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An Overview of Nurses Workload Measurement Systems and Workload Balance

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Abstract. Healthcare organizations need to overcome nurses' shortage issue by reviewing the current workload measurement system. Many workload measurement systems have been developed to meet patient care needs in specified areas. This paper provides an overview of the workload measurement systems and its application. A model to balance nurses' workload in Neonatal Intensive Care is discussed.

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1. Introduction

Issues in nursing workload measurement have been widely proposed, especially in western countries. A survey of 1500 registered nurses using Brooks' Quality Nursing Work Life suggested that nursing workload was too heavy and they have not enough time to carry out their job properly. Nurses not only had little energy left after work, they were also unable to balance their work and family lives, and the rotating schedules affected their lives in a negative way [2].

Nearly half of nurses plan to change their job within the next two years according to the survey from CareerBuilder.com (CareerBuilder.com is an online job site in U.S). The reasons given by the nurses are because their facilities are understaffed, contributing to high stress levels, compromised patient care, department overcrowding and closing of beds [16].

Tarnow-Mordi et al. [20] measured intensive care unit (ICU) workload per shift during each patient's stay for all admissions between 1992 and 1995 to see if hospital mortality is independently related to nursing requirement and other measures of workload, after adjustment for risk using APACHE II (Acute Physiology and Chronic Health Evaluation) equation. They concluded that hospital mortality may partly be explained by excess ICU workload such as inadequate numbers of nursing or medical staff, training, supervision, or equipment. In addition, a study in [12] measured staff's workload in Intermediate Care and found that increasing staffing levels in facilities with high injury rates and low staffing ratios can actually decrease injuries and time-loss rates.

The Canadian Nurses Association [3] defined nursing workload measurement system as a key component of any process to measure nursing resource intensity. The objective of a workload measurement system, as stated by the Nursing Professional Advisory Working Group of the Joint Policy and Planning Committee (JPPC) [14], is to provide the basis for expressing the volume of patient care activity of a service, in terms of a standardized unit of activity or productive personnel time. It is intended to reflect the nursing resources required to accomplish all tasks performed by nursing personnel in a given functional centre. This is measured and recorded as a unit of service. This paper will review some of the works on workload measurement system and discussed its application in balancing the workload of nurses.

2. Workload Measurement System

The workload measurement can be broadly categorized into two types: activity based and dependency based, as illustrated in [13] and [19]. The activity based measures characteristic of nursing care activities and assigns a time value for them. The strength of activity based systems lie in their ability to measure the tasks that nurses actually do in the course of their work. The major limitation of activity based systems is that they focus on care given and ignore the unmet needs of the patient.

Dependency based systems on the other hand, assign consumers to groups on the basis of “critical indicators”. These indicators are on a scale of one to four or five where each level denoting an increasing demand on nursing care time over a 24 hours period. Patient dependency tools, sometimes known as caseload-weighting tools, usually focus on tasks. Examples of tasks include the need for hygiene and physical care such as injections. Dependency based, however, can overlook the psychological care or the support needs of carers, which are important considerations in nursing care [6].

Dependency is often referred to as “classification”, thus Patient Classification System (PCS) is an example of dependency systems [6]. There are thousands of patient classification systems, and they are categorized as prototype or factor systems. The prototype system uses a description of characteristics typical to a patient, placing them in appropriate categories, whereas the factor classification system uses a list of critical indicators, treatments and descriptors of patient care given [15]. The Dutch Patient Classification System [8] that categorizes patients according to the type of care needed, the expected number of visits per week and the total length of the service provided is an example of a prototype system. While the neonatal acuity system [5] discussed in section 3 is an example of a factor classification system.

The PCS have been developed since the 1960’s and became the major method to measure patient needs and clinician involvements required to meet up with the needs. Although the PCS system uses many different methodologies to arrive at the groupings, the intent of this system is to group patients who consume similar resources [14].

Malloch and Conovaloff [9] described the growth of PCS as a four generational progression. The first generation PCSs developed before 1970’s, were intended to supply minimum staffing levels based on gross historical factors. These were calculated manually to estimate ratios (patients per nurses). In this

generation, the systems made only gross inequities between specialty areas and dealt with instabilities in workload by overstaffing.

