

# Digital Simulation in Health Facility Architectural Design

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## ABSTRACT

This paper describes the need and implementation of digital simulation in Indonesia's architectural design of health facilities. The background of this research is based on the detail of complex architectural needs in planning and architectural design in health facilities. Simulation requirements are needed to support the analysis and design exploration stages in architectural design in health facilities. The digital simulation is expected to support the architectural planning process to produce effective, efficient, healthy, and practical designs for building and environmental comfort and optimizing health services. Using the literature review method, the results of this study are expected to contribute to designing and developing architecture in health facilities and being a reference material that is easily understood by the community and stakeholders.

**Keywords:** Digital simulation, Architecture, Healthcare facilities, Design analysis.

## 1. INTRODUCTION

Health facility services require operational support, both medical and physical resources. Health facilities such as hospitals operate 24 hours for seven days, so they require sophisticated facilities and systems with strict security requirements and still provide quality comfort for users to support medical and non-medical activities in it. In terms of architecture, hospitals' indoor and outdoor environments have strict qualifications because they are closely related to infectious zoning and safety. This situation also coincides with the hope of optimizing energy and the principle of sustainability in building performance to achieve the physical environment's effectiveness and efficiency in health facilities.



**Figure 1** Design precision and outcomes in Healthcare Facilities.

The picture above shows the needs in Health facilities, users of Health facilities, and the design outputs for Health facilities. The complexity of the architectural needs in these health facilities is the

author's basis for describing the architectural needs and the correlation supporting the analysis process using digital simulations. In planning and designing Health Facilities, especially in Hospitals, it is necessary to observe and meet (1) the functional, (2) technical, and (3) behavioural needs of users. Relationships and interrelated space needs must be accommodated by Operational Standards according to Government Health Regulations to be used optimally and meet health and safety requirements. Four keys must be considered: safety, health, comfort, and convenience. They are accommodating designs with room sizes according to activities, health protocols, and proximity to space. The architectural conditioning is expected not only to be helpful as a patient recovery room but also to improve the performance of medical staff and services. A healthy space with good thermal conditioning can prevent sick building syndrome. We know that architecture, healthcare facilities, and digitization are evolving rapidly. Digital simulation in architecture can support the analysis process in design. It is hoped that the results obtained are more accurate and can be implemented better in design results.



**Figure 2** Design precision and outcomes in Healthcare Design.

The purpose of this research is reviews the literature on applying digital simulations in the design process in health facilities. Reviews the literature on applying digital simulations in the design process in health facilities. Focus on architectural simulation studies, especially those that can be implemented in the design of health facilities. The research uses descriptive qualitative methods, and the author reviews the literature from previous studies to obtain state of art and embryos for further research development. Architectural simulations and experiments can be the basis of the analysis and testing of architectural products. The product can be tested beforehand related to the feasibility, function, and suitability to achieve effectiveness, optimization and efficiency of building performance in health facilities.

## 2. METHODOLOGY

The research methodology of this research is; first, is knowing, compiling, and narrating the background of the development of this research. Health facilities need buildings and environments that are healthy, effective, efficient and comply with regulations. Secondly, Digital developments can support the process of simulation and experimentation in designing health facilities. Secondly is collecting data. Collect literature related to digital architectural simulation applied in health facility design. The literature includes digital simulations related to 4 critical design aspects in health facilities: safety, health, comfort, and convenience.

