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USING REGRESSION AND FORECASTING METHODS TO PREDICT FUTURE BED OCCUPANCY RATE (BOR) IN COVID-19 MANAGEMENT: A CASE STUDY OF THE PROVINCE OF EAST JAVA

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Abstract

The handling of the COVID-19 pandemic has become a serious challenge for health care systems around the world, including in East Java Province. One important indicator in measuring the availability of health care facilities is the Bed Occupancy Rate (BOR), which describes the use of hospital beds. This study aims to apply regression methods and forecasting techniques to forecast BOR for the next five years in the context of handling COVID-19 in East Java Province. This study used BOR's historical dataset and COVID-19-related data from previous periods as a basis for developing appropriate regression models. Then, forecasting techniques are used to forecast future BORs by considering factors such as trends in the spread of COVID-19, handling measures, and population development. The results of this analysis provide valuable insights for authorities and medical personnel in planning and managing hospital capacity more effectively. The research also provides insights into how changes in the pandemic situation can impact hospital bed usage and assist in strategic decision-making to deal with future challenges.

Keywords: Bed Occupancy Rate, BOR, COVID-19, regression method, forecasting, pandemic handling, health care system, East Java Province

1. INTRODUCTION

The COVID-19 pandemic that has hit the world since early 2020 has shown a profound impact on the global healthcare system. East Java Province, as one of the largest regions in Indonesia, has not escaped serious challenges posed by the spread of the SARS-CoV-2 virus. Handling this pandemic involves various aspects, including the availability of adequate health care facilities to treat COVID-19 patients. One critical indicator in measuring the capacity and effectiveness of a healthcare system is the Bed Occupancy Rate (BOR), which reflects the extent to which hospital beds are used. With the increase in Covid 19 variants, there is an increase in patients who must be hospitalized, this can be seen in the diagram below.

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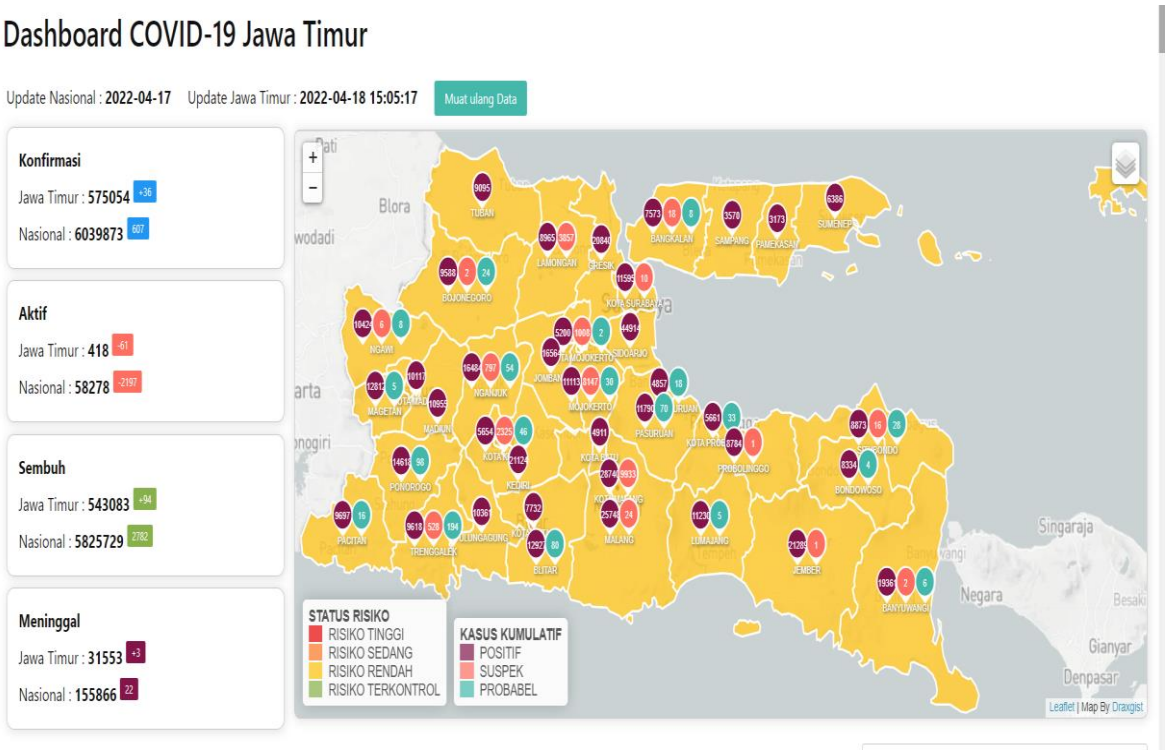

Figure 1: Graph of the Number of Active Positive Cases in East Java Province

From the graph above, it can be seen that the more variants of covid 19, the more active positive cases of patients in the East Java Province Region. The data is taken based on the latest data on corona.jakarta.go.id website.

