SCALABILITY FOR SUPPORTING THE GROWTH OF HOSPITALS:
APPLICATION AT THAILAND HOSPITALS

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Abstract. Public hospitals in Thailand have been forced to serve dramatically increased numbers of patients since the National Health Security Act 2002 gave access to free medical treatment. The challenge to hospitals is to plan for increasing resources and facilities of service processes to serve more patients. A model for analysing the scalability of factors necessary to the growth in hospital size has been developed. In its development, we focused on one part of the hospital, the outpatient department (OPD). The model is an outcome of three-stage study of OPDs. In the first stage, the OPD at a single hospital was investigated for the identification of key factors associated with patient flow. The second stage, the investigation expanded to seven hospitals so to find patterns in performance based on principles of Lean Systems. In the final stage, a descriptive model of "scalability" was created. The objective of the model is to guide hospitals in planning their growth in size.

Keywords: hospital, lean, process analysis, growth, outpatient, planning

1. INTRODUCTION

Similar to other countries, the Thai Government has introduced a care guarantee Act. Public hospitals are obligated to meet performance measures of cost and accessibility. They may meet these, partially, by decreasing waiting and treatment time. Currently, there is pressure on doctors to reduce flow time by contracting consultation time, which may be at the expense of diagnosis and treatment. The sophistication of medical infrastructure and services varies between hospitals. The quality of the operational process becomes a critical factor in the hospital performance. Also, the drastic demand by patients who need to experience the outpatient department would identify the potential of outpatient department. Whereas, being treated for better health soon after the patient arrives becomes the most ambitious perspective of patients’ needs. Long waiting time of patients can bring up huge amount of problems; for instance, some patients decide not to visit a hospital only because of their intolerance to long waiting times due to their weakening health. Long waiting times in outpatient departments (OPDs) are notorious, as Paul and Kuljis (1995) highlight by referring to a report by Thakar and Malin (1989). The focus of research is OPDs, as they form 80% of patient demand in Thailand (Alpha Research, 2006). The greatest demand within an OPD comes from the sub department of internal medicine, which is responsible for the management of nonsurgical treatment of serious diseases such as hypertension and diabetes. The challenge for hospitals is to plan for increasing resources and facilities of service processes to serve greatly increased numbers of patients.

2. LITERATURE REVIEW

By decreasing waiting and treatment times, costs can be reduced, while increasing accessibility. Hall et al. (2006, p.8) stated three goals that benefit from healthcare delay reduction are: waiting time reduction for needed service, timeliness for reaching the service, and elimination of inefficient activities. Hence, the operational cost is reduced. Whereas, service providers suffer increasing workload, which may breach limits of human performance (Wickens et al. 2004, p.331). The need to increase the number of
healthcare service operators has become a matter of current debate (Paavola, 2008). OPDs can be characterized as large dynamic and complex systems with multiple processes having variable cycles with their phasing dependent upon the flow of the conditional demands of patients. Bertrand and Vries (2005, p.28) discuss the application of the concept of the focused factory—created by Wickham Skinner in 1985—to the design of the hospital service process. A focused factory produces a homogenous group of products or services. For the concept to be applicable to hospitals, patients need to be grouped by homogeneous treatment practices and resources. Thus, homogenous groups within the processes and services in the routings of patient flows must be identifiable.

Hall (2006) contends that reduction in delays in the delivery of healthcare requires the optimisation of the service process as the first priority. This is followed by alterations to the arrival processed and changing the queuing process through such practices as prioritisation in triage. The transformation of the service process includes clinical process, management process, and ancillary process (Vissers, 1998). The planning and control of healthcare concerns the interaction between patient flow and resources (Vissers & Beech, 2005). Contributing factors to the servicing of outpatients are—amongst others—patient flow, work activity and information flow at workstations, service time, material flow, such as specimens and documentation. Physical, information, and human resources relating to tasks performed have been concerned.

Success of healthcare initiatives depends upon the local situation and thereby there cannot be a universal best practice (Stacey and Griffin, 2006, p.23). Walshe (2003) comments that various nations, as well as doctor and nurses, criticize international comparisons of the quality health care produced by the World Health Organization. Clinical practices may vary across countries. Therefore, the approach for design should be the application of a process improvement roadmap that leads to an operations model for a shortest lead time at minimum cost. The roadmap would become a guiding tool for improving the service quality.

