

# History of Hospital Design with the Lean Thinking

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Review Article

## History of Hospital Design with the Lean Thinking

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**Abstract:** People believe that good hospital design should inspire health. Architecture has taken on a new role as part of a device that improves patients. However, improving hospital architecture requires a new perspective. This study uses research methods with a qualitative approach. The development of traditional to modern architects is studied by studying various documents and literature. Lean thinking needs to be considered in designing a modern hospital. This study is part of modern hospital design research. Therefore it is necessary to explore the development of hospital design so that the planning can be more efficient with various paradigm changes. This study also examines the differences between traditional and modern design methods, which now prioritize lean thinking in designing hospitals.

**Keywords:** Design, Hospital, Architecture, Lean Thinking.

### 1. INTRODUCTION

An efficient hospital is one of the determinants of hospital quality. A hospital is said to be efficient if it can use all available resources to produce something desired (Moraros, 2016). Along the way, "The development of construction to improve public health has received much support from the provision of relatively advanced infrastructure in the form of waterways to provide sufficient clean water for residents, a giant network of sewers under the city for waste disposal, and many public baths throughout the city. Further, improve the sanitation of the urban environment. From a modern point of view, The contribution of building planning to community service in the past was the establishment of a hospital in the modern sense of the word, namely an institution where the sick and disabled can receive care for a certain period. It is not only the case in Greece, the birthplace of modern medicine in the 4th century B.C., which gave rise to hospitals, the temple of Asclepius, and even Roman military and slave hospitals that can be traced back in time. 1st century B.C." (Acta, 2005)

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and modern design methods, which now prioritize *lean thinking* (downsizing/efficiency) in designing hospitals.

### 2. LITERATURE REVIEW

A hospital is a room, or building specifically used for the investigation and follow-up care of sick people. The words hospital, hotel, spital, and hospice come from the Latin word *hospitium*, which means "place of entertainment for foreigners, inn, inn, guest room." In late Christian times, such hospitals were often associated with monasteries and were primarily intended to accommodate the pilgrim. Today hospitals usually show homes for seriously ill people. "The word *h tel* is an early French term and is the origin of the present word referring to a building that offers accommodation to paying guests — without anything to do with illness. The word hospital (from the Latin *infirmarium*) originally referred to a room or rooms connected to a monastery for the care of sick monks." (Aitken, 1984, p. 9-11)

#### Hospital Buildings in Mesopotamia

There is evidence that the earliest hospitals may have been in ancient Mesopotamia. Reiner (1964, p. 544-549) provides evidence that royal physicians in the Assyrian and Babylonian courts, towards the end of the 2nd millennium B.C., nursed ailing court singers in what may have been a basic hospital or nursing home. "Classical sources also refer to the possibility of

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hospitals in the Hellenistic Age attached to Egyptian temples to Saturn in places such as Heliopolis, Memphis, and Thebes. However, this may indicate sleeping accommodation on the temple grounds, somewhat associated with the Asclepian cult." (Aitken, 1984, p. 7).

Buddhism, with its roots in the 6th century B.C. in India, "Led to the creation of a monastic system, which, like later Christianity, gave rise to healthcare facilities being instituted in and around these monasteries in the early 5th century B.C. The nursing profession may also have originated here (5th century B.C.), and we are told that hospitals in Sri Lanka date back to 431 BC. We know little about the nature and function of these institutions. However, the great King of India, Asoka, is recorded as building hospitals for humans and animals during the 3rd century B.C." (Aitken 1984, p. 7). Then, followed by the spread of Buddhism eastward, hospitals, houses of worship, and healing houses also appeared in China (estimated at the beginning of the 5th century B.C.) and Southeast Asia.

#### The Development of Health Facilities in the Roman Era

"The primitive health care associated with the temple of Asclepius is considered by many to be the forerunner of the true hospital (Thompson 1975, p. 3,4). Founded in Epidaurus in the 5th century B.C., the Asclepian cult revolved around temple complexes usually built in beautiful wooded areas with abundant water supplies. Asclepieia was later built throughout the Roman Empire and flourished until AD 391, when patients usually entered the temple to incubate sleeping in the stoa.

