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智慧病房整建之探討–以某醫學中心為例

Smart Patient Room Design from Concept to Implementation - A Case Study of a Medical Center in Taiwan

吳欣儒

Olivia Wu

指導教授：董鈺琪博士

Advisor: Yu-Chi Tung, Ph.D.

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智慧病房整建之探討-以某醫學中心為例

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本論文係吳欣儒君(P05848013)在國立臺灣大學健康政策與管理研究所完成之碩士學位論文，於民國 107 年 6 月 21 日承下列考試委員審查通過及口試及格，特此證明

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中文摘要

全世界都面臨護理人員短缺的情況，是一個全球性的趨勢。護理人員短缺會直接影響照護品質。將醫院數位化來減少工作量及流程已是一種趨勢。有些護理工作甚至能達到自動化。這個研究將探討智慧病房的設計和實施所面臨的機會及挑戰。以台灣的醫學中心新光吳火獅紀念醫院為例，透過內部分析、外部分析及SWOT 分析來探討如何執行醫院的策略。研究資料包含佔床率、病人滿意度、護理人員比例、離職率、財務收入及成本、改建前後的病房照片。本研究將呈現出透過改建成為嶄新設計的智慧病房，如何達到財務效益、降低護理人員離職率及提升病人滿意度。

關鍵字：醫院策略、護理人力短缺、智慧病房、科技化

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Abstract

The trend of hospital nurse shortages is global and the effects are similar. The lack of nurses is leading to challenges in providing high quality of care. Digital hospitals are becoming a trend to reduce workload and streamline operations. Technology has been able to help automate part of the required care in nursing. The research will explored the opportunities and challenges involved in designing and implementing smart patient rooms. The present study undertakes a case study based on Shin Kong Wu Ho-Su Memorial Hospital, a medical center in Taiwan. The exploration of the hospital's strategy is conducted through an internal, external and SWOT analysis. The supporting data includes secondary data included occupancy rate, patient satisfaction, nurse staffing ratios, turnover rates, revenue, cost, design floor plan and post-construction review. The case study shows how a successful renovation project and newly designed patient rooms can bring about financial benefits, lower turnover, and higher patient satisfaction.

Keyword: Hospital strategy, Nursing shortage, Smart patient room, Technology implementation

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Chapter 1 Introduction

1.1 Background

Societies in which those 65 years and older account for 7%, 14%, and 20% are referred to internationally as aging societies, aged societies, and super-aged societies respectively. Taiwan became an aging society in 1993, and is projected to become an aged society and super-aged society in 2018 and 2026 respectively.[1]

From 1960 to 2015, the proportion of the elderly population aged 65 and over in Taiwan has been similar to that of Korea, and less than that in the other countries in Figure 1.By 2060, the proportion of the elderly in Taiwan, Japan, and Korea will be higher than that in the other countries listed in Figure 2.[1]

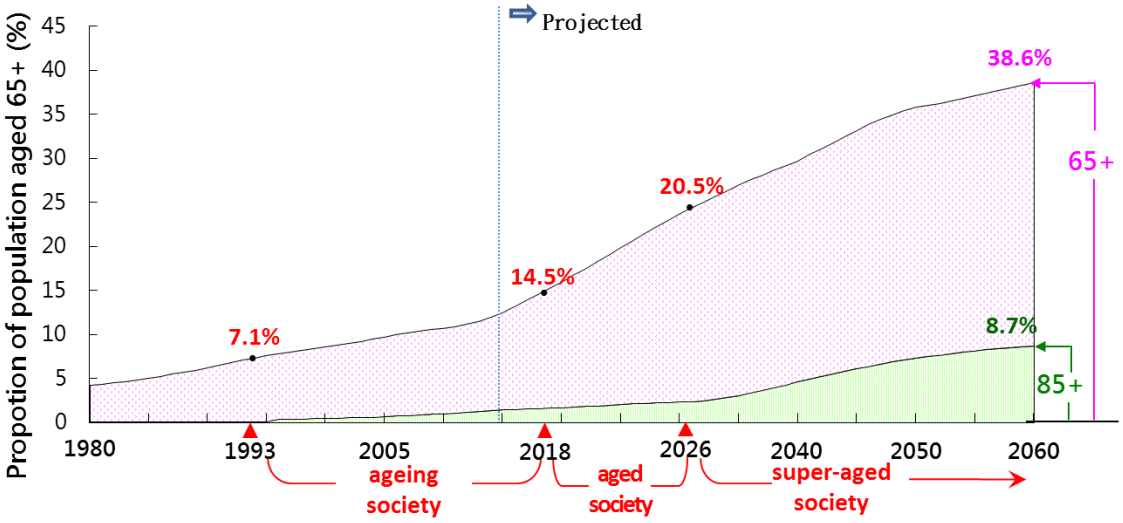

Figure 1: Speed of Population Ageing

Source: Population Projections for R.O.C. : 2016~2060.[1]

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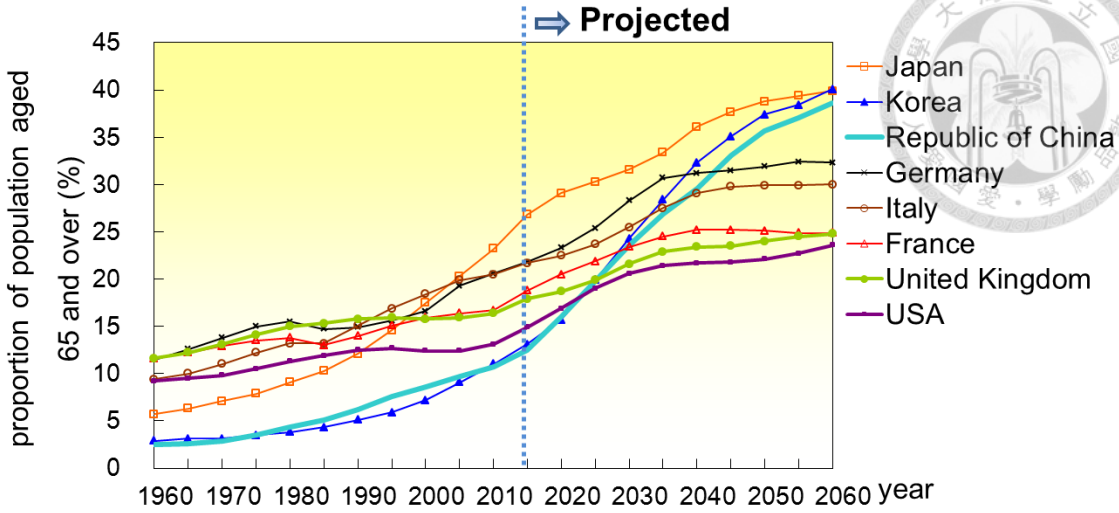

Figure 2: Proportion of 65 and over Population in Selected Countries

Sources: Population Projections for R.O.C. : 2016~2060.[1]

According to Taiwan Union of Nurses Association (TUNA), at the end of 2016, there are 269,350 licensed nurses. However, only 158,318 people are practicing nursing accounting for only 58.4% of the licensed population. The employment rate is very low in comparison to Canada of 86.6% in 2010 and United States of 84% in 2009. [2]

Figure 3: Average Proportion of Registered Nurses in Taiwan from 2009 to 2016

Sources: Taiwan Union of Nurses Association. [2]

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In Taiwan, a study of 108 wards in 32 hospitals demonstrated an association of nursing staffing to patient mortality [3]. The article not only suggests that nurses in Taiwan or assigned 5 times more patients during the night shift than U.S. or European nurses, they are also providing less direct nursing hours. A shortage of direct nursing care hours to patients could risk the quality of care received.

The trend of hospital nurse shortages is global and the effects are similar. The lack of nurses is leading to challenges in providing high quality of care. Management intervention is potentially required to help fix problems in work design and workforce management. Nurses in different countries working under various healthcare systems have reported job dissatisfaction. Literature review showed that various studies conducted in North America [4], European countries [5], China [6] and Taiwan [7] all show the same pattern of dissatisfied nurses in nursing practice.

Nurses and Patients from 13 countries were surveyed to understand how improved nurse staffing and work environments can affect patient care and nurse workforce stability [5]. Observations from large study of different countries indicate that the retention of qualified and committed nurse workforce is critical in improving hospital care. If management can pay more attention to the needs of nurses and help improve the hospital work environment, nurses' may have more job satisfaction and confidence to bring better quality of care to the patients.

Hospitals have been using technology to help provide better quality of care to patients. This includes changing or enhancing their workflow with better health information technology adoption [8, 9] or creating more comfortable rooms that can accommodate technology that can allow for better care of patients [10]. Redesigning rooms have led to better outcomes and less medical errors. The efficient patient room created a better space for both the nurse and the patient helped decrease attrition rate of nurses, and increased patient satisfaction. A smart bedside system can provide better patient centered service during hospital admission [11]. New designs allow for an exploration of patient centered experience that provides a better experience for doctors, nurses and patients. However, with any adoption of technology and design, the hospital administration will also be faced with challenges in utilization of the right amount of technology, adoption of technology and cost considerations for scalability.

Digital hospitals are becoming a trend to reduce workload and streamline operations. Technology has been able to help automate part of the required care in

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nursing. These changes not only provide a better work environment but also decrease the burden on nurses. The benefits of implementing technology in hospitals include better care and safety, reduction in medical errors, and reduction in costs. Hospitals in Taiwan are dealing with an aging population and decrease in the number of nurses who are willing to be part of the workforce. The motivation of writing this paper is trying to understand how a hospital was able to use technology to enhance its patient rooms and help solve the nurse staffing issue.

1.2 Purpose of the Study

Hospitals are developing smart patient rooms are to improve the safety and quality of care. These rooms allow patients to have better control of their environment and allow for nurses to offer better care. The purpose of this study include:

(1) To understand the financial benefits of implementing smart patient rooms.

(2) To understand the impact to nurse staffing ratios after the implementation of smart patient rooms.

(3) To identify the opportunities and challenges involved in designing and implementing smart patient rooms.

1.3 Limitations of the Study

Due to resource and time constraints, there were a limited number of data collected. Other potential limitations include the scope of research, research approach and researcher bias. The scope of research is limited to a case study of a medical center in Taipei. One hospital may not fully represent the medical environment or issues that are present in other medical facilities. In addition, the research approach of a single case study also has its limitations. It is used to simplify and to understand complex real life situations. However, a case study uses a qualitative approach, does not allow for a large group of sample and therefore may not provide generalizations. In addition, a case study is stronger when the researcher has expertise and enough objectivity to provide an in-depth understanding. Therefore could also be potential research bias since the author of the thesis also worked at the institution during the time of the development of the

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patient rooms.

