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Daylight Integration in Healing and Health care Environment: A Simulation-Based Analysis of Patient Wards

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ABSTRACT:
This study is aimed at simulating a daylight assessment of three typologies of patient wards in a proposed super specialty hospital in Raipur, Chhattisgarh. The paper discusses how the building's orientation, Window-to-Wall Ratio, and shading devices will impact the availability, distribution, and quality of daylight inside healthcare spaces. Perpendicular, horizontal, and vertical illuminance, Daylight Factor, and Unified Glare Rating were evaluated under CIE clear and overcast sky conditions using DIA Lux evo to understand visual comfort and daylight performance.
The paper provides evidence-based insights into the optimization of ward design with improved patient comfort, well-being, and recovery. Based on the simulation results, this paper also discusses various architectural strategies of daylight integration into built structures and highlights some practical ways of enhancing natural light in healthcare environments.
Notably, daylight is viewed in the study as an essential ingredient of therapeutic architecture, which plays a major role in regulating circadian rhythms, reducing stress, and improving mood while reducing the use and dependency on artificial lighting. Overall, the research positions daylight as a powerful design tool capable of transforming health care spaces into healthier, more restorative settings. [1], [7]

Keywords: Integrating daylight, healthcare spaces, wellbeing, circadian rhythms, dialux

1. INTRODUCTION:

Architecture today is not about just efficient construction; it is about designing an environment that will actively support human health and well-being. Living in today's fast-paced world means stress, anxiety, sleep disturbances, and other lifestyle diseases have increased steadily. This is partly because people today tend to stay indoors most of the time and often in poorly lit environments dominated by artificial lighting. In this context, the quality of the built environment, especially access to natural daylight, has become increasingly important. [2]
Daylight is a natural, renewable, and cost-free resource with well-documented physiological and psychological benefits. It modulates circadian rhythms, improves sleep, reduces stress, enhances mood, and accelerates healing. In the field of therapeutic architecture—especially in hospitals—daylight functions not just as a visual or functional design element but as an active healing component. [1], [7]

However, a large number of healthcare buildings in India continue to depend heavily on artificial lighting. This perpetuates increased energy use and deprives the patients and staff of the therapeutic benefit from natural light.
Surveys show that more than 80% of the patients prefer naturally lit spaces and that 90% of the healthcare staff believe daylight improves alertness, comfort, and their ability to monitor patients.
This study investigates how daylight can be integrated into healthcare spaces, presenting it as a simple, non-medical, and highly effective tool to enhance healing, patient comfort in today's health-challenged world.

2. LITERATURE STUDY

2.1 UNDERSTANDING DAYLIGHT

Daylighting describes the controlled use of natural light in and around buildings. It is the practice of placing windows, or other transparent media and reflective surfaces so that natural light provides effective internal illumination during the day. Daylight in buildings is composed of a mix of

- DIRECT SUNLIGHT is characterised by very high intensity and constant movement. The illuminance produced on the surface of the earth may exceed 100 000 lux.
- SKYLIGHT is characterised by sunlight scattered by the atmosphere and clouds, resulting in soft, diffuse light.
- REFLECTED LIGHT is characterised by light (sunlight and skylight) that is reflected from the ground: terrain, trees, vegetation, neighbouring buildings etc.

2.1.1 Importance of daylight

Natural light is essential for life, providing visibility for daily activities and supporting plant growth, a major food source. It also influences human perception, cognition, and psychological comfort; as Corradi notes, our assessment of lighting is always compared to experiences in daylight (Corradi, Spechtenhauser, & Auer, 2014, p. 31). Biologically, daylight regulates the circadian rhythm by stimulating hormone production, affecting alertness and sleep patterns (Veitch & Ark Kelin, 1995, pp. 162–168). Lack of daylight can lead to physiological and psychological issues, such as depression, exemplified by Seasonal Affective Disorder in Nordic countries. Thus, daylight is crucial not only for physical health but also for mental well-being. [4]

2.1.2 Daylight physiology and psychology

Daylight plays a crucial role in inspiring, energizing, and positively influencing both the body and mind. However, modern lifestyles confine most people indoors for over 90% of their time, where they are exposed to artificial lighting of only 300–500 lux—far below the natural daylight levels of up to 100,000 lux. This significant light deficit leads to various health and psychological problems. Artificial lighting systems are often designed merely to support visual tasks, neglecting the emotional and biological needs of individuals. As a result, people working under artificial light experience reduced emotional engagement and creativity. Studies have shown that artificial light sources, such as 3500 lux floor lamps, increase the stress hormone adrenaline, while exposure to natural daylight helps normalize these levels. Since the 1980s, research has established a strong connection between insufficient natural light and depression, which often manifests as lethargy, melancholy, anxiety, and loss of motivation. Light directly influences neuro-hormones like serotonin—produced in the hypothalamus—which regulates mood, sleep, metabolism, and overall well-being. [4]

