

The relationship among technology, equipment and space organization in designing hospital architecture

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Abstract

Technology advancement directly affects the way of providing medical services, in terms of both management and architecture facilities, namely space organization. The trend of hospital architecture now is heavily influenced by technological revolutions of medical equipment, mostly in terms of changing machinery size, and consequently providing more efficiency and less requirement of space. The emergence of new technology and the import of medical machinery and equipment actively accelerate these changes.

The role of management and the capability to examine and provide medical care is reflected in the availability of advanced diagnostic and treatment equipment, integrated with information technology systems to transmit data and images. This article focuses on analyzing the effects of science and technology, the digital revolution, and medical equipment on space organization for providing medical services in modern hospitals.

Key words: Hospital Architecture; designing hospital; medical technology; hospital IT system; medical equipment

1. Introduction

According to the World Health Organization (WHO), a hospital is a part of a medical and social organization whose function is to ensure that people receive comprehensive medical care, both curative and preventative care. The hospital's outpatient work extends to the family in its environment. The hospital is also a center for medical teaching and sociobiological research[10]. By this definition, the hospital is not only a health care provider, but the hospital assumes a range of functions and harmoniously links health care to society. This new concept changes the mission, functions, organizational structure, and method of hospital management.

With the rapid development of science and technology, medical imaging technology creates multiple advanced medical equipment, including diagnosis and treatment equipment. Modern technologies are invented regularly and continuously every year – it is completely changing many healthcare methods, and also significantly affecting organizational principles such as the architecture of space for examination and treatment.

2. Hospital information system with healthcare communication

Through the digital transformation process, hypothetical/test situations are considered as input data to create response scenarios; and via the virtual reality system, the interaction between hypothetical situations and the medical tasks of robots is established. Functional probe devices which are capable to check the function of the patient's body such as electroencephalogram, electrocardiogram, respiratory, diagnostic-oriented devices, endoscopes, etc.



Figure 1. New North Hospital – New Zealand[4]



Figure 2. Helsingborg Schmidt Hammer Lassen Hospital – Sweden[3]

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are connected to a central processing unit to offer optimal treatment options and provide doctors with full analysis to evaluate and choose the best capable treatment.

Technology advancements in medical fields in recent years are also provided tools to collect, search, store, transmit, retrieve, query, and ensure the privacy of each medical record, in the field of medical examination, treatment, and health care. These data also support doctors to forecast and analyze the patient's disease stages to find correlations with the disease patterns. Hospital information systems bring many benefits to medicine, most notably assisting to store and analyze data for medical research, remote medical support, and helping doctors to make clinical decisions.

For example, the Mayo Clinic Foundation in Phoenix, Arizona, USA, is remotely connected to a hospital that is located 12 miles away for access to information, data, and patient monitoring.

Middlemore Hospital in Auckland, New Zealand builds a network of outpatient clinics with telecommunications systems. The first trial of its kind in New Zealand enables outpatient clinic centers to transmit diagnostic images to radiologists working at Middlemore Hospital for consultation. [2]

In Georgia, USA, a project to connect 55 small cities and their rural hospitals with major medical centers is implemented to create opportunities for examination and consultation among local specialists, patients, and hospital doctors.

In Finland, the University of Helsinki is connected with hospitals scattered throughout the territory to integrate their mobile institutions of C.T. (computed tomography) and M.N.R. (nuclear magnetic resonance), so that they can effectively respond to the problem of emergency magnetic resonance testing in the field of nerve trauma. [3]

In Italy, an interesting initiative of adopting orthopedic telephone consultations is being launched since 1996 at the Istituto Rizzoli of Milano [4]. This initiative offers patients who reside in the southern regions of Italy and are required to have a first visit to the hospital can have the pre-consultation through postal services. This consultation is also extended to outpatients and programmed control after-surgery patients.



Figure 4. Surgery preparation room - Johns Hopkins University Hospital- Maryland- USA[1]

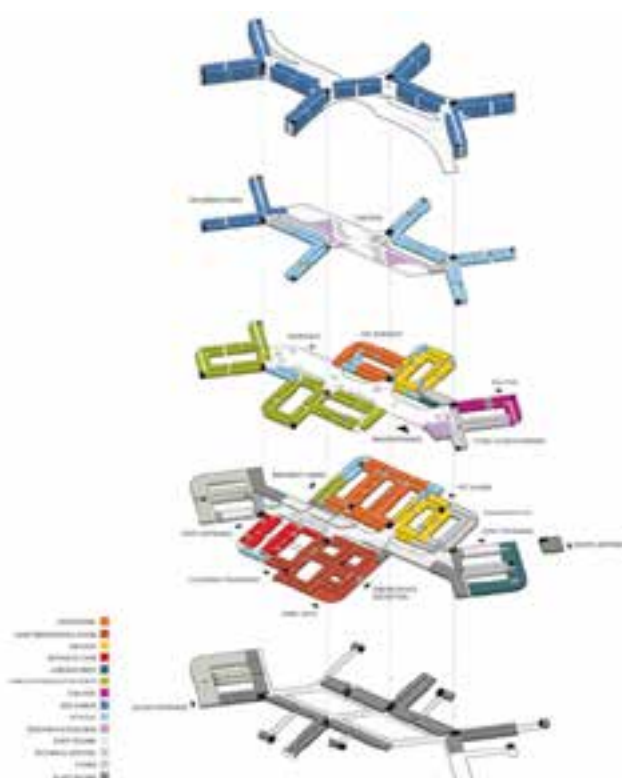


Figure 3. The diagram of the hospital function chain Lynd Park– Germany[3]

In Vietnam, TeleHealth technology allows Hanoi Medical University Hospital to provide remote medical examination and treatment to a range of hospitals across the country. Medical consultation sessions are also held between Hospital 199 and Hanoi Medical University Hospital with the participation of doctors at the two hospitals, resulting in optimal efficiency of treatment.

