



# A Study of Daylighting Impact at Inpatient Ward, Seri Manjung Hospital

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DOI: <https://doi.org/10.30880/ijscet.2022.13.02.021>

Received 10 April 2022; Accepted 27 April 2022; Available online 09 May 2022

**Abstract:** Over the past few decades, there has been a growing interest in passive design strategies in the built environment, such as daylight. Using sunlight as the source, passive daylighting aims to provide effective natural lighting into the building while retaining maximum visual comfort without using mechanical equipment. Various research has shown the benefits of the natural environment to aid in human recovery, including daylighting. The majority of the biophilic design studies focused on workplace and healthcare environments such as hospital design. While biophilic architecture brings the meaning of nature to the internal environment, the positive effects of this biophilia are particularly concerned on healthcare facilities as it puts an element of extreme pressure on the space. This paper aims to understand the relationship between the patients and staffs' experiences of their physical environment, specifically addressing the use of daylighting as aiding the recovery of patients and restorative impact for the users. This paper investigates the effects of daylighting in the inpatient ward at Seri Manjung Hospital through a set of questionnaires distributed to the 50 respondents of male and female users aged 18 and above. This inpatient ward space is built with windows and utilising natural lighting during the day. The participants were asked to share their experience on the lighting conditions in the ward space and the impact on their health and recovery. The outcome of this study has shown that passive daylighting technique and biophilic design in inpatient wards help to increase users' connectivity with nature, improve physical and psychological well-being and accelerate the recovery process. Consequently, incorporating passive daylighting and biophilic design in a healthcare setting will shift the hospital's design to be more sustainable and responsive to the environment

**Keywords:** Passive daylighting, biophilic design, well-being, sustainable, restorativ

## 1. Introduction

Light is part of the natural resources that human life requires in performing daily activities. Light is also the part of the electromagnetic spectrum that is in contact with the human eyes' retinal receptor cells, sending it to the brain (Al-alwan, 2019). The signals received by the brain are based on the range of reception by the environment. Bioclimatic beings have a strong dependence on light, and any interference received from the desired lighting can cause different impacts on the human being. Thus, lighting is an inseparable element of the human environment. Natural lighting, known as daylighting, is a passive design strategy that helps to maximise natural light into the building through façade

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openings such as windows or skylights. Using natural light will reduce the consumption and dependency of artificial lighting thus making it an efficient energy-saving tool. Several studies reported that the restorative benefits of daylighting also improve occupants' health and comfort level, essential in hospital and healthcare facilities. Façade opening such as windows offers visual and physical connections to nature which are essential attributes in a healing environment (Aripin, 2010)

Daylighting is essential in hospital and healthcare facilities because it involves human well-being and health. Patients receiving treatments in hospitals, especially wards, typically spend more time in bed and need lighting to help enjoy the environment. An insufficient amount of illumination will influence patients' depression and anxiety (Walton, 2018). Most of the spaces in this hospital depend on lighting, both natural and artificial lighting. Continuous exposure to artificial lighting can cause serious damage to the eyes' retinas and some harmful effects, including eye fatigue, headaches, and visual disturbances. In addition, it can create boredom, mental, neuropsychological, and physiological effects on the users. Therefore, the need for daylighting is very important in hospitals because it provides positive value to users' health, safety, and ergonomics to better assimilate with the environment.

Some may argue that too much natural lighting will contribute to unwanted glare and heat in the building. Excessive light into the building can produce unnecessary heat gain of interior space and glare on work surfaces, influencing occupants' thermal and visual comfort. However, these issues can be rectified with the proper initial planning of building orientation and placement of windows. Proper building orientation and window placement will provide optimum daylighting requirements based on the space's unique functions. In addition, proper window treatments such as window films and glazing will control the desired sunlight into the building hence reducing the cooling load. This paper examines the effect of daylighting on occupants in the ward spaces in improving their health and productivity level. Optimum daylighting has a major impact on the physical and mental well-being of individuals. These include increasing efficiency, reducing dangerous accidents, increasing mental capacity, increasing satisfaction and well-being (Husein & Salim, 2020). In addition, it can prevent fatigue, increase morale, provide comfort, and improve the quality of work in the space. Therefore, the importance of daylighting needs to be given attention in hospitals and healthcare facilities because it elevates consumers' overall experience and creates a conducive environment.

