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Evaluation of Efficient Ventilation and Natural Lighting in Hospital Wards in Ota, Ogun State, Nigeria

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Abstract:
In the past, hospitals were built with certain elements that improved natural lighting and ventilation. Natural air and sunlight were recognized as significant variables affecting the well-being of patients in hospital wards; therefore, features including south-facing glazing, cross-ventilation, and high ceilings were implemented. Hospital Buildings are more complicated than other types of buildings. However, architects and scientists are now responsible for raising awareness and comprehension of health and happiness issues associated with varied built environments. Several papers and studies have been published, providing the most up-to-date 'state-of-the-art' circulation of research on interior air quality, illumination, ventilation, moisture, acoustics, and construction for the built environment. Natural lighting is an important component of the hospital ward since it not only minimizes patient suffering but also has the potential to increase patient satisfaction. By lowering Raising oxygen, reducing systolic blood pressure, and increasing heart and pulse rates intake, full-spectrum light protects against viral and bacterial illnesses while also improving physical working ability. Weariness, diseases, insomnia, drunkenness, suicide, and other psychiatric disorders are all exacerbated by insufficient natural lighting. As a result, natural lighting has become a priority in medical facility design and is now included in the architecture. Architecture serves a wide range of purposes in the built environment, from office buildings to hospitals, where significant efforts are made to promote comfort and spatial ergonomics.

Keywords: *Ventilation, lighting, spatial, anthropometry*

1. Introduction

Hospitals as part of the built environment must be constructed with appropriate ventilation and efficient natural lighting to offer a comfortable atmosphere that meets indoor environmental quality (IEQ) standards. This is critical for preventing infection and contamination in the clinical area while also keeping a clean atmosphere. A building's design must incorporate sustainable architecture and engineering to satisfy the stated clinical demands. It has been put forth by Zborowsky and Kreitzer (2008) that hospital buildings that consist of adequate indoor environmental quality would pull in, secure, and improve the healing process of the patient as well as the worker's efficiency. Two determinants of indoor environmental quality include: 'Natural Lighting' and Ventilation which will be analyzed in this paper (Mohammed Tauheed Alfa, 2019).

Architecture has a comprehensive function in the built environment, all the way down to the medical area, where conscious attempts are made to ensure comfort and spatial ergonomics. Hospitals were designed in the past times with certain features improving natural lighting and ventilation. Features such as south-facing glazing, cross-ventilation, and

high ceilings were engaged because fresh air and sunlight were prioritized as major factors affecting the well-being of patients in the hospital wards. Florence Nightingale revolutionized hospital design in the late 19th century which later on became known as Nightingale wards. These wards were unique in that they had big windows that allowed for cross-ventilation and plenty of natural light. Florence felt that the amount of light and the quality of the air in a hospital have an essential influence on a patient's rehabilitation (Steven Lockley, 2021). Numerous studies have proven that Nightingale was correct: daylight is an important factor in human health and welfare. Patients, who are in rooms with natural light and views of the outdoors, recover faster and require fewer painkillers. Natural light has been demonstrated to lower blood pressure, lower heart rate, and even treat depression more effectively than medications. Importantly, daylight can reduce hazardous bacteria and viruses, just as Nightingale predicted.

This research is focused on hospital wards in Ota Ogun State with the purpose to evaluate the efficient ventilation and natural lighting in the hospital wards. The geographical profile of Ogun State places it as a State in Southwestern Nigeria. It borders Lagos State and the Atlantic Ocean to the south, Oyo and Osun States to the North, Ondo State to the east, and the Republic of Benin to the west.

Its Capital is Abeokuta; Major Cities – Abeokuta, Ewekoro, Ikenne.

1.1. Research Aim & Objectives

The study aims to assess the natural lighting and ventilation in hospital wards in Ogun State with a view to suggesting the most appropriate means of ventilation and natural lighting in the hospital wards.