2.2 DAYLIGHT AND HUMAN HEALTH

Integrating natural daylight into healthcare facilities brings numerous benefits, including improved brightness, reduced heating costs, and enhanced well-being for patients and staff. Patients prefer environments where they can maintain visual contact with medical professionals, aided by clear signage and effective navigation to reduce anxiety. Access to outdoor views is crucial for patients' physical and psychological health, aiding in the recovery process. Research shows that exposure to natural light indoors can reduce stress, shorten post-operative stays, and alleviate pain. However, excessive exposure to artificial light can lead to various psychological and physical issues. (Husein Ali Husein, 2020) [2]

2.2.1 Daylight and mental health

Natural daylight is much more than just a source of illumination; it profoundly affects human health, mood, and overall well-being. Exposure to natural light helps regulate our body's internal clock, boosts energy and alertness, improves sleep quality, and has been shown to support recovery in healthcare environments. In designing spaces intended for healing or wellness, building orientation plays a crucial role Windows and skylights are essential elements in harnessing daylight; they bring in natural light, provide visual connection to nature, and reduce dependence on artificial lighting. [5]

2.3 DAYLIGHT AND THERAPEUTIC ARCHITECTURE

Daylight plays a crucial role in therapeutic architecture by influencing both physical recovery and psychological well-being of patients. Hospitals and healthcare environments that are designed to maximize access to natural light have been shown to improve recovery rates, reduce stress, and enhance mood (Ulrich, 1984; Beauchemin & Hays, 1996). Windows with views of nature—gardens, trees, or landscapes—can accelerate healing, reduce the need for medication, and create a positive emotional environment. [1], [7]

Therapeutic architecture leverages daylight as a design element to create spaces that are not only functional but also restorative.

Daylight also affects mental health. Benedetti et al. (2001) discovered that bipolar patients in east-facing rooms receiving morning sunlight had hospital stays nearly four days shorter than those in west-facing rooms.

Beyond hospitals, daylight enhances overall well-being by influencing hormone production. Natural light regulates serotonin, cortisol, and melatonin, which control mood, stress, and sleep cycles. Research also shows that workplaces and schools with abundant daylight reduce stress and boost performance. Thus, daylight is not just a visual comfort—it functions like fresh air, vital for physical recovery and psychological health.

2.3.1 Recovery rate comparison

Several studies have shown that the presence of windows and access to natural views can significantly improve recovery rates in patients. Ulrich's well-known study (1984) demonstrated that post-surgical patients in hospital rooms with windows facing natural scenery recovered faster, required fewer strong painkillers, and received more positive evaluations from nurses compared to those in windowless rooms or rooms facing a brick wall. Similarly, Beauchemin and Hays (1996) observed that patients suffering from depression recovered more quickly in sunny rooms than in dimly lit ones. These findings suggest that windows not only provide visual comfort but also directly influence healing processes, leading to shorter hospital stays and better patient outcomes. [12]

2.4 DAYLIGHT AND HEAT GAIN

ll light, whether natural or artificial, is a form of radiant energy that ultimately converts into heat within a space. During winter, this heat contributes positively by helping to warm interiors, but in summer it becomes undesirable and must be carefully controlled to maintain thermal comfort. Effective daylighting design therefore seeks to maximize the collection of daylight during winter while admitting only the amount necessary in summer to reduce reliance on artificial lighting. Because skylight illumination has

