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THE National University Hospital: overcrowding IN THE Emergency department

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It was June 2009, and Benjamin Ong, who had taken over the chief executive officer position at the National University Hospital (NUH) three months earlier, was flipping through the reports that his staff had prepared on various performance measures. Suddenly, he stopped flipping through the papers and fell into deep thought. It was the overcrowding in the emergency department (ED) that caught his attention.

From January 2008 to June 2009, patient arrivals had peaked in the morning, whereas patient discharges had peaked in the late afternoon. A patient who visited the ED between 7 a.m. and 11 a.m. was expected to wait, on average, for more than four hours to be admitted to a ward at the NUH. More than 30 per cent of the patients who visited the ED between 7 a.m. and 10 a.m. had waited six hours or longer to be admitted to a general ward.[[1]](#endnote-1) The prolonged waiting time resulted in a growing inventory (i.e., an increased number of patients) in the ED, which led to serious overcrowding. When the ED was overwhelmed, its ability to respond to large-scale emergencies and disasters could also be compromised.

The NUH was a leading public sector hospital in Singapore, and Singapore’s health sector was acknowledged to be one of the most efficient health-care service providers around the globe.[[2]](#endnote-2) Ong wondered which strategy the NUH should adopt in an attempt to reduce the ED’s overcrowding issues, and how the NUH should execute such a strategy.

BACKGROUND

ED Overcrowding: A Global Problem

Over the past few years, ED overcrowding had attracted much attention around the globe, due to recognition of its emerging threat to both patient safety and quality health care.[[3]](#endnote-3) The negative consequences as a result of ED overcrowding included a higher rate of patient walkouts and a higher number of claims for medical negligence.[[4]](#endnote-4)

According to the Joint Commission on Accreditation of Healthcare Organizations, the use of emergency services by patients with non-urgent medical conditions had a significant influence on emergency overcrowding.[[5]](#endnote-5) ED overcrowding could also be based on various other factors, many of which had their roots outside the ED, such as inefficient operations in specialty wards, bed management units (BMUs), laboratories, and other non-ED areas. In-patient capacity was considered a significant factor in ED overcrowding, while prolonged ED boarding time (i.e., the time from the ED doctor’s decision to admit the patient until the in-patient bed was occupied) was considered the major cause of ED overcrowding, which could be controlled by improving the timing of in-patient discharges.[[6]](#endnote-6)

An early discharge policy could help to ensure a stable patient flow, resulting in bed availability in a timely manner.[[7]](#endnote-7) A study conducted in an Ontario hospital supported the argument that prolonged ED boarding time could be eliminated altogether by moving the peak discharge time to four hours earlier.[[8]](#endnote-8) However, an early discharge policy could also have negative outcomes, such as the probability of readmission, either to the same hospital or to a busier or more crowded hospital, and receiving treatment without optimal attention being paid.[[9]](#endnote-9) Globally, the effective approaches to reducing ED overcrowding included an optimal admission protocol, aggressive bed management, effective scheduling, optimal resource utilization, and early discharge policies.[[10]](#endnote-10)

Health Care in the United States and Singapore

In 2014, Bloomberg ranked Singapore as the country with the most efficient health care.[[11]](#endnote-11) The ranking criteria were based on a country’s life expectancy and its relative and absolute per capita costs of health care. In 2011, Singapore had a population of only 5.18 million[[12]](#endnote-12) but, surprisingly, had a gross domestic product (GDP) per capita equal to US$53,121.40,[[13]](#endnote-13) which was slightly higher than the U.S. GDP per capita of US$49,781.40.[[14]](#endnote-14) However, Singapore spent only 3.9 per cent of its GDP on health care, whereas the United States spent 17.1 per cent of its GDP on health care.[[15]](#endnote-15) Also, Singapore’s mortality rate (per 1,000 people) was just five deaths, in contrast to eight deaths for the United States (see Exhibit 1).[[16]](#endnote-16)