In Thua Thien Hue province, the Department of Health applies GIS to perform remote medical examinations and treatment. Hospitals in the province create and manage health records online, and as a result, most people in the area are now registered with electronic medical records.[6]

Information technology supports connecting local medical centers with central specialized hospitals in primary medical examination and treatment, and to raise community awareness in disease prevention. Additionally, the media serves a critical role in guiding and propagandizing information about disease control and prevention, consequently reducing the number of patients required to visit the hospital.

Medical equipment

The rapid advancements of technology in medical equipment assist hospital architectural design standards seamlessly keep to pace with such medical changing development.

- Equipment for emergency resuscitation: in addition to common emergency equipment such as monitor multi-parameter emergency beds, and surgical instruments, hospitals are also equipped with specialized equipment classified by emergency specialties, such as Respiratory Resuscitation, Cardiovascular Resuscitation, Urological Resuscitation, Gastrointestinal Resuscitation, Toxic Resuscitation, and Intensive Care Unit (ICU).

- Equipment of the operating room is renovated with modern equipment because the operating room is the center of focus where high technology and medical techniques are developed for medical intervention and treatment. Therefore, the working space in the operating room must be comfortable and not interfere with the operation of the surgery. Other microclimate environmental conditions in the operating room (for example clean water, sterile, cold light, high illuminance, cool, clean temperature, air) are continuously circulated and at higher pressure (++) compared to the surrounding, but the noise level must be at the allowable level; and transfusion, blood, medical gas, and necessary consumables must be ready all the time.[7]

- Functional probe devices: many new types of equipment that support easily checking the ability of body functions are available, such as electroencephalogram, electrocardiogram, and spirometer, especially with diagnostic equipment, endoscopic equipment...

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4. New requirements in hospital design adapting to technology and medical equipment

- Instead of visiting hospitals to take a medical test or examination, patients can take medical samples at various

functional departments at different locations. Further, the deployment of telehealth by applying info-communication technologies changes the way of medical examination and treatment. Moreover, designs of the medical examination lines require architects to arrange spaces for patients in a convenient location, so that medical staff can access the patients for conducting operations and the patients do not have to move. This is the core point of view that asks architectural design to change to better satisfy new needs of examination and treatment when information technology and diagnostic technology are changing.

- The core health providers, who should be developed as community hospitals, offer a new perspective on primary treatment. Specifically, these community hospitals provide short-term examination and treatment; deliver re-examination and follow-up patients who completed emergency procedures at major hospitals. With the support of Telehealth, it is possible to maintain an optimal number of doctors who are capable of providing basic healthcare, monitoring the health of patients with special medical needs, and supervising elderly patients or those who require intensive care.

- Solution to divide space: Currently, most hospitals are designed to divide space based on rigid modules. This type of division is less flexible and creates a lot of spread spaces in large sizes without a high frequency of use. With modern medical equipment, medical machinery and equipment are integrated with many functions, making spaces for departments such as general examination, ultrasound, preparation, auxiliary procedures, and auxiliary tests convenient. Functions are "borrowed" among these departments from time to time to maximize the efficiency of the working area. The removal of most of the hard partitions such as brick walls and concrete walls reduces the workload, lowers construction costs, and minimizes the infiltration of water and polluting chemicals over time.

- With the help of telemedicine consultation, online patient classification will significantly reduce the area of outpatient examination and treatment areas. Patients who are screened before coming to the hospital need to be



Figure 5. The modern equipment in the operating room. Medical equipment for neurosurgery[2]



Figure 6. Novant Clemmons Extensive Clinic Transitional care clinic helps to stabilize patients before returning home[8]

designed with an appropriate approach to reduce clutter in the clinic and outpatient treatment.

- The application of information technology in the management and administration of the medical examination and treatment process also reduces the excess movement of patients and their family members, and medical staff will be able to optimize the common areas.

- The height requirements in operating, testing, and scanning rooms need to be updated according to the requirements of medical machinery and equipment. Hospital architecture design also needs to make efforts to optimize power use through the application of energy-saving solutions and devices (automation, smart management, integrated heat recovery air conditioners, led lights, etc.). Architectural and landscape design solutions ensure thermal balance and natural air convection (such as narrow slit ventilation, corridor ventilation, facades with active radiation control, hybrid covering materials, indoor plants, and vertical

gardens). These views in architectural design contribute to maximizing the use of clean energy sources (solar energy, wind energy, heat recovery ... for hot water supply and navigation equipment, and passenger lighting corridor, and basement).

5. Conclusion

Technology and equipment create requirements for fundamental changes in hospital architectural design. Hospital architecture has a critical role in creating space to meet the needs of implementing and applying new medical examinations, treatment processes, and technologies in the hospital. Therefore, shortly hospital design work needs to take important breakthroughs and major changes, reflecting and selectively absorbing major changes in modern technology and equipment. A hospital that performs well in healthcare needs to have the right architectural design, the right technology line design, and the right medical equipment./.

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