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Abstract
Dementia is an irreversible and incurable syndrome that leads to progressive impairment of cognitive functions and behavioural and psychological symptoms such as agitation, depression and psychosis. Appropriate environmental conditions can help delay its onset and progression, and indoor environmental (IE) factors have a major impact. However, there is no firm understanding of the full range of relevant IE factors and their impact levels.

This paper describes a preliminary study to investigate the effects of IE on Hong Kong residential care homes (RCH) dementia residents. This involved six purposively selected focus groups, each comprising the main stakeholders of the dementia residents' caregivers, RCH staff and/or registered nurses, and architects. Using the Critical Incident Technique, the main context and experiences of behavioural problems of dementia residents caused by IE were explored and the key causal RCH IE quality factors identified, together with the associated responses and stress levels involved.

The findings indicate that the acoustic environment, lighting and thermal environment are the most important influencing factors. Many of the remedies provided by the focus groups are quite simple to carry out and are summarised in the form of recommendations to current RCHs providers and users.

The knowledge acquired in this initial study will help enrich the knowledge of IE design for dementia-specific residential facilities. It also provides some preliminary insights for healthcare policymakers and practitioners in the building design/facilities management and dementia-care sectors into the IE factors contributing to a more comfortable, healthy and sustainable RCH living environment in Hong Kong.

Keywords: Dementia, indoor environment, elderly, residential care homes, behavioural problems

1. Introduction

Dementia is an irreversible and incurable syndrome and the immense growth in the number of affected individuals in recent years is a global phenomenon [1]. Prime Minister, David Cameron, for instance has described dementia as being a "national crisis", affecting 800,000 people in the UK [2]. As a result, The World Health Organisation (WHO) and Alzheimer's Disease International have brought dementia to the forefront of the global public health agenda [3], with an urgent call for 'tackling the social and economic burden caused by dementia', while 'enhancing the quality of life (QOL) of people with dementia and their caregivers' [3]. Nations throughout the world are now sharing the challenge to create systematic approaches for dementia prevention, diagnosis and intervention. Australia, Denmark, England, France, Republic of (South) Korea, Netherlands, Norway, Scotland and Wales, for example, have established national dementia plans, being implemented through

collaborations between government agencies, legislators, residential care providers, community care providers, dementia sufferers, family members, physicians and researchers [1].

Past studies (e.g., [4, 5, 6 and 7]) indicate the importance of environmental conditions, as people with dementia depend on their living and surrounding environment to compensate for their increasing frailty and sensory loss [5]. Indoor environmental (IE) factors such as sound and lighting levels have a major impact (e.g. [5, 6, 9 and 10]). Although some effects of architectural forms, layouts and designs are already known (e.g. [11 and 12]), the range of relevant IE factors and their impact levels is yet to be fully determined. There is also lack of firm understanding of the association between IE, behavioural and psychological symptoms of dementia (BPSD) and the quality of life (QOL) of those with dementia and their caregivers.

In Hong Kong, one form of care facility is the Residential Care Home (RCH) for dementia, currently facing the task of providing residents with a healthy living care environment. At present, though, there is a lack of sufficiently reliable information concerning indoor comfort settings in their design to fully meet the needs of those affected by different dementia levels. Meanwhile, the Government plans to build new RCHs and better utilise existing homes for the frail elderly, including the provision of better and healthier living environments [13]. Knowledge of the various IE-BPSD/QOL interactions is needed, therefore, to help in the IE design of dementia-specific residential facilities; identify IE related BPSD problems; develop ways to improve the BPSD/QOL of dementia suffers and their caregivers; and minimise the long term costs of IE-related behavioural and other problems.

The purpose of this study was to investigate the effects of IE on Hong Kong residential care homes (RCH) dementia residents with the Critical Incident Technique. This involved six purposively selected focus groups, each comprising the main stakeholders of dementia residents' caregivers, RCH staff and/or registered nurses, and architects. The findings of this project will generate valuable information to healthcare policymakers and practitioners in building design/facilities management and dementia-care sectors on how to create and maintain optimal IEs for people with dementia and their caregivers, and assist healthcare professionals by signalling IE-related behavioural and other health problems.

