Original Research

A Mathematical Programming based Approach for Nurse Patient Customized Efficient Assignment: A Case Study of the Paediatrics Department at Kasserine Hospital, Tunisia

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Abstract
This paper aims to assign nurses to patients where patient needs, nurses' satisfaction, and efficiency goals are considered. On one side, patients need a customized level of acuities, nursing skills, and care; on the second, nurses look for balancing workloads and appropriate assignment of their skills and experience, and on the third, management looks for higher efficiency. A Mixed integer program is developed and implemented in the context of the pediatrics department at Kasserine hospital, Tunisia. Numerical results showed balanced and more fitful assignments with improved overall hospital costs. Hence, service quality has been enhanced as stakeholders' satisfaction has improved.

Keywords - Nurse's workload; Patient's acuity; Integer program; Pediatrics Department; Hospital; Efficiency.

INTRODUCTION

In order to provide a satisfactory service to existing patients in hospitals, several factors are essential and come into account. These factors are based, primarily, on the human factor, which is the key element of process flexibility and performance. Hence, human resource management is a fundamental element of development where the primary responsibility of nurses is to care for the patient in order to increase his satisfaction. In fact, assigning every available nurse to the right place at the right time to do the right job is a major concern of health organizations. So, this research aims to equitably distribute, or balance, workload as a function of patient characteristics or acuity measures while assigning patients to nurses. In other words, we are trying to find answers to questions like for example: How do nurses balance their workload to care infant in pediatric department?

In order to balance the amount of work between nurses, it should be noted that their planning consists of four steps, namely: nurse budgeting, nurse scheduling, nurse rescheduling, and nurse assignment. With regard to the schedules and budgeting of nurses, they have been widely studied to reduce costs and improve working conditions with the aim of achieving their satisfaction [1]. Therefore, the major goal of nurse scheduling problems is to assign nurses to certain shifts to reduce health staffing costs and improve nurse satisfaction [2].

In this research, an assignment model of nurses to infants is developed in order to minimize the excessive workload of nurses and balance the load, which improves the quality of infant's care and increases the quality of nursing work.

The organization of the paper will be as follows. Section 2 will present some literature review. Section 3 presents the context of the study. Section 4 makes the proposed model and a computational analysis with real data obtained from the pediatric Department of Kasserine Hospital. Finally, Section 5 gives the concluding remarks and future research.

LITERATURE REVIEW

Supply chain (SC) performance evaluation is a complex decision-making problem involving various criteria under uncertainty situations [3]. In this way, numerous studies have been made in order to evaluate the performance of diverse supply chain issues and different methods have been then used. Some of them emphasized Scheduling problems and tried to solve them using optimization methods.

Buchmeister et al. [4] illustrated and discussed the impact of inventory control policies at different demand processes. The results for all stages in supply chains are compared.

Jiuping Xu et al [3] studied the supply chain performance evaluation of a furniture manufacture industry in the southwest of China. They presented in the paper the main uncertainty factors affecting evaluation process, and then they modelled them using a rough data envelopment analysis (RDEA) models.

Asaf Hajiyev et al. [5] constructed different mathematical models of vertical (lift) transportation to decrease a customer average waiting time before service and reduce then energy expenses of the system. The authors introduced and compared various control policies.

XiaoyangZhou et al. [6] developed a sequence of attainable goals for inefficient suppliers rather than a single ultimate goal. In addition to economic sustainability, they also considered social responsibility and environmental protection. So the authors incorporated the dynamic structure and uncertain linguistic information into a context-dependent DEA model and employed classical triangular fuzzy numbers to address the uncertainty.

Jiuping Xu et al. [7] proposed a new bilevel model with multiple decision-makers for solving the project scheduling problem. A case study based on the Wanjiakouzi Hydropower Station is used to demonstrate an application of the developed model.

Nowadays, the hospital system is facing the challenge of the hospital supply chain performance. Human staff resources and especially nurses play an important role in hospital performance as they provide treatment for patients. It is expected that nurses working in the hospital have the necessary skills and experience to effectively manage every day the performance.

The scheduling of nurses is particularly challenging because unlike many organisations, health care institutions work around the clock and the extent to which the satisfaction of nurses can impact not only the working environment and nurses' well-being but also patient's and hospital manager's satisfaction.

For these reasons, in order to ameliorate the performance of the hospital supply chain, this study treated the nurses scheduling problem. In this context, numerous research studies addressed this problem. For example, Azaiez and Al Sharif [8] developed a GP 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.

