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## **The indoor environment in relation to people with dementia**

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### **SUMMARY**

There are currently about 6 million people with dementia in the European Union. With ageing, a number of sensory changes occur. Dementia exacerbates the effects of these sensory changes and alters perception of stimuli. People with dementia have an increased sensitivity for indoor environmental conditions, which can induce problematic behaviour that form a burden for carers day and night. Building technologies can help create supportive and comfortable homes for community-dwelling people with dementia and their carers. This paper, based on literature review, provides an overview of the indoor environment in relation to the ageing senses and dementia syndrome, the responses by people with dementia and the impact on carers. Glare and excess noise may induce troublesome problem behaviours. The range of tolerance or preference of the indoor climate may be narrow or very broad compared to non-demented counterparts. Also, the paper states how to create an optimal indoor environment for people with dementia and their carers by active and passive means, as people with dementia have difficulty controlling equipment, and require higher levels of indoor light.

### **KEYWORDS**

Dementia, Older adults, Senses, Indoor environment, Care

### **INTRODUCTION**

Senses are the primary interface with our environment. Due to biological ageing, a number of sensory changes occur as a result of the intrinsic ageing process in sensory organs and their association with the nervous system (Ebersole et al., 2004). The age-related changes to the senses can be an even greater problem when coping with symptoms of dementia syndrome. Dementia, of which Alzheimer's disease is the best known cause, is the loss of cognitive function of sufficient severity to interfere with social or occupational functioning. Sensory losses or impairments (aggravated by incorrect or malfunctioning visual and hearing aids), together with cognitive and perceptual deficits, make it difficult for people with dementia to interpret and understand the environment. Moreover, people with dementia are known to have an increased sensitivity to environmental conditions, which can result in problem behaviours that form a serious burden for carers and are a cause of long-term institutionalisation. The increased sensitivity seems to stem from the reduction of the individual's ability to understand the implications of sensory experiences (Sloane et al., 2002). Senses, however, can be both overloaded or understimulated, leading to problem behaviours or to sensory deprivation (Mace and Rabins, 2006). Sensory overload is most often caused by abrupt, unexpected environmental changes. People with dementia may become increasingly reactive to their environment rather than acting upon it (Weaverdyck, 1991). Since people with

dementia respond on a sensory level, rather than on an intellectual level (Brawley, 1997), and given some of the cognitive and behavioural problems, extra attention should be paid to their surroundings. In practice, about 90% of people with dementia show problem behaviour at some point in their course (Ritchie and Lovestone, 2002), irrespective of the level of cognitive impairments, that may be related to environmental stimuli or sensory input. Apart from medication people receive, nonpharmacologic interventions can play an important role in managing problem behaviour (Ritchie and Lovestone, 2002).

According to Alzheimer Europe, there are an estimated 6 million people with dementia in the European Union, of which the vast majority lives at home supported by (in)formal care. The home's indoor environment is not only the key factor in providing comfort, but might even be a nonpharmacologic factor in managing problem behaviour, and thus a yet largely unexplored factor in reducing caregiver burden. In practice, the indoor environment is the domain of various professions in the field of technology, not nursing in particular, such as building services engineers, architects and building physicists. Nursing literature often mentions the various indoor environmental parameters in relation to people with dementia in certain care settings, and provides clear indications in the form of anecdotal evidence that people with dementia are generally very sensitive to (changes in) indoor environmental parameters. Unfortunately, nursing sciences have not yielded practical guidelines for the building sector how to create optimal indoor environments for people with dementia, and protocols for psychogeriatric and other professional carers, including geriatric physicians, for signalling building-related problems, and helping people to find the right professionals to carry out certain appropriate home modifications.

This paper reviews the various indoor environmental parameters in relation to the ageing of senses and the impact on community-dwelling older people with dementia. It provides relevant information on how to successfully implement building services for people with dementia.