1.2. Objectives

- To examine the existing spatial analysis of hospital wards.
- To assess the effects of the existing ventilation and natural lighting conditions on patients in hospital wards.
- To suggest means to improve the natural lighting and ventilation in hospital wards.

2. Literature Review

The physical components of natural lighting and ventilation in hospital ward architecture, as well as daylighting and its impact on humans, are critically examined. To give sufficient evidence on the link between the physical characteristics of the hospital environment and human health physically, psychologically, and mentally within the framework of sustainability, an understanding of the subject is established. Desktop analysis, which includes topic and content assessments, is used to present coherent arguments about the subject at hand. Two hospitals in Ota Ogun state are then identified for the pilot studies.

2.1. Natural Lighting

Natural lighting is an important feature of the hospital ward that not only reduces patient distress but may also boost patient happiness. Full-spectrum light prevents viral and bacterial infections while also improving physical working capacity by lowering heart and pulse rates, and systolic blood pressure, and enhancing oxygen intake. Insufficient natural lighting has been seen to have a direct impact on weariness, illnesses, sleeplessness, alcoholism, suicide, and other psychological disorders. As a result, Natural lighting has been prioritized and incorporated into the architecture of medical buildings.

2.2. The Effect of Natural Lighting on Hospital Wards

Although changing the architecture of a hospital after it has been built is difficult, it is critical to address many treatment-related concerns ahead of time for the benefit of both patients and healthcare employees. Historically, medicine has explored evidence-based therapies, which create a method by defining and evaluating changes in outcomes based on the presence or absence of therapy, as well as rating their efficacy. Furthermore, architecture is credited with inventing the concept of evidence-based design. The incentive for studying these linkages is evident because any change in the physical environment could influence sickness progression in a variety of ways. People have believed that the physical environment of a hospital can help a patient's rehabilitation since ancient times. Health care facilities are made up of a variety of spatial zones that aim to prevent, diagnose and treat diseases as well as provide rehabilitation. The prize is given to the medical setting where patients spend the most time; thus, ward settings have a direct or indirect impact on treatment outcomes. Much research has been done to see how different physical ward environments affect sickness outcomes, such as the reduction of hospital-acquired infections. For example, physicians have worked hard to prevent iatrogenic illnesses. Physical segregation among patients, ventilation system components, and easy-to-clean facilities are all important architectural features since illnesses are conveyed through touch.

2.3. The Negative Effects of Artificial Lighting

Artificial lighting advancements have enabled architects to design structures that are larger and deeper, with multiple enclosed spaces that do not rely on natural lighting. While these conditions are manageable, they can harm overall health, productivity, and efficiency. Patients in windowless rooms frequently report increased levels of stress and, in severe circumstances, may be affected by Sick Building Syndrome (SBS).

2.4. The Benefits of Natural Light in Hospital Wards

Natural light and views from windows, on the other hand, can be beneficial to both patients and medical employees:

- Reduce the length of in-patient stays - Patients admitted to brighter wards spend around 41% less time in the hospital than those assigned to darker or windowless quarters, according to studies. Patients in darker rooms died at a higher rate.
- Hasten healing after surgery - Patients recovering from surgery who are in rooms with plenty of natural light and nice views are less worried and have lower blood pressure, both of which are important for healing. Patients in dark rooms, on the other hand, are more prone to experience sadness and confusion after surgery. This might result in a rise in inflammation in the body, which can exacerbate pain and hinder recovery.
- Help to make pain relief more effective - In bright, natural light rooms, about 22% of patients require fewer pain medications. While pain relievers are essential in all hospitals, patients, who require additional pain medication, must deal with any negative side effects as well as higher medical costs while recovering.
- Boost employee morale - Natural illumination improves employee morale and productivity. It has been proven to increase employee energy levels. Employees in a hospital, who are exposed to natural light and views of nature, report lower stress levels and absenteeism due to illness.

