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SOLUTION OF NURSE SCHEDULING PROBLEM IN HOSPITAL MANAGEMENT USING LINEAR PROGRAMMING

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ABSTRACT

H*ospital's key primary mission is to ensure continuous ward care service with appropriate number of nursing staffs and theright mix of nursing skills. The planning and scheduling is done to avoid additional non essential cost for hospital. Nurses' preferencesare taken into considerations such as the number of night shift and consecutive rest days. To present a mathematical modelling technique by means of linear programming as an efficient tool to solve problems related to optimization in healthcare. Hospital must bestaffed 24 hours a day by a limited number of nurses. This paper illustrates how a linear programming solves the nurses schedulingproblems. This paper illustrates how linear programming has been effectively used in Nurses scheduling at a multi-specialty Hospital in Bhopal*

Keyword: *Nurses Scheduling, Linear programming, Nurses staffing.*

1. INTRODUCTION

Nurse scheduling is a multi-objective problem. Systematic approach for nurse allocation is needed to ensure continuous and adequate level of patient care services while maintaining the legislative requirements as well as internal policies. This problem becomes complex when addition factors such as patient admission, nurse qualifications or license to practice, type of disease as well as unforeseen accidents. The personal needs of the nurses such as vacation or work shift preferences add a new dimension to the scheduling problem. The need to balance all the various dimension of the problem makes nurse scheduling a particularly daunting manual task. Operations Research is a science designed to provide quantitative tools to decision-making procedures. It comprises a set of mathematic optimization and simulation methods and models, such as linear programming, nonlinear programming, combinatory optimization, theory of queues, dynamic programming, theory of decisions, etc.

There are various grades of nurses ranging from registered nurse to junior nurse. Some the nurses might be trained to manage certain medical conditions or skilled in certain area such as intensive care. Due to the varied trainings and specializations, certain type of nurses has to be staffed for wards requiring those skills. These varied conditions cause manual nurse scheduling to consume a significant amount of time. Even when the schedule has been planned manually, it not necessarily guarantee the fairness of distribution of work such as the number of night shifts or weekend shifts. While the nurses might have indicated their preferences, the planner might not have taken all these into consideration resulting in poorly designed schedules which has to be modified by the nurses swapping duties or working under undesired conditions. Occasionally, the plans did not attempt to efficiently utilize the manpower properly.

2. LINEAR PROGRAMMING

Linear programming techniques are considered as mathematics based decision-making tool. Such techniquerequires two fundamental types of functions, objective and constraints that is developed to generate closed-form solution. In a typical OR problem, the objective function, often expressed as Z, is formulated to determine the maximum profit while minimizing cost with given set of rules or constraints such as business policies, resource availability, preventive maintenance schedule, transportation distance or time and capacity.

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3. LITERATURE REVIEW

Nursing scheduling has been widely studied since 1960s. Prior to the development of mathematical programming,most nursing scheduling approaches were based on cyclical modeling. Cyclic models consist of regular patterns which be rotated across multiple time periods. The pattern will only repeat after one cycle. These types of models are highly repetitive and regular. Even though such models are considered to be fair in terms of distribution of work, the modelling process ignores the preferences of the nurses.

Howell's approach1 (1966) provides the first cyclical scheduling approach which takes into considerations the behavior and preferences of the individual nurse. Subsequently, nurse scheduling began to adopt heuristic models which are able to consider all the requirements at the planning stage (Maier-Rothe and Wolfe, 2 1973; Isken and Hancock3, 1991). This enables the models to attempt satisfying all the requirements.

The development of mathematical programming also gave rise to various approaches to solving the nurse scheduling problem especially the non-cyclical problem (Harmeier, 1991) rescheduling aims to minimize changes to be original schedule while minimizing costs, rebuilding the schedule with current staff is usually be cheaper option as there is no extra wage to pay, but altering the schedule will alter other nurses schedules as well.

$$Min \quad z = \sum_{i=1}^{7} X_i$$

xi subject to xi≥di

where i = 1.. 7; where xi is the number of nurses assigned to day 1, day 2, etc. and di is the demand of nurses for day 1, day 2, etc.