#### Hospital Development in the Christian era

Even during the early phase of the Christian era, when Christians suffered from severe religious persecution, their selfless dedication to alleviating the suffering of the poor and sick is noted by historians (Cyprian, *De mortalities* VI.1-2). The typical Christian attitude toward the sick is based on Christ's parable of the Samaritan, who prioritized compassion for anyone in need. However, this ethos of concern did not translate into action regarding hospitalization until Emperor Constantine promulgated his Decrees of Tolerance in 311 and 313, granting religious freedom. And then their acts of charity, concentrating on the needs of the wretched, make no distinction between aid for the poor, pilgrims, orphans, the elderly, the insane, and the sick (Thompson & Golden, 1972 p. 6). The earliest nursing homes, called xenodochia in the mostly Greek-speaking East, were originally built to protect pilgrims and envoys between various bishops, eventually helping the less fortunate, sick, and mentally weak. Over time, many of these developed into standard hospitals (Allan, 1990, p. 447). In the 4th century, xenodochia was also a well-known Western institution. Mainly because Emperor Julian the Apostate (361-363)

tried to attract support by establishing his attempt to revive paganism xenodochia as the Christians did." (Acta, 2005)

In a letter to Arsacius, his pagan high priest in Galatia, Julian wrote: "In every city, build up xenodochia so that foreigners may take advantage of our kindness. St Basil of Caesarea (now located in the vicinity of Cappadocia, Turkey) was a pioneer in establishing the hospitalization and care of the disabled and sick. In 369, he founded the famous Basilica of Caesarea which consisted of a hospital that turned out to have as many wards as diseases. He even included a section for lepers who had previously been isolated. Moreover, they were now better cared for for the first time. Hospitals have also expanded residences for medical staff, workshops, nursing homes for travelers and the poor, and industrial schools. The fall of Rome in 476 sparked a prolonged period of development stagnation in Europe (the so-called Dark Ages). However, mainly due to the influence of Christian monasticism, the development of inpatient areas separated from residential settlements continued and thrived.

#### Hospital Developments in the Middle Ages (6th to 10th centuries)

The public hospital movement in large cities is generally financed by city authorities, the Church, and even private sources. Lay doctors played an increasingly important role, especially after the Church forbade monks to practice outside monasteries. Medical dogma, here and in monastic institutions, is based primarily on the teachings of Galen and Hippocrates, who are also highly admired by contemporary Islamic doctors (Allan, 1990, p. 451).

In Jerusalem, Islamic Order Hospital St. John was founded by Brother Gerhard in the 13th century as a charitable organization caring for sick pilgrims in the Holy Land. A warrior element developed from the order took part in the Crusade, and when Acre fell (1291), the movement was allowed to depart for Cyprus. From here moved to Rhodos (1309), settled in Malta (1530), and finally moved to Rome. They are known as Hospitallers, given their brave and selfless record in charitable endeavors and hospital building. The most famous are in Montpellier, Rhodos, Prussia, and various sites in Italy. Currently, St. John's Ambulance evolved from Hospitallers. The related Knights Templar (Order of the Poor Knights of Christ and the Temple of Solomon, or the Teutonic Knights) remained involved in military-religious affairs rather than charity and amassed great power and wealth but was suppressed by Pope Clement V in 1312.

The general hospital (above) does not specialize, but from time to time, special institutions appear. Although the Basilica at Caesarea (4th century) already had rooms for lepers, the leper's houses (House of Lazar)

likely date back to the 11th century. When Europe began to experience an epidemic of leprosy, when this subsided in the 15th century, the houses of lepers were converted by civil authorities into mental hospitals or hospitals for infectious diseases.

### The Development of Hospitals in the Golden Age of Islam

With their eastern conquests consolidated and the western offensive decisively defeated at Tours by the Frankish army under Charles Martel (723), the Islamic revolution, initiated by Muhammad in 632, consolidated its gains and moved into a period of extraordinary stability and development—the Golden Age of Islam, which ended in the 13th century. While Europe was experiencing an era of the dark ages, which finally ended with the Renaissance, Islam succeeded in stimulating development and original thought. Although medical science in Europe stagnated around Galen's doctrine, hospitalization did develop as the need for treatment of disease increased.

