ASSESSMENT OF DAYLIGHT IN RELATION TO THE AGITATION LEVELS OF PEOPLE WITH DEMENTIA

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ABSTRACT

This research aims to develop the design guidelines for designing daylight levels that may positively impact on reducing agitation behaviour in people with dementia based on principles of behavioural and psychological symptoms. The research methodology was based on the literature review, fieldwork and building performance simulation (BPS). Quantitative and qualitative approach was conducted by assessing indoor daylight quality and agitation levels. In addition, evaluation of daylight parameters (i.e. daylight factor and relation to the agitation level) was also carried out during the observation. The results suggest that agitation level is indeed higher in the top floor of the nursing house, mostly in the most occupied areas such as: communal area and dining room. According to the carers, the main reason to such phenomenon might be due to the sundown syndrome that usually happens after tea time. Moreover, the daylight strategies were carried out to increase the effectiveness of daylight illuminance levels for indoor environment.

INTRODUCTION

At the current rate of prevalence in 2015, there are currently 850.000 people with dementia in the UK according to the Alzheimer's Society. The number is estimated to increase to over 1 million by 2025 and over 2 million by 2051 (Fig.1). It is also indicated that 40% of people aged over 65 in general hospitals will be living with dementia and most of the people living in care homes will probably have dementia or cognitive problems. In addition, if no action is taken, the number is predicted to rise to over 2 million by 2051. It is also anticipated that the current annual costs associated with dementia in the UK will almost treble during the same period, to over £50 billion (Department of Health, 2009), whilst this debilitating condition remains a challenge to the UK that cannot be overlooked.

People with dementia are known to be aggressive at times in relation to their surroundings. They may have a sense of loss, causing anxiety and insecurity, which requires them to live in an environment of comfort and empowerment (Alzheimer's Society, 2014). "Alzheimer's is a disease of the mind, not of the home. The environment is not a treatment, and it offers no cure. But many problems related to the disease can be lessened for the person with [Alzheimer's disease] and especially for the caregiver by making changes to the home environment" (Warner, 2000). In terms of indoor quality, good daylight can help people with dementia to perceive what is around them.

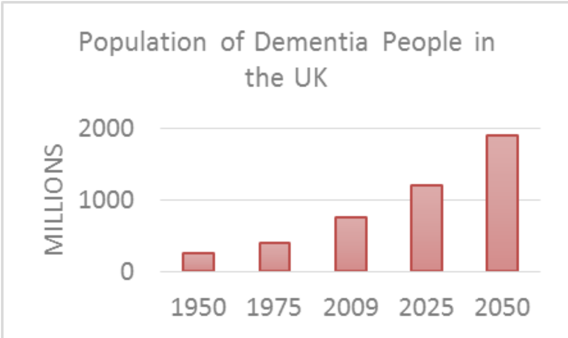

Figure 1 Population of people with dementia in the UK. Source: Alzheimer's Society

Syndromes of behavioural and psychological symptoms are very common in dementia. Agitation is considered as one of the most distressing aspects of dementia, and is one of the main causes of dementia epidemic. According to Ancoli-Israel et al, increased agitation is related with sleep disturbance, circadian disruptions, and shorter daylight hours. A treatment with daylight has been conducted prior to this research. Apparently it causes few side effects and has effectively treated sleep disorders in adults with dementia.

Vision is one of the primary senses and problems with vision can be experienced by people with dementia, which results in agitating behaviour. According to the Alzheimer's Society, three common mistakes can occur during the stages involved in the seeing process for people with dementia, specifically: (i) illusions, (ii) misperceptions, and (iii) misidentifications. They are somehow related to problems that involve both vision and perception called "*visuoperceptual difficulties*". This particular issue may lead to people getting lost or disorientated, encounter difficulties in navigating movement and lose their ability to recognise things. Therefore, it is important to stress that is necessary to improve daylight levels for the indoor environment, as this can reduce visual difficulties and prevent agitation.