The Ministry of Health Singapore

The Ministry of Health (MOH) Singapore was fully devoted to providing quality health care to Singaporeans, which was why it remained committed to ensuring healthier living, preventive health-care programs, and basic medical services for all. The MOH realized that in 2017, compared with 2007, the growing health-care demands of its population, and therefore the public sector, were enriched with approximately 50 per cent more doctors and approximately 70 per cent more nursing staff. As a result, the doctor-to-population ratio reached 1:520 (i.e., 1 doctor for 520 people) in 2012, whereas it had been 1:620 in 2007. The nurse-to-population ratio reached 1:154 in 2012, down from 1:205 in 2007.[[17]](#endnote-17) In addition, the MOH worked closely with public sector hospitals to develop key performance indicators (KPIs) to evaluate hospital performance, such as ED boarding time, bed occupancy rate, and length of stay (LoS). The NUH and all public sector hospitals in Singapore were required to submit weekly reports regarding these KPIs to the MOH Singapore, and the MOH made these statistics public on its website. As such, all public sector hospitals in Singapore, including the NUH, were constantly seeking effective and efficient solutions to provide a high quality of care and to meet the targets for all KPIs.

THE National University hospital singapore

History

Kent Ridge Hospital Singapore was initiated in 1972 and completed in 1984 with a capacity of 280 beds under the supervision of Temasek Holdings, a government investment holding company. On January 15, 1985, Kent Ridge Hospital was renamed the National University Hospital Singapore. The NUH started serving the public on June 24, 1985, with 180 employees treating 56 outpatients and four in-patients. The MOH Singapore decided to strengthen the NUH in 1987 and handed over control to the Health Corporation of Singapore under the MOH. In 1990, the Singapore government acknowledged the vigorous role played by the NUH and decided to elevate its status to one of the major teaching institutes in the field of medical sciences, thereby handing over administration of the NUH to the National University of Singapore (NUS).

In 1986, the NUH started its ED on a 24/7 basis. That same year, the NUH proved its competency level after performing its first successful open-heart surgery. After becoming a major teaching institute, the NUH recognized the importance of computerizing the allocation time in the operation theatre to deal with scheduling issues. In 1996, the operation theatre was equipped with an efficient and effective scheduling process, and in 2000, the NUH deployed its Computerized Patient Support System to manage its patients’ histories. After 2000, the NUH initiated a focus outside of biomedical sciences, to include additional fields, such as engineering, behavioural and social sciences, material sciences, computing, and mathematics in an effort to improve system performance with some permanent solutions on an early basis. As a result, automation was used to influence process improvement. It also improved the NUH’s utilization of in-patient resources and reduced the patients’ LoS at the hospital. However, to achieve better patient outcomes, the NUH still needed to optimize its resource allocation to accommodate more in-patients in a timely manner.

Quality of Health Care

In 2001, the NUH’s administration decided to focus on quality of service (QoS) and established a Quality Improvement Unit that was responsible for visiting in-patients on a regular basis to ensure they were receiving quality health care. In that same year, the NUH initiated a further step toward achieving QoS by establishing a one-stop outpatient treatment facility for women. The following year, in 2002, the NUH obtained three ISO[[18]](#endnote-18) certifications: ISO 9001 (Quality Management System), ISO 14001 (Environmental Management System), and ISO 18001 (Occupational Health & Safety Management System).

The QoS in the health sector could be defined as the right treatment for the right patient at the right time. As such, the administration of the NUH focused on reducing response times by increasing system efficiency, not only in in-patient wards but also in allied departments, such as laboratories and pharmacies. Therefore, the NUH’s lean management team remained engaged in streamlining the processes to improve patient care.[[19]](#endnote-19) In 2003, with the aim to improve overall system performance, the NUH pharmacy introduced the Medicine Top-Up Service and Medicine Delivery Service to address the issues of long queues. To access the services, regular patients phoned in their medication requests to the pharmacist, and their prescribed medicines were delivered to their given address. In 2004, the NUH became the first Singaporean hospital to achieve Joint Commission International accreditation,[[20]](#endnote-20) which was considered an international standard reflecting excellent clinical practices for patient safety and quality of care.[[21]](#endnote-21)

Resources

The NUH remained focused on aligning its resources with society’s increasing demands. As a result, the hospital, which had started functioning with a capacity of 280 beds in 1985, increased to 997 beds in 2010, and then to 1,068 beds in 2011. In addition, the number of employees (180 in 1985) increased to 5,576 in March 2010. In the 1980s, the NUH’s nurse-to-patient ratio was approximately 1:8~10 (i.e., 1 nurse for 8 to 10 patients). Although it later reached 1:6 in September 2010, resulting in better care for patients, the patient demand was much higher in 2010 than in the 1980s.[[22]](#endnote-22) The NUH encouraged its doctors, nursing staff, and allied health professionals to take on effective roles in the NUH health system and, consequently, they were given opportunities to upgrade their knowledge and skillset. Furthermore, selected members of the nursing staff were offered scholarships to pursue postgraduate courses, such as master’s degree programs in nursing at NUS and overseas. In addition, the NUH’s state-of-the-art equipment was also considered a strength.

