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Forecasting The Number Of Nurses In Emergency Installation In Kalabahi Regional Hospital In 2019 Using The Markov Chain

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Abstract: *The Kalabahi Regional Hospital often experiences problems related to the increasing number of patients who come to the hospital to be treated, both from the referral health center and those who come directly to be treated, therefore it is necessary to have good management in empowering nurses at the Kalabahi regional hospital and until Currently, there is still a lack of nursing staff at the Kalabahi Regional Hospital. In improving services to the community, it is necessary to analyze the probability of the number of nurses at the Kalabahi Regional Hospital. One method that is suitable for predicting the number of nurses at the Kalabahi Regional Hospital is the Markov Chain method. The results obtained are that the probability of moving from state one to state one is 0.89, and state one to state three is 0.11. the probability of moving from state two to state one is 0, state two to state one is 0.98, and state two to state three is 0.2. the probability of moving from state four to state one is 0.33, state four to state two is 0.67, and state four to state one is 0. Forecasting the number of nurses in 2019 is 25 people with a total composition of nurses based on education level, namely for nurses as many as 5 people and DIII as many as 20 people.*

Keywords: Forecasting, Nurses, Markov Chain

1. Introduction

The Kalabahi Regional Hospital is a type of general hospital in Alor Regency, as a referral center for advanced health services located in the capital city of Alor Regency, Kalabahi. The Kalabahi Regional Hospital has a number of treatment rooms, one of which is the Emergency Room. Emergency Installation is a service provided for the needs of patients who are in an emergency condition and must be taken to the hospital for quick emergency treatment. The Kalabahi Regional Hospital often experiences problems in the nursing service process due to a shortage of nurses. Until now, the Kalabahai regional hospital has not had a forecast regarding the number of nurses working in the emergency room. Forecasting or forecasting can help calculate the employees needed by organizations including nursing organizations for now and in the future. Managers in charge of the workforce need to predict the future of the workforce in their organization and decide where to meet the need of the workforce, given that workforce forecasting, especially for the nursing workforce is very important, it is necessary to do forecasting so that decisions are made to determine the number and size of the workforce. the need for nurses in the future can run well. A method in mathematics that can be applied in forecasting employment is Markov Chain, Markov analysis is used to find probabilities that will arise in the future, by analyzing the probability at this time. One of the purposes of this method is to predict the future. This technique has various applications in the business world, including market share analysis, loss prediction, prediction of new student admissions at the University, and determining whether a machine will be damaged in the future (Anggriya, 2009). Markov analysis is not an optimization technique, but a descriptive technique that produces probability information. Markov analysis can be applied to other situations, all the time. Markov analysis is almost the same as Decision Analysis, the difference is that Markov Chain analysis does not provide recommendation decisions, but only probability information about decision situations that can help make decisions.

2. Markov Chain Model Process

According to Hamdy A. Taha (1997), the Markov process is a stochastic system that will come to a state in the future facing a situation that immediately anticipates it and only relies on it.

There are three steps in analyzing and modeling the Markov Chain. These steps are:

a. Transition Probability Matrix

According to Siswanto (2007) the dynamics of the observed variables affect each state in the Markov process into a matrix known as the transitional probabilitywith dimension mxn.

The transition probability matrix makes it possible to calculate the probability of a future state based on the current state. After the research data is obtained, it can be seen the need for labor. Thus, it can be arranged in the form of a transition probability matrix and it will be seen the addition and reduction of labor. In this case P_{ij} reflects the probability of changing from state i to state j or from state j to state i, depending on the placement, from i to j or vice versa. This placement will of course have consequences on the operation matrix. There are no standard guidelines for this. If a vector with dimensions $(1xm)$ is multiplied by a matrix with dimensions (mxn) then this multiplication will produce a vector with dimensions $(1xn)$. On the other hand, if matrices with dimension (mxn) are multiplied by vector with dimension $(nx1)$, it will produce a vector with dimension $(mx1)$. The dimensions of this vector, according to the explanation of the placement of and to, of course must conform to the rules of matrix operations. The following description will explain this:

P_{ij} = probability of being in state j in the future based on current state i. For example, P_{12} is the probability of being in state 2 in the future and previously being in state 1. For more

details, it can be seen in the following matrix, where P is the transition probability matrix.