2.5. Ventilation

The ventilation measures seen in the majority of hospitals have been deemed inadequate thereby adding to the poor indoor air quality and pollution. Research has also shown that the recuperation process of the patients and working conditions of health staff have been greatly improved in the design attributes of healthcare facilities that focus on ventilation. Khalid *et al*., 2019; Sadrizadeh *et al*., 2018; Shi *et al*., 2018; Verheyen *et al*., 2011 stressed the various research works that have analyzed the indoor thermal comfort of wards and the effects it has on patients, both in naturally ventilated wards (NV) and artificially ventilated wards by the use of certain strategies. However, research has shown that no exact temperature is optimal for persons living in certain enclosures in buildings. Nevertheless, the temperature seen as agreeable for healthy daily living is between 20° and 24°C, with importance allotted to individual choices and preferences shown. The thermal comfort of a person can be influenced by the number of activities engaged in and the choice of clothing (Djongyang *et al*., 2010; Gou *et al*., 2018; Kamalha *et al*., 2013); thus, patients in the wards are usually provided with hospital gowns to synchronize the bodily reactions related to clothing and ventilation.

2.6. The Benefits of Natural Ventilation in Hospital Wards

When natural ventilation is used in a healthcare setting, the top benefits include connecting patients to nature for healing, resiliency planning to keep the facility ventilated in the event of a natural disaster, and lower operating costs owing to possible energy savings. Manually opening and closing windows to freshen and cool the indoor environment is often associated with natural ventilation. While this is true, clever automation of roof and façade openings can make life easier for building occupants while also maintaining building security. Other advantages include better humidity control, fewer operating and maintenance expenses, improved health and wellness, and access to daylight.

- It regulates impurities. You may believe that the air quality in your neighborhood is poor, especially if you live in a busy city center, yet the air inside is often more polluted than the air outdoors.
- Air quality control.
- Stop the condensation.
- Lower the temperature.
- Health advantages.

3. Methodology

This report examines a collection and organization of the body of knowledge and continuing research on natural lighting and ventilation approaches in hospital wards. Its goal is to uncover possible study areas for hospital design techniques, notably in the areas of daylighting and ventilation. A literature review, desktop analysis, and pilot tests of hospital structures were used in this study's methodology.

3.1. Pilot Studies

The major goal of the pilot studies is to look into how physical aspects like types of apertures, the number of openings, interior materials used, and more are implemented in hospital wards. In the context of the hospital ward, lighting and ventilation approach in tropical climes, such primary data would add to the body of knowledge on daylighting and ventilation. The hospitals were visited independently, with each visit lasting at least 1 to 2 hours. The physical conditions of a single bed, two-bed ward, and eight-bed ward in indoor surroundings were studied. The reviews are qualitative and are based on the researcher's critical observation and understanding of ventilation and daylighting in hospital wards in retrospective studies. The information acquired from the medical professionals working in the wards supplements and confirms the basic data gathered. The main findings will focus on the physical components of daylighting and ventilation in the ward environment, with a special emphasis on lighting design and implementation, as well as its relationship to other environmental aspects. These include building orientation, window design, access to view, visual comfort of the ward environment, lighting (natural and artificial), ventilation (natural and artificial), and color. These are the most significant physical characteristics that have an impact on hospitalized patients. The two hospitals involved in the pilot tests will be referred to as Ace Medicare with AM-1 and State Hospital with SH in the following paragraphs.

3.2. Study Area

The focus of this study is on hospital wards in Ota, Ogun State. Ogun State is located in south-western Nigeria, according to its geographical profile. It is bordered on the south by Lagos State and the Atlantic Ocean, on the north by Oyo and Osun States, on the east by Ondo State, and on the west by the Republic of Benin.

Abeokuta is the capital, while Abeokuta, Ewekoro, and Ikenne are the major cities.