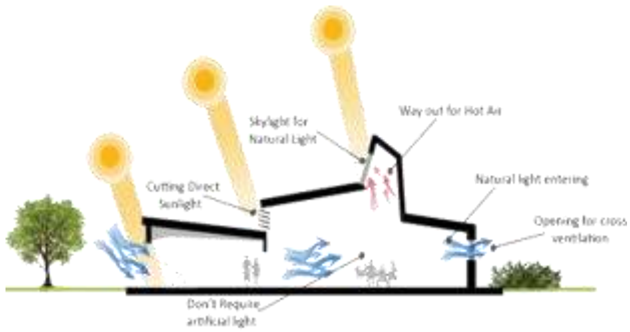

FIGURE 1: DAYLIGHT INTEGRATION

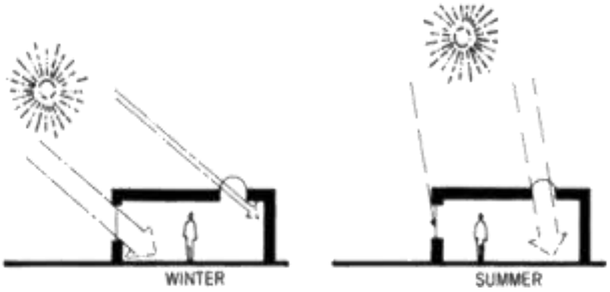

FIGURE 2: SUMMER AND WINTER SUN

the highest light-to-heat ratio, it provides balanced illumination but can also lead to overheating, as skylights receive significantly more solar radiation in summer than in winter. In contrast, south-facing vertical glazing performs more efficiently, capturing greater solar gains during winter and admitting less direct radiation in summer due to the sun's higher altitude. The concept of "light without heat" refers to the strategic use of daylight to achieve optimal illumination and passive solar warming in winter, while minimizing excessive heat gain and glare in summer through appropriate orientation, glazing selection, and shading device design. [3], [5]

2.4.1 Overcoming heat gain

Overcoming heat gain and heating challenges in daylighting requires an integrated design approach that combines strategic architectural planning with advanced materials and intelligent control systems to ensure a balance between natural light and thermal comfort. Effective architectural strategies include the use of well-designed shading devices, such as external overhangs and awnings that block high-angle summer sun while allowing low-angle winter sunlight to enter, as well as vertical fins or screens that protect east–west façades from low-angle glare. Vegetation, particularly deciduous trees and seasonal vines, can also provide natural shading by obstructing solar heat in summer and permitting sunlight penetration during winter. Window design plays a critical role in managing heat gain; maintaining a window-to-wall ratio of approximately 30–40 percent, incorporating clerestory or high-level windows, and optimizing window placement help improve daylight penetration while reducing glare and thermal load. Thermal mass materials such as concrete or brick further support temperature regulation by absorbing excess heat during the day and releasing it gradually at night. Advanced technologies complement these passive strategies through the use of high-performance glazing systems, including low-emissivity coatings, spectrally selective glass, and double or triple glazing, which significantly reduce solar heat gain while maintaining high daylight transmittance. Dynamic smart shading systems and daylight-redirection devices enhance performance by adjusting to real-time conditions, ensuring optimal daylight use while preventing overheating. Together, these integrated strategies enable buildings to harness daylight effectively while maintaining comfortable indoor environments throughout the year. [3], [5]

2.5 PARAMETER AFFECTING DAYLIGHT IN BUILDING

Daylighting design is shaped primarily by climate, which influences sun availability, sky conditions, cloud cover, and seasonal variations that affect both the thermal and visual comfort of indoor environments. [3]
Latitude further determines the sun's height and daylight duration throughout the year, with higher latitudes experiencing greater variation between bright, high-angle summer sun and dim, low-angle winter sunlight; this makes careful planning of window orientation and shading essential.
Site conditions such as surrounding buildings, vegetation, and ground surfaces also play a major role by either obstructing or reflecting daylight into interior spaces, while roof openings and skylights typically receive more unobstructed sky exposure. [5]
Orientation strongly impacts daylight quality: north-facing glazing provides soft, uniform light, while south-facing windows admit useful winter sun; in contrast, east and west façades often cause glare and overheating
Glazing design must consider size and transmittance, as larger windows increase daylight but also heat gain, and additional glazing layers reduce light transmission.
Roof-based systems like skylights provide abundant top lighting but may cause overheating, making clerestories, monitors, or sawtooth roofs preferable for controlled illumination. [5]
Building form influences daylight penetration, which typically reaches only 4–5 meters from openings, making atriums effective for lighting deeper spaces. [5]
light-coloured surfaces with high reflectance—especially ceilings—enhance daylight distribution, while darker floors and furnishings help control glare.

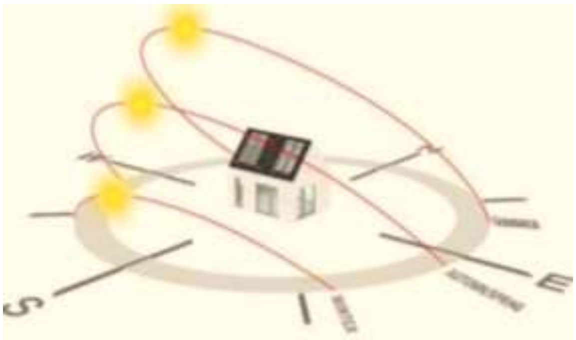

FIGURE 3. ORIENTATION OF BUILDING

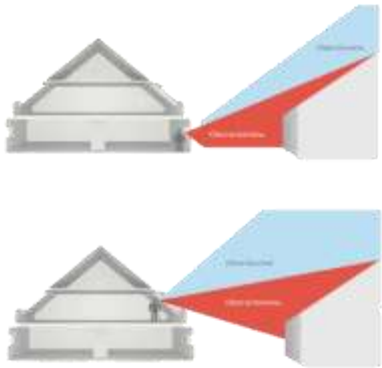

FIGURE 4. OBSTRUCTION ON SITE

2.6 DAYLIGHT DESIGN PARAMETERS

2.6.1 Existing Daylighting Design Metrics [3]

One of the biggest challenges facing daylighting design is the lack of availability of an appropriate, universally accepted daylighting metric. This is primarily because different stakeholders prioritize different aspects of daylighting, ranging from energy savings to architectural visual performance to cost efficiency.

