A Critical Analysis of Architectural Design Strategies for Prevention and Control of Covid-19 Infection in Health Care System: The health security implications in Akwa Ibom State

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ABSTRACT

The study sought to assess architectural design strategies for prevention and control of Covid-19 infection in health care system: The health security implications in Akwa Ibom State. Correlation survey design was adopted in the study and the study was conducted in Akwa Ibom State. The population of the study comprised architects, medical doctors, nurses, mid-wives and lab technicians. Based on the experience of the respondents and their ability to provide the needed information, purposive sampling technique was used to select 40 architects, 30 medical doctors, 20 nurses, 20 mid-wives and 20 lab technicians, giving a total of 130 respondents used for the study. The Instrument titled "Architectural Design Strategies for Health Care System Questionnaire (ADSHCSQ)" was used. Face and content validation of the instrument was carried out by an expert in test and measurement/evaluation from University of Uyo to ensure that the instrument was accurate for the study while Cronbach Alpha technique was used to determine the level of reliability of the instrument which generated a reliability coefficient of 0.80. The value was high enough to justify the use of the instrument. The researcher subjected the data obtained to descriptive statistical analysis used to answer the research questions and simple regression used for test of the hypothesis. The test for significance was done at 0.05 alpha levels. The study revealed that there is very high level of covid-19 infection in Akwa Ibom State. The study also proved that architecture play important roles in building healthy environments including Design for Social Distancing, Design to enhance Natural Ventilation, Design to Enhance Daylight or Sunlight, Design with Adaptive Finishing Materials and Construction Methods and Flexible design with sustainability features. Finally, the result proved that there is significant effect of architectural design strategies on effective safety and protection of human lives in Akwa Ibom State. One of the recommendations was that governments should enact federal legislation to encourage state and local governments to adopt and enforce healing design building codes as a key strategy for making communities more resilient to disease.

KEYWORDS: Architectural Design Strategies, Prevention and Control of Covid-19, Heath Care System and Akwa Ibom State

Introduction

Sustainable architecture according to Kim cited in Emmanuel, Osondu and Kalu (2020) is the adoption of efficient energy and material resources in buildings, incorporation of the dwellers into micro-climate control and the natural environment. The purpose of sustainable design is to find architectural responses, promote the well-being/coexistence of inorganic elements, living organisms and humans that make up the ecosystem. The architectural design process of a healthcare facility should be an integral part of infection prevention and control mechanism. Van-Khai (2016) added that the goal of sustainable architecture for hospital design apart from low energy and low carbon emission, it must integrate design strategies for infectious disease prevention and control (IPC). According to World Health Organization (WHO), infection disease prevention and control (IPC) is a scientific method and hands-on solution intended to avert harm or health dangers initiated by infection to patients and health workers (WHO, 2020). In the epidemic of widely drug-resistant tuberculosis which occurred in 2006 in Tugela Ferry-South Africa, the architectural design of the hospital building took a significant share of the blame (Alcorn, 2007). The implication is that human health and well-being are intrinsically connected to the built environment. According to Center for Disease Control (CDC, 2019) with regard to the mode of Covid-19 mode of transmission and in collaboration with Lateef (2009), it has become imperative for a balance between the concept of open access design and the need for control measures to lessen the rate of infections. The architecture of hospitals has been evolving from time to time to fit into the demands of the healing process. According to Guenther and Vittori (2008) and Cameron (2010), there exists a long-recognized relationship between health and architecture, they added that the relevance of suitable building in the healing process is well known to both medical and architectural professionals.

Statement of the Problem

It is sad to say that the rapidly emerged threat of Covid-19 virus is impacting heavily on the health system across the world. The global disruption of today's health system draws much more attention to the architectural design structures of healthcare centres to see if their built environment were erected to be disease resilient. It is due to this fact that this research is carried out which is in order to find out the architectural design strategies for prevention and control of covid-19 infection in health care system.

Objective of the Study

Specifically, the study sought to:

1. Find out the extent of Covid-19 in Akwa Ibom State
2. Find out the roles of architecture in prevention and control of Covid-19 infection
3. Assess the extent to which the architectural design strategies could predict effective safety and protection of human lives in Akwa Ibom State

Research Questions

1. What is the extent of Covid-19 in Akwa Ibom State?
2. What are the roles of architecture in prevention and control of Covid-19 infection?
3. What is the extent to which architectural design strategies could predict effective safety and protection of human lives in Akwa Ibom State?