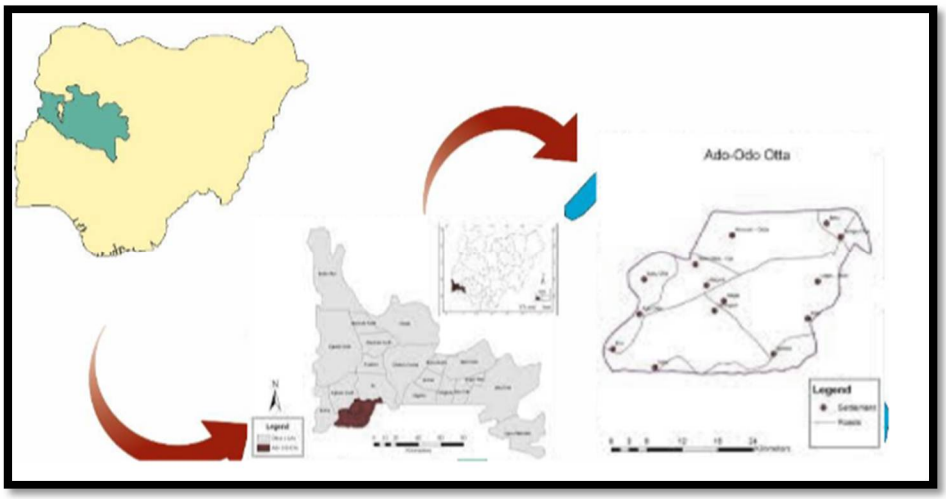

Figure 1: Showing the Map of Ota, Ogun State, Nigeria

4. Findings: Physical Aspects Affecting Daylighting Design

4.1. Spatial Layout of Building

Ace Medicare is a 3-floor hospital building. The wards are located on the ground to the last floor. There are three types of wards in this clinic, namely: the 2-bedded ward, private wards which are located on the 1st and 2nd floor, and the 8-bedded wards are located on the ground floor. The walls are named based on the number of bed spaces.

The two wards on the first and second floors look into the courtyard space to provide the patients with access to natural light and ventilation. They follow the same design but the spatial configuration for the Two Bedded room is a little bigger than the Private room.

The nurses' station is located close to the wards for ease of access to patients' needs. The nurses' station is provided with three windows looking into the courtyard space as well to provide natural ventilation.

4.1.1. Natural Lighting and Ventilation in the Wards

The Two bedded and private wards were provided with just one 1.7x1.3m windows on either side of the room, an entry door of 900mm width, and a 600x450mm window. The window design engaged in these wards was Sliding windows, which provided natural ventilation entry to one side only, based on the side left open in the room, and a top-hung casement window for the convenience of the patient.

The doors were noticeably left agape to allow natural ventilation into the room to assist the heavily draped windows. There was a walkway space surrounding these wards for ease of movement into the rooms; however, it causes the windows not to have direct air coming from the courtyard but from a distance of 1200mm from the courtyard railing to the window, thereby causing minimal airflow into these wards.

The drapes were made of cotton with the intention of glare removal which could cause discomfort to the eyes of the patients; however, the airflow has become minimized as the drapes absorb the majority of the natural ventilation that comes from the open window.

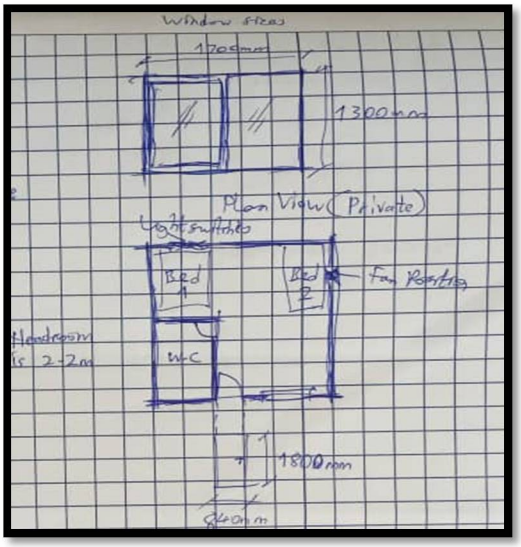

Figure 2: Showing Sketches of the Spatial Layout and Components of the Two-Bedded Wards

