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Original Research

Evaluation of CT Scan Room Layout and Design for Optimization Radiology Service Delivery

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Abstract

Background: The effectiveness of CT scan procedures is significantly influenced by the spatial design of radiology rooms. Inadequate room layouts can hinder workflow efficiency, reduce patient comfort, and compromise safety and regulatory compliance.
Objective: This study aims to evaluate the layout of the CT scan room at Jaury Jusuf Putera Academic Hospital and propose improvements in accordance with national hospital design standards.
Methods: A qualitative case study approach was employed, utilizing structured field observations to assess the functionality of seven designated spaces within the CT scan unit.
Results: While five essential rooms were present, the absence of a patient toilet and a changing room highlighted partial non-compliance with applicable regulatory standards.
Conclusion: It is recommended that hospital management revise the current spatial configuration to incorporate the missing support rooms. Such modifications are expected to enhance patient comfort, optimize workflow, and ensure greater adherence to national standards.
Keywords: CT scan room; hospital design standards; radiology layout; regulatory compliance

Introduction

The spatial configuration and architectural design of radiology departments are critical in delivering safe, efficient, and patient-centered diagnostic imaging services, particularly in computed tomography (CT) procedures. Inadequately designed layouts can disrupt workflow, compromise service quality, and diminish the overall patient experience. In high-demand diagnostic units such as CT scan rooms, design inefficiencies may directly affect operational performance and erode patient trust.

In Indonesia, the infrastructure and operational standards for hospital radiology services are governed by a set of national regulations. The Nuclear Energy Regulatory Agency (BAPETEN), through Regulation No. 4 of 2020, outlines radiation shielding requirements and safety protocols, while also emphasizing the need for supporting facilities such as patient toilets and changing rooms. Complementing this, the Ministry of Health's Regulation No. 24 of 2020 provides comprehensive spatial guidelines for CT scan units, including specifications on minimum room dimensions and the inclusion of essential functional zones such as control rooms, uninterruptible power supply (UPS) rooms, and sanitation facilities. These regulations are designed to uphold both safety and service quality within medical imaging departments.

Despite the clarity and detail of these standards, implementation remains uneven particularly in regional hospitals constrained by limited physical space, financial resources, or technical planning expertise. Prior research has documented how the absence of patient-supportive facilities, such as toilets and dressing areas, can hinder workflow, reduce patient privacy, and ultimately lower satisfaction levels (Granja et al., 2013; Syafrina et al., 2021). While much focus has been placed on radiation safety and equipment functionality, the human-centered dimension of spatial design is often neglected during the planning and development phases.

Several factors contribute to these design gaps, including the prioritization of core technical rooms over ancillary spaces and insufficient collaboration between healthcare professionals and architectural planners. Conversely, design strategies that emphasize ergonomic flow, spatial efficiency, and systematic planning have demonstrated strong potential in enhancing both operational effectiveness and patient comfort (Benitez Fogliatto et al., 2018).

Against this backdrop, the present study seeks to evaluate the spatial layout of the CT scan unit at Jaury Jusuf Putera Academic Hospital in relation to national regulatory requirements. The study aims to identify spatial deficiencies that may impede service quality and compliance, and to propose evidence-based design recommendations that support patient-centered care, improve workflow efficiency, and enhance alignment with applicable regulations.

Methods

Study Design

This study employed a descriptive qualitative approach using a single-case study design. The objective was to assess the spatial configuration and adequacy of the CT scan facility at Jaury Jusuf Putera Academic Hospital in accordance with national regulatory standards. This methodological framework enabled an in-depth, contextual examination of the physical infrastructure without reliance on statistical analysis or hypothesis testing.

Samples

The sample comprised seven designated rooms within the CT scan unit: the operator room, UPS room, machine room, gantry (examination) room, toilet, changing room, and waiting area. A purposive sampling technique was utilized to select spaces with direct functional relevance to radiology workflow and patient safety. Inclusion criteria encompassed rooms that were actively in use or officially designated to support CT scan operations based on standard hospital layouts. Rooms that were not directly related to CT procedures or not integrated within the CT installation structure were excluded. Since the study focused on spatial analysis rather than human subjects, the unit of analysis was architectural space. Accordingly, the sample size was determined by the hospital's structural layout and functional zoning.

Instruments

Data collection was facilitated by a structured observation checklist developed in reference to BAPETEN Regulation No. 4 of 2020 on radiation protection and Ministry of Health Regulation No. 24 of 2020 concerning hospital infrastructure standards. The checklist contained seven assessment items corresponding to each of the evaluated rooms. Each item was measured on a binary nominal scale: "Available" or "Not Available." The checklist was applied directly by the principal investigator during on-site assessments. As the study was descriptive in nature and involved a single-observer evaluation, expert judgment, validity testing, and inter-rater reliability assessments were not applicable.

