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Scheduling Of Nursing Staff in Hospitals – A Case Study

[1,]O.Vinod Kumar , [2,]B.V.Lakshmi , [3,]G.Ravindra Babu , [4,]T.Yugandher
[1,]Professor,Dept of Sci & Humanities, Dhruva Institute of Engineering & Technology.,Toopranpet, Greater Hyderabad,Telangana.
[2,]Assoc.Professor,Dept of Sci & Humanities, Dhruva Institute of Engineering & Technology.,Toopranpet, Greater Hyderabad,Telangana.
[3,]Professor,Dept of CSE., Avanthi Institute of Engg.& Tech., Greater Hyderabad,Telangana.
[4,]Assoc.Professor,Dept of Sci & Humanities, Guru Nanak Group of Institutions, Hyderabad,Telangana.

ABSTRACT: *In the face of national attention paid to rapidly escalating medical errors and patient safety, healthcare organizations have recently expanded different employee initiatives that promise to enhance healthcare quality management programs. The Institute of Medicine (IOM) reports suggest that 58 percent of the medical error-related Indian hospital deaths may have been prevented. The IOM reports recommend improvements in healthcare quality systems to resolve patient safety errors. Similarly, the insurance company consultant Health- Grades examined comprehensive data from 2000 to 2012 and concluded that about 195,000 deaths in Indian hospitals can be attributed to medical errors. Furthermore, errors inflate medical costs due to longer and more costly hospital stays. The Juran Institute has estimated the cost of poor quality as nearly a third of our direct medical expenses. By comparison, 14.9 percent of real Indian Gross Domestic Product was spent on healthcare in 2006, far beyond the expenditure for Germany, France, Italy, Britain, and Japan. Concern about the increasing worldwide number of high profile major errors raises the demand for cultural and structural change in healthcare systems. Some research demonstrates the psychological and systemic barriers that prevent learning from healthcare errors . In response to the troubling number of hospital errors, many healthcare organizations have undertaken initiatives targeted toward patient safety. In a longitudinal study of surgeons, the development of a patient safety data system identified several process improvement factors. Redesigning hospital processes for best practices based on competitive benchmarking has emerged as one of the most common approaches. Indeed, worldwide fervor for patient safety has promoted the successful application of a variety of quality management practices on a global scale.*

I. INTRODUCTION

There is increasing interest in the implementation of several different types of quality programs in healthcare. In a recent survey, healthcare CEOs expressed a 62% likelihood of launching a new quality initiative in the next year, as compared to 52% for manufacturing CEOs, 31% for education top administrators, and 35% for other service CEOs. For the various quality initiatives, those healthcare CEOs report actual use of each of the quality programs is 79% for Continuous Quality Improvement (CQI) and Total Quality Management (TQM), 8% for the Six Sigma System, and 7% for the Malcolm Baldrige National Quality Award (MBNQA) system. For the first winner of the Baldrige Award in the healthcare category, Sister Mary Jean Ryan, CEO of SSM Health Care, attributes CQI to the success of SSM. For healthcare quality management programs, employee commitment and control initiatives have become a major focus. Comparing U.S. health care workforce commitment from 2003 to 2004, there has been an increase from 91 to 97.6 percent, while commitment for the overall U.S. workforce has dropped from 99.7 to 97.6 percent. Employee commitment is critical to maintain quality program success when 40 percent of healthcare workers reported intentions to leave the field in the last few months. A study of healthcare employee commitment revealed key predictors are organizational support, job skill enrichment, quality control, and a culture of continuous learning. This study adopts the perspective of theory-driven empirical research as an approach to the theory building process

The idea that the metabolic syndrome results merely from interplay between an individual's emetic inheritance and dietary habits now appears to be an oversimplification. Epidemiologic findings showing that infants born small are prone to develop this syndrome have led to the 'thrifty phenotype' or 'fetal origins hypotheses, the 'predictive adaptation with subsequent mismatch between early and later environments hypothesis' and the 'developmental origins of disease hypothesis' (DOHAD). These closely related hypotheses have a common factor, the concept of critical windows [such as fetal, early neonatal and puberty periods] during which the individual is highly susceptible to 'programming' of adaptations for future stressful events.