3.3 METHODOLOGY

3.1 Time Variances

Service processing times and waiting times are the two time parameters in a hospital service process. Waiting to be served in the service process takes the largest proportion of the patient flow time. The time influences on making the following decisions: number of service facilities, number of servers at a service facility, and efficiency of the servers (Hillier & Lieberman 1974, p. 438).

3.2 Resource Utilization

After decisions have been made for capacity investment, resources in hospitals become fixed. Like hotels and airlines facilities, resources in hospitals need to be utilized to make profit in their business. The challenge for managers is to balance daily demands with an available capacity (Fitzsimmons & Fitzsimmons 2008, p. 257).

3.2.1 Job Design

Job design for a production process work environment needs to include the tools and machines that humans use to better perform their jobs. The design also concerns factors in the relation to the physical limitations of humans, such as size, weight, grasping pressure, and the simplicity of equipment usage (Lee & Schniederjans, 1994). In hospitals, human activities dominate many service operations. In some service stages, automated, or semi automated, equipment improves productivity; for example, the measurement of blood pressure. Nonetheless, many jobs—for example, examination, diagnosis, and triage—tasks require judgment that cannot be mechanized or automated. Job design also includes designing facilities location, utilizing existing equipment, minimizing skill requirements for cost cutting, grouping work tasks for specific skill development and efficiency improvement, designing self-teaching jobs for learning time reduction, equalizing work assignments for idle time reduction; and providing environmental conditions which improve productivity (Lee & Schniederjans, 1994).

3.2.2 Line Balancing

Task assignments have an impact on operational processes. If times to complete tasks in an operational process vary due to unevenness in the number and complexity of tasks assigned to workstations, the workload may be unbalanced. A hospital service process is like an assembly line at some stations. A workstation may become idle because the preceding workstation requires a longer time to complete its tasks. The slow station establishes line congestion by blocking the flow of the process, thereby causing a bottleneck in the process. The solution is to redesign processes such that individual workstations, which may include one or more persons, complete tasks within the same cycle time.

3.3 Space Management

Effective facility design improves the efficiency of service operations. It involves space management, allocation, planning, and forecasting. Performance of a
service facility relies on the design and layout which supports the facility’s elements; for example, hospitals usually locate outpatient departments on the ground floor and wheelchair and stretcher storage near the front of hospitals for convenience and speed of access.

Space design needs to take into account flexibility, for example, to support organizational growth, which demands more space for additional facilities and resources. Flexible spaces are required to support various activities by allowing their activities to expand into the flexible space at an intermediate growth rate. Design for flexibility protects against loss of productivity for individual work stations. Flexible space becomes utilized for high potential activities. Thus, flexible space should not be dominated by permanent activities.

For space planning and management programming, problems, such as the demand for space expansion, need to be analysed. The result of the analysis can be used to support the design to improve the performance of the station. Programming includes forecasting and estimating demand on space. Space programming applies to all sized organizations from small firms to entire facilities, buildings and locations of large organizations. The space planning process enables organizational goals to be set. The space that accommodates functions and activities at the right locations provides better productivity. For example an emergency department should be located at the front part of hospitals where urgent cases can be immediately treated. Adjacent activities should be located next to each other. Efficient space allows performers to finish their tasks within the space—that is a utilization criterion. An organization with a high degree of dynamical changes needs to be quite flexible.

3.3.1 Space Utilization

Space planning has been developed from several techniques. According to Cotts, Roper and Payant (2010), the methods of either Brauer or Muther are preferred by many facility managers for planning space utilization. Under Brauer’s method (1992), there is collaboration with the users in defining space utilization. Priority is given to how the users define their working environment. Thus, facilities including space and construction can satisfy their requirements. Muther’s method (1974) is called “Systematic Layout Planning”. The facility layout involves data gathering based on materials flow, space relationships, and relationships of activities. Muther’s method is widely used, from offices to manufacturing.