With a focus on daylight levels in the dementia homes and care centres, this research aims to develop the design guidelines for designing daylight levels that may positively impact on reducing agitation behaviour in people with dementia. The research project intends to explore several examples of dementia-friendly housing, and investigate the potential elements that can be applied in practice. Furthermore, it will evaluate how the methodology of building performance simulation enhances the effect of daylight in indoor spaces. Those above aims raise the following core objectives:

- To understand the relationship between daylight and the agitation levels of people with dementia.
- To improve the environment for people with dementia in respect of their activities of daily living.
- To review the effectiveness of daylight in challenging agitating behaviour symptoms in regards to dementia people.

CONTEXT

Dementia has become more widely known as a set of symptoms which result from various common brain illnesses, including the common ones, such as Alzheimer's disease and vascular dementia (Alzheimer's Society, 2014). Although the estimated median survival for those with Alzheimer's disease is 7.1 years and for vascular dementia it is 3.9 years, there is still considerable individual variability (Fitzpatrick et al., 2005). It is also recognized as a progressive terminal illness for which there is currently no cure (Shuster, 2000; Lloyd-Williams & Payne 2002; Burgess 2004). To a broader extent, the definition of dementia is a better foundation for developing a neurological clinical approach. In this perspective, dementia may also be defined as acquired and persistent impairment of intellectual faculties, affecting several cognitive domains that are sufficiently severe to impair competence in daily living, occupation, or social interaction (The Neuropathology of Dementia, 2014).

For quite some time, behavioural and psychological symptoms have been known to be part of dementia. The 1999 Update Consensus Conference provided additional knowledge and produced a statement on the definition of the BPSD: "The term behavioural disturbances should be replaced by the term behavioural and psychological symptoms of dementia (BPSD), defined as: symptoms of disturbed perception, thought content, mood, or behaviour that frequently occur in patients with dementia." (Finkel & Burns, 1999).

Dr. Aloysius "Alois" Alzheimer who was a Bavarian-born German psychiatrist noted in his 1907 paper on Alzheimer's, that his patient imagined "people were out to murder her", "seems to have auditory hallucinations", "dragged objects here and there and hid them", and that often "she screams for many hours in a horrible voice". In that case, Dr. Alzheimer identified delusions, hallucinations, activity disturbances and aggression, as part of the clinical presentation. John Zeisel described it as the four A of AD: agitation, aggression, anxiety and apathy. Throughout several participants of consensus groups, a simple method of defining behavioural and psychological symptoms in dementia has been concluded (Jeste and Finkel, 2000):

Behavioural Symptoms	**Psychological Symptoms**
Identified on the basis of observation of the patient, including physical aggression, screaming, restlessness, agitation, wandering, culturally inappropriate behaviours, sexual disinhibition, hoarding, cursing and shadowing	Identified on the basis of interviews with patients and relatives; these symptoms include anxiety, depressive mood, hallucinations and delusions. A psychosis of Alzheimer's disease has been accepted since the 1999 conference.

Table 1 Identification of behavioural and psychological symptoms. Source: The International Psychogeriatric Association

Agitated behaviour such as wandering and physical aggression is a leading symptom of dementia, whilst agitation is said to be the symptoms most often reported to be severely distressing to carers. As originally defined by Prof. Jiska Cohen-Mansfield and Billig (1986), agitation is an act of inappropriate verbal, vocal or motor activity that is not explained by an outside observer to result directly from the needs or confusion of the agitated individual. Cohen-Mansfield has lead this field and discovered in an observational study that agitated behaviour (in particular abusive or aggressive toward self or other, constantly asking questions, taking off clothes in the activity room) were manifested at very high frequencies (Cohen-Mansfield, Marx, and Rosenthal, 1989).

