International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 10-No.4 (2024) pp. 1101-1110
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Visual comfort is one of the human needs in patient isolation rooms

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Article Info:

DOI: 10.22399/ijcesen.637
Received : 16 November 2024
Accepted : 18 November 2024

Keywords:

Visual comfort,
personal safety,
security,
quality of life,
internal environment.

Abstract:

Lighting passed through many stages, as the need for it has appeared since ancient times. To increase the level of lighting during the day, artificial lighting is sometimes used to create a state of integration to compensate for the areas where light does not reach within it. This causes a condition of anxiety and disturbance. The current research addresses the study of the efficiency of natural lighting within healthcare buildings, specifically patient isolation rooms, which requires more of this sample of research. As natural lighting is provided within the vacuum of the patient's isolation room, one of the causes of comfort, specifically visual comfort, The isolation room reduces stress and reflects positively on the patient's psychological condition, to achieve comfort, calm and relaxation. It is a basic requirement for the quality of human life in healthcare facilities, as stated in Egypt's Agenda 2030, which emphasizes supporting patients and providing all necessary means for their safety and security.

1. Introduction

The health of patients, their psychological condition, and their sense of security to a great extent related to the internal environment of the space designated for the treatment and residence of patients, and one of the most important of these spaces inside hospitals is the space of the isolation room inside hospitals. In which the patient may be forced to remain alone and isolated for a medium to long period to receive the required health care. There is no doubt that lighting is one of the visual elements of great importance in the interior design of any architectural space to adequately demonstrate and understand its importance and create an internal environment supportive of recovery by achieving visual comfort with it.

Many scientific studies have addressed visual comfort as one of the most important elements in achieving internal environmental quality due to its strong impact on human health and increasing production rates inside many buildings, especially hospitals, schools, and administrative buildings, but they have not addressed how to create a standard, visually comfortable model for the internal space of a patient isolation room inside hospitals.

2. Research problem

The problem of the research is that the patient inside the patient isolation room remains alone inside the room at all times of the day, which requires studying the natural lighting levels inside the patient's isolation room space, so that he and the treating team can practice activities inside the space without anxiety or feeling of disturbance.

Research and studies have monitored risks related to patients inside isolation rooms specifically, which is the risk of patients falling while moving inside the room, as a result of the lack of sufficient natural light, which affects their personal safety.

A patient isolated alone in an isolation room is considered a special case that requires providing safety, and this is achieved by providing sufficient lighting inside the space.

Reducing the use of artificial lighting, thus reducing the burden on the country and contributing to solving the energy crisis

3. The aim of research

Providing sufficient natural lighting during the day inside the patient's isolation room.
Proposing solutions that increase light components inside the patient's isolation room. Deducing the relationship between the area of the openings and the intensity of illumination. Improving psychological condition and security for the patient. Providing an ideal model with standard spaces and specifications that improve visual comfort in patient isolation rooms. Figure 1 shows the connection between human comfort and the quality of environmental safety as an input to the patient's quality of life in the health care sector. The definitions related to the research paper is shown in table 1.

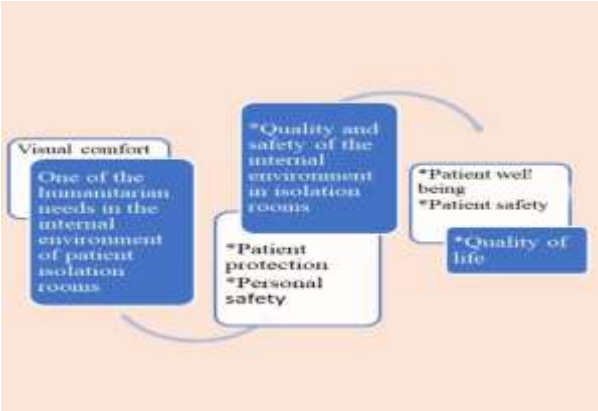


Figure 1. *The connection between human comfort and the quality of environmental safety as an input to the individual's quality of life in the health care sector*