3.3.2 Facility Layout

Normann (2001) states that logic of service: “forces us to shift our attention from production to utilization, from product to process, from transaction to relationship. In this sense the service logic clearly frames a manufacturing logic rather than replaces it”. Based on Hameri (2011), May (2004) illustrates that patient-centred service operations at Griffin Hospital, UK, benefitted from a well designed facility. In addition the hospital also has the benefit that staff feels as if they are working as a team and giving more personalized service. According to Higgins (1999), decentralizing control allows decisions to be made locally for unexpected situations, thereby improving management of uncertainty such that an unexpected situation can be responded to in a timely fashion. Decentralization not only simplifies the command structure, but also maintains the robustness of an organizational system.

3.3.3 Production Flow Analysis

Production Flow Analysis (PFA) is a technique for planning the change to Group Technology in existing batch and jobbing production factories (Burbidge, 1991). It produces a cellular layout within dependent production cells, which often form the unit for capacity planning and production location. Different cells together operate according to a rhythm, which usually in job-shop cases feeds the parts for final assembly or downstream supply chain (Hameri, 2011). The PFA methodology is applied to define the material flows inside the groups. A process and material flow analysis could show what process and equipment are needed and how the general material flow will take place. Some element of process flow analysis (determining the type and quantities of processing equipment and calculating there space requirement) after the product analysis and its importance in development of some of the data required for facility design. Material flow analysis, how to develop flow, and distance are an essential data on creating layouts there are tools for presenting layout design (Heragu 2006, p. 55).

3.4 Service Capacity

Service demand often varies and this can cause overloaded workstations or facilities to be idle, including performers, tools, and machines. Demand for hospital services is usually less in summer and autumn (Fitzsimmons and Fitzsimmons, 2008). In other seasons, patients may need to wait for service. Lovelock and Wright (1999) suggest that for successful management of capacity, patterns or determinants of demand need to be understood. To balance service demand and service capability, Sasser (1976) identifies two common strategies for managing capacity: levelling capacity and chasing demand. Levelling capacity is market-oriented. It is applied where capacity is
limited and service demand is high. For example, a level capacity strategy is the use of price incentives which encourage users to come at times of low demand. Chasing demand is operations-oriented, managing situations where capacity is variable and resources can be adjusted to satisfy service demand blowfluctuations by scheduling the workforce according to demand. A workforce is one of the variable facilities in an organizational system, because its capacity is limited by skills and professional classifications, for example doctors, nurses, pharmacists, pathologists, and maintenance technicians are the workforce of hospitals but their skills are very different. According to Armistead and Clark (1994), chasing demand should encompass the significant elements of cost of variation, speed of reaction, and range of variation. Fitzsimmons and Fitzsimmons (2008) conclude that the two strategies may be combined as a hybrid strategy called yield management. An example of the hybrid strategy application is when a hospital uses the chase demand strategy for staff scheduling based on seasonal periods, and a level capacity strategy on its fixed number of patient beds. However, at times inadequate capacity still remains a problem for most service organizations, regardless of which strategy is applied. Armistead and Clark (1994) suggest organizations should face such situations by using a coping strategy which either disregards service quality standards or attempts to manage a decline in some of its service standards. The problem of widely variable demand affects most service organizations that interact with humans either mentally or physically, such as health care, transportation, food service, accommodation, and entertainment. Good service managers know the importance of demand and capacity management. Fitzsimmons and Fitzsimmons (2008, p. 264) state, “Service capacity is defined in terms of an achievable level of output per unit time...for service providers the measurement of capacity is based on a busy employee and not on observed output that must always be less than capacity”. It is essential to track service times. To better understand the existing service process, the related variables would be the mean value of service rate per busy service provider, the number of service providers at individual service steps, and the mean value of arrival rate at individual service steps. The number of service facilities is directly related to the mean value of arrival rate at each individual service step because, assuming a uniform work load among the facilities, mean arrival rate at each facility equals the total mean arrival rate to all facilities divided by the number of facilities.

3.4.1 Networking

Within the operational system of organizations, the provider has to find a way to position himself, and enhance and leverage the value creating process of the customer (Enquist, Camén & Johnson, 2011; Vargo & Lusch, 2004; Alter, 2008).

