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Evaluation of Passive Cooling Strategies in Urologist Specialist Hospital, Ikoyi, Lagos State

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Abstract:- In a hot climate, keeping a building's interior comfortable means slowing down the pace at which heat enters the structure and promoting the expulsion of extra heat. The current study examined the various passive strategies which can lead to optimal cooling in specialist hospitals in Nigeria. A qualitative research design was adopted as a blueprint and strategy for the study. Secondary data sources were adopted, existing studies were reviewed and the text was analyzed using a content analysis technique. From the analysis, the passive cooling strategies identified include; Natural ventilation, stack ventilation, sun shading system, insulation and evaporating cooling. Based on the available strategies, it is more acceptable to deploy passive cooling in general healthcare centres and specialized hospitals in particular.

Keywords:- *Passive, Cooling, Strategies, Urologist, Specialist, Hospital.*

I. INTRODUCTION

Global warming and ozone depletion are caused by carbon emissions from the use of non- renewable energy sources, which are taken into account by the climate models along with the growing energy use in buildings. 48 per cent of the energy used is used in buildings, with 8 per cent of that amount coming from construction (Maleki,2011). Whereas, heating, ventilation, air conditioning, and lighting account for the majority of the structures' 40% energy use during operation (Kamal,2012). Passive cooling reduces solar heat gain by controlling interior temperature through the use of renewable energy sources such as the sun and wind (Inusa & Alibaba, 2017). It also utilises natural heating and cooling processes to provide comfortable interior temperatures. Through radiation, conduction, or convection, energy moves naturally in a passive design without the need for an electrical device (Song, et.al., 2021). In a hot (or warm) climate, keeping a building's interior comfortable means slowing down the pace at which heat enters the structure and promoting the expulsion of extra heat. The basic idea behind passive cooling solutions isto stop heat from developing or to remove it after it has already arrived (Kamal,2012).

The review of existing literature indicated that a study abounds on passive cooling strategies in other countries and Nigeria inclusive. For instance, Kanoma, et.al. (2022) assessed the potential of passive cooling in selected Universities buildings in the North East Sub-region. Another study by Hu, et.al., (2021) investigated the effectiveness of passive cooling strategies for residential buildings in the USA. Furthermore, Izobo-Martins, et al. (2022) looked into the passive cooling techniques used in a few malls in southeast Nigeria. Moreover, Muhamad et al. (2019) investigated a thorough approach to passive design methods for public hospitals in Malaysia.

Analyzing the review, most of the studies have been conducted regarding passive strategies in residential, shopping malls, and other house types; and a few studies on hospitals and health centres. Therefore, the paucity of studies on passive cooling strategies in hospitals is another motivation for the current study. Due to the geographical gaps, further study is required in Nigeria to bridge the identified gaps. Based on the identified contents gap and geographical gap, the current study aims to conduct a wide study to identify and prioritize passive strategies which can lead to optimal cooling in specialist hospitals in Nigeria.

II. LITERATURE REVIEW PASSIVE COOLING

Passive cooling is a sustainable method of maintaining appropriate temperatures for people's health, which improves thermal comfort in buildings by regulating energy flows by convection, radiation, or conduction and keeps them from overheating. Techniques for heat amortization, heat dissipation, and sunlight control can all be used to produce passive cooling (Marcolini, Almeida &; Barreira, 2022). The principle of passive cooling involves transferring energy from one area to another to bring the temperature below that of the surrounding surroundings (Geetha and Velraj 2012; Parys et al. 2012). The fundamental cooling element of the passive cooling idea is preventing heat from entering the building (Song et al. 2021; Elzeni et al. 2021). Passive cooling, also referred to as zero energy building techniques, can lower heat intake through the envelope, remove heat from the building, or modulate changes in internal temperature by storing and releasing heat (Alam, Sanjayan, & Zou, 2019). Cool envelope materials can help reduce unwanted heat gain through the envelope. These materials include cool- and light-coloured roof and wall products (Testa & Krarti, 2017), fluorescent materials, thermometric materials, direction-ally reflective materials, solar-retro reflective materials, and advanced window and shading solutions (Zhao, et al., 2019). Innovative glass

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technologies can also be used to control thermal and solar energy flows both passively and actively (Song et al. 2021).