Based on the research aim and objectives of this study, it has been demonstrated that the most appropriate strategy is a qualitative case study method. The case study approach has a distinct advantage when the researcher is asked to analyzes a set of contemporary events which the researcher has little or no control over. Although there are limitations in this research methodology, the data collected are enough to reach valid conclusions for this study.

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Chapter 2 Review of the Literature

2.1 Nursing Practice

Hospital nurse shortages are creating a serious challenge to providing high quality care. Management intervention is potentially required to help fix problems in work design and workforce management. Nurses in different countries working under various healthcare systems have reported job dissatisfaction. Literature review showed that various studies conducted in North America [4], European countries [5], China [6] and Taiwan [7] all show the same pattern of dissatisfied nurses in nursing practice.

International studies in North America, Britain and Germany [4], and in Europe [5] showed that work environment is related to job satisfaction, burnout and nurse shortage. In 1998 to 1999, 43,329 nurses from more than 700 hospitals in the United States, Canada, England, Scotland and Germany were sampled [4]. Nurses in the United States, Canada, England and Scotland had low morale and were emotionally exhausted. More than 30 percent of the nurses under the age of 30, in England and Scotland, expressed their desire to leave their job in the next year. Most of the nurses believe that physicians and nurses are clinically competent and have good working relationships. However many believe that there are not enough registered nurses and staff to get the work done due to a lack of supportive services. In addition, fewer than half of the nurses in each country believed that their hospitals is responsive to their concerns, have the opportunity to participate in policy decisions or are publicly acknowledged for their contributions to patient care.

Nurses and patients from 13 countries (33,659 nurses and 11,318 patients from 12 European countries and 27,509 nurses and more than 120,000 patients the United States) were surveyed to understand how improved nurse staffing and work environments can affect patient care and nurse workforce stability [5]. A substantial portion of nurses reported care deficits, high nurse burnout, job dissatisfaction and intention to leave their current positions. Patients' and nurses' ratings of hospitals were similar; whether patients would recommend their hospitals to others was associated with the nurses' ratings of their hospital work environment and nurse staffing. Nurses lacked confidence that hospital management would help solve identified problems in patient care.

In China, a qualitative study of nursing leaving nursing practice explored mismatched expectations between an individual and organization and an individual

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perceptions of power can lead to voluntary leaving [6]. In depth interviews with 19 nurses indicates that ineffective nursing employment happens when experienced nurses choose to leave and when they continue to stay with a dehumanized attitude towards their patients. Nurses who have higher perceptions of power may choose to leave. Nurses with low perception of power will feel that they lack autonomy and managerial support. These nurses may compromise their expectations of nursing, resulting in lack of enthusiasm and commitment at work.

In Taiwan, nurses have experienced low job satisfaction and low professional commitment due [7]. Research has demonstrated that there is an association of heavy workload to job dissatisfaction. The study aimed to develop a Clinical Nursing Practice Environment Scale model that emphasizes both organizational and individual factors to create a positive practice environment. A sample of 687 registered nurses completed the questionnaires and provided initial evidence that the scale is reliable. The scale of 29 items can be grouped into a five factor solution including: availability of safety equipment and devices, pay and benefits, mutual respect and support among co-workers, support of advanced in-service training, and workforce security and safety.

Observations from large study of different countries indicate that the retention of qualified and committed nurse workforce is critical in improving hospital care. If management can pay more attention to the needs of nurses and help improve the hospital work environment, nurses' may have more job satisfaction and confidence to bring better quality of care to the patients.

2.2 Shortage of Nurse Staffing and Its Effect on Patient Outcomes

According to the International Council of Nurses [12], the potential shortage of nurses will happen in countries where a shortfall of nurses entering the workforce are not able to replace the number of older nurses who may prematurely exit or reduce their practice hours. The shortage of employed nurses along with an older patient and nursing population will have a direct effect on maintaining health care. Currently, there are research looking at nurse to patient ratios and their effects and implementations and suggest that there is an association between lower nursing workloads to better patient outcomes in areas such as mortality, falling and infections.

Better hospital nurse staffing, more educated nurses and improved work

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environments have been associated with lower hospital mortality. Across-sectional analyses of data of 10,184 staff nurses, 232,342 patients from 168 nonfederal adult general hospitals in Pennsylvania suggested that each additional patient per nurse was associated with a 7% likelihood of dying within 30 days of admission and a 7 % increase in the odds of failure to rescue [13]. Each additional patient per nurse was associated with a 23% increase in the odds of burnout and a 15% increase in the odds of job satisfaction.

Another study showed how work environment and nurse staffing could affect mortality rates. The effects of nurse staffing was studied in the outcomes of 1.2 million patients to about 39,000 hospital staff nurses in 665 hospital in four large states in America [14]. The 30-day inpatient mortality and failure-to-rescue data showed that decreasing the workloads by one patient/nurse was virtually nil in hospitals with poor work environments. In average environments, the odds for death and failures decreased by roughly 4% and in hospitals with the best environments, the odds decreased by 9% or 10%. In addition, a 10% increase in more BSN (bachelor's degree in nursing) educated nurses decreases the odds on patients dying about 4%, some hospitals have 40% more BSN nurses than others which means the mortality difference would be reduced by (0.96^4) 15% this translates to a workload of eight patients versus four which is associated with a 31% increase in mortality.

Nurse staffing levels and the proportioned nurses with a bachelor's degree was also associated with 30-day inpatient mortality in nine countries [15]. Each additional patient per nurse is associated with a 7% increase in the odds of a patient dying within 30-day of admission. Every 10% increase in a bachelor's degree decreased this likelihood by 7%.

In Taiwan, a study of 108 wards in 32 hospitals demonstrated an association of nursing staffing to patient mortality [3]. Average direct nursing care-hour was 4.95 hours per patient day, which is approximately 21% of a full day care of 24 hours. Therefore, the shortage of direct nursing care hours to patients could risk the quality of care received. In addition, the article mentioned that in some Taiwanese hospital, during the night shifts, a nurse can be assigned up to 20-30 patients which are five times of a U.S. or European nurse. The study does not directly comment on the ideal nurse to patient ratio but suggested that increasing nurse staffing to help improve quality care.

Higher nurse staffing also resulted in fewer infections and complications.

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Inmedical patients, higher nurse staffing levels resulted in reduced numbers of urinary tract infections, pneumonia, upper gastrointestinal bleeding and shock in medical patients and lower rates of failure and urinary tract infections in major surgery patients [16]. A study of 35 nursing units in 3 hospitals, not only looked at nurse staffing and skill mix but also temporary nurse staffing and turnover [16]. One finding was that the greater use of LPN (licensed practical nurses) decreased patient fall. Units that used temporary RN (registered nurse) staff to provide equal or more than 0.3 hours of care had 1.552 times greater rate of patient falls and 4.169 times greater for injury-related falls. Increased use of temporary RN staffing resulted in greater patient falls in both non injury related and injury related falls; this suggest that temporary RN staff may be detrimental to the quality of care. The authors suggest that unfavorable work environments for nurses can lead to the increase of using temporary RN staff and poor quality of care.

The levels of nurse staffing is may also predict the number of patient falls [17]. The study of 11 hospitals examines the missed nursing care by studying the relationship between the hours per patient day (HPPD) with patient falls. Hour per patient day explained 13% of the variance in patient fall falls. Missed nursing care negatively affects patient falls by about 9.2% of the variance in patient falls. A particular study suggested that lower fall rates were associated with higher staffing up to a 15 hours per patient day in step down, medical and combined medical surgical units [18]. Fall rates were higheston medical units. The relationship between nursing hours was the strongest on medical units.

Other adverse effects that had a significant relations with nurse staffing included pneumonia, wound infection and sepsis [19]. For every 10% extra time patients spent with assistants, they had a 1% increase of developing a urinary tract infection and 2% increase in the chance of developing pneumonia [20]. Patients who had pneumonia, wound infection or sepsis had a greater probability of death during hospitalization.

In the future, older patient populations have an increased length of life will also require more complex care. Older nurses will also be challenged by age-related changes such as chronic diseases, visual impairments, pain and aches associated with arthritis [12]. There is a potential that they will require longer times for recovery. When older more experienced nurses exit their practice or reduce their working hours, a lot of their knowledge, and clinical expertise may be lost. The ICH is tailoring employment

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strategies to help in retention of older nurses so that they can continue their contribution to training and mentoring next generation of nurses.

To deal with changing patient and system needs the International Council of Nurses that is a federation of more than 130 nurse associations that represents millions of nurses, published their perspective that there is scientific evidence that lower nursing workloads leads to better patient outcomes [21]. A few countries, such United States, Korea, and Australia have set mandatory minimum nurse to patient ratios or developed policies to help ensure safe and quality patient care and to recruit and retain nurses by the bedside. All these articles suggests that shortage of nursing can affect patient outcomes and therefore it is important to not only look at staffing levels, but also staff composition, the number of care hours, and the work environment.

2.3 Use of Technology in Healthcare

Hospitals have been using different level of health information technology adoption to integrate into its workflow [8, 9]. In Korea there are fully digitized hospitals that have comprehensive applications for direct care, support care and smart care [9]. To better serve end users they use barcode, radio frequency identification technologies, smart phone, mobile technologies and data analytics. To help improve quality of care, work efficiency and patient safety, different applications such as electronic medical record (EMR), clinical decision support (CDS), closed loop medication administration (CLMA), mobile EMR and dashboard system of care coordination, clinical data warehouse system (CDW) and patient engagement solutions are designed.

Hospitals have been investing in technologies as a strategy to improve their financial performances [22]. However, if investments in high technology medical services that are not accompanied by enough patient volume then the investment cost and excess capacity can negatively affect the financial performance. Hospitals are required to look at reimbursement rates or to increase patient volume by marketing to promote the adoption of new technology. Key factors in creating a positive financial performance included, occupancy rate, length of stay, revenues per inpatient day, and staffing intensity. Occupancy rate and length of stay are not related to operating margin or total margin because these two factors can contribute to lowering operating expense but inpatient revenues can potentially be offset by other cost variables such as staffing.

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Overall, hospitals offering a larger number of rare high technology services are expected to provide better financial performances.

The role of technology in health care innovation have been suggested to be used in three areas: consumer engagement for self-management, integration of physical care and mental healthcare, and data-driven care that measures outcomes and is responsive to performance metrics [23]. The first area suggests that consumers will be able to help define the course of their own healthcare by using mobile applications, smart phones, wearables and sensors. The second usage is in the integration of behavioral healthcare into care settings that require a lot of coordination. The third usage allows data and outcomes to be captured and examined at various levels including patient, provider, organization and system levels. An example of this would be using data in electronic health records that could be used to help individuals monitor their own behavioral health.

However, as hospitals try to increase the adoption of technology they are also faced successes and adoption issues. Hospitals with high levels of healthcare technology will potentially be equipped with larger and more complex systems than the hospitals with basic care for common diagnosis [24]. This suggests that hospitals with greater healthcare technology will be likely associated with improved health outcomes. For example in Korea, the 30-day mortality in low healthcare technology hospitals was 1.567 times greater than those with high healthcare technology.