Daylight factor: It is defined as the ratio of indoor daylight illuminance at a point on a horizontal plane to simultaneous external illuminance on an unobstructed plane under overcast sky conditions This metric was very easy to use and, therefore, had gained widespread popularity; however, it only accounts for overcast sky conditions as the "worst case scenario" and does not measure lighting in partially cloudy or clear sky conditions, making it a poor metric for the generalization of daylighting under other sky conditions.

Daylight Autonomy (DA): DA gives a measure of the percentage of time during which the daylight illuminance levels meet or exceed a previously set threshold usually based on task requirements. It uses work plane illuminance (the light level at the horizontal work surface) as the evaluation criteria to determine if there are sufficient light levels for a particular task under daylighting alone

Useful Daylight Illuminance (UDI): UDI is similar to DA but improves upon it by adding an upper limit that excludes glare conditions to account for visual comfort. It essentially evaluates the percentage of occupied times in a year when the lighting falls within the range of neither too dark (usually less than 100 lux) nor too bright (more than 2000 lux)

Continuous Daylight Autonomy (CDA): CDA is another approach similar to DA which provides partial credit for task lighting using daylight alone which falls below the lighting threshold for the task. The partial credit is calculated as the ratio of the daylight level to the required threshold.

Spatial Daylight Autonomy (SDA): SDA adds a spatial element to the quantification of DA. It is "an annual daylighting metric that quantifies the fraction of the area within a space for which Daylight Autonomy exceeds a specified value"

Annual Sunlight Exposure (ASE): To account for the glare potential of daylighting, IES has recommended the use of ASE, which gives the percentage of interior space that receives at least 1000 lux for at least 250 annual occupied hours

While these metrics are a good starting point for measuring daylighting, they focus only on illuminance levels and generally account for visual tasks and the energy-saving potential of daylighting. They are also oriented towards task lighting, which is typically lighting on the horizontal work surface. Lighting for the regulation of the circadian rhythm needs to be measured on the vertical surface in front of the viewer's eyes and can often have very different illuminance values

2.6.2 Daylight through structures [5]

Skylights and roof lanterns: Skylights are glazed openings in the roof that let natural light into interior spaces. They are popular in both residential and commercial buildings for their efficiency in daylight delivery

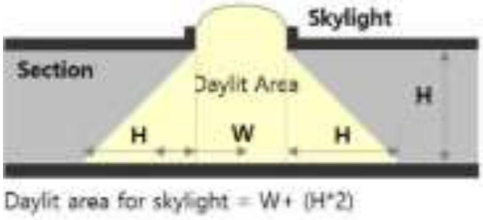

FIGURE 5: SKYLIGHT SECTION

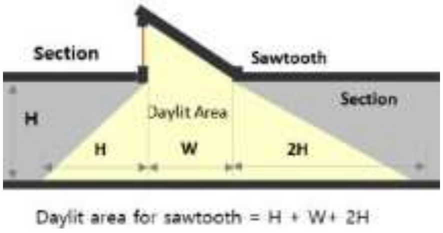

FIGURE 6: SAWTOOTH ROOF SECTION

Sawtooth roofs: They are designed to capture diffused daylight while reducing harsh direct solar gain. The opaque, insulated angled sections limit unwanted heat transfer while allowing natural light.

Atriums: An atrium is a large open space in a building, usually lit by a glass roof or walls. Atriums offer daylight to central circulation and public spaces while creating visual links to the outdoors

Light reaching lower floors depends on reflections from surfaces. Light-coloured walls and reflective materials help distribute light better. Upper floors need less window area because they receive more direct sunlight, while lower floors depend on light that is reflected.

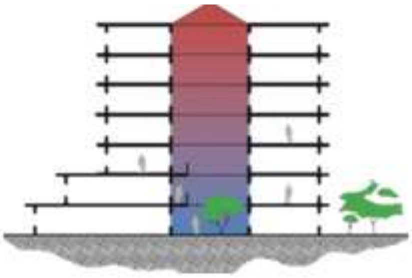

FIGURE 7: ATRIUM

FIGURE 8: PERFORATION AND SCREENS

Perforation and solar screen: Perforations, like solar screens or patterned façades, let daylight in while managing glare and solar heat gain. Solar screens have been used in traditional buildings to maximize natural light without causing discomfort from heat.

