Modeling Nurse Scheduling Problem Using 0-1 Goal Programming: A Case Study Of Tafo Government Hospital, Kumasi-Ghana

Wallace Agyei, William Obeng-Denteh, Emmanuel A. Andaam

Abstract: The problem of scheduling nurses at the Out-Patient Department (OPD) at Tafo Government Hospital, Kumasi, Ghana is presented. Currently, the schedules are prepared by head nurse who performs this difficult and time consuming task by hand. Due to the existence of many constraints, the resulting schedule usually does not guarantee the fairness of distribution of work. The problem was formulated as 0-1goal programming model with the of objective of evenly balancing the workload among nurses and satisfying their preferences as much as possible while complying with the legal and working regulations.. The developed model was then solved using LINGO14.0 software. The resulting schedules based on 0-1goal programming model balanced the workload in terms of the distribution of shift duties, fairness in terms of the number of consecutive night duties and satisfied the preferences of the nurses. This is an improvement over the schedules done manually.

Keywords: Nurse scheduling Problem, Goal programming,Hard and Soft Constraints, Balanced workload, Nurses Preference, Out-patient Department.

1. INTRODUCTION

In the face of growing shortage of nurses in many countries [1], managers of hospitals are under constant pressure to efficiently utilize and retain currently available nurses without jeopardizing their satisfaction. One possible way is to generate high quality schedules that guarantee fairness of distribution of workload and satisfy the preference of nurses whilst adhering to hospital working policy as well as legal and contractual obligations. This is of critical importance as continuous disregard of nurses' preference and unbalanced workload among nurses will results in frustrations, absenteeism, fatigue, low morale and poor job performance which all have a direct impact on the quality of patient care [2]. Nurse scheduling problem involves assigning nurses to work for a shift on a given day over a period (week, month or year) subject to a number of constraints such as demands for patient care, hospital staffing requirement, nurses' skills, hospital policies and legal regulations as well as attempting to evenly balance workload among the nurses while simultaneously satisfying their preferences. The constraints are usually categorized into two groups: hard and soft constraints. The hard constraints are a number of working regulations and hospital policy which must be satisfied and can under no circumstance be violated. On the other hand the soft constraints are nurses' personal preferences which can be violated but their violation is associated with a penalty. Nurse scheduling is a complex and time consuming task. Even though the problem has been a subject of interest of many researches for the past five decades, still the task of creating a schedule for nurses is done manually in many hospitals in Ghana by the head nurse. Several authors have previously addressed nurse scheduling problems using goal programming methods. Arthur and Ravidran [3] were the first to use goal programming approach for nurse scheduling problem. They divided the problem into two phases, where phase 1 is to assign the working days and days off for each nurse while phase 2 is to assign the shift types of their working days. They aim simultaneously to minimize staff size, preferences, staff dissatisfaction and deviation between scheduled and desired staffing levels. Musa and Saxena [4] proposed an interactive goal programming procedure for solving nurse rostering problem for a unit with 11 nurses in hospital taking considerations of the hospital policies and nurses' preferences. With a two week planning period and one shift to be scheduled, the complexity of the tackled problem remains low. Ozkarahan & Bailey [5] proposed a goal programming version of the integrated personnel scheduling model of the time of day and day of week problems in order to schedule nurses over a weekly period. Their nurse scheduling model showed the flexibility of goal programming in handling various goals which fulfilled the hospital's objectives and the nurses' preferences. Berrada, et al. [6], in their goal programming model for nurse scheduling used for hard constraints the administrative and union contract specifications, while work patterns and nurses preferences has been formulated as soft constraints. The outcome shows satisfactory result by combining goalprogramming approach and tabu search technique. Moores et al. [7] formulated the student nurse allocation problem using goal programming. The problem was to produce a 3-year schedule for student nurses to comply with the minimum practical and theoreticalstandards whilebeing used as part of the hospital work force. Azaiez & Al Sharif [8] developed a goal programming model that includes hospital objectives such as ensuring a continuous service with appropriate nursing skills and staffing size, and nurses' preferences such as distributing night shifts and weekends off fairly and avoiding isolated days on and off. Ismail et al. [9] also used the goal programming approach with the considerations of hospital's objectives as hard constraints and the nurses' preferences as soft constraints to develop the schedules. Both models solved by Azaiez & Al Sharif [8] and Ismail et al. [9] are measured to execute reasonably well. Nevertheless, their models limit to one off schedule where they have to build new schedule for each planning period. Harvey and Kiragu [10] presented a mathematical model for cyclic and non-cyclic scheduling of 12 hours shift nurses. The model is quite flexible and can accommodate a variety of constraints. In spite of this, the model deals with small requirements which are not appropriate to embed in real situations. Janal et al. [11] proposed a cyclical nurse scheduling using goal programming technique. Their model considered the hospital's objective and nurses' request for three weeks planning period and three shift works for 18 nurses. Later the Ismail et al. [12] proposed a master plan for cyclical nurse scheduling model for planning period of 12 days for 12 nurses with three shifts where the hospital objectives were treated as hard constraints that must be satisfied and nurses request as soft constraints that can be violated. Although nurse scheduling problem has been intensively explored in literature for different characteristics with variety of solution techniques and complex search algorithms [13][14], a lot of these models have focused on small size nurses, few days of scheduling period, with small set of goals and constraints which make the schedules not practical enough. This is mainly due to the high complexity of solving such problems. Therefore, this study is carried out to highlight the new model of the nurse scheduling problem with a goal programming approach that includes several objectives or goals to achieve subject to both several hard and soft constraints. The schedules will rely on fairness among nurses and will consider nurses' preferences to maximize their satisfaction. This will help the nurses to provide adequate quality of service.