An example of slow adoption has been linked to physician resistance to change [25]. Although physicians are optimistic about the technology of electronic health record systems [26], physicians are concerned about patient care. They are frustrated with the unfriendly interfaces and data searches that are in existing EHRs. This attitude is also prevalent in a UK outpatient service department. The role out delays was not because of a technical system delivery but the larger issue was a sociotechnical system change [27].

Another example of adoption issues, is in the developing an ambient intelligence [4] environment for end-user service provisioning in a hospital pharmacy. The pharmacy staff wanted to see if discharged elder patients could use a self-care ubiquitous application for drug monitoring, or if the AmI environment can help reduce the waiting time for drug dispensing [28]. For drug monitoring, patients expressed discomfort with the use of mobile devices; they didn’t want to use a smartphone or tablet to receive

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reminders and suggested that a phone call would suffice. For the reduction of waiting time, the pharmacy was successful in using RFID card to detect a patient at the main entrance and allow then to prepare the medicine while they are coming to the stand. This help reduced waiting time when patients received their medicine.

These articles suggest that the overall sentiment towards technology in healthcare is optimistic. However, technology appropriateness, information accessibility and user acceptance are critical for successful adoption of technology. In addition, there should also be an analysis of a hospital performance when investing into high technology medical services.

2.4 Smart Patient Rooms

Hospitals are looking into creating more comfortable rooms that can accommodate technology that can allow for better care of patients [10]. The authors discussed how confronting design challenges in technology, culture, healing environment, universal rooms and administrative needs can yield to better rooms in various hospitals. The Center for Health Design Pebble Project showed that redesigning patient rooms in a cardiac critical care unit in Methodist Hospitals have led to decrease in patient falls and patient transfers. Fewer transfer of patients leads to fewer errors. In Barbara Ann Karmanos Cancer Institute, the redesigned rooms had a 30% reduction in medical errors, a reduction in patient falls because of improved lighting and room layout. In Bronson Methodist Hospital, the location of sinks and air inflow design resulted in a 10 to 11% decline in nosocomial infection rates. The efficient patient room created a better space for both the nurse and the patient; there was decrease of nurse attrition rate from 23% to 3.8% and an increase in patient satisfaction by 18%. The authors mentioned that universal rooms are one of the better ways to confront a capacity issue while maximizing safety and quality.

However, for certain rooms such as the ICU that requires higher nurse skill levels, using a universal design may not be appropriate. Designing a smart ICU is much more complex and requires a design team to be more knowledgeable and forward thinking [29]. The design team will need to understand the requirements of the patients, staff and visitors. The rooms should allow for better care of the patients and should provide better functionality, ease of use, healing, safety, infection control, communications and

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connectivity [30]. Each room should be zoned for work, care and visiting. In addition, where the medical devices will be placed, privacy of the patients, the logistics and waste management are all important design considerations. A smart ICU requires data of various formats to be electronically integrated so that it can be proactively use to enhance and monitor patient safety to facilitate care [31]. Therefore an advanced ICU informatics design should include a robust infrastructure that allows for connectivity and interoperability and the implementation of middleware solutions that allow for ease of use.

A smart hospital room environment would allow for various wireless and wired senor technology to be integrated [32]. Part of a smart patient room design should also allow a patient to control the environment and interact with the hospital facility. Another part should be more clinically oriented and allow for doctor's to offer better care. The authors mention that patients are willing to pay for technology improvements in healthcare and that their design concept is to provide an easy, cost-effective, modular design that is user-friendly for the elderly, disable and diseased people. The system should also allow faster turnaround time by avoiding fragmented clinical workflows and allow better electronic access to patient data and critical clinical information. The application allows for environmental controls (TV, bed, blind and lights), hospital facilities (patient help and food menu) and information. Some of the design featured mentioned are presented on a touch pad application that allows for the patient to all the nurses at any time, display their upcoming visits, the time and temperature.

A smart bedside system can provide better patient centered service during hospital admission [11]. A tertiary university hospital in Korea used analyzed their system logs and found that TV and internet entertainment service use was 62.7%, followed by the personalized menu, which captured individual health information of laboratory test results, hospital fee check, message logs, and daily medical information (28%). The log information also captured some usage of information support for hospital guide and health information (4.9%) and service ordering for meal order or bedsheet change (4.4%). The technology data management system helped capture the service utilization to help develop and upgrade future functions.

In general, the literature explores the design concepts and implementation of smart patient rooms. There is a common theme in providing a patient centered design to provide a better experience for both the patient and the clinicians involved. The design

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of the room can enhance the experience for doctors, nurses and patients. The usages of technology and cost considerations are also discussed in order to cost-effectively scale up the implementation.

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Chapter 3 Method

3.1 Case Study

The paper will be using a case study as its research methodology. A case study is appropriate to explain contemporary events that require no control in behavioral events. A case study is frequently used to interpret strategies or relations; to determine why certain decisions are made at a point in time [33]. Business cases can help explain the mechanism contributing to a described event. It is important to note that academic business research and business case studies are different academic [34]. An academic business research is concerned mainly with inducing principles but business case studies are focused on analyzing particulars of a situation. Not all facts are relevant and the case method is introduced in the business education with the assumptions that learning must reflect actual practice and allow for a discussion of the various variables at play.

3.2 The Object of the Study

The object of the study is Shin Kong Wu Ho-Su Memorial Hospital. The case study will show why implementation of smart patient rooms can help improve performance despite a decrease in nursing staff. A single case study is proposed because the circumstances are unique, the timeframe is fixed and the situation is not replicable.

3.3 Data Collection

The data source includes secondary data collected from meeting notes and power point presentations during preconception, design and implementation of the smart patient rooms. The research topic and data was approved by the Institutional Review Board of Shin Kong Wu Ho-Su Memorial Hospital (file number of IRB: 20180604R) in June 27, 2018. The nurse shortage issue is reflected in the closure of hospital beds between 2012 to the first half of 2014. The various analyzed that lead to strategic options was collected during the period of brainstorming from April of 2014 to the end of 2014. These data include nurse staff ratios, number of hospital beds and occupancy. In addition, four types of data were reviewed during 2013 to 2017 as followed:

1. Indicators of quality control: occupancy rate, and patient satisfaction.

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2. Nurse staffing indicators: nurse staffing ratios and turnover rates.
3. Financial indicators: revenue, cost.
4. Design of patient room: design floor plan and post-construction review.

3.4 The Framework of the Study

The research frame work is based on Yin's guidance on case study research design [33]. Yin instructed a researcher to determine: which data to be collected, the research propositions, the units of analysis, the logical linking the data to the propositions and the criteria for interpreting the findings. A strategic analysis requires data collection of the organizations internal and external situation. According to Hill, Schilling and Jones, an internal analysis involves understanding a company's resources and competitive advantage and the external analysis includes the identification of opportunities and threats [35].

An internal analysis is a three step process. First to understand resources under the VRIO framework that requires managers to understand a company's resources for its value, rarity, inimitability and organization. Second, the analysis on whether these resources can create a long-term sustainable competitive advantage. The third is understanding how these advantages can lead to profitability. The external analysis identifies the elements and conditions that either allow or endanger the company to be more profitable. These data would allow for a SWOT analysis to help determine the kind of strategy the company can pursue.

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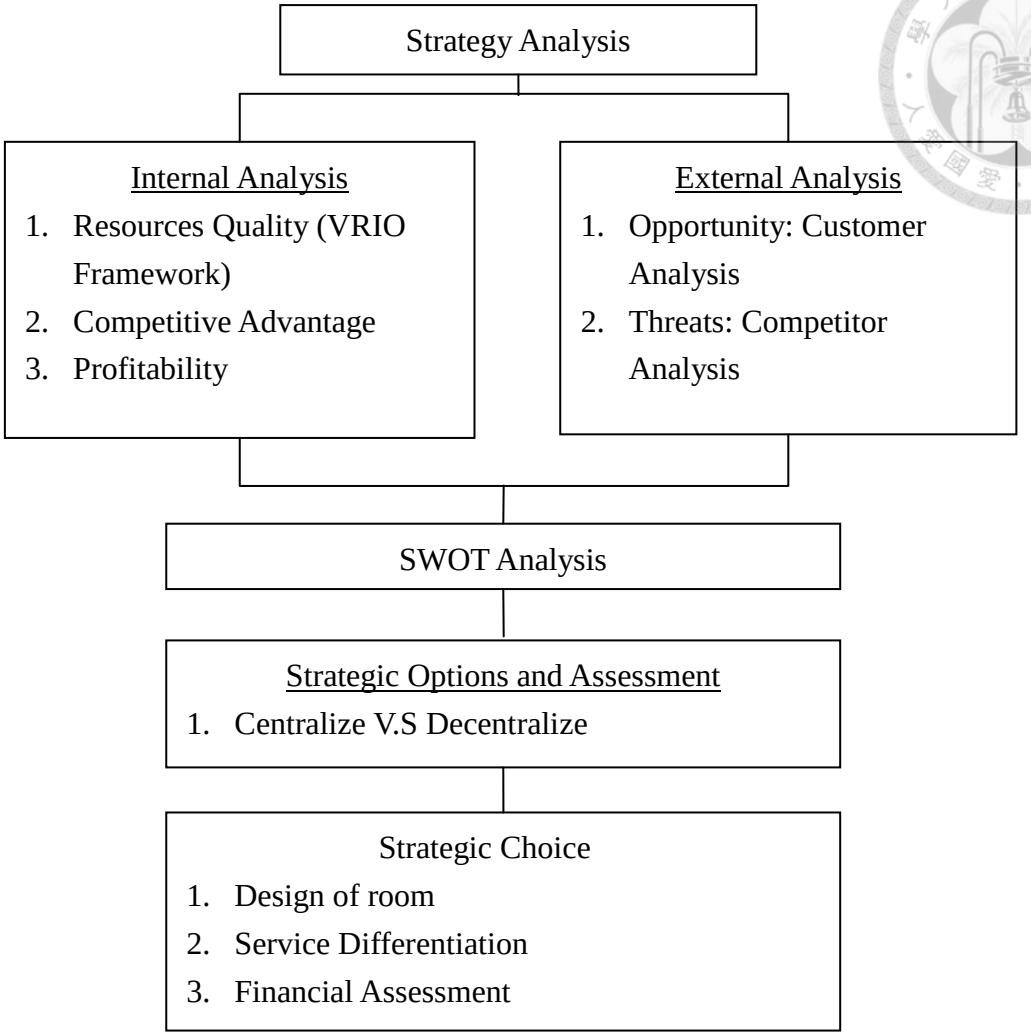

Figure 4: Framework of the Study

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Chapter 4 Results

4.1 Introduction to the Hospital

Founded in September 2 1992, Shin Kong Wu Ho-Su Memorial Hospital with the mission to provide patient centered medical care, contribute to society through quality medical services, develop professionalism, and pursue excellence through innovative medical education and research programs. The non for profit hospital's vision is dedicated "to maintaining professionalism, enthusiasm and spirit of service to achieve health, hope and happiness of our community and to strengthen our role as one of the most reliable medical centers" [36]. Located in Taipei, Taiwan, it services 4 major districts including Shilin, Beitou, Sanchong, and Luzhou District. In 2001, the Department of Health accredited the hospital to be a medical center. In 2014, the hospital consisted of 981 beds, 42 separate medical divisions and featured services including health management center, PET center, cardiac CT center, brain MRI center, cosmetic center, myasthenia gravis center, blood purification center, international healthcare center, early developmental intervention, and robot-assisted surgery.

