JOURNAL FOR UNDERGRADUATE RESEARCH

Centre For Undergraduate Research
University of Abuja
Vol.1, No 2, Dec, 2023
ISSN: 1115-7534
Published by Centre for Undergraduate Research

Exploring the Effectiveness of Natural Lighting on the Spatial Configuration of Selected Health Centers towards Enhancing Optimal Hospital Occupants' Productivity

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Abstract

The paper attempted to assess the effectiveness of applications of natural lighting with respect to the architectural documented spatial configuration of selected health centers. The raw data of the variables gathered though case study method and observation schedule (checklist) in the wards was analyzed with the use of descriptive analytical tools.

The results show, among others, that the application of natural lighting, reflectivity/transmission of light which are more effective heat protection technique were totally at the lowest level of consideration in case study one, while skylight was substantially applied in case study two. In essence, the most potent natural lighting measures and some advanced natural lighting strategies that are quite effective at achieving productivity in buildings were noted to be absent in Lagos state general hospital Nigeria, where the least effective were seen in some instances. The study recommends that natural lighting both transparent and opaque surfaces of the building envelope will maximize the amount of solar penetration that induces natural lighting in both indoor spaces and building's structure. Architects must focus on natural light intake to enhance the productivity of staff and recovery of patients.

Keywords: Natural Lighting, Spatial Configuration, Hospital Occupants' Productivity & Health Centers

INTRODUCTION

Science has evolved and so many cures are invented but medical staff still reports more dissatisfaction in their work environments nowadays, patients are also not satisfied with the healthcare delivery they get. Traditionally, hospitals have been places where attention was primarily focused on the efficiency of medical care and hygiene. By studying human needs and reflecting on them, one may develop solutions to solve many of the existing problems in health care and one of the problems is poor lighting condition and the kind of environment where such health centers are located.

The purpose of this study is to explore how architecture can be an active part of the healing process, primarily through emphasizing solar penetration of health care environments and assessing the exploration of natural lighting to enhance productivity of patient in health care center. This study contributes towards a better quality of life within the healing environment, by exploring how natural light can be integrated within built form to create a healing environment.

The argument that natural light is to be efficiently incorporated into lighting design in healthcare settings is not only because it benefits patients and staff, but also this type of light is delivered at no cost and it is in a form that prefer generally for all people. Several studies have shown the importance of light in decreasing depression, reducing fatigue, improving alertness, modulating circadian rhythms, and treating conditions such as hyperbilirubinemia among infants (Nehzat. et. al 2011).

The meaning of well-being is hard to define and often misunderstood. Well-being is frequently seen rather narrowly, though it is essentially a holistic concept that includes physical, mental, social, and economic well-being. In this project, the exploration of the impact that elements of nature such as natural light has on patient's wellbeing and staff productivity, will be evaluated and adequately applied in this study

Lighting has become a major issue which its insufficiency tends to decrease well-being of patient in most health centers (Nehzat et. al 2011). Few health centers building have a workflow system in place that can be improved in some ways when properly studied, but most lack adequate lighting system and thus have become a fast-rising issue that needs to be checked and well managed. (Nehzat et. al 2011).

The current investigation assesses the exploration of natural lighting to enhance well-being of patient in health care centers, this study will try to answer the following questions: How does exposure to natural lighting affect patient recovery? How will exposure to natural lighting impact the wellbeing of patients? How does 'one-day' patients' be made part of a more integrated and wholesome experience?

1.1 Literature Review

This section provides an overview of the theories and concepts upon which the study is produced. It also provides a review of the literature on natural daylighting strategies in Hospital Building Design. Natural daylighting strategies play a crucial role in hospital building design, influencing various aspects of patient well-being, staff productivity, energy efficiency, and overall environmental sustainability. This theoretical and conceptual literature review explores the importance of incorporating natural daylighting strategies in hospital architecture

In their study, Veitch and McColl (2001) emphasize the significant impact of daylighting on patient comfort, recovery rates, and overall satisfaction with the healthcare environment. Similarly, Ulrich et al. (2008) highlight the positive effects of natural light exposure on reducing stress levels, enhancing mood, and promoting healing among patients in hospital settings.

According to Gauthier et al. (2015), effective daylighting design in hospitals involves careful consideration of building orientation, window placement, glazing properties, and shading devices to optimize natural light penetration while minimizing glare and solar heat gain. The integration of light shelves, skylights, and light tubes can further enhance daylight distribution within hospital interiors, as suggested by Mahdavinejad et al. (2018).

Research by Rashid et al. (2019) underscores the association between access to natural daylight and improved circadian rhythms, sleep quality, and recovery outcomes for hospitalized patients. Furthermore, studies by Boyce et al. (2012) and Hadi et al. (2016) highlight the positive impact of daylighting on reducing the risk of hospital-acquired infections through enhanced ventilation and microbial control.

Theoretical frameworks proposed by Zimring et al. (2013) and Schweitzer et al. (2014) elucidate the link between natural daylight exposure and staff well-being, cognitive function, and job satisfaction in healthcare settings. By providing ample daylighting in work areas, hospitals can improve staff alertness, concentration, and performance, ultimately leading to better patient care outcomes.