## 2. Literature Review

### 2.1 The Impact of Daylighting on Human

Lighting quality in the environment requires three important factors: human needs, architectural design, and environmental-economic considerations. Human needs are the ability and ease of sight, while architectural design needs include communicating with the environment, including aesthetics, health, and comfort. Environmental-economic considerations are the provision of appropriate quantity and quality, including lighting for the environment. For example, a 5% increase in lighting brightness intensity can impact the human presentation of the environment, including increased visual acuity, biological brightness effects, and psychological effects (Walton, 2018). In addition, human activities are influenced by intensity, colour, direction, source type, and light diffusion in the spatial environment. Therefore, these impact the behaviour, enthusiasm, efficiency, and effectiveness of the activities performed in the space (Lim, Hirning, Keumala, & Ghafar, 2017). Daylight is a form of energy radiation generated and projected by the sun and benefits human life. Natural light will be reflected or absorbed by the objects on the surfaces it emits. Human beings often use this natural lighting for outdoor uses and indoor spaces. In the interior of the building, this natural lighting provides a focused source of vision and increases productivity.

Lighting is a part of the electromagnetic waves received by the retinal receptor cells of the eye and then send the signal to the brain. It plays a crucial role because it can influence human behaviour and is essential to our lives. In particular, it helps maintain a normal sleep-wake cycle that is in sync with the natural diurnal cycle of night and day by affecting human neuroendocrine and neurobehavioral responses (Lockley & Dijk, 2002). A new branch of photobiology research has emerged as a result of these and related discoveries, which are focused on day-light/light exposure and its 'non-visual' impacts on humans (Czeisler & Wright, 1999; Berson, Dunn, & Takao, 2002; Lockley, 2009; Rea, Figueiro, Bierman, et al., 2010). People's long-term health and happiness are now commonly acknowledged to be strongly influenced by the types, patterns, and intensities of light they are exposed to. Physiologically, a healthy individual will receive these waves of light in the range of 400-700nm in the form of a colour spectrum (Leccese, Montagnani, & Rocca, 2016). These waves of the illumination spectrum will enter the eyes, then head to the brain, which signals the human being to adapt to the environment around him. Lack of natural light can lead to lethargy, fatigue, lack of motivation, and even depression experienced by individuals (Walton, 2018). An indoor environment illuminated with natural lighting will make us physically more active, improve work productivity, and improve sleep quality. In addition, the body's hormonal balance will be improved, and it slows down the ageing process. Daylighting will also reduce the level of carbon dioxide in the environment while improving consumers' health. When the balance of the body is obtained through this natural lighting, the feelings of drowsiness, lethargy, and fatigue will be reduced. It also has a positive effect on health, thereby improving mood, metabolism, and level of consciousness.

## 2.2 Daylighting in Hospitals and Healthcare Facilities

Hospitals and healthcare facilities were built to provide healthcare treatments to patients and improve human well-being. So, this treatment space, an internal space that serves as therapy, needs to have quality in terms of environmental design. Research has shown that a therapeutic environment requires a high degree of flexibility, peace, intimacy, and relaxation so that such spaces can reduce anxiety and panic to its users (Leccese et al., 2016). In addition, the lack of attention to this ward's physical design and interior space causes users to be dissatisfied. Daylighting is one of the important environmental factors in providing a therapeutic effect to patients. Therefore, the importance of having a healthy and conducive hospital environment gives impetus and encouragement to the patients' psychology in the healing process. The importance of receiving the optimal amount of daylighting to the design will positively impact the healthcare setting, especially in the ward space. Providing adequate light levels in hospital buildings can substantially impact the health and well-being of patients and their caregivers. Reduced stress and fewer medical blunders can be achieved by ensuring enough lighting (Ferenc, 2011; Huisman, Morales, van Hoof & Kort, 2012; Nhut & Nam, 2010; Boubekri, 2008). Daylighting can reduce human resources, stress, and confusion for users and further increase the hormonal awareness of users of the space (Walton, 2018).