## **INDOOR CLIMATE AND THERMAL COMFORT**

Thermal comfort is defined by ASHRAE as 'the state of mind, which expresses satisfaction with the thermal environment'. Whole-body thermal comfort is evaluated using the PMV-model (Predicted Mean Vote) by Fanger (1970). This model was developed with college-age students, and validated for older people with 128 older subjects. In principle, older adults do not perceive thermal comfort differently from younger college-age adults. The effects of gender and age can be accounted for by model parameters, such as activity and clothing level (Havenith, 2001). On average, older adults have a lower activity level, and thus metabolic rate, than younger persons, which is the main reason that they require higher ambient temperatures. The ability to regulate body temperature tends to decrease with age (Havenith, 2001). In general, older adults have reduced (i) muscle strength, (ii) work capacity, (iii) sweating capacity, (iv) ability to transport heat from body core to skin, (v) hydration levels, (vi) vascular reactivity, and (vii) lower cardiovascular stability (Havenith, 2001). A number of studies have been conducted on older adults and their preferences of, and responses to, the thermal environment. Some studies found differences in heat balance, or preferences for higher or even lower temperatures between the old and the young, while others have given support to the PMV-model, which is based on the assumption that all age groups have the same thermal preference.

### **Dementia and thermal comfort**

There is also an alternative thermophysiological definition of thermal comfort, which is based on the firing of the thermal receptors in the skin and in the hypothalamus. Comfort in this sense is defined as the minimum rate of nervous signals from these receptors (Mayer, 1993). The traditional concept of thermal comfort is vague for people without an unknown 'state of mind' and without the ability to express themselves reliably. Due to the pathology of many dementia patients, involving atrophy of brain tissue, the perception of the thermal environment, as well as the thermoregulation may be different from non-demented older adults. Much of this is suggested by anecdotal evidence. In a descriptive paper on the housing situation of his demented father, Steinfeld (2002, pp 3) states that over time, his father's "*ability to sense thermal comfort seemed to deteriorate. There were many days when I would arrive to find the heat well near [32°C] or more. And, in the summer, the opposite occurred with the air-conditioning.*" Expressing satisfaction with the thermal environment, or dissatisfaction in particular, could be expressing certain observable behavioural symptoms. Another problem, illustrated by Steinfeld (2002), is that individual thermal preferences may differ greatly within the population of older adults with dementia.

### **Thermal comfort and domestic heating systems in practice**

The positive aspects of good thermal comfort are often mentioned in literature. Bathrooms should be comfortably warm, since people undress in these rooms (Brawley, 2002; Petersen, 2002). According to Warner (2000), a demented person may not realise that a bathroom is too cold, only that he or she is uncomfortable, and may not associate the room's temperature with the experienced discomfort or have the ability to communicate it. This often results in frustration, anger or attempting to get away from the discomfort. The diminished understanding of the surroundings also puts demands on the way systems are installed. Electronic (heating) equipment should be kept out of the bathroom as much as possible (Petersen, 2002), although heat lamps installed in the ceiling are an alternative solution (Brawley, 1997; Warner, 2000; Bakker, 2003). Hot radiators (and water pipes) should be blocked or covered, since people may have difficulty judging the temperature of the device, and pose hazards in case of fall incidents (Mace and Rabins, 2006, Lach et al., 1995). A solution is to install radiant floor heating instead (Brawley, 1997), which also help occupants to keep 'cold feet' warm.

Bedrooms should be thermally comfortable too (Petersen, 2002). Nocturnal unrest may be caused by people being too cold or too warm, and can contribute to people going out of bed, which brings along the risk of fall incidents (Blom et al., 2000). In hot summers, silent air-conditioning systems can help people fall asleep, which is both important to people with dementia, and their partners. The position of the outlets of air-conditioning systems or mechanical ventilation, as well as ceiling fans, deserves extra attention. Outlets directing air on curtains or papers on tables can cause them to move. Warner (2000) states that such movement might give the impression that someone else is in the room, even ghosts and thieves.

Thermostats are known to be troublesome for people with dementia. Covers can be placed over the controls (Brawley, 1997), or thermostats can be pre-set and be disguised (Lach et al., 1995), or simply placed out of sight. Steinfeld (2002) states that the system's delay in providing hot or cold air is one of the problems, since people forget that they manipulated the system's interface and then think the system is malfunctioning or broken. In his example, the person with dementia overcompensated, and would leave the room with the temperature set all the way up, resulting in extreme indoor temperatures. Those required the temperature to be set the other way, and caused frustration. Steinfeld (2002) concludes that passive systems

require far less intervention on the part of the resident, and that thermostat controls should only function within the optimal thermal comfort range. Warner (2000) and Petersen (2002) describe another consequence of discomfort. People may start to undress as a solution to perceived warm discomfort. Undressing can be embarrassing to all involved. Some may even consider the 'exhibitionist' behaviour as sexual disinhibition, whereas the cause lies in thermal dissatisfaction. In case of cold discomfort, one may put on inappropriate clothing. Warner explicitly states that the carer's views of a comfortable room temperature may not be the same as those of a person with dementia.