3.5 Robustness

Higgins (1999) explains that having robustness in a planned operation means less reactive decisions as there are less need for persons to seek ways to repair the plan. In reality, the demand and the provision of service operation vary and that can sometimes cause a crisis situation in the system. Critical operational management requires more than technical expertise, it also requires teams to work well together as a cohesive unit. The aviation industry pioneered resource management with its cockpit resource management. This later evolved into crew resource management (CRM) that considered the entire crew onboard the aircraft as a cohesive team. The objective of the concept of CRM was to address the issues arising in the late 1960s—early 1970s which caused accidents such as failure to communicate intent and plans; failure to delegate tasks and assign responsibilities; failure to set priorities; failure to utilize available data; inadequate leadership; inadequate monitoring; and preoccupation with minor mechanical problems (Wiener, 1993). Team resource management (TRM) incorporates the theoretical approaches developed in CRM for the hospital training for the critical operation environment in hospitals (Bleakley et al. 2004). Kohn, Corrigen and Donaldson (2000) identified four critical areas that improve safety in an operating theatre. Key elements of the four critical areas are building an environment for the safe use of equipment, building a no-blame environment for investigating and reporting near misses, building an effective team, and recognizing the correlation between individual and system errors. The study of Hugh (2002) confirmed that TRM contributed to a decrease of accidental injuries during surgical operations from 1 injury per 200 cases to no injuries per 2000 surgeries.

3.5.1 Resilience

A resilient system is one that can respond rapidly to unexpected and unplanned situations to quickly bring the system back to smooth operation that is directed towards the performed goal. This requires a flexible system, efficient communication and resource gathering taking place at critical points. Resilience should avert a disaster or major disruption by recognising variations that occur out of the control range. These resilient characteristics are able to cope with severe pressures and conflicts between safety and the primary performance goals, by managing the activities of an organization to predict and avoid threats (Hale &
Heijer, 2006). Based on Woods and Hollnagel (2006), the term resilience refers to a system that utilizes the potential abilities of its resources including engineered characteristics and highly adaptive abilities in a controlled manner in various situations, but it should not be used to describe for human uncontrolled behaviour. Fujita (2006) explains that service providers who are located at the front end, such as nurses, doctors and maintenance people, are inherently proactive and adaptive. These abilities allow them to accomplish good outcomes in unexpected events. However, human characteristics may sometimes bring bad outcomes. McColl-Kennedy and Sparks (2003) claim that negative emotions, such as anger, affect not only co-workers but also customers. According to Woods and Hollnagel (2006), resilience is especially concerned with understanding how well the system adapts and to what range or sources of variations. Resilience engineering aims to support for the cognitive processes of reconstructing an organization’s standard. Developing indicators and measures of contributors to resilience maintains an organization’s safety. They also state that the features of flexibility, buffers, instability, and tolerance and patterns of interactions across scales, such as responsibility and authority, are examples of resilience engineering. Fujita (2006) stated that the above abilities assist a system to be robust, so features are required to make a system resilient.

3.5.2 Sensitivity analysis

Any organization can face the changes on a daily basis. For example, a hospital environment is challenged by has been challenged by varying demands, need for equipment replacement, and managing employee illness, absentee, etc. The decision maker can tolerate the changes by using information which can be supplied by sensitivity analysis. Sensitivity analysis is used when analyses the change of variables by emphasizing on the possible uncertainties surrounding the outputs. As the results of analysis, decision-makers can preview the consequence and the actions can be planned in advance. However, finding correct information and right amount of information is a significant challenge. Otherwise, this approach can be time consuming for decision-makers to find deliberated solution (Rae, Rothley & Dragicevic, 2007). Sensitivity analysis application in linear programming provides information about sensitive parameters which can assist the management decision maker respond to the change (Hillier & Lieberman, 1974, p.24). Sensitivity analysis concerns different scenarios over the ranges of factors which are constraints of linear programming. The system robustness can be designed based on mathematical statistical records. One way to find it is to look at historical demand. This can be determined by obtaining and applying the information about the inventory level that need to be managed. Standard deviation (σ) of demand in the planning timeline and confidential level (CL) influence the decision making for system robustness design. It is important to maintain the flexibility of service facilities for sustain the system. In addition, resilience plays a major role when a system is out of order.

![Figure 1: Distribution of service demand](image)

To have a flexible system, a management needs to support its operational system by not having too much and not running out of materials and facilities. The desired level balances demand and supply in an unstable situation. That is why inventories are essential. In particular, an inventory system maintains adequate a stock. Whilst inventories are important, too many can increase the business operational cost.

