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Abstract. This paper is an architectural study of modern hospital design. This study aims to apply lean thinking in modern hospital design planning where the patient is the center. The methodology conducted the research with a qualitative approach through observation and case studies from Dharmais Cancer Hospital Jakarta. Lean thinking approach in the design process, making improvements mainly related to elements and space utilization in the hospital, including integration with information systems and medical technology. Hospital design is carried out by identifying and eliminating waste or activities that are not added value through radical continuous improvement by flowing products (materials, work-in-process, output) and information, using a pull system from stakeholders to pursue excellence and perfection. Thus, it is hoped that the design of the hospital building can be effective in its space program. An architectural design change based on lean thinking is expected to add value to patients and better management of key resources in terms of services, both in the form of access and better room layout.

Keywords: Lean Thinking, Architectural Design, Modern Hospital Design, Cancer Hospital.

INTRODUCTION

The hospital functions as a health service facility for the wider community and plays a role in accelerating the healing and recovery of patients in patients as expected [1]. However, in carrying out its functions, there are not a few problems faced. Hospital services are one of the determinants of quality in hospitals. A hospital is said to be efficient if it can use all available resources to produce something desired [2]. A hospital is a room or building specifically used for the investigation and follow-up care of sick people. In late Christian times, this kind of 'hospital' was often associated with monasteries and was primarily intended to accommodate pilgrims. Today hospitals usually show homes for seriously ill people. The word hospital (from the Latin *infirmarium*) originally referred to a room or rooms connected to a monastery to care for sick monks [3].

Services at the Jakarta Dharmais Cancer Hospital are very important to be improved. The obstacles faced by the hospital are the limited facilities to help people living with cancer, temporary shelters, and the hospital environment in curing cancer. For efficient hospital development, integration between service units is needed. For example, an outpatient unit is a service unit highly integrated with other installations in the hospital in its operations. Other closely related installations include functional medical staff room units, hospital administration, radiology, laboratories, medical records, maintenance, logistics, pharmacy, and others. The form of direct observation of the integration system can be the basis for optimizing the room. The high demand resulted in many prospective patients queuing and waiting in the lobby. The linkage between units in the hospital shows a gap that can improve.

In a hospital, planning for health facilities and supporting medical equipment and services are important for treating patients with the right diagnosis of their disease. The number of medical equipment with renewable technology must be supported by the layout and infrastructure of a supportive hospital building so that this investment can be effective. This study aims to define a new paradigm for optimizing health services by adopting a *lean thinking approach* in the hospital design process. Lean is a management system that is completely focused on efficiency. Lean is a philosophy of long-term growth through efforts to increase customer value, society, and the economy to reduce costs, speed up intervention time, and improve quality through total waste elimination [4]. Lean was first discussed in the automotive industry by the Toyota management system in the 1890s [5]. Since then, lean has attracted the interest of various industrial fields in the world and is applied to many aspects other than manufacturing [6]. That is, by making improvements, especially regarding elements and space utilization in the hospital, so that the design of the hospital building can be effective in its space program.

METHODS

This research is analytical with a qualitative approach through observation and case studies from hospitals at Dharmais Cancer Hospital Jakarta. This research was conducted for quality improvement by understanding the problems the participants felt, which was realized by efficient design using *lean thinking design inspiration*. This case study effectively shows the relationship between the subject and the hospital system and building that will be the object of research. Implementing the Lean concept starts with making a big picture/value stream map of related units in the hospital service process. In each process, there is an interaction between man, machine, method, material, and environmental elements. In each value stream process, activities that cause non-value added or waste will be identified using lean tools.

The following are data analysis steps: (1) Service System Description. The aim is to discover the processes in the outpatient unit at this time through the Value Stream Mapping; (3) Finding the root of the problem. After an overview of the outpatient service process flow and supporting data, we will get gaps/deficiencies that may become problems in the future. Everything that does not provide *value* to the service is considered a problem because it is a waste and must be eliminated. (4) Planning and improvement ideas. The proposed improvement design includes floor plan improvement, room layout proposal, visual management improvement, improvement of outpatient service process flow, and elimination of unnecessary processes to increase service value. (5) Conclusions and recommendations are based on the analysis results and proposed improvements.

DISCUSSION

Redefining Modern Hospital Design: Lean Thinking

Technological advances of every age have influenced architectural design. However, there has been no systematic research linking hospital design typologies to support primary hospital processes. In addition, the architect has not made a post-occupancy evaluation to assess the extent to which the design responds to hospital processes or understand which physical configuration is a better solution to functional requirements.

