acoustic Performance/Construction
Bedroom	R_w/STC 50
Dining room/activity areas/social spaces	R_w/STC 50 + discontinuous construction
Kitchen	R_w/STC 55 + discontinuous construction
Utility rooms/ administration	R_w/STC 50 + discontinuous construction
Services room	R_w/STC 45 to R_w/STC 65 depending upon contents of services room (45 for flowing water, 65 for mechanical) + discontinuous construction
Hallway	R_w/STC 45 wall + R_w/STC 30 solid-core door fitted with acoustic seals to its perimeter. Door to be fitted with soft-closing mechanism.
Bathroom or toilet not accessed directly from bedroom	R_w/STC 50 + discontinuous construction

Reverberation control within bedrooms is also very important. An acoustically absorbent ceiling is recommended along with soft furnishings such as curtains and upholstered furniture. HVAC equipment and ductwork should be designed to satisfy the recommended design sound levels presented in Table 3 along with their equivalent balanced noise criteria (NCB) curves to minimise tonality.

6.4 Dining Room, Activity Areas and Social Spaces

The architectural layout should ensure that there is minimal foot traffic through activity areas, dining room and social spaces. The room sizes should be limited to ensure that the number of people present in each space is limited by the room capacity without resulting in overcrowding. Smaller room sizes also help to lower the reverberation time.

Control of reverberation time within these spaces is critical and as such ceiling heights should not be excessive. Acoustically absorptive finishes should be applied to the ceilings and walls as required to achieve the reverberation time specified in Table 2. Soft floor coverings such as carpet and cushioned vinyl are preferred over hard flooring such as tiles or timber to reduce the noise from sources such as trolleys, footfalls and items being dropped.

The seating arrangements within these rooms are important and as such, people should be placed to help enable everyone to see the faces of the people they are conversing with and situated close to each other to ensure good hearing. Large dining room and activity tables should be avoided and chairs in social spaces placed close together so residents can talk.

The choice of furnishings needs to be consistent with the acoustic requirements of the space. Upholstered furniture and curtains can be used to help soften the space, while placemats will reduce the level of sound from cutlery and crockery when the dining room tables are being set and cleared.

Different activity areas and social spaces should be provided for residents with dementia with different levels of function. For severe or late-stage residents with dementia a sensory room is beneficial where stimuli such as pleasant aromas and music can be used to create physical and emotional connections to the resident. Music and other sounds can be used to draw people to therapeutic/recreational programming, however for residents who do not want to be immersed in noisy activity, quieter areas should be made available.

6.5 Toilets and Bathrooms

Noise from toilet and bathroom exhaust fans has the potential to cause anxiety and confusion to people with dementia and should be attenuated. For example, Stanfield (43) described the instance where his father became anxious due to noise from a fan that operated automatically when the light was turned on. The father did not understand the source of the noise as he had turned on a light and not a fan.

As the use of toilets and bathrooms has the potential to generate inexplicable and loud noises reverberation control is required to reduce the impact of these noises. Reverberation control is also desirable as it helps to facilitate the playing of music and other soothing sounds to calm the person with dementia during assisted bathing. The easiest way to incorporate reverberation control is by installing an acoustically absorptive ceiling in the space. The ceiling would need to consist of panels that are resistant to moisture, mold/mildew and bacteria, chemical fumes and are able to be scrubbed clean if required.

6.6 Kitchen

In dementia care facilities there can be two different types of kitchens; domestic-style activity kitchens usually located adjacent to the dining room for use by residents and commercial-type service kitchens used to prepare meals for the residents. In many older dementia care facilities, the service kitchen is connected to the dining room by an opening through which the food is served.

The domestic-style activity kitchens usually consist of a small counter where residents can make themselves drinks and simple snacks. The activities conducted in this type of kitchen are used to facilitate a level of independence for the residents whereby familiar sounds from kitchen activities generate recall and act as sensory prompts.

Commercial-type service kitchens need to be acoustically isolated from dining and living areas to ensure that noise from the kitchen does not impact upon residents. In new buildings the service kitchen should be located away from areas of the building habituated by residents. In buildings where the service kitchen is located adjacent to the dining room, serving hatches should be fitted with acoustically rated bi-fold windows rather than the metal roller shutter that is frequently employed in this type of application.

The noise level within the service kitchen should be minimised by installing acoustic absorption to areas of the ceiling, using a rubberised or slip-resistant polyvinyl chloride (PVC) floor rather than tiles, incorporating acoustic attenuation into the kitchen supply and exhaust air systems and procuring low noise equipment such as dishwashers and blenders.