$$P = \begin{pmatrix} P_{11} & P_{12} & \dots & P_{1m} \\ P_{21} & P_{22} & \dots & P_{2m} \\ \vdots & \vdots & \dots & \vdots \\ P_{n1} & P_{n2} & \dots & P_{nm} \end{pmatrix}$$

$$(P_{11} \quad P_{12} \quad \dots \quad P_{1n}) \times \begin{pmatrix} P_{11} & P_{12} & \dots & P_{1m} \\ P_{21} & P_{22} & \dots & P_{2m} \\ \vdots & \vdots & \dots & \vdots \\ P_{n1} & P_{n2} & \dots & P_{nm} \end{pmatrix}$$
$$= (P_{11} \quad P_{12} \quad \dots \quad P_{1m})$$

3. Data Analysis Techniques

The analytical method used in this research is Markov Chain. There are several steps of labor forecasting using Markov Chain are:

a. State determination

Determination of the state in terms of the state of education level, the state of adding nurses, and the state of reducing nurses.

b. Calculating probability values between states

Calculate the probability value between states using the following formula:

$$Probability = \frac{number\ of\ possible\ outcomes\ (m)}{total\ number\ of\ possible\ outcomes\ (n)}$$

c. Formation of the transition probability matrix

Transition probability matrix is a matrix that contains information that regulates the movement of the system from one state to another. The transition probability matrix is often called a stochastic matrix because it is a probability. The transition P_{ij} is fixed and does not depend on time t, where P_{ij} is the one-step transition probability moving from state i to state j. The transition probability matrix is used to calculate the composition of education levels.

For the calculation of the transition probability matrix, the following formula can be used:

$$P_{ij} = \frac{number\ of\ possible\ outcomes\ (m)}{total\ number\ of\ possible\ outcomes\ (n)}$$

d. Predicting labor needs by using labor forecasting models.

$$Y = a + bX;$$

Y = number of workers; X = Period

e. Determine the prediction of the composition of the composition of the workforce for

the formula for multiplying two matrices is:

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} B = \begin{bmatrix} e & f \\ g & h \end{bmatrix}$$

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \times B = \begin{bmatrix} e & f \\ g & h \end{bmatrix} = \begin{bmatrix} a.e + b.g & a.f + b.h \\ c.e + d.g & c.f + d.h \end{bmatrix}$$

4. Results and Discussion

a. Result

Table 1. List of Number of Nurses in Emergency Room Nurses at Kalabahi hosoital

year	*number of nurses*
2016	*24*
2017	*24*
2018	*25*

Source: Head of Emergency Room at Kalabahi hospital

Table 1 states that the number of emergency room nurses at the Kalabahi Hospital in 2016 was 24 people in 2017, as many as 24 people in 2018 and as many as 25 people.

The list of reductions in the number of nurses in the emergency room of Kalabahi hospital from 2016 to 2018 is listed in table 2 below.

Table 2. List of Reductions in Emergency Room Nurses at Kalabahi hosoital

No	Education	*Period*		
		2016	*2017*	*2018*
1	*Ners*	*0*	*2*	*0*
2	*Diploma III*	*1*	*0*	*0*
Total		*1*	*2*	*0*

Source: Head of Emergency Room at Kalabahi hospital

Based on table 2, the total reduction of nurses in the emergency room of RSD Kalabahi for 2016 Diploma III was 1 person, in 2017 there were 2 nurses, and in 2018 there was no reduction in nurses.

The list of additional nurses at the Kalabahi hospital from 2016 to 2018 is listed in table 3 below.

Table 3. List of Additional Nurses in Emergency Room Nurses at Kalabahi hosoital

No	Education	*Period*		
		2016	*2017*	*2018*
1	*Ners*	*0*	*2*	*0*
2	*Diploma III*	*1*	*0*	*1*
Total		*1*	*2*	*1*

Source: Head of Emergency Room at Kalabahi hospital

Based on table 3, the total addition of nurses in Emergency Installation at Kalabahi Hospital for 2016 Diploma III was 1 person, in 2017 Nurses were 2 people in 2018 Diploma III was 1 person.

b. Discution

Table 4 Probability of the Number of Nurses for emergency installations at Kalabahi Hospital

Years	Number of nurses
2016	0.33
2017	0.33
2018	0.34
Total	1.00

⇨ B

The probability of the Number and Composition of Nurses in the emergency installation of the Kalabahi Hospital can be seen in table 8 below.