The Dilemma

The NUH operated a busy ED with 38 in-patient wards. These in-patient wards had five main sources of patients: the ED, high dependence wards (HDWs), intensive care units (ICUs), referral patients (electives), and same-day-admission (SDA) patients. In the NUH, among those patients who visited the ED, almost 20 per cent were admitted to general wards (GWs), as decided by the ED doctor, based on the patient’s medical condition. From January 2008 to June 2009, patients waited an average of 2.82 hours (169 minutes) between the decision to be admitted and their occupation of a bed in an in-patient ward; 136 of those 169 minutes were used by the BMU to locate a vacant bed, complete the bed allocation procedure, and transport the patient to the ward. The situation worsened during peak working hours, with the average ED boarding time reaching more than four hours for patients who visited the ED between 7 a.m. and 11 a.m., while between 7 a.m. and 10 a.m., more than 30 per cent of those patients waited six hours or longer. This situation resulted in a growing number of patients in the ED, and ultimately led to serious overcrowding until the late afternoon. Such a situation increased the probability of missing the optimal time for treatment, resulting in worse patient outcomes and possible adverse publicity.[[23]](#endnote-23)

Dealing with ED Overcrowding

Singapore was also known for having the fastest aging population in the world, where a people who were 60 years old or older normally had some chronic diseases, and the fertility rate was low. Within this scenario, ED overcrowding made the situation more critical. For the NUH, operation management had played an important role in dealing with scheduling issues and improving patient flow. In April 2009, the NUH took the first step toward reducing ED overcrowding by discharging more patients before 12 noon to free up some in-patient beds earlier, in the hope of making the beds available in a timely manner (see Exhibit 2). Later, in May 2009, the NUH took the second step toward reducing ED overcrowding by introducing its first off-site 30-bed ward located at the West Point Hospital.

in-patient wards

Critical Care Wards

In 2009, the NUH was equipped with a total of 38 in-patient wards, including five ICUs and five HDWs. Patients were typically admitted to the ICU or an HDW from the ED, and after recovery, were usually either transferred to a specialty ward that was considered an internal transfer or were discharged from the hospital. Patients could also be transferred again to the ICU or to an HDW if they had a special medical condition. The NUH also operated two isolation units for patients who had potentially infectious diseases. Isolation units were equipped with external viewing panels to protect the safety of doctors and nursing staff, who were able to observe the patient by using the monitoring system and thereby avoid entering the room.

General/Specialty Wards

The NUH dedicated 19 wards to various medical specialties, while some in-patient wards shared more than one specialty because of the similar nature of the medical problems and a similar LoS. At the time of admission, patients were examined, and based on the diagnosis, they were referred to the relevant specialty ward. Male and female patients were assigned to different wards. Most patients were admitted to the general medicine ward from the ED, while patients admitted for urgent surgical procedures were typically from referral sources (electives) and SDA patients. Specialty wards worked independently under the umbrella of the NUH and had their own dedicated nursing staff and cleaning teams. The in-patient wards were categorized into classes A, B, and C, based on their available facilities (see Exhibit 3). Class B2 and C wards were known as subsidized wards because they received maximum financial support from the government. As a result, beds in subsidized wards were always in high demand.

Gynecology Wards

The NUH operated two obstetrics and gynecology (OG) wards and included a delivery ward. The OG wards were reserved for women who were admitted to deliver babies, and these patients followed a different pattern of admission. These patients usually arrived directly to the delivery ward, and after delivery, were admitted to the OG wards. These patients were sometimes admitted through the ED or were SDA patients based on a medical condition and were later transferred to the OG wards. These patients had a shorter LoS, typically one to three days, depending on their medical condition.

Pediatric Wards

The NUH also operated a dedicated children’s ED (CED) in addition to the general ED. The CED had its own admission process and was equipped with one pediatric intensive care unit and four pediatric wards for infants and children up to the age of 18. The CED and ED operated independently, with the consensus of administration to not use each other’s resources.

in-patient Admission Sources

In-patient admissions were divided into the five main categories detailed below (see Exhibit 4). To calculate the admission rate, the initial admission source for each patient was counted only once. Patients might have experienced various transfers, such as a transfer from the general ward (GW) to the HDW or from the ICU and then back to the GW, but these internal transfers were not considered in the admission-rate calculations.