6.7 Outdoor Areas

Outdoor areas include garden areas and balconies. Noise intrusion should be minimised into these areas using acoustic barriers, solid balustrades and absorptive treatments as required. Depending upon local government regulations, it might be possible to erect signs that say “Quiet Area” so that members of the public are more considerate in their noise generating activities.

To obtain the maximum benefit associated with the stimuli garden areas can offer, there needs to be specific and easily identifiable sound sources. The placement of sound reflecting surfaces such as paving and concrete is important, as reflections off these surfaces can result in echoes, long-delayed reflections or reverberation that affects the ability of a person with dementia to understand their environment.

The impact of noise emissions associated with activities within outdoor areas needs to be considered. For example, the use of tools such as petrol lawnmowers and leaf blowers for grounds maintenance needs to be considered when determining the composition of the outdoor area, as more grass may mean a longer time is required for mowing and hence the potential for increased noise exposure to residents.

7. CONCLUSIONS

This paper has presented a brief overview of how noise impacts upon people living with dementia. Through the application of the EAT design principles, guidelines have been provided for the acoustic design of dementia care facilities with the ultimate aim of creating facilities that are calming and engaging for people with dementia in residential care.

REFERENCES

1. Nightingale F. Notes on Nursing: What it is, and what it is not. New York, USA: D. Appleton and Company; 1860.
2. Australian Institute of Health and Welfare. Dementia in Australia. Canberra: AIHW. 2012.
3. Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. Neurology. 1993; 36(4): 2412-2414.
4. Draper B. Understanding Alzheimer's and other dementias. Longueville Books, Sydney. 2011.
5. Brush J, Meehan R, Calkins M. Using the environment to improve intake for people with dementia. Alzheimer's Care Quarterly. 2002; 3: 330-338.
6. Mendez M, Cherrier M, Meadows R. Depth perception in Alzheimer's disease. Perceptual Motor Skills. 1996; 83: 987-995.
7. Marx MS, Werner P, Feldman RC, Cohen-Mansfield J. Progression of eye disorders in a nursing home. Journal of Visual Impairment and Blindness. 1997; 91(6): 571-578.
8. Cohen-Mansfield J, Taylor J. Hearing aid use in nursing homes. Part 1: Prevalence rates of hearing impairment and hearing aid use. Journal of the American Medical Directors Association. 2004; 5(5): 283-288.
9. Rutledge JP. Lighting as an environmental tool for the elderly. Contemporary Long Term Care. 1987; 10: 42-44.
10. Valla P, Harrington T. Designing for older people with cognitive and affective disorders. Archives of Gerontology and Geriatrics. 1998; Supplement 6: 515-518.
11. Ebersole P, Hee P, Schmidt-Luggen A, (editors). Toward Healthy Aging. 6th edition. St Louis, USA: Mosby; 2004.
12. Weaverdyck SE. Intervention to address dementia as a cognitive disorder. In: Coons DH, editor. Specialized Dementia Care Units. John Hopkins University Press, Baltimore, USA. 1991. p. 224-244.
13. van Hoof J, Verkerk MJ. Developing an integrated design model incorporating technology philosophy for the design of healthcare environments: A case analysis of facilities for psychogeriatric and psychiatric care in The Netherlands. Technology in Society. 2013; 35: 1-13.
14. Overman-Dube JA, Barth M, Cmiel C, Cutshall S, Olsen S. Environmental noise sources and interventions to minimize them: A tale of 2 hospitals. Journal of Nursing Care Quarterly. 2008; 23(3): 216-224.
15. Devlin AS, Arneill AB. Health care environments and patient outcomes: A review of the literature. Environment and Behavior. 2003; 35(5): 665-694.
16. Wysocki AB. The effect of intermittent noise exposure on wound healing. Advanced Wound Care. 1996; 9: 35-39.
17. Redwine L, Hauger RL, Gillin JC, Irwin M. Effects of sleep and sleep deprivation on interleukin-6, growth hormone, cortisol, and melatonin levels in humans. Journal of Clinical Endocrinology and Metabolism. 2000; 85; 3597-3603.
18. Design and Dementia Community of Practice. Dementia friendly design considerations: Noise-physical interventions. Alzheimer Knowledge Exchange. 2011.

