A FEASIBILITY STUDY OF CENTRALIZATION OF INTENSIVE CARE UNITS

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ABSTRACT

Centralization of Intensive Care Units (ICU) is a concept that has been around for about decades and the OECD countries have led the way in adopting this. Singapore Hospital which was built in 1981, before the concept of centralization of ICUs took off, recognizes the importance of having a centralized ICU to better handle major disasters. Using simulation models, this paper attempts to study the feasibility of centralization of ICUs in a Singaporean hospital, subject to space constraints.

INTRODUCTION

From the beginning of organized nursing care, it was recognized that nurses were able to provide the best nursing care if the sickest patients were placed closest to the nursing stations, often with a higher nurses/patients ratio for these patients. However, a large number of studies conducted at individual hospitals worldwide indicate high cost of intensive care. The present Singapore Hospital was built in 1981, with modern facilities to cater to a rapidly modernizing country. The ICUs which formed an integral part of the hospital have evolved through the years and currently boast of a total of 55 beds for adult care and 8 beds for pediatrics. The adult ICUs are divided into 6 different departments: surgical, cardio thorax, care unit, neurology, cardiac care, burns, and medical care units. Centralization of the ICUs will benefit patients in the day to day operations of the hospital in the same way as how it will benefit casualties suffering from disasters. The reduction of transit time for these patients may prove crucial in their chances to survive. Centralization plans are hampered by a variety of constraints such as space, costs and staffing. Cost of relocating the ICUs in a centralized location may prove to be hefty, but the Hospital can look to it as an investment to upgrade facilities and capabilities. In terms of staffing, it is severely understaffed and is looking to hire more hands. Using simulation models, this feasibility study of centralization of ICUs has been accomplished to determine the optimum number of ICUs required for daily operations and the possibility to fit the optimum number of ICUs into the proposed area of centralization.

The structure and organization of intensive care units are diverse and vary between countries. Pollark et al [3] described the structure of American ICUs. The number of ICUs per hospital increases with hospital size. Depasse et al [1] evaluated major similarities and major differences between Western European countries in ICU nurse staffing, education, training, responsibilities and initiative. Their findings reveal variations in nurse staffing patterns among European countries and in their systems of training and education. Further, Goh and Mok [2] discussed that the physicians at local hospitals in UK were able to maintain assessment skills in recognition and requesting for transfer of the most ill and efficiently utilized resources available at the regional centre. Managing ICUs is a difficult task, because individual units are highly complex.

MODELING OF THE INTENSIVE CARE UNITS

ARENA 7.0 which is a simulation-based software tool for evaluating, planning or re-designing hospitals is used to model the process flow and breakdowns in the process when it happens. Before a model for the ICUs can be developed, a general work flow chart is provided to illustrate the entities, resources and locations involved. ICU patients are admitted into the ICU from various channels. Most are admitted after a serious operation such as multiple bypass surgery to monitor their progress, while others can be admitted through Accident and Emergency department due to heart attacks. Some may be transferred from other ICUs or normal wards due to deterioration of conditions. The entry of patients into the ICUs is modeled after the general admission of patients into the ICUs as a guide to how many beds are being occupied throughout the year.

The *Create Module* in the Basic Process panel is used to simulate the admission of patients into the hospital. The entities per arrival are set to one patient per arrival. The maximum number of arrivals is set to infinity as the assumption that the hospital does not refuse admission to patients is being made. The modeling of the patients being admitted into the different ICUs is done by using the *Decide Module* which utilizes the N-way by chance which is the ratio of patients admitted to the different ICUs. Here the patients are routed to the different ICUs which simulate the length of stay of each patient based on the statistical input in the *Process Module*. The *Decide Module* includes options to make decisions based on one or more conditions or based on one or more probabilities. Conditions can be based on attribute values, variable values, the entity type, or an expression. Here we chose N-way by chance, using the ratio derived from the statistics supplied by the Hospital. The *Resource* represents the various ICU departments as shown in Table 1. The capacity of the resource is fixed according to the number of beds each ICU department has. Several important assumptions were made before developing the simulation model. One assumption was that patients stay in the same ICU department as a very small percentage of patients are moved around from one ICU to another. The other assumption was machine down times were zero as these were covered by similar machines from another ICU. This is possible as most ICUs employ similar setup.