According to Ochoa and Capeluto (2011), incorporating daylighting strategies in hospital design not only reduces reliance on artificial lighting but also contributes to energy savings and environmental sustainability. Daylight harvesting systems, as discussed by Andersen et al. (2017), can further optimize energy performance by dynamically controlling artificial lighting levels based on available daylight, occupancy patterns, and user preferences. Ulrich et al. (2018) conducted a longitudinal study examining the effects of natural light exposure on patient recovery rates in hospital rooms. The results demonstrated a significant correlation between access to daylight and shorter hospital stays, reduced analgesic use, and higher patient satisfaction scores. Similarly, a study by Beauchemin and Hays (1996) investigated the impact of window views and daylight exposure on postoperative patients' pain medication usage and recovery times, revealing a positive association between daylighting and improved recovery outcomes.

Schweitzer et al. (2014) conducted a survey-based study to assess the impact of daylighting on staff well-being, job satisfaction, and performance in hospital settings. The findings indicated that healthcare workers in naturally lit environments reported higher levels of alertness, job satisfaction, and overall work performance compared to those in artificially lit spaces.

Boyce et al. (2022) conducted field studies in hospital workplaces to evaluate the influence of daylighting on staff productivity, communication, and collaboration. Their findings suggested that access to natural light positively affects staff morale and teamwork dynamics, leading to improved patient care outcomes.

Andersen et al. (2017) conducted a post-occupancy evaluation of daylighting strategies in a hospital building, assessing their impact on energy consumption, lighting quality, and user satisfaction. The results demonstrated significant energy savings and improved visual comfort in spaces with optimized daylighting design features.

Ochoa and Capeluto (2016) conducted a simulation-based study to evaluate the energy-saving potential of different daylighting strategies in hospital buildings. Their findings highlighted the importance of daylight harvesting systems, solar shading devices, and energy-efficient lighting controls in achieving sustainable lighting solutions.

Gauthier et al. (2010) conducted a case study analysis of hospital projects that successfully implemented natural daylighting strategies, identifying common design principles, challenges, and lessons learned. Their findings underscored the importance of interdisciplinary collaboration, stakeholder engagement, and performance-based design criteria in achieving successful daylighting outcomes.

Mahdavinejad et al. (2010) conducted a comparative analysis of daylighting design strategies in hospital buildings across different climatic regions, exploring their adaptation to varying environmental conditions and contextual factors. Their study highlighted the need for context-sensitive design approaches that balance daylighting performance with climatic considerations and user needs.

Theoretical frameworks proposed by Zimring et al. (2013) emphasize the importance of considering human factors, such as circadian rhythms, visual comfort, and psychological well-being, in daylighting design decisions for healthcare environments. These frameworks advocate for a user-centered approach that prioritizes the physiological and psychological needs of patients, staff, and visitors, while also addressing functional requirements and performance objectives within the built environment.

Studies by Rashid et al. (2019) underscore the significant impact of natural daylight exposure on patient recovery rates, stress reduction, and overall satisfaction with the healthcare environment. Theoretical models proposed by Schweitzer et al. (2014) and Hadi et al. (2016) elucidate the physiological mechanisms underlying the health-promoting effects of daylighting, including its influence on circadian regulation, immune function, and hormonal balance. Design guidelines outlined by Mahdavinejad et al. (2018) highlight key principles for optimizing natural daylighting in hospital buildings, including building orientation, fenestration design, daylight harvesting techniques, and glare control measures. These strategies aim to maximize daylight penetration while minimizing solar heat gain, glare, and energy consumption, thereby creating a comfortable and visually stimulating environment for patients, staff, and visitors.

Research by Andersen et al. (2017) explores the energy-saving potential of daylighting strategies in hospital design, emphasizing the importance of daylight harvesting systems, energy-efficient lighting controls, and passive design strategies.

Research by Olatunji et al. (2018) emphasizes the importance of architectural design and building orientation in harnessing natural daylight effectively. Proper orientation of hospital buildings can maximize daylight penetration while minimizing solar heat gain, contributing to a comfortable indoor environment.

Studies by Adeyinka et al. (2019) highlight the role of building form and facade design in optimizing daylight performance. Incorporating features such as light shelves, shading devices, and high-performance glazing can control glare and distribute daylight evenly throughout hospital spaces. Research by Adedeji and Fagbenle (2020) underscores the value of daylight modeling and simulation tools in predicting and optimizing daylight levels in hospital buildings. These tools allow designers to evaluate different design scenarios and make informed decisions to enhance visual comfort and reduce energy consumption.

The integration of daylighting strategies with sustainable design practices is explored in studies by Olubodun et al. (2021). Strategies such as passive solar design, natural ventilation, and energy-efficient lighting systems complement daylighting initiatives, resulting in holistic and environmentally responsive healthcare facilities. User preferences and comfort are essential considerations in daylighting design. Research by Adebayo and Oluwatayo (2017) investigates patient and staff perceptions of daylighting in healthcare environments, emphasizing the positive impact of natural light on mood, healing, and overall satisfaction.