Jlassi et al [9] proposed a goal programming (GP) model that accommodates both hard and soft constraints for a monthly planning horizon. The hard constraints should be adhered to strictly, whereas the soft constraints can be violated when necessary. The relative importance values of the soft constraints have been computed by the analytical hierarchy process (AHP), which are used as coefficients of the deviations from the soft constraints in the objective function.

M'Hallah and Alkhabbaz [10] presented mixed integer model that minimize outsourcing nurses, and considered nurses' preferences. The model has been applied in Kuwaiti health care units.

Bateni et al. [11] used a mathematical model to increase the nurses' preferences and decrease the outsource nurses to cover the demands of each day.

Hamed Jafari et al. [12] proposed a mathematical model to maximize nurses' preferences. They generated the optimal solution and, then, they applied a simulated approach to solve the problem in a reasonable time.

Liang et al. [13] proposed two multi-objective optimization models. the first one was functional care delivery model, and the other one was primary care delivery model. Those models seek to minimize the total patient waiting time and the total nurse overtime. They applied the models in one of the largest oncology clinics. The results approved that the proposed models were capable of reaching an optimal solution.

Ahmed Ali El Adoly et al. [14] used a mathematical model, which is based on the idea of multi-commodity network flow

model. The model was applied to a real case study in an Egyptian hospital. The results demonstrate the advantage of using the proposed model because it allows to improve the level of nurses' satisfaction.

For nurse assignment, Mullinax and Lawley [15] have developed an integer programming model. They used heuristics to assign nurses to patients and they looked for balancing workload of nurses based on patient acuity in a neonatal intensive care. Nevertheless, Punnakitikashem et al. [16] have proposed a two-stage stochastic integer programming nurse assignment model to decrease excess workload of nurses, while Sundaramoorthi et al. [17] have evaluated nurse-patient assignments through a simulation model from real data. However, Sir et al. [18] have developed several nurse–patient assignment models to reach a balanced assignment in terms of population-based acuity metrics and a decrease in overall survey-based perceived workload. In contrary, Ageiz and Abd El-mageed [19] have proposed a program of the acuity tool-based nurses' assignment. Consequently, they have approved that the majority of nurses in the experimental group was satisfied with the method of assignment based on acuity scores after implementation of the program.

CONTEXT OF THE STUDY

Kasserine Regional Hospital "KRH" is located north of Kasserine exactly at Habib Bourguiba Avenue. The hospital began operations in 1986.

The KRH has several clinical services, all of which are operational: hemodialysis, psychiatry, cardiology, internal medicine, surgery, pediatrics, etc.

The KRH welcomes patients from the city center and the surrounding areas, but due to its limited capacity for equipment and staff, the hospital transfers patients to other hospitals in the event of a serious situation or an excess of patients.

In institutions with a pediatric department, continuity of service must be ensured for the care and control of patients. This service has 17 rooms for children and 8 rooms for newborns, each room has 4 to 5 beds, and 26 nurses. The workstations therefore correspond to different hours (day work, night work).

The policy chosen by the hospital and health managers for the assignment of nurses is weekly and non-cyclical.

Work multiplanes in the pediatric department occurs in cases of epidemics such as measles or in winters because children get sick more often in this season. Temperatures drop and it becomes difficult to avoid the germs that swarm inside which justifies the multiplication of patients suffering different diseases such as Rhinopharyngitis, Bronchiolitis, laryngitis, Influenza, Angina, Gastroenteritis...

KRH's pediatric department faces many problems, the most important of which is the assignment of nurses. Making nursing schedules is a very complex task, partly because it takes a lot of time and does not necessarily ensure the best possible schedule. On the other hand, the service is very sensitive, a misallocation can lead to harmful effects.

In health facilities with a paediatric department, continuity of service must be ensured. The positions therefore, correspond, to different hours (day work, night work). This assignment can be daily, weekly, monthly or annual, depending on the assignment policy chosen by the hospital and health managers

Similarly, the night is quieter and less busy than the day. To conduct our study well, we conducted a survey with nurses in the paediatric department to assess the workload situation as well as the preferences of nurses.

TABLE I
BREAKDOWN OF NURSES BY SEX

sex	Effective	Percentage
Women	8	80%
Man	2	20%

From this table we can see that most nurses are women (80%) but men account for only 20%.

TABLE II
. BREAKDOWN OF NURSES BY AGE

Age	Effective	Percentage
Less than 30 years	6	60%
between 30-40 years	4	40%

The majority of paediatric nurses (60%) are under 30, while 40% of nurses are between the age of 30 and 40.