Numerous rating scales with the aim of measuring and quantifying agitation have been previously developed by researchers and frequently used by clinicians in nursing homes and care centres. Many instruments have been devised to measure aggressive and agitated behaviour in different patient populations and in a variety of settings, but none has been developed for or is appropriate to use with acute psychiatric patients in an emergency setting. One of the most extensively used agitation rating measurements is the Cohen-Mansfield Agitation Inventory (CMAI) (Cohen-Mansfield, 1986)

Physical/Aggressive	1-Never	2-Less than once a week	3-Once or twice a week	4-Several times a week	5-Once or twice a day	6-Several times a day	7-Several times an hour
1. Hitting (including self)	1	2	3	4	5	6	7
2. Kicking	1	2	3	4	5	6	7
3. Grabbing onto people	1	2	3	4	5	6	7
4. Pushing	1	2	3	4	5	6	7
5. Throwing things	1	2	3	4	5	6	7
6. Biting	1	2	3	4	5	6	7
7. Scratching	1	2	3	4	5	6	7
8. Spitting	1	2	3	4	5	6	7
9. Hurting self or others	1	2	3	4	5	6	7
10. Tearing things or destroying property	1	2	3	4	5	6	7
11. Making physical sexual advances	1	2	3	4	5	6	7

Table 2 Sample of CMAI questionnaire. Source: Instruction manual for the Cohen-Mansfield Agitation Inventory

Light therapy has been proven to reduce agitation behaviour in people with dementia. A study has been shown that evening exposure to bright white light (>1,000 lux at the cornea) for 2 hours has been shown to decrease nocturnal activity and the severity of evening agitation (“*sundowning syndrome*”) of people with dementia. In addition, exposure to bright morning light has also been shown to reduce agitation among elderly patients with dementia. When they were exposed to 2,500 lux for 2 hours in the morning for 20 day periods, their agitation reduced. Patients were significantly more agitated on non-treatment days (Ancoli-Israel, 1995).

A recent study on the subject of light treatment has also been conducted to increase circadian stimulation during the day which may improve sleep, depression and agitation in people with related dementia disease. A light source producing low levels of 300 to 400 lux of a bluish-white light with a colour temperature of more than 9000 K was installed in the bedrooms, whilst light exposure occurred during daytime hours for a period of four weeks (Figueiro, 2014). The result suggested that the patients were calmer, eating better and their overall behaviour was more manageable. It also significantly reduced scores for depression and agitation.

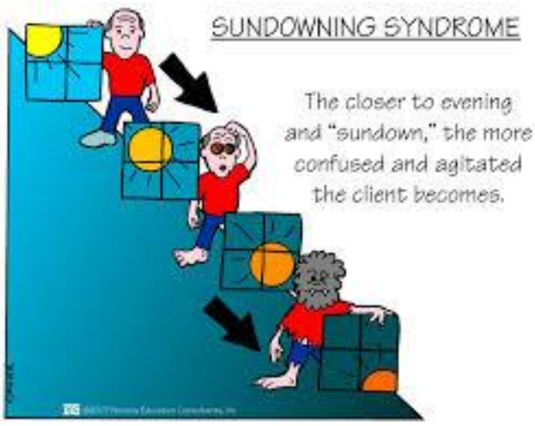

Figure 2 Sundown Syndrome in Illustration

Agitation in elderly people might increases or decrease depending on environmental changes, such as daylight. This has been specified as “*sundown syndrome*” (Van Someren, 2000). It refers to a state of confusion in late afternoon, in the evening, or at night which causes a variety of agitated behaviour for instance pacing and wandering (Glenn Smith, 2014). One study indicates that agitation from sundown syndrome is a common cause of institutionalisation of older patients suffering from dementia (Muralee, 2005). Other clinical features of sundown syndrome include mood swings, abnormally demanding attitude, suspiciousness, and visual and auditory hallucinations in the late afternoon and evening (Harper, 2001).