From the foregoing, several studies have investigated natural day lighting at various scale and research methods. The literature review highlights the pressing issue of ineffectiveness of application of the daylighting variables in the design of hospital building of developing countries. However, a notable gap in the literature is the lack of comprehensive studies that address the integration of day lighting strategies at a national scale. Nigeria. Thus, the current study exploring the effectiveness of natural lighting on the spatial configuration of selected health centers at Nigeria scale and a developed countries scales

MATERIALS AND METHODS

This chapter explains how data has been gathered for the research and how it has been put together and categorized.

Research Methods

An initial literature review was undertaken to give the author a broad overview of what health centers facilities entailed. Online data was gathered from health centers publications on how natural lighting affect spatial configuration. Other areas of concern such as movement patterns for both patients and staff and how these can also be solved architecturally were also looked at.

Primary Sources of Data

Primary data for the study includes information from direct sources such as:

i. Case study method

ii. Carrying out site visits for the direct observation on existing facilities.

iii. Taking photographs of such visited existing facilities and producing diagrams for illustrative purposes of such.

Secondary Sources of Data

Secondary data is generated through the following:

i. Use of existing literature from textbooks, publications, magazines, and unpublished materials and internationally recognized and accepted research encyclopedia.
ii. Use of the internet for further information and data collection on how natural lighting affect spatial configuration..

Case studies

A case study approach of data collection allows in-depth, multifaceted explorations of complex issues in their real-life settings. The case study approach is usually adopted when there is need to obtain an in-depth of an issue, event, phenomenon of interest or its natural-real life context (Thomas, 2011)

A case study can be described as an intensive, systematic investigation of a single individual, group of people, or a unit, which is aimed to generalize several units.

The case study used for this study are;

1) Sepulveda Ambulatory Care, Northern Los Angeles.
2) Barnabas Health Ambulatory Care Center, Livingston, New Jersey.
3) Ambulatory Care Center, Brandywine Valley, Philadelphia.
4) Lagos state government general hospital, Mushin

With the exception of Sepulveda, barnabas health, Brandywine Valley ambulatory care centers tours were taken in and around the others to make personal observations that were not captured in discussions or documents received.

Discussions were conducted on the effectiveness of applications of natural lighting on the spatial configuration of selected health centers to be acquainted with basic procedures and required spaces needed and any other relevant information. Informal discussions held were found to be valuable as relevant issues not thought about initially came up during interactions.

Observations of interest were documented under each case study as comments. These were observations that generally pointed either towards standardization or modernity or the lack of it.

The parameters for the variables which satisfy the research questions and objectives are used to assess the case studies. Data obtained were analyzed and presented in form of figures, plates, tables, while data collected during the case study are documented in form of drawings such as floor plan, site plan, and section.

Conclusions were then drawn as to strong points of the industry worthy of emulation or adaptation in the design.

Case Study Selection Criteria

In the strategic selection of where this research case study exercise is to be carried out, the following parameters were duly taken into consideration.

I. A random selection of building that offers similar natural lighting strategies.
II. The relation of the building to the site and its immediate environment.
III. Accessibility and integration of the day lighting in the building design.

Sepulveda Ambulatory Care

Sepulveda ambulatory care is a major outpatient facility charged with caring for the 1.4 million veterans living in northern Los Angeles, Sepulveda has redefined its mission and become a comprehensive ambulatory care, education and research facility, services are restricted to the veterans who have been Honorable discharge from military services and those in services

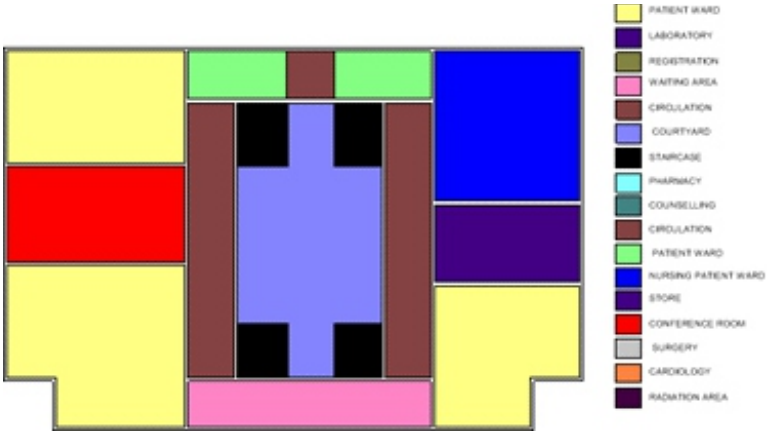

Figure 1: Ground Floor Plan Sepulveda Ambulatory Care Center, Los Angeles
Source: Author's Field Work, 2021.