2. MATERIALS AND METHOD

The nurse scheduling problem in the outpatient department (OPD) at Old-Tafo Government Hospital in Kumasi Ghana is used as a case study in this paper. The department has 24 nurses but currently 3 are on leave (2 on study leave and 1 maternity leave) and schedule them for 28 days (4 weeks) period and are required on a 24 hour basis, 7 days in week. The nurses are classified according to their qualifications: registered, enrolled and auxiliary nurses, however all the nurse have been trained extensively to handle outpatient cases. Nurses are assigned to work in three shifts: morning (M), afternoon (A) and night (N) orhas a day off. The morning shift is from 8am – 2pm, counting for 6 hours. Theafternoonshift is from 2pm – 8pm counting for 6 hours. The night shift is from 8pm-8am counting for 12 hours. There is a minimum staffing requirement for each shift: for morning and afternoon shifts, at least five nurses are required and for night shift; 3 nurses. The schedules are rotated among the nurses at the end of the cycle.

Notations:

n: number of days in the schedule ($n = 28$)
m: number of nurses available
k: index for nurses, $k = 1,2,3,\dots,m$
i: index for days within the schedule,$i = 1,2,3,\dots,n$
M_i:staff requirement for morning shift for day$i$, $i = 1,2,3,\dots,n$
A_i:staff requirement for afternoon shift for day$i$, $i = 1,2,3,\dots,n$
N_i:staff requirement for night shift for day$i$, $i = 1,2,3,\dots,n$

Decision variables:

$$Q_{i,k} = \begin{cases} 1, \text{if nurse } k \text{ is assigned amorning shift for day } i \\ 0 \text{ , otherwice} \end{cases}$$

$$R_{i,k} = \begin{cases} 1, \text{if nurse } k \text{ is assigned an afternoon shift for day } i \\ 0 \text{ , otherwice} \end{cases}$$

$$S_{i,k} = \begin{cases} 1, \text{if nurse } k \text{ is assigned a night shift for day } i \\ 0 \text{ , otherwice} \end{cases}$$

$$T_{i,k} = \begin{cases} 1, \text{if nurse } k \text{ is assigned a day off for for day } i \\ 0\text{, otherwice} \end{cases}$$

Formulating the constraints for this model:

Hard constraints:
Minimum staff requirement for each shift must be fulfilled:

$$\sum_{i=1}^{m} Q_{i,k} \geq M_i \ \forall \ i = 1,2,3,\dots,n \ (1)$$
$$\sum_{i=1}^{m} R_{i,k} \geq A_i \ \forall \ i = 1,2,3,\dots,n \ (2)$$
$$\sum_{i=1}^{m} S_{i,k} \geq N_i \ \forall \ i = 1,2,3,\dots,n \ (3)$$