TABLE III
BREAKDOWN OF NURSES BY DURATION OF EXPERIMENTS

Duration	Effective	Percentage
1-5years	6	60%
5-10 years	3	30%
10-20 years	1	10%

The majority of nurses (60%) have experience between 1 and 5 years, 30% are experienced from 5 to 10 years and 10% have experience of 10 to 20 years.

TABLE IV
THE EXISTENCE OF OVERWORK IN THE SERVICE

	Effective	Percentage
yes	10	100%
No	0	0%

All pediatric nurses (100%) stated that there is an overload of work in the service. All nurses (100%) overwork is due to the high number of patients. 80% of nurses said that overwork has adverse impacts on patient health and nurse satisfaction.

Based on the results of our investigation, we can conclude that all paediatric nurses in HRK confirm the existence of overwork in this department. So the majority of healthcare team does not find a space of time to perform certain important tasks such as rigorous monitoring of patients, education of patients (on a disease, treatment or diet especially for diabetics, heart patients ...), hand washing, prevention of bedsores, communication ...

We can record that overwork has exceeded its impact on poor care to go to medication errors which is most often a risk factor to patient safety.100% of nurses find poor care one of the negative effects of overwork.

PROPOSED MODEL

In every hospital in the world, nurse-patient assignment is a basic routine for all healthcare units, but maintaining this routine is always difficult. Usually, the responsible nurse assigns each nurse to a group of patients. And as some patients need more care than others, extending the needs of a small number of patients may consume most of the nurse's time, while other patients receive only a minimal care. In this section, we developed an optimization model to propose an assignment of nurses to infants in a paediatric department of Kasserine hospital.

The desired objective is to minimize excess workload on the nurses, in order to increase quality of patient care, improve the quality of nursing work, and decrease the burden of nursing shortage.

A patient acuity system is an implement for determining, validating, and monitoring individual patient care requirements over time to make decisions such as patient assignments and effectiveness of nursing interventions. To measure a patient's acuity, it is necessary to have a detailed acuity system. Although hospital acuity systems are not explicitly defined, the first task is to develop a detailed acuity system. In the following steps, we present a brief explanation of this system along with some example acuity computations. For the calculation of the acuity scores, we have based our study on the research of [16]. In fact, the first acuity indicator in the paediatric department is respiratory status and the second indicator is the medications.

- Indicator 1: Respiratory status

This indicator is used to measure the amount of care associated with monitoring patient respiratory status. If the patient requires no oxygen, then, the respiratory status is assessed with the vital signs as a matter of convenience. If the patient needs oxygen administration, the respiratory status is assessed according to administration mode. To obtain an acuity score for indicator 1, we divide twenty-four by assessment frequency. For example, if a patient is receiving oxygen via pressure ventilation every 2 hours, then the score would be 24/2 = 12, indicating that respiratory status is assessed twelve times in a day, see Table V.

TABLE V
ACUITY SCORE FOR INDICATOR 1 CRITERIA

Indicator1 criteria	Acuity score
Free flowing O2	12
Nasal cpap	12
Pressure Ventilation	12
Jet ventilation	24

- Indicator 2: medications

We assign a score for each prescribed medication and we calculate the total sum that represents the score for the indicator. For example, we suppose a patient is prescribed two antibiotics, one every eight hours and the other every twelve hours. The module score is obtained by adding the two individual medication scores 24/8 + 24/12 = 5.

TABLE VI
ACUITY SCORE FOR INDICATOR 2 CRITERIA

Indicator 2 criteria	Acuity score
Day or less	1
18hrs	1
12 hrs	2
8 hrs	3
6 hrs	4
4hrs	6
2 hrs	12
1hrs	24

Patient Classification Systems (PCS) have been widely used to determine how many nursing hours a patient needs for his/her care. The model objective is to distribute acuity as uniformly as possible among nurses subject to some constraints. The proposed model assumes that patient acuity scores have been tabulated and that the number of nurses is given.

I. Problem description

Nurse-Patient assignment is a complex task because scheduler must consider multiple and contradictory goals, such as minimizing total costs while maximizing satisfaction of nurses' preferences. Literature specifies that the satisfaction of nurses is linked to their workload and working conditions.

Planning in healthcare is mostly manual, time-consuming and does not always yield the best results. Also, specialized software dealing with automated planning can be used, but it is, generally, very costly.

Nurse assignment aims to assign nurses to a certain number of patients to meet the needs of the hospital. This can lead to improved efficiency of hospital resources.