➢ *Passing Cooling Strategies/Techniques*

By controlling interior temperature with renewable energy sources like the sun and wind, passive cooling is a design technique used to achieve thermal cooling and reduce solar heat absorption (Song et al. 2021). In a "passive" solar design, the interior is kept in balance by utilizing natural heating and cooling processes. Also, in a passive design, energy moves naturally by conduction, convection, or radiation without the use of an electrical device. Apart from diminishing heat transfer and eliminating surplus heat, passive cooling eliminates the necessity of relying exclusively on mechanical cooling (Alam, et.al., 2019).

Using natural cooling, improves indoor air quality, lessens the disparity in temperature between the outside and inside of the building, and creates a better, more pleasant living and working space. Additionally, it can lessen the effects on the environment, including greenhouse gas emissions and energy consumption. Within the trend of sustainable building, there has been an increase in interest in passive design for either heating or cooling, especially in the previousten years. During the warmer months, well-designed enclosures maximize air circulation for cooling purposes and block out the sun (Taleb, 2014).

➢ *Natural Ventilation*

Air moving via openings, such as inlets and outlets, from a building's exterior to the interior is referred to as natural ventilation. By eliminating "spent" air from the air without the need for mechanical systems and giving residents access to fresh air, natural ventilation is an effective approach to save energy. Utilizing the idea of natural ventilation, cross ventilation and stack effect are two cooling strategies.

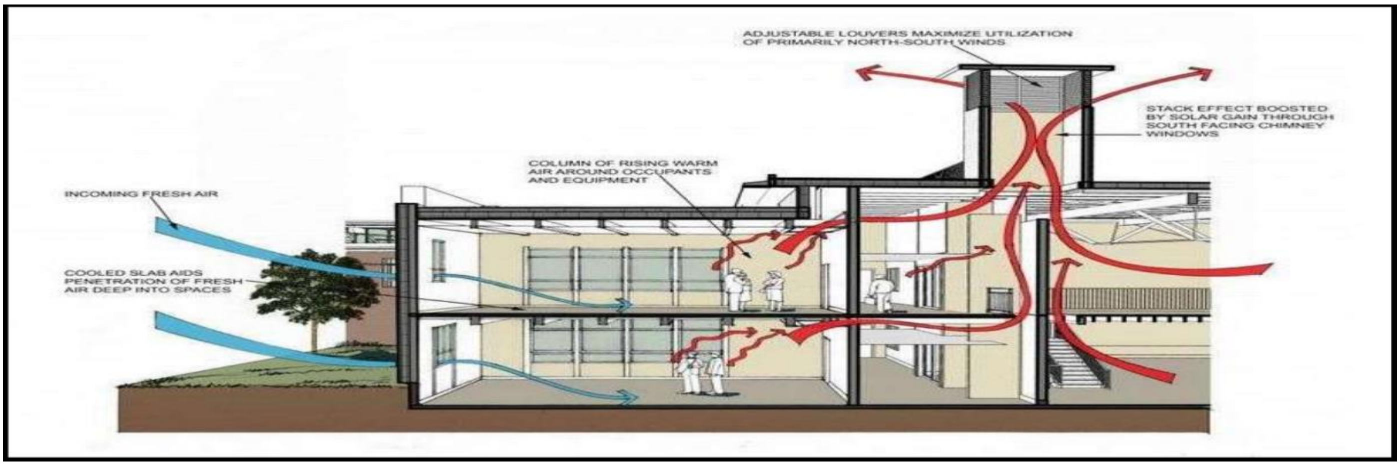

Fig 1 Air Flow in a Building
Source: Hay, 2010

➢ *Stack Ventilation*

The stack effect, sometimes referred to as the chimney effect, is caused by air entering and exiting a building and is fueled by the thermal buoyancy effect through shaft and inlet apertures (outlet). When there is a temperature differential between the interior and outside of the height difference, there is a difference in density between the inside and external air, which results in thermal buoyancy. Positive pressure develops in the upper portion of the building and negative pressure forms in the lower portion when the indoor temperature is higher than the outside temperature. A neutral plane is created between these two pressures at a specific height, where the pressures are equal (Wahab et al., 2018).