Research Hypothesis

$H0_1$. There is no significant extent to which architectural design strategies predict effective safety and protection of human lives in Akwa Ibom State.

Conceptual Review

Concept of Heath Care System

Health care system is the organization of people, institutions, and resources that deliver health care services to meet the health needs of target populations (Wikipedia, 2017). There is a wide variety of health systems around the world, with as many histories and organizational structures as there are nations. Tacitly, nations must design and develop health systems in accordance with their needs and resources, although common elements in virtually all health systems are primary healthcare and public health measures (White, 2015). Health systems have a vital and continuing responsibility for people's health throughout the lifespan. They are crucial to the healthy development of individuals, families and societies everywhere. The real progress in health towards the Millennium Development Goals and other national health priorities depends vitally on stronger health systems based on primary health care. According to the World Health Organization (WHO), each national health system should be directed to achieve three overall goals: good health, responsiveness to the expectations of the population, and fairness of financial contribution. Progress towards them depends crucially on how well systems carry out four vital functions such as: service provision, resource generation, financing and stewardship (WHO, 2000). Comparing the way these functions are actually carried out provide a basis for understanding performance variations over the time and among countries. There are minimum requirements which every health care system should meet equitably: access to quality services for acute and chronic health needs; effective health promotion and disease prevention services; and appropriate response to new threats as they emerge (WHO, 2002).

Concept of Covid-19 Pandemic

An outbreak of COVID-19 caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) began in Wuhan, Hubei Province, China in December 2019, the current outbreak is officially a pandemic (Murphy and Bell, 2020). The virus is typically rapidly spread from one person to another via respiratory droplets produced during coughing and sneezing. It is considered most contagious when people are symptomatic, although transmission may be possible before symptoms show in patients. Time from exposure and symptom onset is generally between two and 14 days, with an average of five days. Common symptoms include fever, cough, sneezing and shortness of breath. Complications may include pneumonia, throat pain and

acute respiratory distress syndrome (Hafeez, Ahmad, Ali Siddqui, Ahmad and Mishra, 2020). Currently, there is no specific antiviral treatment or vaccine; efforts consist of symptom abolition supportive therapy. Recommended preventive measures include washing your hands with soap, covering the mouth when coughing, maintaining 1-meter distance from other people and monitoring and self-isolation for fourteen days for people who suspect they are infected (CDC, 2020). The standard tool of diagnosis is by reverse transcriptionpolymerase chain reaction (rRT-PCR) from a throat swab or nasopharyngeal swab. The infection can also be diagnosed from a combination of symptoms, risk factors and a chest CT scan showing features of pneumonia (Velavan and Meyer, 2020).

Concept of Architecture

Architecture is both the process and the product of planning, designing, and constructing buildings or other structures (Encyclopedia, 2017). Architectural works, in the material form of buildings, are often perceived as cultural symbols and as works of art. Historical civilizations are often identified with their surviving architectural achievements (Pace, 2004). The practice, which began in the prehistoric era, has been used as a way of expressing culture for civilizations on all seven continents (Wikipedia, 2016). For this reason, architecture is considered to be a form of art. Texts on architecture have been written since ancient time. The earliest surviving text on architectural theory is the 1st century AD treatise *De architectura* by the Roman architect Vitruvius, according to whom a good building embodies *firmitas*, *utilitas*, and *venustas* (durability, utility, and beauty). Architecture began as rural, oral vernacular architecture that developed from trial and error to successful replication. Ancient urban architecture was preoccupied with building religious structures and buildings symbolizing the political power of rulers until Greek and Roman architecture shifted focus to civic virtues (Caves, 2004). Indian and Chinese architecture influenced forms all over Asia and Buddhist architecture in particular took diverse local flavors (Wikipedia, 2019). During the European Middle Ages, Pan-European styles of Romanesque and Gothic cathedrals and abbeys emerged while the Renaissance favored Classical forms implemented by architects known by name (Wikipedia, 2007). The roles of architects and engineers became separated. Modern architecture began after World War I as an avant-garde movement that sought to develop a completely new style appropriate for a new post-war social and economic order focused on meeting the needs of the middle and working classes. Emphasis was put on modern techniques, materials, and simplified geometric forms, paving the way for high-rise superstructures. Many architects became disillusioned with modernism which they perceived as ahistorical and anti-aesthetic, and postmodern and contemporary architecture developed (Wikipedia, 2014). Over the years, the field of architectural construction has branched out to include everything from ship design to interior decorating.