The conception of building out smart patient room was initiated as a response to a nursing shortage and the need for single beds. From May 2014 to June 2015, management went through multiple meetings to plan, design and construction, and implementation of the smart patient rooms. Specifically, the planning stages occurred during May to December 2014, design and construction occurred from January to May of 2015 and the first patients were admitted in June of 2015.

4.2 Internal Analysis

4.2.1 Resources Quality (VRIO Framework)

VRIO is a business analysis framework that can help an organization evaluate its internal resources and capability. The framework helps clarify the competitive advantage of its resources by determining its value, rarity, inimitability and organizations. The hospital focused on examining two main resources, nurses and the number of beds that are required for bedside care. The numbers of nurses and levels of nursing are critical for quality bedside care. Nurses are highly valuable employees to the

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hospital. They are rare and hard to imitate as they require licenses and years of practical training to provide professional care. The organization is organized to train and deploy the necessary number of nurses to service the various wards. However, it is also at risk when nurses leave their professions or go to other hospitals. The number of beds and its occupancy are also important resources to review. The number of beds is a highly valued and rare resource as the number of beds in the hospital is required to be registered and approved by the Ministry of Health. Beds and bedside services at medical centers are hard to imitate as medical centers requires intensive capital investment, highly skilled professionals and intensive practical training to provide quality care. The organization is an accredited medical hospital with years of experience in providing quality medical services but will need to adjust its practices depending on regulatory requirements, accreditation standards, and staffing levels.

4.2.1.1 Nurse Staffing

Historically, the trend of nurse staffing decreases after February, after bonus are given and job openings are available in the market. Graduation season happens in June and that is when new nurses are hired. However in 2014, the average staffing shortage number was around 50nursesfor a medical center of 918 beds. Specially, the lowest number of nurses of 742 occurred in June of 2014 (Figure 5). Resignation of nurses occurred in all clinical levels with the highest in N2, N1 and N. In terms of seniority, resignation occurred the highest for nurses with 2 to 5 years of experience and those with less than one year of experience. There was also a high number of nurses leaving at 5 to 10 years of experience from the hospital. There were multiple reasons of nurses leaving the hospital. The exit interviews indicated that 60% of the nurses left for the top three reasons. The reasons include finding another job, family reasons, or going back to school and test preparation. In order to understand why nurses left for other jobs, the superintendent and senior managers conducted a discussion to see what could be done to increase retention at all levels. Prior to the discussion, there were already financial incentives and salary increases given to the newly admitted nurses. However, nurses with more seniority had the burden of training these new nurses and wanted to be adequately compensated as well. One of the major changes that 60% of the nurses demanded was to have better technological solutions to their work. Younger nurses no

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longer want to work at hospitals with archaic, manual processes when competing hospitals already have better nursing information systems and processes that can reduce the burden of care for nurses. Nurses wanted a full adoption of electronic medical records; they didn't want to decipher through physician notes when the system was already in place. These requirements made the administration staff review the working conditions of the nurses and to understand how a smart hospital ward could potential reduce workload.

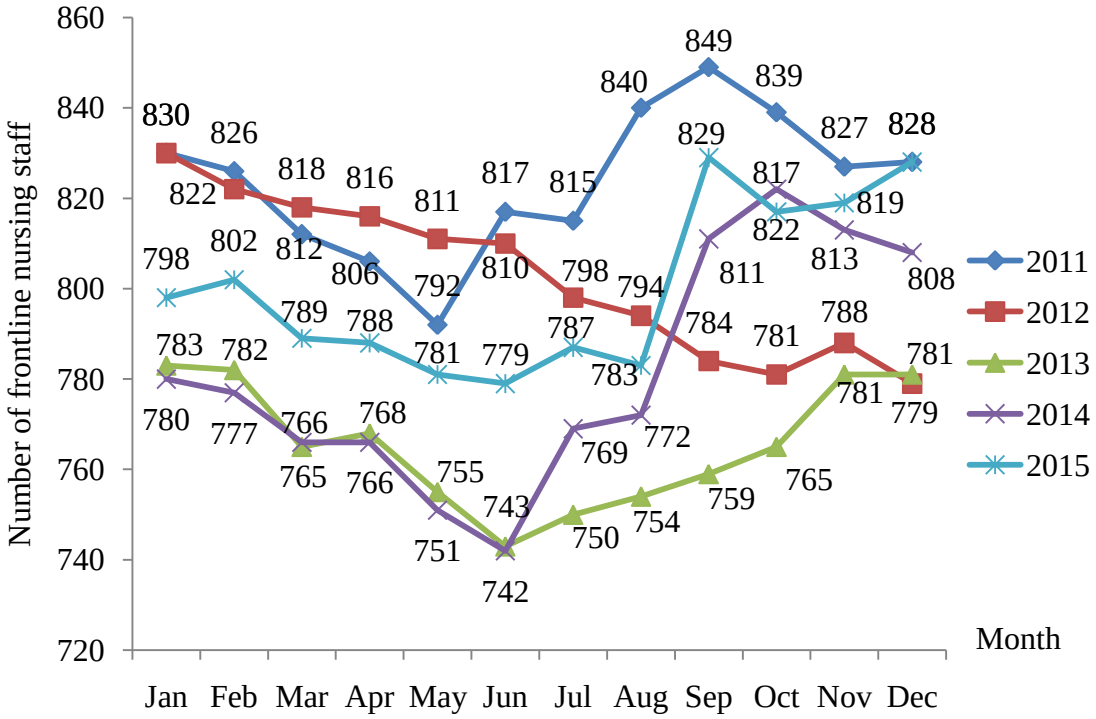

Figure 5: Number of Frontline Nursing Staff from 2011 to 2015
Source: Shin Kong Wu Ho-Su Memorial Hospital[37]

Table 1: Clinical Ladder Levels and Seniority of Resigned Nurses from 2012 to 2013

Year		2012		2013	
		Number	%	Number	%
Total number of resignation		210	100%	194	100%
Clinical Ladder Levels	N4	1	0.5%	1	0.5%
	N3	18	8.6%	18	9.3%
	N2	70	33.3%	52	26.8%
	N1	38	18.1%	44	22.7%
	N	48	22.7%	49	25.3%
	Not part of promotion	35	16.7%	30	15.5%

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Year		2012		2013	
		Number	%	Number	%
Seniority	>1	76	36.2%	59	30.4%
	1~2	4	1.9%	7	3.6%
	2~5	68	32.4%	73	37.6%
	5~10	51	24.3%	38	19.6%
	10~15	9	4.3%	13	6.7%
	15~20	2	1%	3	1.6%
	20~25	0	0.00%	1	0.5%

Source: Shin Kong Wu Ho-Su Memorial Hospital[37]

4.2.1.2 Bed

The number of beds was 918 in 2013 and decreased to 872 in 2014 (Table2). The reduction of beds included general beds, intensive care beds, and emergency observation beds. The closures of beds were due to the decrease in the number of nurses. In addition, there was a high level of nurses leaving the ICU and created a negative cycle as more burden was left to those who stayed on. The level of required care at the ICU, required more senior nurses and could not easily be replaced. Therefore, in order to maintain quality the hospital had to close off certain beds. Part of the solution was to centralizing ICU from different floors to offer better care. Emergency observation beds were also reduced along with general beds.

Table 2: Changes of Hospital Beds from 2013 to 2014

Items of bed	2013	2014
Total beds	918	872
General beds	559	526
Psychiatric beds	25	25
Intensive care beds (ICU)	77	69
Infant care beds	25	25
Nursery beds	49	49
Emergency observation beds	61	40
Hemodialysis beds	105	105
Hospice beds	-	8
Isolation beds	2	2
Subacute respiratory care beds (RCC)	-	8
Other	15	15

Source: Shin Kong Wu Ho-Su Memorial Hospital[37]

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Hospital beds are vital to the operations of a medical center. The current accreditation standards require that 60% of the beds are fully covered by the National Health Care insurance. Therefore changes in 2014, also lead to further adjustments in the number of single beds, double beds and beds fully covered by NHI (rooms with three beds). Table 3is a retrospective analysis that shows the tradeoff between increasing single beds and decreasing the number of double beds. Since fully NHI covered beds had to be at least 60% of the total hospital beds, the increase in single beds also means the decrease in double beds. Although it is expected that single beds are more profitable, there is a constraint in developing more due to bottlenecks in regulatory requirements, nurse staffing, and hospital layout.

Table 3: Adjustment of Beds from2014 to 2015

	2014		2015		Adjustment of beds					
	Number	%	Number	%	10A	8A	Hospice	RCC	6A	ICU
Single bed	43	6.3	54	8.2	13	-4	2	0	0	0
Double bed	232	33.7	198	29.9	-18	-8	0	0	-8	0
Beds fully covered by NHI	413	60	411	61.9	-15	-1	6	8	8	-8
Total	688	100	663	100						

Source: Shin Kong Wu Ho-Su Memorial Hospital[38]

4.2.1.3 Occupancy rate

From 2012 to 2014, the hospital had 50 single beds. During the reduction of nurses in the hospital, the occupancy of general and single beds decreased. Specifically occupancy has been above 80% in 2012 and has fallen in 2014 to 73.2% for general beds and 83.4% for single beds (Table 4). The occupancy of single beds was consistently higher than general beds, suggesting that the need for single beds was high.

Table 4: Occupancy Rate of Bed

Year	2012	2013	2014
General beds	80.1%	77.5%	73.2%
Single bed	89.6%	87.1%	83.4%

Source: Shin Kong Wu Ho-Su Memorial Hospital[37]

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4.2.2 Competitive Advantage

Academic medical centers, provides a depth and breadth of specialty capabilities are preferred resources for complex care. However, a total care solution also requires offering customers with what the market views as the best product. In addition to providing quality medical care, the competitive advantage of the hospital is built upon having a culture focused on its customer, on providing quality customer service and on being able to adapt to its operating environment. Overtime, these advantages help the hospital differentiate its services and help the organization create value. These differentiators help generate a value proposition that combines commitments to teaching research and patient care.