CALCULATING DAYLIGHT FACTOR

The daylight factor method, also called *split flux method*, is a method of daylighting analysis recommended by the CIE (Commission Internationale de L’eclairage) and is used in more than 100 countries around the world to determine the performance and levels of daylighting systems in a building (Winkelmann and Selkowitz, 1985). There are three components which are taken into consideration for calculating daylight factor, specifically:

1. Sky component (SC): the direction of the opening and angle of the sky (more relevant to wall window design).
2. External reflectance component (ERC): the light entering the building reflected from external objects and surfaces (less of a consideration for windows on flat or low pitched roofs).
3. Internal reflectance component (IRC): the light that is reflected internally from all ceiling, wall and floor surfaces and fixtures and fittings within the building.

CIBSE Code for Interior Lighting suggests a Daylight Factor of 5% or more for a well-lit appearance, while a factor of less than 2% does not look well-lit and electric light will be in use generally throughout the day.

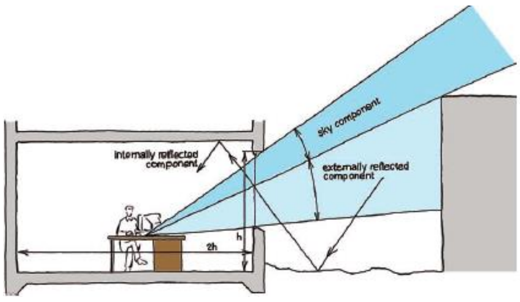

Figure 3 Components of daylight factor. Source: Design primer daylight design

RESEARCH METHODOLOGY

This research was conducted based on the literature review, fieldwork and building performance simulation (BPS). The fieldwork assessments applied a qualitative approach to indoor daylight quality and agitation level, whereas a quantitative approach was completed by evaluating daylight parameters (i.e. daylight factor and relation to the agitation level). Furthermore, the assessment by BPS was also implemented to analyse the current condition of the indoor daylight environment and understand the comparison between fieldwork and computer-based procedures.

Dementia Nursing Home

Focusing on Kenton Manor Residential and Nursing Home in Newcastle upon Tyne, the fieldwork was performed in order to assess the daylight factor of the building and its relation to the agitation levels of elderly people with dementia. According to its purpose, this three storey house is divided into two parts; the residential and the nursing home. The residential part is currently occupied by elderly people without the symptoms of dementia, and they have more services both indoors and outdoors. The nursing house is occupied by elderly people who have the symptoms of dementia and who generally require more carers to take care of them.

The facilities on the ground floor (residential) are accessible to the public, while the first and second floors (nursing home) can only be accessed under staff permission.

Period of Study

The fieldwork was completed in July 2015 in two separate weeks. The first week (9^{th}, 11^{th} and 13^{th}) was undertaken over the course of the whole working day; morning (9 am to 11 am), afternoon (2 pm to 4 pm), and evening (6 pm to 8 pm), in order to evaluate the daylight conditions. It is important to point out that the time was chosen, given that during summer, the daylight contribution is higher than any other season.

Date	Times	Weather Conditions
9^{th} July 2015	9.00 to 11.00 14:00 to 16:00 18:00 to 20:00	Overcast sky Shade illuminated by clear blue sky Overcast sky
11^{th} July 2015	9.00 to 11.00 14:00 to 16:00 18:00 to 20:00	Shade illuminated by clear blue sky Sunny sky Overcast sky
13^{th} July 2015	9.00 to 11.00 14:00 to 16:00 18:00 to 20:00	Overcast sky Shade illuminated by clear blue sky Shade illuminated by clear blue sky

Table 3 First week schedule of fieldwork

Fieldwork in the second week (21^{th}) was carried out only during tea time (4 pm to 6 pm), due to the fact that 'sundown syndrome' occurs approximately at that time, according to the carers. Therefore, the aim is to study whether it is true that the exterior daylight causes sundown syndrome by measuring illuminance and the daylight factor.

