ORIGINAL ARTICLE

Emergency Room Nurse Scheduling at a Public Hospital in Jakarta during Covid-19 Pandemic, Using TPB Algorithm Method

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ABSTRACT

Introduction: The emergency room (ER) is a department that has a high potential risk of exposure to the Covid-19 viruses. Nursing management must anticipate the ratio of nurses and patients in the ER is maintained at a minimum ratio of 1:4. Nurse scheduling is not an easy job to provide satisfaction to the nurses by distributing schedules evenly but operating costs can be kept to a minimum. This study is aimed to meet the demands of nurses in line with the current patient growth with two days off per week and to determine the individual correct shift pattern to achieve 40 hours per week during the Covid-19 Pandemic. **Method:** the modified Tribrewala, Phillipe, and Browne (TPB) algorithm. **Results:** The current ER nurse ratio to the patient is 8 nurses for 9 patients (0.8>0.25). The required ER nurses based on TPB algorithm calculations are 35 people per day. The current ER Nurses' shift patterns do not match with the calculated shift pattern based on the TPB methodwhich meets the government regulations that each nurse works 40 hours per day. The number of nurses who are on vacation based on vacation optimization is 5 nurses per day. **Conclusion:** The ER of a Public Hospital in Jakarta has enough workforces during the Covid-19 pandemic; however, the shift patterns and vacation optimization still need improvement.

Keywords: Tribrewala, Phillipe and Browne (TPB) algorithm, Emergency room (ER) Nurse, calculation, Occupational health, and safety, Shift work.

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INTRODUCTION

According to the Hospital Law of the Republic of Indonesia No. 44 of 2009 that the hospital is defined as a health service institution that provides complete individual health services such as inpatient, outpatient, and emergency services. Hospitals have an obligation to provide emergency services to patients according to their abilities, implement and maintain health service standards in the hospital as guidance in serving patients. A heavy burden is currently being felt by all health workers when facing the Covid-19 pandemic. Nurses and other health workers who are directly at the forefront of health services have responsibilities in handling Covid-19 in their respective work areas and they must maintain their stamina, physical, and mental. The emergency room (ER) is a department that has a high potential risk of exposure to the Covid-19 viruses from patients who come to this unit as accentuated by WHO (2021) that health workers potentially suffer from illness, trauma, and death in response to Covid-19 related patients (1).

In anticipating a surge in patients coming to the ER, nursing management must anticipate the schedule of nurses appropriately in this unit to prevent a shortage of nursing staff in delivering professional care and the ratio of nurses and patients in the ER can be maintained at a minimum ratio of 1:4, which means every 1 nurse can handle 4 patients (2).

Nurse scheduling is one of the challenges in health organizations that is difficult to solve. The uncontrolled number of patients, the critically ill patients, the characteristics of the organization, the presence of absences and personal requests for vacations, and the qualifications and specialties of the nurses themselves are some of the factors why nurse scheduling is difficult (3).

According to Indonesian Labour Law no. 13 of 2003, the applicable working hours in Indonesia are seven hours a day and 40 hours in a week for employees with six working days. As for employees with five working days in a week, their obligation to work is eight hours in a day and 40 hours a week. However, the above working time provisions do not apply to certain work sectors, for example, hospitals that provide 24 hours service. This service can be arranged by doing shift work that can cover 24 hours of service while the workers still get 40

hours of work per week with a balanced day off.

According to another research the shift work is defined as one or a group of people who are scheduled or arranged to work at the workplace in a 24-hour period (4). Shift work is a strategy of scheduling work hours in such a way that different groups of permanent employees perform the same job tasks in different timeframes for 24 hours (5).

Taufik (2019) in his study mentioned that basically, there are 3 (three) important aspects that need to be considered in the selection of a shift system, (5) namely Workforce Health and Safety, Work Performance and Social Interaction.

Nurses are vulnerable to psychosocial hazards including frequent contact with patients, shift work, overwork, and physical threats (6). According to another research the shift workers, especially those who work at night, can be affected by several health problems including sleep disorders, fatigue, heart disease, high blood pressure, and gastrointestinal disorders (5). All these health problems, plus a lot of stress can automatically increase the risk of accidents for night shift workers.

Workforce scheduling is the allocation of human resources at a certain workstation with a predetermined time and place in carrying out the tasks that have been planned to achieve company goals (7). Nurse scheduling is not an easy job as it can be contrary to the goal of giving satisfaction to nurses by distributing schedules evenly but operating costs can be kept to a minimum (8). Taufik (2019) (5) describes the criteria for work shifts that must be agreed upon by management and workers include working hours per day should not exceed 8 hours, the number of consecutive night shifts for a worker should be kept to a minimum, every night shift must be followed by at least 24 hours off day, each work shift plan must include weekends, at least 2 consecutive days.