4.2.2.1 Customer Focus

The hospital takes pride in providing accessible quality care to patients and providing a healthy workplace for its employees. This commitment to quality care is seen through its achievements in getting multiple SNQ (symbol of national quality), providing emergency medical capacity assessment for severe illnesses and being a senior-friendly health organization. The Taipei City has issued the hospital two awards related to providing an ideal work environment; one award was for best company to work for and the other one is awarded for providing an excellent healthy workplace. The work environment impacts the drive and performance of work employees who work in the hospital. In addition, many of our employees are also customers of the hospital. Therefore, the hospital culture of getting feedback from employees and patients are key competitive advantages.

One of the competitive advantage is derived from the medical center's focus to provide quality customer focused culture. By making an effort to measure and monitor its patient satisfaction and customer service, the hospital aims to provide both successful medical outcomes as well as hospitable experiences. To improve its in-patient services, the hospital collects opinions from patients during their stay at the hospital and these forms are collected at the nursing stations. To improve its out-patient service, customers are able to go online to the website to provide feedback to the hospital. These opinions and suggestions are taken seriously. Dedicated staff in the quality department

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consolidate these opinions twice a year and present them to the Quality and Patient Safety Committee for discussion and potential improvements.

Patients have given the hospital feedback that they would like to have better accommodations for their caretaker. They would like to have an additional bed and a living room space for visitors and a simple kitchen to be able to prepare both hot and cold food during their stay. Many of the patients mentioned that they would prefer to have a single bed and am willing to pay for the upgrade if there is availability.

4.2.2.2 Customer Service

Providing excellent customer service is a key competitive advantage of Shin Kong Hospital. The hospital believes that care involves providing a network of care for chronic disease management, quality and timely diagnostic treatment to its customers, and added value services.

One example of this effort can be seen in the hospital's effort in being part of the this can be seen in its effort in passing the Health Promotion Administration's accreditation of quality cancer treatment institution and implementing the Cancer Patient Navigation Program. This program provides services for patients from diagnosis to completion of treatment. A multidisciplinary team and manager team help provide personalized medicine, coordination and support. The oncology nurse managers are proactively managing the patients by providing medical information, consultation, accompaniment, and to help guide and track the patients relating to their condition and care.

The second example of customer service can be seen in the hospital's medical check-up and diagnostic examination services. The professional and patient centered services helps lower wait times for exams and provide streamlined medical exams. Customer services start two days prior to the day of the exam to remind the patients of their appointment and preparation requirements. On the day of the exam, there is a personal guide that will take the customer to each of the check up and diagnostic rooms. Follow ups are given on the day of the invasive treatment and within a month to ensure the delivery of their examination report. If the screening tests suggest a presence of disease or cancer, the hospital staff will contact the customer within the day of the completing the report, to help the customer schedule a clinical visit. In addition, for

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international patients, the hospital provides pre-visitation planning that includes treatment plan and pricing and airport pickup, accommodation options for the patient and their families, and post-hospital follow up with the patient's local health provider and reimbursement needs. Table 5 shows how the hospital is devoting thought in designing better customer experience from pre-visit planning, hospital visit to post-hospital follow up. The process is designed to provide a simple, efficient, all inclusive, one-stop health service center that offers a wide range of check-up programs, based on age, gender, and individual needs.

Table 5: Examples of Customer Services

	Health Management Center	International Healthcare Center-inpatient services
Pre-visitation Planning	Two days before health checkup, the staff will call to remind the client of the appointment and required preparations.	1. Treatment plan and cost estimate before hospitalization 2. Airport pick-up service
Hospital Visit	Nurse guides the client through the examination process and takes the client to each of the check-up stations.	1. Accommodation needs of family members during hospitalization 2. International medical care center staff provides bedside care
Post-hospital Follow up	1. The staff will make a call after an invasive examination to make sure the client is feeling well. Another call after a month will be made to confirm the delivery of the report. 2. If there is a major abnormality the client will be notified by the next day of the completion of the health report. The staff will also assist in the registration for the next follow up.	1. Insurance fee payment after hospitalization 2. A medical mission team to track the conditions of referral patients

Source: Shin Kong Wu Ho-Su Memorial Hospital[39]

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4.2.2.3 Adaptive

The health care landscape in Taiwan, forces hospitals to face significant reductions in reimbursement as well as rising expenses related to staffing, consumer expectations, and advances in technology. In order to continue its competitive edge, the organization has to be able to create value. One of the major strength of the hospital is that it is adaptive and open to learning from other hospitals and suppliers of various technology solutions. During the planning stages, the hospital visited multiple medical centers in Taiwan and also went to visit three hospitals in Singapore to understand various bedroom designs and how technology was integrated into their hospitals. Various technology suppliers also provided site visits and allowed managers to ask questions on integration, implementation, change of processes and prices for the different options. These visits included all levels of the management, physicians, nurses, IT and administration and allowed for active discussions and a practical solution for what is needed at the current stage. The adaptive nature of the hospital culture allows it to look into alternatives and be able to provide the market with leading edge products of applications with existing products or services.

4.2.3 Profitability

During the planning stages, a financial forecast was made for the conversion of a single nursing station. The financial projection (Table 6) showed that the hospital would be able to breakeven with an occupancy of 48%. The initial assumption was to have 21 rooms and a total of 22 beds; one of the room was a doubles room. Based on the accreditation standard in 2015, the nurse to patient ratio would require at least one nurse per seven patients in the morning shift and one nurse for nine patient in the night shift. Other assumptions include, a requirement of four ward managers, a visiting staff physician, and renovation cost that would be depreciated in 10 years. The financial projections indicated that renovation cost could easily be recovered. Payback periods were estimated for occupancy of 60%, 70% and 80% (Table 7). The current occupancy of the hospital was around 80% but the staff wanted to conservatively forecast the occupancy of the new rooms.

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Table 6: Financial Projection

Assumptions			
Occupancy rate of break-even point		48%	
Rooms		21	
		NT$/Month	%
Revenue		6,369,110	100.0%
Minus adjustment point value of NHI		299,300	4.7%
Net medical income		6,069,810	95.3%
Variable Costs	Professional expenses	896,655	14.1%
	Tax	15,663	0.2%
	Material costs	1,483,847	23.3%
	Other*	574,650	9.0%
	Subtotal	2,970,815	46.6%
Marginal profit/Month		3,098,995	48.7%
Fixed Costs	Personnel expenses	1,365,031	21.4%
	Property Plant &Equipment	451,228	7.1%
	Capital cost	135,368	2.1%
	Allocated ward cost**	1,147,368	18.0%
	Subtotal	3,098,995	48.7%
Profit and loss/ Month		0	0.0%

*Other variable cost include allocated laboratory and examination related costs
**Allocated ward cost includes fixed cost of laboratory, examination, nursing station and administration expenses
Source: Shin Kong Wu Ho-Su Memorial Hospital[39]

Table 7: Projection of Payback Period

Occupancy	60%	70%	80%
Projection of payback period	3.3 Years	2.2 Years	1.6 Years

Source: Shin Kong Wu Ho-Su Memorial Hospital[39]

4.3 External Analysis

An external analysis helps the organization identify strategic opportunities and threats within its operating environment. There is an opportunity for the hospital to cater to patients who are willing to pay more for a single hospital bed. There is currently an unmet need for single beds for various customers including those needing pediatric care, postnatal care, post-surgical care, physical checkup clients and chemotherapy. In addition, international patients who are used to single bed hospitals also often require the privacy and quiet during their stay. These customers have a common need. They prefer to have more privacy, a reduction in noise, better family support and improved

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infection control.

The average length of stay has fallen substantially over the years and people are more willing to spend more for a better room. Specifically, in Taiwan, it is common to buy additional medical insurance. Patients are willing to either pay out of pocket or to use their private insurance to cover their stay. Therefore the hospital can take advantage in the current conditions to build out its single bed hospital and to help formulate and implement strategies to make it become more profitable and also outperform its rivals.

The hospital looked into the competitive structure of the industry by analyzing how other hospitals have pursued similar or different kinds of competitive strategies. The four hospitals in Table 8 are each selected for different benchmarking reasons. National Taipei University Hospital (NTU) is selected because it is the leading medical center in Taiwan that is the main benchmark for accredited medical center in Taiwan. The Tri-Service General Hospital is selected because not only it is a medical center it also built out a full floor for a single hospital bed rooms and a website that marketed its services. The Taiwan Adventist Hospital is selected due its niche strength in catering to international patients. The Landseed hospital is a regional hospital but is selected because it is one of the early pioneers in building specialty hospital bed rooms that had hotel features and amenities. These four hospitals provided reference to the potential number of bedrooms, price, room size, staffing requirements and occupancy levels shown in the chart below. The high level of occupancy of 80% to 100% shows that there is a high level of need among medical centers and those that serve international patients.

Table 8: Comparison of Selected Hospitals

Hospital	National Taiwan University Hospital	Tri-Service General Hospital	The Taiwan Adventist Hospital	Landseed Hospital
Location	Taipei	Taipei	Taipei	Taoyuan
Name of ward	15C ward	Grand ward	8F ward	Monarch ward
Number of room	13	10	30	28
Number of bed	13	10	30	28
Room charge under National	NT$ 8,000	A grade NT$9,000 A + grade	NT$6,800	NT$ 9,000 NT$12,000 NT$15,000

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Hospital	National Taiwan University Hospital	Tri-Service General Hospital	The Taiwan Adventist Hospital	Landseed Hospital
health insurance (NHI)		NT$12,000 Special A-grade NT$15,000		
Uninsured, out of pocket	NT$10,240	NHI + NT$1,180	NT$ 7,600	-
Taiwan ping	15	16-18 18-20 20-26	8-10	8 11 15
Square meters	49.59	52.9-59.5 59.5-66.12 66.12-85.96	26.45-33.06	26.45 37.37 49.59
Nurse–patient ratios	1:4-5	1:6	1:6	1:7
Occupancy rate	80-90%	80-90%	Almost 100%	45.2%

Source: Shin Kong Wu Ho-Su Memorial Hospital[40]

The biggest threat is rivalry among established hospitals including threats of substitutes. If there is an oversupply of single bed and pricing discounts, the profitability of the single beds may be at risk. However, this risk is mitigated because there is a high entry barrier for oversupply of single bed hospital since most hospitals rely most of their revenues from the National Health Insurance and would need approval to increase or decrease the number of hospital beds. Most medical centers are built with the economies of scale, creating brand loyalty, and cost advantages that incumbent firms can't easily replace.