2. Literature Review

2.1 Nature and level of dementia

Dementia is one of the most pressing health challenges in the world today, and one that many countries can no longer disregard [141]. It is a progressive and largely irreversible clinical syndrome that is characterised by a decline in cognitive abilities and a high prevalence of BPSD such as agitation, depression and psychosis [15 and 16]. Behavioural and psychological problems can bring tremendous distress for those afflicted by dementia and their caregivers/family and this is often the reason for referral of dementia patients for placement into high-cost residential or nursing home care [17, 18 and 19]. The costs and burden relating to the care of people with dementia not only imposes huge economic stress on

affected families, but also exerts significant pressures on the economic, health and social systems in many countries [20 and 21], with the current total worldwide cost of dementia care estimated to be US$604 billion [3]. The costs of social care, unpaid caregivers and productivity loss relating to dementia impose a significant negative impact on national economies (around 1.0% of aggregate worldwide GDP) with the highest proportions incurred in high-income countries [3]. As worldwide dementia cases are projected to double every 20 years (i.e. from 35.6 million cases in 2010 to 115.4 million cases in 2050), the societal cost of dementia care is likely to rise even faster in the near future [3].

In Hong Kong, dementia-related conditions are now one of the five biggest non-communicable causes of death [22]. In view of this, public spending on elderly services in Hong Kong has grown by 145% from 1997 to 2010 [230]. Based on the current incidence rate of dementia and the projected elderly population, the numbers of people suffering from dementia in Hong Kong is expected to increase significantly to 0.33 million by 2050 [24], and the need for long-term care for a large number of such sufferers will strain local health and social systems, and budgets. While the greatest proportion of direct costs of dementia care is associated with institutional support in care homes, effective dementia care in RCHs may help lessen the economic burden of caregivers, family, the community and the government in the long term [3]. If interventions could delay both disease onset and progression by just one year, there is estimated to be nearly 9.2 million fewer cases in 2050, mostly attributable to decreases in persons needing a high level of care [25]. With increasing evidence that the development of BPSD is associated with further cognitive decline (e.g. [26]), greater impairment in activities of daily living [27] and poorer QOL of dementia sufferers and caregivers (e.g. [19]), recognising the factors that can aggravate BPSD offers the best chance of alleviating the progression of dementia and promoting the wellbeing of both sufferers and caregivers.

2.2 Potential building and construction industry contribution

Research in the built environment has provided increasing evidence that a healthy and comfortable living environment can be therapeutic, and is considered to be an enabling factor in maintaining enjoyable activities for the chronically sick [28 and 29]). As residents in RCHs spend most their time within the boundaries of the home, they depend on its environment to compensate for the physical and cognitive frailties associated with their condition [5 and 11]. Since the physical environment in which we live is a universally recognised domain of QOL [30], maintaining and promoting the QOL of demented people in long-term residential care is particularly critical to their well-being, safety and health [31]. The provision of a healthy and comfortable built environment is therefore of crucial importance. The effects of architectural forms, layouts and designs are already known to some extent (e.g. [11, 12, 32, 33 and 41]), while existing guidelines in the ‘Universal Design Guidebook for Residential Development in Hong Kong’ [34] provide general guidance and encourage good environmental design practice (i.e. Chapter 5-Environmental Factors [34]) applicable to a wide variety of people of varying abilities with age-, disability- or illness-related problems. However, as the Government has pointed out, there is a current lack of understanding of user-specific needs and indoor physical environment effects on RCH

dementia residents [35]. In particular, little is known of the detailed implications of specific IE conditions (acoustical, illumination, thermal and indoor air quality levels, etc) on dementia residents and their caregivers.

2.3 Dementia and the indoor living environment

Recent studies have identified the general effects of four environmentally related factors on people with dementia: noise, lighting, temperature and air quality. Van Hoof et al. [6] review the impact of i) air and odour, ii) light and lighting and iii) the acoustic environment on older people suffering from dementia in the Netherlands in relation to the ageing of their senses and dementia, and suggest that light and lighting are the most important environmental parameters affecting the behaviour and well-being of dementia sufferers. Noise and acoustical environmental are considered the second most important parameter [7]. Good lighting, on the other hand, increases safety, particularly in relation to mobility [38 and 39]. This is particularly important for those with dementia since the increase of both contrast and brightness occurs in the image projected onto their retina – and retinal dysfunction is common [10]. For example, research by van Hoof et al. [5] indicates that high intensity lighting with a highly correlated colour temperature emitted by ceiling-mounted luminaires can positively influence the restless behaviour of institutionalised older adults with dementia. However, in a similar study, the lighting conditions of nursing homes were found to be poor, with many older residents living in a rather dark environment [40].