The amount of light, whether natural or artificial, impacts the consumers differently according to its reception level. This natural lighting depends entirely on the sun rays emitted through the openings or windows found in the ward walls directly into the interior space. Activities can be carried out easily and smoothly if the consumers receive optimal lighting. Therefore, the strategic placement of windows is very important, especially in the ward space. Some initial design thoughts are required, for instance, the climatic consideration, building orientation, and fenestration of natural lighting received to avoid excessive glare and discomfort to users. Furthermore, studies have shown that the reception of daylighting at an optimal level in the interior space will reduce energy consumption and be a great means for the energy-saving initiative in hospitals and healthcare facilities. Energy audit in a hospital has shown that lighting consumed the highest amount of energy (36.3%), followed by biomedical equipment (34.3%), office equipment (8.9%), motorised equipment (8.7%), communication devices (4.1%), and other miscellaneous items (7.7%) (Saidur, Hasanuzzaman, Yogeswaran, Mohammed, & Hossain, 2010).

## 2.3 Impact of Daylighting on Patient's Health and Recovery

Hospitals and healthcare facilities will be great beneficiaries if the full potential of daylighting is utilised, particularly in the ward space, because it can provide illumination to the space, reduce heating costs, and provide better physical and mental health to patients and staff. Patients who are generally delicate in mental and physical well-being also want quality and conducive environment while under the medical staff's treatment. There is a growing body of evidence that daylight and window views have positive effects on patients, such as decreasing stress, length of stay and maintaining/restoring circadian rhythms (Acosta, Leslie, & Figueiro 2017; Chiu et al. 2018; Choi, Beltran, & Kim 2012; Iyendo, Uwajeh, & Ikenna 2016; Schweitzer, Gilpin, & Frampton 2004; Ulrich et al. 2008). Optimum illumination of interior ward space will help in wayfinding, determining access, providing signs, visual indicators, and clear navigation. It is an important element for visitors and patients not to feel anxious and disturbed when entering the hospital (Kramer, 2018). In addition, access to the environment outside the hospital is also very important because it ensures the safety and well-being of users. Through this, daylighting will also affect the human body and soul which are related to the individuals' mental and physical health. These positive results are very useful for the patients' health and recovery process who receive treatment in the ward (Aripin, 2010). The design of the ward also influences the physical aspects, including the orientation of the building. Among other things, creating a sustainable environment helps the healing of patients as well. The design of the windows and access to the external view affects the patients psychologically and, in turn, helps to speed up the recovery process. Visual comfort is crucial in providing satisfaction to users in the ward through the continuity of daylighting, artificial lighting, and colour on the physical aspect. The design will provide a comfortable and cosy environment in influencing users' emotions.

The symbiotic relationship between humans and nature can be further nurtured through biophilia. Biophilic design refers to concepts adapted to the conditions of the natural environment. It is an architectural approach that aims to connect the occupants of a building with nature. This term is originated back in the 1960s by a psychologist, Eric Fromm, and was later propagated by a biologist, Edward Wilson in the 1980s. Some of the elements of biophilic architecture are natural ventilation and daylighting, which are essential in creating a conducive and healthy environment for the public (Totaforti, 2018). This architectural approach unites nature with buildings or spaces to make this environment unified and alive. The symbiotic relationship between human beings and nature is significant because it creates a harmonious and conducive environment in the home and workspace (Kellert & Elizabeth, 2017). Therefore, this approach is a crucial tool for humans to connect with nature, appreciate each other better, and create a harmonious living environment.

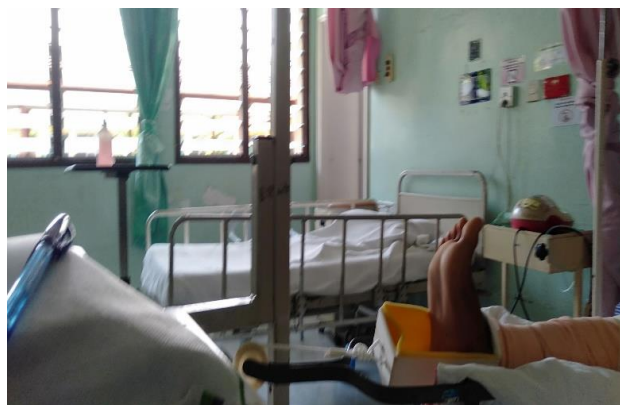
The internal environment of building space is influenced by two distinct elements, either natural or artificial lighting. Harvesting natural light will reduce dependency on artificial lighting. One of the criteria for biophilic design is the fenestration of daylighting into the interior space of a building. Well-designed façade openings will allow ideal