4.4 SWOT Analysis

By identifying an organization's strengths, weaknesses, opportunities and threats allows it to strategically plan its business competition. In general, the strength of the hospital is in its medical expertise, its financial soundness and its willingness to invest in updating its facility and medical equipment. Its weakness is that it has been in operations for more than 20 years and a lot of its information technology planning is behind its peers. There is opportunity to fulfill the unmet need for single beds that require pediatric care, postnatal care, post-surgical care, physical checkup,

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chemotherapy. Patients are willing to pay more for a single room and there is support in the organization to renovate the rooms. The threat lies in the fact that there is a nationwide shortage of nurses and some of the competition have already built out their single beds.

A TOWS matrix is a variant of the SWOT analysis and helps the organization think about how to make the most of its strengths, circumvent its weaknesses, capitalize on opportunities and manage its threats. The TOWS matrix in Table 9 gives a more detailed analysis on how the organization should build out its single beds, strengthen its information technology investment, and maintain its medical prowess. With the shortage of nurses, the organization will have to adapt parts of its service by not compromising service and quality. Some of these issues can be resolved by having a better information technology system that can help medical staff have a better working environment that can help reduce the workload for nurses.

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Table 9: TOWS Matrix

Internal Factors / External Factors	Strengths 1. The hospital is an accredited medical center that provides accessibility quality service and care. 2. The hospital is fiscally sound for growth and expansion. 3. The hospital is willing to invest in new medical technologies and equipment.	Weaknesses 1. The hospital has been operating more than 20 years and some of the spaces require modernizations. 2. The lack of healthcare IT connectivity to mobile and medical devices makes it less competitive to its peers.
Opportunities 1. Patients and their caretakers are willing to pay more for a single bed. 2. International patients often prefer single bed that provides privacy and quality of care.	SO 1. The standard in quality of care and services leads to brand recognition. 2. Single beds are operating at full capacity and both patients and medical staff all believe more should be built. 3. The hospital has an opportunity to redesign its bedrooms to fit different type of customers.	WO 1. Renovations and additions allows the hospital to not only modernize its space but also explore how to better attract and service different types of customers. 2. The hospital can use this opportunity to understand its technological gaps to help formulate its future healthcare IT needs.
Threats 1. Nation-wide issue of nurse staff shortage that may affect care. 2. Competitors are also building out single beds in their hospitals.	ST 1. The hospital needs to make sure quality care and services is provided despite the shortage of nursing staff. 2. Non-medical services can be a differentiating feature among competitors.	WT 1. Technology investments can help reduce the workload of nursing staffs and help provide better medical care. 2. Renovating single beds provides better comfort to patients, their family and caretakers.

Source: Shin Kong Wu Ho-Su Memorial Hospital[40]

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4.5 Strategic Options and Assessment

The hospital decided to build more single beds but had two options of either having a centralizing the renovation on one floor that consist of a central hub, a large communal nurse station, medications room, supply room and other support room or to build out a decentralized nursing unit to service two renovated rooms on a few selected floors in Table 10. In comparison to the decentralized design, a centralized design would and allow for 3 more beds. Some of the nurses preferred a decentralized model because they believe they can provide better specialty care for patients on different floors (Table 11). The nurses would be trained in existing specialized wards versus a newly built centralized ward that would be servicing a variety of patients. The solution was to provide better training and more senior nurses and a floor manager to tend to non-medical services to provide not only professional medical care, privacy and a sense of luxury. The final decision was based on providing a better patient experience. In this case, a more centralized design (Table 12) would help deliver quality care, provide a modern environment with privacy and visitation control.

Table 10: Location of Beds

	Centralize	Decentralize
Definition	All single beds managed by a nurse station on a single wing	A few single beds scattered on various floors; managed by several nurse stations
Location	On a single floor; the tenth floor	On the third, sixth, seventh, eighth, ninth, and tenth floor
Number of Rooms	21	18

Source: Shin Kong Wu Ho-Su Memorial Hospital[40]

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Table 11: Comparison of Centralize and Decentralize Medical Care:

	Centralize	Decentralize
Types of nursing care	General nursing care: A centralized nursing station that provides general nursing care for various types of specialties including: pediatric, obstetric& gynecologic, and post-surgical care. Nurses are required to be able to provide complex medical care.	Specialist nursing care: The hospital is divided by floor or wings to focus on a variety of patient types that allowed for highly specialized nursing care.
Nurse Training	Centralized training produces better experience for international patients and out of pocket services.	Training of nurses are disseminated to serve two beds on each floor; harder to provide quality services for international patients and out of pocket services.

Source: Shin Kong Wu Ho-Su Memorial Hospital[40]

Table 12: Comparison of Centralize and Decentralize Non-medical Services:

	Centralize	Decentralize
Service	Standardize services on the same floor for patients who are willing to pay out of pocket.	Different service, pricing and room types on each floor. Only two rooms would be renovated rooms with digital features.
Hospital Room Design	After renovating a complete ward, the style will be consistent.	Only a few rooms are renovated per floor. New designed rooms are mixed in with older rooms and could be aesthetically displeasing.
Visitor Control &Restrictions	Electronic access and control doors can be set at a single entrance to help control visitation to maintain privacy.	There are only two single rooms per floor. It will be difficult to build control doors on the floors that are designed to be open wards.
Client Perception	A floor manager will be hired to provide personalized hotel like services. Renovated space will provide modern rooms that provide privacy and a sense of luxury.	Partially renovated space lacks personalization and privacy.

Source: Shin Kong Wu Ho-Su Memorial Hospital[40]

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4.6 Strategic Choice

The following section will cover the strategic choice of the hospital including design of the room, service differentiation and financial results. Although the hospital did not strategically layout it's choice by using the 4P method of marketing, upon analysis it was able to capture and promote a brand or product's unique selling points in designing specific product, price, place and promotion for the smart patient rooms. These specifics will be mentioned in the sections below.

4.6.1 Design of room

The final decision was to redesign and renovate one wing on the tenth floor. The wing originally included one bed, two bed or three bed options. Most of the original rooms were either with two beds are with three beds and only had a simple shower room and sofa bed for the caretaker. There were only a few single rooms and each provided a small visitation space, a refrigerator, a television and a simple sofa bed for the caretaker.

The hospital decided to keep the original structures and the number of rooms but to reduce the number of beds (Table 13), 42 beds were reduced to 22 beds. The final product consisted of 20 single beds and 1 double room. 21 beds were used for financial projects because the double room only mostly had single occupancy. The ward was branded to Tong Shin Ward reflected the pavilion services already offered in the hospital. The triple rooms that were covered by the national health insurance were converted into larger one bedrooms provided more living space.

Table 13: Before and After of Renovated Smart Patient Rooms

Item/Status	Before	After
Location	10F	10F
Name of ward	10A ward	Tong Shin ward
Number of room	21	21
Number of bed	42	22
Number of single room	6	20
Number of double room	10	1
Number of triple room	5	0
Average nurse–patient ratios	1:9	1:6

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

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The key priorities werenot only to bring comfort, privacy and independence for the patients and their caretakers, but also to allow the clinical team to work better. After the renovation, all the rooms on the tenth floor wing provided more comfort, privacy, and independence. The design concept included having a visitation space, bedside interactive systems, a kitchenette, a private bathroom, a sophisticated lighting system and other heart-warming services. Table 14shows the before and after photos of the renovations which also included door access control, a more modern reception area, and a private discussion room.

Table 14: Before and After Features of Renovated Smart Patient Rooms

Features	Items
Visitation space	recliner sofa, individual air-conditioning control, table and desk
Bedside interactive systems	Apple TV, cable TV channels, patient information system, Android app for the hospital, wireless internet, self-adjustable medical beds, and a computerized nurse calling system
Kitchenette	minibar, refrigerator, electric kettle, and dish dryer
Private bathroom	shower stall, bidet toilet seats, heater, safety handrail, bath, bath towel,toiletries,hair dryer, and non-slip slippers
Lighting system	allows for various choice of mood lighting and automatic motion detection sensors
Other services	a welcome fruit basket, daily free newspaper, asafety deposit box, and two bottles of complimentary mineral water daily

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

The hospital was able to promote the newly designed rooms in the hospital wide morning meetings. Doctors were the first to be informed of the new rooms so that they could offer the rooms to the customers who may have the need. In addition, the staff who was working at the in-patient reception desk were also able to share the new options to the patients. The strongest promotion still came from the word of mouth of patient who experienced the new rooms and its detailed services. Because the hospital did not readjust the structure of the rooms and only renovated the interiors, there were essentially three smart patient room types as shown in Table 15.

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Table 15: Room Type of Smart Patient Rooms

Room type	Superior Deluxe	Premium Deluxe	Deluxe Suite
Taiwan ping	9	11	17 (Features: Adjoining Living Room, Visitor's Restroom)
Square meters	29.75	36.36	56.20
Room charge under NHI	NT$ 9,500	NT$ 12,500	NT$ 20,000
Uninsured, out of pocket	NT$ 10,098	NT$ 13,098	NT$ 20,598

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

Various digital features were assessed and tried out. One room had a digital arm but due to the lack of connectivity to the hospital information system the featured could not be implemented. The final digital features are shown in Table 16. These digital features include an interactive multimedia system, a patient information system and a nursing station dashboard. The interactive multimedia system not only provides entertainment through television and Apple TV, it also provides basic information about the hospital, in-patient instruction and discharge instruction and patient education materials. The patient information system provides detailed information on the medical team, the treatment plan and the patient's schedule of examinations and surgery. This system also allows the patient's family to better understand the patient's progress and to be able to help inform the clinical team through the IV drip alarm if they require any assistance.

Table 16: Before and After Photos of Renovated Smart Hospital Rooms

Item/ Status	Before	After
Door access control	N/A	

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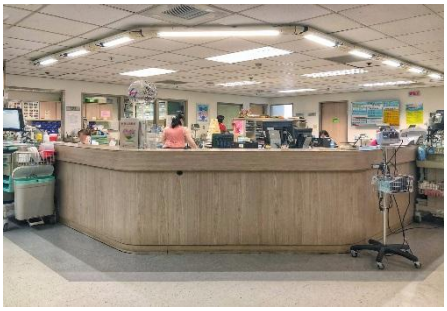
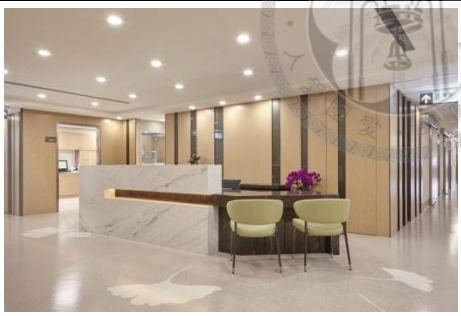
Item/ Status	Before	After
Reception area		
Discussion room	N/A	
Single room		
Double room		
Triple room		

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

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The medical team can use the interactive multimedia system to display and explain examination results such as X-ray and ultrasound images. The nursing station dashboard provides the medical team with updates of the schedules of the patients and also medical team (Figure 6). The set up and linkages of these systems are shown in Figure 7. The hospital team wanted to make sure that connectivity is simple and will not clutter the room. During the design phase, the Hospital also considered using a bed-side information system with a touch panel computer that was supported by a cantilever and kept one room to test the facilities. However, the final decision was not to adopt the system due to issues relating to infection control, system integration and usability.