Well-designed perforations provide balanced daylight, enhancing visual comfort while reducing unwanted direct sunlight.

Clerestory windows are high vertical windows, often located near the roofline. They are designed to improve daylight entry.

Direct solar gain: When they face the equator, these windows can increase natural light and provide passive solar heating.
Glare management: Direct sunlight can create glare, so proper positioning and shading are important.
Indirect lighting: Clerestory windows often light up light-coloured interior walls, which reflect daylight further into the space.
Diffuse lighting: This method softens light, reduces shadows, and gives even illumination in interior areas.
Light well: A lightwell, or air shaft, is an open vertical space inside a building. It allows natural light and ventilation to reach areas that would otherwise stay dark or poorly ventilated.
Design features: Lightwells may have glazed walls or bricks to improve daylight reflection, vertical glass panels, steel frames, or open shafts for plants.

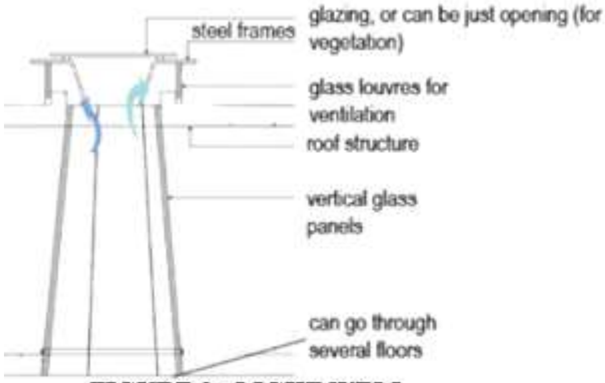

FIGURE 9: LIGHT WELL


FIGURE10: LIGHT TUBE

light tubes: Light tubes, also called tubular daylighting devices (TDDs), are mounted on roofs to direct natural light into specific areas inside buildings.
Design and construction: Light tubes look like recessed ceiling fixtures. The tube itself is a passive part, often with a highly reflective inner coating or a light-conducting fibre optic bundle to carry daylight effectively.
Fibre optics: A fibre optic concrete wall makes a solid concrete wall translucent by embedding optical fibre cables within it.
Function: It allows natural daylight and even shadow images to pass through thick concrete walls. It also provides daylight in spaces where traditional windows cannot be used.
Light shelves: Light shelves are horizontal reflective surfaces meant to improve daylight entry from windows, especially on walls facing the equator.
Design: A reflective shelf is mounted outside or inside the window. It is often paired with a projecting eave to block direct summer sun. Sunlight reflects off the shelf onto the ceiling. This action reduces deep shadows and the need for artificial lighting.

FIGURE 11: FIBRE OPTICS

FIGURE 12: LIGHT SHELVES

2.7 INFERENCES

This research shows that daylight is more than just light. It significantly impacts health, comfort, and the quality of a building, especially in healthcare settings. We look at how different types of daylight act indoors and how people perceive and experience these effects. Studies on human sleep, physiology, and psychology clearly indicate that natural daylight helps regulate sleep cycles, improve mood, reduce stress, and even prevent depression. The research outlines that effective daylight design must balance light and heat. Too much sunlight can cause overheating or glare. Therefore, factors like building orientation, shading, glazing, colors, and materials are crucial during the design phase. We also examined various daylighting tools, including skylights, atriums, light shelves, clerestories, light wells, fiber optics, and solar tubes. Each tool has its own strengths, which can be selected based on a building's needs. Light metrics such as daylight factor (DF), daylight autonomy (DA), useful daylight illuminance (UDI), and spatial daylight autonomy (SDA) help designers measure the amount of light a building allows indoors. These metrics also help ensure comfortable light levels throughout the year. The insights gained from this research can guide future building projects for both researchers and designers. This will help create new environments that encourage healing, improve well-being, and enhance the overall experience for everyone who uses them.

3. COMPUTER STIMULATION USING DIALUX:

This daylight assessment through simulation is performed for three patient wards in a proposed hospital in Raipur, Chhattisgarh. It seeks to understand the impact of orientation, WWR, and shading elements on the availability and distribution of daylight within the patient spaces.

This research has highlighted that daylight is one of the most important environmental factors in healthcare design, enhancing patient recovery, visual comfort, and overall well-being. In many hospitals, however, inappropriate orientation or poorly sized windows are restricting daylight penetration, hence increasing their dependency on artificial lighting.