Table 1. *Definitions related to the research paper*

Definitions:	
A- Comfort	
1	**Webster defined it as**: a condition of feeling encouraged toward mental and physical well-being, especially freedom from need, anxiety, pain and problems, something that gives or evokes a sense of comfort for the particular relief of mental tension [1].
2	**As Giarma defined it**, it is a pleasant condition of organic, psychological, and physical harmony between man and the environment [2].
3	**Another definition**: It is the mental condition that expresses satisfaction with the general features of the environment surrounding him with its physical, organic, psychological and social characteristics [3].
B- Light	
Defined by: Englezou Light: It is electromagnetic rays that we can see with the naked eye, and it is considered the main controller of the sense of sight through long waves (infrared), or short waves called (ultraviolet waves), which he called them the colors of the spectrum and through reflection Light waves on the eye are automatically transmitted to the mind to be recognized and translated into images [4].	
C- Visual comfort	
It is to strengthen the human feeling and response to the illuminated environment and its interaction with the eye, then the body, and then the rest of the senses, as vision is the process by which we perceive objects and colors depending on the eye's sensitivity to light, and transforming them into signals. A positive neurological effect that reaches the brain, giving a feeling of comfort and stimulating self-recovery [5].	
From the above, the researcher can conclude that: Visual comfort is an emotional condition that the patient feels when the lighting is harmonious with the interior space and a sufficient balance of light is achieved. Concept of visual comfort is improved through the lighting conditions and the general view of the room, which is a translation of the condition that the eye feels as a result of the clarity of objects.	
D- Natural lighting	
It is the amount of light incident perpendicularly on a specific area of space per second, from light emanating from a natural light source for a specific day period and is measured in the lux unit [6].	
From the previous paragraph, the researcher can conclude that: **The intensity of natural lighting can be defined from an architectural point of view:** It is the intensity of light falling on the work surface, through which activities can be clearly carried out on that surface. This density varies from time to time within the space depending on the hours of the day, starting from sunrise until sunset. From the above, it may come to the researcher's mind that in the case of isolation rooms, there can be more than one working surface. Sometimes it is the patient's bed or the complementary furniture surface inside the room, such as a table, and at other times it is the flat floor of the room, which in turn is responsible for the regular movement of the patient's feet without stumbling. As a result, the room floor is sufficiently flat. It can also be concluded that: The intensity of lighting changes according to the time variation during daylight hours, and also during the annual seasons, as well as according to the direction and area of the windows in each space. On the one hand: It can also be concluded that the intensity of artificial lighting is a constant intensity compared to natural lighting, and that the only effect on its intensity is the expected lifespan of the performance of the artificial light source, or the presence of some defect in the intensity of electricity that leads to a disturbance in the intensity of the lighting.	

4. Lighting in patient isolation rooms

Lighting in patient isolation rooms is considered one of the technical systems of great importance because it helps in achieving the functional performance requirements of the medical team and the patient. It

also helps in achieving visual comfort for patients and all workers and is a means of preventing the risk of falling. Therefore, attention must be given to the level of lighting intensity as follows [7] :

- Regular lighting level.
- Avoid excessive differences in the level of lighting intensity for spaces between which there is constant movement (day and night), such as patient isolation rooms, roads, lobbies, and nursing stations.
- If the lighting level is less than the required level, medical errors may occur due to lack of clarity of vision, and thus we lose the safety and security required as a human requirement to improve quality of life in health care settings.

4.1 Natural lighting

It is preferable to have a source of natural lighting for patient isolation rooms, as natural lighting contributes to improving the health and safety of patients. An example of this is the study prepared by Makeniz Health Center in Admundum, Alberta, Canada [8], which shows that the period of a patient's stay in a room with access to daylight is less than the length of the patient's stay in a room that does not receive natural daylight for approximately four days,

A similar study conducted at Anha University Hospital in Korea shows that there is a 41% reduction in the length of stay in rooms with daylight compared to artificially lit rooms for those suffering from infectious diseases.

Other studies reported a significant decrease in hospital infections, as sunlight may kill a large number of bacteria even behind the glass, thus speeding up the recovery of patients. Excluding sunlight in hospitals, specifically patient isolation rooms, increases the risk of infection and infection depression and other health problems.

4.2 Lighting and its role in regulating the patient's movement inside the isolation room:

The importance of relying on lighting has increased in order to enhance the functional and sustainable aesthetic performance of the internal and external spaces in health facilities in general, as lighting is one of the priorities of interior design. Lighting is also important in providing safety and meeting the patient's needs inside the isolation room. In general, the lighting used in the various isolation rooms is natural lighting and artificial lighting, however, with the difference in means, techniques and with the different daily time, natural lighting is the most importance in psychologically accepting the space, the feeling of colors and shape as a result of natural light.

During the day, it is desirable to benefit from natural lighting as much as possible, due to the physiological health benefits it brings to humans. Vision is not the only thing that needs light. Light is an environmental factor, such as air, water, and temperature [9].

4.3. The relationship between lighting and psychological safety in patient isolation rooms:

Providing indirect lighting helps provide an atmosphere of calm and reduce nervous tension among patients and visitors, meaning it achieves the human need for calm and relaxation [10].