Hospital buildings in the Islamic era took the example of the Christian teaching hospital (Nestorian) in Jundi-Shapur. Islam developed its impressive hospitals (bimaristan) in Cordoba, Baghdad, Damascus, Bokhara, Seville, and Cairo. A total of 34 major ones have been identified. Tudela, who visited Baghdad in 1160, wrote that there were 60 hospitals in the city and 50 in Cordoba. The largest and most magnificent was the Mansuri hospital in Cairo (completed in 1284). This self-contained institution has four large grounds, each with a fountain in the center, separate wards for men and women and for different ailments, a pharmacy, lecture halls, and an outpatient department (from which patients are visited in their homes). House, a chapel, and a library. The fountain cools the fever ward. Musicians and storytellers comfort the sick,

Hospitals in Cordoba, Baghdad, Damascus, and Cairo, in particular, also served as medical education centers, attracting students from Europe and the Far East, spanning the void of Medieval scientific stagnation to the founding of its European medical school in Salerno." (Acta, 2005)

### 3. RESEARCH METHOD

The study uses a research method with a qualitative approach. The qualitative method is one of the research strategies to produce descriptive data, the results are in the form of written or spoken words from the results of observations or studies of certain documents. The development of traditional to modern architects will be studied by studying various documents and literature. Lean thinking must be considered when designing a modern hospital.

## 4. RESULTS AND DISCUSSION

### History of Hospital Design and Typology Development

During the early 18th century, hospitals continued to be places of charity, especially in German-speaking countries; Civilian hospitals were primarily focused on bringing the poor off the streets and preventing people from falling ill. However, during this century, epidemics such as cholera-stricken cities, extremely high death rates due to no medical treatment to cure patients, and overwhelming hospital infections. Since the mid-18th century, with the industrial revolution and the development of sewage systems by John Snow in London, the sanitary conditions of the city have improved significantly (Tulchinsky, 2018). Hospital design principles relate to the exhaustion of natural ventilation in all spaces. Thus a hospital corridor typology emerged, and then a pavilion building typology emerged,

Most hospitals built in Europe in the 19th century adopted a pavilion system, allowing the patient wards to receive natural light and a constant flow of fresh air. The Academie des Sciences committee recommended this typology as an ideal layout that provides advantages such as the flexibility to gradually expand the building's capacity by adding more pavilions next to each other.

Since the mid-1950s, the 'wide-foot' or matchbox model has emerged with the advent of maternity departments and intensive care units due to technological innovations. The space design must therefore be adapted to accommodate the new technical equipment. The typology consists of a multi-story building containing a patient ward on top of a lower-rise building that holds other functions. Nevertheless, the expectation that outpatient departments are growing rapidly and inpatient wards reduce the adoption of low-level typologies again (Wagenaar *et al.*, 2018).

It can be concluded that the technological advances of each era 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 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 resembling blocks to shopping malls and techno-utopias to zoned campuses with a distinct local feel and a focus on sustainability.

Hospitals today no longer look like hospitals. "While churches have minarets, schools have playgrounds and hotel lobbies. Urban public hospitals only have the size to announce themselves. Except for



the H and the ubiquitous emergency sign, more ambulances, and maybe a bunch of smokers on I.V.s, contemporary hospitals are often only recognized by their size. If anything, many new hospitals can be thought of as big box stores or industrial parks.

Hospital architecture is not always so difficult to understand. The buildings from the 1950s and 1960's scream, I am a hospital. It is a tower that soars over a vast multi-story bearing, with a circular driveway and thousands of identical windows. A good example was Chicago's Mercy Hospital, designed by CF Murphy in 1968. Such hospitals are markedly cheaper and much larger. The general form of the building with an elevator and open directly to the nurse's station; a straight and wide corridor with continuous wooden fences; and a lobby with a gift shop.

### 1. Hospital Mall

Mall-shaped hospitals pioneered by healthcare architecture Stephen Verderber are called horizontalism, where hospitals are spread across their sites and sometimes multiple, in low-rise pavilions. Hospital malls are the classic architecture of so-called patient-centered care, a movement that saw patients become consumers in the 1970s and 1980s. Some of the characteristics at this time are:

- a) Color games in hospital interiors have emerged since the 1980s, including unique color combinations and aiming for patients to relieve stress when entering.
- b) Simultaneously, the space between the hospital buildings becomes significant, giving rise to a healing garden and other therapeutic-laden landscapes. Even the view from the hospital window could be considered healthy. All of these features – campus-like plans, polychromies, and connection with nature – are meant to distract patients from the business of being terminally ill.
- c) The growing influence of the hospitality industry and the importance of privacy in buildings in the U.S. led to entire inpatient rooms in each hospital, including facilities that allowed family members to stay – a concept unimaginable in a post-war hospital with rigid visiting hours. Then the emergence of exclusive clinics and hospitals with luxurious facilities such as hot tubs and fitness rooms gave certain hospitals a competitive advantage. The children's hospital even boasts a lobby with features commonly found in theme parks, such as rides, which seem enjoyable.