Noise levels determine the quality of sleep, and have been found to lead to increased agitation and fear in individuals with dementia [12], with high noise levels triggering fear and other negative feelings, and reducing the amount of social interaction of those affected [36 and 37]. The risk of temperature-related mortality increases with natural ageing, especially for persons with physical vulnerabilities [40]. People with dementia have particular problems in adequately reacting to the thermal environment, for example, to don or shed clothes, or to ask for help or to complain [6, 33 and 41]. It is suggested that aspects including user-technology interaction, divergent needs and preferences, safety issues and minimisation of negative behavioural reactions and draught should be considered in implementing HVAC systems for dementia sufferers [6]. Indoor air quality (IAQ) and ventilation are also significant factors in producing a wide range of discomforts, with adequate ventilation being needed, for example, when there are high humidity levels and in steam-filled bathrooms [5]. A recent study found that air pollution significantly increases the risk of dementia [43].

It is known, therefore, that the effects of dementia disorders are generally aggravated by an age-related decline in sensory perception that affects vision, smell and hearing progressively through the years and, as a result, damages the perceptions of dementia adults of IE conditions. Our understanding of the impact of the IE on dementia to date, however, is limited to ad hoc studies of acoustical, lighting, thermal and indoor air quality and then only in general terms. There is lack of similar studies to date in countries such as Hong Kong, one of the most densely populated cities in the world and situated in a subtropical climate region with hot and humid summers. The dense concentration of buildings, congested public spaces, and urban pollution affect people's health, especially those who are socially and/or physically

vulnerable. The physical environment in Hong Kong, therefore, is likely to be different from that of many other countries because of different climatic conditions and space for both social interaction and privacy. Hence, it is important to quantify the extent to which IE factors and the behavioural and psychological performance of dementia patients in Hong Kong differ from the findings of Garre-Olmo et al.'s [44] western study, for example. In other words, the question to be dealt with in this study is 'how, and to what extent, do indoor environment factors affect the well-being of RCH dementia residents and their caregivers in Hong Kong?'

3. Research method

This qualitative study aimed to explore the context and experiences of indoor environment (IE)-related behavioural and psychological symptoms of dementia (BPSD) in residential care homes (RCHs) in Hong Kong. Qualitative research does not identify trends or suggest any generalization of the results across whole populations. The purpose of this research method is to collect data that illuminates the phenomena under study. In this way, a deeper understanding is obtained from the full and meaningful responses provides by the participants [45]. Sample size becomes less relevant with this particular approach as the priority is the creation of patterns and themes that adequately represent the participant's descriptions. Qualitative research is a recognised and rigorous social research method that is used to gain in-depth knowledge and understanding of a particular phenomena, issue or question [46]. This research strategy is often used to understand quantitative findings or to explore a topic for the first time and is quite often used in building and environment research. For example, recent work Ali & Nsairat [47] utilises qualitative perceptions of a variety of expert and lay stakeholders in studying international green building assessment tools. Similarly, Hamza & Greenwood [48], in studying the impact of energy conservation regulations on the design and procurement of low energy buildings, use semi structured interviews with a diversity of personnel from large construction companies, architectural practices and building performance consultants. Elmualim et al's [49] investigation of the barriers and commitment of facilities management profession to the sustainability agenda also solicited qualitative experiences from the main stakeholders

Approach: Data were collected using the critical incident technique (CIT) within a focus group context. CIT is a set of procedures for collecting direct observations of human experiences of their own or of others, in such a way as to broaden knowledge of sparingly documented or poorly understood areas [50]. Focus groups, on the other hand, elicit a multiplicity of views and emotional processes within a group context. Six focus groups were formed to explore the behavioural problems of dementia residents caused by IE, identify the key causal RCH IE quality factors, together with the associated responses and stress levels involved.

Participants: A total of 36 participants including RCH staff and/or registered nurses and professional caregivers of dementia sufferers (recruited from four RCHs - termed RCH1, RCH2, RCH3 and RCH4 here), were purposively selected [51] to form six focus groups with six to eight participants in each group [52]. The staff involved included three consultant architects specialising in indoor environment design from both public and private sectors, and

33 Cantonese practitioners including RCH superintendents and managers, registered nurses, nurses-in-charge, physiotherapists and frontline care workers. In general, each professional caregiver or nurse in RCH was responsible for the care of approximately 35-140 older people suffering from dementia, aged between 65 and 107 years. The dementia diagnosis of the elders is from early to middle and late stage (Table 1). These participants represented the key stakeholders involved in dementia care in RCHs in Hong Kong.