A neo-Lamarckian concept has emerged, partially from observations in animals and more recently with the use of sophisticated molecular biological tools that supports nutritional and several other environmental stimuli being able to ‘program’ characteristics not only for the individual’s lifetime but also for subsequent generations. Expanding capacity, the number of beds in the unit, is not an option, as ICU care is an unusually expensive therapy. Reducing capacity is not an option either, as this would risk deserving patients being denied admission to the unit or released prematurely. Thus, the ICU administrator’s problem is how to better utilize the existing capacity so as to relieve what upon occasion is a bed shortage and better serve the patients without incurring additional cost. Patients, however, are only one of several constituencies to which the administrator is accountable, and the preferences of those constituencies in the prioritization process often conflict. One especially prominent conflict in our sample hospital is between the operating surgeons and the ICU physicians. This is a potential conflict in any hospital that has an ICU.

The basis for the conflict is that the surgeons must schedule elective surgeries and the operating theater well in advance, and assume there will be an empty bed in the ICU, whereas the ICU physicians set their admissions priorities based upon *all* the applicants’ needs. In this setting, the administrator often must deny admission to an elective-surgery _ES. patient, ex ante, thereby forcing the surgeon to cancel and reschedule the surgery, which can have several negative consequences. First, this can wreak havoc with both the surgeons’ schedules and those of the supporting staff, and waste the time of some highly skilled people. Second, the cancellations require changes in the operating theater’s schedule. Last, they can cause great psychological stress on patients, few of whom view their own surgeries as being ‘‘minor’’. To resolve the conflict, the surgeons have proposed reserving some ICU beds exclusively for ES patients. Though blatantly self-serving, this is not necessarily a bad idea. Indeed, some form of reservation strategy might be a very good idea that offers the administrator a way out of a very ticklish managerial situation. But lives rather than personal sensibilities are involved in the bed-reallocation process.

Therefore, in lieu of tinkering with the actual bed arrangements, we use a simulation model to explore the implications of a bed-reservation strategy. The model generates the data that are relevant to evaluating the effects of two specific forms of reservation strategy: a classic dependency unit _DICU. Attached to the surgery department, and a novel flexible bed allocation FBA scheme that reserves beds for ES patients. The strategies are evaluated on various performance criteria both for ICU patients as a group and for patients delineated by each of four distinct sources from which the unit receives its referrals. The model’s parameters are determined empirically from historical data. The unavoidable interaction between the different environmental compartments, lets humans to be the direct or indirect target of the pollution. In fact polluting agents follow a cycle starting and ending to humans. While it is very easy to break the biogeochemical cycles, any attempt to escape from the pollution circle results unsuccessful. In most of the cases, drug consumption is due [or at least is increased] to pathologies related to the environment pollution such as allergies and pulmonary diseases caused by polluted air, stomach diseases caused by polluted foods and so on. This paper presents a single-phase goal programming algorithm for scheduling nurses in one unit of the hospital. The goals represent the scheduling policies of the hospital and nurses preferences for weekends on and off. An application to one unit of hospital with 11 nurses resulted in satisfactory schedules. The computer time to solve the problem using a goal programming algorithm was very reasonable.

II. DATA OF THE PROBLEM

The zero-one goal programming heuristic procedure described above was used to schedule 11 nurses [7 full-time and 4 part-time] in one unit of the hospital for the day shift. The schedule, for a two-week period, should satisfy the following goals set by the management of hospital:

- All nursing staff members are scheduled for their contracted time.
- A minimum number of nurses each of classification **[Table 1]** are needed.
- A predetermined number of nurses **[Table 2]** are desired for patient care.
- All full-time nurses get at least one weekend off. If the weekend off with the constraint that no full-time nurse has three or more consecutive days off.