The buffer stock is given by \( n \sigma_n \), where \( \sigma_n \) is the standard deviation and \( n \) is the safety factor (Buffa & Sarin, 1987, p.119). In a hospital operational service with a labour intensive system, resources calculations are required to establish the facilities need to take into account the uncertainties of both the patient mix demand and urgent circumstance. In this case, the service buffer is given by \( Z \sigma_d \), where \( \sigma_d \) is the standard deviation of daily demand and \( Z \) is the safety factor for the desire confidence level (CL).

![Figure 2: Sensitivity analysis of hospital service system](image)
3.6 Operational Costs

Operational costs can be either fixed or variable. A fixed operational cost is not a decision variable, for example the payroll of an operations manager. A variable cost is a decision variable, for example payroll, overtime, second shifts, outsourcing, hiring and laying-off, excess inventory and backlog, and inconsistency of service rates. Buffa and Sarin (1987) describe how the behaviour of cost, with respect to changes in decision variables, is not easy to quantify. Often, cost approximations are made by assuming the costs to be linear or quadratic functions of the appropriate decision variables. These assumptions can be used to create simple models, such as linear programming, to determine the minimum cost for planning.

3.6.1 Economy of Scale

Higher productivity can lower operational costs. However, variable outcomes do not affect fixed costs. Utilizing resources associated with fixed costs is improved by increasing units of output and spreading fixed costs across individual units. More units of output spread the fixed costs responsibility resulting in a lower unit cost. The operational environment of more outcomes with less cost is called economies of scale. From an economic perspective, cost changes with an increase of output and input numbers. The model of economies of scale can identify organizational size. At some stage, an organization’s management team forces operational/manufacturing processes to increase their outputs to a stage where the costs actually increase. At this stage the firm has gone beyond an optimal volume, so their high outcomes cause higher costs; this is called diseconomies of scale (Buffa & Sarin, 1987).

3.6.2 Hospital Costs

The basic unit of capacity is the hospital bed, and bed occupancy level is a variable figure which needs to be managed. The level of bed occupancy influences how revenue flows through the wide-range of healthcare services of a hospital. Hospital resource utilization and hospital service revenue depends on the demands of the patient mix variety. The demand on other hospital services, such as outpatient service, laboratories and X-rays, then flows from the variety of patients. The demand on hospital services is highly variable in nature, so therefore it is hard to maximize the bed occupancy levels, for example emergency demand must be served and service facilities must be available. Emergency cases arrive on a random basis. This creates a problem for scheduling. Therefore as a result, the patient mix scheduling and the flow of patient variety arrivals must be considered. Patient flow can be effectively managed for scheduled patients for example patients of an internal medicine clinic who are required to have regular appointments at the hospital.

A major challenge for a hospital service operation is the cost of service incurred when the demand increases. Insufficient services may impact on a patient’s well-being when the hospital allows the patients to wait for service. The two primary considerations, for service capacity plan decision making, are waiting time before being served and service cost. This means a total operational cost model, which includes the cost of waiting and the cost of service, must be developed. Reasonable estimates of the waiting costs and the service costs need to be obtained to create this model. Of these two costs, the waiting cost is usually the more difficult to evaluate. In the waiting line, the cost of waiting would be the cost per unit of time for a customer waiting for a service. This cost is not a direct cost to the hospital, but if the hospital ignores the cost of waiting and allows a long wait, customers ultimately will take their business elsewhere. Thus, the business of the hospital will experience loss from selling its service. Therefore service cost relies on the hospital service facilities in the service process. Figure 3 illustrates a hospital’s operational cost curve. With more patients, the service resource utilization is better and as a result the service cost per patient decreases from point A to point B. The optimum point is at point B, where the operational cost is at the minimum and the utilization of facilities is at the maximum level. As the number of patients continues to increase beyond the maximum utilization of facilities, waiting time is incurred. The waiting time increases when the arrival rate increases, but the service rate is constant. This situation forces the operational cost from the optimum point B into diseconomies of scale up to point C. The cost curve maintains the same level of service quality until point B.
where the total operational cost is at its minimum and after point B operational cost increases as does the cost of waiting for the service facilities.