<INSERT TABLE 1>

Focus Groups: Ethical clearance was obtained from the Hong Kong Polytechnic University's Human Ethics Research Committee. Written informed consent was gained from all participants before the focus groups commenced. Six focus groups were held in four RCHs of a large publicly owned hospital in Hong Kong. The researchers collaborated with hospitals that provide publicly owned long-term RCHs for dementia residents. Collaborating with RCHs facilitated engagement with elderly adults with dementia as well as their proxies and caregivers, and offered a comfortable and safe setting for their participation.

Data collection: The CIT was used to elicit key indoor environmental (IE) quality factors leading to the behavioural and psychological symptoms of dementia (BPSD); to explore the context and experiences of BPSD caused by IE; and to identify their responses (and stresses) involved. Open-ended questions and probes were used during the focus group to discuss: a) the most severe adverse events they could recollect of BPSD when triggered by poor IE (such as high/low temperatures, high noise levels and poor lighting), b) how they could have been avoided/reduced and c) instances of how the degree of dementia affected what happened. Each focus group lasted 1.5 to 2 hours and was facilitated to encourage open discussion and to ensure confidentiality. The facilitators elucidated and recapitulated key points to capture the lived experiences of the participants [52].

Analysis: A phenomenological approach was used for the analyses in order to gain insight into people's lived experiences [53]. The focus groups were audiotaped and transcribed verbatim, with these transcripts being read and reread as an initial step before commencing rigorous thematic analyses. Consistent with recommendations for multiple coding of qualitative research data [54], three coders reviewed the transcripts including: a participant, the facilitator of the workshop and a member of the research team not present during the focus group sessions [55]. Data were coded into categories and concepts, with the results being reported according to the themes that emerged from the data. The anonymity of participants was protected by randomly assigned participant numbers.

Reliability and validity within qualitative research is addressed from a different but equally relevant approach than in quantitative research. Quality, rigor and trustworthiness are terms used to conceptualize reliability and validity which can be established through a number of processes, including triangulation. Triangulation is "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study"[56]. Data in this study were gathered from a multiple stakeholders

across four sites using CIT within a focus group context. Our approach used a documented process of cross checking data from multiple perspective thus establishing quality, rigor and trustworthiness of the outcomes.

4. Results

The focus group members identified the key quality factors leading to BPSD in the RCH as the acoustic environment, thermal environment, indoor air quality and lighting.

In terms of *acoustic environment*, some stated that dementia residents are quite sensitive to mechanical noise, and their behaviours are affected by electronic devices, such as the air-conditioners, electric fans, TV and announcement speakers, etc., inside the RCHs. As some members said:

'Sometimes, the noise generated by the electric fans or TV sets confused the dementia residents and caused emotion disorder…They feel annoyed and ordered me to close the devices…'

'Speakers were placed in every room in our RCH…They are used for making announcements to our staff and the patients. For example, reminding them of breakfast, lunch and bath time etc…Sometimes, the announcements are too loud and affect the older residents, leading them to BPSD problems such as emotional outbursts, shock and headaches'

'The dripping water from the air conditioners causes a nuisance to our female dementia resident; she yelled at me with anger and requested to close the air conditioner....'

Some of the caregivers also pointed out that some RCHs, such as RCH4, are located on the lower floor of public residential blocks. Dementia residents are affected when renovation or refurbishment work is carried out during the daytime - leading to headaches, insomnia and hallucinations. Another source of acoustic discomfort in RCH indoor environments is the noise of other residents' snoring. Due to the limited space and high demand for dementia residential care in Hong Kong, many RCH dementia residents live in a crowded environment. For example, three residents can be occupying a single small living area. Some residents, therefore, especially those in early and middle dementia stages, are affected and annoyed by their 'noisy' neighbour at night**.** In general, the focus group members indicated that noise induced a variety of BPSD problems such as headaches, dysphoria, insomnia, emotional outbursts and crying, depression, howling and hallucinations.

Concerning *thermal environment*, it was pointed out that temperature meters are installed to monitor the temperature in almost every room in the RCHs. In order to maintain a comfortable indoor temperature for residents, room heaters are turned on when the indoor temperature is below 15℃, and air conditioners turned on when the temperature is above 28℃. The participating nurses and caregivers pointed out that some BPSD problems occur when heaters/air-conditioners are not switched on sufficiently early enough to maintain a comfortable indoor thermal environment. For instance, high indoor temperatures drive

dementia residents to dysphoria and insomnia while low indoor temperatures make them feel anorexic.

On the other hand, some participating caregivers pointed out that elders sometimes put on clothes when the room is hot, or remove some clothes when the room is cold. These abnormal behaviours, however, are thought to be a result of personal preference and improved sense of security. As the metabolism of people slows and the subcutaneous fat layer thins with ageing, this also explains why they perspire little, even when fully dressed in hot weather.