Emergency Department

The ED was typically the entry point of any hospital that had the capability to provide initial medical treatment for minor and adverse medical conditions, including injuries and a broad variety of illnesses. At the NUH, almost 19.7 per cent of patients who arrived at the ED were admitted to specialty wards, while 68.6 per cent were discharged based on stable medical conditions, casualties, or referrals to other hospitals. The remaining patients were transferred to an ICU-type in-patient ward, an HDW, or an isolation ward. Outpatients were those patients who were admitted and discharged from the ED without an overnight stay or referral to an in-patient ward, after having received necessary treatment, including minor surgical procedures. In contrast, in-patients were all patients who visited the ED first, and based on the doctor’s recommendation, were transferred to an in-patient ward and referred to as “ED-GW patients.” Outpatients had a higher probability of revisiting the ED than in-patients.

Intensive Care Unit

The ICU was considered one of the NUH’s most expensive units in terms of operational expenses and was, therefore, reserved for those patients who had the most critical conditions. These patients might be admitted from the ED, specialty wards, or referrals from other hospitals or outpatient clinics, due to the severity of the illness. Because of limited bed capacity and to accommodate more patients who had critical medical conditions, ICU patients were transferred to specialty wards when they were considered out of danger and in a stable condition.

High Dependence Wards

The NUH operated HDWs for patients who required less intensive observation and nursing care than ICU patients, but more care than those in specialty wards. Patients could be admitted to HDWs from the ICU, the ED, specialty wards, or referrals from other hospitals. Depending on their medical condition, HDW patients could be discharged directly from the HDW or transferred to specialty wards.

Elective Patients

Patients referred by clinical physicians for surgeries involving less urgent medical conditions were known as elective (EL) patients. The admission of these patients was prescheduled based on available resources such as the surgeon, an operation theatre, and allied resources. For these reasons, EL patients were advised to arrive at the hospital for admission in the afternoon, one day prior to surgery. The beds for these scheduled patients were reserved to avoid delays in bed allocation, while admission in the afternoon helped them to bypass the crowd of discharged patients. After their surgical procedures, these patients were transferred to in-patient wards, where they remained until they were discharged.

Same-Day-Admission Patients

SDA patients had the most urgent medical conditions and visited the operation theatre for surgical procedures before admission to the ward. The NUH SDA unit was equipped with approximately 50 beds that were allocated on a temporary basis until recovery. SDA patients were transferred to a specialty ward after their recovery and remained there until they were discharged.

**HOSPITAL OPERATIONS**

**Emergency Department Operations**

Patients who visited the ED typically presented an array of adverse medical conditions. The ED at the NUH dealt with a variety of patients on a 24/7 basis, ranging from those who had urgent medical conditions to those who had minor issues. ED staff at the NUH were required to follow a standard operating procedure, such as initially taking the patient’s temperature, having the nursing staff screen the patient, and referring patients who had a high temperature to a temperature facility. Otherwise, the patient was moved forward to the registration counter to register and pay the initial deposit fee. After the registration process was complete, a triage nurse evaluated the patient’s medical condition.

Triage nurses at the NUH were responsible for categorizing patients based on their most and least severe medical conditions, determining the most appropriate treatment area, providing guidance to patients and their relatives, assisting the ED doctors, and controlling the congestion within the ED. After an initial assessment, the patient was referred to an appropriate doctor who performed a complete medical assessment of the patient, and based on the results, decided whether to refer the patient for admission to a ward, request tests from the lab to further diagnose the problem, or advise the patient to take prescribed medication along with bed rest at home (see Exhibit 5). The calculation for the ED boarding time until admission to the in-patient ward started immediately after the doctor decided to admit the patient. At the NUH, approximately 20 per cent of those patients who visited the ED became ED-GW patients.[[24]](#endnote-24)

In-patient operations were complex phenomena based on the various medical conditions. Consequently, poor patient flow due to inefficient operations led to bottlenecks and, ultimately, ED overcrowding.[[25]](#endnote-25) The probability of bottlenecks greatly increased during peak hours, due to a higher number of patients requiring limited resources such as the ED doctors, the ED nurses, and other support staff. Bottlenecks could be expected at any stage of ED operations, from the patient’s entry until the patient’s exit (see Exhibit 5).

