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Assessment Factors of Indoor Comfort and Health in Hospital Buildings Based on Green Building Systems in Palu City

William Arrang Sarungallo[1]*, Tutang M. Kamaludin[2], Lilianti Y. Sunuh[3], Zet Mallisa[4]
[1,2,3,4]Universitas Tadulako, Palu, Sulawesi Tengah

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ABSTRACT

This study aims to evaluate the comfort and health levels of rooms in Anutapura Hospital, Undata Hospital, and Tadulako University Hospital, with a focus on the application of green building principles, particularly in terms of room comfort and health. The study also identifies factors influencing comfort and health, such as smoking bans, control of carbon dioxide (CO_2) and carbon monoxide (CO) levels, and the use of refrigerants. The research method used is qualitative, involving interviews and field observations to gain an in-depth understanding from respondents directly involved in the hospital building construction. The respondents consisted of five people: two from Anutapura Hospital, one from Undata Hospital, and two from Tadulako University Hospital. Observations were made on facilities such as smoking prohibition signs, ventilation, air conditioning systems, and parking areas. The results show that Tadulako University Hospital scored the highest (13 points), followed by Undata Hospital (11 points), and Anutapura Hospital (8 points), based on comfort and health parameters. Tadulako University Hospital excelled in air quality control and the use of refrigerants with low Global Warming Potential (GWP). Key factors influencing room comfort and health include freedom from tobacco smoke, ventilation, CO_2 and CO sensors, and the use of environmentally friendly refrigerants.

Corresponding Author:
William Arrang Sarungallo
Universitas Tadulako, Palu, Sulawesi Tengah
Email: will.william.lfc@gmail.com

INTRODUCTION

The increase in human activities and climate change has led to global warming, affecting the environment. The rise in global average temperatures is caused by the greenhouse effect, in which the concentration of greenhouse gases increases due to human activities. Especially since the mid-20th century, the concentration of carbon dioxide in the atmosphere has continued to rise along with the industrial revolution (Ruhenda HN et al., 2016). This environmental issue has sparked global awareness, prompting worldwide campaigns for environmental preservation. Various efforts and innovations have been made to prevent more serious environmental damage, including in the building sector (Bayu Widiarsa et al., 2021).

Green building is a development concept that focuses on the efficient use of resources, minimizing negative environmental impacts, and creating healthy spaces for occupants (Achmadi & Okita, 2021). The core principles of green buildings include energy efficiency, use of environmentally friendly materials, sustainable water management, and good air quality. Applying these standards in public buildings such as hospitals is crucial, as these structures serve not only as healthcare centers but also play a role in fostering public health (Aziz, 2022).

An environmentally friendly hospital (Green Hospital) is a facility that is intentionally designed, constructed or renovated, operated, and maintained based on sustainable health and environmental principles (Kementerian Kesehatan, 2018). Previous studies on green hospitals abroad have shown positive impacts on patients, including increased patient satisfaction and comfort, improved healthcare quality, reduced risk of hospital-associated infections (HAIs), enhanced physical and mental health, and higher recovery rates (Amelia & Ilyas, 2023).

The hospitals under study are Anutapura Hospital Palu, Undata Hospital Palu, and Tadulako University Hospital. The evaluation of comfort and indoor health in these three hospitals provides a clear picture of the application of green building principles and helps identify which hospital best implements these principles in

terms of comfort and health.

Identifying and analyzing factors that influence comfort and indoor health is useful for understanding how each hospital can improve the application of green building principles. These factors also offer insights into the strengths and weaknesses in the design and management of hospital buildings and how they impact occupant comfort and health.

Literature Review

Green Buiding

Green buildings reflect a commitment to environmental preservation in the construction sector. As a response to global warming, green buildings offer solutions to mitigate environmental impacts (Lilo et al., 2014). They are designed to optimize energy efficiency, protect the environment, reduce pollution, maintain occupant health, effectively utilize space, and harmonize with nature throughout their lifecycle (Hong & Minfang, 2011).

According to Indonesian Regulation Permen PUPR 02/PRT/M/2015 on "Green Buildings," sustainable development requires integrating technical, economic, social, and environmental aspects effectively. The design of environmentally friendly buildings is essential in combating environmental damage and climate change. The Green Building Council Indonesia (GBCI) is responsible for green building certification.

Green buildings aim to reduce resource consumption while improving environmental quality. They are a key component of sustainable development, which strives to enhance human life quality while protecting Earth's ecosystems (Wu & Low, 2010).

Comfort

Comfort is a subjective assessment of the environment by individuals. Thermal comfort is a key indicator of green building performance and is affected by environmental factors like temperature, humidity, air velocity, and radiant heat. Good natural ventilation and insulation significantly improve indoor comfort (Mahin et al., 2023).

Indoor air quality is also crucial to health. Inefficient HVAC systems can lead to pollutant buildup, such as CO_2, formaldehyde, and VOCs, causing respiratory issues (Schiavon et al., 2021). Green building promotes cross ventilation and low-emission materials as solutions.