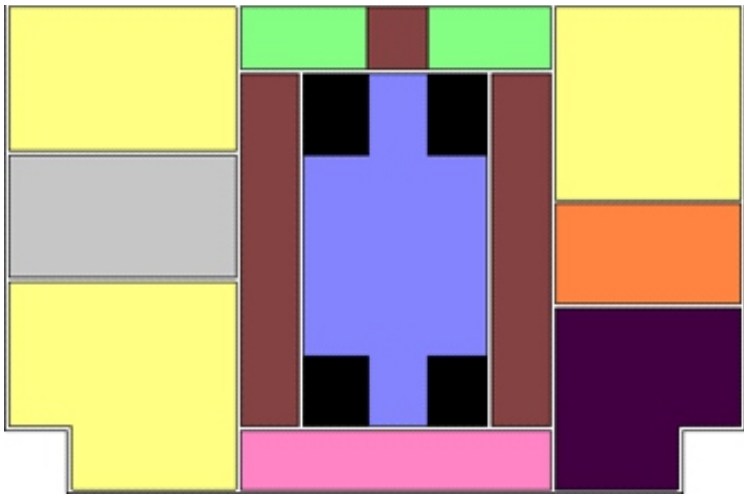

Figure 2: First Floor of Sepulveda Ambulatory Care Center, Los Angeles
Source: Author's Field Work, 2021.

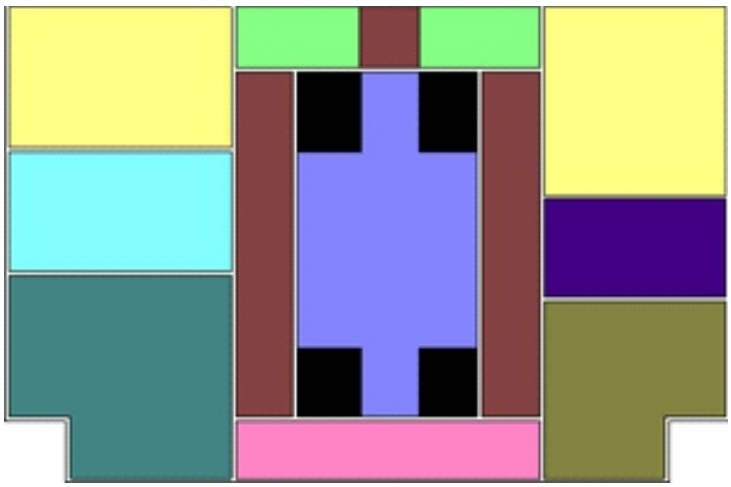

Figure 3: Second Floor Plan of Sepulveda Ambulatory Care Center, Los Angeles
Source: Author's Field Work, 2021.

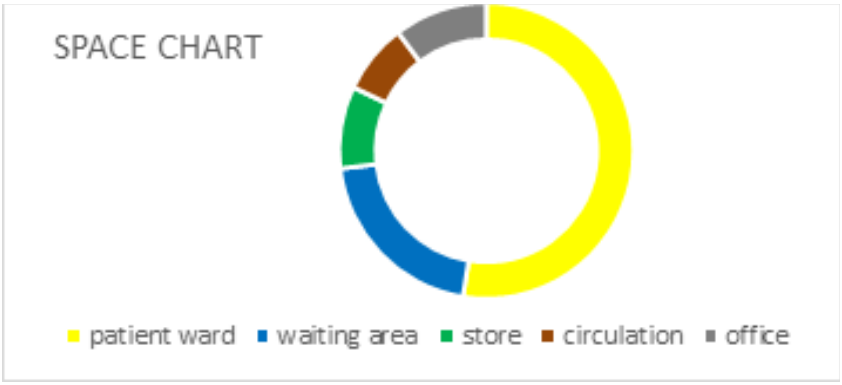

Figure 4: space chart of Sepulveda ambulatory care
Source: Author's Field Work, 2021.

Figure 5: Sepulveda ambulatory care day lighting stragetic
Source: http://pinterest.com/pin/SACC16111losangelesCA

Figure 6: internal day lighting strategic at Sepulveda ambulatory care open space
Source: http://pinterest.com/pin/SACC16111losangelesCA

Table 1: Checklist for Sepulveda ambulatory care center

variables			
openings	**Low**	**Medium**	**High**
			✓
Glazing type	**clear**	**Tinted**	**colored**
	✓		
orientation	**0%**	**50%**	**100%**
skylight	**0%**	**50%**	**100%**
		✓	
Outdoor view	**low**	**Medium**	**high**
			✓
Finishes reflectivity	**low**	**Medium**	**high**
			✓

Variables	**Features**	**Remarks**
reflectivity	Wall and floor with white paint finishes or material	Wall finishes enhances reflectivity of light
window	High height window with a clear glass plane	allowing a high transmission of daylight thus it helps to improved mood and work performance (Sameer *et al.,* 2015)
skylight	Design and incorporate direct skylight within the open space , double sheet glass supported with steel truss	enhance penetration of light in the passage and open space permits daylight to enter from above through a glazed opening in the roof (Sameer *et al.,* 2015)

Glazing	Single and double sheet glazed used	the more the sheets or the greater the thickness of Glass the more the daylight diminished
Building orientation	Position of building in relation to its location and climate	The longer side of the building is facing north -south and it is properly oriented, as this reduces the amount of glare the building will see at sunrise and sunset (HMC architects 2019)
Outdoor view	Practice of soft and hard landscape around the building.	Well landscape d, creates environment that simulate the mind and enhances wellbeing

Source: Author's Field Work, 2021.

Barnabas Health Ambulatory Care

Barnabas health ambulatory care center is one of the major outpatient facilities that provide the most medical quality in an environment designed to set a new standard for patient. The facility accommodates increase access to medical office space and to an expansive referral network.