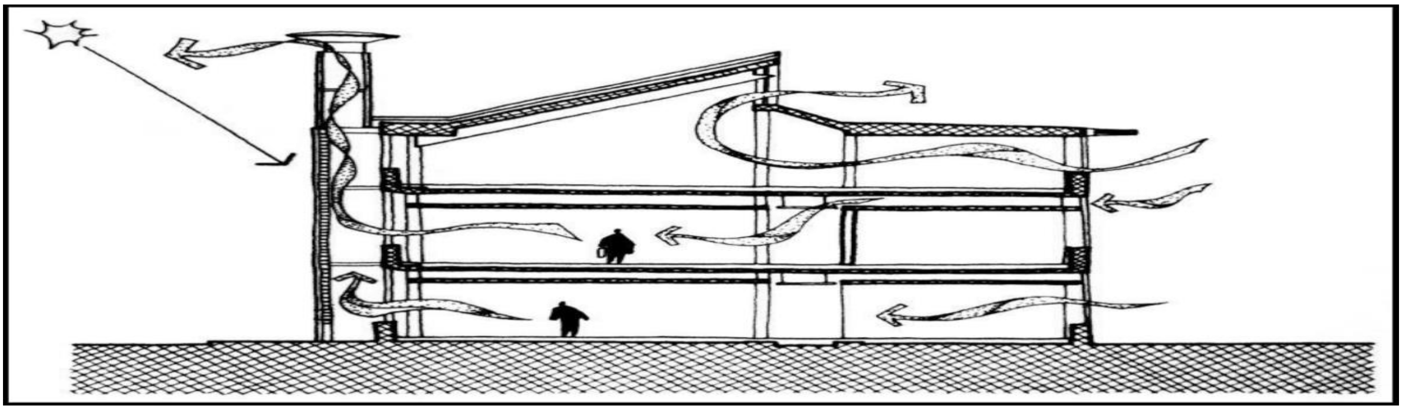

Fig 2 The Stack Effect: Hot Air Rises Due to Buoyancy, and its low Pressure Sucks in Fresh Air from Outside
Source: Mark & De Kay, 2014

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➢ *Sun Shading System*

Building occupants' visual and thermal comfort are significantly impacted by solar radiation. Solar shading systems manage the amount of light that enters a structure through apertures or glass facades, so affecting the perspective of the surrounding landscape. Additionally, they control heat flow through glazed building envelopes and lessen solar heat input. There are several ways to achieve solar shading: covering the roof (cooling roof), covering with plants and trees, covering with solar panels, and covering with surface shading. Controlling the amount of daylight that enters a building with shading devices helps to reduce uncomfortable phenomena like glare (Bellia et al., 2018).