Data Collection

Field observations were conducted over the course of one week in March 2025. Using the structured observation checklist derived from national regulatory standards, the researcher evaluated key spatial components essential to CT scan functionality. Each room was assessed using a binary scale indicating the presence ("Available") or absence ("Not Available") of required elements. All assessments were performed by the principal investigator to ensure procedural consistency. Operational definitions for each spatial component were clearly established prior to data collection to enhance the credibility of observations. Photographs and field notes were also gathered to supplement the checklist data and provide contextual documentation.

Data Analysis

The collected data were analyzed descriptively and compared against the minimum infrastructure requirements specified in relevant national regulations. A gap analysis approach was employed to identify spatial deficiencies and evaluate their potential impact on workflow efficiency, patient experience, and regulatory compliance. Due to the non-numerical nature of the data, no statistical techniques were applied. The analysis prioritized regulatory alignment and actionable insights over inferential metrics.

Ethical Considerations

The study protocol received ethical approval from the Health Research Ethics Committee of Politeknik Muhammadiyah Makassar. As the research did not involve human participants, informed consent was not required. Nonetheless, formal permission to conduct spatial assessments and collect documentation within the hospital premises was obtained from institutional authorities. All data were treated with confidentiality, and no identifying details were disclosed in the reporting of results.

Results

This study employed structured field observations to evaluate the compliance of the CT scan unit at Jaury Jusuf Putera Academic Hospital with applicable national regulatory standards. The assessment focused on seven key spatial components, as outlined in BAPETEN Regulation No. 4 of 2020 and Ministry of Health Regulation No. 24 of 2020. Each room was evaluated using a binary scale, with “Available” indicating the room’s presence and functional readiness, and “Not Available” indicating its absence or lack of operational functionality. A summary of the observational findings is presented in Table 1.

Table 1 Observed Availability of CT Scan Unit Rooms

Room Type	Availability Status
Operator Room	1 (Available)
UPS Room	1 (Available)
Equipment Room	1 (Available)
Gantry Room	1 (Available)
Patient Toilet	0 (Not Available)
Changing Room	0 (Not Available)
Waiting Room	1 (Available)

Source : Primary Data 2025

Existing Floor Plan of the Radiology Department at Jaury Jusuf Putera Academic Hospital (Left) and the Standard CT Scan Room Layout as Specified in Ministry of Health Regulation No. 24 of 2020 (Right)

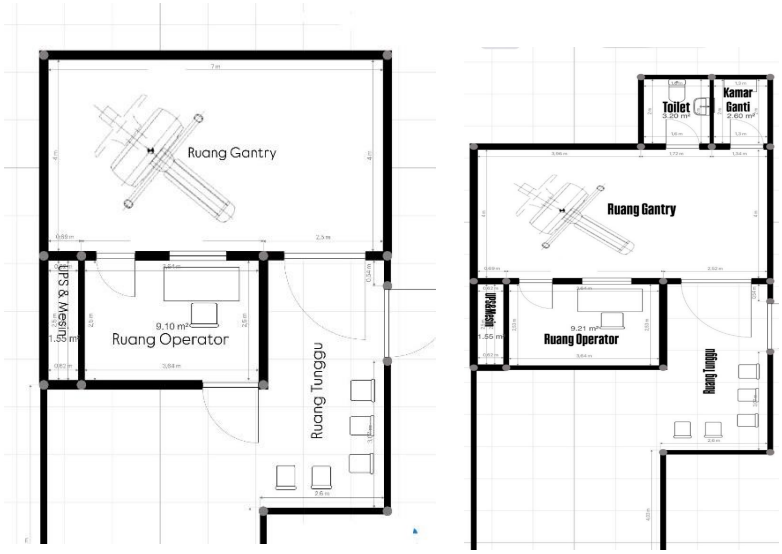

Figure 1. Spatial Layout Design of CT Scan Unit

Of the seven required spatial components, five were found to be present and in accordance with the relevant technical guidelines. However, two essential supporting facilities a patient toilet and a changing room were absent. The lack of these spaces constitutes a notable gap in regulatory compliance and raises concerns regarding patient privacy, comfort, and the efficiency of operational flow.

In addition to the structured observation checklist, spatial layout diagrams were utilized to compare the existing floor plan with the recommended configuration stipulated in the Ministry of Health Regulation No. 24 of 2020. This visual comparison corroborated the checklist findings, clearly illustrating the absence of designated patient-centered facilities and emphasizing the need for spatial modifications to enhance service quality and patient experience.

Instead of employing statistical methods to assess agreement or reliability, the study applied a direct compliance assessment approach. Each required room component was evaluated based on its presence or absence, using regulatory standards as the benchmark. This method was deemed appropriate given the descriptive and infrastructure-focused nature of the study, where quantitative reliability testing was not applicable.