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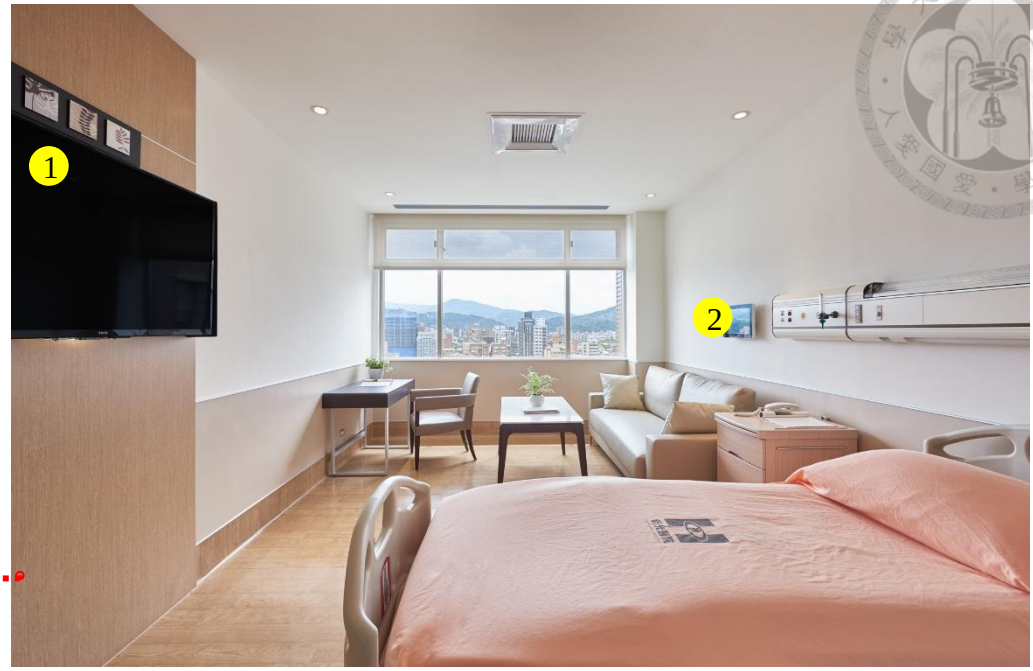
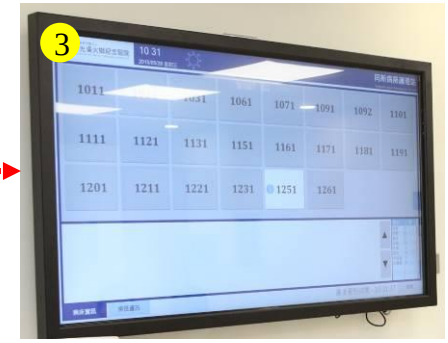


1. Interactive multimedia system
- Environment introduction
- Inpatient instruction
- Discharge instruction
- Patient education
- Apple TV

2. Patient information system
- Weather and Time
- IV drip alarm
- Bed information
- Medical team information
- Treatment plan including schedule of examination and surgery



3. Nursing station dashboard
- Convenient access to the core system
- Better interface to help manage the beds and patient needs

Figure 6: Digital Features in a Hospital Room

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

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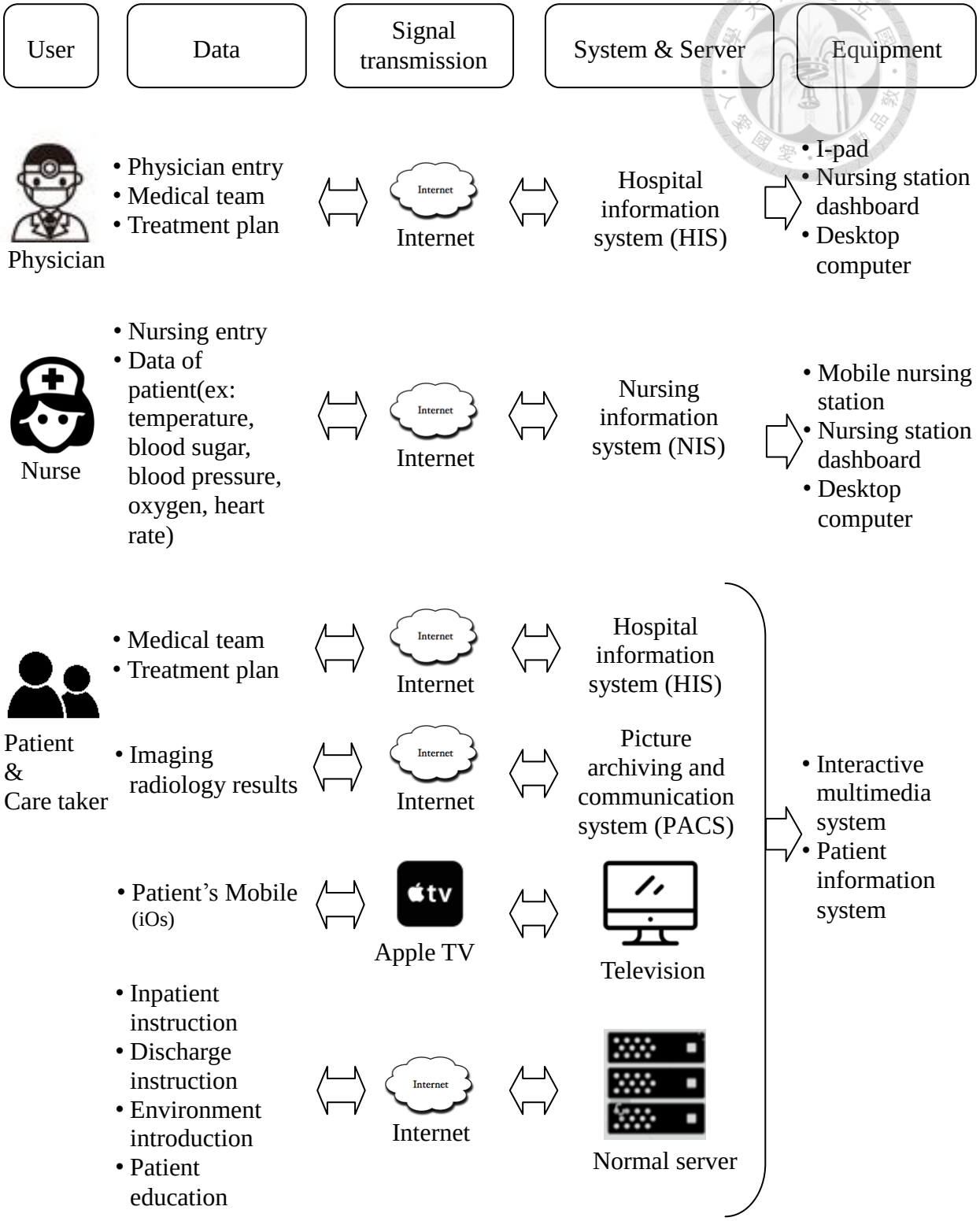

Figure 7: System Architecture

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

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4.6.2 Service Differentiation

The hospital designed the space cater to patients who are willing to pay more for a single hospital bed and more attentive service. The main customer segment included international patients and those needing pediatric care, postnatal care, post-surgical care, physical checkup clients and chemotherapy. They prefer to have more privacy, a reduction in noise, better family support and improved infection control. To offer a differentiated service, the hospital reviewed the service models of high-end hotels where the customers can get most of its services inside their rooms. The new service design was to make sure that the customers will have the least amount of traveling time they are in the hospital. Table 17 shows how customers in the Tong Shin Ward in comparison to standard hospital wards can stay to receive most of their examinations and services without leaving their room. Specifically, nutrition counseling and dispensary are moved to the bedside. These services allow the patients have the optimal amount of time to restand recover in privacy. In addition, these changes in services also fall in line with the government policies that hospitals should create patient-centered care.

Table 17: Comparison of Locations of Examinations and Services

Hospital visit	Examinations and Services	Standard Hospital Wards			Tong Shin Ward	
		B1F	1F	2F	1F	10F
Hospitalization	Check in		V		V	
	Electrocardiogram	V				V
	Blood test		V			V
	Pre-anesthesia evaluation			V		V
	X-ray		V		V	
	Nutrition Counseling	V				V
Post-hospitalization	Dispensary		V			V
	Cashier		V			V

Source: Shin Kong Wu Ho-Su Memorial Hospital[41]

4.6.3 Financial Assessment

The financial assessment of the renovation project of the tenth floor ward was successful as shown in Table 18. After the renovation, 42 beds were reduced to 21 beds, occupancy rate increased from 70% in 2014 to 82% in 2017. The patient mix shifted

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from general medicine, pulmonarymedicine, internal medicine to internal medicine and surgery. The change in the revenue mix resulted in an increase of uninsured and out of pocket expenses from 27.1% in 2014 to 65.9% in 2017. Costs remained relatively the same. Variable cost includes mostly professional expenses of doctors and material costs. The professional expenses of nurses, attending physicians and floor managers were included in fixed cost. Although nurse staffing decreased from 17 to 14, an additional floor manager was hired, therefore the personnel expense was relatively the same. Property Plant & Equipment and Capital cost was derived from depreciating $54.15 M for 10 years. Profitability increased from 3.6% to 19.1% respectively.

In addition, the price volume analysis shows that volume of patients decreased but the revenue increased because the average cost per patient increased. The specifics are show in Table 19; the number of patient decreased from 882 to 467 per month but revenue more than doubled and increased by NT5.4M. Specifically, the average length of stay reduced from 7.2 days in 2014 to 6.2 days in 2016, and the average revenue per day of stay increased dramatically, leading to better turnover and financial results.

In summary, the shortage in nursing staff led of hospital beds of 918 beds to 872 beds, the built out of single beds and the implementation of smart patient rooms. Although the original intention was not built on increasing profitability, Table 20 shows that medical revenue still increased during the two years after renovation. The tenth floor ward was not the only contributing factor to this increase many other operations and strategic changes also implemented to help change the revenue mix to increase medical revenue from the uninsured from 27.4 % in 2014 to 33.8% in 2017.