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Table 5 Probability of Number and Composition of Nurses emergency installation at kalabahi hospital

Education	Period		
	2016	2017	2018
Ners	0.25	0.25	0.24
Diploma III	0.75	0.75	0.76

⟹ C

1. Probability of the composition of nurses (the composition of nurses based on the number of existing workers)

$$CXB = \begin{bmatrix} 0{,}25 & 0{,}25 & 0{,}24 \\ 0{,}75 & 0{,}75 & 0{,}76 \end{bmatrix} \begin{bmatrix} 0{,}33 \\ 0{,}33 \\ 0{,}34 \end{bmatrix}$$

$$= \begin{bmatrix} 0{,}25(0{,}33) & 0{,}25(0{,}33) & 0{,}24(0{,}34) \\ 0{,}75(0{,}33) & 0{,}75(0{,}33) & 0{,}76(0{,}34) \end{bmatrix}$$

$$CXB = \begin{bmatrix} 0{,}25 \\ 0{,}75 \end{bmatrix}$$

Based on the multiplication of the transition probability matrix based on the level of education, the probability for Nurses is 0.25 and Diploma III is 0.75.

2. Probability of reducing the number of nurses (transferred to another field/room, moving or leaving at their own will and this reduction in nursing staff is included in one state, namely state three)

$$DXB = \begin{bmatrix} 0{,}00 & 1{,}00 & 0{,}00 \\ 1{,}00 & 0{,}00 & 0{,}00 \end{bmatrix} \begin{bmatrix} 0{,}33 \\ 0{,}33 \\ 0{,}34 \end{bmatrix}$$

$$= \begin{bmatrix} 0{,}00(0{,}33) & 1{,}00(0{,}33) & 0{,}00(0{,}34) \\ 1{,}00(0{,}33) & 0{,}00(0{,}33) & 0{,}00(0{,}34) \end{bmatrix} \begin{bmatrix} 0{,}33 \\ 0{,}33 \\ 0{,}34 \end{bmatrix}$$

$$DXB = \begin{bmatrix} 0{,}33 \\ 0{,}33 \end{bmatrix}$$

Based on the multiplication of the transition probability matrix on the reduction in the average number of nurses, the workforce is transferred to another field/room. Moving or leaving at their own will and this reduction in nursing staff is certain to occur. From the calculation of the matrix the average reduction of nurses with a probability of 0.33 while Diploma III is 0.33.

3. Probability of adding nurses

$$EXB = \begin{bmatrix} 1{,}00 & 0{,}00 & 0{,}00 \\ 0{,}00 & 0{,}00 & 1{,}00 \end{bmatrix} \begin{bmatrix} 0{,}33 \\ 0{,}33 \\ 0{,}34 \end{bmatrix}$$

$$= \begin{bmatrix} 1{,}00(0{,}33) & 1{,}00(0{,}33) & 0{,}00(0{,}34) \\ 0{,}00(0{,}33) & 0{,}00(0{,}33) & 1{,}00(0{,}34) \end{bmatrix} \begin{bmatrix} 0{,}33 \\ 0{,}33 \\ 0{,}34 \end{bmatrix}$$

$$EXB = \begin{bmatrix} 0{,}66 \\ 0{,}34 \end{bmatrix}$$

Based on the multiplication of the transition probability matrix for the addition of nurses, the average workforce is transferred to other fields/rooms. Moving or entering of their own volition and the addition of nurses is certain to occur. From the calculation of the matrix the average reduction of nurses with a probability of 0.66 while the DIII with a probability of 0.34.

Based on the multiplication of the transition probability matrix for the addition of nurses, the average workforce is transferred to other fields/rooms. Moving or entering of their own volition and the addition of nurses is certain to occur. From the calculation of the matrix the average reduction of nurses with a probability of 0.66 while the DIII with a probability of 0.34.

4. Calculate the probability between states

To calculate the Transition Probability Matrix, the author calculates the displacement between states, the first is the displacement from state one to state one and three. The number of shifts of nurses from state one (Ners) to state one (Ners) for 2016-2018 is obtained from:

a. Nurse education in 2016 in the table of the number of nurses and composition (table 4) - {[Nurs education in 2016 in the table adding to the number of nurses (table 3)] + [Nurs education in 2016 in the table on the number of nurses who experienced changes in education level (table 5)]} = 6-(0+0)=6
b. Nurse education in 2017 in the table on the number of nurses and composition (table 4) - {[Nurs education in 2017 in the table adding to the number of nurses (table 3)] + [Nurs education in 2017 in the table on the number of nurses who experienced a change in education level (table 5)]} = 6-(2+0)=4
c. Nurse education in 2018 in the table of the number of nurses and composition (table 4) - {[Nurs education in 2018 in the table adding to the number of nurses (table 3)] + [Nurs education in 2018 in the table on the number of nurses who experienced changes in education level (table 5)]} = 6-(+0)=6