BMU Operations

The NUH bed utilization rate was approximately 85 per cent because 15 per cent of the bed capacity was reserved for emergency patients only. The BMU’s centralized computerized system enabled staff to check the status of all beds in the in-patient wards, including bed occupancy, bed vacancy, expected time of vacancy, and cleaning process after vacancy.

After patients were referred for admission to an in-patient ward, they had the right to choose the in-patient ward of their choice with some limitations, such as the specialty area. Most patients preferred to choose highly subsidized wards that were funded by the government. However, only Singapore nationals, permanent residents, valid employment pass holders, and valid work permit holders were entitled to be admitted to such wards (see Exhibit 3). After the bed requests were registered in the BMU, the staff preferred to accommodate those patients in the specialty wards first, depending on the availability of in-patient beds. Otherwise, patients were required to wait in the queue for up to six hours before being assigned to an available bed in an in-patient ward, regardless of the specialty required. This situation resulted in complicated bed allocations, unnecessary travel time for the doctor, delays in specialized treatment, and ultimately, the worst patient outcomes.

After the bed was allocated on a provisional basis and occupied by the patient, the BMU staff started negotiations with the in-charge bed allocation staff (i.e., the ward nurse) of the in-patient wards. This negotiation was done on an individual basis according to the specialty, gender, and type of ward until the patient was accepted for admission into a specialty ward. The BMU would immediately inform the ED about the availability of a bed to initiate the ED discharge process and transfer the patient to the in-patient ward. The transfer of patients was still based on their medical condition. If the medical condition did not support the transfer of the patient to a specialty ward, the bed could be allocated to another patient and a new request would be initiated for the original patient, based on their less severe medical condition. The ED nurse initiated the ED discharge process based on the patient’s stable medical condition and submitted the ED discharge application to the ED doctor along with complete lab reports to obtain approval for the patient’s discharge from the ED. The ED nurse was responsible for transferring the patient to a specialty ward with the help of a porter, and the ward nurse finalized the admission process by admitting the patient (see Exhibit 6).

Unnecessary delays in the patient-flow process resulted from human factors and inefficient BMU processes based on a complex bed allocation system. The complicated process, from the initiation of the bed request until the bed was occupied, was evaluated against two parameters, such as the time taken for the bed to be allocated—calculated from the time of the bed was requested until the time the bed was allocated—and the time taken for the bed to be occupied—calculated from the time the bed was allocated until the time the bed was occupied.

Transfer from the ED to In-patient Wards

After the ED doctor decided to admit the patient to the in-patient ward, the ED sent a bed request to the BMU, which initiated a search for an appropriate bed. Because the BMU had updated information about patients’ expected discharge, a bed could be assigned if it was occupied but was expected to be available soon. The ED was immediately informed about the availability of the bed, whereas the cleaning team required 30 minutes to clean the bed. Meanwhile, the ED proceeded with the patient’s discharge process, and the BMU allocated (e.g., set aside) the bed after the ED confirmed the patient’s discharge. The ED nurse and the porter then transferred the patient to the ward, handing the patient over to that ward’s nursing staff, who then finalized the formal admission process in the presence of the ED nurse, and the bed was occupied (see Exhibit 7).

The patient-transfer process was highly influenced by the human factor. Consequently, delays could be expected at each step, such as ED doctors and nursing staff having no time to discharge patients because they were busy attending to other ED patients; or similarly, porters not being available, especially during peak hours, and ward nurses being too busy dealing with admitted patients. These delays could possibly be minimized but could not be completely eliminated.

In-patient Ward Operations

ICUs, HDWs, and specialty wards shared similar operational procedures; the only difference was the level of care, ranging from the most critical to the least critical medical conditions. The NUH in-patient wards were totally independent and had dedicated teams of doctors and associated staff on a 24/7 basis. Doctors typically preferred to have their patients in the same wards to enable timely medical facilities, in addition to saving time on their rounds. Senior doctors’ rounds were scheduled twice a day—once in the morning and the once in the evening—due to their busy schedules, which included surgical procedures, administrative duties, and related duties. Doctors also needed to make themselves available for emergency calls on a 24/7 basis.