Discussion

The findings of this study indicate that the CT scan unit at Jaury Jusuf Putera Academic Hospital exhibits partial compliance with the spatial and technical standards mandated by national regulations. While key functional areas such as the operator room, UPS room, equipment room, gantry (examination) room, and waiting area were present, the absence of a patient toilet and changing room reflects a critical deficiency in spatial planning. These missing support facilities not only represent architectural gaps but also directly impact patient privacy, comfort, and the overall efficiency of diagnostic workflows.

This observation aligns with prior studies by Niehoff et al. (2022) and Granja et al. (2013), which highlight that diagnostic quality and patient satisfaction are influenced not solely by medical technology and clinical protocols, but also by the environmental context in which services are delivered. Specifically, the availability of support rooms contributes significantly to patient-centered care. Incomplete infrastructure in radiology departments has been linked to extended waiting times, inefficient staff circulation, and reduced patient trust, as documented by Syafrina et al. (2021) and Diniati et al. (2021). These shortcomings are frequently attributed to spatial planning practices in regional and mid-tier hospitals that tend to prioritize equipment installation over holistic, patient-oriented design considerations, as noted by Maulana et al. (2019) and Wirajaya et al. (2023).

To mitigate these issues, healthcare institutions must adopt strategic design approaches that balance regulatory compliance with functional and patient-centered imperatives. Evidence-Based Design (EBD), which connects the built environment to clinical outcomes, has been shown to improve patient experience and reduce stress during diagnostic procedures (Ottu et al., 2023; Paramita et al., 2022). In the context of CT scan services, this includes integrating private changing areas, accessible restrooms, and clearly organized spatial pathways that facilitate logical patient flow.

Technically, hospitals may explore retrofitting options such as modular room configurations or prefabricated partitions that can introduce missing facilities without requiring extensive structural modifications or disruptions to imaging equipment operations. Sarhan et al. (2025) proposed such modular approaches for emergency departments, which could be adapted for radiology environments. Additionally, spatial optimization methods such as Systematic Layout Planning (SLP) and graph-theoretic modeling have demonstrated utility in aligning room arrangements with safety, staff productivity, and efficient patient movement, as suggested by Benitez Fogliatto et al. (2018) and Rybkin and Wilson (2010).

Moreover, the integration of Spatial Decision Support Systems (SDSS) can enhance the planning process by enabling the simulation of layout alternatives before implementation. As highlighted by Jabarullah et al. (2021), these tools support data-driven, evidence-informed decisions that improve the alignment of architectural layouts with operational needs.

Importantly, regulations issued by BAPETEN and the Ministry of Health should not be viewed solely as compliance checklists, but rather as frameworks guiding the development of effective, safe, and humane healthcare environments. The real challenge lies in translating these normative standards into practical, context-sensitive spatial solutions.

While this study contributes valuable insights into regulatory gaps and architectural limitations in a specific healthcare context, it is limited by the exclusion of stakeholder perspectives. Future research should incorporate qualitative feedback from clinical personnel, infrastructure planners, and patients to foster more comprehensive and contextually appropriate design recommendations. Participatory design methodologies and simulation-based planning are recommended to support the development of diagnostic imaging environments that are not only compliant, but also responsive to the needs of patients and healthcare providers alike.

Conclusion

This study concludes that the current spatial configuration of the CT scan unit at Jaury Jusuf Putera Academic Hospital only partially adheres to national infrastructure standards. The absence of critical patient-centered facilities, specifically a toilet and a changing room, underscores a notable shortfall in regulatory compliance. Although the core technical rooms required for CT operations are present, the lack of these supporting spaces compromises patient comfort, privacy, and the efficiency of diagnostic workflows revealing a disconnect between regulatory expectations and their implementation at the facility level.

To address these spatial deficiencies, it is recommended that hospital administrators undertake a comprehensive spatial audit of the radiology department. This process should identify opportunities to repurpose or retrofit underutilized areas adjacent to the CT unit. Practical interventions may involve the incorporation of compact, modular support facilities such as changing areas and accessible toilets, designed in a manner that avoids disruption to the existing radiological infrastructure. Active collaboration between clinical personnel, hospital management, and architectural design teams is essential to ensure that any spatial modifications align with both technical safety standards and patient-centered care principles.

This case further emphasizes the need to interpret regulatory compliance not merely as an administrative obligation, but as part of a broader institutional commitment to creating humane, efficient, and dignified healthcare environments. Enhancing the spatial design of diagnostic facilities should be regarded as a strategic investment in service quality and operational resilience. Future improvements should prioritize flexible, adaptive design solutions that accommodate evolving patient needs while maintaining alignment with national healthcare infrastructure standards.

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