Measurement Parameter

Illuminance was measured using the Hagner Digital Luxmeter model E2. It has a measurement range from 0.1 lux to 199.900 lux, with accuracy better than about 3% (+/- 1 in the last digit on the display), and a temperature range from -5^{o}C to +55^{o}C. The measuring point started from the first point adjacent to the window, the next point went to the middle part of the room, and the last point was at the back.

The measurement point always settled in the central line perpendicular to the window. In addition, the exterior and interior part of the space was taken into consideration each time the measurement was conducted.

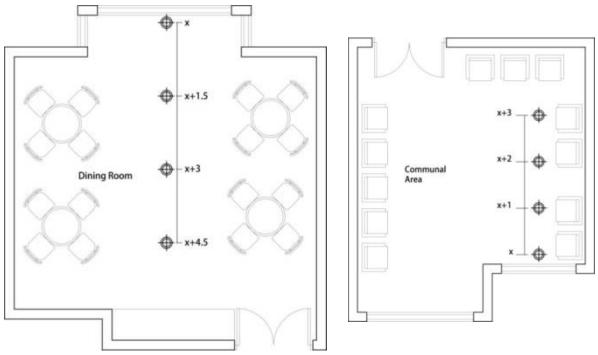

Figure 4 Plan view: measurement points in dining room (left) and communal area (right). Source: author's diagram

A working plane height of 0.8 m was applied according to the standard height of the indoor furniture. It is important to note that the range of measurement may vary according to the dimensions of each different space.

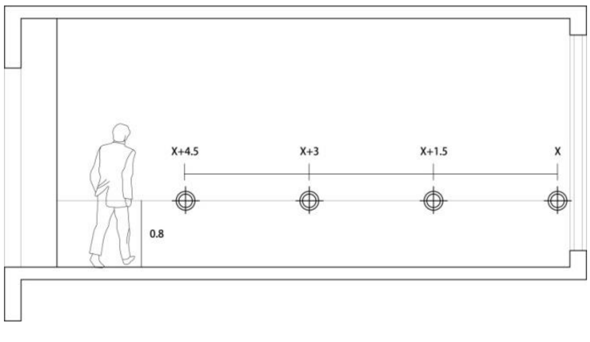

Figure 5 Section view: measurement heights. Source: author's diagram

Current daylight factor (%) was evaluated by calculating the mean illuminance for interior daylight (Ei) and dividing it with the exterior daylight illuminance (Eo). The aim was to understand whether the daylight factor complies with the benchmarks suggested in the literature: a daylight factor of 5% or more for a well-lit appearance, while a factor of less than 2% does not appear well-lit and therefore, electric light will be in use regularly throughout the day (McNair et al., 2013).

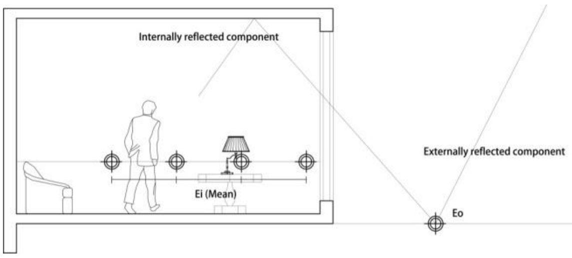

Figure 6 Daylight factor. Source: author's diagram

The equipment used for measuring the indoor temperature is the "Vaisala HUMICAP® Hand-Held Humidity and Temperature Meter HM34". This particular piece of equipment has several features, such as temperature measurement range from -20 to +60 °C (-4 to +140 °F), measurement range from 0 to 100 % RH (Relative Humidity), and fast response with ±2% accuracy.

As mentioned in the previous chapter, the CMAI questionnaires are used to identify the agitation levels of people with dementia that occur every week. In this case, one week of observation was performed by the carers in order to complete the CMAI questionnaires. The agitation levels were observed by paying attention to the activities undertaken by the residents with dementia in each different space. With the minimum value of 29 and maximum value of 203, the agitation level results will be analysed in conjunction with the daylight levels.