This simulation, using Dialux Evo, presents the assessment and comparison of daylight performance for three wards under CIE clear sky conditions. The study investigates horizontal, vertical, and perpendicular illuminance, along with the daylight factor, to find out which orientation supports healthier lighting conditions.

Findings from this research provide evidence-based insights into how ward orientation, window design, and shading strategies can be optimized to create a comfortable, energy-efficient, and daylight-responsive healthcare setting.

3.1 DESCRIPTIVE ANALYSIS

The Venkatesh Medi serve hospital is located in Kamal Vihar Raipur Chhattisgarh. The hospital comprises a 5-story building with a total area of 108381 sqft. The second floor of hospital comprises three wards oriented in different direction with different floor area and wall window ratios. the ward 1 is oriented towards southeast ward2 southwest and ward3 to northwest Additionally, opening characteristics vary inside wards and differences in window dimensions impact daylight entry and distribution.

- Seasons Simulated: 12 JUNE 2025, 12 DECEMBER 2025
- Time Range: 12:00 PM (UTC+5:30)
- Weather Conditions: Clear and overcast skies.
- Eye Level: 1.2 m above the floor (seated patient perspective) and 0.8 m above floor (Most human activity surfaces (beds, desks, trolleys, tables)
- Clearance height: 3.1 m
- Utilisation: healthcare premises (wards, patients room) general lighting 4.1

FIGURE 13: PLAN LAYOUT OF WARDS

FIGURE 14: SITEPLAN OF VENKATESH MEDISERVE HOSPITAL

3.2 METHODOLOGY

The daylight simulation for the three hospital wards was carried out in DIA Lux using a consistent and systematic methodology. First, architectural drawings were collected, and the exact dimensions, window sizes, WWR values, and shading elements for the southeast (15% WWR), southwest (7% WWR), and northwest (5% WWR) wards were documented. These layouts were then modelled in 3D within DIA Lux, ensuring accurate placement of walls, ceilings, floors, and window openings. Material properties were assigned using standard reflectance values suitable for healthcare interiors, such as high-reflective ceilings (70–85%), medium-reflective walls (50–60%), and low-reflective floors (20–30%). The location was set to Raipur, and a CIE Standard Overcast Sky was selected to maintain uniform assessment conditions. Calculation settings were configured to include perpendicular, horizontal, and vertical illuminance, daylight factor, and glare (UGR) at a working plane height of 0.85 m. Simulations were run separately for each ward under identical parameters to ensure fair comparison. The resulting false-colour daylight maps and numerical outputs were exported and examined to assess daylight penetration, distribution, and comfort. Finally, the three wards were compared based on illuminance values, daylight factor, and glare, allowing conclusions to be drawn about which orientation performs best and what design improvements are required

ROOM TYPE	ORIENTATION	WWR	FLOORAREA
Ward 1	southeast	15%	299 sqm
Ward2	southwest	7%	416 sqm
Ward3	northwest	5%	347 sqm

TABLE1: ROOM PROTOYPE

3.3 ANALYSIS

3.3.1 WARD 1

The south-east facing ward with a 15% WWR exhibits a mixed daylight performance, considering the average values for both seasons. While useful early-morning sunlight, which can support patient comfort and circadian rhythm alignment, is received, the general daylight factor remains at an undesirably low value of ≈0.88%, indicating that daylight does not deeply penetrate into the room. At the same time, vertical illuminance levels ≈657 lux are relatively high near the window zone, predicting discomfort or glare during morning hours. Horizontal illuminance ≈234 lux is moderate and more balanced; however, this uneven distribution also points toward the necessity for design adjustments. Even with a 15% WWR, the ward still depends partly on artificial lighting throughout the day, and controlled shading or light-diffusing elements would be required to reduce high vertical brightness.

PARAMETERS	21 JUNE 2025	21 DECEMBER 2025	SEASONAL AVERAGE
Horizontal illuminance	163 lux	306 lux	234 lux
Vertical illuminance	139 lux	1175 lux	657 lux
Unified glare	<10	<10	<10
Daylight factor (overcast)	0.88%	0.88%	0.88%