## **INDOOR AIR QUALITY AND SMELLS**

Indoor air quality (IAQ) deals with the content of indoor air that could affect health and comfort of building occupants, and is closely linked to building materials, ventilation, and human activities. Our awareness of the presence of airborne chemicals relies on two sensory systems: olfaction and chemesthesis (common chemical sense). The first sense gives rise to the perception of odours, and the second gives rise to the perception of pungent sensations (Cometto-Muñiz, 2001). The olfactory sense in older adults with dementia is affected by ageing and specific pathologies. This directly influences the perception of freshness of air and smells, and poses restrictions to the way indoor air quality is maintained. Moreover, the specific lifestyle of older people with dementia may influence the indoor air quality.

Age-related losses of smell and fine taste normally begin after the age of sixty (Ebersole et al., 2004). Age-related sensory changes include a decrease in the number of olfactory cells, and a possible decrease in size and number of taste buds. Changes in smell are attributed to loss of cells in the olfactory bulb in the human forebrain, and a decrease in the number of sensory cells in the nasal lining (Ebersole et al., 2004). A history of upper respiratory infections, exposure to tobacco smoke and other toxic agents negatively influence smell. There is strong evidence that smell perception declines markedly with age (Ebersole et al., 2004).

### **Smells, safety and the need for ventilation**

A decreased sensitivity to odours may be dangerous, and can contribute to the inability to detect the odour of leaking gas, a smouldering cigarette, spoiled food or something inappropriate (Warner, 2000; Ebersole et al., 2004). Therefore, alarms may be helpful in the home environment, such as gas and smoke alarms and fire detectors (Blom et al., 2000; Petersen, 2002; Mace and Rabins, 2006). Olfactory dysfunction can also have social implications. Ebersole et al. (2004) state that people experience habituation to, and unawareness of, the own body odour. In case of incontinence, people may be unaware of the smell of urine that accompanies them. Unpleasant smells (urine, strong cleaning products) are known to cause overstimulation (Cohen and Day, 1993), and should be removed from the home as much as possible. Textile floor covering and upholstery should be easy to clean when dealing with incontinence and leakage. At the same time, it is as a source of volatile organic compounds, as well as a dust reservoir containing biological contaminants.

Homes can greatly benefit from an adequate ventilation system, which should be as silent as possible, should not require user interaction to operate, and should not cause any draughts (Warner, 2000). Windows should be easily operable to allow for fresh air to enter. Especially in high-rise building, where one can open windows and balcony doors, one should install security locks to prevent people from climbing out (Mace and Rabins, 2006). Ventilation openings in general should be easy to reach, in order to prevent the risk of falls. Artificial deodorisers are no substitute for good ventilation, and may even pose dangers when people mix up a bowl of potpourri for savoury snacks. Brawley (2002) mentions that during bathing,

steam-filled rooms may be stressful for people with dementia. Automated ventilation systems may be an option to get rid of excess moisture, but can have problems of their own. Steinfeld (2002) describes how his demented father got anxious by the noise generated by the fan that activated automatically when the light was turned on. The old man did not understand the source of the noise, as he turned on the light, not a fan! The anxiety was thought to be increased by the acoustics of the bathroom. In this example, improvements to IAQ can lead to problems caused by inexplicable and loud sounds. At the same time, pleasant odours can have positive effects. During bathing, people with dementia could enjoy the smell of nice soap or bathwater with fragrance (Petersen, 2002; Bakker, 2003), which can alleviate stress. Olfactory sense activation, for instance, by exposing people to smells from the adjacent kitchen (Mace and Rabins, 2006), improves appetite and food intake by stimulating the salivary glands, and hence can result in weight gains. It is even claimed that smells can improve wayfinding, for example, locating the kitchen (MCSS, 1990).