Visual comfort through natural lighting is also emphasized. Natural lighting enhances psychological well-being and productivity (Muhaimin, 2023). Optimally designed openings reduce energy usage and improve lighting quality.

In conclusion, green building principles promote not only resource efficiency but also healthy, comfortable, and productive indoor environments, which are essential for sustainable development and human well-being.

Indoor Health

Indoor Environmental Quality (IEQ) is a major component of green building systems. It includes air quality, natural lighting, noise control, and thermal comfort, all contributing to users' physical and psychological health.

Efficient ventilation is crucial for indoor air quality. High concentrations of CO_2, VOCs, and dust particles can increase respiratory risks and reduce productivity (Schiavon et al., 2021). Green buildings encourage cross ventilation and low-emission materials.

Personal comfort systems, including microclimate control and adjustable lighting, help reduce thermal stress and improve sleep and focus (Luo et al., 2022). Thus, green buildings aim to create biologically and psychologically healthy indoor environments.

Parameters of Room Comfort and Health

Key parameters in assessing room comfort and health include:

Smoking Prohibition: Indoor spaces must be smoke-free to improve air quality (SE Menteri PUPR No. 01/SE/M/2022);

CO_2 and CO Control: Excessive CO_2 can harm health, and CO from vehicle exhaust is dangerous; therefore, sensors are essential for monitoring air quality SE Menteri PUPR No. 01/SE/M/2022);

Refrigerant Use: Air conditioners must use environmentally friendly refrigerants, as harmful ones can negatively impact health and the environment (SE Menteri PUPR No. 01/SE/M/2022).

Research Location

The research was conducted at three sites: RSUD Anutapura Palu, RSUD Undata Palu, and Tadulako University Hospital Palu.

1. Anutapura Hospital is located on Jalan Kangkung No. 1, Donggala Kodi, Ulujadi District, Palu City, Central Sulawesi. It is classified as a Type B hospital.

Figure 1. RSUD Anutapura Palu

2. Undata Hospital was established on August 7, 1972, originally located on the coast of Palu Bay and named "Undata," meaning “Our Medicine.” It provides preventive, curative, and rehabilitative services under the motto “Mosangu Mosipakabelo.” It is now located on Jalan Trans Sulawesi, Talise, Mantikulore District, and is a Type B non-teaching hospital

Figure 2. RSUD Undata Palu

3. Tadulako University Hospital is a State University Teaching Hospital (RSPTN), officially renamed in 2015 under Rector Decree No. 2565/UN28/KP/2015. It is located on Jalan Soekarno Hatta, Km. 9, Tondo, Mantikulore District, Palu City.

Figure 3. Tadulako University Hospital

METHODOLOGY

This study adopts a qualitative research methodology, aiming to gain an in-depth understanding of the implementation of indoor comfort and health practices within hospital buildings. Data collection was conducted using two primary techniques: semi-structured interviews with selected respondents and direct field observations of environmental features within the hospital premises.

The interview process focused on gathering insights regarding policy implementation, ventilation systems, air quality management, and refrigerant usage. Meanwhile, field observations were used to verify physical indicators such as the presence of no-smoking signage, the configuration and condition of ventilation systems, air conditioning units, and other environmental control mechanisms.

The data analysis process involved organizing and summarizing the findings into key themes and variables, followed by interpretation and conclusion drawing. The qualitative approach enabled the researchers to capture not only observable conditions but also the contextual and practical challenges faced by each hospital in applying green building principles related to indoor health and comfort.

RESULTS AND DISCUSSION

Assessment Results at Anutapura Hospital, Undata Hospital, and Tadulako University Hospital

The assessment of indoor comfort and health conditions at RSUD Anutapura Palu resulted in a total score of 8 points. This score comprises 5 points awarded for the enforcement of a smoking prohibition policy within hospital facilities and 3 points attributed to the hospital's efforts in managing the use of refrigerants, particularly in relation to environmental considerations.

At RSUD Undata Palu, the evaluation yielded a total of 11 points. The score includes 5 points for the implementation of a smoke-free environment, reflecting compliance with indoor air quality standards. Additionally, 3 points were earned for measures related to the monitoring and control of indoor concentrations of carbon dioxide (CO_2) and carbon monoxide (CO), both of which are critical indicators of air quality. The remaining 3 points were attributed to the hospital's refrigerant management practices, indicating moderate alignment with environmentally responsible cooling technologies.

Tadulako University Hospital achieved the highest score among the three facilities, with a total of 13 points. This score includes 5 points for its comprehensive implementation of smoking prohibition, 3 points for the monitoring and control of indoor CO_2 and CO levels, and 5 points for its proactive approach to managing refrigerants by utilizing substances with lower Global Warming Potential (GWP), thereby demonstrating a stronger commitment to sustainable and environmentally friendly building operations.

Comparison of Assessment Results

Tadulako University Hospital achieved the highest overall score of 13 points, reflecting a strong performance in terms of indoor environmental comfort and health. All three hospitals demonstrated a commendable level of commitment to maintaining a smoke-free indoor environment, as evidenced by the installation of no-smoking signage in designated areas.