Providing adequate lighting in patient isolation rooms is important for light activities such as browsing and reading

Good lighting of identification signs and directional signs it is only a response to the human need to recognize the place and find the way.

The quality and level of interior lighting carries a message to the user's mind that expresses the status of the building and the level of services it provides, and this is a response to the human need for symbolic signs and connotations.

Distributing the lighting so that it allows the speakers' faces to be seen clearly is important for seeing facial expressions, as they complement the language of the dialogue. The color of the lighting must also be appropriate to give the correct impression of the patient's skin color [11].

4.4. Natural lighting requirements in patient isolation rooms

Distributing windows and choosing their locations to obtain the greatest amount of natural light and choosing means to control shading so that the patient can enjoy the sun's rays without obtaining excessive glowing solar energy [12].

It is preferable to allocate some open spaces (such as courtyards, for example) in the building, allowing patients to benefit from the violet rays, interact with the environment, and break boredom, while taking into account the privacy factor [13].

In planning the site, the heights of buildings and the distances between them should be taken into account so that no building blocks natural light from another building close to it or facing it. Hence the importance of studying the different angles of the sun throughout the year to avoid this.

From the previous, the researcher can conclude that: With increasing window surfaces to increase the amount of natural light, it is necessary to take into account shading means that can be controlled to prevent glare, and also to achieve privacy, if the glass is of the transparent type.

The researcher notes that studies have shown that patient isolation rooms must be oriented south, which ensures the effectiveness of light, but taking

into account the necessary treatments to reduce heat flow, so as not to carry mechanical cooling.
The researcher confirms that when windows are distributed in the patient's isolation room to gain the greatest amount of light, it may be necessary to increase the area of the window at the bottom of the room, which makes the window seat may be close to the surface of the floor of the room, and this contradicts the requirements for a sense of security, which was a basic requirement for the Egypt 2030 agenda to achieve safety for patients in health care settings.
The researcher confirms that the quality of glossy glazed floors may increase the glare occurring in the patient's isolation room compared to non-glossy floors, as in Figure 2.

Figure 2. *The difference in glare and light reflection. On the right is an example of glossy floors and on the left is a matte floor [14].*

4.5 Artificial lightining in patient isolation rooms

Artificial lighting inside patient isolation rooms has a major role in providing the clear vision necessary to follow the treatment process, even in spaces where natural lighting is provided [15]. This does not replace the use of artificial lighting units permanently to enhance the efficiency of light within the space, which is called the Integration of natural and artificial lighting for access to the required limit.

4.6 Artificial lighting requirements in patient isolation rooms

Lighting must be of the energy-efficient type so as not to increase burdens on the country [16].
Lamps must be smooth, easy to clean and change.
It must be at the same level as the ceiling without any protrusion, so as not to create edges for bacteria to multiply. It is prohibited to use halogen lamps that cause glare and heat in spaces, so as not to increase the proliferation of bacteria.
It is preferable that the operating switches be of the smart type to avoid the patient with the contagious disease coming into contact with the switches.
The locations of the lamp operating panels must be well distributed so that they are close to the patient's bed and the doors.
It is preferable that the lamps be of a special type, which is lamps that operate with violet rays, as they are useful in killing germs and viruses.

4.7 Patient isolation room inside hospitals

The primary activity within the space of the patient isolation room is to provide medical care to the patient, who is the focus of the treatment process, and to control him so as not to transmit and spread the infection from him to others, and thus the largest space inside the space of residence, and the space of residence is divided into three basic areas [17]:
- The patient area (a basic area for lighting): It occupies the largest space within the space and contains the patient's bed, a bedside table, and some complementary furniture [18].
- The bathroom area (a basic area for lighting): contains the sanitary equipment necessary for the patient's hygiene
- The separating lobby area (a basic area for lighting): It is a separating area between the patient's area and the rest of the spaces of the hospital's internal environment (figure 3). **T**he researcher confirms that the patient's isolation room and its annexes are considered essential areas that require natural lighting more than other accommodation rooms. Perhaps the reason is that the patient is in the isolation room alone without an accompanying to carry out his activities and needs, such as entering the bathroom, for example.

5. Simulating reaching ideal standards and specifications

For natural lighting as a goal of achieving visual comfort as one of the requirements of human needs in patient isolation rooms **.**The simulation takes place in two stages:
The first stage: determining the ideal standards and specifications for the isolation room, its area, the ideal finishing colors, and determining the ideal orientation of the windows.
The second stage: extracting an ideal standard model that provides sufficient natural lighting within the space and achieves visual comfort, by specifying window areas and specifications**.** The figure 4 shows the simulation method.