19. Baker R, Bell S, Baker E, Holloway J, Pearce R, Dowling Z, et al. A randomized controlled trial of the effects of multi-sensory stimulation (MSS) for people with dementia. British Journal of Clinical Psychology. 2001; 40: 81-96.
20. Zeisel J, Silverstein NM, Hyde J, Levkoff S, Lawton MP, Holmes W. Environmental correlates to behavioral health outcomes in Alzheimer's special care units. The Gerontologist. 2003; 43: 697-711.
21. Kovach RC. Sensoristasis and imbalance in persons with dementia. Journal of Nursing Scholarship. 2000; 32: 379-384.
22. Kovach RC, Wells T. Pacing of activity as a predictor of agitation for persons with dementia in acute care. Journal of Gerontological Nursing. 2002; 28(1): 28-35.
23. Snowdon J, Miller R, Vaughan R. Behavioural problems in Sydney nursing homes. International Journal of Geriatric Psychiatry. 1996; 11: 535-541.
24. Gerdner LA, Buckwalter KC, Hall GR. Temporal patterning of agitation and stressors associated with agitation: Case profiles to illustrate the Progressively Lowered Stress Threshold Model. Journal of the American Psychiatric Nurses Association. 2005; 11: 215-222.
25. Joosse LL. Do sound levels and space contribute to agitation in nursing home residents with dementia? Research on Gerontological Nursing. 2012; 5(3): 174-184.
26. Fleming R, Bowles, J, Mellor S. Peppertree lodge: Some observations on the first fifteen months of the first C.A.D.E. unit. Australian Journal on Ageing. 1989; 8(4): 29-32.
27. Fleming R, Bowles J. Units for the confused and disturbed elderly: Development, design, programming and evaluation. Australian Journal on Ageing. 1987; 6(4): 25-28.
28. Fleming R. An environmental audit tool suitable for use in homelike facilities for people with dementia. Australian Journal on Ageing. 2011; 30(3): 108-112.
29. Fleming R., Crookes P, Sum S. A review of the empirical literature on the design of physical environments for people with dementia. Sydney: Primary Dementia Collaborative Research Centre, UNSW, 2008.
30. Fleming R, Forbes I, Bennett K. Adapting the ward for people with dementia, Sydney: NSW Department of Health, 2003.
31. van Hoof J, Kort HSM, Duijnstee MSH, Rutten PGS, Hensen JLM. The indoor environment and the integrated design of homes for older people with dementia. Building and Environment. 2010; 45(5): 1244-1261.
32. Social Care Institute for Excellence. Dementia Gateway Environment: 9 Noise levels. 2011. [cited 2014 July 21]. Available from: http://www.scie.org.uk/publications/dementia/dementia-friendly-environments /environment/files/noise-levels.pdf
33. Day K, Carreon D, Stump C. The therapeutic design of environments for people with dementia: A review of the empirical research. The Gerontologist. 2000; 40(4): 397-416.
34. Nelson J. The influence of environmental factors in incidents of disruptive behavior. Journal of Gerontological Nursing. 1995; 21(5): 19-24.
35. Kovach C, Taneli Y, Dohearty P, Schlidt AM, Cashin S, Silva-Smith AL. Effect of the BACE intervention on agitation of people with dementia. The Gerontologist. 2004; 44(6): 797-806.
36. Bakker R. Sensory loss, dementia, and environments. Generations. 2003; 27(1): 46-51.
37. Dementia Enabling Environments. Sound. 2014. [cited 2014 August 10]. Available from: http://www.enablingenvironments.com.au/AdaptaHome/Sound.aspx.
38. Alzheimer's Australia. Wandering behaviour of people with dementia. 2011. [cited 2014 July 21] Available from: http://www.fightdementia.org.au/services/wandering.aspx.
39. Brawley, EC. Environmental design for Alzheimer's disease: A quality of life issue. Aging and Mental Health. 2005; 5(Supplement): 97-83.
40. Stimson S. Why should I conduct a noise study on my dementia unit? National Council of Certified Dementia Practitioners. c 2103. [cited 2014 July 16] Available from http://www.nccdp.org/resources-dementia-unit.htm.
41. Standards Australia/Standards New Zealand. Acoustics - Recommended Design Sound Levels and Reverberation Times for Building Interiors. 2000.
42. McManus M, McClenaghan C. Hearing, Sound and the Acoustic Environment for People with Dementia. Dementia Services Development Centre, University of Stirling, 2010.
43. Standfield E. My father's room. Alzheimer's Care Quarterly. 2002; 3(1): 1-6.