Each nurse is assigned only one shift a day:

$$Q_{i,k} + R_{i,k} + S_{i,k} + T_{i,k} = 1 \ \forall i = 1,2,3,\dots,n \text{ and } k = 1,2,3,\dots,m \qquad (4)$$

Maximum and minimum working days per the 4 week schedule must be fulfilled:

$$\sum_{k=1}^{m} (Q_{i,k} + R_{i,k} + S_{i,k}) \geq 17 \ \forall \ i = 1,2,3,\dots,n \ (5)$$
$$\sum_{k=1}^{m} (Q_{i,k} + R_{i,k} + S_{i,k}) \leq 19 \ \forall \ i = 1,2,3,\dots,n \ (6)$$

Each nurse has 4 consecutive days of night shift thenfollowed by 3 consecutive days of day off:

$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} = 7, i = 1, k = 4,8,18 \qquad (7)$$
$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} = 7, i = 5, k = 1,11,21 \qquad (8)$$
$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} = 7, i = 9, k = 6,14,19 \qquad (9)$$
$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} = 7, i = 13, k = 3,9,16 \qquad (10)$$
$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} = 7 \ i = 17, k = 5,12,20 \qquad (11)$$
$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} = 7, i = 21, k = 2,7,17 \qquad (12)$$
$$S_{i,k} + S_{(i+1),k} + S_{(i+2),k} + S_{(i+3),k} = 4 \ i = 25, k = 10,13,1 \qquad (13)$$

Each nurse has at least one day off during weekends in the 4 week schedule:

$$T_{6,k} + T_{7,k} + T_{13,k} + T_{14,k} + T_{20,k} + T_{21,k} + T_{27,k} + T_{28,k} \geq 1 \text{ , } k = 1,\dots,m \qquad (14)$$

Each nurse cannot be assigned to work for more than 6 days consecutively:

$$T_{i,k} + T_{(i+1),k} + T_{(i+2),k} + T_{(i+3),k} + T_{(i+4),k} + T_{(i+5),k} + T_{(i+6),k} \geq 1, k = 1,2,3,\dots,m \qquad (15)$$

Minimum night shift per the 4 week period is 25% of the total work load:

$$\sum_{i=1}^{n} T_{i,k} \geq 4 \; \forall \; k = 1,2,3 \ldots, m \qquad (16)$$

Minimum morning shift per the 4 week period is 30% of the total work load:

$$\sum_{i=1}^{n} Q_{i,k} \geq 5 \; \forall \; k = 1,2,3, \ldots, m \qquad (17)$$

Soft Constraints:
All the nurses have the same workload:

$$\sum_{k=1}^{m} \left(Q_{i,k} + R_{i,k} + S_{i,k}\right) = 18 \; \forall \; k = 1,2,3 \ldots, m \qquad (18)$$

A nurse should not be assigned morning shift immediately after night shift or afternoon shift the next day:

$$Q_{i,k} + R_{(i+1),k} + S_{(i+1),k} \leq 1 \; \forall i = 1,2,3, \ldots, n-1 \qquad (19)$$

A nurse should not be assigned afternoon shift immediately after morning shift or night shift the next day:

$$R_{i,k} + Q_{(i+1),k} + S_{(i+1),k} \leq 1 \; \forall i = 1,2,3, \ldots, n-1 \qquad (20)$$

Avoid any off-on-off day patterns:

$$T_{i,k} + Q_{(i+1),k} + R_{(i+1),k} + S_{(i+1),k} + T_{(i+2),k} \leq 2 \; \forall i = 1,2, \ldots, n-2, k = 1, \ldots, m \qquad (21)$$

Avoid any on-off-on day patterns:

$$Q_{i,k} + R_{i,k} + S_{i,k} + T_{(i+1),k} + Q_{(i+1),k} + R_{(i+1),k} + S_{(i+1),k} \leq 2 \; , \forall i = 1,2, \ldots, n-2 \; k = 1, \ldots, m \qquad (22)$$

Formulating the goals for this model:
The soft constraints are incorporated in the model as the goals and formulated as follows:

Goal 1: This goal ensures that all nurses are scheduled to have 18 days as possible in the 4-week schedule:

$$\sum_{k=1}^{m} \left(Q_{i,k} + R_{i,k} + S_{i,k}\right) - d1_k^- + d1_k^+ = 18 \; \forall \; k = 1,2,3, \ldots, m \quad (23)$$

Here $d1_k^-$(respectively $d1_k^+$) is the amount of negative (positive) deviation from goal 1 for nurse k. Both positive and negative deviations are penalized.