Indeed, the main objective seeks to allocate an optimal number of qualified nurses for each shift while minimizing the cost and maximizing the nurses' preferences.

Therefore, the purpose of this research is to propose a model that takes into account all the factors affecting nursing patients. To achieve this goal, it is necessary to understand patient classification systems, nursing resource allocation, nurse workload and patient care outcomes.

The need to propose a patient-nurse assignment is important for the three actors of the paediatric Department: Patients, Nurses and department leadership.

- First step: This is a significant problem for hospitals' administration because it considers the minimization of the hospital cost while considering better use of available resources such as the number of available nurses.

Therefore, Nurses' scheduling should meet the daily demands of the department as well as satisfy staffing policies such as those dictated by a union. Goals can conflict with each other making it difficult to determine the work schedule.

- Second step: Good working conditions for nurses are certainly necessary not only for the satisfaction of nurses but also for the patients. Similarly, good working conditions promote the quality of care.
- Third step: Better assignment of nurses improves the service provided to patients, hence, a better satisfaction of these patients. This leads to an improvement of the department performance.

II Notation and variables

The following notation is required to formulate the model:

- **Indices**

N: is the set of all nurses indexed by n
P: is the set of all patients (infants) indexed by p
K: is the set of shifts in the department indexed by k: k = 1 , 2 and 3 for the day (7 a.m.–13 p.m.) (13pm- 19 PM) and night (19p.m.–7 am.) shifts respectively
J: is the set of the days of the monthly planning period indexed by j

- **Parameters**

C_{pk}: is the acuity of an infant p in the shit k
a_k: is a specified upper bound on the total acuity in shift k
b_k: is a specified upper bound on the number of patients for nurses in shift k
UD: is the upper limit on the total number of nurses to assign to the day and night shift
LD: is the lower limit on the total number of nurses to assign to the day and night shift

Variables

$$X_{pnkj} = \begin{cases} 1, if\ an\ infant\ p\ is\ assigned\ to\ nurse\ n\ in\ shift\ k\ for\ day\ j \\ 0, otherwise \end{cases}$$

$$Y_{nkj} = \begin{cases} 1, if\ nurse\ n\ is\ assigned\ to\ shift\ k\ for\ day\ j \\ 0, otherwise \end{cases}$$

W_{min}: The minimum assigned acuity
W_{max}: The maximum assigned acuity
W_n: $The\ acuity\ workload\ of\ nurse\ n$
The model is presented as follow:

Mathematical model

$$Min\ Z = W_{max} - W_{\min}$$

Subject to

$$W_{\min} \leq W_{\mathrm{n}} \quad (1)$$

$$W_{\max} \geq W_{\mathrm{n}} \quad (2)$$

$$W_{\mathrm{n}} = \sum_{p=1}^{P} \sum_{k=1}^{K} \sum_{j=1}^{J} C_{pk} X_{pnkj}, \forall n = 1, \ldots, N \quad (3)$$

$$\sum_{n=1}^{N} X_{pnkj} = 1, \forall p = 1, \ldots, P, k = 1, \ldots, K, j = 1, \ldots, J \quad (4)$$

$$X_{pnkj} \leq Y_{nkj}, \forall\, p = 1, \dots, P, n = 1, .., N, k = 1, \dots, K, j = 1, \dots, J \quad (5)$$

$$\sum_{p=1}^{P} X_{pnkj} \leq b_k\, Y_{nkj}, \forall\, n = 1, .., N, k = 1, \dots, K, j = 1, \dots, J \quad (6)$$

$$\sum_{p=1}^{P} C_{pk}\, X_{pnkj} \leq a_k, \forall\, n = 1, .., N, k = 1, \dots, K, j = 1, \dots, J \quad (7)$$

$$\sum_{k=1}^{K} Y_{nkj} \leq 1, \forall\, n = 1, .., N, j = 1, \dots, J \quad (8)$$

$$Y_{n3j} + Y_{n1(j+1)} \leq 1, \forall\, n = 1, .., N, j = 1, \dots, J-1 \quad (9)$$

$$\sum_{n=1}^{N} Y_{nkj} \leq UD, \forall\, k = 1, \dots, K, j = 1, \dots, J \quad (10)$$

$$\sum_{n=1}^{N} Y_{nkj} \geq LD, \forall\, k = 1, \dots, K, j = 1, \dots, J \quad (11)$$