In addition, because of the geographical location of the city, Hong Kong has an unstable and wet spring, with a hot and humid summer. Dementia residents often suffer from skin ailments such as itchy scalps and fungus related problems. To counter this, most of the RCHs use dehumidifiers to reduce humidity levels. However, this increases electricity consumption and associated energy costs, ultimately borne by the residents in the form of increased accommodation fees. A similar issue arises with RCH3, which is located close to a vehicular flyover, so all the windows facing the flyover are kept closed all year-round to avoid excessive noise and pollutants entering the building. This means that the air-conditioning units of the rooms in this situation have to be switched on most of the year, again resulting extra costs

For *indoor air quality (IAQ),* all RCHs except RCH2 are located in urban areas. The windows in these RCHs (except for the rooms in RCH3 facing the flyover) are opened in the daytime for natural ventilation, while during the summer time the air conditioning or fans are operated to provide ventilation. Cases of BPSD triggered by poor air conditioning are rare, but as one focus group member said:

'There is a rubbish collection point near our RCH. Some insects such as mosquitoes, cockroaches and ants pester the elders who are living in our care home. Some acrid odours come through the window to the rooms.'

In general, the reaction of early stage dementia residents toward IAQ was considered the same as normal people; for example, being annoyed when their room becomes poorly ventilated, stuffy and muggy. However, middle to late stage dementia sufferers have little reaction to poor ventilation and odour because of their poor olfactory sensation levels.

With regard to *indoor lighting and illumination*, BPSD problems had been experienced when the light in the RCHs was dim or at dusk, with symptoms such as dysphoria, wandering, emotional disorders ('wanting to go home and cook' or 'wanting to find family members'), and insomnia. Many experience the problem of 'sun downing', which is a sense of feeling confused, restless and insecure during the late afternoon or early evening when the indoor light is dim. This results in being nervous and anxious about 'going home' or 'looking for a wife/husband or family' during the late afternoon.

Glare, such as light reflection from glass can also lead to hallucination and emotional disorders. For example:

'A resident with middle stage dementia thought that toilet paper was on his desk when he saw the reflection light of window on the desk ...' (Interviewee from RCH 3).

'... thought there is a 'ghost light' or 'flame from a burning incense stick' when they saw the light from the night lights in the corridor. He wants us to stay with him until the flame/light is gone' (Interviewee from RCH 4).

'Some residents (early stage or middle stage) thought the mosquito killer lamp was on fire when it was switched on. They screamed and attempted to use water to put out the 'fire' (*Interviewee from RCH 3*).

'... believed there were many people going up and down the mountain outside when she saw the reflection light of window' (Interviewee from RCH 1).

'... felt that many insects were on her bed when light was reflected from the facades of the adjoining building into the room in the afternoon' (*Interviewee from RCH 3*)

'*... believed that there are many rats running around when she saw the light reflection on the polished floor'* (*Interviewee from RCH 4*).

Lighting is therefore a key IE factor affecting residents, especially those in early and middle stage dementia. A number of sensory changes during ageing occur due to the ageing process in sensory organs and their association with the nervous system. Age related sensory changes can be severe when coping with dementia symptoms. One of the common comments in the focus group discussions was dementia sufferers in the RCHs prefer dim and constant light to bright light, as the bright light is not comfortable to them. On the other hand, they are also sensitive to the 'very dim' lighting too.

Other issues brought out in the focus group discussions included problems with glass mirrors in bathrooms, where dementia residents simply '*can't recognise the person in front of the glass is themselves'*, thinking someone else was wandering around the bathroom; the need to place furniture and home appliances in appropriate locations so as to avoid causing falls; and that all medicine cabinets and clean cabinets should be locked as security against unwanted access. In addition, dementia residents can become upset if they find themselves in a new location as they find it difficult to remember the place of their bathroom or bed.

Table 2 summarises the key IE factors affecting dementia residents in RCHs in Hong Kong identified by the focus groups.

<INSERT TABLE 2>

5. Discussion

The issue of acoustic comfort and illumination were most frequently and extensively discussed by the focus groups. Previous research suggests that poor acoustic comfort triggers fear and other negative feelings, reducing the amount of social interaction of those affected [6 and 36]. This investigation of the acoustic environment in the RCHs in Hong Kong also suggests that the sounds generated by electronic devices or electrical installation - such as TV, air-conditioners and announcement speakers - trigger an emotional disorder in dementia residents. Generally, if electrical installations, such as air conditioners and fans, are noisy, the caregivers turn them off so reduce their effect, but this increases internal room temperature and humidity - creating temperature and humidity effects instead. An alternative, as pointed out by one of the architects, is that a noisy air conditioning unit may be caused by vibration because of loose screws on the front panel of the unit or other mechanical problem. Professional repair or replacement is therefore needed for detailed checking.