The 8 bedded wards have light natural coming into the space through two types of windows on opposing sides of the wall. One window type is used on the side opening into the exterior of the building, this type is a 'Top hung four-sided casement window' with a size of 1.8x1.5m. There are three in number positioned in-between every two beds on that side of the ward. This window provides direct natural ventilation and lighting into the space. On the opposite side of the wall, the window type engaged is the 'Sliding window' positioned on the wall on the walkway coming from the atrium space. The windows, two in number, provided minimal natural lighting and ventilation because it was positioned a bit away from the direct source. For protection against glare, blinds were used in this ward, which provides enough protection and allows the majority of air to flow into the space even when in use.

Figure 3: Images Showing the Courtyard Space Allowing Natural Light and Ventilation into the Wards

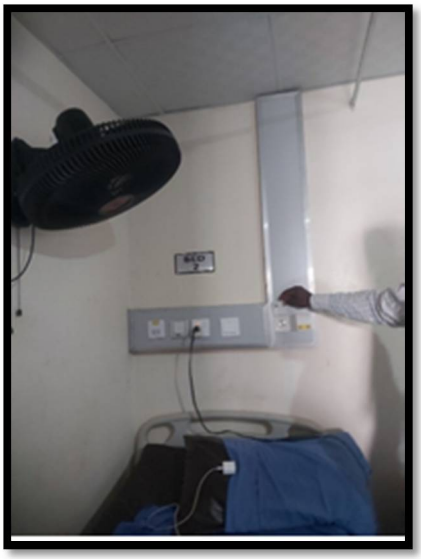

Figure 4: Images Showing Available Ventilation and Lighting Fixtures in a Two-Bed Ward in AM Ward

4.1.2. Artificial Lighting and Ventilation in the Wards

For the two private wards, there were artificial lighting and ventilation fixtures on each patient's bedside for ease of access and use. This was providing consideration for individual preferences and sentiments. There was an electrical panel above the head of the patient's bedside where the switches for the fixtures were positioned. The artificial light was a switched-operated ceiling fixed light that provided adequate light personally for the patients and mildly for the entire room. This fixed light will provide illumination into the space to provide visual comfort to the patient, especially during the nighttime. The mechanical ventilation strategy engaged was a 'Wall hung Ox rotating fan' operated by the use of a drawstring. This fan is placed next to the patient's bedside for their ease of operating the drawstring. This option allows the patients to decide when the fan will be turned off and on without causing discomfort to the next patient but enough to keep the room cool as in the case of the private rooms, for the comfort of the visitors of the patients.

For the 8 bedded wards, the artificial ventilation strategy engaged was the use of one Air-conditioning unit, fitted on the exterior wall of the ward. From observation, this unit will provide unequal cooling effects to the patients in this ward as one AC is inadequate to effectively cool the entire ward.

4.1.3. The Colour Scheme, Furniture Layout, and Materials Used

The general colour scheme used in all three wards was a mixture of white and cream. The walls were painted white with a glossy finish, achieved by the use of a Satin white paint. This choice allows the spread of light generally into the wards. This is an advantageous choice as it makes full use of whatever natural light enters the wards. The furniture layout is quite simple and allows ease of movement for the patients and the medical stuff.

4.1.4. Floors and Ceiling

The floors in the wards were made of vitrified tiles and the ceiling was made of gypsum white which improves lighting and is cool enough to be used in the wards.

4.2. Assessment of the Effects of the Existing Ventilation and Natural Lighting Conditions on Patients in Hospital Wards

The table below highlights the results from the questionnaires administered to the patients in all the wards in Ace Medicare exclusive of the 8 bedded ward which was unoccupied at the time of visitation. The questionnaires were made as simple and direct as possible due to the nature of the health of the target population. The questionnaire was admitted by the use of Google forms and answered by the patients by proxy of the researchers. 11 patients were able to fill in the questionnaires, 3 of which were in the Private wards and 8 were in the two-bedded wards.