$$\sum_{p=1}^{P} X_{pnkj} \geq Y_{nkj}, \forall\, n = 1, .., N, k = 1, \dots, K, j = 1, \dots, J \quad (12)$$

$$Y_{n3j} + Y_{n3(j+1)} \leq 1, \forall\, n = 1, .., N, j = 1, \dots, J-1 \quad (13)$$

$$Y_{nkj} + Y_{nk(j+1)} + Y_{nk(j+2)} + Y_{nk(j+3)} \leq 3, \forall\, n = 1, \dots, N, k = 1,2, j = 1, \dots, J-3 \quad (14)$$

$$\sum_{j=1}^{J} Y_{n3j} \leq 3, \forall\, n = 1, .., N \quad (15)$$

$$\sum_{j=1}^{J} \sum_{k=1}^{K} Y_{nkj} \leq 6, \forall\, n = 1, .., N \quad (16)$$

The objective function consists on balancing nurses' acuity workload by the determination of the gap between both the maximum and the minimum assigned workloads. Constraints (1) and (2) concern the identification of the minimum and the maximum assigned workloads respectively. Constraint (3) is related to the calculation of the acuity workload assigned to each nurse. Constraint (4) assures that each infant is assigned to only one nurse in shift k; while constraint (5) assures that an infant is assigned to a nurse in shift k only if this nurse is assigned to a shift k in the day (If Ynkj=0 so Xnpkj=0). Constraint (6) guarantees that the number of patients assigned to each nurse in a shift cannot exceed bk. Constraint (7) assures that the total amount of acuity assigned to a nurse does not exceed a specified threshold in the shift. Constraint (8) assures that a nurse cannot work both the day and night shifts in a work day (only one shift per day). In constraint (9), a nurse assigned to a night shift cannot be assigned to the first day shift on the next day. Constraints (10) and (11) show that the overall number of nurses assigned to a day or night shift should be in the specified range. Constraint (12) guarantees that each nurse will be assigned to at least one infant in the shift k. Constraint (13) shows that a nurse should not work two consecutive night shifts. Constraint

(14) guarantees that a nurse cannot work more than 3 consecutive days with day shifts. In constraint (15), a nurse cannot work more than 3 night shifts/week. Constraint (16) shows that each nurse can have one day off after 7 days of work.

ANALYSIS OF THE MODEL

I. Computational experiments

Computational experiments are performed on real and simulated case instances using CPLEX 10.0 on personal computer Intel® Core 2 Duo CPU 2.0 GHZ. The calculations were carried out on a windows cluster. We used ILOG OPL 6.1 as modelling language and the mixed integer solver from CPLEX 10.1 (ILOG, 2010) commercial software for all the variants of the problem. Our algorithms are coded in C++ using Microsoft Visual Studio 6.0. CPU times are given in second.

II. Simulation scenario

This section presents a simulation scenario considering a simple example tested by the proposed model. This scenario is based on the following input data:

- Number of nurses=3;

- Number of patients=2;
- Number of shifts=3;
- Number of planning days=1;
- Patients acuity = [[1, 1, 1],[1, 0, 0]];
- A=[200, 300, 500];
- B=[5, 5, 5];
- UD=5;
- LD=1;

Table VII presents the obtained nurses-to-patients assignment planning while Table VIII details the obtained nurses workload.

TABLE VII
OBTAINED NURSES-TO-PATIENTS SIMPLE EXAMPLE ASSIGNMENT PLANNING

Patient index p	Nurse index n	Shift index k	Day index (j)	Assignment variable (Xpnkj)
1	1	1	1	1
1	1	2	1	0
1	1	3	1	0
1	2	1	1	0
1	2	2	1	0
1	2	3	1	1
1	3	1	1	0
1	3	2	1	1
1	3	3	1	0
2	1	1	1	1
2	1	2	1	0
2	1	3	1	0
2	2	1	1	0
2	2	2	1	0
2	2	3	1	1

2	3	1	1	0
2	3	2	1	1
2	3	3	1	0

TABLE VIII
OBTAINED SIMPLE EXAMPLE TOTAL NURSES ACUITY WORKLOAD

Nurse index (n)	Total acuity workload (Wn)
1	2
2	1
3	1
Workload deviation	1

As a first test, we can show the effectiveness of the proposed model, which has provided a totally balanced workload between the different nurses.