"The various currents in the post-World War Two hospital architecture have shared one main goal: to 'normalize' the healthcare environment. Instead of looking like hospitals, these buildings have gone from shopping mall-like to techno-utopia to zoned campuses with a distinct local feel and a focus on sustainability. The projected picture of hospital architecture in the late 20th century is sometimes just a thin layer. Beneath the cheerful décor, all the critical systems – computers, technical equipment, and communications – handle the demands of modern medicine without compromise. A significant architectural component in this 'backstage' architecture was the development of interstitial floors, in which the entire hospital level was left to mechanical equipment. Zeidler designed the hospital visionary; it has a long-span space frame structure with mountable mobile units [7]. Showing the world that hospitals can adapt and evolve, driven by ever-changing demands [8]."

Making the hospital look like a shopping center succeeded in shifting expectations about disease and medicine. "The intent is to make the patient feel normal (not feel sick). However, nowadays, people expect more from hospitals. With the belief that good hospital design should inspire health, architecture has taken on a new role as part of a device that improves patients. But improving hospital architecture requires a new perspective. The results are often imaginative for companies that do not specialize in large hospital health care design. In hospital planning, architects must embrace medical technology and landscapes as inspiration, not as constraints or things to be disguised [8]."

Traditionally, an architect leads the design process, immediately starting to develop common alternatives based on a handful of hospital leaders' perspectives, preferences, and experiences. While based on streamlining hospital operational needs (*lean thinking*), the emphasis is on processes that add value to patients. "In traditional planning, the focus is on architecture, not hospital operations. Architects understand the life expectancy of the current building and where the next expansion is most appropriate [9]." They estimate, prepare diagrams and visualize the shape of the hospital building based on architectural studies.

In today's hospital design, *lean thinking* is needed. It means that the hospital's needs lead the design, not the architect. "Through a series of studies, multifunctional teams look at how work is done today and how they can do it better in the future, then design for that target. They research relationships and pathways across facilities. Much more of the planning and development process goes into the first phase of *Lean-led design*. With *Lean-thinking design*, changes include: The amount of time spent in each phase (more in the early phases, less later); A completely different perspective comes from seeing each step as an opportunity to design more value for the patient into each process

(optimizing the parts); and There is an opportunity to ask bold questions and change the general perception of how hospitals can provide value to patients (optimizing the whole) [9]."

Design with lean principles (downsizing) focuses on consumer needs and the effectiveness of the building in its operations. The more "*lean thinking*" is used to consider operational elements in planning, the more effective the resulting design will be.

Patient-Centered Care Approach in Raising Hospital Operational Performance

Keene [10] was the first researcher to reveal the importance of patient-centered hospital operations, known as *Patient Centered Care* (PCC). "PCC is an innovative approach to health care planning, delivery, and evaluation based on mutually beneficial partnerships between health care providers, patients, and families [11]." "PCC emphasizes that hospital administrators need to see from the patient's perspective or imagine themselves as a patient to understand patient needs and become a patient-focused hospital. All hospital components, including clinicians, must apply the PCC concept and the mindset that the patient is the only patient available so that they are truly focused and do not make decisions without involving the patient [12]."

With a deficit in the quality of care in public hospitals, "Improving the hospital work environment may be a relatively high-cost strategy to improve safety and quality in hospital care and increase patient satisfaction [13]." According to Silow et al.[14], PCC is a movement that puts forward a combination of the most integrated variety of services and accelerates the healing of patients by focusing on their needs and knowledge of the healing process. For this reason, the approaching model should be more integrated with good information services, health workers' competence, and service culture improvement in hospitals related to this paradigm shift.

Patient-Centered care is "A healthcare setting in which patients are encouraged to be actively involved in their care, with a physical environment that promotes patient comfort and staff dedicated to meeting the patient's physical, emotional, and spiritual needs. Attributes of a patient-centered care model can include: 1) Organizational culture that encourages staff to be sensitive to patient needs during hospital stays; 2) Architectural and interior designs that give a *home-like* feel and encourage patient mobility, family involvement in the care process, and space for solitude and social activities; 3) Emphasis on patient and family education; 4) Recognition that nutrition is an integral part of health and a source of pleasure, comfort, and intimacy [15]."

Integrative medicine can develop and provide solutions. The health crisis provides systemic change. That will require a commitment to focus on prevention and health promotion and to respect "the therapeutic relationship and bond that forms when trained providers and patients will need a change of focus. Technology, including electronic medical records that enhance interdisciplinary communication and teamwork, will require drivers [16]." More integrative drug providers must be trained to provide high-tech, high-touch healthcare. The emphasis is on learning to facilitate healing.