Architectural Design Strategies

Sustainable architecture is the use of design strategies that reduce the negative environmental impact from a built environment. Architects take the site landscape, energy management, and stormwater management into consideration when planning, and then use environmentally friendly systems and building materials during construction (Carbonnier, 2018). The key concepts that enable architects to design and build environmentally-friendly houses and other eco-friendly buildings hinge on energy efficiency and sustainable resources. Sustainable strategies embrace the full spectrum of technologies developed to ensure buildings are as

environmentally-friendly as possible (Tobias, 2020). When designing a building with sustainability in mind, architects uses the following architectural strategies:

Passive Sustainable Design: Passive strategies involve taking advantage of natural environmental factors such as sun orientation and climate when siting and being thoughtful about window placement and operation (Carbonnier, 2018). This enables designers to literally manage day-lighting and natural ventilation to their own advantage, and in this way reduce the energy requirements for the house.

Active Sustainable Design: Active design strategies involve various engineers who design and implement highly efficient HVAC, electrical, plumbing, and other systems, which are designed to have small environmental footprints.

Renewable Energy Systems: Renewable energy systems, including those that harness solar and wind energy, are also great options for some buildings. These systems are often used in conjunction with passive design strategies (Tobias, 2020).

Green Building Materials: While some building materials are more sustainable than others, the basic strategy here is to use materials that don't plunder natural resources and are manufactured using responsible manufacturing techniques. It is also important to avoid materials that contain pollutants. The strategy also includes using recycled materials.

Indigenous Landscaping: Landscaping choices can make a big impact in civic building water consumption. By using trees, plants, and grasses that are native to the area, architects can greatly reduce irrigation needs (Carbonnier, 2018). Landscaping can also be used as part of a passive energy strategy. For instance, planting trees that shade the roof and windows of the house on hot days reduces solar heat gain inside the building.

Stormwater Management: Whether the building being constructed is a small rural cottage, a house in the suburbs, a skyscraper in the city, or a public building in the country, stormwater management is essential. Plumbing engineers design storm drains that channel water away from buildings. Traditionally, downspouts from gutters were connected to storm drains, but in the interests of sustainability, it is advisable to allow rainwater to be absorbed into the garden, or, better still, for rainwater to be collected in one or more rain barrels. Other measures that can assist with sustainable stormwater management include green roofs that are planted to enable infiltration of rainwater and permeable surfaces for driveways and parking areas. Retention ponds also help to reduce runoff, particularly in urban environments.

The Roles of Architectural Design Strategies in Controlling of Covid-19

When architectural spaces are conceptualized and designed with a clear goal, such space can promote or aid the inhibition of infectious diseases. This was first experimented with by Florence Nightingale cited in Emmanuel et. al. (2020), when she launched the hospital ward model, stated that natural daylight and cross ventilation are significant components to disinfect and lessen the infection occurrence in hospitals (Young, De Smith, Chambi and Fin, 2011). Below are some design strategies to employ in adapting our domestic, commercial, residential, and hospital spaces for infection, prevention, and control.

Design for Social Distancing: Provide adequate spacing in waiting areas, corridors, hallways, stair and entrance lobby to support social distancing of at least 1000 mm apart. This will not only reduce contact transmission but will create safe distancing since current research reveals that aerosol droplets travel only short distances of 1000 mm to 2000 mm before settling on surfaces (Baker, Stevens and Bloomfield, 2001). Corridors should be designed to discourage informal conversations by eliminating nook with bench or ledge. The ledge corridor design was earlier introduced to hospital design by Carthey (2008) to encourage interactions among team members.