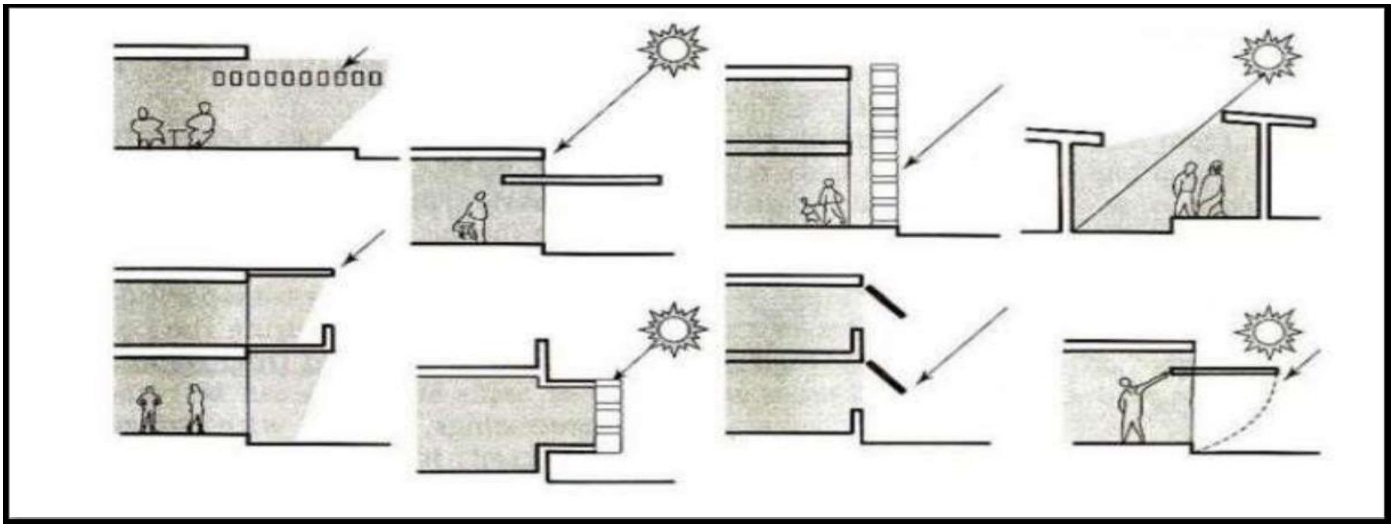

Fig 3 Different Types of Sun Shading Devices
Source: Kamal, (2012)

➢ *Insulation*

A passive design technique called insulation is used to lessen heat gain or loss caused by temperature differences between the inside and outside of a building. In hotter areas, insulation is applied to the wall or roof's outside surface, which faces the outside, to create a thermal mass that is strongly coupled with the interior and weakly coupled with the outside (Kamal, 2012).

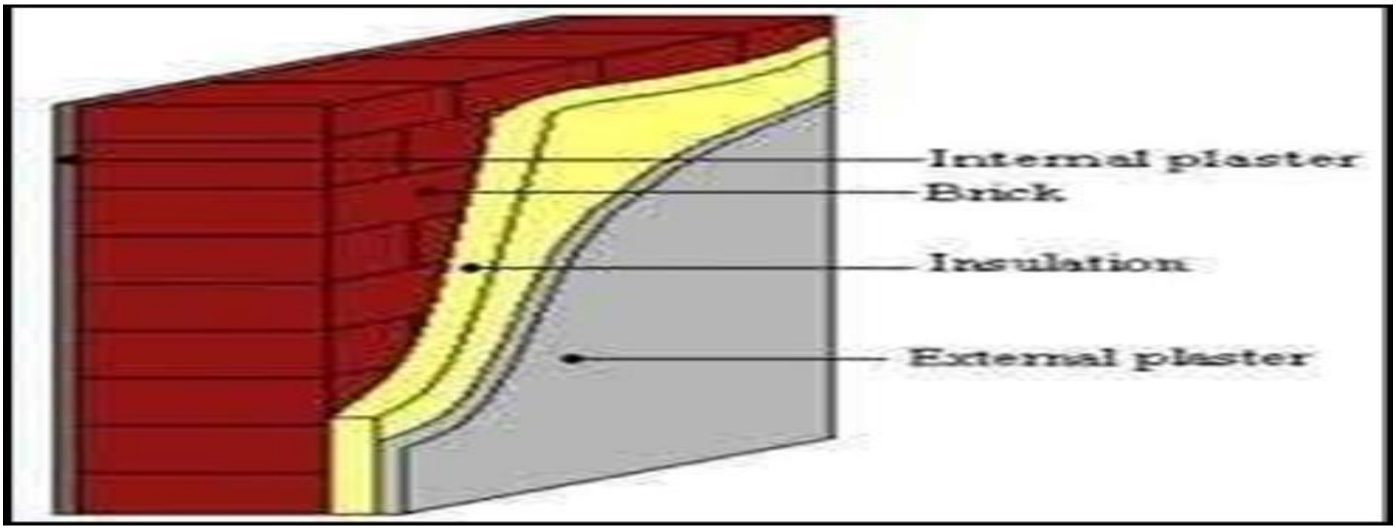

Figure 4 Insulation Placed on the Exterior Surface of the Wall
Source: Abdelgadir et al., (2019)

➢ *Evaporative Cooling*

A technique called evaporating cooling uses water to lower temperature through air cooling. With the use of an evaporative cooling system, the air is cooled to a temperature closer to that of a wet bulb by transferring the latent heat of water evaporation into sensible heat loss. (Bellia et al., 2018). The process of evaporating water to cool the air to a suitable temperature is the basis of adiabatic cooling, sometimes referred to as evaporative cooling. This method of ventilation and cooling employs water as the refrigerant. Water turns from a liquid to a gas through evaporation in an air stream during the evaporative cooling process. Heat is taken out of the air to provide the energy needed for this transfer. This mechanism cools the air as a consequence.