Goal 2: it avoids assigning a nurse to morning shift immediately after a night shift or an afternoon shift the next day.

$$Q_{i,k} + R_{(i+1),k} + S_{(i+1),k} - d2_k^- + d2_k^+ = 1 \; \forall i = 1,2,3, \ldots, n-1 \qquad (24)$$

Here $d2_k^-$(respectively$d2_k^+$) is the amount of negative (positive) deviation from goal 2 for nurse k. Only positive deviations are penalized.

Goal 3: it avoids assigning a nurse to an afternoon shift immediately after morning shift or night shift the next day:

$$R_{i,k} + Q_{(i+1),k} + S_{(i+1),k} - d3_k^- + d3_k^+ = 1 \; \forall i = 1,2,3, \ldots, n-1 \qquad (25)$$

Here $d3_k^-$(respectively$d3_k^+$) is the amount of negative (positive) deviation from goal 3 for nurse k. Only positive deviations are penalized.

Goal 4: it avoids off-on-off patterns. This goal attempts to have minimum isolated day or nightshifts for all nurses.

$$T_{i,k} + Q_{(i+1),k} + R_{(i+1),k} + S_{(i+1),k} + T_{(i+2),k} - d4_k^- + d4_k^+ = 2 \; \forall i = 1,2,3, \ldots, n-2 \; k = 1, \ldots, m \qquad (26)$$

Here $d4_k^-$(respectively$d4_k^+$) is the amount of negative (positive) deviation from goal 4 related to isolated day/night shifts on, for day i and nurse k. Only positive deviations are penalized.

Goal 5: it avoids on-off-on patterns. This goal attempts to have minimum isolated day or night shifts for all nurses.

$$Q_{i,k} + R_{i,k} + S_{i,k} + T_{(i+1),k} + Q_{(i+1),k} + R_{(i+1),k} + S_{(i+1),k} - d4_k^- + d4_k^+ = 2 \; \forall i = 1,2,3, \ldots, n-2 \; k = 1, \ldots, m \qquad (27)$$

Here $d5_k^-$(respectively$d5_k^+$) is the amount of negative (positive) deviation from goal 4 related to isolated day/night shifts off, for day i and nurse k. Only positive deviations are penalized.

Assigning importance weights
The importance of weights assigned to the goals shows the relative importance of goals in comparison to the others. The penalty of breaking these goals shows their importance.The penalty levels are represented by P_1,P_2,P_3,P_4 and P_5. In this model, goal 1 which ensures all nurses having the same workload is considered as the most important goal. Also goals 2 to 5 were considered in succession. After a number of evaluations and comparison, weights are assigned to each goal in order of importance$P_1 = 100$, $P_2 = 70, P_3 = 50, P_4 = P_5 = 20$. It must be noted that these weights may differ from one hospital to another or departments within the same hospital.

The objective function
The objective function consists of minimizing the sum of the weighted deviations from the corresponding goals. The first priority is to minimize goal 1 to unwanted deviation as possible and this corresponds with the first summation term in (28) then followed by goal 2, goal 3, and goal 4 and goal 5 in succession.

$$\text{Minimize}\left(P_1\left[\sum_{k=1}^{m} d1_k^- + d1_k^+\right] + P_2\left[\sum_{i=1}^{n-1}\sum_{k=1}^{m} d2_{i,k}^+\right] + P_3\left[\sum_{i=1}^{n-1}\sum_{k=1}^{m} d3_{i,k}^+\right] + P_4\left[\sum_{i=1}^{n-1}\sum_{k=1}^{m} d4_{i,k}^+\right] + P_5\left[\sum_{i=1}^{n-1}\sum_{k=1}^{m} d5_{i,k}^+\right]\right) \quad (28)$$