Methodological Limitation

As mentioned in the literature review, the outdoor illuminance should be constant as identified in CIE overcast sky standard (5000 lux), which is possible to perform in the computer based simulation. However, the outdoor illuminance might change from day to day in the real fieldwork situation. It should also be noticed that even a slight gap between moving from the outdoor environment to indoor space will provide a very different illuminance result due to the rapid movement of the sun and cloud. However, without doubt this will produce a variety of daylight illuminance, it the consistency of both outdoor and indoor illuminance needs to be considered to obtain the desired daylight factors.

It has also been previously mentioned that the fieldwork studies were conducted during a two week timeframe where daylight contributes the most throughout the year. Consequently, it gives limited results with regards to the illuminance from being analysed to other seasons of the year. Thus, the parameters for future research need to be extended to further improve the assessment of daylight illuminance and indoor temperature.

The quantitative result was carried out by relating the daylight factors to agitation level. By undertaking the fieldwork survey, the author managed to obtain the agitation level results in a week and moreover, its relation to daylight factors. However, there is a limitation in doing so by applying building simulation due to its non-availability of simulated agitation behaviour. Therefore, a manual calculation was applied to achieve an appropriate result. Nonetheless, broader quantitative simulations that included the above elements would need to be conducted.

Computer Based Simulation

The indoor daylight assessment was applied using building performance simulation (IES Virtual Environment 2014). The floor plan, sections, elevations and 3D model are included in the appendices. The spaces, indoor furniture and outdoor environments were modelled in Model IT. The daylight illuminances were calculated using RadianceIES. In order to match with the real life situation, the daylight measurement settings were defined in terms of fieldwork time and place. The weather file used for the simulation was NewcastleEWY.fwt (ASHRAE Climate Zone derived) under the CIE standard overcast sky.

Figure 7 Communal Area modelled in IESVE. Source: author's diagram

DISCUSSION AND RESULT

The results based on the fieldwork observations are described in the following sections and collected, as explained in the research methodology. The percentage of daylight factor is calculated and discussed, as well as the ratio in relation to the agitation levels. The indoor temperature and relative humidity are measured in the communal area located on the first floor.

	DF (Morning)	DF (Afternoon)	DF (Evening)	Agitation Level
Communal Area 1	1.8	2	1.27	32
Communal Area 2	2.26	2.33	1.58	151
Communal Area 3	2.13	2.09	1.67	168
Dining Room 1	1.6	1.03	1.11	29
Dining Room 2	2	1.17	1.48	154
Dining Room 3	1.6	1.06	1.42	168
Corridor 1	1.6	1.87	1.32	29
Corridor 2	1.74	2	1.69	168
Corridor 3	1.94	2.3	1.9	151
Bedroom 1	2.3	0.8	1.46	29
Bedroom 2	2.23	0.9	1.54	33
Bedroom 3	2	0.8	1.76	119
Bedroom 4	2.1	0.9	1.65	79
Bedroom 5	2.1	1.2	1.3	81
Bedroom 6	2.2	1.1	1.4	82
Conservatory	3	2.5	1.2	29

Table 3 Results of DF values and agitation level. Source: field assessment

At the end of the first week, the CMAI questionnaires are collected based on the observations performed by the carers and it appears that there is no significant proof regarding how the indoor temperature affects the agitation behaviour. The result shows that spaces on the ground floor do not demonstrate any high agitation levels within the range of 29 to 33, due to the fact that it is a residential area. As expected, most of the agitated behaviour takes place in three commonly used spaces of the nursing home which are; the communal areas, dining rooms and corridors which ranges from 151 to 168.

However, it can be identified that the agitation level of residents in the corridor is higher on the second floor, while the ones in the communal areas and dining rooms are higher on first floor, particularly in the afternoon. In addition, it is also previously referred to that agitation behaviour starts in the afternoon and continues in the evening.