This study is aimed to meet the demands of nurses in line with the current patient growth with appropriate distribution of vacation among the shift team with two days off per weekand to determine the individual correct shift pattern to achieve 40 hours per week during Covid-19 Pandemic. Based on the foregoing, nurse scheduling in the ER of a Public Hospital in Jakarta needs to be evaluated scientifically so as nursing management can determine the schedule of ER nurses appropriately to prevent workforce shortage during the Covid-19 pandemic.

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MATERIALS AND METHODS

This study uses quantitative data that was obtained from a Public Hospital in Jakarta. The data used in this study consisted of primary data which is the result of data processing in this study, while secondary data come from the documents that have been provided by the hospital such as the schedule of nurses in the ER, data on the number of patients in 2020 handled by nurses and working hours data.

The method used in this research is the modified Tribrewala, Phillipe, and Browne (TPB) algorithm method as done by Ikasari, Pawennari, and Fatimah (2019) and Gea (2020) (7,8), by changing the tabular table format of workforces scheduling for three shifts. This algorithm starts with a forecasted demand profile and determines the vacation of a worker at a time. The steps for nurse scheduling with the TPB method are described as follows:

a. Determine the day with the largest workforce requirement, then determine the second-largest day, and so on. Place the requirements of days that have the same requirements in the schedule until 2 unique consecutive days are obtained and show the schedule for 5 working days and 2 vacations. If this is not possible then do Step 2.
b. If there are 2 consecutive pairs of vacations, select the day that has the least need on the day that is close together. If this cannot be done, then do Step 3.
c. Choose the most reasonable pair of days, for example, choose a Saturday and Sunday pair as a vacation.

In this study, the approach taken from the TPB method is as follows:

a. Schedule a workforce of 3 shifts a day during the workday
b. Determine 2 days off from work for each worker
c. Determine workforce needs.

Gea (2020) explained that changes to the rules for selected vacations are made as there are several considerations and constraints. The following is an explanation of changing the vacation rules in the modification of the algorithm of TPB (8):

Preposition1: Choosing vacations with the least workforce requirements.

Min {Di}, i

Description:

Di = Workforce requirement on particular day.

i = Day (Monday to Sunday)

Preposition2: After vacations, scheduling the morning shift that has the most workforce requirements, choosing a day off before the morning shift is choosing the day where the next day has the most workforce requirements for the morning shift.

Max {$D1_{i+1}$}

Description:

$D1_{i+1}$ = The need for the workforce in the morning shift after a vacation.

Preposition3: Before vacations, scheduling the night shift that has the most workforce requirements, choosing

the day off after the night shift is choosing the day where the previous day has the most workforce requirements for the night shift.
Max {*D*3*i*-1}
Description:
*D*3*i*-1= The need for the workforce in the night shift before a vacation.

Selection of the right vacation is when the need for the workforce on that day is at least taking into account the need for the workforce in shift-Morning (M) after the most days off where the choice of a day before shift-M is to choose a day off where the next day the workforce needs on shift-M the most and considering the need for the workforce in shift-Night (N) before the most vacations where the selection of days off after shift-N is to choose the day that needs the most workforce. Based on the principle of selection, vacation optimization can be determined by equation (2-1) (8).

V = (*D*3*i*-1+ *D*1*i*+1) – D*i*
V = Vacation

RESULTS

The nurse requirement in one week at the ER of a Public Hospital in Jakarta consisting of 3 shifts per day and there are 8nurses on duty in one shift. According to Ikasari, Pawennari, & Fatimah (2019) (7), the following iteration steps are described below:
a. Determine the number of workforce requirements per day in one week and divide the workforce requirements into 3 work shifts (Table I).
b. Determine vacations (Table II)
1) Choosing a vacation based on the largest V value that results from the number of workforce requirements in shift-N before vacations plus the need for the workforce in shift-M after vacations minus the workforce needs on that day.
2) Put value 0 on all shifts selected as vacations. For example, determining the value of vacations on Saturdays and Sundays, the number of the workforcerequirements on that day is 24, the need for workforce on the previous day (Friday) on shift-N is 8 and the need for the workforce on the following day (Monday) on shift-M is 8 so:
V = (*D*3*i*-1+ *D*1*i*+1) – D*i*
V = (8+8) – 24
V = -8
3) To produce the V value on another day, it can be done with the same calculation as the V value on the previous day. After calculating V on all days other than vacations, the next step is to choose the greatest V value. This is in accordance with the factors described previously. Since in iteration 1, the V values on each day are all the same, namely – 8, then the V value can be chosen on the most reasonable day. In this study, Saturday and Sunday were chosen as days off since they had consecutive vacations. To select a vacation, it can be marked by giving the value 0 as shown in Table III.