## **LIGHT AND LIGHTING**

The best known benefits of adequate lighting are visual, i.e., being able to see, and prevention of falls. Ageing negatively affects vision. In general, the performance of the human eye deteriorates at early age. Many people aged 45 and over wear glasses to compensate for presbyopia. Vision impairments stemming from the normal ageing process include (i) an impaired ability to adapt to changes in light levels, (ii) extreme sensitivity to glare, (iii) reduced visual acuity, (iv) restricted field of vision and depth perception, (v) reduced contrast sensitivity, and (vi) restricted colour recognition (Brawley, 1997). After the age of 50, glare and low levels of light become increasingly problematic. People require more contrast for proper vision and have difficulty perceiving patterns. After the age of 70, fine details become harder to see, and colour and depth perception may be affected (Brawley, 1997). Apart from the influence of ageing, there are diseases leading to low vision and eventual blindness.

Light also plays a role in regulating important biochemical processes, immunologic mechanisms, and neuroendocrine control, via the skin and via the eye (Hughes and Neer, 1981). Light exposure via the eye is the most important stimulus for synchronising the biological clock (circadian system), which lies in the hypothalamic suprachiasmatic nuclei (SCN). Retinal cells involved are particularly sensitive to bluegreen light. In older adults, light levels needed for orchestration of the SCN are significantly higher than those required for proper vision, due to opacification and yellowing of the vitreous and the lens (Hughes and Neer, 1981). In practice, many older adults are not exposed to high enough illuminance levels (Aarts and Westerlaken, 2005). Light also has an effect on the pineal gland that secretes melatonin, a hormone that is involved in sleep. Sufficient amounts of particularly bluegreen light suppresses melatonin secretion, while during darkness melatonin secretion is stimulated. About 40 to 79% of older people suffer from chronic sleeping problems and insomnia (Aarts and Westerlaken, 2005). Exposure to sufficient amounts of light can improve sleep quality.

### **Lighting and dementia**

Persons with Alzheimer's disease frequently show a number of visual dysfunctions, even in the early stages of the disease (Kergoat et al., 2001). These dysfunctions include impaired spatial contrast sensitivity, motion discrimination, and colour vision, as well as blurred vision. Altered visual function may even be present if people with dementia have normal visual acuity and have no ocular diseases (Kergoat et al., 2001). The diminished contrast sensitivity may exacerbate the effects of other cognitive losses, and increase confusion and social isolation. According to Mendez et al. (1996), persons with Alzheimer's disease have disturbed interpretation of monocular as well as binocular depth cues, which contributes to visuospatial

deficits. In people with Alzheimer's disease, the SCN are affected by the general atrophy of the brain, leading to nocturnal restlessness due to a disturbed sleep-wake rhythm, and wandering (Waterhouse et al., 2002). The timing the sleep-wake cycle can show a far wider variation; times of sleep and activity can vary substantially from day to day, or can be temporarily inverted (Waterhouse et al., 2002). High intensity lighting may play a role in the management of dementia. Bright light treatment by table-mounted luminaires is applied to entrain the biological clock. The results of this therapy on managing sleep, behavioural, mood, and cognitive disturbances show preliminary positive signs, but more research is needed (Forbes et al., 2004). Another approach that is gaining popularity, also for ethical and practical reasons, is to increase the general illuminance in rooms by ceiling-mounted lighting. Studies, including van Someren et al. (1997), showed effects as lessened nocturnal unrest, a more stable sleep-wake cycle, and improvement to restless behaviour. More relevant is how to implement these results in the home situation. According to Hatfield et al. (2004), the deterioration of activity/rest cycles is a common and progressive feature in home-dwelling people with Alzheimer's.

### **Lighting and dementia in practice**

Apart from raising general lighting levels indoors, many researchers state that lighting should be consistent, that glare from windows and lights should be eliminated, and access to natural daylight should be provided. According to Brawley (1997) and Blom et al. (2000) consistent light sources may help to eliminate frightening shadows, avoid distraction, and lessen the number of hallucinations. Dim shadows and glare can distort images even further, contributing to a resident's hallucination (Brawley, 1997). Misinterpretations of inappropriate lighting, shadows, and even distorting of floors, walls and furniture have been reported (Blom et al., 2000), which can cause people with dementia to fall. Highly polished floors are a common source of glare and should be avoided (MCSS, 1990; Cohen and Day, 1993). Lighting in the bathroom and bedroom should be designed in such a way that it provides an enabling and restful atmosphere, with enough light to facilitate (un)dressing and grooming (Petersen, 2002). When people get out of bed at night to go and visit the bathroom, the path to the bathroom should be well illuminated (Warner, 2000) to limited to risk of fall incidents. Extra lighting in the closets could help people find clothes. In kitchens lighting should increase safety on the work blade. The dining area itself should be well-lit in order for people to see and appreciate their food (Petersen, 2002; Mace and Rabins, 2006). Extra lighting in the cupboards could help people find food or utensils.