3. RESULTS AND DISCUSSION

The problem of scheduling nurses at the outpatient department of Old-Tafo Government Hospital with 21 nurses of three shifts for 28 days scheduling horizon was modeled and solved using 0-1goal programming. The model consisted of 2197 hard and soft constraints, 1026 decision variables and 2082 deviational variables. This model was solved using LINGO14.0 optimization software on an Intel® CORE with 2.13 GHz processor speed and 4GB RAM running Windows 7 Ultimate and its optimum results is presented in Table 1.Table 1 shows the patterns of the shift of the working day and off day for the 28 days (4 weeks) scheduling period developed by using the 0-1goal programming model while Table 2 shows the manual schedule prepared by the head nurse of the unit. In the 0-1goal programming schedule, can be observed that goal one is achieved. Thus, all the nurses have the same 18 days of total number of shifts per the 28 days period. However, the manual schedule prepared by head nurse in Table 2 is unbalanced with respect total number of workloads for the nurses. Also the schedule produced manually has shown that there is inconsistency in the distribution of night shifts for the nurses as four nurses are assigned 8 days of night shifts whereas the rest of the nurses all have 4 days in the 28 days period. But the developed model using goal programming technique produced a very consistent and fair schedule in terms of 4 night shifts for each nurse. Moreover, it can also observed from Table 1 that goals 2 and 3 are fulfilled as there is no there is no afternoon shift followed by morning shift or night shift and there also no morning shift followed by afternoon shift or night shift in the next day however this constraint is violated several times in the manual schedule prepared by head nurse. Additionally the off-on off and on- off- patterns which is goal 4 and 5 respectively are violated in both manual and the goal programming schedule except that in the goal programming schedule these violations occur either the beginning or the end of the schedule. In either case, these violations may be avoided by simply assigning days on or off properly at the beginning of next schedule.

Table 1. Roster developed using 0-1 goal programming model

		Name																				
	Days	M.T	E.A	G.A	P.O	R.G	C.S	J.O	S.B	W.M	L.G	N.A	F.O	D.A	A.A	B.S	E.M	L.S	M.I	T.F	M.D	B.O
Week 1	Sun			M	N	M	A	A	N	M	A				A	M			N	A	A	M
	Mon	A		M	N	M	A	A	N	M	A				A	M			N	A		M
	Tue	A	M		N		A	A	N		A		M		A		M	M	N	A		M
	Wed		M	A	N	M			N	A			M	A		A	M	M	N		A	
	Thur	N		A		M		M		A		N	M	A		A	M	M			A	N
	Fri	N	A	A			M	M		A	M	N			M	A				M	A	N
	Sat	N	A			A	M				M	N	A	M	M	A	M			M	A	N
Week 2	Sun	N	A	M	M	A			A	M		N	A	M			M	A	M			N
	Mon		A	M	M		N		A	M	A		A	M	N			A	M	N	M	
	Tue			M		A	N	M	A	M	A			M	N		A	A	M	N	M	
	Wed		A	M	M	A	N	M			A		A		N	M	A		M	N	M	
	Thur	M	A		M	A	N				A	M	A	A	N	M		M		N	M	
	Fri	M	A	N				A	M	N	A	M	A	A		M	N	M	A		M	
	Sat	M	A	N		M		A	M	N	A	M	A				N	M	A			
Week 3	Sun	M		N	A	M			M	N		M	A			A	N	M	A			A
	Mon			N	A		M	A		N		M		M	M	A	N		A	M		A
	Tue		M			N	M	A	A				N	M	M	A		A		`M	N	A
	Wed	M	M		M	N		A	A		M	A	N		M			A			N	A
	Thur	M	M		M	N	A	A	A		M	A	N	A				A		M	N	
	Fri			A		N	A			A	M		N	A	M	M	A			M	N	M
	Sat	A	N	A	M			N	M	A		M			M	M	A	N	A			M
Week 4	Sun	A	N		M		M	N	M	A		M		M			A	N	A	A		
	Mon	A	N	A			M	N	M			M		M	A		A	N		A		M
	Tue	A	N	A	A	M		N		M					A			N	M	A	M	M
	Wed			A	A	M	A			M	N	A	M	N	A	N			M		M	M
	Thur	M			A		A		A	M	N	A	M	N	A	N	M		M			
	Fri	M			A				A		N	A	M	N		N	M		M	M	A	A
	Sat		A			M	M	A			N	A		N		N	M	M		M	A	A
	Total	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**
	M = Morning shift, A= Afternoon shift, N = Night shift																					

Table 2. Manual roster prepared by the head nurse.