The hospital information system is an effort to improve services in implementing PCC in hospitals to provide services to the community. The development of a computer-based hospital information system in Indonesia began in the late '80s. The hospital, as one of the public health service institutions, will serve patient transactions in their daily lives. The provision of services and actions in many ways will affect the condition and comfort of the patient.

The use of this system is very dependent on the level of management needs in the hospital. Computerization is needed in hospitals to avoid unwanted errors. Such as data redundancy, unintegrated data, human error, and delays in information, considering that health factors are very important for a person. Hospital information systems broadly have two functions: the hospital service information *system and the Hospital Management Information System* (SIMRS). The two functions are interrelated and complement each other so that, in the end, they will create an integrated and reliable system [17]

The operational roles of information systems in hospitals include: a) Speed, for example, the speed in completing hospital administrative work; b) Accuracy with SIMRS transaction data checks is enough to compare reports between units produced by SIMRS and can also prevent data duplication for certain transactions so that data accuracy is guaranteed; c) Integration: If the patient must enter data in each unit with a manual system, then with SIMRS, the data is enough to be entered only once in the registration section; d) Improved services, the effect of SIMRS felt by patients is the faster and more accurate the service. Currently, patients do not have to wait long to complete their administration, either inpatient or outpatient, because when the data is needed, they can view it relatively quickly and accurately; e)Increased efficiency, if the speed and accuracy of the data increase, the time needed to do administrative work will be faster, and avoid repeated requests for laboratory examinations because the previous examination results are lost.

Hospital services are divided into two major parts: medical and non-medical. A real example of a computer-based information system to support non-medical services has been implemented in hospitals. The Computerized Billing System is an example of a transaction processing system or electronic billing for administrative and financial service

functions. This system can guarantee fast hospital financial management, transparency, and responsibility. Ease of reporting, the computer-based reporting process only takes a few minutes, so you can concentrate more on analyzing the report. Of all the roles of the computer-based SIMRS, "it will increase the productivity the performance of medical personnel. The administrative staff in hospitals improve or facilitate health services [18]", so that almost all hospitals have been equipped with computerized technology in their hospital information systems.

Start with Lean

Lean is defined as thin (slender). *Lean* is defined as a set of tools, management systems, and methodologies that can change hospitals in managing and managing to reduce errors, reducing waiting times, eliminating all barriers, and supporting the activities of doctors and employees aimed at improving the quality of service and patient care [19].

Lean is a management system that is completely focused on efficiency. *Lean* is a philosophy of long-term growth through increasing customer value, society, and the economy to reduce costs, speed up intervention time, and improve quality through total *waste elimination* [4]. *Lean* was first discussed in the automotive industry by the Toyota management system in the 1890s [5]. Since then, *lean has* attracted the interest of various industrial fields in the world and is applied to many aspects other than manufacturing[6].

Lean concepts in health care have been carried out by Virginia Mason *Medical Center* in Seattle, Washington, since 2002, which has managed to reduce inventory levels by up to 53% within two years [20]. *Lean thinking's* goal in health care is to focus continuously on how appropriate health services can be delivered efficiently, safely, and of the highest quality, by turning *waste* into something of value [21]. Implementing *lean hospitals* as a form of customer satisfaction-oriented service improvement is necessary. In health care, the most important management problem is providing high-quality patient care [22]. Farrell[23] views that *lean* is the best formal approach. Meanwhile, Young and McClean[24] provide evidence and state that there is no reason that *lean should* not be an important element in health care.

Lean is widely adopted in health care practices [20]. The reason is that *lean thinking* promises the most efficient use of resources. Resources in the field of health services are very valuable and need to be optimized to provide the maximum service both in terms of the number of people served and the quality of services provided [9]. Doss and Orr[25] conclude that *lean* provides practical benefits for health care organizations by changing the value flow of services, providing compassionate care to patients, improving the work system of doctors and nurses, and providing visible sustainable benefits to society.

Lean thinking is also very important to be applied to hospital design. With *lean thinking*, it is hoped that the resulting design is the most efficient to answer the challenges of the times and in the future [26]. Hospital design is done by "identifying and eliminating waste *or* non *-value-adding activities* through *radical continuous improvement* by flowing products (*materials, work-in-process, output*) and information using a *pull system* from stakeholders to pursue excellence and perfection [27]."