During the 1980's researchers saw the introduction of care related to diagnostic groups. More emphasis was given to community care due to the increased use of computers, equipment and informatics. Relieving and agency staffs were employed to provide more adaptable responses to variations in workload. However, there was still little concentration on skill combination.

Technology and research increased significantly in the 1990's, and there was a move towards greater consumer and family participation. More sensitive patient classification systems were developed due to frequent pressures from the society. The challenge for this generation was to calculate nursing workload on a shift basis in a practical way, but to this point this has not been attained. Moreover, sorting of nursing skill level, which is elemental for a fully responsive patient classification system, has not been achieved.

In the fourth generation, the system's objective is to be able to use technology to forecast nursing care needs in real hours with a specific skill combination, and to create extensive statistical information for the organization. Speculation about fourth generation includes use of technology not presently available, for this reason system development is still fully focused on the requirements of third generation systems.

A classification system in the evaluation of a patient with chronic low back pain was described by [10]. The classification system was used to develop a supervision program for a 55-year-old patient with a medical diagnosis of lumbar spine and was instructed in symptom reducing strategies for positioning and functional movement. [4] gives an implementation of Patient Classification System while [1] focuses on redefining existing nursing resource measurements, with an eye towards contemporary issues such as severity measurement, productivity and clinical decision making.

Assorted standard measuring tools to measure nursing resource intensity have been discussed and can be used to predict overall nursing staff requirements in certain departments. However, research analysis performed over the years show that while workload measurement systems can assume to support the nurse managers in taking his/her verdicts, no tools have been shown to answer all queries regarding workforce management [18]. The viability of using an acuity system is weighed down with problems because acuity methodology does not include many of the activities involved with patient's actual care. For example, an elderly person diagnosed with pneumonia is allotted a specific number of care hours, but the same patient may need assistance with dressing, feeding, bathing and other activities that require supplementary care time in addition to the pneumonia care plan [7]. Moreover, many of the early workload data was also captured manually and was not linked to payroll data, patient registration data, or health records. The process for capturing workload manually was time consuming, susceptible to error and limited the use of workload data. As such, workload information was not shared with administrators or staff nurses and internal trends in workload were not routinely available. Workload data was also not compared across nursing units and comparative data across hospitals was not available [17].

Nevertheless, there are still advantages in using workload measurement tools to provide decisions to support proposals for nurses scheduling and as a basis for organizational and funding decisions. If the inputs are precise, a nursing

workload measurement system with restrictions can provide a tool to support nursing resource consumption decisions when used with quality data, other trending data and the qualitative reports of direct care nurses [2].

3. Model of Balancing Workload

PCS, patient census, staff turnover rate, patient acuity, and skill mix can be used collectively to develop a profile of the practice setting, to identify needed resources and to demonstrate the impact of workload on patient and nurses outcomes [17]. The model discussed in this section and obtained from [5] deals with the daily assignment of workload to staff nurses in an intensive care nursery that provides health care for critically ill infants. The objective of the model is to balance the nursing workloads with constraints by assigning an equal amount of patient acuity to all nurses in charged.

In using this model, a detailed neonatal acuity system was first developed. The neonatal acuity system consisted of fourteen modules. The acuity score for each module is calculated in the following manner. For example, in module 1, if a free flowing device is used to administer oxygen to an infant, and is assessed every two hours, then the acuity score of module 1 is twenty four hours divided by the frequency of the assessment, that is 24/2=12. The patients acuity score is then taken as the sum of the acuity score of each module. A statistical experiment was carried out to evaluate the inter-rater reliability of the acuity score by using a balanced randomized complete block design with patients treated as blocks.