In general, this result indicates that there is an effect provided by outdoor daylight on the agitation level, as suggested by the literature review.

In accordance with the fieldwork assessment, several building simulations were conducted using IESVE 2014 with the aims of achieving representative results in relation to the fieldwork.

The final results suggest that the use RadianceIES as a tool for conducting daylight strategies is considered as an effective solution with several daylight parameters. Although there has been found several gaps in between building performance simulation and fieldwork measurement, the difference is negligible. Therefore, there are explanations about how the building performance simulation can be used to provide the opportunity for improved visual comfort and provision of daylight levels.

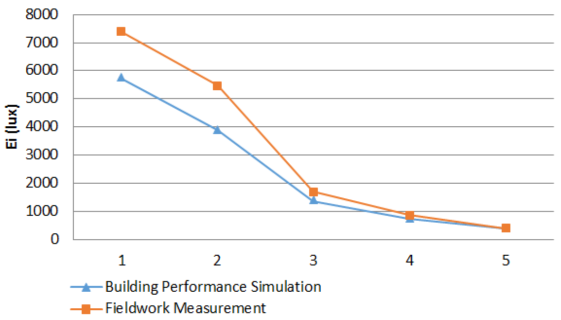

Figure 8 Graphical comparisons between BPS and fieldwork measurement in Communal Area. Source: field assessment and IESve simulation

Light Shelf

Light shelf provides daylight through apertures located in the perimeter walls of a building. In order to maximize the daylight penetration and reduce window glare, the daylight glazing are placed as close to the ceiling as possible for bouncing daylight deep into the room by the ceiling. In this simulation, a comparison was made between the BPS base case and light shelf.

Taking the indoor daylight in communal area 3 into consideration, the result shows that light shelf (Figure 9) contributes to higher daylight levels especially in the front zone (25%) and the rear zone (5.3%). The reduction of daylight level in the middle zone might be due to window apertures that are not well-oriented. Meanwhile, the light shelf is shown to be more effective in dining room 3, with daylight levels higher than base case and fieldwork measurement. As previously mentioned, the window layout also has an impact to the result. In this case, dining room 3 shows an increasing of daylight levels from front (4.6%), middle (40.3%) and rear zone (65%) respectively.

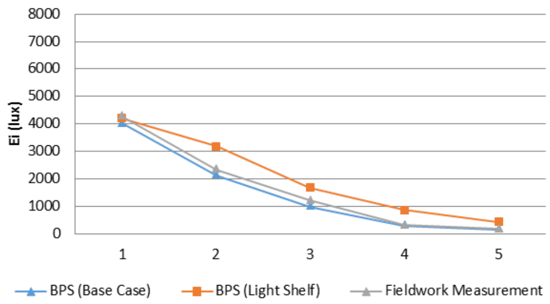

Figure 9 Graphical comparisons of dining room 3 between BPS and fieldwork measurement. Source: IESve simulation

Light Shelf

Daylight tube designs were applied in conjunction with a lower window. Due to its enclosed configuration, daylight tube designs do not need to have elements that deal with glare control which makes the designs simpler.

Based on the following result (Figure 10), the daylight tube is proven to contribute a significant amount of daylight levels. It can be understood, since the daylight tubes are installed throughout the whole corridor, giving the full access of daylight to the surface. The difference is significant between this new solution with the base case, being 43% in the front zone, 69% in the middle zone, and 94% in the rear zone.