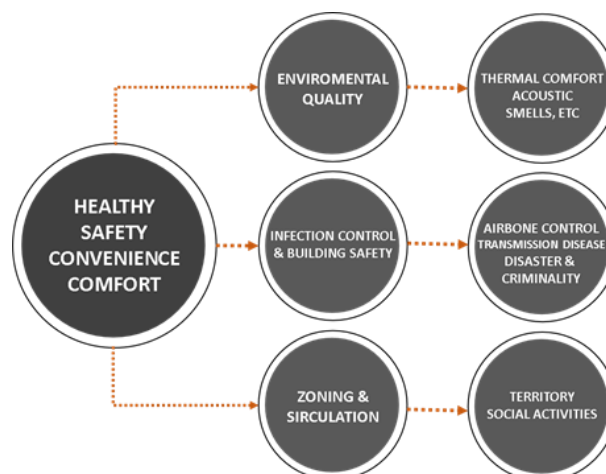


**Figure 3** Methodology of research.

Thirdly, we analyze the data. Examine the literature obtained and conclude state of the art as the basis for further research to produce useful and novelty findings. Fourthly, the discussion step examines the substance of each piece of literature. Then concludes the needs and digital tools needed for the design process in health facilities from the literature review. After all, we summarized and narrated related to digital architectural simulations that can be implemented in the analysis and testing of design results in health facilities.

## 3. RESULTS AND DISCUSSION

In the result discussion stage, we discussed digital simulation in design application in health facilities; we referred to the interrelationships and expectations of the four critical health facility designs mentioned in the previous chapter, namely: Health, safety, convenience and comfort. The relationship between the four keywords is related to design needs, conditions in the field, design analysis, and risk management when unexpected things occur in the building or environment of health facilities.



**Figure 4** Substance of observation of Health Facilities design and digital architectural simulation.

The picture above shows what substances we need to discuss and sharpen in the design of Health facilities with digital architectural simulations. First, we need to discuss that it is necessary to pay attention to the achievement of environmental quality. The output of this observation is to know the existing condition both before and after the health facility is built related to the thermal comfort of the building and the environment, the level of good comfort and noise threshold, olfactory comfort, and air pollution.

Thermal comfort is not only a requirement for comfort, safety and health but can also support energy effectiveness and efficiency. By optimizing thermal comfort, we can create a balanced environmental quality and help reduce excess energy consumption. Thermal comfort can also affect building users' physical

performance and sensory perceptions, such as those related to concentration, physical performance, and stress levels. Design strategies that we often encounter in buildings in optimizing thermal comfort are conditioning the orientation of the building, the dimensions of space and building mass, conditioning the location and dimensions of air ventilation, air movement, humidity, construction and materials used and even other external factors such as position and selection of vegetation, inside and outside the building.

Wahyudi et al. [1] studied about Evaluation of the OTTV value of Meuraxa hospital building, Banda Aceh. This research carried out resulted in a reference design of the envelope and obtained the causal factors that influence the magnitude of the OTTV value from performing a calculation simulation on all the variables in the Hospital Emergency Installation Building. Concerning the limit of the overall thermal transfer value on the outer wall or called the Overall Thermal Transfer Value (OTTV) of the Indonesian National Standardization Agency SNI 03-6389-2011, which is a maximum of 35 Watt/m<sup>2</sup>, the researchers studied three components, namely: wall conduction, solar radiation and glass conduction. To the orientation of the building facade. To get the expected results, the researchers simulated modifications of U<sub>f</sub> (double glass), U<sub>w</sub> (Outer Wall Insulation), WWR (glass ratio), a (paint colour), SC (shade tool and spec. glass). The simulation results obtained form the basis of existing conditioning in energy conservation efforts.

The next point in achieving environmental quality is discussing the other side of health facilities. Where noise is a concern, and the achievement of design completion is related to environmental quality. The noise standard for health facilities is 55 dBA. Meanwhile, it is undeniable, with both medical and non-medical activities and existing local environmental factors, and this is sometimes difficult to achieve. We can make some efforts, one of which is acoustic conditioning with architectural elements. During the design process, we can simulate first to find out the possible results of the noise level that occurs and the options that are carried out if the noise level is above the standard threshold. Joko et al. [2] investigated the acoustic evaluation in the Neonatal Intensive Care Unit (NICU) in a hospital in Indonesia. Research on acoustic conditions for health facilities in Indonesia is still limited. This study describes the acoustic conditions in the NICU room with objectives, subjective and simulation methods based on the soundscape concept. The noise limit in the treatment room is 35 dBA. From the test, and it was found that the SPL decreased. The noise comes from 8.9 dBA ventilator alarm and 8.2 dBA medical personnel activity. To improve the soundscape in a particular treatment room such as the NICU, it can implement dampers such as curtains, glass partitions, and acoustic dampers on the ceiling.