The second task is to develop a mathematical model (integer linear program) that assigns patients to nurses subject to constraints with the assumption that the patient acuity score have been tabulated and the number of nurses is given. The mathematical model for the problem is as given below:

Minimize $\sum_{k=1}^{p}\left(Y_{k,\max} - Y_{k,\min}\right)$

Subject to

$$\sum_{j=1}^{m} x_{ij} = 1 \qquad i = 1...n \qquad (1)$$

$$\sum_{k=1}^{p} z_{jk} = 1 \qquad j = 1...m \qquad (2)$$

$$\left\{\sum_{i=1}^{n} s_{ik} C_i X_{ij} \le Y_{k,\max}\right\}\left(1 - u_j\right) \qquad j = 1...m, k = 1...p \qquad (3)$$

$$\left\{\sum_{i=1}^{n} s_{ik} C_i X_{ij} \ge Y_{k,\min}\right\}\left(1 - u_j\right) \qquad j = 1...m, k = 1...p \qquad (4)$$

$$\left\{\sum_{i=1}^{n} s_{ik} X_{ij} \le B_k Z_{jk}\right\}\left(1 - u_j\right) \qquad j = 1...m, k = 1...p \qquad (5)$$

$$\left\{1 \le \sum_{i=1}^{n} s_{ik} x_{ij} \le b_k z_{jk}\right\} u_j \qquad j = 1...m, k = 1...p \qquad (6)$$

$$\left\{\sum_{i=1}^{n} s_{ik} C_i X_{ij} \le a_k\right\} u_j \qquad j = 1...m, k = 1...p \qquad (7)$$

$$Y_{k,\max} \le A_k \qquad k = 1...p \qquad (8)$$

Variables

$$x_{ij} = \begin{cases} 1 & \text{if patient } i \text{ assigned nurse } j \\ 0 & \text{otherwise} \end{cases}$$

$$z_{ij} = \begin{cases} 1 & \text{if nurses } j \text{ assigned zone } k \\ 0 & \text{otherwise} \end{cases}$$

$Y_{k,\max}$ = *maximum assigned acuity of zone k*

$Y_{k,\min}$ = *minimum assigned acuity of zone k*

Parameters

$$s_{ik} = \begin{cases} 1 & \text{if patient } i \text{ is in zone } k \\ 0 & \text{otherwise} \end{cases}$$

$$u_j = \begin{cases} 1 & \text{if nurse } j \text{ is admit nurse} \\ 0 & \text{otherwise} \end{cases}$$

A_k = *specified upper bound on the total non admit acuity of zone k*

a_k = *specified upper bound on the total admit acuity of zone k*

B_k = *specified upper bound on the number of patients fort non admit nurses in zone k*

b_k = *specified upper bound on the number of patients for admit nurses in zone k*

C_i = *acuity of patient i*

The objective function minimizes the sum of ranges over all zones, thus balancing nurse workload. Constraint (1) assures that each patient is assigned to exactly one nurse, while (2) assures that each nurse is assigned to exactly one zone. Constraint (3) establishes $Y_{k,\max}$ as the maximum assigned acuity among non-admit nurses in zone k, while (4) establishes $Y_{k,\min}$ as the minimum. These two constraints interact with the objective function to minimize the range in zone k. Constraint (5) assures that a non-admit nurse is assigned no more than a specified number of patients, while (6) assures the same for admit nurses. It also guarantees that each admit nurse will be assigned at least one patient. This is necessary since admit nurse acuity is not included in the range computations, and thus it is possible that an admit nurse would receive no assignment. Constraint (7) assures that the total amount of acuity assigned to an admit nurse does not exceed a specified threshold, while (8) does the same for non-admit nurses. This model distributes the nurses among zones so that the optimal assignment of patients to nurses is possible. To simplify this problem, a zoned-based heuristic was developed. This heuristic used bin packing heuristic first fit decreasing (FFD) to assigns nurses to zones while the second step computes patient assignments within each zone.

4. Conclusion

To develop the best PCS, the system must recognize its unique patient population, be valid and reliable, go beyond measuring tasks, incorporate the caregiver's knowledge, support the facility's mission and vision, and lastly remain applicable to various types of patient care delivery models [11]. Workload measurement system that provided reliable data and information can support the clinicians in taking their decisions or actions for cost budgeting, scheduling, daily assignment, management and patient supervision program.

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