With the increase in positive cases, it will affect the number of patients in the hospital. This can be seen in the following figure.

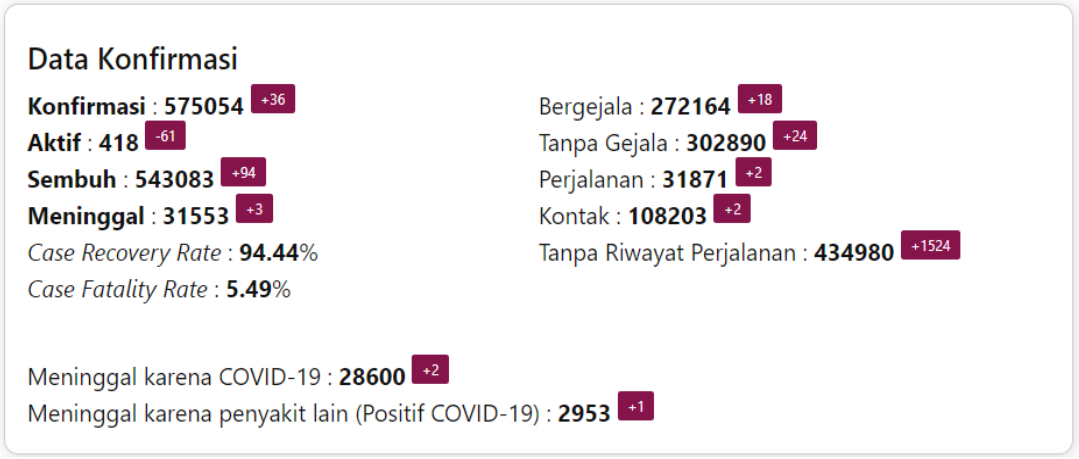

Figure 2: Jakarta Covid-19 Confirmed Case Data

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From the data above, it can be concluded that 688 or about 0.1% of patients confirmed with Covid-19 are currently being treated at referral hospitals spread across East Java Province. Based on the number of patients, it was found that the value of bed usage in the East Java Province Region was 695 or 5% (kemkes.go.id), this number was decreasing because the positive confirmation state was sloping, but with the development of more and more covid 19 variants, the positive confirmed cases of covid 19 could not be predicted.

In the context of handling the pandemic, the availability of hospital beds is a very important aspect. High rates of bed use could indicate a heavy burden on the healthcare system, which in turn could affect hospitals' ability to care for patients with serious conditions, including COVID-19 patients. Therefore, understanding BOR trends that may occur in the coming timeframe can provide valuable insights for the planning and management of healthcare facilities.

In this article, we aim to apply regression methods and forecasting techniques to forecast BOR for the next five years in the context of handling COVID-19 in East Java Province. By integrating historical BOR data with information related to COVID-19 and other relevant factors, we hope to provide a clearer picture of how hospital bed use is expected to evolve as the pandemic situation changes and population development.

2. RESEARCH OBJECTIVES

The main objective of this study is to develop a regression model that can forecast BOR in East Java Province over the next five years, taking into account the impact of handling COVID-19 and population development. Specifically, the study aims to:

1. Analyzing the historical trend of BOR in relation to the development of the COVID-19 pandemic in East Java Province.
2. Develop adequate regression models to link COVID-19-related factors, coping measures, and population development with BOR.
3. It uses forecasting techniques to forecast BOR over the next five years based on a regression model developed.

Case Study

Sudi case in this study is the bed occupancy rate or the percentage of bed use in handling Covid-19 cases, especially in the East Java Province. The choice of East Java Province is because East Java Province is the capital of the Republic of Indonesia, and the population level of East Java Province is quite high. Thus, the percentage rate of Covid-19 sufferers is the largest. This can be seen from the Table below.

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Table 1: Number of Projected Population by Province and Gender (Thousand People)