Determining the value of V on Monday is done the same as the previous formula as follows:
V = (*D*3*i*-1+ *D*1*i*+1) – *Di*
Vacation optimization is the workforce requirement of shift-N on a day that is reduced by one day from the selected day (shift-N on the day before the selected day) plus the need for the workforce for shift-M on the day added by one day from the selected day (shift-M on days after the selected day) minus the amount of workforce required on the selected day. To find the value of V on

Table I: Tabular table format of ER Nurse scheduling for three shifts

Days	Monday			Tuesday			Wednesday			Thursday			Friday			Saturday			Sunday		
Required Nurses/day	24			24			24			24			24			24			24		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Table II: Calculation of V value every day

Days	Monday			Tuesday			Wednesday			Thursday			Friday			Saturday			Sunday		
Required Nurses/day	24			24			24			24			24			24			24		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
V		-8			-8			-8			-8			-8			-8			-8	

Table III: Determination of Score (-1) before and after Off days

Days	Monday			Tuesday			Wednesday			Thursday			Friday			**Saturday**			**Sunday**		
Required Nurses/day	24			24			24			24			24			24			24		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Schedule	-1						-1								-1	0	0	0	0	0	0
V		-8			-8			-8			-8			-8			-8			-8	

Tuesday to Sunday can be done in the same way as the value of V on Monday.

c. One day after the vacation in iteration 1 is Monday, schedule workers in shift-M by marking value -1 and one day before the vacation in this iteration is Friday, namely in the shift-N by marking the value -1. In the middle of the two, namely Wednesday, schedule the workforce for shift-Afternoon (A) by giving a value of -1 as shown in Table IV.

d. On the remaining days, compare the workforce requirements on shifts-M and A between the scheduled day of shift-M on Monday and the scheduled day for shift-A on Wednesday, i.e. Tuesday, as well as the need for the workforce on shifts-A and N between the scheduled day of shift-A on Wednesday and the scheduled day of shift-N on Friday, i.e. Thursday. Schedule workers on shifts-M or A on Tuesdays and on shifts-A or N on Thursdays by selecting the greater workforce requirement in each shift. Because the value of the required value of the workforce required is the same, then the assignment can be selected on shift-M or shift-A on the day between the scheduled shift-M on Monday and the scheduled day shift-A on Wednesday, i.e. Tuesday. In this iteration, the workforce is scheduled for shift-M, then on the scheduled day of shift-A on Wednesday and the scheduled day of shift-N on Friday, i.e. Thursday, the workforce is scheduled for shift-A, so the scheduling in iteration 1, shift-M on Monday and Tuesday, shift-A on Wednesday and Thursday, and shift-N on Friday and vacations on Saturday and Sunday as shown in Table IV.

e. After scheduling the workforce on days and shifts with values of -1 and 0 on vacations, the next step is to determine the need for new requirements which will be used as shift needs in the next iteration (Table V).

To determine the number of the new required workforce or the remaining workforce that has not been scheduled, it can be done by reducing the need for a workforce with the scheduled workforce for each shift. As in the need for shift-M on Monday, it is reduced by the scheduled workforce on shift-M. Likewise, the other shifts are carried out, in the same way, every day.

The way to calculate iteration 2 is exactly the same as how to calculate iteration 1, it must be remembered to always choose the largest number when placing the number (-1) outside the off days and outside the day before and after the off (Table VI).

The iterations have reached 35 times as shown in table VII with a workforce requirement ≤ 0, since the calculation of the number of workforces is the same as the number of iterations, so the 3 work shifts per day and

Table IV: Determination of Score (-1) on Tuesday and Thursday

Days	Monday			Tuesday			Wednesday			Thursday			Friday			**Saturday**			**Sunday**		
Required Nurses/day	24			24			24			24			24			24			24		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Schedule	-1			-1			-1			-1					-1	0	0	0	0	0	0
V	-8			-8			-8			-8			-8			-8			-8		

Table V: Iteration 1

Days	Monday			Tuesday			Wednesday			Thursday			Friday			**Saturday**			**Sunday**		
Required Nurses/day	24			24			24			24			24			24			24		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Schedule	-1			-1			-1			-1					-1	0	0	0	0	0	0
New required Nurses/ shift	7	8	8	7	8	8	8	7	8	8	7	8	8	8	7	8	8	8	8	8	8
V	-8			-8			-8			-8			-8			-8			-8		