Figure 3. *The isolation room spaces and the internal spaces attached to it [19]*

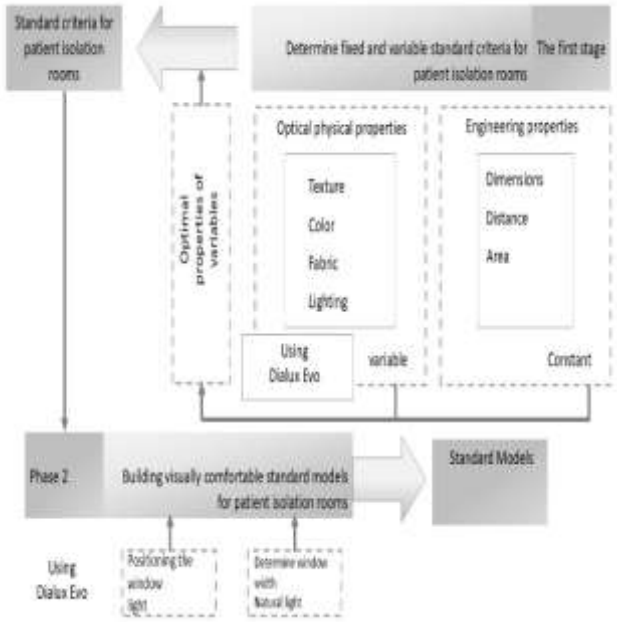


Figure 4. *The simulation methodology, as prepared by the researcher*

5.1. Tools

The research uses the Dialux Evo program, version 8.2, in the first phase of the study to model the study cases represented by a single isolation room with one bed, and in the second phase to produce the standard model.

The program relies on determining the location of the model with coordinates, and the program also relies in its calculations on European averages. (British Standard European 2EN BS Norm) To measure average lighting intensity, the results of which have been validated and tested according to international standards and by an accredited lighting laboratory.

The program also draws light intensity distribution curves from (0.10:15000lux) and expresses them in color gradation.

As for how the program works: it is done by entering the specifications and areas of the model to be created, its geographical location, the orientation of the windows, and specifying the proportions and areas of the windows in three dimensions.

As for the program's error rate and accuracy: through previous studies and research, its results were compared to actual results on the ground, and it turned out that the expected error rate is equal to 0.15% for every 100 lux in the program, meaning every 100 lux is considered 101.5 lux in reality [20].

Choosing the orientation of the isolation room space to be simulated: through theoretical studies, research, investigation and extrapolation by the researcher, it became clear that the isolation rooms must be oriented south, opposite the direction of the prevailing winds, in order to prevent the spread of infection and preserve the rest of the hospital spaces from the flow of infection with the wind.

Timing of measurements: The results are measured on the twenty-seventh of December, as it is the month with the lowest light intensity and at twelve o'clock in the afternoon, considering that it is the middle of the working hours and daily activity inside the isolation room.

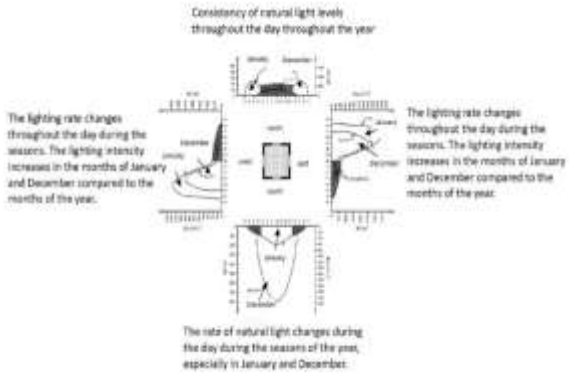


Figure 5. *The intensity of lighting during the months of the year*

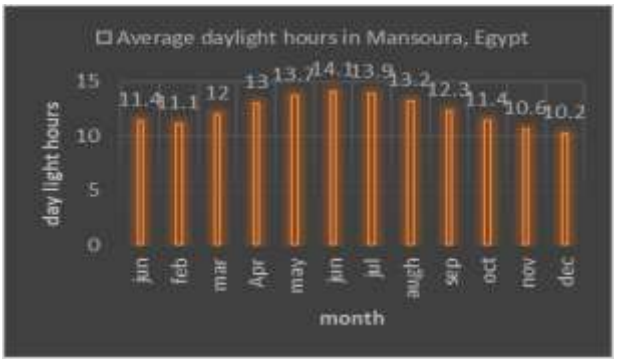


Figure 6. *The hours of daylight during the months of the year, as prepared by the researcher*

Average daylight in Mansoura City, Dakahlia Governorate [21].