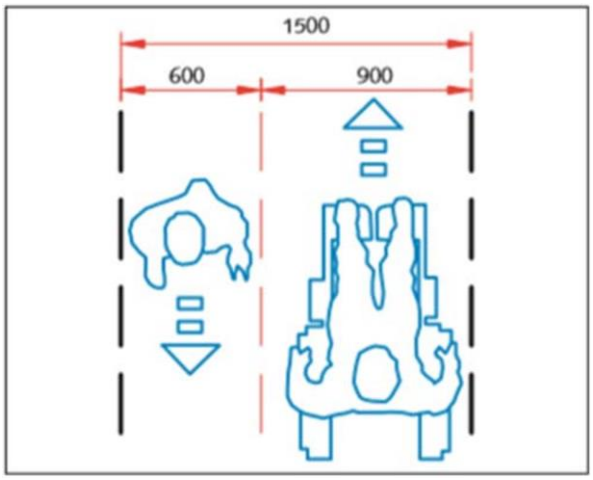

Fig. 1: *Corridor width as recommended by UKDH (2013)*

Design to enhance Natural Ventilation: Ventilation considerably is the movement of air within a space, often shaped by variance in air pressure. Ventilation is very critical in mitigating nosocomial and other infectious diseases. Recent studies have shown that an appropriate ventilation rate can effectively decrease the cross-infection risk of airborne infections in healthcare facilities and public spaces (Zhao, Jiang, Li, Yang and Zhang, 2009; Hua, Yuguo, Seto, Patricia, Ching and Sun, 2010). Natural ventilation can provide a higher ventilation rate than power-driven ventilation in an energy-efficient manner.

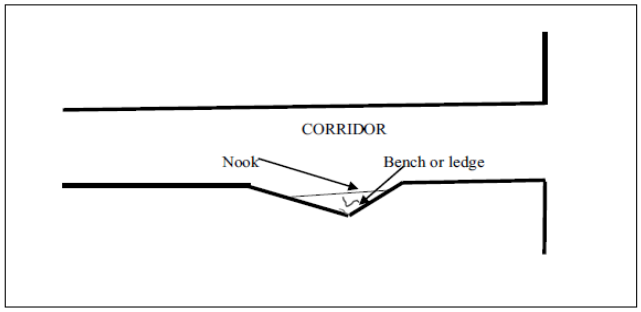

Fig. 2: *E.g. of corridor nook earlier proposed and being use by some hospitals (Carthey, 2008)*

Design to Enhance Daylight or Sunlight: There is evidence that good fenestrations and daylight in structures can sway the spread of airborne pathogens. Evidently, before the advent of antibiotics, ventilation, and sunlight were thought to be a significant safety measures against infectious diseases (Nightingale Florence cited in Emmanuel et. al., 2020). Advanced Studies indicated that sunlight can kill a variety of bacteria such as anthrax, tuberculosis, etc. (Hockberger, 2000). A more recent study by Strong (2020) posited that a diffused sunlight or

daylight over two layers of glass from a north window was discovered to be very effective in killing hemolytic streptococci within thirteen days without antibiotics, with the similar strain surviving in the dark, at room temperature for one hundred and ninety-five (195) days. Daylighting is a good germicidal factor and can inhibit infection (Lateef, 2009).

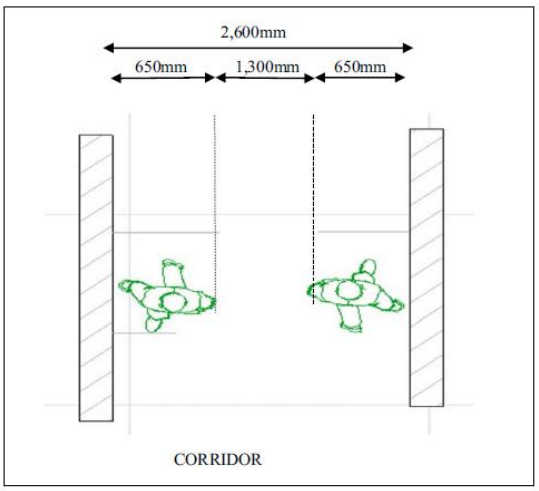

Fig. 3: *Suggested minimum Corridor width (Emmanuel et. al., 2020)*

Design with Adaptive Finishing Materials and Construction Methods: Florence Nightingale stated that the plaster used in construction, which has many tiny voids, was thought to be the locality and transmission of pathogenic factors. Hence, it is necessary to choose the type of plaster with high solidity or to use covering material such as special paints. Recent studies on coronavirus(covid-19) suggest that the virus behaves differently and possesses different life span with different material surfaces. Thus, architects must rethink the material selection process, material specification writing and treatment of surfaces (Khai, 2016).

Flexible design with sustainability features: Although not directly concerned with the infection prevention requirements, it is necessary to enhance natural day light and natural ventilation to create a healthy, friendly environment for people and nature by adaptive expandable architecture measures (Khai, 2016). In addition, create safe psychology for patients on vision and sound, clearly show the entrance, avoid corridors that are too long and avoid seeing unfavorable views. Hence, a flexible design should be able to adapt to changes and accommodate new challenges such as the novel covid-19 pandemic (Hobday and Dancer, 2013).