### **NOISE AND ROOM ACOUSTICS**

The sense of hearing begins to be affected by the age of 40. High frequency pitches are the first to become less audible, with a lesser sensitivity to lower frequency pitches (Ebersole et al., 2004). The ability to understand normal conversation is usually not disturbed at first, but when combined with the presence of background noise comprehension may be affected. In the USA, about one third of the community-dwelling older people are hearing impaired (Ebersole et al., 2004). A laboratory study from Japan (Sato, 2005) involving 20 younger and 20 older subjects using various speech tests showed that speech recognition (intelligibility) scores of the older listeners were 25% lower than those of young adults for any kind of speech test. The effect of this difference is equal to the 5dB increase of ambient noise.

### **Sounds in practice**

In institutional settings, noise has been associated with poor sleep, reduced ability to perform tasks and agitation (Sloane et al., 2002), and these effects are likely to be similar at home. Meaningless background noise should be eliminated as much as possible, as hearing aids

magnify this too. It can be hard to sort meaningless cues and stimuli from those that are meaningful or important. People with dementia often cannot learn to compensate for this (Mace and Rabins, 2006) or perceive the sounds as offensive (Brawley, 1997). Hearing aids are crucial for those with hearing loss, and may prevent a state of sensory deprivation (Cohen-Mansfield and Infeld, 2006). To many, the bathroom is a place that can cause great stress, partly because of sounds and acoustics. According to Warner (2000), it is important to consider problematic sounds that may be confusing or irritating, including rushing water, the toilet flushing, exhaust fans and HVAC systems, washing machines, and outside noises, such as traffic or people (Brawley, 1997; Warner, 2000). Inside the bathroom, whirlpools can cause fear and agitation because of the sound they produce (Brawley, 1997). A silent bedroom is crucial to good sleep, of both the person with dementia as the partner (Warner, 2000; Mace and Rabins, 2006). During the preparation of meals and dinner sound can be distracting too (Petersen, 2002), and excessive background noise should be limited (Warner, 2000). A common strategy to limit reverberation times indoors is the placement of textile floor covering, which may be uneasy for wheelchairs and walkers (Warner, 2000). When cleaning is required, the sound of hovering can be frightening.

## **DISCUSSION**

People with dementia may react and respond different to the indoor environment in comparison with non-demented counterparts. Current building regulations tend to be primarily written for the needs of older people with a physical impairment (primarily mobility problems), rather than for people with mental or cognitive impairments. Even when recommendations are being made with people with dementia in mind, even these can have short-comings. Even though dementia can significantly change the interpretation of sensing, the extent is highly individual and in constant flux (Bakker, 2003). According to Zeisel (2005), an entire environment should be designed so what people see, hear, touch and smell all give them the same, consistent, information about the environment in a holistic manner to understand the environment around us. The sensitivity of people with dementia stretches beyond sensitivity for actual physical conditions, for instance, to operational factors. Invasive technology, like lights switching on seemingly spontaneous, curtains moving, and noisy ventilation systems can cause distress. There is need for more indoor environmental research in relation to older adults and people with dementia for both home and institutional settings. Until there is more evidence on the needs of people with dementia in relation to the indoor environment, the process of modifying the indoor environment often relies on trial and error. Warner (2000, p. 20) provides a good example; *“Try to discover [the] comfort zone. It’s probably not the same as yours. Consider the home’s temperature, lighting, and sounds [..]. Be extra-sensitive in doing so – even the motion or [draught] from a ceiling fan can be annoying. Your [partner] may not know what is wrong, only feel uncomfortable. [The] only means of expression may be agitation or desperate efforts to escape the discomfort”*. As we all try to understand the implications of dementia, we can try to create suitable indoor environments for this group of people.

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