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Table 18: Before and After Financial Comparison in 2014, 2016 and 2017

		Before renovation 2014		Renovation after one year 2016		Renovation after two year 2017	
Occupancy rate		70%		74%		82%	
Beds		42		21*		21*	
		NT$/Month	%	NT$/Month	%	NT$/Month	%
Medical revenue from NHI		4,980,739	72.9%	4,014,747	32.8%	5,149,987	34.1%
Medical revenue from uninsured, out of pocket		1,853,081	27.1%	8,238,342	67.2%	9,939,726	65.9%
Revenue		6,833,820	100.0%	12,253,088	100.0%	15,089,713	100.0%
Minus adjustment point value of NHI		607,650	8.9%	522,732	4.3%	655,411	4.3%
Net medical income		6,226,170	91.1%	11,730,357	95.7%	14,434,303	95.7%
Variable Costs	Professional expenses	663,127	9.7%	850,986	6.9%	1,083,786	7.2%
	Tax	7,412	0.1%	32,953	0.3%	39,759	0.3%
	Material costs	1,350,300	19.8%	3,287,957	26.8%	1,245,399	8.3%
	Other**	900,921	13.2%	1,011,284	8.3%	4,472,431	29.6%
	Subtotal	2,921,760	42.8%	5,183,180	42.3%	6,841,375	45.3%
Marginal profit/Month		3,304,410	48.4%	6,547,176	53.4%	7,592,928	50.3%
Fixed Costs	Personnel expenses	1,944,810	28.5%	1,972,715	16.1%	1,965,889	13.0%
	Property Plant & Equipment		0.0%	327,177	2.7%	354,972	2.4%
	Capital cost		0.0%	120,427	1.0%	120,427	0.8%
	Allocated ward cost***	1,110,337	16.2%	1,936,167	15.8%	2,267,263	15.0%
	Subtotal	3,055,147	44.7%	4,356,486	35.6%	4,708,551	31.2%
Profit / Month		249,263	3.6%	2,190,691	17.9%	2,884,376	19.1%

*The doubles room mostly had one occupant so the revenue was calculated based on 21 beds.

**Other variable cost include allocated laboratory and examination related costs

***Allocated ward cost includes fixed cost of laboratory, examination, nursing station and administration expenses

Source: Shin Kong Wu Ho-Su Memorial Hospital[42]

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Table 19: Price-volume analysis in 2014 and 2016

Price-volume analysis	2014 (A)	2016(B)	Variance (B-A)		The impact of reduced service on medical income	The impact of increasing unit price on medical income
Medical revenue/Month	6,833,820	12,253,088	5,419,268	79.3%		
Days of stay / Month	882	467	-415	-47.1%	-3,215,420 (7,748*415)	8,646,505 (18,515*467)
Average revenue/Day of stay	7,748	26,263	18,515	239.0%		
Average length of stay	7.2days	6.3days	-0.9days	-12.5%		

Source: Shin Kong Wu Ho-Su Memorial Hospital[42]

Table 20: Medical Revenue of Hospitalization from 2014 to 2017

	2014		2015		2016		2017	
	NT$	%	NT$	%	NT$	%	NT$	%
Medical revenue of hospitalization from NHI	1,828,338	72.6	1,853,560	69.8	1,940,264	68.9	2,124,536	66.2
Medical revenue of hospitalization from uninsured, out of pocket	690,267	27.4	801,854	30.2	875,320	31.1	1,084,580	33.8
Total	2,518,605	100	2,655,414	100	2,815,584	100	3,209,116	100

Note: Expressed in thousands of New Taiwan dollars

Source: Financial Statements of Shin Kong Wu Ho-Su Memorial Hospital[38]

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Chapter 5 Conclusions and Recommendations

5.1 Conclusions

The hospital consistently request feedback and conduct surveys from its customers for the renovation and services provided. During the first four months (from June 1 to September 1 in 2015) of operations of the 10th floor ward, the hospital requested for feedback from its customers and made additional changes in digital equipment, the environment, and bathroom. These changes include adjusting the brightness and content of the various digital equipment for information clarity and the comfort of the patient. In terms of the environment, the hospital also added various decorations to make the interior design livelier and aesthetically pleasing. These changes include adding paintings and decorative arts in the hallway and in the private meeting rooms. In the bathroom, the hospital added various amenities, labels and instructions to provide better ease of use.

In addition, multiple customer surveys were conducted throughout the year. A customer satisfaction survey for 50 people was conducted using the patient information system during their stay at the Tong Shin Ward. The survey results in Table 19 shows that patients were satisfied with the service and medical quality, equipment, and other features. Only food and pricing received scores below 90%, respectively of 86.2% and 83.6%. The hospital also conduct biannual patient satisfaction surveys to compare the ward to the rest of the hospital. Figure 8 showed that patients were more satisfied with the 10F smart patient ward after the renovation and that in general, patients were more satisfied with the 10F ward than the other wards.

Table 21: Satisfaction from patient information system during 4 months after renovation in 2015

Category	Item	Score	Satisfaction (%)
Service and medical quality	Admission process	4.72	94.4
	Staff attitude	4.8	96
	Medical quality	4.77	95.4
	Ward noise	4.68	93.6
Equipment and property	Equipment	4.75	95
	Internet	4.54	90.8
Other	Food	4.31	86.2
	Charge	4.18	83.6
	Environment	4.75	95

Source: Shin Kong Wu Ho-Su Memorial Hospital[43]

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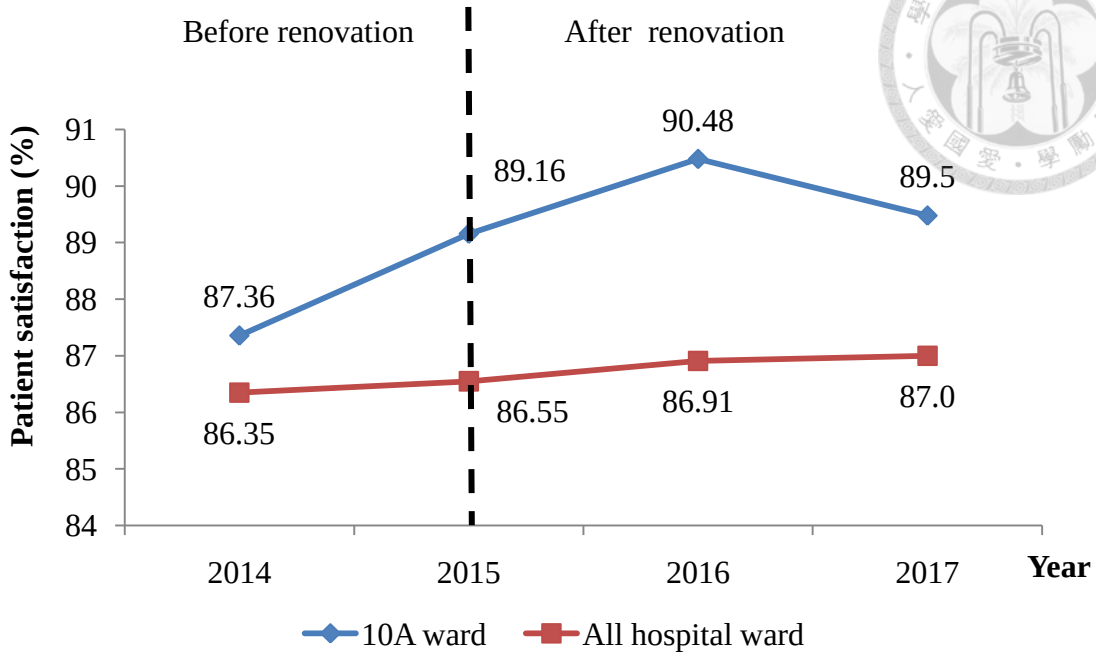

Figure 8: Patient Satisfaction of 10A Ward and All Hospital Ward from 2014 to 2017
Source: Shin Kong Wu Ho-Su Memorial Hospital[42]

In conclusion, the renovation project was a successful transformation for the 10F hospital ward. Many of the management metrics such as occupancy rate, patient satisfaction, nurse staffing turnover rates, and revenue all improved. The financials indicated that after renovation, profit per month increased from NT$249,263(3.6%) to NT$2,190,691(17.9%) in 2016 to 2,884,376 (19.1%) in 2017. The newly designed patient rooms were able to bring not only comfort, privacy and independence for the patients and their caretakers, but also to allow the clinical team to work better. Occupancy rate increased to 4% from 70% in 2014 to 74% in 2016. Patient satisfaction of smart patient ward was higher than Shin Kong hospital in 2015-2016. Patient satisfaction of smart patient ward grew by 3.12% from 2014 (before renovation) to 2016 (after renovation). An internal survey indicated that 48% of the customers who experienced the Tong Shin Ward, said they would return due to its privacy, quiet surrounding and smart patient bedroom design.

Turnover rates of nurse staffing at 10A Ward was 3.28% before the renovation and lowered to 1.19% after the renovation. There are various factors contributing to the lowered turnover rates. A smart hospital ward reduced the workload and allowed the average nurse–patient ratio to move from 1:9 to 1:6. In addition to technological

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solutions, there were multiple meetings with the nurses to understand their demands and the management adjusted the working environment, salary and bonus structure. Additional stipend was also give to staff with foreign language abilities. Senior nurses were staffed at the Tong Shin Ward to provide better service. This transformational success has also led to the hospital in rethink about other renovation, technological and operational opportunities.

5.2 Recommendations

The object of the study is to understand how the implementation of smart patient rooms can help improve the performance of the hospital. The investigation revealed smart patient rooms can provide patients and their care takers a positive customer experience but also bring financial benefits to the hospital. In addition, it's inferred that hospitals faced with regulatory pressures and operational challenges will need to be adaptive to help organizations thrive amidst uncertain change. Technological and digital innovations can help hospitals with some of these operations challenges. In this case study, the hospital was faced with a decrease in nurse staffing and lack of single hospital beds. The hospital was able to rectify the problem by redesigning a ward and its services with the help of technological innovations. These solutions helped the hospital to continue building its competitive edge in providing quality medical service and patient safety.

The circumstances are unique to this hospital and the design was limited to a single ward. However, this case can be of reference for other hospitals thinking of using technology to find impactful solutions. First, when assessing technological solutions, an organization will have to look for integrated solutions that can help build an ecosystem that allows for connectivity with on premise systems, including mobile applications and services. Second, when implementing a new hospital ward, there is also an opportunity to reexamine and streamline how hospital services and clinical care are delivered. Third, the regulation for telemedicine are being re-examined by the government and could offer a more holistic care for patients in the future where more interactive communication between the patient and the physician from a home setting.

In conclusion, hospitals should be organized around people's needs, working closely with health and social care servicesand contributing to public health services.

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These are all part of a greater mission of World Health Organization of bring “Health For All” and that “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” In the future, hospitals will need to be aware of other trends such as big data, artificial intelligence, cloud computing, internet of things, personalized medicine. Specifically, hospitals will have to understand government initiated projects such as My Health Bank, NHI-MediCloud System, NHI mobile App, that are all created in the effort to reduce wastage of medical resources and to improve patient safety and drug safety.

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