Figure 7: Natural Day lighting strategy Barnabas Ambulatory Care Center
Source: http://rendina.com/portfolio/barnabashealthambulatorycarecenter.

Figure 8: Internal natural Day lighting strategy of waiting area & the radiation room
Source: http://rwjbh.org/barnabashealthambulatorycarecenter.

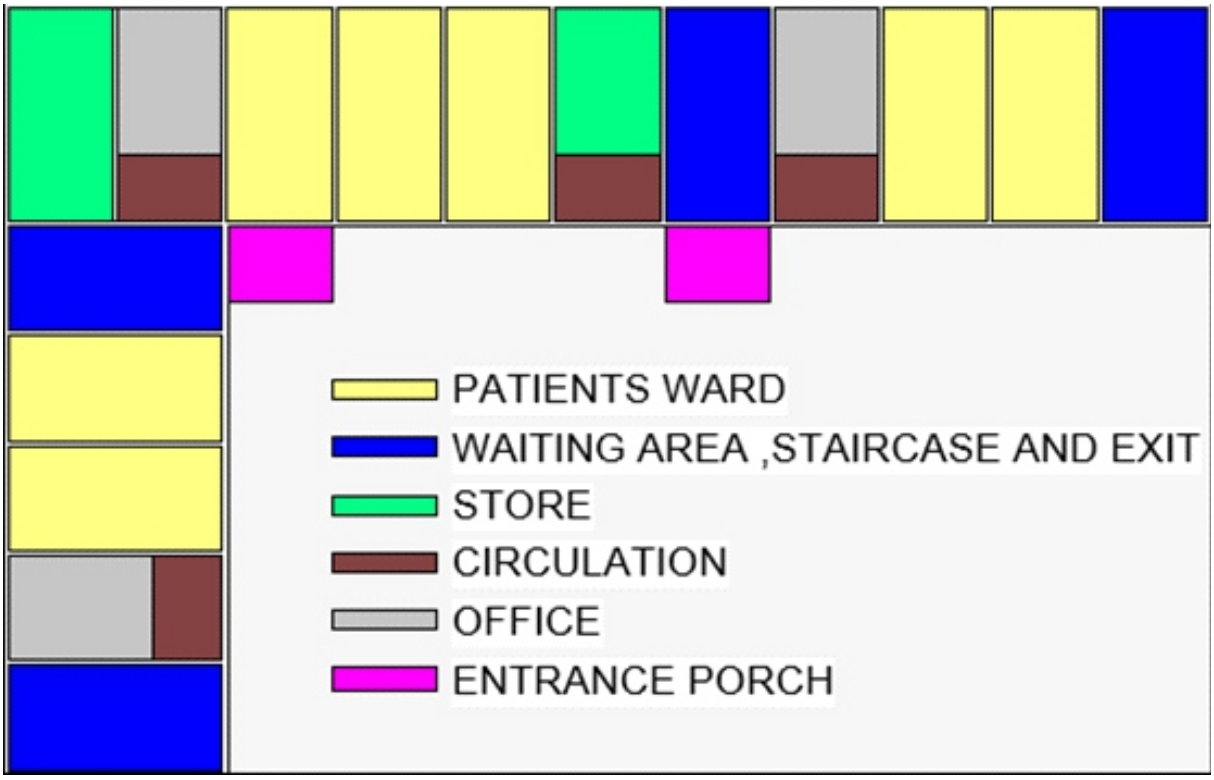

Figure 9: Ground and Typical First Floor plan of Barnabas Ambulatory Care Center
Source: Author's Field Work, 2021.

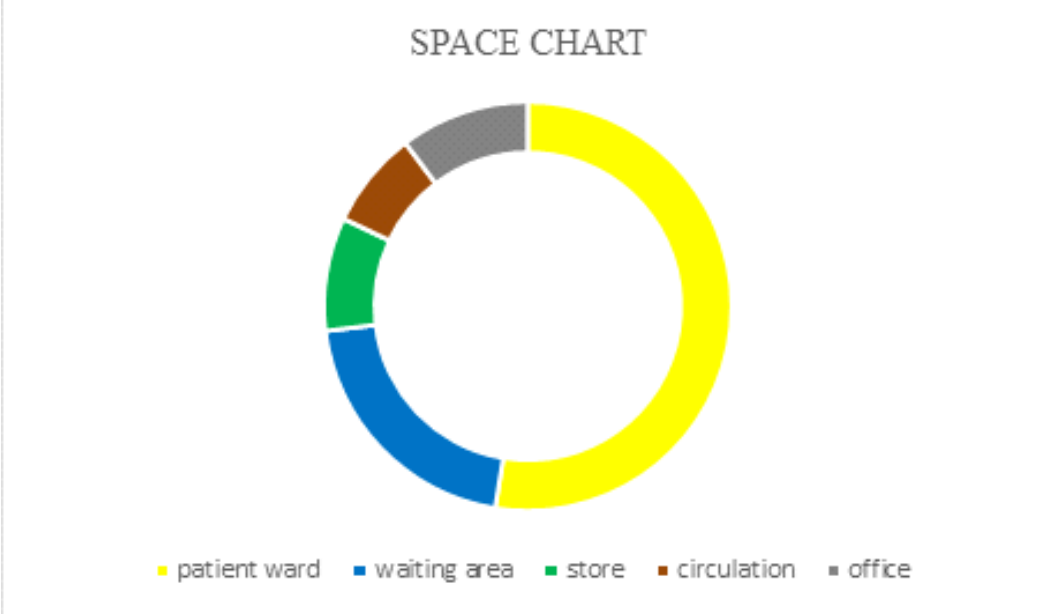

Figure 10: circulation space of barnabas ambulatory care center
Source: Author's Field Work, 2021.