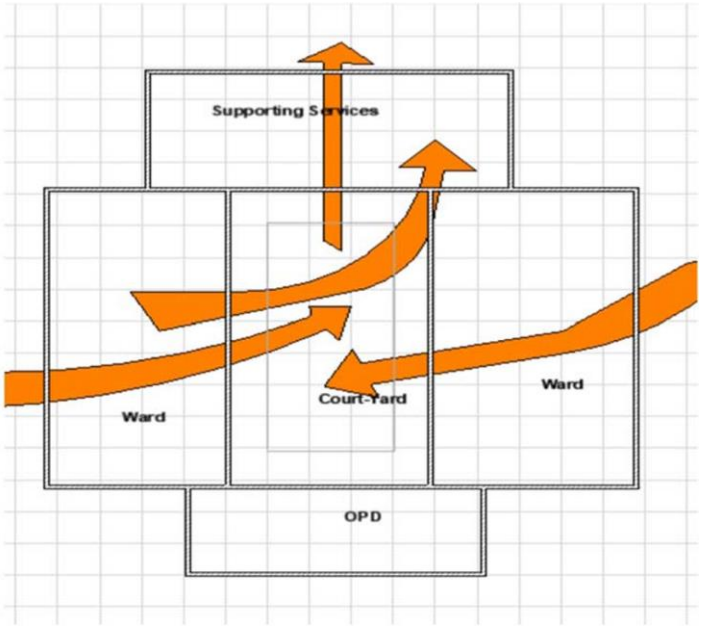

Fig. 4: *Example of Court-Yard approach (Emmanuel et. al., 2020)*

Methodology

Correlational survey design was adopted in the study and the study was conducted in Akwa Ibom State. The population of the study comprised architects, medical doctors, nurses, mid-wives and lab technicians. Based on the experience of the respondents and their ability to provide the needed information, purposive sampling technique was used to select 40 architects, 30 medical doctors, 20 nurses, 20 mid-wives and 20 lab technicians, giving a total of 130 respondents used for the study. The Instrument titled "Architectural Design Strategies for Health Care System Questionnaire (ADSHCSQ)" was used. Face and content validation of the instrument was carried out by an expert in test and measurement/evaluation from University of Uyo to ensure that the instrument was accurate for the study while Cronbach Alpha technique was used to determine the level of reliability of the instrument which generated a reliability coefficient of 0.80. The value was high enough to justify the use of the instrument. The researcher subjected the data obtained to descriptive statistical analysis used to answer the research questions and simple regression used for test of the hypothesis. The test for significance was done at 0.05 alpha levels.

Results

Research Question One: The research question sought to find out the extent of Covid-19 in Akwa Ibom State. To answer the research percentage analysis was performed on the data, (see table 1).

Table 1: Percentage analysis of the extent of Covid-19 in Akwa Ibom State

EXTENT	FREQUENCY	PERCENTAGE (%)
VERY HIGH EXTENT	63	48.46**
HIGH EXTENT	36	27.69
LOW EXTENT	19	14.61

VERY LOW EXTENT	12	9.23*
TOTAL	**130**	**100%**

**** The highest percentage frequency**
*** The least percentage frequency**
SOURCE: Field survey

The above table 1 presents the percentage analysis of the extent of Covid-19 in Akwa Ibom State. From the result of the data analysis, it was observed that the highest percentage (48.46%) of the respondents affirmed that the extent is very high, while the least percentage (9.23%) of the respondents stated that the extent of Covid-19 in Akwa Ibom State high.

Research Question Two: The research question sought to find out the roles of architecture in prevention and control of Covid-19 infection. To answer the research percentage analysis was performed on the data, (see table 2).

Table 2: Percentage analysis of the roles of architecture in prevention and control of Covid-19 infection

ROLES	FREQUENCY	PERCENTAGE (%)
Design for Social Distancing	32	24.62**
Design to enhance Natural Ventilation	28	21.54
Design to Enhance Daylight or Sunlight	26	20
Design with Adaptive Finishing Materials and Construction Methods	21	16.15*
Flexible design with sustainability features	23	17.69
TOTAL	**130**	**100(%)**

**** The highest percentage frequency**

*** The least percentage frequency**

SOURCE: Field survey

The above table 2 presents the percentage analysis of the roles of architecture in prevention and control of Covid-19 infection. From the result of the data analysis, it was observed that the tagged "Design for Social Distancing' (24.62%) rated the highest percentage affirmed by the respondents of the roles while the "Design with Adaptive Finishing Materials and Construction Methods" (16.15%) rated the least percentage affirmed by the respondents of the roles of architecture in prevention and control of Covid-19 infection.