Table VI: Iteration 2

Days	Monday			Tuesday			Wednesday			Thursday			Friday			**Saturday**			**Sunday**		
Required Nurses/day	23			23			23			23			23			24			24		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	7	8	8	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Schedule	0	0	0	0	0	0	0	-1		-1				-1				-1			-1
New required Nurses/ shift	7	8	8	7	8	8	7	7	8	7	8	7	8	7	7	8	8	7	8	8	7
V	-7			-7			-7			-7			-7			-8			-8		

Table VII: Iteration 35

Days	Monday			Tuesday			Wednesday			Thursday			Friday			**Saturday**			**Sunday**		
Required Nurses/day	0			0			0			0			0			0			0		
Job Shift	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
Required Nurses/shift	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schedule			-1			-1			-1	0	0	0	0	0	0	-1			-1		1
New required Nurses/ shift	0	0	-1	0	0	-1	0	0	-1	-1	0	0	0	-1	0	-1	0	0	0	-1	0
V		1			1			1			2			2			1			1	

2 days off a week require 35 people. There are negative numbers on the need for new required nurses per shift that indicate overstaffing on certain days.

Iterations results:

a. Saturday-Sunday: Iteration 1, 8, 15, 22, 29
b. Monday-Tuesday: Iteration 2, 9, 16, 23, 30
c. Wednesday-Thursday: Iteration 3, 10, 17, 24, 31
d. Friday-Saturday: Iteration 4, 11, 18, 25, 32
e. Sunday-Monday: Iteration 5, 12, 19. 26, 33
f. Tuesday-Wednesday: Iteration 6, 13, 20. 27, 34
g. Thursday-Friday: Iteration 7, 14, 21, 28, 35

DISCUSSION

Nowadays and due to the pandemic of COVID-19, nurses are working under the highest pressure benevolently all over the world. This urgent situation can cause more fatigue for nurses who are responsible for taking care of ER for 24 hours (9). The patient visits data at the ER from January to December 2020 with an average of 847 patients per month. There are 38 nurses who work in three-shift and 4 people with non-shift who work in the morning and are responsible for the managerial, operation, and administrative tasks in the ER. These 4 nurses are excluded from this study as they are non-shift workforces.

The ER serves 28 patients/day, or 9 patients/shift. According to the schedule, the allocation of on-duty nurses is 8 people per shift or 24 people in one day while the remaining 14 people are off duty, sick due to COVID-19 or other illnesses, annual leave, and absence with permission. The ratio of nurses to patients in the ER is usually 1:4, but the current data shows a ratio of 1:1, meaning that the needs of nurses have been met and exceed the standards commonly used in the world.

The work schedule for nurses who work in the morning and evening services is 7 hours each, while at night is 11 hours with an overlap of 30 minutes between the morning duty and the afternoon duty nurses and 30 minutes between the night duty and the morning duty nurses. So, in one working day, there is an excess of 1 hour of coverage for handover.

Nursing management considers shorter morning and evening service time is to reduce fatigue in nurses by handling a greater number of patients in the morning and evening than at night.

The shift pattern being implemented now is 5 working days and 2 days off with a total of 8 ER nurses per shift, but the pattern is irregular and often changes for various reasons so the total hours are also not well distributed, many of ER nurses get 43 hours per week, some of them get 35 and 39 hours per week.

Another research study shows that TPB application help the process of scheduling the event of changes relating to the scheduling so that the scheduling process can be done at any time by efficiently and effectively (10). Based on the calculation with the TPB algorithm method, the ER of a Public Hospital in Jakarta just requires 35 nurses per day and each nurse will get two days off per week. The number of nurses who are on vacation based on vacation optimization is 5 nurses per day. Since the hospital has currently 38 nurses per day, there are 3 extra nurses who can be used as a backup to replace nurses who take annual leave, sick leave, maternity leave, covid-19 isolation, and absence with and without permission.

CONCLUSION

The required ER nurses based on TPB algorithm calculations are 35 people per day while the hospital has currently 38 nurses who work in shifts. There are 3 extra nurses who can cover those who are on annual leave, sick leave, maternity leave, covid-19 isolation, and absence with and without permission. The current ER Nurses' shift patterns do not match with the calculated shift pattern based on the TPB method which meets the government regulations that each nurse works 40 hours per day. The ideal number of nurses who are on vacation based on vacation optimization is 5 nurses per day.

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