It is obvious from the cost curve (Figure 3) that service cost and waiting time before being served create conflicting pressures on the decision maker. Maximizing the utilization of hospital facilities can reduce service cost per patient. With a small number of patients, providers are better able to engage in high service quality. On the other hand, long waiting times are undesirable and incur a high level of waiting cost. Therefore to reduce service cost, it is necessary to strive for full facility utilization which results in a decrease in service cost. The position on the cost curve indicates whether a decision needs to be made on service facilities.

The hospital operational cost in a mathematical statement, where waiting cost is denoted as WC, SC refers to the service cost and TC is the total operational cost which aims to be minimized, would be to:

\[
\text{Minimize } TC = SC + WC
\]

Table 1: Patients who visit the diabetes clinic held in Internal Medicine.

<table>
<thead>
<tr>
<th>Type of patient (AP)</th>
<th>Category</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appointment</td>
<td>On-time</td>
<td>first</td>
</tr>
<tr>
<td></td>
<td>Internal-referred</td>
<td>first</td>
</tr>
<tr>
<td></td>
<td>Late</td>
<td>last</td>
</tr>
<tr>
<td>No-appointment (no AP)</td>
<td>No-show</td>
<td>last</td>
</tr>
<tr>
<td></td>
<td>External-referred</td>
<td>last</td>
</tr>
</tbody>
</table>

The hospital operational cost in a mathematical statement, where waiting cost is denoted as WC, SC refers to the service cost and TC is the total operational cost which aims to be minimized, would be to:

\[
\text{Minimize } TC = SC + WC
\]

**4. PATIENT FLOW**

The first stage of our study was a pilot exercise that focused on a medium-sized hospital. Its purpose was to identify essential elements of a model of the operations of outpatient servicing. The study covered, inter alia, patient flow, work activity and information flow at workstations, service time, material flow, such as specimens and documentation. It required an examination of each workstation’s physical layout and equipment, staffing levels, job descriptions, task analyses and service demands. Service demand is a critical constraint, as the hospital is compelled to treat anyone who seeks medical treatment. This includes information behaviour, the context in which the service providers work, and the reasons for their actions. It encompasses why and how they collaborate through the series of treatment phases in managing the health of patients. Within an Internal Medicine clinic of an outpatients department, patients fit two major categories—with or without an appointment—and subcategories as shown in Table 1.

The services are delivered to patients through direct and indirect interaction. For example at the Internal Medicine clinic, patients meet staff face-to-face when
patients attend the service activities. The seven direct service activities include welfare checking; registering; weight measuring; blood pressure measuring; nurse interview; doctor examine; and dispatch where patients pick up medicine. At indirect servicing, staff who perform the service activities, such as typing prescription orders, labelling medicine envelopes, collecting medicines, and inspecting medicines work without having patient contact. Figure 4 shows the order of service steps of an IM clinic of the medium sized hospital.

The activities for Internal Medicine are presented in the flow diagram shown in Figure 5. It includes information flow, patient flow, and flow of staff. The overall picture of the Internal Medicine sub-department such as number of staff, location of service stations and layout is also presented. Figure 5 shows by way of example, the places of interaction (i.e., service steps) between outpatient and hospital personnel, the flow of staff and the locations of services.

Figure 5: The flow diagram within Internal Medicine at the medium sized hospital.

Figure 6: OPD comparison of the seven hospitals in three different sizes.
For the second stage, the study explored the elements of the service process which provides for outpatient at an Internal Medicine clinic of the medium sized hospital and the understanding of the application of the elements that have been in the hospital are the path for scaling the outpatient service process. This stage has included seven hospitals. The evidence from this exploration analysis supports the model scaling. The study has explored Internal Medicine clinics of OPDs in seven hospitals. These seven hospitals are categorized in three different sizes as presented in Figure 6. Four hospitals are medium sized (M), two are medium-large sized (ML), and one is large sized (L). The operational processes and service patterns for treating outpatients at seven hospitals were observed.

Table 2: Hospital details

<table>
<thead>
<tr>
<th>Hospital Size</th>
<th>Medium</th>
<th>Medium-large</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
</tr>
<tr>
<td>No. of Bed</td>
<td>440</td>
<td>320</td>
<td>300</td>
</tr>
<tr>
<td>Location</td>
<td>All hospitals are located in the middle part of Thailand</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7: The activities of seven hospitals in the service pattern.

Figure 8: The service pattern of seven hospitals.