The following are *five lean principles* that can adapt to the Graban[20] hospital service system: "(1) *Value*, specifically must be seen from the point of view of the end consumer (patient); (2) *Value Stream*, identify all stages of the process that add value to all and across departments, eliminate stages that do not provide value; (3) *Flow*, keeping the process running smoothly by eliminating factors that cause delays, for example, the emergence of service quality problems or resource allocation; (4) *Pull*, avoid pushing a job based on the availability of existing resources, let a service process occur due to a need or a request from the patient (so that it is efficient and by the patient's needs); (5) *Perfection*, pursue service perfection through continuous improvement [28]".

Lean concept (downsizing) starts with making a big-picture value stream map of the outpatient department, including related units in the service process. In each process, there is an interaction between elements of human resources (man), instrument (machine), implementation system (method), materials, and the supportive environment (environment). Implementing the lean concept produces a more efficient process with minimal costs, faster service time, and better service quality, reducing *non-value-added activities*.

Thus *lean* uses a collaborative model to eliminate waste. In architectural design or construction projects, designers should have *lean thinking* or process improvement throughout the organization. Introducing design concepts that use lean thinking will help make it more efficient and save waste when entering the design of new physical environments.

Examples of Lean Thinking Application in Dharmais Cancer Hospital ,Jakarta Design

Dharmais Cancer Hospital, Jakarta, is located on S.Parman Street Kav.84-86 West Jakarta, Indonesia. The Dharmais Cancer Hospital is a health service institution providing complete individual health and inpatient, outpatient, and emergency services.

From the results of a survey with a sample of the Outpatient Unit of Dharmais Hospital, some activities do not provide added value in access and movement of patients and workers in the hospital, so the impact on the performance of hospital units is less than optimal. In line with the lean concept, which states that all forms of waste for customers and do not bring added value must be eliminated or minimized, the researchers got the main problem from patient complaints obtained from data in registration services - medical records and pharmacies (Examples can be seen in Table 1).

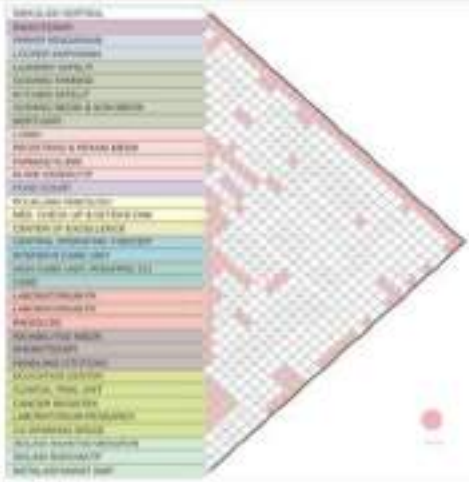
Overcoming the root of the problem that is a factor waste on system plot process take care way, it is proposed by eliminating the existing non-value added. Systemic optimization efforts are very difficult because it involves policies and regulations that bind hospitals. For this reason, researchers provide more suggestions for optimization through planning for space programs and improving access from each work unit in the hospital. For example, the movement of nurses must be taken into account, distance from: patients, medical records, medicines they must prepare, and scheduling or changing shifts that do not interfere with the workload [29]. Based on the Table 1, an approach to the relationship between space can optimize services that are less precise based on the survey results.

The design is made not only for architectural needs, but also must be able to answer the needs of the organization or all stakeholders, both intra-organizational and inter-organizational [30]. Application of the proximity concept to access and function space is described in the form of a space function diagram. The linkage between functions, especially between the existing building and the hospital tower that will be planned, is important and is a derivative of the study from the Masterplan.

TABLE 1. Root Problems in the Outpatient Unit of Dharmais Cancer Hospital

Sourcer	Root Problem	Repair
Human Resources	Not enough competent	By chance conducted course or exercise; Made standardization work; Apply culture good service.
	Less than optimal in doing p e behavior work safe and orderly	Using method *error-proof* to reduce the chance of negligence with innovation which easy and cheap.
	Organizational activities not optimal	To do discussion, consultation and studies appeal in hospital other and change pattern management.
Area	Place of cashier not strategic enough.	Organize counter cashier location
	The layout of the medical record storage space is less strategic and does not meet the workplace safety requirements.	It must expand the medical record storage room to accommodate the existing number of stores.