Questions	Very Good	Good	Fair	Poor
How do the existing daylighting features affect visibility?	25%	75%	0%	0%
How do the existing daylighting features affect comfort?	0%	100%	0%	0%
How do the existing daylighting features affect movement?	0%	75%	25%	0%
How do the existing ventilation features affect indoor air quality?	25%	0%	25%	50%
How do the existing ventilation features affect comfort?	0%	25%	50%	25%
How do the existing ventilation features affect recovery?	0%	100%	0%	0%
Rate how the wards are without electricity.	0%	25%	0%	75%
Rate how the wards are with electricity.	100%	0%	0%	0%

Table 1: Patients Prioritize

From the table above, it can be seen that patients prioritize.

4.3. To Survey the Existing Types and Numbers of Windows and Lighting Fixtures in Hospital Wards

This table shows the compilation of the types of windows, number and location of ventilation and lighting fixtures from the researcher's observation analysis.

Fixture	Location	Type	Size	Number
Private and 2 Bedded Wards				
Window	On the entrance wall into the wards	Top hung casement windows Sliding window Bathroom windows-casement	2000x1500mm 1700x1300mm 600x450mm	0 1 per room 1 per room
Light	above the patient's bed	A ceiling fixed light	100mm dia	2 per room
Fan	On the side of the patient's bed	An Ox rotating fan	Small size	2 per room
8 Bedded Wards				
Fixture	**Location**	**Type**	**Size**	**Number**
Window	On the entrance wall into the wards	Top hung casement windows Sliding window Bathroom windows-casement	2000x1500mm 1700x1300mm 600x450mm	3 2 2
Light	above the patient's bed	A ceiling fixed light	100mm dia	0
Air conditioning	The opposite wall of the entrance	Split unit	1500mm	1

Table 2: Ace Medicare

5. To Suggest Means to Improve the Natural Lighting and Ventilation in Hospital Wards

5.1. Ventilation

Ventilation, unlike fan-assisted ventilation, relies on the natural forces of wind and delicateness to transport

- Regular air into structures. Outside air is essential in buildings to diffuse smells, provide oxygen for breathing, and
- Provide warm warmth. Warm comfort is frequently linked to an individual's mental state, which expresses
- Happiness or annoyance with the warm environment.

Ways in which Natural ventilation can be improved in hospital wards

- Create an opening on the external wall of the building to increase the velocities of airflow in proportion to the dimension and position of the hall.
- Secondly, the opening will allow air to flow in from the side and below in order to push hot air up and out, thus, ensuring constant fresh air.
- Clerestories (high-level windows) should be introduced on the walls facing the lobby so as to allow the stack effect in required places.
- For optimal comfort, the use of a casement window is advised in order to have 100% air flow.
- To shade the building from solar radiation, increase the soft scape elements, particularly trees and bushes. and introduction of green walls Eg wall vines, aloe vera plants
- Clad the inside of the structure with insulating materials to allow for a naturally ventilated internal atmosphere Eg bamboo

5.2. Natural Lighting

Natural lighting is also known as daylighting is a technique that efficiently brings natural light into a building it must be generated naturally, the common source which is the sun. This is as opposed to artificial light, which is typically produced by electrical appliances such as lamp

Ways in which Natural lighting can be improved in hospital wards

- Provision of more windows in each ward on the exterior wall of the building and proper use of double-pane glass casement windows with argon gas insert to reduce the effect of excessive heat
- Use of brighter colors when painting the hospital wards Eg white and cream
- Provision of the larger windows in wards that occupy more than two patient
- Installation of vitrified ceramic or stone floors with a polished finish, which are used to maintain and does not incubate bacteria

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