Based on Table 2, size is identified by the number of beds provided for inpatients, which is indicative of overall resources, funding and public visibility. The objective was the revelation of the defining characteristics of various sized hospitals by exploring, more broadly, the elements of the model using the first stage of this pilot study in an Internal Medicine clinic. Process flow analysis identified
the steps for mapping the value stream of tasks. An analysis of the seven outpatients departments identifies a shared service pattern for outpatients as shown in Figure 7. The activities in the service pattern are all the same, but the processes within individual department are different in each hospital studied. It is evident that the medium-large sized and the large-sized hospitals have empowered the outpatients department by setting up work cells within one area, based on cellular manufacturing.

The five steps within internal medicine that are directly connected to the serving of patients are: checking patient welfare, registration, measuring weight and blood pressure, interviewing by a nurse, examining by a doctor, and dispatching medicine. Seven hospitals have the same pattern of service steps as presented in Figure 8.

The results of the pilot study indicate that there is much opportunity for improvement in patient flow, especially reduction in waiting time. The application of techniques from lean manufacturing may allow hospital to serve more patients through productivity improvement. However, applying lean concepts may be to the detriment of patient welfare. Reducing service times may result in more errors in diagnosis and treatment. Patients may take longer to recover and, consequently, placing workload demands on the hospital over a longer period. Staff, pushed to work faster, may become dissatisfied and disaffected. The various tools applied can support the understanding of the service process for internal medicine for three different sized hospitals. The five steps within Internal Medicine that are directly connected to the serving of patients are: checking patient welfare, registration, measuring weight and blood pressure, interviewing by a nurse, examining by a doctor, and dispatching medicine. Seven hospitals have the same pattern of service steps. Pathology testing is excluded for the following reasons. Firstly, it does not apply to all patients. For instance, patients suffering hypertension do not routinely undergo pathology testing, whereas all diabetics do. Secondly, a doctor must have results from pathology before examining a patient. So that results are available when doctors start to examine patients, registration of patients and pathology testing commence early in the morning. Finally, pathology is a service external to the outpatients department.

6. HOSPITAL SCALABILITY

Further data from seven hospitals included the three hospitals from pilot study is collected in order to establish scalability. The final stage of our research is the development of a model or models by using the analytical tools from industrial engineering and, in particular, lean operations. Developments of a model depends on us identifying the functions of personnel and the possibility for reallocation of tasks—for example, from medical consultant to triage nurse—so the hospital can become more responsive to the needs of outpatients. Obstacles to patient flow may be reduced, by applying a model that includes human aspects of planning and control of outpatient services. Human-centred planning is essential for the operational improvement of hospitals.

The extent of the hospital scalability aims to meet the objective as the basis to guide hospitals to create a model for their growth. The analysis of the hospital scalability is divided into 5 tiers including factor, parameter, method, decision, and plan. For the scalability, hospitals need to consider departments of the entire hospital which involve in patient service process. The analysis brings together factors of departments. From factors, parameters are used to identify the contribution of individual factors to the process. Factors may correlate to parameters, which some factors may relate to all aspects of parameters.

Practical decision making in hospitals is a highly sophisticated process especially when planning to improve future operational systems. Operations planning problems focus on a minimum patient flow time, a maximum service capability of staff and facilities, a maximum service system robustness, and a minimum operational service cost.

6.1 Hospital Scalability Optimization

In the hospital service process, queuing-type situations that discourage patient flow time arise in a wide variety of contexts. Therefore it is not possible to use only one decision-making methodology because of the mixed patient demand situations. A hospital offers service capability through its staff and facilities. Vastly fluctuating employment could severely diminish this capability. An important part of a service operation and its impact on the staffing environment is the recognition of the wide fluctuations in individual patient demand and demand quantity. Staff and task allocation need to meet the desired level of resource utilization. A decision concerning the size of staff, as well as the allocation of facilities and the cooperation of shared resources, directly effects the flexibility of a service process. To optimize flow time, resource utilization (staff, facilities, and space), robustness and service cost, decisions about each of these areas need to be made at the appropriate level of the hospital service process. For example, a decision on purchasing equipment not only needs to consider the efficiency of the equipment including size and capacity, but also space management, such as location and space availability. Before the decision is made for the purchase of the additional equipment, various measures for optimal scalability are required. The four optimum areas for scalability include maximum robustness, minimum flow time, maximum resources.
utilization, and minimum service cost. An integration of the four areas for optimal scalability should provide decision-makers with sufficient information for them to understand the entire service operational environment. The appropriate level of utilization at the desired level of robustness at an acceptable flow time needs to be measured. However, decision-makers should be aware of service cost. The service operational cost may not be at the minimum cost to achieve the appropriate level of utilization at the desired level of robustness.