Source: Field Survey, 2022



Description:
Round pink indicates close relationships, ... shows related
Source: Processing of the Field Survey, 2022

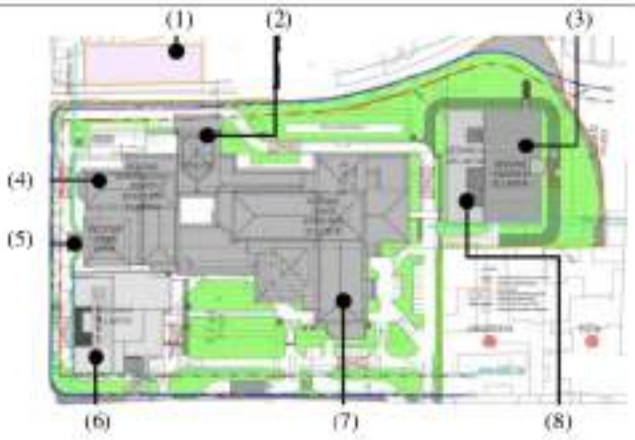
FIGURE 1. A Half-Matrix Showing Adjacency Relationships in Dharmais Cancer Hospital

Connectivity in the future is the main thing that can foster a clear and definitive flow of its functions. The showing Adjacency Relationships Matrix is generally used to collect and record relationship data directly. Such as through questionnaires and interviews; listing possible combinations of factors and isolating significant combinations; analyzing predetermined relationship data; summarizing optimum relationship data; communicating conclusive data (the results of conclusions); explaining the existing conditions or predicting the desired relationship, and; Starting to analyze the relationship in more detail [31]. We can see the figure A Half-Matrix diagram in Figure 1.

Figure 2 below is a Perspective Architectural Design plan from Dharmais Cancer Hospital.

FIGURE 2. Architectural Design PERSPECTIVE

The following is an example of a design drawing with the influence of *lean thinking* in it (Figure 3 and 4).



Notes:

(1) Additional parking area plans. The hospital will acquire the land as an additional hospital and a shelter for street venders who now occupy the sidewalk along the hospital grounds.

(2) The existing mosque will be preserved.

(3) Building B parking 12 floors. It is a new building that will be built together with building A to meet parking needs after all buildings are fully functional.

(4) The existing hospital administration building. It will maintain the existing administrative building to accommodate the office spaces required for hospital services.

(5) It will maintain the existing Multipurpose Building.

(6) Building C, 18 floors. The building for a woman & children's cancer center will be built in the first development phase, focusing on executive patient services (non-government insurance).

(7) The existing hospital building. It will focus the existing building on providing government insurance and emergency services after building C is completed.

(8) It is building A 20 floors. It is a new building that will be built in the second phase, with the function of a Medical Service and a Service Building, replacing the existing service buildings scattered, which will meet the regional requirements.

FIGURE 3. New Hospital Design

Notes:

On the ground floor, there is a comfortable waiting area. There is an admission place that is not too big because all patients are expected to have digitally registered, so they come at the appointed time.

On the 2nd, 3rd, and 4th floors, a large atrium is different from the usual hospital. The concept of the waiting room becomes smaller, and it does not require a large lobby to accommodate the waiting

	room. Poly rooms are arranged on the 3rd and 4th floors so that patients can eat and drink and are more relaxed when they wait.
	
The facility is trying to be developed a large place/space for patients to gather with their families. Then there is an outdoor space so patients can also walk around. This place is to maintain comfort and create a sense of family before death because the patient can no longer be treated.	For a doctor's office, the work desk is shared, it is not certain for certain specialist doctors, but they are expected to work here comfortably. It can also use this room can also be used for discussion or presentation regarding handling patients and research.

FIGURE 4. Example Design

CONCLUSIONS

The hospital is a building with complex planning. It has a fundamental problem, the connectivity between functions must be in harmony with the institution's operations. This study reveals the optimization efforts of hospital design, particularly the Dharmais Cancer Hospital Jakarta, so operations and management can run effectively and efficiently through optimizing access and services. A change in architectural design is expected to add value to patients and better management of key resources in terms of services, both in the form of access and better room layout. In today's hospital design, *lean thinking* is needed. Design with lean principles (downsizing) focuses on consumer needs and the effectiveness of the building in its operations. The more *lean thinking* is used to consider operational elements in planning, the more effective the resulting design will be.

Further research is needed on hospital buildings and their planning by considering the development of hospital digitization systems to the most sophisticated level. The transition to digitalization decisions with renewable technology will change the hospital's internal layout, hospital operations, and system planning. It must implement hospital technology design according to the needs of the hospital program based on the needs of the user.

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