daylighting fenestration. It is done by optimising the amount of natural light while reducing glare and heat gain in the building. Biophilic design improves the quality of the indoor environment and comfort, which are crucial elements in healthcare facilities. It offers a more harmonious approach to dealing with stress in the workplace, increasing motivation, patients' healing, and health recovery. This design can also reduce anxiety and improve users' physical health (Husein & Salim, 2020). Daylighting and natural ventilation obtained from the natural source in the environment will be important elements in the design because they affect the interior quality and greatly impacts the users. On the other hand, seamless coordination with artificial elements in the interior environment such as structure, building shape, colour, ambience, furniture selection, layout, and even other details cannot be ignored (Huang, Huang, & Sun, 2018).

Daylighting affects the interior space, especially the ward, putting psychological pressure on two conditions: receiving enough natural lighting and the other with the windows closed. Meanwhile, in terms of physiology, this change in pressure is measured through Heart Rate Variability (HRV), exposure to natural light (Andrea & Stefano, 2019). The results can be concluded that exposure to natural light from the ward interior space will relieve stress due to parasympathetic activities. The restorative effect of natural lighting obtained from the design of windows on the ward space, which also provides a view of the outdoor landscape, will reduce hospital stay, reduce serotonin by 8%, and lower pain perception by 22% (Totaforti, 2018). This natural lighting will also enhance the body's biological cycle and reduce faults, transparency, and visual clarity on the environment. In addition, it will also be able to reduce feelings of stress and increase positive feelings. The study also concluded that the consequences of too much exposure to artificial lighting in the ward space could cause psychological and physical problems such as headaches, fatigue, depression, and stress on the eyes.

### 3. Methodology

Seri Manjung Hospital was built in 1992 and later was completed in 1995 on a 46-acre land. This hospital is classified as a specialist hospital and has a 305-bed capacity. The total construction cost of this hospital was about RM73 million. The survey was conducted to collect data on the impact of daylighting on human health and the well-being of occupants in the ward space. The inpatient ward of Seri Manjung Hospital is utilising a series of jalousie windows for daylighting fenestration. The mechanism of this type of window is the louvres are joined onto a track so that the opening or closing of the louvres glass are in unison to each other. The respondents who participated consisted of patients and staff working in the adult inpatient ward of Seri Manjung hospital (figure 1). The age of the respondents is 18 years and above, and it was informed to the respondents that this study was conducted to get feedback from their experiences on daylighting quality in the hospital ward space. 50 questionnaires were distributed to respondents in this ward space: 18 males and 32 females (figure 2). 60% or 30 of 50 respondents consisted of inpatients: 10 males and 20 females and 40% or 20 respondents are medical personnel consisted of medical officers, medical assistants, nurses, and pharmacists: 8 males and 12 females. The questionnaire summarised users' experience of daylighting reception, the duration of exposure to adequate lighting levels, the importance of daylighting to their activities, and health recovery throughout their stay in the ward. This approach is preferred to provide anonymity and ensure greater confidence to the respondents. A quantitative approach was used to show a significant relationship between users and the daylighting received in the ward space. Their responses were documented, and Statistical Package for Social Sciences (SPSS) software program was used to analyse data. This study highlights the restorative effect of daylighting in inpatient ward space and its potential in hospitals and healthcare facilities settings. The research framework outlines the objectives, data collection, selection criteria, methodology, data analysis, and research outcome are shown in figure 3.