Similarly, when the sound of the TV or announcement is too loud, caregivers turn down the volume. Of course, this is heavily reliant on an ad hoc process of caregivers paying attention to such issues. Also, individual residents have different levels of tolerance and those hard of hearing may actual prefer an *increase* in volume on occasions, suggesting the need for a more considered solution to the problem, by providing individual headsets, separate areas for such residents or more automatic controls. The use of sound-absorbing screens, partition, wall panels or ceiling finishes is recommended. For the healthcare facilities, such as ward rooms, surface materials should be selected that enhance good room acoustics and allow for regular cleaning and disinfection to prevent contamination and the growth of micro-organisms.

Similar to the findings of previous studies that people with dementia react especially to indoor lighting levels [6, 38, 39 and 57], our focus groups suggested that the dementia residents are sensitive and poor internal lighting (too bright or too dim) and external shade. For example, they interpret very dim lights as being something mysterious, such as ghost lights or incense stick flames, while bright light can lead to discomfort and insomnia. Light reflection from outdoors and shade also creates hallucinations for some dementia residents. For example, one resident believed reflected sunlight on a desk to be ‘insects’. It is important, therefore, to minimise the impact of light reflection - perhaps by the use of curtains in the afternoon. Again though, some form of segregation may be needed to accommodate those residents in need of more light due to weakened eyesight, etc.

In addition, shiny, reflective or glare producing flooring system should be avoided. In Hong Kong, epoxy floor finishes are the most common form of flooring use in many healthcare and RCHs and the reflective nature of these finishes creates hallucinations for some dementia residents, where they interpret the moving objects or lighting on the floor as rats or ghosts. In this case, it seems that reflective floor finishes should be minimised to reduce the BPSD of dementia residents. Resilient flooring with non-slip surface and non-reflective nature is an appropriate option.

Compared with van Hoof et al.'s findings [7] concerning the impact of thermal comfort on the dementia sufferers in the Netherlands, the focus group discussions in this study indicate that thermal comfort and indoor air quality (IAQ) are relatively less significant in discomforting dementia residents in Hong Kong. The thermal environment is generally well stabilised due thermostatically controlled air-conditioners, heaters and dehumidifiers. The use of special curtains, such as light-coloured and opaque fabrics, helps to reflect more sunlight and reduce heat gain. The IAQ was similarly well controlled, except for the RCH 3 where there is an adjacent refuse collection point. This is common in Hong Kong, where many refuse collection points are located inside public housing/estates due to land scarcity in urban areas. In addition, products and furniture with high volatile organic compound composition should not be used. In this case, ventilation planning and systems are needed to minimise odours and provide a good IAQ free from any irritating noises from the building services system.

Overall, the indications are that many people with dementia are sensitive to poor IE environments in terms of acoustic discomfort, poor lighting etc. As described above, the focus groups provided simple remedies for the more frequent problems that occur, and these are summarised Table 3 in the form of recommendations to current RCHs providers and users.

<INSERT TABLE 3>

For the development of new/future dementia-specific RCHs, careful scrutinisation of both indoor environment design and external surrounding environment is needed. Due to rising energy costs and high electricity consumption in enhancing the IE comfort of RCHs, new RCHs will need to have greater energy efficiency. Providing energy-saving concepts and technologies is also important in promoting a green and healthy indoor environment for the future of RCHs in Hong Kong

A final issue concerns the extent to which people in different degrees of dementia (i.e. mild, moderate or severe) [58 and 59] respond differently to indoor environmental conditions. Lawton and Nahemow's [60] ecological theory of long-term care design is that the environment has the potential to assist or create obstacles to higher functioning levels. This suggests that an improved IE should slow down the adverse effect on behavioural outcomes as personal competence diminishes. This has yet to be empirically tested, however, as no cross-sectional research has been conducted to determine and compare the degrees of association between building IE and BPSD.