TABLE 1: Representation of Resources

Resource Name	Representation
Resource 1	Neuro ICU
Resource 2	Medical ICU
Resource 3	Burns ICU
Resource 4	Surgical ICU
Resource 5	Cardiac Care Unit (CCU)
Resource 6	Cardio Thorax ICU

RESULTS

The results shown are a collection from 10 replications over a period of 365 days. An average total of 342 patients were admitted into the ICUs while a total 336 were discharged within the same period of time. The average number of days a patient stays in an ICU, would be 6.1873 days. In comparison to the actual figures obtained from the Hospital, a total of 388 patients were admitted into ICUs in the year of 2003. Table 2 depicts the actual and simulated values of average bed usage per month and the recommended number of beds in accordance with the 70% occupancy rate as prescribed by most Intensive Care Societies. A discrepancy is found between the actual value and the simulated results and this may be due to difference in time duration. However, this is within the tolerance limit for the validation of simulation models.

The centralization process starts with identifying the auxiliary rooms required to compliment the normal operations of the ICUs. Recommendations made here are based on the concept of having clusters of ICUs within the proposed site instead of having one single area housing all the beds. The design factors considered for setting up a centralized ICU are: site selection, size of the ICU, patient area, central station, storage room, soiled and clean utility rooms, staff room and doctor's on-call room. The proposed size of an ICU cluster would be that with 8 beds and 3 to 4 auxiliary rooms. These clusters would be spread out over the proposed area. Each cluster would take up an area of 23.6 meters by 21.6 meters. Each ICU will be 5m by 5m and the auxiliary rooms will be set to a standard 4m by 4m. It was earlier proposed that all existing resources be torn down and cleared to make space for a whole new ICU centre. However, this would greatly affect the ICU capabilities of the Hospital as it would mean the tearing down of the CTICU and SICU. This will effect a 27 ICU bed reduction for the hospital, which is totally unacceptable.

TABLE 2: Average Bed Usage and Number of Beds Recommended

ICU type	**Simulated Average** (Yearly Basis)	**Actual Average** (Monthly Basis)	**Average No. Of Beds** Recommended	**Actual (Existing No. of Beds)**
Burns	0.595	0.604	4	4
CCU	4.18	5.48	5	8
CTICU	8.759	8.772	9	17
MICU	3.854	2.652	4	8
Neuro	4.458	6.312	5	8
SICU	4.914	5.69	5	10
		TOTAL	32	55
		Recommended	**46**	-

After close examination of the floor plan and the optimum number of rooms, this study suggests that the hospital keep its CTICU and SICU, together with its auxiliary facilities. The optimum number of ICU beds is 46. Keeping the 27 beds of SICU and CTICU means a total of 19 new beds need to be created to meet 46 beds. The available floor space for these 19 beds is about $1157m^2$. The proposed area for a cluster is $510m^2$. The available floor space is more than that required of 2 clusters. The additional 3 beds to the 2 clusters of 8 beds would have to share a space of $136m^2$. This is definitely adequate as the ICU bed room size is $20m^2$.

CONCLUSION

This study has successfully met the objectives of proposing a solution to the centralization of ICUs. A simulation model of patients' admission was developed to predict the flow of patients into the ICUs and the occupancy rates of the ICUs. The recommendation of having clusters of ICUs is an original idea that was proposed after deliberating through the different models for a layout of an ICU. The clusters were a necessity as the primary goal of the ICU is to provide a low patient to nurse ratio where the nurses are able to monitor the patients physically. Lastly, this is not the perfect solution as many of the auxiliary facilities are not within recommended distances because of space constraints. However, those that are more crucial to the operation of an ICU have all been sited around the ICUs to minimize the disruption to operations.