In all these ways, mall hospitals are blurring the lines between health care, recreation, and shopping to normalize disease. Nowadays, the mall hospital looks rather conventional. Dartmouth-Hitchcock Medical Center in Lebanon, New Hampshire, an early and important mall hospital designed by Shepley Bunch in 1991, has been open for a quarter of a century. In their book *Medicine Moves To the Mall* (2003), authors

David C and Beverlie Conant Sloane describe how major changes in American healthcare played out in hospital architecture, beginning with Medical City Dallas in 1974. As they point out, the big idea behind Dartmouth-Hitchcock is not a city or an atrium but the backbone of a public circulation offering retail, dining, and everyday amenities to patients, staff, and the wider community.

This hospital-city metaphor is often explicit, with corridors masquerading as streets, as if outside, with 'street' lights and benches, giving the hospital a public aura, no matter the pedigree. The large ceiling adds to the illusion that the interior space is outside. A tiered atrium means users can see where they are going across levels, giving them a sense of control like never before.

### 2. Technology-Based Hospital Design

While this projected picture of normality pervades hospital architecture in the late 20th century, sometimes, it is 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. The interstitial section predates the mall hospital, having appeared at the St Louis Kahn Institute for Biological Studies in La Jolla, California, in 1966, and at Tufts Medical Center, Boston, Massachusetts, and McMaster University Health Science Center in Hamilton, Ontario, in 1972. Described by architectural theorist Reyner Banham as a major medical megastructure, McMaster occupies a special category of its own in hospital history. Designed by Craig, Zeidler, and Strong (now Zeidler Partnership Architects) to be big and visionary, it features a long-span space frame structure with mountable mobile units, showing the world that hospitals can adapt and evolve, driven by changing demands. Of modern medicine.

However, the dream of a techno-utopian hospital persists in North America and Europe. Hôpital Européen Georges-Pompidou in Paris, which opened in 2001, looks more like a city within a city than a mall. Another striking example is Morphosis's Cedars-Sinai Comprehensive Cancer Center in Los Angeles (1988). In this dismantled project, the architects tried to avoid what critic Paul Goldberger called a gentle, warm and playful approach by confronting cancer's harsh and unsentimental realities. The innovation comes from grouping all cancer protocols under one roof and using underground sites. This project represents an in-depth exploration of the potential of architecture to communicate compassion, claims the Morphosis website.

### Efforts to Redefining Modern Hospitals

Making hospitals look like shopping malls has shifted expectations about disease and medicine. The buildings intended to make visiting them seem normal. 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. However, improving hospital architecture requires a new perspective. The results are often imaginative for companies that do not specialize in large hospital healthcare design. Architecture in hospital planning began when architects embraced medical technology and landscapes as inspiration, not as constraints or things to be disguised.” (Adams, 2017)

As stated by “Grunden and Hagood (2012), the following:

#### 1. Changes in Traditional Hospital Design to Design based on Streamlining Needs (Lean Thinking)

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. It means that hospital's needs lead the design, not the architect's. Through a series of disciplined exercises, multifunctional teams look at how work is done today and how it can be done 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; drawing came later. With Lean-thinking design, changes include:

- ❖ The amount of time spent in each phase (more in the early phases, less later on);
- ❖ A completely different perspective comes from seeing each step as an opportunity to design more value for patients into each process (optimizing parts).
- ❖ There is an opportunity to ask bold questions and change the general perception of how hospitals can provide value to patients (optimizing overall).

#### a. Traditional Design

In traditional planning, the focus is on architecture, not operations. Architects understand the life expectancy of the current building and where the next expansion is most appropriate. They estimate, prepare diagrams and visualize the shape of the hospital building based on architectural studies.

##### a) Pre-design

The architectural team firmly took the lead, guiding hospital leaders through the basics, such as where to site buildings, how high they could be, and so on. At this stage, the main blocks of functional and proximity areas emerge, along with a rough time frame and budget. The project team, led by a strategic and clinical operations

consultant, guides facility staff through the design process. Its members hone in on their clients expectations and see how the new building will work for patients and staff. From the start, the focus was on the future; however, without a detailed examination of the current state of affairs, the opportunity to dispose of waste remains largely untested.