Table 2: Checklist for Barnabas Ambulatory Care Center

openings	**Low**	**Medium**	**high**
		✓	
Glazing type	**Clear**	**Tinted**	**colored**
	✓		
orientation	**0%**	**50%**	**100%**
skylight	**0%**	**50%**	**100%**
			✓
Outdoor view	**low**	**Medium**	**high**
	✓		
reflectivity	**low**	**Medium**	**high**
			✓

Deductions

From the case study conducted, it was observed that, the factors that enhance productivity of staff through the integration of natural lighting has the lowest level of consideration in Barnabas health ambulatory care center

The orientation of the building is very poor exposing the entire building surface to the sun rise and sun set which result in high heat gain and also limited numbers of window in the east and west help in reducing the heat gain to the building but stopping natural light at the corridors making the use of artificial light unavoidable which increase the light bill.

Ambulatory Care Center, Brandywine Valley

The two-floor facility features different specialty care that include allergy, cardiology, gastroenterology, nephrology, neurology, and orthopedics.

The center also has a rehabilitation service, gyms for physical therapy, and ambulatory surgery center. The surgery center will provide outpatient surgeries to children of all ages.

The facility contains the following unit: Registration, laboratory, examination room, x -ray room, Counseling unit, Radiology etc.

Figure 11: Ground Floor Plan of Ambulatory Care Center, Brandywine Valley
(http://www.bizjournals.com/prnewswire/press_releases/2015/10/06/DC21607)

Figure 12: First Floor Plan Ambulatory Care Center, Brandywine Valley
http://www.bizjournals.com/prnewswire/press_releases/2015/10/06/DC21607

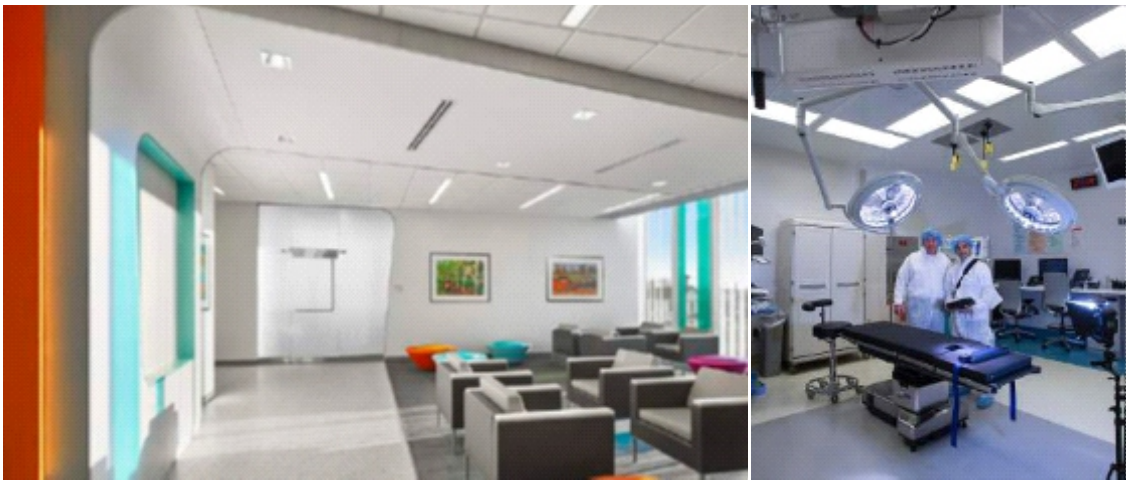

Figure 13: Day lighting in the internal space of the waiting area of the ward & the operation theater hall
(http://www.bizjournals.com/prnewswire/press_releases/2015/10/06/DC21607)

Table 1: Checklist for ambulatory care center, Brandywine valley

openings	**Low**	**Medium**	**high**
			✓
Glazing type	**clear**	**Tinted**	**colored**
			✓
orientation	**0%**	**50%**	**100%**
skylight	**0%**	**50%**	**100%**
	✓		
Outdoor view	**low**	**Medium**	**high**
	✓		
Floor Finishes reflectivity	**low**	**Medium**	**high**
			✓
wall Finishes reflectivity	**low**	**Medium**	**high**
			✓

(Source: Author's Field Work, 2021.)