To fill in the table for the transfer of the number of nurses from state one to state three for 2016-2018, namely:

a. From state one (nursing education) to state three (reduction of nurses) for 2016 it is obtained from the table of reduction of nurses (table 2) in 2016 which is 0
b. From state one (nursing education) to state three (reduction of nurses) for 2017 it is obtained from the table of reductions in nurses (table 2) in 2017 which is 2
c. From state one (Nurse education) to state three (reduction of nurses) for 2018 it is obtained from the table of reduction of nurses (table 2) in 2018 which is 0

Below is a table of displacement from state one to state one and three.

Table 6Transfer from State One to State One and Three

No	State displacement		Period			Total
	Dari	Ke	2016	2017	2018	
1	1	1	6	4	6	16
2	1	3	0	2	0	2
Total			6	6	6	18

From table 9 above, the probability of the transition matrix for moving from state one to state one and three can be obtained in general as follows.

$$P_{1,1}\text{years}2016 = \frac{6}{6} = 1{,}00$$
$$P_{1,1}\text{ years } 2017 = \frac{4}{6} = 0{,}67$$
$$P_{1,1}\text{years } 2018 = \frac{6}{6} = 1{,}00$$
$$P_{1,3}\text{years } 2016 = \frac{0}{6} = 0{,}00$$
$$P_{1,3}\text{ years } 2017 = \frac{2}{6} = 0{,}33$$
$$P_{1,3}\text{years } 2018 = \frac{0}{6} = 0{,}00$$
$$P_{1,1}\text{ total} = \frac{6+4+6}{6+6+6} = \frac{16}{18} = 0{,}89$$
$$P_{1,3}\text{total} = \frac{0+2+0}{6+6+6} = \frac{2}{18} = 0{,}11$$

Based on the above calculations, it can be summarized as in the following table 7.

Table 7 Probability of moving from State One to State One and three

No	state transfer		Period			Total
	From	To	2016	2017	2018	
1	1	1	1,00	0,67	1,00	0,89
2	1	3	0,00	0,33	0,00	0,11
Total			1,00	1,00	1,00	1,00

In the table above, the calculation of the transition matrix is as follows.

$$FXB = \begin{bmatrix} 1{,}00 & 0{,}67 & 1{,}00 \\ 0{,}00 & 0{,}33 & 0{,}00 \end{bmatrix} \begin{bmatrix} 0{,}33 \\ 0{,}33 \\ 0{,}34 \end{bmatrix}$$
$$FXB = \begin{bmatrix} 0{,}89 \\ 0{,}11 \end{bmatrix}$$

And next to fill in the table for the number of shifts of nurses from state two to state one for 2016-2018, namely:

a. From state two (DIPLOMA III education) to state one (Ners education) for 2016 it is obtained from the table of changes in the level of education (table 4.5) in 2016 which is none
b. From state two (DIPLOMA III education) to state one (Ners education) for 2017, it is obtained from the table of changes in the level of education (table 4.5) in 2017 which is none
c. From state two (DIPLOMA III education) to state one (Ners education) for 2018, it is obtained from the table of changes in the level of education (table 4.5) in 2018 which is none

The number of shifts of nurses from state two (DIII education) to state two (DIPLOMA III education) for 2016-2018 is obtained from:

a. DIPLOMA III education in 2016 in the table of the number of nurses and composition (table 4) - {[DIPLOMA III education in 2016 in the table for adding nurses (table 3)] + [DIPLOMA III education in 2016 in the table for the number of nurses who experienced changes in level education (table 5)]} = 18-(1+0)=17
b. DIPLOMA III education in 2017 in the table of the number of nurses and composition (table 4) - {[DIPLOMA III education in 2017 in the table for additional nurses (table 3) + DIPLOMA III education in 2017 in the table of the number of nurses who experienced changes in education level (table 5) = 18-(1+0)=18
c. DIPLOMA III education in 2018 in the table of the number of nurses and composition (table 4) - {[DIPLOMA III education in 2018 in the table for adding nurses (table 3) + [DIPLOMA III education in 2018 in the table for the number of nurses who experienced changes in education level (table 5)]} = 19-(1+0)=18

To fill in the table of the number of nurses moving from state two to state three for 2016-2018, namely:

a. From state two (DIPLOMA III education) to state three (reduction of nurses) for 2016 it is obtained from the table of reduction of nurses (table 2) in 2016 which is 1
b. From state two (DIPLOMA III Education) to state three (reduction of nurses) for 2017 it is obtained from the table of reduction of nurses (table 2) in 2017 which is 0
c. From state two (DIPLOMA III education) to state three (reduction of nurses for 2018 is obtained from the table of reductions in nurses (table 2) in 2018 which is 0

Table 8. Movement from state two to state one two and three.