The next concern in the design of health facilities is controlling and preventing the spread of infection and disease. The vulnerability of the spread of infection is not only found in service facilities with a high risk of infection. However, it is also possible to meet in public areas such as patient waiting rooms, lobbies, pharmacies, or even in entertainment facilities at health facilities such as canteens, bakeries, gift shops. So, it is good to assume that we need to look at the spread of infection in health facilities as a whole, without exception. As a preventive measure in terms of building and environmental conditioning related to infection, we can check the spread of airborne in every room. Yang et al. [3] studied the spread of airborne infections in hospitals. This study describes efforts to prevent the spread of infection in hospitals. They analyzed openings' sealing and filling performance to ensure airtight performance in isolation wards and simulating air currents in isolation wards. Review and analyze local and international laws and regulations regarding isolation wards. This study analyzed the performance and effects of airtight spaces in isolation wards using CFD (Computational Fluid Dynamics) simulation. The results showed that isolation wards had better airtight performance than general wards.

Previously we discussed how we need to look at the effectiveness and efficiency of energy in health facilities. Zoning in Health facilities consists of several sections, public- non-infectious zoning, public-infectious zoning, private-non- infectious zoning and private-infectious zoning with their respective functions and categories. Each zoning and use of space to achieve energy effectiveness and efficiency. To meet the standards of effectiveness and energy efficiency in terms of buildings and the environment in health facilities, we can optimize public zonings such as waiting rooms, lobbies, registration rooms, outpatient rooms, inpatient rooms and other rooms that are not related to medical equipment. Require standard conditions. That does not mean closing the possibility of effective and efficient thermal conditioning in only a few spaces. However, operational standards in diagnostic, medical, and operating rooms must be by operational medical standards, which require equipment that usually uses much energy.

Jiménez Mejía et al. [4] discussed the relationship between building comfort and energy requirements in exceptionally patient recovery rooms in hospital buildings. It increased energy efficiency in residential buildings achieved the best achievements by selecting construction materials and systems for building envelopes. This study saw the need to maintain the temperature in the room as an effort to support the patient's recovery process from the comfort side of the building. Based on simulations using Software Design-Builder V 6.1 and EnergyPlus V 8.9, if the building envelope design is optimized, it can protect the building

from excessive external heat flow. Another result is that the acquisition of solar radiation transmitted through the facade impacts the indoor temperature. In addition, it was shown that the envelope design with large glass and without a sun protection system results in excessive internal thermal loads.

Of the four works of literature reviewed, 2 of them studied related to thermal comfort. Simulation and experimentation of digital architecture using Overall Thermal Transfer Value (OTTV) software, Design-Builder V 6.1, and EnergyPlus V 8.9. From the test results, it can be concluded that it is very influential on users' comfort, both patients, medical staff and visitors. Thermal comfort is closely related to the health aspect of design achievement in health facilities. The third study discusses acoustics in the service room, diagnostics, and hospital infection. The acoustic evaluation method provides recommendations for acoustic conditioning with the implementation of dampers so that patient comfort and focuses on medical staff's work can be achieved. The third study analysis implemented CFD (Computational Fluid Dynamics) simulation to avoid the spread of airborne infections for health facilities. The results showed that isolation wards had better airtight performance than general wards. Closely related to aspects of building safety and the environment of health facilities. Security achievements are related to the physical building and disasters and related to the spread of infection.

#### 4. CONCLUSION

Given the background of this research, health facilities are a community need. It also provides a stimulus and reminder of the need for designing health facilities of medium and high complexity. Technological advances also require health facilities to continue to grow and are expected to answer the demands of needs according to future conditions. The design of Health facilities is expected to answer the design needs more readily and minimize the risk of the possibilities that have been analyzed during the design process and the designs that have been developed. With complex requirements, digital architectural simulation can help produce efficient, effective and healthy designs on healthcare facilities. In the analysis and simulation process, four aspects must be observed: the achievements of safety, health, comfort, and convenience. Digital architecture and healthcare facility design will continue to evolve. So it is necessary to update knowledge and its application so that architects can continue to produce architectural works that suit their needs.

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