Variables	Features	Remarks
reflectivity	Wall and floor with white paint finishes or material	Wall finishes enhances reflectivity of light

window	High height window with a clear glass plane	allowing a high transmission of daylight thus it helps to improved mood and work performance (Sameer *et al.*, 2015)
skylight	Design incorporate direct skylight within the open space, double sheet glass supported with steel truss	enhance penetration of light in thepassage and open space permits daylight to enter from above through a glazed opening in the roof (Sameer *et al.,* 2015)
Glazing	Colored glazing	the more sheets or the greater the thickness of glass the more the daylight diminished
Building orientation	Position of building in relation to its location and climate	The longer side of the building is facing north-south and it properly oriented , as this reduces the amount of glare the building will see at sunrise and sunset (HMC architects 2019)
Outdoor view	Practice of soft and hard landscape around the building.	Well landscape d, creates environment that simulate the mind and enhances wellbeing

Source: Author's Field Work, 2021.

Deductions

From the case study conducted, it was observed that, the factors that enhances productivity of staff through the enhancement of natural lighting was considered in the design of Ambulatory Care Center, Brandywine Valley, the design encompass the enhancement of daylight to the interior view, view to the nature from patient bed and the use of vibrant colors of the interior spaces

The building form is suitable for the location; the elongated side of the building is facing north and south which give the building the advantage to reduce solar radiation.

Lagos state government general hospital Mushin

The hospital is fully equipped with medical facilities to provide care for all fields of internal medicine and an internal medicine and an intensive care unit for babies with state-of-the-art incubators. The specialist consultations available include endocrinology, orthopedic, nutrition, general surgery, pediatric, optometry, obstetrics, gynecology and cardiology.

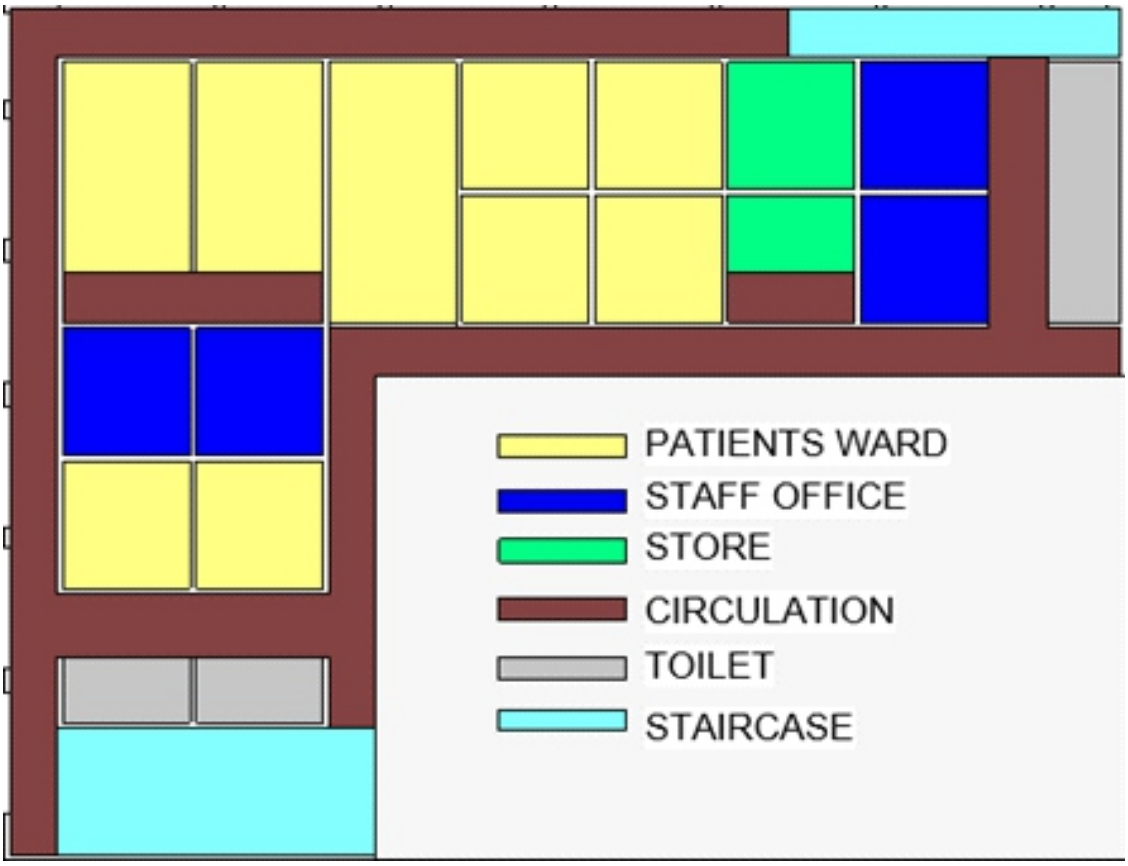

Figure 14: ground and first floor of Lagos state government general hospital Mushin emergency unit

Source: Author's Field Work, 2021.