Table 1: Minimum And Desired Number of Nurses

Nurse type	Minimum nurses Needed	Desired no. of nurses
RN	1	3
LPN	1	2
NA	2	2

The data regarding the contracted days for all 11 nurses is shown in table2

Table 2: Contracted Time And Weekend Preference For Nurses

Nurse Number	Types of nurse	Contracted no. of days	Preferred Weekend
1	RN	10	2
2	RN	10	1
3	RN	8	1
4	LPN	6	2
5	LPN	10	1
6	NA	10	2
7	NA	10	2
8	NA	4	2
9	NA	10	1
10	NA	10	1
11	NA	2	2

III. ZERO-ONE GOAL PROGRAMMING PROGRAM

A zero-one programming can be written as follows:

$$\text{Min } z = \sum_{i=1}^{m} P_i (d_i^- + d_i^+) \qquad \text{---------} (1)$$

$$\text{Subject to } \sum_{j=1}^{n} a_{ij} x_j + d_i^- + d_i^+ = b_i \qquad \text{----------} (2)$$

$$x_j = 0 \text{ or } 1 \ \forall \qquad \text{------------} (.3)$$

$$d_j^-, d_i^+ \geq 0 \ \ \forall\ i \qquad \text{------------} (4)$$

$$d_j^-, d_i^+ = 0 \ \ \forall\ i \qquad \text{------------} (5)$$

Where z is the achieving (objective) function.
P_i is the priority assigned to i^{th} goal.
d_i^- is the negative deviation.
d_i^+ is the positive deviation.
a_{ij} is the coeff. of j^{th} decision variable in the i^{ih} goal.
X_j is the j^{th} decision variable.
m is the number of goals., n is the number of decision variables.

Formulation of Goals.

G1: Contracted time

The objective of these goals is to assure that each nurse works for her/his contracted time. The goal for the first nurse is formulated as follows

$X_{1,1} + x_{1,2} + \ldots\ldots + x_{1,14} + d_1^- - d_1^+ = 10$,

Where $x_{i,j}$ is the i^{th} nurse working on j^{th} day

Similarly, ten other such goals, one for each nurse, were established.

G2: Minimum Number of Nurses

Satisfaction of this goal will mean that at least a certain known number of in each classification is assigned on each day. The goal for the assignment of an RN for the first day can be written as follows:

$X_{1,1} + x_{2,1} + x_{3,1} + d_{12}^- - d_{12}^+ = 1$,

Similar goals are developed for RN's for the remaining 13 days in the schedule and for LPN's and NA's for the 14 days this results in a total of 42 goals.

G3: Number of nurses for Patient care

These goals are similar to goals needed for a minimum number of nurses. For example, for assignment of RN's on the first day, we have

$X_{1,1} + x_{2,1} + x_{3,1} + d_{54}^- - d_{54}^+ = 3$.

G4: Weekend off for Full-Time Nurses

The purpose of this goal is to assure that nurses get one weekend off. If the weekend cannot be given off, then two should be off in that week. This goal for the first Full-

Time Nurse can be written as follows:

$X_{1,1} + x_{1,2} + \ldots\ldots + x_{1,7} + d_{96}^{-} - d_{96}^{+} = 5.$

A total of seven goals were needed for seven full-time nurses.

G5: Weekend off preference for Full-Time Nurses

This goal attempts to assign the preferred weekend for full-time nurses. For the first nurse, this goal can be written as follows:

$X_{1,13} + x_{1,14} + d_{103}^{-} - d_{103}^{+} = 0.$

Similarly goals can be written for six other full-time nurses.

G6: Weekend off preference for Part-Time Nurses

These goals are similar to goals presented for full-time nurses. For example, for the third nurse the goal is:

$X_{3,6} + x_{3,7} + d_{110}^{-} - d_{110}^{+} = 0.$

Four such goals are needed for four part-time nurses.

G7: Three Consecutive Days Off

This goal assures that no full-time nurse gets three consecutive days off. For nurse 1, this goal can be written as:

$X_{1,1} + x_{1,12} + d_{114}^{-} - d_{114}^{+} = 5.$

A total of seven such goals were needed.

3.2: Formulation of Achieving Function

The formulation of achieving function requires priorities of different goals. The following priorities were used in developing the schedule:

Priority 1: Achieve the contracted time goals.

Priority 2: Achieve the minimum number of nurses goals.