TABLE 2: SIMULATION RESULTS FOR

FIGURE 15: DAYLIGHT RENDER FOR WARD 1

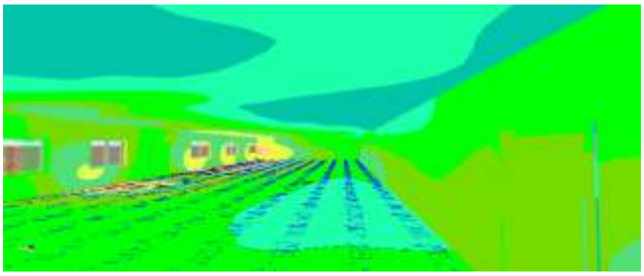

FIGURE 16: FALSE COLOUR MAP OF 21 JUNE 2025

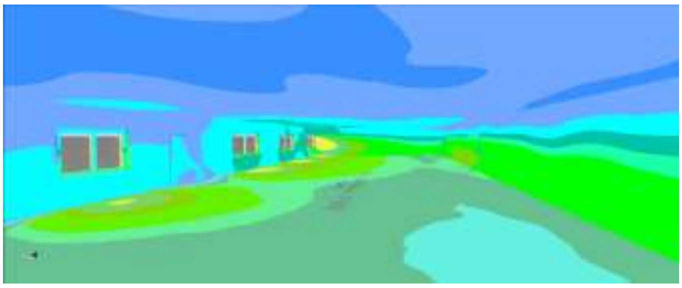

FIGURE 17: FALSE COLOUR MAP OF 21 DECEMBER 2025

3.3.2 WARD 2

The south-west ward, with a 7% WWR, gets strong afternoon sun, yet overall daylight performance is poor due to the small window area. The average horizontal illuminance of 207 lux is moderate, but the vertical illuminance remains rather low, at about 38.5 lux, leaving the rear part of the ward dark throughout the day. The daylight factor is very low at 0.5%, indicating weak daylight penetration and high dependency on artificial lighting. Although glare remains well-controlled (UGR <10), the small window size confines useful daylight while still allowing some heat gain from south-west sun to occur in the window zone. Increasing the WWR and providing proper external shading would help distribute daylight better while controlling the harsh afternoon light.

PARAMETERS	21 JUNE 2025	21 DECEMBER2025	SEASONAL AVERAGE
Horizontal illuminance	137 lux	278 lux	207.5 lux
Vertical illuminance	23.3 lux	54.5 lux	38.5 lux
Unified glare	<10	<10	<10
Daylight factor (overcast)	0.5%	0.5%	0.5%

TABLE 3: SIMULATION RESULTS FOR WARD 2

FIGURE 18: DAYLIGHT RENDER FOR WARD 2

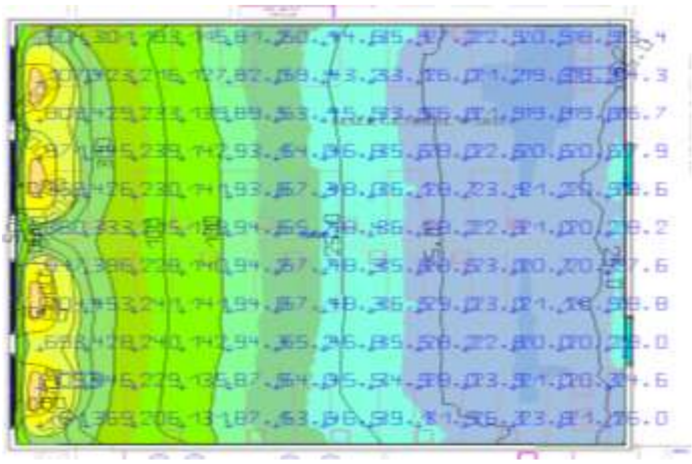

FIGURE 19: FALSE COLOUR MAP FOR 21 JUNE 2025

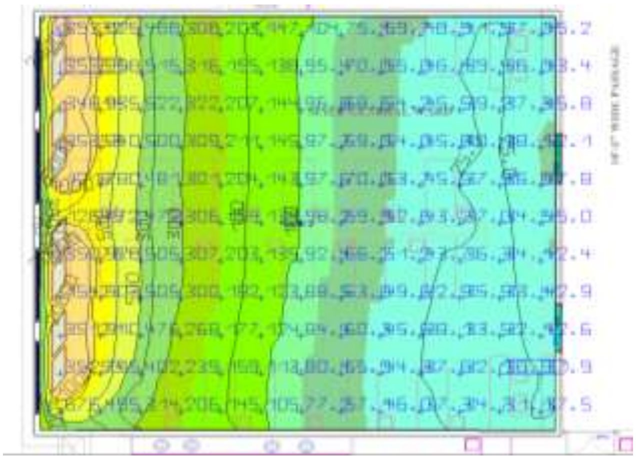

FIGURE 20: FALSE COLOUR MAP FOR 21 DECEMBER 2025

3.3.3 WARD 3

Since the north-west ward with a 5% WWR receives only late-afternoon sun, it gets very limited light. Overall daylight inside is thus extremely weak. Though the area near the window reaches higher brightness due to the angle of afternoon sun, the average horizontal illuminance rises only to 86.9 lux and the vertical illuminance is just 55.15 lux, thus both recording unsatisfactory daylight spread within the room. A daylight factor of 0.3% confirms extremely low daylight penetration, partly because of the small window size and the orientation. A higher WWR would be required in the ward, but with proper shading of the sharper late-afternoon light for acceptable daylight performance.