From the figure 5 and 6, it is clear that the hours of daylight in summer reach 14.1 hours in the month of June, which is the highest daylight hours throughout the year, while it reaches its lowest levels in the month of December, bringing the number of hours of daylight to 10.2 hours. Through this, the simulation is done on December 27 to provide the maximum. It is estimated for the lighting during this period that is dominated by clouds, and of course the lighting intensity may change during the rest of the seasons to achieve higher levels than in December, but at the latest. It does not reach the point of glare, but this increase can be controlled through shading methods. The measurement is made according to the work surface of 80 cm, which is the height of the patient's bed, specifically at the longitudinal axis, where the space is divided into a mediocre unit every 60 cm, as the bed is considered the focus of activities within the isolation room, given that it is centered exactly in the middle of the room.

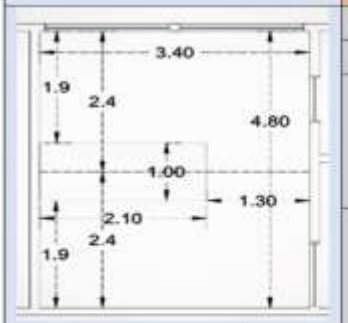
5.2. Lighting levels:

According to the activities inside the patient's isolation room, the European standard rates for natural lighting depend on several standards distributed over the expected activities inside the isolation room, which are approved in the design standards code for hospitals and health facilities inside Egypt and also approved in the Dialux program, as is shown in table 2.

Table 2. *The permissible lighting intensity levels, (adapted by the researcher)*

Table of lighting levels approved by the Egyptian Code 22		
Luminance in lux	Measurement level	Activity
100	Vacuum floor	General lighting
300	Patient pillow	Reading
300	Patient work surface bed	Simple check
5	Patient pillow	Night lighting lighting/monitoring

Table 3. *Standard specifications for isolation rooms (adapted by the researcher)*

Product Model	Elements	
	4.8 * 3.4m	Dimensions
	1 * 2.1 m	
	2.4 meters from the exact center of the room	bed axis
	1.9m	The distance between the bed and the window
	Antibacterial white paints	the color

5.3. Standard specifications for achieving the highest prevalence of lighting in patient isolation rooms

Table 3 shows the standard specifications for isolation rooms, and then a standard model is presented.

5.4. Results of the previous stages:

There is no doubt that the window is the focus of the simulation based on which the amount of light falling into the space is determined. It is the common vertical level between the room and the external daytime environment. The height of the window seat must be equal to the height of the patient's bed, for two reasons: the first is so that the patient can communicate from the bed with the external environment, and the second reason is that the window seat must not be lower to low levels so as not to create fear within the patient, which affects him always staying from windows, especially at high altitudes. Increasing the height of the window longitudinally leads to found of the largest amount of light, after ensuring the floor height, which codes and studies have confirmed that in all cases, the height of the floor after finishing in the isolation rooms is not less than 2.8 m.

So, based on the previous two paragraphs, it can be said that the height of the window may reach 2 m, and accordingly, the width of the window plays an important role in determining the window area that provides appropriate lighting in the isolation room.

The researcher pay attention that in the isolation rooms specifically, there may not be any fallen beams that obstruct or reduce the height of 2 m agreed upon in the previous paragraph.

Perhaps the reason is that there is a void under the belly of the ceiling that may reach 70 cm, to allow the installation and maintenance of industrial ventilation, cooling and fire. This makes it equal at the end of the beams, which may also reach a depth of 70 cm.

5.5 Simulate the virtual model.

Simulation depending on the window area. First: The width of the window along the entire wall, which is 3.4 meters wide. Through the above: It was found through the program that the intensity of lighting at the axis of the bed in the middle of the room reached 1400 lux, while it reached the end of the room to 650 lux, which confirms that these rates are higher than permissible and cause discomfort in the isolation room as a result of increased glare.

Second: The location of the window is in the middle of the room. It was shown through the program and trial and error as attempts to reach the permissible standard number, it turned out that when simulated with a window width of 1.25, the lighting intensity was 300 lux, which is the permissible rate for practising activities. The figure 7 shows light penetrating through a window in the entire wall and light penetrating through a window in the middle of the wall is shown in figure 8. The figure 9, shows the change in lighting intensity in the middle of the patient's bed depending on the change in window width.