In the in-patient wards, the day started with the nursing staff taking the temperature and blood pressure readings of all admitted patients and recording these readings on a history sheet. The nursing staff was also required to confirm whether patients had taken their prescribed medications. Later, at approximately 9 a.m., the senior doctors, along with any duty doctors, would do the rounds in the wards and evaluate the patients’ conditions. During this time, further treatment was recommended for some patients, others were informed about their expected discharge, and yet others received their discharge orders. Patients typically received discharge orders only in the morning round and no later. After the doctors completed their rounds, at approximately 12 p.m., the discharge documentation was initiated, and the BMU was asked about the expected availability of in-patient beds.

Beds normally became available after 3 p.m., as the peak discharge hours were between 2 p.m. and 3 p.m., depending on the completion of discharged documentation, the receipt of medication, and guidance by the nursing staff on the use of medicines and any prescribed rehabilitation exercises. The cleaning team was required to complete the bed cleaning process within 30 minutes immediately after its vacancy. Meanwhile, a nurse and a porter escorted the patient to the ward, and the ward nurse would admit the patient and complete the admission. The ward nurse immediately performed the temperature and blood pressure screening, prepared the patient file, and reported to the duty doctor. The duty doctor performed the initial checkup of the patient and prescribed treatment, whereas the senior doctor also remained available for emergency calls. In the evening, the nursing staff repeated the routine checkup for all admitted patients and updated the history sheet. The senior doctors, along with the duty doctors, would conduct their evening round, and based on the patient’s condition and history sheet, they would provide further treatment or forecast the expected discharge date. Later, the nursing staff would follow the doctors’ instructions provided during the evening round until the next morning (see Exhibit 8).

The expected discharge date was forecasted approximately one to two days prior to the day of discharge, starting from the doctor’s evaluation of the patient’s condition in a routine ward round. Then, based on the patient’s medical condition, the doctor would forecast the patient’s date of discharge and inform the patient. The doctor could refer the patient to a laboratory for some tests to examine the exact stage of recovery. The nursing staff assisted the patient with the laboratory tests and submitted the report to the doctor on duty in the next round. The next morning, the same process was repeated. When the doctor considered it appropriate to discharge a patient (i.e., a patient was expected to recover fully at home), the doctor would ask about the patient’s willingness to be discharged from the hospital. The patients in subsidized wards often had no intention of being discharged, whether or not they had fully recovered in hospital (see Exhibit 9)**.**

In-patient operations were not as simple as they seemed. Doctors and associated staff spent busy days dealing with patients who had various levels of medical conditions. Sometimes, due to no availability of in-patient beds in specialty wards, patients were admitted to any available bed on a temporary basis (despite the specialty required) and were later transferred to a specialty ward. The NUH strictly focused on its policy to avoid unnecessary transfers and to give preference to those patients who had more critical medical conditions, such as ICU patients already receiving maximum care. For this reason, the NUH categorized some patients as a lower priority for transfer into specialty wards to save unnecessary transportation time and achieve the best utilization rate of resources such as doctors.

**THE DECISION**

Between January 2008 and June 2009, after the ED doctor’s admission decision, patients were required to wait 169 minutes, on average, before occupying a bed in an in-patient ward; 136 minutes of those 169 minutes were used by the BMU to identify an available bed, complete the bed allocation procedure, and transport the patient to the ward. The situation worsened during peak working hours. The average ED boarding time was more than four hours for patients who visited the ED between 7 a.m. and 11 a.m., while more than 30 per cent of those patients waited six hours or longer. This situation resulted in growing inventory (i.e., number of patients) in the ED, and ultimately led to serious overcrowding until late afternoon. The NUH needed to re-examine the possible causes for overcrowding in its ED and the prolonged ED boarding time, identify the bottlenecks, and find solutions.

