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A novel client service quality measuring model and an eHealthcare mitigating approach

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ABSTRACT

Objectives: Facing population ageing in Hong Kong, the demand of long-term elderly health care services is increasing. The challenge is to support a good quality service under the constraints faced by recent shortage of nursing and care services professionals without redesigning the work flow operated in the existing elderly health care industries.
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1) Developing a model for measuring Total Quality of Services,
2) Using the Total Quality of Services measure to assess staffing conditions, i.e. shortage or surplus, and to measure the effectives of catering new services,
3) Incorporating Information and Communication Technologies (ICT) to mitigate the staff shortage problems and to enhance efficiency of care,
4) Utilizing the Total Quality of Services measure to quantify the improvement and providing an indicator for services assessment in future.

Methods:

1. Model Development
   We use Finite Capacity Queuing Model to develop a model for Total Quality of Services and use the balk rate of the model to set up an efficiency rate. We then assume multiple independent queues existed in the model and calculate the accumulated efficiency rates to give The Total Quality of Services measure.
2. Model Simulation
   We conduct simulation on the model and check for its validity.
3. ICT Solutions
   To keep up a desired quality service, we developed a "Residents Clinical Service Monitoring and Quality Control System" to test the appropriateness of the model. We designed the system to (i) make sure that clinical nursing care staff will run the nursing care protocol; (ii) cut substantially manual operation cost and possible human errors; (iii) give exception alerts for caring rules; (iv) promote efficient communication between staff and cost saving.
4. Field Trials
   We carried out field trials for over 2 years and enhanced the system periodically.

Results: The Total QoS measure based on Finite Capacity Queuing Model is a reliable method and an effective measurement for Quality of services. The value is good for measuring the staffing level and offers a measurement for efficiency enhancement when incorporate new technologies like ICT.
The implemented system has improved the Quality of Service by more than 14% and the extra released manpower resource will allow clinical care provider to offer further value added services without actually increasing head count.
Conclusions: We have developed a novel Quality of Service measurement for Clinical Care services based on multi-queue using finite capacity queue model M/M/c/K/n and the measurement is useful for estimating the shortage of staff resource in a caring institution. It is essential for future integration with the

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existing widely used assessment model to develop reliable measuring limits which allow an effective measurement of public fund used in health care industries.

1. Introduction

According to the Hong Kong Population Project 2012–2041 report [1] published by Hong Kong Census and Statistics Department, the Dementia in elder article by Yu et al. [2] and Demographic changes article by Yip et al. [3], the age distribution of the Hong Kong's population will change dramatically in the next ten years. These changes will continue in the coming decades and the size and some aged population ≥65 and especially the oldest ≥80 will increase. From [1], the percentage of people ≥65 years of age will double from its current 1.0 Million (14%) to 1.67 Million (22%) in 2024 and to 2.18 Million (28%) in 2034. The working population (age from 20 to 65) will also expect to drop from its current 5.2 Million (74%) to 5.08 Million (67%) in 2024 and to 5.21 Million (63%) in 2034. It is interesting to note that population is getting older while the working population is shrinking. This prediction is in line with the world projection [4–6] in most developed countries where ageing population will be in the range of 22% in Switzerland to 28% in Japan.

Facing population ageing and nurse shortage, undoubtedly, the demand of C&A Homes (Care and Attention Homes) service will be gradually increased. To balance resource allocation and C&A Homes service quality, it is a great chance to make use of Knowledge Engineering intelligence to maximize the efficiency of the service system. With the challenges of manpower shortage, resource limitation and rental increase, the current practices predominantly limited by the manual operations needs to change and shall merge the latest Information and Communications Technologies (ICT) [7,8] to keep operations more effective. The decision to change from manual operations to ICT is rather difficult to make because there is no quantitative way to measure the service quality. Creemers and Lambrecht [9] adopted queuing networks to study service quality in Hospitals by using a complicated hospital model consisting of 12 G/G/1 (for six surgeons) with 3 G/G/m queues (for the recovery wards) composing Intensive Care Unit (ICU), Surgery Sessions and Recovery Wards. This complicated model is not suitable for modeling C&A Homes services. This paper will first formulate a simplified queuing model and derive a Total Quality of Service (Q_{S_T}) for measuring C&A Homes quality level.