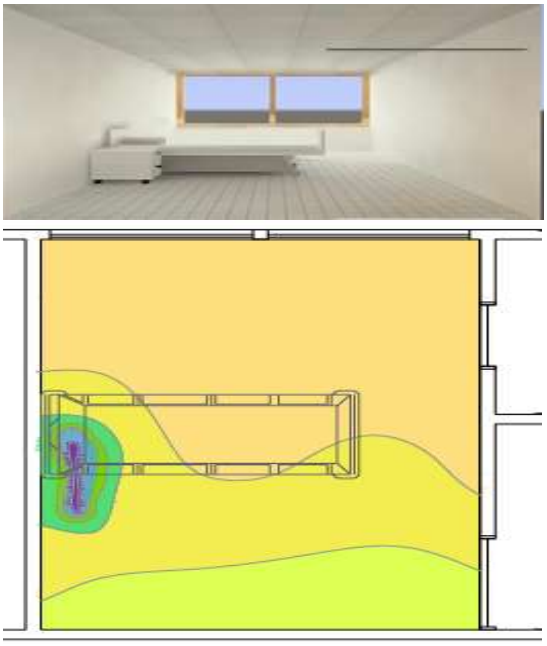


Figure 7. *Light penetrating through a window in the entire wall*

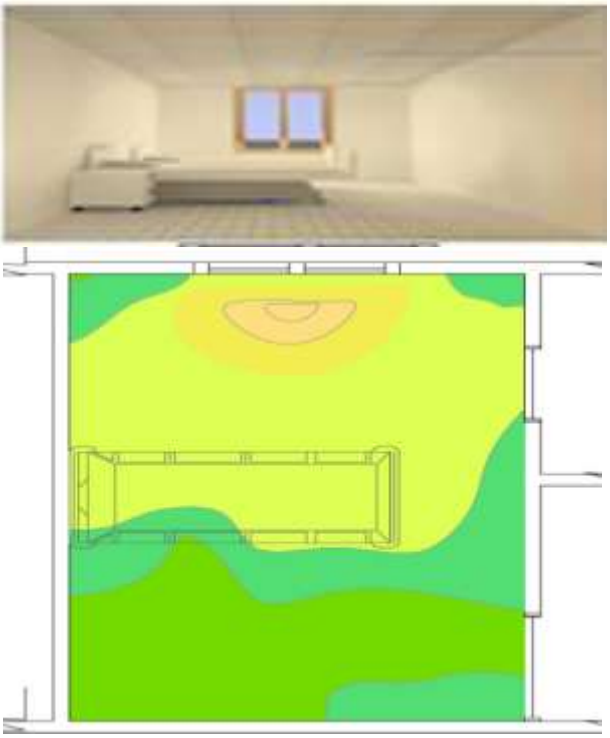


Figure 8. *Light penetrating through a window in the middle of the wall*

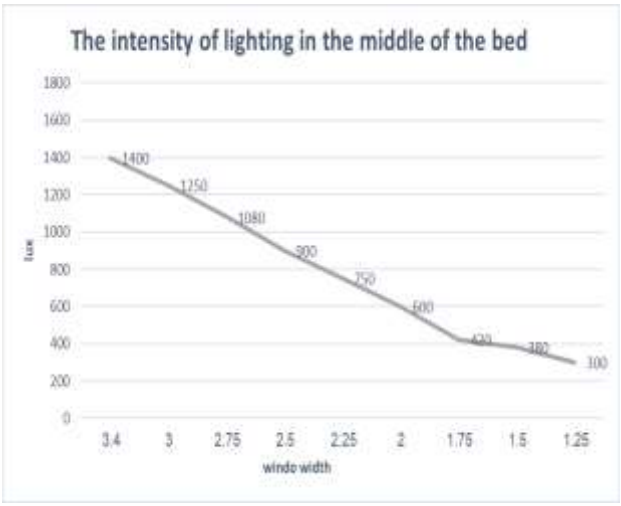


Figure 9. *The values of illumination intensity depending on changing the width of the light window.*

The figure 10, shows the change in lighting intensity at the end of the room depending on the change in window width.

5.6 The preferred location of the approved window to achieve the highest spread of light

First: Place the window on the right of the room with the same dimensions as before: 1.25*2 m. In this case, it shows that the average lighting intensity is very high at the end of the bed, while it