PARAMETERS	21 JUNE 2025	21 DECEMBER 2025	SEASONAL AVERAGE
Horizontal illuminance	71.8 lux	102 lux	86.9 lux
Vertical illuminance	51.2 lux	59.1 lux	55.15 lux
Unified glare	<10	<10	<10
Daylight factor (overcast skies)	0.3%	0.3%	0.3%

TABLE 4: SIMULATION RESULTS FOR WARD 3

FIGURE 21: 3D DAYLIGHT RENDERING OF WARD 3

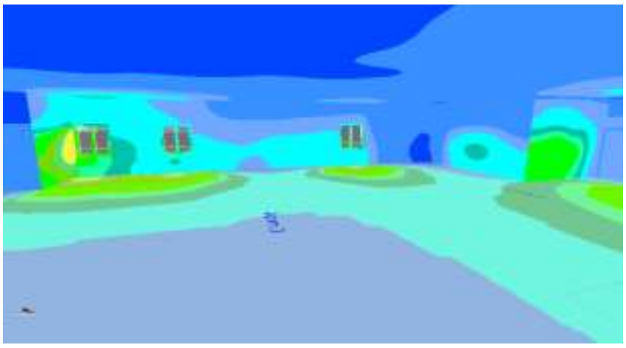

FIGURE 22: FALSE COLOUR MAP FOR 21 JUNE 2025

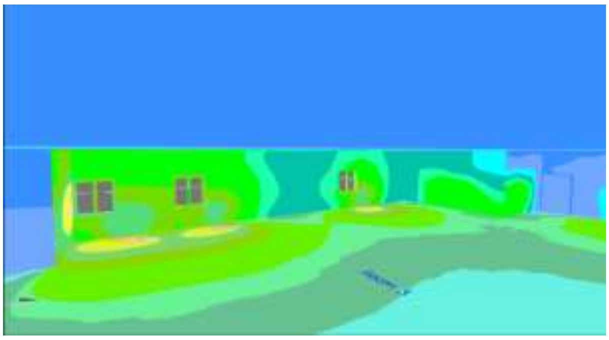

FIGURE 23: FALSE COLOUR MAP FOR 21 DECEMBER 2025

the simulations clearly showed that higher WWR have higher daylight, but only when shading is minimal and low WWR (5% in ward 3) significantly limited daylight, proving inadequate for healthcare spaces where therapeutic daylight plays an important role.also,a key observation was that some wards showed high perpendicular illuminance but low horizontal illuminance, it means direct sunlight was hitting the window surface, but the interior was not receiving evenly distributed daylight. this is particularly visible in ward 2, where strong sunlight produced higher readings on the window plane but uneven distribution across the ward space

3.6 RESULTS:

Best daylight performance: The South-East ward gives the most balanced and comfortable daylighting with the least glare risk. It supports circadian rhythm and visual comfort due to its gentle morning sunlight.

Most problematic daylight distribution: The South-West ward experiences uneven daylight—strong sun on window zones and dark interiors. This causes visual imbalance and increases cooling loads.
Least recommended orientation: The North-West ward fails to meet basic daylight criteria. Its low WWR and poor orientation prevent daylight from reaching patient areas.
Design implications:

- SE orientation works well with controlled shading.
- SW and NW orientations require higher WWR + shading devices such as louvers, fins or overhangs.
- Increasing DF above 2% is desirable for wards to improve patient comfort and reduce energy load.
- Vertical illuminance should be improved for better circadian health, which is lacking in the SW and NW wards.

3.7 CONCLUSION:

The simulation concludes that South-East orientation with a higher WWR provides the most effective daylighting for hospital wards in Raipur, achieving good illuminance levels, a higher daylight factor, and better internal light distribution.
The South-West ward, although receiving strong sunlight, requires design improvements—particularly increased glazing area and shading—to avoid dependency on artificial lighting and to control afternoon heat gain.
The North-West ward performs the weakest and is the least suitable for patient areas without major design interventions such as enlarged windows or advanced daylight-redirecting systems.
In summary, South-East orientation is recommended for healthcare wards, while South-West and North-West orientations must be carefully redesigned to meet minimum daylight standards. Current design at Venkatesh Medi serve Hospital is suboptimal, with most areas receiving insufficient daylight.
Orientation, WWR, glazing, and shading are key for patient-centered, energy-efficient, and therapeutic hospital environments.

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