This model can also be used to test the effectiveness of the adoption of ICT technologies to mitigate the challenges. However, the existing healthcare solutions [10–12] restricted by managing the stakeholders access of health care historical data including staff, clients/patients and client's/patient's families will not able to give more intelligent real thyme clinical decision support or emergency handling to cut the risk of untimely actions. Although some systems in-built with alert functions [13,14] have been proposed, they were more clinical specific and would not be suitable for general C&A Homes applications.

C&A Homes operations are flow complicated, operator explicit and region specific. When adopting ICT technologies, if the real work-flow is not redesigned and implemented to cater for culture diversity, management focus and assessment requirements, it is theoretical possible and technically unworkable for solving the C&A Homes challenges in their daily operations. Redesign of daily work flow [7] will face resistance even with incentives from the nurse and caring staff as they have to adopt new work flows which are substantially different from their early training and normal daily practice.

In order to maintain or offer better quality service, based on a medium size C&A Homes in Hong Kong, we have developed a "Residents Clinical Service Monitoring and Quality Control System" embraced with the necessary intelligence and ICT engineering's innovation. The system composed of five ICT subsystem modules, namely Centralized Monitoring & Alert Module, Vital Sign Data Capture Module, Attendance Recording Module, and Body Chart Tools Module, to improve the caring services efficiency. We will compare their effectiveness using the Total Quality of Service measure derived from the proposed M/M/c/K queuing model. The proposed system was evaluated and compared using a queue composing 8 nurses, 35 caring staffs and 5 helpers serving over 200 in-patients under a traditional manual and an ICT incorporated environment. Over 14% staff resources enhancement was resulted using ICT compared with a 6% deficient in a manual operated environment which means a release of 8% staff resource for other tasks or duties.

2. Material and methods

To measure the Quality of Service in ICT or health care, most people adopted subjective approach [15], decision approach [16] or Quality of Services in telecommunications approach [17]. Algaet et al. [15] used Quality of service (QoS) to find the ability to send the client's needs (constraints) with the best criteria (preferences) established by the client and they calculated non-functional characteristics of the service, Telemedicine and relates medical technologies and the subjective approach is to give effective medical care remotely based on criteria/constraints. Oddershede et al. [16] used a scientific multiple criteria decision method AHP (Analytic Hierarchy Process) for identifying high-priority requirements of an ICT system in health related activities and this approach allowed elaborating a profile and characterization of the ICT support requirements in healthcare service. The use of decision approach based on AHP modelling and empirical evaluation permits to capture human perspective and allowed designing profiles characterization that would help to configure network traffic and different scenarios for simulating and evaluating network behavior. Kang et al. [17] proposed a wireless system for remote cardiograph in which FEC-based error control with interleaving in the data-link layer can meet reliability. Their approach can predict the behavior of the wireless system for real-time remote ECG monitoring in terms of key QoS metrics and this telecommunication approach is for measuring the traffic characteristics and connectivity requirements of ECG applications.

The above three approaches would not be able to offer a quality measure for comparing quality services levels differs and providing indications for improvements which hinders interpretation and comparison of findings between models in the C&A Homes quality services area. Although Creemers and Lambrecht [9] built a model for Belgian Hospital, it cannot be applied in Hong Kong because their work flow in a Hospital is complete differently from a C&A Homes in Hong Kong and their model do not give a quantitative measure for direct comparison.

We use a simplified queuing model [18,19] to build a quality measure to analyze the quality of C&A Homes services. This is bench marked by using the effectiveness of ratio staff policies to model a care unit as a closed multi-server queuing system [20].