Regarding ventilation strategies, each hospital adopted a different approach. Anutapura Hospital relies exclusively on mechanical ventilation through air conditioning (AC) systems and does not incorporate natural ventilation into its design. Undata Hospital employs a hybrid method, alternating between air conditioning and natural ventilation depending on the operational context. In contrast, Tadulako University Hospital has developed a more balanced ventilation system that integrates both natural airflow and mechanical cooling, aligning with green building principles that emphasize energy efficiency and occupant well-being.

It is noteworthy that none of the hospitals have yet implemented indoor air quality monitoring tools such as carbon dioxide (CO_2) or carbon monoxide (CO) sensors, which are essential for real-time detection and control of indoor pollutants. Concerning refrigerant usage, both Anutapura and Undata Hospitals utilize cooling agents with zero Ozone Depletion Potential (ODP), which indicates no direct harm to the ozone layer. However, these refrigerants still possess relatively high Global Warming Potential (GWP), contributing to long-term environmental impact. Tadulako University Hospital, on the other hand, employs refrigerants that not only have zero ODP but also a lower GWP, thereby offering a more environmentally sustainable solution in alignment with contemporary green building standards.

Factors Affecting Indoor Comfort and Health in Hospitals

Based on the assessment findings, several key factors were identified as significantly influencing the level of indoor comfort and health in the three hospitals evaluated. The absence of cigarette smoke within indoor areas plays a vital role in maintaining clean air quality. Enforcing a strict no-smoking policy helps minimize the presence of harmful airborne particles and gases, thereby supporting the respiratory health and general well-being of occupants.

The availability of proper ventilation and a continuous supply of fresh air is another essential factor. Well-designed ventilation systems facilitate air circulation, allowing for the removal of indoor pollutants and excess carbon dioxide (CO_2), which helps maintain a healthy, oxygen-rich environment and enhances thermal comfort.

The installation of carbon dioxide (CO_2) sensors in combination with mechanical ventilation systems is critical for monitoring and controlling indoor air quality. These technologies enable real-time detection of CO_2 concentration levels, ensuring that ventilation can be adjusted accordingly to keep indoor air within safe and comfortable thresholds.

The presence of carbon monoxide (CO) sensors and adequate ventilation in parking facilities is also a major consideration. Since vehicle emissions in enclosed or semi-enclosed parking areas can lead to dangerous CO accumulation, effective monitoring and ventilation systems are essential to prevent toxic exposure and ensure safety for both patients and staff using these spaces.

The use of air conditioning (AC) systems must also be considered in terms of both efficiency and maintenance. Properly functioning and regularly maintained AC units help regulate indoor temperature and humidity, providing thermal comfort while reducing the risk of mold growth and airborne pathogens that can impact occupant health.

Lastly, the Global Warming Potential (GWP) value of the refrigerants used in cooling systems is a crucial environmental factor. Selecting refrigerants with low GWP not only reduces the hospital's ecological footprint but also aligns with sustainable building practices, contributing to a healthier indoor environment over the long term.

CONCLUSION

Based on the assessment of indoor comfort and health in three hospitals in Palu City, it can be concluded that each hospital has made efforts to apply green building principles, particularly in the aspects of air quality, smoking prohibition, and the use of environmentally friendly refrigerants. Anutapura Hospital received a total score of 8 points, consisting of 5 points for smoking prohibition and 3 points for refrigerant management. Undata Hospital received 11 points, including 5 points for smoking prohibition, 3 points for carbon dioxide (CO_2) and carbon monoxide (CO) control, and 3 points for refrigerant control. Tadulako University Hospital scored 13 points, with 5 points for smoking prohibition, 3 points for CO_2 and CO control, and 5 points for refrigerant management.

All hospitals demonstrated a commitment to smoke-free indoor environments, as indicated by the presence of proper no-smoking signage. Each hospital employed different ventilation approaches; some rely fully on mechanical ventilation (air conditioning), while others have begun to integrate natural ventilation. Air quality monitoring sensors, such as for CO_2 and CO, were not yet uniformly available across the sites. In terms of refrigerants, the types used generally had zero Ozone Depletion Potential (ODP), although the Global Warming Potential (GWP) values varied. These differences reflect the diverse technical strategies and capacities of each hospital based on their respective planning and infrastructure conditions.

Overall, the findings suggest that the implementation of indoor comfort and health principles based on green building standards has begun to take shape in hospitals across Palu City, although there remains room for further improvement in several technical and operational aspects. This evaluation provides a useful foundation for continuous improvement efforts toward creating hospital environments that are healthier, safer, and more sustainable.

The factors identified as influencing indoor comfort and health in the hospital buildings include freedom from tobacco smoke, availability of fresh air and effective ventilation, the presence of CO_2 sensors and mechanical ventilation systems, ventilation and CO sensors in parking areas, proper and well-maintained air conditioning equipment, and the selection of refrigerants with low Global Warming Potential (GWP). These factors are essential considerations in the design and management of hospital facilities to ensure both the health of building occupants and environmental sustainability.

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