		Name																				
	Days	**M.T**	**E.A**	**G.A**	**P.O**	**R.G**	**C.S**	**J.O**	**S.B**	**W.M**	**L.G**	**N.A**	**F.O**	**D.A**	**A.A**	**B.S**	**E.M**	**L.S**	**M.I**	**T.F**	**M.D**	**B.O**
Week 1	Sun	A	A	N			M	N	M	N	A	A		A	M	M	N	M	A		N	
	Mon	A	A	N		A		N	M	N	A		M	A	M	M	N	M	A		N	
	Tue	M	A	N		A		N	M	N	A		M	A	A		N	M	A	M	N	
	Wed			N	A	M	A	N	M	N		A			A	M	N	A		M	N	M
	Thur	M	N		A	A	A		A		M	A	N	N		A			M	M		A
	Fri	M	N			A	A				M	A	N	N	M	M		A	M	A		
	Sat	A	N		A	M	M				M	M	N	N	A			A	M	A		
Week 2	Sun	A	N	A				M	A	M			N	N	M	M	M	A		A	A	M
	Mon	A		A	N	N		M	A	M	N	M			A	A	M		N		A	M
	Tue				N	N	M	A	A	M	N	M			M	A		A	N	M	A	A
	Wed	A		A	N	N	A	A			N	M				M	M	A	N	M	M	
	Thur	A	M	A	N	N	M		M		N	M		M	A		M	A	N			
	Fri		M	A			M	N		A		A		M	A	N		M		A	M	N
	Sat		M	A				N	M	A				M	A	N	A	M		A	M	N
Week 3	Sun		A				A	N	M	A			A	M	A	N	A	M			M	N
	Mon		M		M	M	A	N		A	M		A			N	A		M	A		N
	Tue	N		N	M	M			A	M	`M	N	A	A	M			N	M	A	A	
	Wed	N	A	N		M			A		A	N	A	M	M		M	N		M	A	
	Thur	N	M	N	A	A			A		M	N		M	M		M	N	A		A	
	Fri	N		N	A	A	M	A		M	M	N	M			A		N	A			M
	Sat					M	M	A	N	A			M	A	N	A	M			N	M	A
Week 4	Sun		M		M		M	A	N	A	A			A	N		M		M	N	M	A
	Mon	M	M		M	A		M	N				M	A	N	A	A		M	N	A	
	Tue			M		A			N		A	M	M	A	N	A	A	M		N		M
	Wed	N	A	M	N	M	N	A		N		A					A	M	A		M	M
	Thur	N	A	M	N	M	N	M		N			A	M		M	A		A		A	M
	Fri	N	M	A	N	M	N	A		N	M	A	A	M		M		A			A	
	Sat	N	M		N		N	A	M	N	M	A	A		M			A	M	M		A
	TOTAL	**19**	**20**	**18**	**17**	**21**	**18**	**20**	**19**	**19**	**19**	**18**	**17**	**20**	**21**	**19**	**19**	**21**	**19**	**18**	**20**	**16**
	M = Morning shift, A= Afternoon shift, N = Night shift																					

4. CONCLUSION

In this paper, a nurse scheduling problem based on a real case study in the outpatient department (OPD) of Tafo Government in Kumasi, Ghana that takes both hospital management requirements as hard constraints and nurses' preference as soft constraints was presented and formulated as 0-1 goal programming. The model was then solved using LINGO14.0 software. The resulting schedule includes balanced schedules in terms of the distribution of workload, fairness in terms of the number of consecutive night duties and the preferences of the nurses. This is an improvement over the manual schedules prepared by the head nurse, which is costly in terms of labor as well as inefficient in producing a good schedule. Future work is to implement the schedules in different departments in the hospital and also adapting the schedules to provide flexibility in case of disruptions.

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