Province	Projected Population by Province and Gender (Thousand People)									
	Man			Woman			Sum			
	2018	2019	2020	2018	2019	2020	2018	2019	2020	
Aceh	2619,9	2656,1	2691,8	2623,5	2660,2	2696,3	5243,4	5316,3	5388,1	13
North Sumatra	7229,4	7312,2	7392,7	7246,5	7327,2	7405,7	14476	14639,4	14798,4	4
West Sumatra	2692,6	2727	2760,6	2719,3	2752,5	2785,1	5411,8	5479,5	5545,7	11
Riau	3440	3497	3553,2	3277,6	3338,1	3398	6717,6	6835,1	6951,2	10
Jambi	1795,2	1813,5	1831,3	1731,9	1752,7	1772,9	3527,1	3566,2	3604,2	20
South Sumatra	4257,1	4308,1	4358	4134,4	4189,1	4242,8	8391,5	8497,2	8600,8	8
Bengkulu	993,6	1004,5	1015,2	955	967,2	979,1	1948,6	1971,8	1994,3	27
Lampung	4289,9	4327,8	4364,3	4087,8	4129,8	4170,6	8377,7	8457,6	8534,8	9
Kep, Bangka Belitung	739,9	748,5	756,9	692,1	702,6	712,9	1432,1	1451,1	1469,8	29
Kep, Riau	1111	1144,7	1179	1063,8	1096,9	1130,5	2174,8	2241,6	2309,5	26
East Java Province	5212,6	5241,1	5267,8	5215,4	5262,9	5308,6	10428	10504,1	10576,4	6
West Java	24576,5	24845,4	25111,2	23899	24177,7	24454	48475,5	49023,2	49565,2	1
Central Java	17048,2	17144,9	17237,3	17310,2	17407,6	17500,9	34358,5	34552,5	34738,2	3
In Yogyakarta	1887,3	1911,3	1935,4	1931	1957,3	1983,8	3818,3	3868,6	3919,2	18
East Java	19510	19619,2	19722,2	20011,9	20125,6	20233,7	39521,9	39744,8	39955,9	2
Bantam	6381,1	6470,2	6557,9	6149,7	6244,1	6337,4	12530,8	12714,3	12895,3	5
Bali	2169,3	2195,4	2221,4	2139,9	2166,6	2193,1	4309,2	4362	4414,4	16
West Nusa Tenggara	2480,8	2522,6	2563,9	2596,9	2629,8	2662	5077,7	5152,4	5225,9	14
East Nusa Tenggara	2655,5	2693,7	2731,6	2704,7	2743,5	2781,8	5360,3	5437,2	5513,4	12
West Kalimantan	2534,6	2563,4	2591,4	2450,5	2482,3	2513,5	4985,1	5045,7	5104,9	15
Central Kalimantan	1359,1	1377,2	1394,9	1253,5	1272,6	1291,4	2612,6	2649,8	2686,3	24
South Kalimantan	2105,2	2131,4	2156,7	2057,1	2084,9	2111,9	4162,4	4216,3	4268,6	17
East Kalimantan	1861,5	1882,5	1902,9	1712,3	1737,2	1761,8	3573,8	3619,7	3664,7	19
North Kalimantan	361,8	368	374,1	321	327,6	334,2	682,8	695,6	708,4	34
North Sulawesi	1261,4	1270,7	1279,6	1213	1223,4	1233,4	2474,4	2494,1	2512,9	25
Central Sulawesi	1528,2	1546,8	1565,1	1473,8	1495,3	1516,6	3001,9	3042,1	3081,7	22
South Sulawesi	4277,1	4313,4	4348,5	4471	4506,2	4540,3	8748,1	8819,5	8888,8	7
Southeast Sulawesi	1314,6	1333,8	1352,9	1309	1329,8	1350,6	2623,6	2663,7	2703,5	23
Gorontalo	583,8	588,8	593,5	582,3	587,6	592,8	1166,1	1176,4	1186,3	32
West Sulawesi	673,3	682,8	692,2	666,8	676,4	686	1340,1	1359,2	1378,1	30
Maluku	882,2	891,4	900,4	867,3	877,1	886,7	1749,5	1768,5	1787,1	28
North Maluku	621,2	629,3	637,3	597,5	606,3	615	1218,8	1235,7	1252,3	31
West Papua	494,9	506,4	518,1	446,5	457,2	468	941,4	963,6	986	33
Papua	1734	1756,1	1777,7	1566,2	1591	1615,4	3300,2	3347,1	3393,1	21
Indonesian	132683	134025,6	135337	131478,7	132886,3	134266,4	264161,6	266911,9	269603,4	

Source Url: https://www,bps,go,id/indicator/12/1886/1/amount-penduduk-hasil-Projectsi-menurut-provincial-dan-gender-gender,html

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From the table above, it can be explained that the population of East Java Province is ranked 6th out of the entire Republic of Indonesia.