6. Conclusion

Reducing or delaying the onset and progression of dementia improves QOL and helps the workforce to continue working longer. It also helps promote savings in healthcare, reduce the work needed for caregivers and release those involved for more productive activities in society. In this study, Critical Incidents Technique-based focus group discussions were developed to shed some light on the relationship between the indoor environment and those afflicted with dementia. This identified the key IE factors that qualitatively most affect Hong

Kong's RCH dementia residents, in terms of BPSD, and their caregivers from a range of potential sources (including acoustical, luminary, thermal and indoor air quality). The findings indicate the acoustic environment, lighting and thermal environment to be the most important influencing factors - fear and other negative feelings being triggered by poor acoustic comfort; poor internal lighting leading to hallucinations; and the occurrence of dysphoria and insomnia with high indoor temperatures and anorexia with low indoor temperatures.

The study generates a new understanding of how to create and maintain optimal IEs for people with dementia and their caregivers, and assist healthcare professionals by signalling IE-related behavioural and other health problems. By early effective environmental intervention, this generates a 'win-win' situation for dementia sufferers, caregivers, the community and the government by alleviating behavioural and psychological suffering of the demented patients, reducing the burden and distress of the caregivers, decreasing the running cost of RCHs and, by reducing the effects of dementia on residents and caregivers in general, releasing government funds and people's time for more productive activities.

This being a preliminary study, further research is needed to confirm its results on a larger scale. In addition, as noted above, the effect of IE on different degrees of dementia has yet to receive empirical treatment. This important issue will indicate whether different IE considerations are needed depending on the dementia stage reached and highlight the aspects of indoor environmental parameters essential for enhancing the behavioural and psychological well-being of both those with dementia and their caregivers. In addition, there remains a pressing need for future research to better understand the relationship between IE, the BPSD/QOL of people afflicted with dementia and the QOL of associated caregivers.

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Table 1: Background of the focus group participants

Name	Focus Group No.	Position	Type of RCH/ Organisation	Gender	Age group	Experience (Years)	No. of Patients (stage of dementia sufferer under caregiving)
Interviewee 1a	Group 1	Superintendent	RCH1	M	40	>7 years	140; from early to late stages
Interviewee 1b	Group 1	Superintendent	RCH2	F	40	>7 years	50; from early to late stages
Interviewee 1c	Group 1	Superintendent	RCH3	F	50-60	>7 years	120; from early to late stages
Interviewee 1d	Group 1	Superintendent	RCH4	F	50-60	>7 years	50; from early to late stages
Interviewee 1e	Group 1	Superintendent	RCH5	F	40	>7 years	50; from early to late stages
Interviewee 1f	Group 1	Architect	Architectural firm	M	50-60	>7 years	Experience in hospital and care home design
Interviewee 2a	Group 2	RCHs Service coordinator	Hospital	F	50-60	>7 years	50; from middle to late stages
Interviewee 2b	Group 2	Registered nurse	RCH1	F	50-60	>7 years	140; from early to late stages
Interviewee 2c	Group 2	Registered nurse	RCH1	F	40-50	>7 years	140; from middle to late stages
Interviewee 2d	Group 2	Care worker	RCH2	F	50-60	>7 years	50; from early to late stages
Interviewee 2e	Group 2	Architect	Government body	M	50-60	>7 years	Involved in healthcare building design
Interviewee 2f	Group 2	Architect	Architectural firm	F	50-60	>7 years	Involved in healthcare building design
Interviewee 3a	Group 3	Registered nurse	RCH1	F	30-40	>7 years	140; from early to late stages
Interviewee 3b	Group 3	Care worker	RCH1	F	50-60	>7 years	140; from early to late stages
Interviewee 3c	Group 3	Physiotherapists	RCH1	F	<30	1-3 years	140; from early to late stages
Interviewee 3d	Group 3	Care worker	RCH1	F	50-60	>7 years	140; from early to late stages
Interviewee 3e	Group 3	Care worker	RCH1	F	50-60	3-5 years	140; from early to late stages
Interviewee 3f	Group 3	Care worker	RCH1	F	<30	1-3 years	140; from early to late stages
Interviewee 4a	Group 4	Care worker	RCH2	F	40-50	1-3 years	50; from early to late stages
Interviewee 4b	Group 4	Registered nurse	RCH2	F	30-40	<1 year	50; from early to late stages
Interviewee 4c	Group 4	Nurses-in-charge	RCH2	F	50-60	>7 years	50; from early to late stages
Interviewee 4d	Group 4	Care worker	RCH2	F	40-50	3-5 years	50; from early to late stages
Interviewee 4e	Group 4	Care worker	RCH2	F	30-40	5-7 years	50; from early to late stages
Interviewee 4f	Group 4	Care worker	RCH2	F	30-40	3-5 years	54; from early to late stages