Programming begins during this phase and consists of two component documents:

- ❖ Functional programs. This narrative document describes the basic assumptions—for example, the number of patient visits the new E.R. will accommodate and whether it includes a fast-track option, for how many hours per day.
- ❖ Program for calculating basic hospital needs in the form of worksheets that include space requirements.

The planners arrived at the size and number of rooms and square footage of the clinical department based on data from historical and projected volumes, operating models, and formulas created over time by experience in other projects. However, the calculation may not be sacred. The space allocation may not meet the needs of the maintenance process and has not been checked before programming. Space and proximity calculations sometimes weigh more on how the last few projects are carried out than on the specific needs of these clients.

##### b) Schematic Design

The schematic design began a few weeks later when the architects returned with a different floor plan. The generalized large block of space now shows where the room is going. Major structural pieces—columns, stairs, elevators, and the like—were completed. on-stage or public areas are distinguished from off-stage or service and staff areas. If the hospital has requested standard rooms from the start, a structural grid with columnar placement can be made to accommodate that. Otherwise, the column does not move in the wrong place, reducing the chances of optimal standardization. If a mock-up is called, it will be created now. In traditional designs, mock-ups are created primarily to see how a single patient room will look and where it is headed.

The organization sets its goals and budget and identifies which patient floors will be affected. Department managers and selected staff members form user groups and review plans to provide feedback. Unless members of the user group have been involved in major hospital renovations, they may not know what to expect or what is expected of them. Formal training and data collection are rare. At the end of the schematic design, departments and adjacencies are defined, can no longer be moved, and the design is frozen. Other functions are involved now, such as engineering, site planning, and interior and exterior design. Adequate

space for equipment must be allocated now. Because so many major decisions have been made hastily, traditional schematic design can create confusion and conflict between staff, leaders, and architects. Completing this phase of work can take months.

c) Design development

During design development, refinements become specific, room by room. Only now, after critical building elements have been thrown in stone, have user groups started discussing whether the new space meets their operational needs. For example, in the operating room (OR), the group will consider table placement, lighting, and anesthesia machines. The room's internal workflow is only now considered: Where will the circulation nurse be located? How will the item be opened or prepared for the next patient? Minor issues can be changed, such as the counter across the room from the automatic drug dispenser. It is too late to fix the problems that have arisen, such as the circulation or placement of major components. At this stage, the architect produces floor plans, elevations, and section details and considers things like telecommunications, I.T., and electrical and mechanical systems.

d) Construction Process

Whether the traditional design has been used to date, user group participation is complete. Architects now prepare construction documents for presentation to construction managers. The construction document translates the final decision into detailed drawings that will determine what kind of facility the general contractor and subcontractors will build. Project managers, architects, engineers, and even subcontractors may have individual contracts with the hospital. Managing work among these groups while maintaining a schedule is difficult and can be a source of friction, cost overruns, order changes, and delays. Communication between all parties must be maintained.

e) Building Operations

The new building, with new spaces and technology, is ready for occupancy. Architects and engineers take key hospital personnel through the commissioning of the building, showing them how the new facility operates, how the physical plant and HVAC systems work, how the alarm system operates, and so on. Moving to a new medical facility requires careful planning long before construction ends. Moving and adjusting to a new space is stressful. Adding stress is a non-standard job. Without a plan across facilities and facilitated workplace organization, supplies and equipment can be put into the space provided without considering overall standardization. The result is a missed opportunity to influence hospital culture through efficient and standardized use of space. It is a loss that will resonate well in the future.

**b. Planning by prioritizing the Lean Thinking Principle**

The 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.

a) Main Planning

The main planning goal remains to develop a long-term view of how construction projects will fit together to create a constantly updated hospital. Learning in the hospital. Lean minds tend to ask bold and paradigm-shifting questions about how healthcare will be delivered in the future. They constantly look for new ways to remove departmental barriers and patient delivery. The main planning stage is collecting data about the different service areas, observing each one, and mapping out the way work is currently being done on a general level. Using data from current state value flow maps, hospital leadership can decide how these service lines can work together better in the future. Starting with an agreement to standardize at an early stage makes the design easier for architects to accommodate. Subsequent decisions may require the removal of structural columns, which can be costly. Inventions made after major planning quickly become impossible to accommodate.