Priority3: Satisfy weekend preferences of full-time nurses, assign at least one weekend or two days off and do not violate the "three consecutive days off" constraints. Achieve desired number of nurses for patient care.

Priority 4: Satisfy the weekend preference for the part-time nurses.

The weights for the four priorities were taken as 9,7,5 and 3. A summary of goals, weights, and deviations to be minimized as shown in table.3.

Table3: Summary of Goals, Priority Levels, Weights And Deviations to be Minimized

Goal description	Total no. of Goals	Goal priority level	Goal weight	
1.Satisfy contracted days	11	1	9	Absolute
2Satisfy minimum requirement	42	2	7	Negative
3. Satisfy weekend preference for full-time nurses	7	3	5	Absolute
4. Satisfy goal that three or more consecutive days are not off	7	3	5	Absolute
5. Weekend off for full-time nurses.	7	3	5	Absolute
6. Satisfy desired no. of nurses' goals	42	3	5	Negative
7. Satisfy weekend preference for part-time nurses	4	4	3	Absolute

The achieving function can be written as follows:

$$\textit{Minimize } Z = P_1\sum_{i=1}^{11}(d_i^- + d_i^+) + P_2\sum_{i=12}^{53}(d_i^- + d_i^+) + P_3\sum_{i=54}^{109}(d_i^- + d_i^+) + P_4\sum_{i=110}^{113}(d_i^- + d_i^+)$$

$$+P_3\sum_{i=114}^{120}(d_i^- + d_i^+)$$

Subject to seven constraints shown in Formulation of Goals.

IV. RESULTS AND DISCUSSION

The scheduling problem with 154 decision variable and 120 constraints was solved using the algorithm described in [3]. The CPU time on a UNIVAC 1100 for solving this problem was 28.3 sec. The schedule for one two-week period is shown in **Table 4** and the schedule for all individual nurses is shown in **Table.5**.

Table4: Schedule for two-week period using the algorithm

Nurse type	M	T	W	R	F	S	S	M	T	W	R	F	S	S
RN	2	2	1	1	2	1	1	2	2	1	1	1	1	1
LPN	1	1	2	1	2	1	1	1	1	1	1	1	1	1
NA	4	5	4	3	3	3	3	4	3	3	3	3	3	2

Table 5: Schedule for individual nurses for two-week period

Nurse	M	T	W	R	F	S	S	M	T	W	R	F	S	S
1	1	1	1	1	1	0	0	1	1	1	0	1	1	0
2[a]	1	1	0	0	1	1	1	0	0	0	0	0	0	0
3[b]	0	0	0	0	0	0	0	1	1	0	1	0	0	1
4	0	0	1	1	1	1	1	0	0	0	0	0	0	1
5	1	1	1	0	1	0	0	1	1	1	1	1	1	0
6	1	1	1	1	0	1	1	1	1	0	1	1	0	0
7	1	1	1	1	1	1	1	1	0	1	0	1	0	0
8	0	1	0	0	0	1	0	0	0	0	0	1	0	1
9	1	1	1	0	1	0	0	1	1	1	1	0	1	1
10	1	1	1	1	1	0	0	1	1	1	1	0	1	0
11	0	0	0	0	0	0	1	0	0	0	0	0	1	0

a) In this scheduling period, nurse 2 has the second week off.
b)In this scheduling period, nurse 3 has the first week off.

It is worth mentioning that all nurses work for their contracted time. The preferred weekend off is allocated to all nurses except nurses number 2 and 8. It should be noted that nurse number 2, for this scheduling period, took one week off. Also nurse number 8 is a part time nurse and the relative importance of satisfying this goal was the lowest. The desired number of nurses for RN and LPN cannot be met because of the low total number of RN'S and LPN'S working in this unit, but the goal of minimum number of nurses is satisfied for all days of the two-week period.

V. CONCLUSION

In this paper we study the nursing staff members with their scheduled times on contracted time by taking care of patients with weekend off for full time and part time basis on giving the priorites on equal oppurtunites. The analysis performed has provided the applicability based support system which desired for patient care.

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