III. Computational results

To test the effectiveness of the proposed mathematical model, we compared the obtained results (in terms of total nurses' acuity workload and total nurses' workload differences) to operational methods produced by the pediatric department. In this department, the planning horizon of the nurses' assignment consists of 7 days.
The input real case study data related to this department (from 7/09/2020 to 13/09/2020) are detailed as follows:

- Number of nurses=10;
- Number of patients=26;
- Number of shifts=3;
- Number of planning days=7;
- Patients acuity = [[6, 12, 4],[15, 8, 12], [8, 13, 10], [8, 8, 7], [5, 11, 13], [1, 12, 1],[2, 12, 1],[8, 12, 8],[15, 12, 12],[1, 4, 1],[4, 8, 8],[12, 8, 8],[8, 4, 4],[4, 4, 4],[8, 12, 8],[5, 12, 12],[8, 5, 8],[1, 4, 1],[2, 5, 5],[8, 4, 8],[4, 12, 12],[6, 5, 5],[6, 6, 12],[2, 2, 2],[4, 6, 6],[8, 6, 8]];
- A=[200, 250, 500];
- B=[13, 13, 13];
- UD=4;
- LD=1;

Table IX presents the total nurses acuity workload as well as the total nurses' workload differences of both the nurses-to-patients assignments model and the real case study assignment. Columns 3 and 5 measures the deviation of respectively the actual total acuity workload and the proposed model total acuity workload face to the mean of the total nurses' workload. The calculation of the deviation is based on the following formula:

Deviation= (total acuity workload-Workload Mean)/Workload Mean

As illustrated in this table, we notice a significant imbalance of the real case study acuity workload assignments, in which the deviation regarding the average Workload can reach 0.279. In the other hand, the proposed model presents a greatly reduced deviation between all the nurses' workloads (it has not exceed 0,002), which justifies its important amelioration in the nurses' assignment process of the paediatric department.

TABLE IX
COMPARISON OF TOTAL NURSES ACUITY WORKLOAD

Assignment	Actual total acuity workload	%deviation	Proposed model acuity workload	% deviation

Nurse1	489	0,27943485	382	-0,00052329
Nurse 2	305	-0,20198849	382	-0,00052329
Nurse 3	457	0,19570905	383	0,00209314
Nurse 4	428	0,11983255	382	-0,00052329
Nurse 5	332	-0,13134485	382	-0,00052329
Nurse 6	333	-0,12872841	382	-0,00052329
Nurse 7	341	-0,10779696	383	0,00209314
Nurse 8	341	-0,10779696	382	-0,00052329
Nurse 9	314	-0,17844061	382	-0,00052329
Nurse 10	482	0,26111983	382	-0,00052329
Mean	382,2		382,2	
Workload difference	184		1	

Figure 1 summarizes the balance degree between the nurses acuity workloads of both the real case study actual nurses assignment and the proposed nurses assignment planning. As shown in the figure, there is a considerable variation in the real case study assignment, which can justify the need of the pediatric department to balance the total acuity workload between the different nurses. On the other side, the application of the presented mathematical model has noted an almost completely balanced nurses' acuity workload.

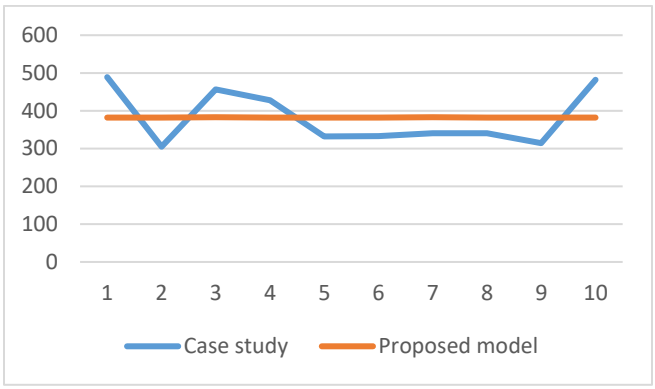

FIGURE 1.
PERFORMANCE OF THE PROPOSED NURSES-TO-PATIENTS ASSIGNMENT MODEL

As a conclusion, we can deduce that the implementation of the acuity tool proved its efficiency not only face to the enhanced quality of care provided to patients on the unit, but also regarding the nurses satisfaction and then the economical level considered by the department manager.

CONCLUSION

The nurse scheduling problem is an interesting for hospital's staff. In general, it is efficiently utilize the time and effort, to balance the workload.

In this work, we proposed a linear integer program that assigns nurses to patients and minimizes excess workload. We provided computational results demonstrating the effectiveness of the model. This study was welcomed by the staff, managers, and administrators and offered a desired positive change. Therefore, future work will focus on modification of Model by using genetic algorithms.

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