A variety of relationships constitute the components for hospitals scalability. Figure 9 represents the optimal scalability, which identifies any given set of decision variables for scalability. The result is then used to support an organization’s plan, which is in turn compared with a cumulative saving for the next investment term.

In the graph (Figure 10), the demand for the hospital service utilities is presented. The entire service process for the time of the planning horizon is taking the full capacity of the resources. Because the point for the operational cost is the decision variables, a new facility is placed to allow the flexibility in the service process. The robustness level is returned to the beginning level at the starting point. In this circumstance, the demand for the facility (staff and/or medical equipment) at point 1 triggers the call for the investment planning decision.

Comparing the investment lead time of the three periods; investment 1 (point 0-1), investment 2 (point 1-2), and
investment 3 (point 2-3), There are comparative differences in robustness, investment period between facility ordering at point 1, point 2, and point 3.

For investment 1, resources have been utilized to the maximum level at point 1, which provides the operational cost of the hospital to operate at minimum. The decision maker may decide to expand the resources in the organization at this stage. Otherwise, if the hospital plan to invest when the resource utilization come to point 2, then the operational cost is become higher than the operational cost at point 1. Even though, the hospital has the time span longer for an investment 2 than an investment 1. However, there is less for robustness for investment 2 because the resources have been utilized more than an investment 1. At point 3, resources have been over utilized which result to the service activities to operate at the lowest robustness. The decision point at point 2 and point 3 is beyond the economy of scale which makes the operational cost is higher at point 2 and is highest at point 3. The decision point is basically depended on the decision-maker which may consider the investment period. The hospital may not be ready to extend the service resources in the short investment period as investment 1. The decision-maker may consider the longest investment period which is the investment 3.

6.2 Scope of Scalability

The extent of the hospital scalability aims to meet the objective as the basis to guide hospitals to create a model for their growth. The analysis of the hospital scalability is divided into five tiers: factor, parameter, method, decision, and plan. For the scalability, hospitals need to consider departments of the entire hospital which involve in patient service process. The analysis brings together factors of departments. From factors, parameters are used to identify the contribution of individual factors to the process. Factors may correlate to parameters, which some factors may relate to all aspects of parameters.

First tier: concerns factors that contribute significantly to the hospital service process. They include input materials, equipment/machine, people and capital. The concerned factors are considered as resources for being an important role for the hospital growth.

Second tier: identifies parameters that characterise the factors’ contribution for the hospital service process. Parameters include time variance, service capacity, resource utilization, space management, robustness, and operational cost. Each parameter demonstrates the process attribute that the factors need to be considered in order to present the ability of the existing service process.

Third tier: are methods that include time analysis, line balancing, economy of scale, facility design, sensitivity analysis, and process analysis is the achieved data for parameter. Identified data is used for supporting the decision in the later tier. Exploring individual parameter provides a better process understanding.

Fourth tier: involves decisions relating to team discipline, job/task allocation, resource allocation, investment period, networking alliance, and service capacity. The decision may be based on the optimal scalability which is the result from compromising the four optimum areas: minimum flow time, maximum utilization, maximum robustness, and minimum cost.

Fifth tier: concerns planning including floor plan, skill plan, resource plan, and capital plan. This tier includes management procedure plan for resilience, CRM, scheduling, and network cooperation

7. CONCLUSION

The hospital scalability is introduced for guiding hospitals which the study is based on the hospitals in Thailand. This study provides basic operational factors considered for small hospitals that plan to enlarge their capacity. The hospitals directly participating in this study may be able to use the results as a basis for studying how to improve their outpatient operational processes.

8. FURTHER STUDY

The outcome of the further study will be a planning model for reorganising outpatients departments. The model will be implemented at a small sized hospital for validating the model application. This result may act as an exemplar for the design and development of hospitals across Thailand.

REFERENCES


**AUTHOR BIOGRAPHIES**

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