b) Predesign

Hospital leadership begins pre-design by looking at how current processes are performed at the forefront and planning how best to do so in the future. While the architect is valued as a team member, the hospital is still in the lead. The architect can be viewed as a customer at this stage—excited to receive process information that will inform the design. Dennis Robert states, No one communicates with nurses like other nurses. Architects are very caring people, but we live in a different world. Nurse leaders with architectural knowledge help us go beyond architectural questions to operational questions that affect design. We are better architects when we can truly understand the doctor's needs.

c) Value Stream Mapping

Planning with a lean approach is a systematic approach to healthcare architecture design that focuses on defining, developing, and integrating safe, efficient, and waste-free operational processes to create the most supportive and patient-focused physical environment. The sleek design is all about making the right job easier to do.

Rule 1. Activities

- ❖ Think systems, not silos. Look for opportunities to share space between services—for example, preparation and recovery rooms that cater to all invasive procedures.
- ❖ Standardization in design promotes defect-free standard work. Standardize configurations to reduce variation in work processes and increase



long-term flexibility. Standard layouts in co-working spaces such as treatment rooms allow instant familiarity and reduce the potential for error.

#### Rule 2. Connection

- ❖ Create a visual workplace. Establish visual cues that allow staff to determine normal from abnormal right away in their workplace. Designate parking spaces for frequently used equipment to prevent time spent searching while in use.
- ❖ Waiting is futile. Carefully check the waiting area outside the entrance (common lobby and reception area). Do not design a sub-waiting area for queuing patients; rather than shifting the wait from one area to another, strive to move the patient through the system with a smooth one-piece flow.

#### Rule 3. Path

- ❖ The path must be direct. Make pathfinding intuitive. Make it easy to visualize the destination from the entry point. Keep in mind that straight corridors facilitate stretcher travel with minimal waste of motion.
- ❖ Design in smooth flow and movement. Design a layout for a smooth flow, where work takes place in one direction where the start and end are nearby. Consider how work begins and ends and handovers and the journey in between. For example, can patients and family members who come in for imaging be able to enter and exit the same door near their car?
- ❖ Space must be intentional. Design for every square foot needed and nothing more, that space will solve problems is a myth: Excess space leads to increased travel distance (waste of motion) and hoarding supplies and equipment (waste of supplies). Process redesign solves the problem.

#### Rule 4. Continuous Improvement

- ❖ The environment is easy to change. Consider using standard modular equipment, casework, and workstations on wheels to provide flexibility for continuous improvement. Make storage accessible, flexible, visual, and temporary. Create long, shallow equipment spaces to prevent items from being lost or having to be moved to reach items behind. Define a visible parking space for each section.

#### d) Design development

With traditional designs, participants meet separately (or in one long and tedious meeting) with interior designers, lighting, telecommunications, mechanics, plumbing, medical equipment specialists, etc.

#### e) Building Information Model

Building Information Modeling Software is the most advanced design technology available today. BIM

drawings of one floor or department are realistic three-dimensional models that can overlay every detail and track proposed building changes in real-time. (Grunden and Hagood, 2012) ”

## 2. To Start Lean

The collaborative model eliminates waste and unnecessary activities so that planning accommodates efficiency in the workflow and flow of activities in the utilization of the building. A practical approach to planning that adopts lean thinking is that the earlier, the better, but it is never too late. Lean Thinking, applies the principles of eliminating unnecessary activities (waste) and continuous improvement in implementation to support planning.

### Lean Thinking approach for observing ineffective use of space

APICS Dictionary (2005) defines Lean as a business philosophy emphasizing the efficient use of resources (including time) in various activities in institutions such as hospitals. “Lean focuses on identifying and eliminating non-value-adding activities in an institution's operations, and supply chain management, which is directly related to customers (Gaspersz, 2011).”

<sup>3</sup> 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, reduce waiting times, remove all barriers and support the activities of doctors and employees aimed at improving the quality of care patient care (Graban, 2016).”

“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 (Boos and Frank, 2000). Lean was first discussed in the automotive industry by the Toyota management system in the 1890s (Emiliani, 2006). Since then, lean has attracted the interest of various industries worldwide and has been applied to many aspects other than manufacturing (Edwards, 2004). ”

Implementing the lean concept in health care has been carried out by the Virginia Mason Medical Center in Seattle, Washington, since 2002, reducing inventory levels by 53% within two years (Graban, 2010). The goal of lean thinking 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 (Baril *et al.*, 2015). Implementing lean hospitals as a form of customer satisfaction-oriented service improvement is necessary.