Interviewee 5a	Group 5	Registered nurse	RCH3	F	<30	<1 year	50; from middle to late stages
Interviewee 5b	Group 5	Nurses-in-charge	RCH3	F	30-40	5-7 years	120; from early to late stages
Interviewee 5c	Group 5	Care worker	RCH3	F	50-60	>7 years	34; from early to late stages
Interviewee 5d	Group 5	Registered nurse	RCH3	F	<30	1-3 years	50; from early to late stages
Interviewee 5e	Group 5	Care worker	RCH3	F	50-60	>7 years	6 -10; at late stage
Interviewee 5f	Group 5	Registered nurse	RCH3	F	40-50	>7 years	34; from early to late stages
Interviewee 6a	Group 6	Care worker	RCH4	F	50-60	>7 years	40; from early to late stages
Interviewee 6b	Group 6	Registered nurse	RCH4	F	>60	>7 years	49; from middle to late stages
Interviewee 6c	Group 6	Nurses-in-charge	RCH4	F	<30	<1 year	49; from middle to late stages
Interviewee 6d	Group 6	Care worker	RCH4	F	50-60	3-5 years	40; from middle to late stages
Interviewee 6e	Group 6	Care worker	RCH4	F	<30	1-3 years	40; from middle to late stages
Interviewee 6f	Group 6	Care worker	RCH4	F	40-50	1-3 years	40; from middle to late stages

Table 2: Key IE factors affecting dementia residents in RCHs in Hong Kong as highlighted by focus groups

Name	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Acoustic environment						
Noise from A/C and fans (including water dripping)	√	√	√		√	
Noise from TV	√	√	√		√	√
Noise from announcement speakers	√		√	√	√	
Disturbance from renovation	√		√		√	√
Noise from other sufferers	√					√
Thermal environment						
Insufficient cool indoor air during summer	√	√	√	√	√	√
Cold indoor environment during winter	√	√	√	√	√	√
Indoor humidity level	√	√	√			√
Indoor air quality (IAQ)						
Poor ventilation and stuffiness	√	√	√			√
Odour from rubbish collection points	√				√	
Lighting						
Internal illumination (bright /very dim)	√	√	√	√	√	√
Glare/light reflection from glass/window	√	√			√	√
Sunlight	√	√	√	√	√	√
Light from night lights/mosquito killer lamp	√	√	√			√
Others						
Reflective floor finishes	√	√	√			√
Black spot mould	√					√
Reflection from mirror	√	√	√		√	√

Table 3: IE recommendations

IE factor	Recommendations
Acoustics	Keep noise to a minimum; avoid rooms shared by many dementia residents; carry out regular maintenance and renewal of appliances such as A/C systems; lower media broadcast sound and provide individual headsets and/or special media rooms; replace window-type air conditioning units with split-type air conditioning units; use sound-absorbing screen/partition/wall panels and surface materials such as acoustic ceiling tiles to enhance room acoustics and allow regular cleaning and disinfection to prevent contamination and the growth of micro-organisms.
Lighting	Avoid bright lights, dim lights and glare; turn on or increase interior lights before dusk, particularly during wintertime; encourage residents' exposure to sunlight for at least an hour a day; use the curtains to cover windows, or replace plain glass with frosted glass; use non-glare and non-slip materials for flooring; cover mirrors with curtains when not in use; maximise use of natural light for improved health and reduced energy costs; ensure a uniform surrounding or general lighting; adequate indoor lighting with minimum glare for ease of vision and reduced hallucinations; lighting (including colors) to induce a calm, inspiring, or comforting feeling; regular checking and measuring lighting levels; avoid shiny and reflective floor coverings.
Temperature	Maintain steady temperature with supporting heaters/air-conditioners; use special curtains (i.e. made of tightly woven, light-colored, opaque fabrics) to reflect more sunlight and reduce heat gain; close monitoring of indoor temperature and the physical condition of residents, in particular on hot summer and cold winter days.
Humidity/Ventilation	Maintain a dry indoor environment and apply the anti-microbial coating and mold-resistant paint to wall and ceiling surfaces, especially to damp, humid or moist areas such as bathrooms; provide a dehumidifier and keep floor surfaces dry to reduce the risk of injuries from slipping or falling, especially in the spring-summer period; use resilient flooring with non-slip surfaces; provide access to natural ventilation; avoid using building materials, products and furniture with a high volatile organic compound composition.
Changing environment	Do not move furniture or alter the indoor environment frequently; place photographs or guide signs in full view in corridors; paint different beds with various colour to allow residents to find their beds easily.