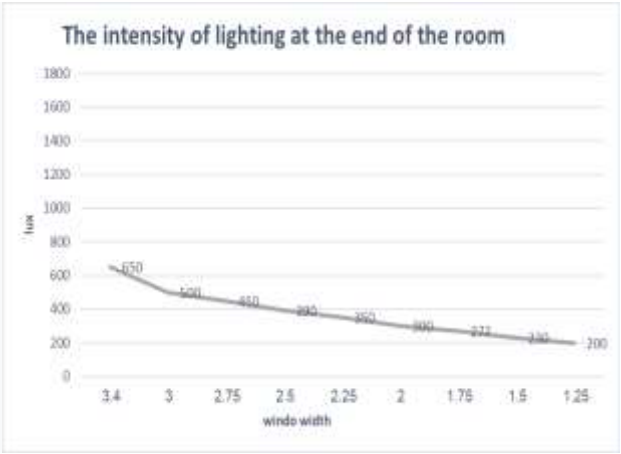


Figure 10. *The values of illumination intensity at the end of the room*

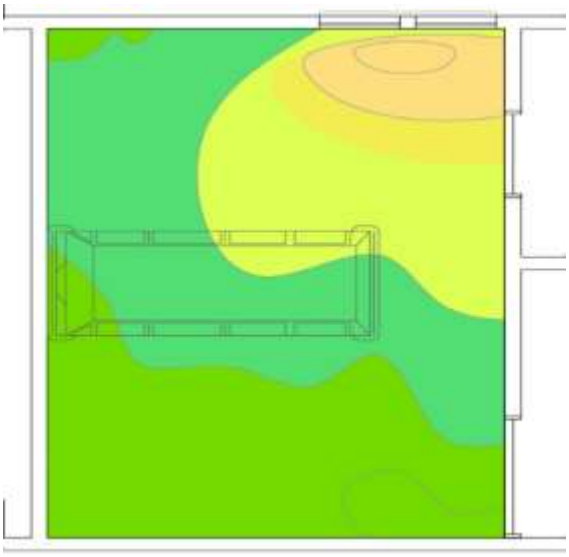


Figure 11. *Light penetrating through a window on the right side of the room*

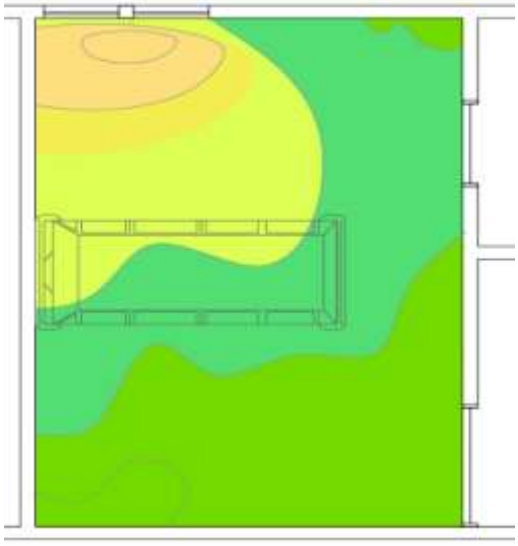


Figure 12. *Light penetrating through a window on the left side of the room*

is homogeneous for the patient's head and the rest of the room. Second: Place the window on the left of the room with the same dimensions as before: 1.25*2 m. In this case, the lighting intensity in the middle of the bed becomes very high, and then it begins to become even and then declines at the end of the room **Third:** Place the window in the middle of the room with the same dimensions as before: 1.25*2 m. In this case, the illumination intensity is highest at the entire bed, and then homogeneous is achieved, starting on the patient's right and then declining at the end of the room. From the previous, the researcher can say that it is preferable to the highest case of homogeneity, and accordingly, the first case is the most one. Figure 11 shows light penetrating through a window on the right side of the room and the figure 12 shows light penetrating through a

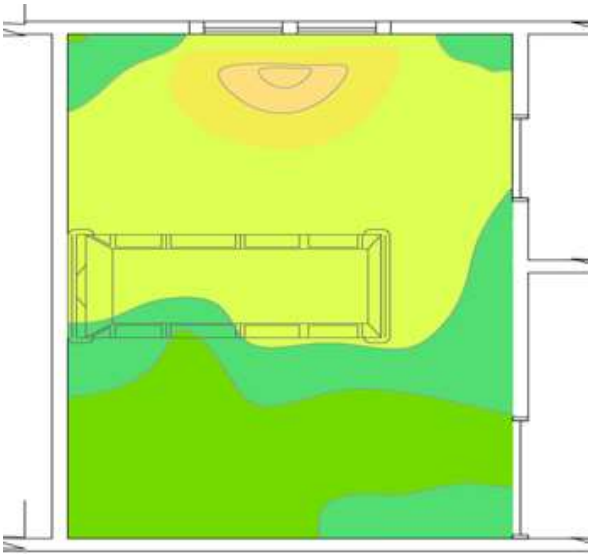


Figure 13. *Light penetrating through a window in the middle of the room*

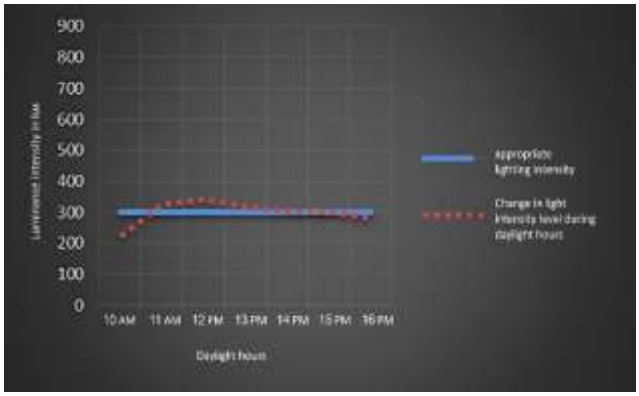


Figure 14*. Lhe spread of light during daylight hours at the researcher's disposal*