In the context of health care, the most important management issue is, "providing high-quality patient care (West, 2001). Farrell (2007) views that lean is the best formal approach. Meanwhile, Young and McClean (2009) 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 healthcare practices (Graban, 2010). 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 in terms of the number of people served and the quality of services provided (Grunden & Hagood, 2013). Doss and Orr (2007) conclude that lean provides practical benefits for healthcare organizations by changing the value stream 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. "Hospital design is carried out by identifying and eliminating waste or non-value adding activities through continuous radical activities by channeling products (materials, work-in-process, output) and information using a pull system from stakeholders to pursue excellence and perfection (Gasperz, 2010)."

Lean (downsizing), is a concept for continuous improvement that is useful for increasing efficiency, quality, productivity, safety, and employee and patient satisfaction. Lean works by eliminating and reducing waste or activities that do not have added value in the service process, especially related to patient waiting times, process flow, and activities that do not add value from the patient's point of view. Based on the definitions above, the lean focus is on the continuous improvement of customer value through identifying and eliminating activities that do not provide added value, which is waste. Graban (2016) states that there are five principles in a lean mindset, namely: (1) Establishing value from the point of view of the end customer (in this case, the patient); (2) Identifying all steps in the value stream, eliminating every step that does not provide value; (3) Creating value-added steps that occur in an integrated manner so that the workflow is smooth; (4) Establishing added value (value added) in the service process drawn from customer perceptions (customer/demand pull); (5) Gaining perfection through continuous improvement.

The simplest and most elegant thing about lean, which comes from the Toyota culture, according to Graban (2016), consists of two parts, namely:

1. Total elimination of waste. Waste or waste is any activity that does not help the patient's healing process. All waste must be eliminated or minimized

to reduce hospital costs, increase patient satisfaction and improve patient and employee safety. Examples of waste that often occur in hospitals are as follows: Patient waiting time to be examined by a doctor; Patient waiting time for the next stage; There is an error that endangers the patient; Unnecessary movement, for example, far away from the pharmacy and cashier

2. Respect for people. Respect has a broad meaning, such as how leaders are committed and trust their employees to participate in helping solve problems and reduce waste. Furthermore, motivate employees to care more about patients and the hospital environment without them feeling bored and forced and build cooperation between implementing employees and management, so there is no assumption that management manages the system and solves problems. Moreover, it makes decisions while implementing employees to carry out instructions.

The following are five lean principles that can be adopted in the hospital service system (Graban, 2011): "(1) Value, and 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."

So when the lean concept is used in the healthcare industry, eliminating waste and respecting people is respect for patients, employees, doctors, communities, and stakeholders of the hospital and the environment, so all actions taken must be accepted by all involved. In the design of lean thinking architecture, this must also be applied, and the design must be very efficient and, as far as possible, meet the needs of all stakeholders. Lean focuses on identifying and eliminating non-value-added activities (waste/non-value-adding activities) in an institution's operations, and supply chain management, which is directly related to customers (Gasperz, 2011).

Lean concept (downsizing) starts from making a big picture value stream map, for example, from 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). The purpose of implementing the lean concept (downsizing) is to produce a more efficient process, with minimal costs, faster service time, and

better service quality to reduce non-value added activities.

From the theories above, the principles of lean optimization of hospitals that can be carried out are:

1. Identify the value of the hospital based on the patient's perspective
2. Identify the value stream mapping on the value that will be applied in the hospital
3. Minimize the workflow in the implementation building based on the identification information of the values applied in the hospital.

Examples of data analysis steps in the lean thinking design process are: “ (1) Service System Description. The aim is to discover the processes in the outpatient unit at this time through 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. ”

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. Using lean in design is the earlier, the better, although it is never too late.

## 5. CONCLUSIONS

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. However, improving hospital architecture requires a new perspective. The results are often imaginative for companies that do not specialize in large hospital healthcare design. Architecture in hospital planning began when architects embraced medical technology and landscapes as inspiration, not as constraints or things to be disguised. An efficient hospital is one of the determinants of hospital quality. A hospital is said to be efficient if it can use all available resources to produce something as desired.

Lean principles focused on customer needs and the effectiveness of the building in its operations. The more lean thinking is used in planning, the more effective the resulting design will be. Technological advances of

every age have influenced architectural design. 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. Is recommended further research is needed to examine this.

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