Research Question Three: The research question sought to find out the extent to which architectural design strategies could predict effective protection of human lives in Akwa Ibom State. To answer the research descriptive analysis was performed on the data, (table 3)

Table 3: Descriptive statistics of the extent to which architectural design strategies could predict effective protection of human lives in Akwa Ibom Sate.

Variable	N	Arithmetic mean	Expected mean	R	Remarks
PROTECTION	130	14.54	12.5	0.70	*Moderately Strong
ARCHITECTURAL		15.92	12.5		

Source: Field Survey

The above table 3 presents the result of the descriptive analysis of the extent to which architectural design strategies could predict effective protection of human lives in Akwa Ibom Sate. The two variables were observed to have Moderately Strong at 70%. The arithmetic mean for protection (14.54) was observed to be greater than the expected mean score of 12.5. In addition to that, the arithmetic mean as regards architectural (15.92) was observed to be higher than the expected mean score of 12.5. The result therefore means that there is remarkable extent to which architectural design strategies could predict effective protection of human lives in Akwa Ibom State.

Hypothesis One: The null hypothesis states that there is no significant extent to which architectural design strategies predict effective protection of human lives in Akwa Ibom State. In order to answer the hypothesis, simple regression analysis was performed on the data (see table 4)

TABLE 4: Simple Regression Analysis of the extent to which architectural design strategies predict effective protection of human lives in Akwa Ibom State

Model	R	R-Square	Adjusted R Square	Std. error of the Estimate	R Square Change
1	0.70a	0.48	0.48	1.33	0.49

***Significant at 0.05 level; df= 128; N= 130; critical R-value = 0.197**

The above table 4 shows that the calculated R-value (0.70) was greater than the critical R-value of 0.197 at 0.5 alpha levels with 128 degrees of freedom. The R-Square value of 0.48 predicts 48% of the extent to which architectural design strategies predict effective protection of human lives. This rate of percentage is highly positive and therefore means that there is significant extent to which architectural design strategies predict effective protection of human lives in Akwa Ibom State. It was also deemed necessary to find out the influence of the variance of each class of independent variable as responded by each respondent (table 5).

TABLE 5: Analysis of variance of the extent to which architectural design strategies predict effective protection of human lives in Akwa Ibom State.

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	212.40	1	212.41	120.35	.000b
Residual	225.90	128	1.77		
Total	438.31	219			

a. Dependent Variable: Human Live
b. Predictors: (Constant), Architectural Design Strategies

The calculated F-value (120.35) and the P-value as (.000b). Being that the P-value (.000b) is below the probability level of 0.05, the result therefore means that there is significant extent exerted by the independent variables i.e. architectural design strategies on the dependent variable which is human live. The result therefore is in agreement with the research findings of Carbonnier (2018) who avowed that sustainable architectural design strategies reduce the negative environmental impact from a built environment. The key concepts that enable architects to design and build environmentally-friendly houses and other eco-friendly buildings hinge on energy efficiency and sustainable resources. Sustainable strategies embrace the full spectrum of technologies developed to ensure buildings are as environmentally-friendly as possible (Tobias, 2020). The significance of the result caused the null hypotheses to be rejected while the alternative was accepted.

Conclusion

Health care delivery system is the organized response of a society to the health problems and needs of the population. Countries differ considerably by the levels of income and economic potential, diversity of health problems and needs, the way they organize their response, as well as

in the degree of central management, sources of financing and control of their health care system regarding coordination, planning and organization. As COVID-19 has shown, an outbreak can occur at any time. Architecture can be an agent to help reduce the risk, and to make communities more resilient to disease. Architecture play an important role in building healthy environments using health-giving attributes as light, airflow, nature, spatial design, and the right building materials play in promoting healing, and controlling the spread of disease. Therefore, the study reveals that there is significant extent to which architectural design strategies predict effective protection of human lives in Akwa Ibom State.

Recommendations

Based on the findings of this study, the following recommendations was deemed necessary:

1. Governments should enact federal legislation to encourage state and local governments to adopt and enforce healing design building codes as a key strategy for making communities more resilient to disease.

2. Architects and engineers directly involved in designing or constructing health-care facilities should be given a form of training in public health.

3. The Building Industry, Including Building Owners and Operators should be encouraged to utilize high-efficiency filtration systems (MERV 13 or higher) to remove particulate matter (PM), VOCs, and airborne pathogens in indoor spaces.

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