4. PROBLEM DEFINITION

Consider a hospital that is open seven days a week. Based onpast experience, the number of nurses needed on a particular day is given as follows.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
No of Nurses	250	175	235	100	175	340	120

Every nurse works five consecutive days, and then takes two days off, repeating this pattern indefinitely. How can we minimize the number of nurses that staff the hospital?

4.1 Model

A natural first attempt at this problem is to let xi be the number of people working on day i.

Let X_1 be number of nurses starting duty on Sunday (Sunday – Thursday)

Let X_2 be number of nurses starting duty on Monday (Monday – Friday)

Let X_3 be number of nurses starting duty on Tuesday (Tuesday – Saturday)

Let X_4 be number of nurses starting duty on Wednesday (Wednesday – Sunday)

LetX_5 be number of nurses starting duty on Thursday (Thursday – Monday)

Let X_6 be number of nurses starting duty on Friday (Friday –Tuesday)

Let X_7 be number of nurses starting duty on Saturday (Saturday – Wednesday)

The demand for the number of nurses in the hospital on Sunday: 120, Monday: 250, Tuesday: 175, Wednesday: 235, Thursday: 100, Friday: 175 and Saturday: 340 respectively.

Let X_i be the number of workers who begin their five day shift on day i.

Our objective is $X_1+X_2+X_3+X_4+X_5+X_6+X_7 \geq 0$

Consider the constraint for Sunday staffing level of 120. Those who start their shift on Sunday (X_1), they will work for consecutively 5 days, that is, Sunday to Thursday. Those, who start their shift on Monday (X_2), they will work for consecutively 5 days, that is, Monday to Friday. Similarly, those who start their shift on Tuesday (X_3), they will work Tuesday to Saturday and so on.

We can formulate the following table.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Sunday Shift	*	*	*	*	*	--	--
Monday Shift	_	*	*	*	*	*	-
Tuesday Shift	_	_	*	*	*	*	*
Wednesday Shift	*	_	_	*	*	*	*
Thursday Shift	*	*	-	-	*	*	*
Friday Shift	*	*	*	-	-	*	*
Saturday Shift	*	*	*	*	-	-	*

Similar arguments give a total formulation of

Minimize $z = \sum_{i=1}^{7} X_i$; X_i subject to constraints

$X_1+ X_4+X_5+X_6+X_7\geq 250$
$X_1+ X_2+ X_5+ X_6+ X_7\geq 175$
$X_1+ X_2+ X_3+ X_6+ X_7\geq 235$
$X_1+ X_2+ X_3+ X_4+ X_5\geq 100$
$X_2+ X_3+ X_4+ X_5+ X_6\geq 175$
$X_1+ X_2+ X_3+ X_4+ X_5\geq 340$
$X_3+ X_4+ X_5+ X_6+ X_7\geq 120$
$X_1+X_2+X_3+X_4+X_5+X_6+ X_7\geq 0$; / $xi\geq 0$ for all i

4.2 Solving the Model

Since this model has 7 variables, we cannot solve the problem manually. Hence, we can solve the LPP by using solver. If we solve the LPP, we will get the feasible solution (Min Z = 305.3333). But, unfortunately minimum demand of nurses will not be in decimal point. Hence, we have to solve the above LPP by Integer Programming Problem (possibility of extension). In the above LPP, the demand for requirement of nurses in each day was assumed values.

5. CONCLUSION

Nurses shifting allotment is a well developed area. Note that our model has only one type of shift, but the model is easily extended to other types of shifts, with differing shift costs. The resulting schedule includes balanced schedules in termsof the distribution of shift duties, fairness in terms of thenumber of consecutive night duties and the preferences of the nurses. This is an improvement over the traditional manual approach which is costly in terms of labor as well as inefficient in producing a good schedule. Nurse rostering is a complex scheduling problem that affects hospital personnel on a daily basis all over the world. The need for quality software solutions is acute for a number of reasons. In particular, it is very important to efficiently utilize time and effort, to evenly balance the workload among people and to attempt to satisfy personnel preferences. A high quality roster can lead to a more contented and thus more effective workforce.

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