**Fig. 1 - Ward area at Seri Manjung Hospital**

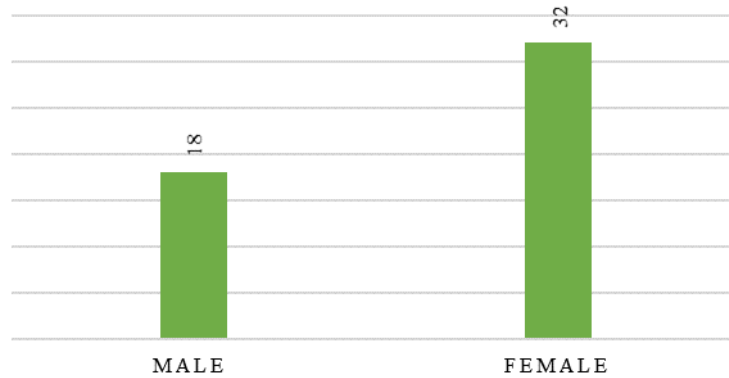


Fig. 2 - Respondents gender

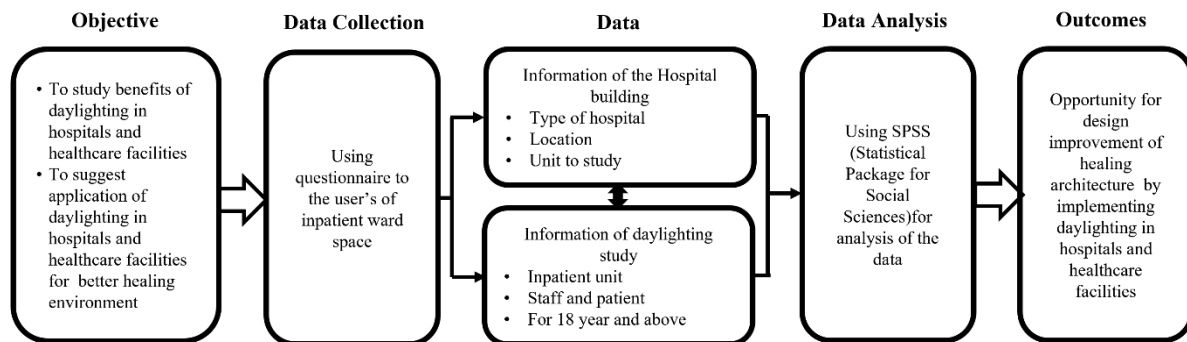


Fig. 3 - Research framework design

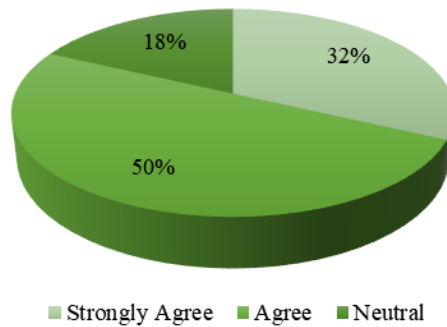
## 4. Results and Discussions

Hospitals and healthcare facilities were built on a more stringent building code compared to other buildings. One of the building codes that need full compliance is the façade opening for natural lighting and ventilation. It is done to ensure the safety of the occupants. Seri Manjung Hospital is listed as a specialist hospital; therefore, multiple health divisions and treatment for critical illnesses are offered here as well. One of the health services provided here is the inpatient ward. Based on the feedback by the occupants of the inpatient ward, Seri Manjung Hospital, there are six identified strategies to increase the potential of daylight. They are:

- i. Importance of daylighting
- ii. Daylighting improves productivity
- iii. Benefits of daylighting
- iv. Strategic window placement
- v. Glare problem
- vi. Influence patient's recovery

### 4.1 Importance of Daylighting

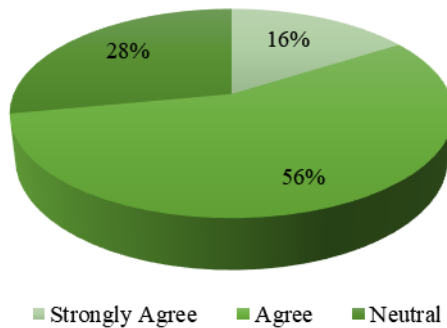
According to the questionnaire analysis, daylighting is important in the ward environment as illustrated in figure 4 where most users are satisfied with the lighting conditions. Of the 50 respondents, 25 (50%) people agreed with daylighting in the ward space, followed by 16 (32%) people who strongly agreed that they get sufficient natural light and daylight is important for their daily routines. On the other hand, 9 (18%) people chose a neutral stance. The users have well-received daylighting conditions in the ward space, and they feel very comfortable with it. Therefore, most respondents (82%) were satisfied with the daylighting quality in the ward space.