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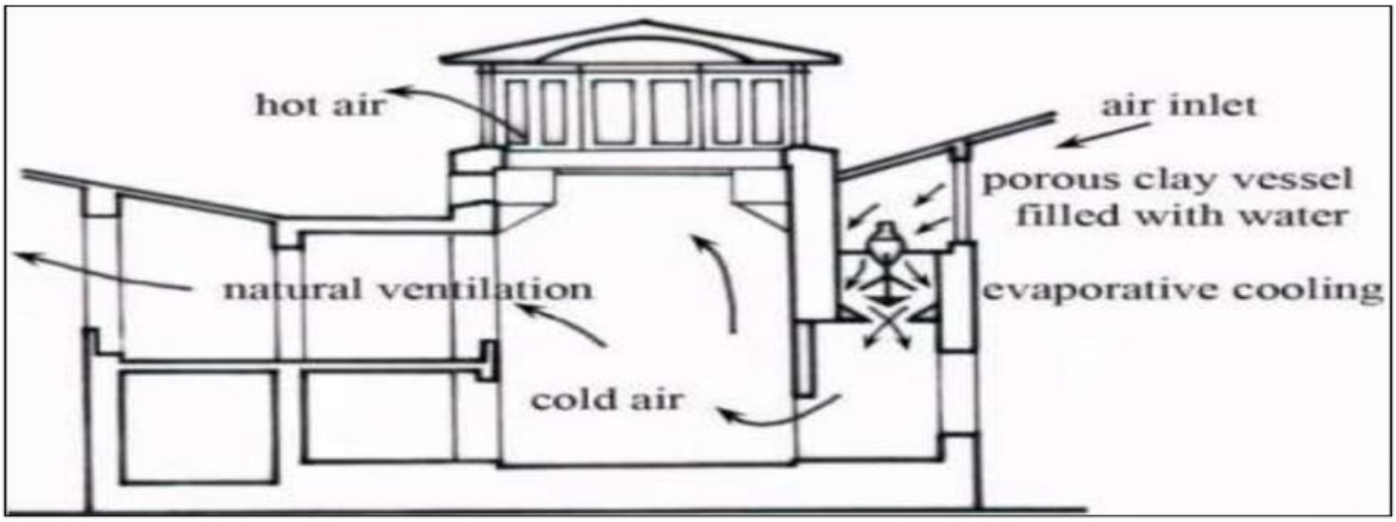

Fig 5 Evaporative Cooling

➢ *Specialist Hospital: Naturally Ventilated Ward*

The hospital is a sophisticated structure housing several engineering systems and cutting-edge medical technology that provides care for patients. To control for infections and pollution in the internal environment, the majority of hospital spaces must adhere to existing laws and regulations and meet certain clinical requirements. The primary goal of hospital architecture is to ensure optimal ventilation in medical facilities. Proper ventilation not only shields patients, employees, and guests from dangerous situations and tainted air, but it also keeps building occupants comfortable in terms of temperature.

Yau et al. (2011) examined several studies on ventilation in medical facilities and offered the most recent, pertinent data for scholars to use. The primary goals of effective ventilation in an occupied room, according to the authors, are to remove heat produced by the space and givefresh air to the occupants. Research has also indicated that greater ventilation and hospital design layout can improve patient health and create a comfortable working environment for the staff who are on duty (Zimring, Joseph & Choudhary, 2004).

The three main tenets of ward design are lighting, ventilation, and hygiene (Tai. & Ng, 2005). The demands of the patients and personnel should be the main priorities of the ward's interior design (Joseph & Rashid, 2007). One popular technique for offering high airflow rates with less energy usage is natural ventilation. Natural ventilation is now a desirable alternative, particularly when building expensive healthcare facilities, thanks to recent technological developments and improvements made possible by mechanical systems and other control systems. Yuan et al. (2018) observed that installing mechanical ventilation is less expensive when there are no indoor emissions, as long as the filtration efficiency and envelope air tightness meet the necessary standards. This finding has implications for the study's economic benefit. To stop the transmission of any airborne illnesses, the World Health Organization (WHO) has suggested a minimum ventilation rate.