No	state transfer		period			P_{ij}
	From	To	2016	2017	2018	
1	2	1	0	0	0	0
2	2	2	17	18	18	53
3	2	2	1	0	0	1
Total			18	18	18	54

$$P_{2,1}\text{ years } 2016 = \frac{0}{18} = 0{,}00$$
$$P_{2,1}\text{ years } 2017 = \frac{0}{18} = 0{,}00$$
$$P_{2,1}\text{ years } 2018 = \frac{0}{18} = 0{,}00$$
$$P_{2,2}\text{ years } 2016 = \frac{17}{18} = 0{,}94$$
$$P_{2,2}\text{ years } 2017 = \frac{18}{18} = 1{,}00$$
$$P_{2,2}\text{ years } 2018 = \frac{18}{18} = 1{,}00$$

$$P_{2,3} \text{ yesars } 2016 = \frac{1}{18} = 0{,}06$$

$$P_{23} \text{ years } 2017 = \frac{0}{18} = 0{,}00$$

$$P_{2,3} \text{ years} 2018 = \frac{0}{18} = 0{,}00$$

$$P_{2,1} \text{ total } = \frac{0+0+0}{18+18+18} = \frac{0}{54} = 0{,}00$$

$$P_{2,2} \text{total} = \frac{17+18+18}{18+18+18} = \frac{53}{54} = 0{,}98$$

$$P_{2,3} \text{ total } = \frac{1+0+0}{18+18+18} = \frac{1}{54} = 0{,}02$$

Table 9. Probability of moving from state two to state one, two and three

No	*State transfer*		Period			P_{ij}
	From	To	2016	2017	2018	
1	2	1	0,00	0,00	0,00	0,00
2	2	2	0,94	1,00	1,00	0,98
3	2	3	0,06	0,00	0,00	0,02
Total			1,00	1,00	1,00	1,00

Formation of transition probability matrix

Table 10 Transition Probability Matrix

i	1	2	3
j			
1	0,89	0,00	0,11
2	0,00	0,98	0,02
4	0,33	0,67	0,00

After being entered into table 10, the transition probability matrix is transposed, and the results are presented in the following table

Table 11 Transpose Transition Probability Matrix

i	1	2	4
j			
1	0.89	0.00	0.33
2	0.00	0.98	0.67
3	0.11	0.02	0.00

Table 12. Probability Matrix for the addition of the number of nurses

State	1	2	3
4	0.33	0.67	0.00

Predicting labor needs by using labor forecasting models.

For forecasting nurses, the author uses a formula to predict the next period, the formula is:

$$Y = a + bX$$

$$Y = number\ of\ workers;\ X = period$$

To get the values of a and b, the author uses a linear trend equation and based on data from 2016-2018, the value is obtained.

Table 13. Helper table to find the value of adan b

No	X	Y	XY	X^2
1	-1	24	-24	1
2	0	24	0	0
3	1	25	25	1
$n = 3$	$\sum X = 0$	$\sum Y = 73$	$\sum XY = 1$	$\sum X^2 = 2$

$$a = \frac{\sum Y}{n} = \frac{73}{3} = 24$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{1}{2} = 0{,}5$$

$$Y_{2019} = a + bX = 24 + 0{,}5 \times 2 = 24 + 1 = 25$$

So the results of the forecast for the number of nurses in 2019 are 25 people.

5. Conclusion

Based on the results of data analysis and discussion, it can be concluded that in this study, the results of calculations using Markov Chains have been obtained that the probability of moving from state one to state one is 0.89, state one to state three is 0.11. The probability of moving from state two to state one is 0, state two to state two is 0.98, state two to state three is 0.02. The probability of moving from state four to state one is 0.33, state four to state two is 0.67 and state four to state 3 is 0. Forecasting the number of nurses in 2019 is 25 with the composition of nurses based on education level, namely for nurses as many as 5 people and Diploma III as many as 20.

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