Exhibit 1: Spending on Health care, by country, 2013 and 2014 (in US$)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Countries | GDP Per Capita | Health-Care Expenditure  (% of GDP) | Life Expectancy  (In years) | Mortality Rate  (Per 1,000 People) | GDP Per Capita | Health-Care Expenditure  (% of GDP) | Life Expectancy  (In years) | Mortality Rate  (Per 1,000 People) | Bloomberg Ranked  Most Efficient Healthcare | |
| 2013 | | | | 2014 | | | | 2013 | 2014 |
| Singapore | 55,980.20 | 4.5 | 82 | 5 | 56,284.30 | 4.9 | 83 | 5 | 2 | 1 |
| Hong Kong | 38,364.20 | 5.4 | 84 | 6 | 40,169.50 | 5.3 | 84 | 6 | 1 | 2 |
| Italy | 35,420.90 | 9.2 | 83 | 10 | 35,222.80 | 9.2 | 83 | 10 | 6 | 3 |
| Japan | 38,633.70 | 10.2 | 83 | 10 | 36,194.40 | 10.2 | 84 | 10 | 3 | 4 |
| South Korea | 25,997.90 | 7.2 | 82 | 5 | 27,970.50 | 7.4 | 82 | 5 | 8 | 5 |
| Australia | 67,652.70 | 9.4 | 82 | 6 | 61,979.90 | 9.4 | 82 | 7 | 7 | 6 |
| Israel | 36,281.20 | 7.9 | 82 | 5 | 37,206.20 | 7.8 | 82 | 5 | 4 | 7 |
| France | 42,627.70 | 11.6 | 82 | 9 | 42,725.70 | 11.5 | 82 | 8 | 19 | 8 |
| United Arab Emirates | 42,831.10 | 3.5 | 77 | 2 | 43,962.70 | 3.6 | 77 | 2 | 12 | 9 |
| United Kingdom | 42,294.90 | 9.3 | 81 | 9 | 46,297.00 | 9.1 | 81 | 9 | 14 | 10 |
| China | 6,991.90 | 5.4 | 76 | 7 | 7,590.00 | 5.5 | 76 | 7 | 37 | 26 |
| United States | 52,980.00 | 16.9 | 79 | 8 | 54,629.50 | 17.1 | 79 | 8 | 46 | 44 |

Note: GDP = gross domestic product

Source: Created by case writers based on The World Bank, “GDP per Capita,” accessed May 21, 2016, http://data.worldbank.org/indicator/NY.GDP.PCAP.CD; Health statistics Food and Health Bureau Hong Kong, accessed April 13, 2016, www.fhb.gov.hk/statistics/en/statistics/health\_expenditure.htm; Bloomberg, “Bloomberg Rankings, Most Efficient Healthcare 2014: Countries,” accessed April 13, 2016, www.bloomberg.com/rank.

Exhibit 2: percentage of patients discharged before 12 p.m. from the National University Hospital singapore, October 2008 to December 2010

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month and Year | Percentage of patients discharged before 12 noon | | | | | | | Criteria |
| 0–5% | 5–10% | 10–15% | 15–20% | 20–25% | 25–30% | 30–35% |
| October 2008 | – | 9.1 | – | – | – | – | – |  |
| April 2009 | – | – | 13.7 | – | – | – | – | UCL: 30%  LCL: 5.4%  Average  17.7% |
| May 2009 | – | – | 13.8 | – | – | – | – |
| June 2009 | – | – | – | 17.4 | – | – | – |
| July 2009 | – | – | – | 18.9 | – | – | – |
| August 2009 | – | – | – | – | 21 | – | – |
| September 2009 | – | – | – | – | 20.5 | – | – |
| October 2009 | – | – | – | 18.7 | – | – | – |
| November 2009 | – | – | – | – | 20.5 | – | – | UCL: 32.5%  LCL: 19.3%  Average  25.9% |
| December 2009 | – | – | – | – | 23.3 | – | – |
| January 2010 | – | – | – | – | 24.4 | – | – |
| February 2010 | – | – | – | – | – | 26.9 | – |
| March 2010 | – | – | – | – | – | 28.3 | – |
| April 2010 | – | – | – | – | – | 28.2 | – |
| May 2010 | – | – | – | – | – | 28 | – |
| June 2010 | – | – | – | – | – | 26.7 | – |
| July 2010 | – | – | – | – | – | 25.3 | – |
| August 2010 | – | – | – | – | 24.6 | – | – |
| September 2010 | – | – | – | – | – | 26.3 | – |
| October 2010 | – | – | – | – | – | 25.6 | – |
| November 2010 | – | – | – | – | – | 26.3 | – |
| December 2010 | – | – | – | – | – | 28.4 | – |

Note: UCL = upper control limit, the highest level of acceptable quality, which means a maximum of approximately 30 per cent of patients were discharged before 12 noon; LCL = lower control limit, the lowest level of acceptable quality, which means a minimum of approximately 5.4 per cent of patients were discharged before 12 noon; Average = sum ÷ (quantity of numbers).

Source: National University Hospital documents.