➢ *Previous Studies*

In their study, Kakuturu et al. (2022) evaluated the efficiency of passive cooling design techniques to lessen overheating in UK epilepsy care facilities. The study found that night ventilation, shade, and high albedo surfaces were the most effective combination tactics for avoiding overheating using dynamic thermal modelling software. The risks of overheating in bedrooms at night were not eliminated by passive cooling systems in 2050s and 2080s future climate change scenarios.

Song, et al. (2021) conducted a study on the application of traditional passive cooling techniques to warm, arid regions in Iran, taking economic cost and efficiency analysis into consideration. They did this by using the literature analysis. Their results confirmed that it is recommended to use a passive cooling system in a tropical climate.

In a different study, Hu, et al. (2023) examined the efficacy of passive cooling techniques for residential buildings in the USA using a systematic review and meta-analysis. According to the review, implementing different passive solutions can result in, on average, a 2.2 ◦C decrease in interior temperature, a 31% reduction in cooling load, 29% energy savings, and a 23% increase in thermal comfort hour extension.

Furthermore, Freeman (2019) used an integrated design approach to research Jordanian advancements in passive cooling design. Using the literature study as a guide, the researchers concluded that, because passive cooling systems have no negative environmental effects and emit no greenhouse gases, they are a great option for building design.

Abbakyari and Taki (2017) examined several passive design techniques to increase the energy efficiency of a common mass house type in Nigeria. To choose a sample for the EnergyPlus tool's thermal analysis, a case study of mass housing was conducted. The initial step was to optimize the building fabric, which included suggesting a

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long-term substitute for the traditional brick material. The use of passive techniques to reduce the energy demand for cooling came next. The building simulation revealed a noteworthy decrease in cooling of thirty per cent. This is noteworthy in particular because Nigeria relies on fuel-based backup power production systems due to its insufficient and inconsistent electricity supply.

Using the bioclimatic approach, Inusa and Alibaba (2017) conducted a study on the implementation of passive cooling techniques in residential buildings: a case study of Northern Nigeria. Based on the analysis, the study concluded that implementing these strategies will lower energy consumption, provide a more comfortable living environment, and result in energy-efficient, low-carbon buildings that respect the environment.

In a different study, Izobo-Martins, et.al (2022) Investigated Passive Cooling Strategies in Selected shopping malls in southwestern Nigeria. Adopting the observation guide and case studies. It was observed that the selected shopping malls did not fully adopt passive cooling design strategies as it was observed that most of them still depend on HVAC systems. This indicates that passive cooling design strategies were not considered when the malls were at the design stage.

III. METHODOLOGY

This study adopted a qualitative research design and relied absolutely on the use of secondary data sources. On that note, existing studies on passive cooling strategies were reviewed and analyzed. Content analysis technique. Shava et al. (2021) stated that qualitative content analysis is one of the research methods used to analyze text data.

IV. RESULTS AND DISCUSSION

The current study focused on the evaluation of passive cooling strategies in a urologist specialist hospital, in Ikoyi, Lagos State. Specifically, the study examined the identify and prioritize passive strategies which can lead to the optimal cooling in specialist hospitals in Nigeria. Adopting qualitative research design and content analysis, the study identified various passive cooling strategies suitable for urologist specialist hospitals. The identified cooling strategies include; Natural ventilation, stack ventilation, sun shading system,insulation and evaporating cooling.

With little to no energy usage, the aforementioned passive cooling techniques enhance indoor thermal comfort in healthcare buildings by controlling heat uptake and dissipation. It is more acceptable to deploy passive cowlings in general healthcare centres and specialized hospitals in particular. Given Nigeria's unstable power supply and expensive electricity expenses throughout the study period. Furthermore, because passive cooling enhances indoor comfort, boosts energy efficiency, and adds to sustainable and aesthetically pleasing features, it offers a dependable, affordable, and energy-efficient building design option.

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