**Fig. 4 - Importance of Daylighting in The Ward Space**

#### 4.2 Daylighting Improves Productivity

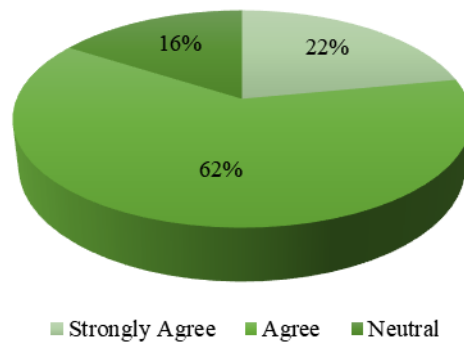
Next is whether optimum daylighting can be a factor to increase productivity, as demonstrated in figure 5. The feedback received from the respondents witnessed that 28 (56%) of the respondents agreed that optimum daylighting has contributed to the increased productivity in the ward space. On the other hand, 14 (28 %) of the respondents opted for neutral while 8 (16%) of the respondents strongly agreed with the contribution of daylighting to improve the performance of work and activities performed in the ward space.



**Fig. 5 - Daylighting Influences Better Productivity**

#### 4.3 Benefits of Daylighting

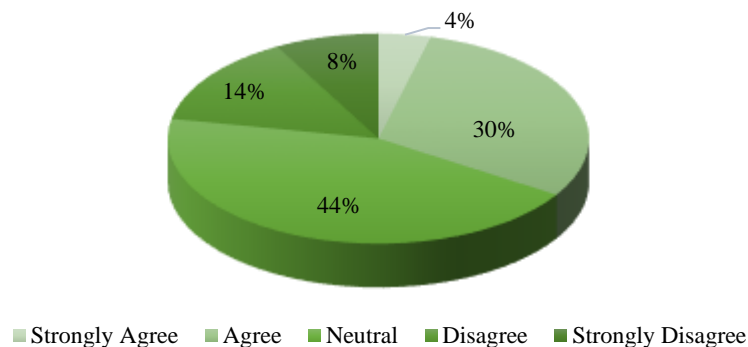
The benefits of daylighting are well documented, and this strategy analyses the benefits of daylighting in the ward space. Users' exposure to daylighting is beneficial for carrying out daily routines and aiding the recovery process. Daylighting is beneficial to us mentally and physically. Through the findings, as shown in figure 6, daylighting is beneficial for both patients and staff. It was found that 31 (62%) of the respondents agreed with the benefits received from daylighting, 11 (22%) of the respondents strongly agreed, and only 8 (16%) of the respondents were being neutral. The analysis agrees with the findings by Walton (2018), which through optimum exposure of daylighting, it helps to speed up the healing process and improve work performance.



**Fig. 6 - Benefits of daylighting**

#### 4.4 Strategic Window Placement

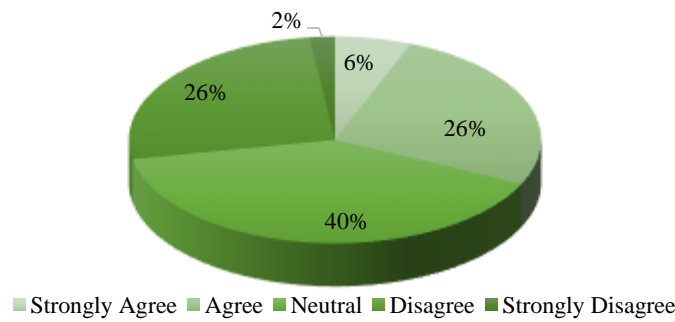
According to Kim, Zadeh, Staub-french, Froese, & Terim (2016), window placement plays an important role because it is a factor that allows natural light to enter the space of the indoor environment and it also influences the activities carried out. Following the question stated in the questionnaire, whether the placement of windows that receive light during the day interfere with the activities carried out. The respondents' findings illustrated in figure 7 has shown that 4 (8%) of the respondents strongly disagree with this statement, followed by 7 (14%) of respondents that chose to disagree. Meanwhile, 22 (44%) of the respondents were neutral, 15 (30%) of the respondents agreed, and 2 (4%) of the respondents strongly agreed with the statement.