In conclusion, the use of daylight based simulation has been found to be appropriate to evaluate several applicable daylight strategies. However, it is important to note that a combination between light shelf and daylight tube can produce high levels of illuminance, but at the same time may increase the opportunity of glare. This might be an issue that needs to be addressed for a further research

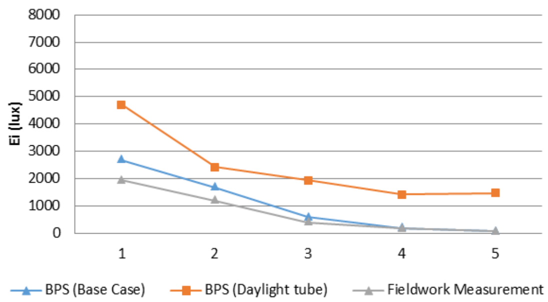

Figure 10 Graphical comparisons of corridor 2 between BPS and fieldwork measurement. Source: IESve simulation

CONCLUSION

Agitation is considered as one of the most challenging behaviour in the field of dementia research. The present research sets out to investigate the effects of daylight intervention on agitation in those with dementia living in nursing homes. The author conducted the daylight measurement to achieve daylight factor values in accordance to agitation level of dementia patients. In addition, daylight factors were measured by luxmeter during the observation process in order to relate with the agitation level. The result suggested that the best value of daylight factor was achieved only in conservatory, with DF value in between 2% and 5% almost throughout the day, due to large dimension of windows facing three sides. However, only by observing the nursing house in the middle and top floor, the best daylight factor value was apparently achieved in the middle floor. A likely explanation for these findings is that the window layout has lower window sill, which provides more daylight to the indoor space.

When agitation was evaluated through observation, patients with dementia in the study sites were significantly more agitated in the top floor compared to the middle floor where it has less DF value. After evaluated weekly through staff caregiver reports using the CMAI questionnaires, agitation was reportedly occurred mostly in communal areas, dining rooms, and corridors of all spaces after tea time. The fact that daylight factors value in the top floor is higher than the middle floor, strengthen the above argument. However, it should be noticed that not all spaces in the top floor have a high agitation level. The corridor in the middle floor has higher agitation level with daylight factor below 2% in the afternoon. The space appears to be gloomy and therefore, requires artificial lights. However, it might create shadow which may result in visual misperceptions by people with dementia. According to the caregivers responsible in the middle floor, several patients sometimes could accidentally fall down whenever they walk on the corridor. The shadow caused by the artificial light in the corridor could be mistaken for a hole in the floor. Therefore, an equal distribution of light is necessary to give more visual comfort to the people with dementia.

Prior to the building simulation process, an observation was taken to confirm the window size and area in accordance with BS5925:1991 Code of practice for ventilation principles and designing for natural ventilation. The results suggest that all windows are larger than the minimum requirement of window area, except for corridor in the middle floor. Since no improvement can be obtained by increasing the window size, an installation of daylight tube would be necessary to enhance the daylight levels. Whereas the communal area and dining room in the top floor could use a better daylight scheme to have more daylight access, such as light shelf.

With the aim of developing the design guidelines for daylight that may reduce the agitation level of people with dementia, the indoor daylight illuminance was assessed using RadianceIES from the software IESve. In addition, it would associate the results with fieldwork measurement, using the guidelines and recommendations provided from the literature review. Under the CIE overcast sky condition, the daylight simulation results suggest that the accuracy of illuminance between fieldwork measurement and BPS can be achieved by considering the space geometry, daylight ambient bounces, and outdoor components. A simulation was also conducted to enhance the daylight levels by providing several daylighting solutions such as light shelf and daylight tube. However, a further simulation regarding to solar heat gain and glare risk still needs to be done in order to achieve more appropriate results.

In order to modify the use daylight factor measurement as a tool to find relationships between daylight factor and agitation levels of dementia patient, a self-calculating daylight factor could be a future solution. The writer would suggest using RadianceIES to achieve the illuminance level needed to calculate daylight factor, rather than measuring manually. This can enhance the effectiveness of conducting daylight strategies with different daylight parameters. There is not much information on how to measure agitation levels apart from doing CMAI questionnaires; however, this particular matter could be a part of a more extensive study.

Thus, this literature highlights the importance of daylight to reduce the agitation level of people with dementia by the above-mentioned recommendations.

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