window on the left side of the room. The light penetrating through a window in the middle of the room is shown in figure 13. The analysis of the spread of lighting during daylight hours in the first case is shown in figure 14.

5.7 Comments

The location of the bed relative to the room is fixed and not variable. The reason is due to the relationship of the location of the bed to the location of the polluted air intake, which must be higher, completely behind the patient's head. The previous experiments are specific to patient rooms only and not to the hallway separating the isolation room from the hospital corridors. Naturally, the lighting there is artificial, but this problem can be solved by using light transmission tubes.

6. Results and Recommendations.

6.1. Results:

The research paper resulted in a clear, hypothetical concept that can be used during the architectural

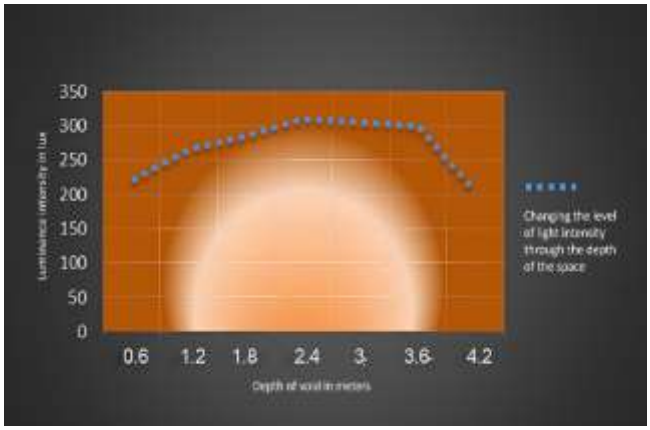


Figure 15. *The spread of light through the depth of the room at the researcher's discretion*

design process for patient isolation rooms. The research paper showed the importance of natural lighting in designing isolation rooms for patients and the extent of its impact on the psychological and physical comfort of patients. Simulation programs have an effective role as they can see real results and detect errors before implementing them. The necessity of starting the design process for natural lighting in the initial stages of design and not at the end. Homogeneity of natural lighting and achieving the required levels in patient isolation rooms play a role in achieving visual comfort for the patient.

Figure 16. *The means of light transmission tubes for internal spaces such as lobbies and corridors*

Patient calm, relaxation, and safety are one of the results of achieving visual comfort. Visual comfort can meet the patient's human needs, such as recognizing signs and revealing ambiguities in space

Homogeneous natural lighting in the patient's isolation room can ensure his safety from the risk of falling. Shading facilities are very important in patient isolation rooms, especially in the summer months. The location and area of the window plays a great role in achieving a homogeneous level of lighting. Unifying colors in patient isolation rooms enables the highest light diffusion rate within the room to be achieved. Through simulation, it was found that the best location for the window is on one side of the room, completely contrary to what is expected and commonly accepted that the window must be in the middle. Means of transmitting natural light are very important in strengthening places where natural light does not reach, such as roads, corridors, and lobbies, to achieve a visually comfortable daytime environment. The efficiency and safety of the internal environment cannot be achieved by losing the required levels of lighting intensity. The quality of the internal environment in patient isolation rooms is only achieved by achieving homogeneous of lighting in the isolation room space There are physiological correlates of the patient related to achieving an appropriate level of lighting intensity

6.2 Recommendations

Simulation programs must be used in the process of designing internal environment requirements to identify errors. The state must completely separate patient isolation rooms from hospitals due to their standards that are not in line with the rest of the hospital spaces. Organizations must pay attention to the standards for isolation room spaces to provide ideal models that meet the requirements that can achieve patient comfort before recovery. The special code is very important for patient isolation rooms that includes the necessary directions and treatments to meet humanitarian needs. Researchers must research and investigate to link human needs to quality of life. Specialists must conduct experiments with simulation programs using colors other than white to clarify the different effects of colors on lighting intensity levels.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest**: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

- **Acknowledgement:** The authors declare that they have nobody or no company to acknowledge.
- **Author contributions:** The authors declare that they have equal rights on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement**: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions

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