**Fig. 7 - Placement of window position**

#### 4.5 Glare Problem

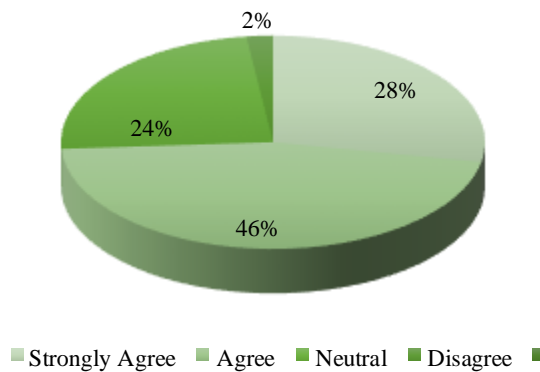
Excessive daylighting exposure into the interior space can create glare, giving unnecessary discomfort for both patient and staff, hence limiting their movement in the space. The survey conducted concerning the glare problem faced by the respondents is shown in figure 8. The findings show that 1 (2%) of the respondent strongly disagreed, and another 13 (26%) of respondents did not agree with the statement. This is because the position of their beds and workspaces do not suffer from such glare problems. Meanwhile, 20 (40%) of the respondents were neutral, another 13 (26%) agreed, and 3 (6%) strongly agreed with the glare problem experienced. It shows that the design of ward space for natural lighting in Seri Manjung Hospital needs to be designed more efficiently.



**Fig. 8 - Glare problem**

#### 4.6 Influence Patient's Recovery

This questionnaire was conducted to investigate the correlation concerning the health and recovery of patients with the existing daylighting conditions received. Apart from medicine, the natural environment that has this illumination affects the patient's recovery. The findings through the questionnaire illustrated in figure 9 regarding the influence of natural light on health recovery are that only 1 (2%) of the respondents disagreed and 12 (24%) of the respondents were neutral. Furthermore, it was found that 23 (46%) of the respondents agreed and 14 (28%) of the respondents strongly agreed with the statement that this natural light influences them for recovery while seeking treatment. Therefore, most respondents support the idea that this daylighting is an essential component in aiding recovery.



**Fig. 9 - Influences patient's recovery**

Several measures can be executed to optimise daylighting. Among them is to design the windows more spacious and arrangement the patients' bed to get sufficient and equal daylighting, especially in the ward space. In addition to increasing the amount of natural light input, the design of this window also provides an exterior view. Therefore, it provides a psychological effect and physiological benefits to the user. Future research may find suitable materials for these windows that provide optimal natural lighting and avoid glare simultaneously.

#### 5. Conclusion

This paper explores the potential of daylighting and whether this approach influences the healing process while providing satisfaction to users in the ward space. Through the incorporation of biophilic design and the use of elements from natural sources may positively impact the indoor space quality. This biophilic design approach, i.e., daylighting, has an important effect on reducing artificial light. This study indicates that designers should be mindful of the natural influences on the design that creates a conducive hospital environment, thereby speeding up the patient' healing process. An efficient daylighting design will contribute to a sustainable and healthy environment while providing comfort to its users. Common issues related to excessive natural light in the building such as glare and heat gain can be rectified with good climatic understanding and building orientation. Furthermore, architectural intervention can improve the existing hospitals and healthcare facilities, such as strategic placement of façade openings and fenestration of natural light. Building materials such as glazing, and window films will help to improve thermal comfort and it offers a better user experience during their stay for treatment and recovery.



Consumers' exposure to artificial lighting of the ward space on an ongoing basis will cause psychological and physical problems such as headaches, eye strain, depression, and even fatigue. On the other hand, the sun is the healthiest and cheapest natural source and supplies light energy to all living beings. Therefore, the importance of daylighting derived from the sun rays to the interior space can provide an approach of self-confidence, satisfaction, and even mental comfort. In addition, it can also avoid the presence of disappointment and frustration among the users. Daylighting also directly improves the health and productivity of individuals and is a source of mobility and motivation. In addition, exposure to this lighting will provide significant happiness and comfort that helps the patients' recovery process in the health care process. Therefore, ward spaces that receive natural lighting should prioritise architecture for space design for healing purposes. More detailed research and studies are needed to investigate building techniques to optimise the benefits of this natural lighting to the building and its occupants.

## Acknowledgement

For any further enquiries regarding the topic, do not hesitate to get in touch with the author.

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