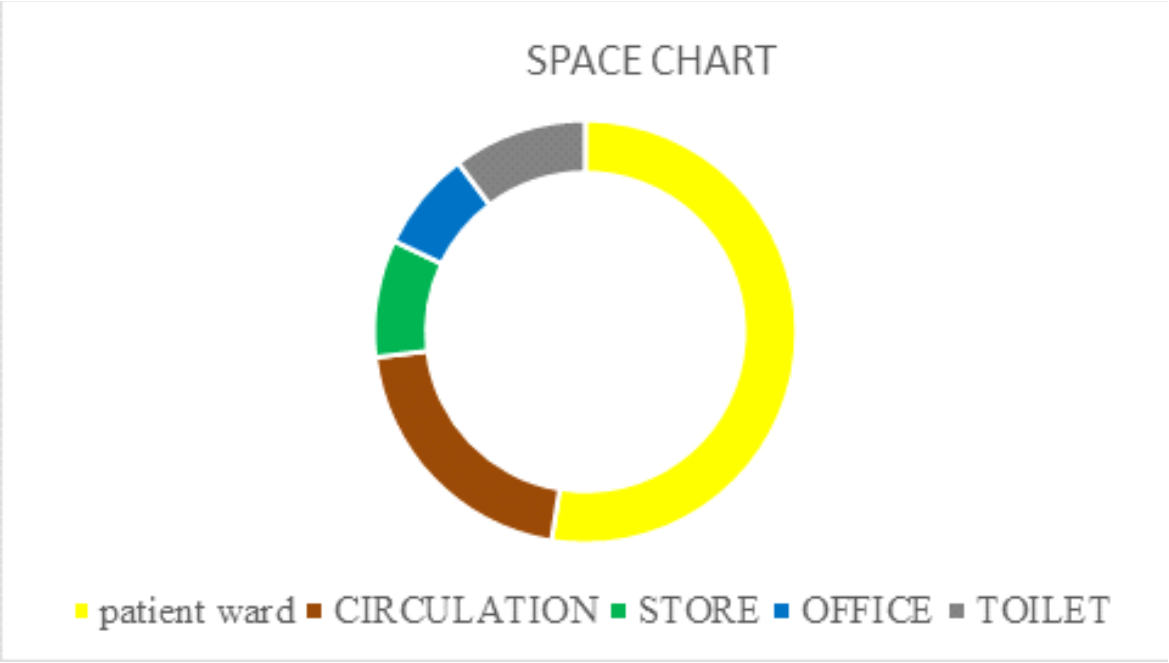

Figure 15: space chart of Lagos state government general hospital Mushin emergency unit

Figure 16: External Natural Day lighting strategy of Lagos state government general hospital Mushin
Source: Author's Field Work, 2021.) (Source: Author's Field Work, 2021.

openings	**Low**	**Medium**	**high**
		✓	
Glazing type	**clear**	**Tinted**	**colored**
	✓		
orientation	**0%**	**50%**	**100%**
skylight	**0%**	**50%**	**100%**
	✓		
Outdoor view	**low**	**Medium**	**high**
	✓		
reflectivity	**low**	**Medium**	**high**
			✓

Variables	**features**	**observations**
reflectivity	Wall and floor with white paint finishes or material	finishes enhance reflectivity of light
window	Window with medium height used in some patient ward	allowing a high transmission of daylight thus it helps to improved mood and work performance (Sameer *et al.,* 2015
skylight	**----------**	**----------**
Glazing	Single sheet, clear glazed used	the more sheets of glass the more the daylight diminished
Building orientation	Position of building in relation to its location and climate	The longer side of the building is facing north - south and it properly oriented

Table 1: Checklist forLagos state government general hospital Mushin

Source: Author's Field Work, 2021.

Discussion

From case studies conducted, it was observed that several factors needed to be considered before setting health center facility

- The site must be properly situated, the site location must be in close proximity to its users. It must be located in a directly access to day lighting area, the site selected must enjoys adequate variable of day lighting such as Skylight, outdoor view, shaded opening and good orientation and this ensures the smooth delivery of healthcare by the workers.

- Position of building must be in relation to its location and climate the longer side of the building is facing north-south
- Building must focus on natural light intake to enhance the productivity of staff and recovery of patients.
- The space that must be in ambulatory care center was noted during the case study and spaces are registration, laboratory, examination room, x -ray room, Counselling unit, Radiology telematic, pharmacy, surgery room, cardiology, pulmonary, Nursing home care, Patient ward, Diagnosing area, radiation treatment room.

3.1 Results and discussion

	Case study1	Case study 2	Case study 3	Case study 4
Opening				
low				
medium		✓		✓
High	✓		✓	
Percentage	**40%**	**20%**	**25%**	**15%**
Glazing type				
clear	✓	✓		✓
Tinted			✓	
colored				
Percentage	**30%**	**30%**	**10%**	**30%**
Orientation				
0%				
50%				
100%				
Skylight				
0%				✓
50%	✓		✓	
100%		✓		
Percentage	**30%**	**40%**	**30%**	**0%**
Outdoor view				
low				✓
medium		✓		
High	✓		✓	
Percentage	**40%**	**20%**	**30%**	**10%**

Finishes reflectivity				
low				
medium				✓
High	✓	✓	✓	
Percentage	**40%**	**20%**	**30%**	**10%**

Table 1: table showing the evaluation of the four case study

(Source: Author's Field Work, 2021.)

Conclusion and Recommendations

The study recommends that natural lighting both transparent and opaque surfaces of the building envelope will maximize the amount of solar penetration that induces natural lighting in both indoor spaces and building's structure. A properly designed natural lighting system can effectively contribute to maximizing the solar penetration. Architects must focus on natural light intake to enhance the productivity of staff and recovery of patients.

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