**Exhibit 3: Types of In-patient Wards at the National University Hospital Singapore**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ward Type** | | **Number of Beds** | **Daily**  **Ward Fee**  **(in S$)** | **Facilities** |
| Deluxe Suite | | 1 | $762.91 | Air-conditioning, attached sitting room, television, telephone, mini fridge, and attached bathroom |
| Class A | | 1 or 2 | $527.51 | Air-conditioning, television, telephone, and attached bathroom |
| Class B | B1 | 4 | $224.70 | Air-conditioning, television, telephone, and attached bathroom |
| B2 | 6 | $75.00 | Fan-ventilated, shared bathroom, and entitlement for government subsidy |
| Class C | | 8 | $41.00 | Fan-ventilated, shared bathroom, and entitlement for government subsidy |

Source: National University Hospital, “Ward Types,” accessed August 30, 2016, https://www.nuh.com.sg/patients-and-visitors/patients-and-visitors-guide/choice-of-accomodation/ward-types.html; S$ = SGD = Singapore dollars; S$1 = US$0.73 on August 30, 2016.

Exhibit 4: National University Hospital’s General ward admission sources (January 1, 2008 to december 31, 2010)

Note: ICU-GW = patients who were first in the intensive care unit and were subsequently transferred to a general ward; HDW-GW = patients who were first in the high dependence ward and were subsequently transferred to a general ward; ED-GW = patients who first arrived in the emergency department and were subsequently transferred to a general ward; GW = general ward; EL = elective; SDA = same-day-admission; six months data (July 1, 2009 to December 31, 2009) is excluded.

Source: Created by the case writers based on Pengyi Shi, Mabel C. Cou, J. G. Dai, Ding, and Joe Sim, “Models and Insights for Hospital Inpatient Operations: Time-Dependent ED Boarding Time,” *Management Science* 62, no. 1 (2016): 1–28.

**EXHIBIT 5: process flow at the National University Hospital’s EMERGENCY DEPARTMENT**

Temperature screening

Registration & payment

Fever facility

Nursing triage

Consultation with ED doctor

Admission to inpatient wards

Lab test/X-ray

Pharmacy

5–10 minutes

15–30 minutes minminutes

1–3 hours

1.5 hours

15 minutes

3–10 hours

No fever

Note: ED = emergency department.

Source: Created by case writers based on operational analysis.

**Exhibit 6: process flow at the National University Hospital’s Bed management unit**

Allocation of provisional bed

Negotiation for allocation of bed in concerned ward

Bed allocated

Reported to ED to start ED discharge process

ED nurse & porter transferred the patient

Available

Yes

No

Time taken for bed allocation

Time taken for bed occupied

Not Available

ED patient requested for bed

BMU bed allocation

Decision to discharge by ED doctor

Note: ED = emergency department; BMU = bed management unit.

Source: Created by case writers based on operation analysis.

**EXHIBIT 7: NATIONAL UNIVERSITY HOSPITAL’S TRANSFER PROCESS FROM THE EMERGENCY DEPARTMENT TO AN IN-PATIENT WARD**

ED

Initiated bed request

BMU notified by ED

BMU searched for bed

Bed assigned

Bed cleaning

Bed allocated

ED confirmed the patient discharge

Patient discharged from ED

ED nurse & porter transferred the patient

Patient handed over to nursing staff of ward

Patient admitted/

Bed occupied

ED informed

ED informed

Note: ED = emergency department; BMU = bed management unit.

Source: Created by case writers based on operation analysis.

**EXHIBIT 8: NATIONAL UNIVERSITY HOSPITAL’S IN-PATIENT WARD OPERATIONS**

Morning rounds of senior doctor

Parallel Operations

Discharge documentation prepared

BMU informed

Patient discharged

Bed cleaned

Admission actualized

ED informed by BMU

ED discharged the patient

Patient arrived

In-patient Ward Operations

Initial screening & history file

Initial checkup by duty doctor

Routine evening checkup by nursing staff

Evening rounds of senior doctor

Note: BMU = bed management unit; ED = emergency department.

Source: Created by case writers based on operation analysis.

**EXHIBIT 9: National University Hospital’s in-patient discharge process**

Patients’ check-up/Discharge forecasted

Day of discharge

Lab tests recommended

Tests reports submitted to doctor

Patients’ willingness to get discharged

Discharge process executed/Necessary documentation (Clearance)

Pharmacy informed for medicine

Medicine received from pharmacy

Guidance about the use of medicine

Bed vacated

Poor medical condition

No

Yes

Discharge decision by doctor

Stable medical condition

Source: Created by case writers based on operation analysis.

Endnotes

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