3. METHOD

a. Regression and Forecasting Method

This study uses the Regression and Forecasting method, the use of regression because it has a determining factor or variable used is the previous value. While the classification of determining factors is several variables. In this study, the variable used was the Bed Occupancy Rate (BOR) Value whose data was obtained from https://www.kemkes.go.id/downloads/resources/download/Ketersediaan-Tempat-Tidur-RS-Covid19/BOR-RS-7-APRIL-2022.pdf. In addition to being seen from variables, regression is used because the output of this study is an arbitrary number. The second method used is forecasting, this is because the determinant of the application is in units of time, namely months and years. The working principle of this forecasting method is that there is an element of time.

b. Formula for Linear Regression

The formula of Linear Regression with the least or simple squares method is:

$$a = \frac{(\sum y)(\sum x^2)-(\sum x)(\sum xy)}{n(\sum x^2)-(\sum x)^2} \quad (1)$$

$$b = \frac{n(\sum xy)-(\sum x)(\sum y)}{n(\sum x^2)-(\sum x)^2} \quad (2)$$

$$y = a + b.x \quad (3)$$

Figure 3: Linear Regression Formula

c. Determining the Dataset

The data used in this study is Bed Occupancy Rate (BOR) data from East Java Province. Data taken from 2020 to 2022 in April.

Table 2: BOR Data Set

Year	DRILL
06-Aug-21	8845
06-Sep-21	2134
06-Oct-21	1107
06-Nov-21	536
06-Dec-21	478
06-Jan-22	1749
06-Feb-22	10147
06-Mar-22	1071

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4. RESULT

To get the Bed Occupacy Rate value in 2023 and 2027, there are several stages that we must do.

1. Data Processing Techniques

In this study we conducted the following data processing techniques:

A. Use of data visualization techniques

By using data visualization techniques related to the COVID-19 Bed Occupanct Test, it is hoped that it can be a reference for predictions in the future.

B. Use of prediction techniques

In this study, researchers show how data is processed using prediction techniques. Using the Python programming language and various complete libraries makes it easy to process data using prediction techniques like this.

C. Use of data splitting techniques

Spliting data here aims to obtain comparative information between new Bed Occupancy Rate cases. So that later it will produce information on the prediction of bed availability in tackling covid 19 from this comparison.

D. Implementation of decision tree classification

Finally, the implementation of the decision tree to find the final result of the classification process. That way it can determine how the future trend related to the Covid-19 Bed Occupanct Rate in Indonesia and in the province of East Java Province

2. Data Visualization

The next process is to visualize examples of Bed Occupancy Rate trends in East Java Province from various points of view as follows:

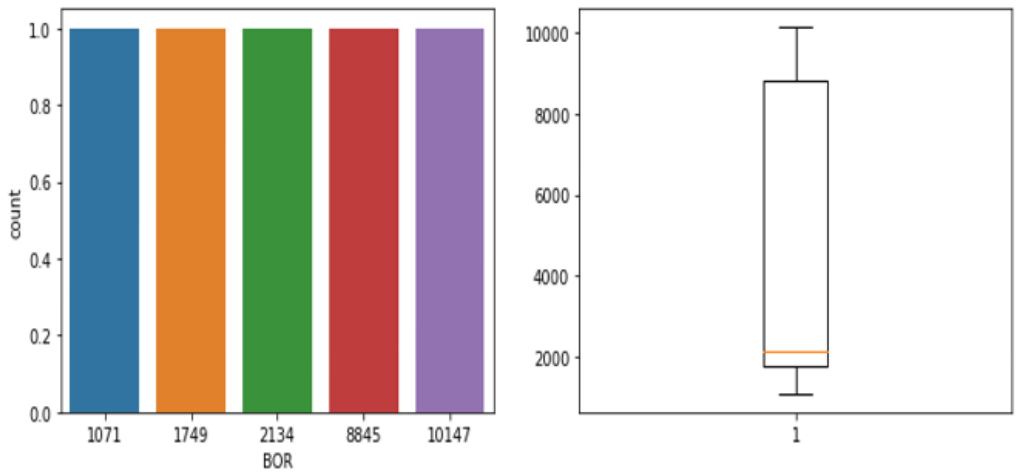

Figure 4: Bed Occupancy Rate in East Java Province

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From the picture above, it can be explained that the largest BOR is 2134. With the following script:

```
f = plt.figure(figsize=(12,4))
f.add_subplot(1,2,1)
sns.countplot(df['BOR'])
f.add_subplot(1,2,2)
plt.boxplot(df['BOR'])
plt.show()
```

2. Modeling Process

In this study, we will predict the next 5 years, using linear regression with the formula:

$$Y = a+bx$$

Where Y is a consequent variable that is a dependent variable. Variable a represents a constant, while b is a regression coefficient, which is the magnitude of response generated by variable X (independent variable), which is also called a predictor.

```
In [12]: print(x_train.shape)
         print(y_train.shape)
         print(x_test.shape)
         print(y_test.shape)
```

Then we project the data \

```
In [16]: coef_dict={
             'features':x.columns,
             'coef_value':lin_reg.coef_
         }
         coef = pd.DataFrame(coef_dict, columns=['features','coef_value'])
         coef
```

Figure 5: Dependent Variables

Continued to predict \

```
In [17]: y_pred = lin_reg.predict(x_test)
```

```
In [19]: lin_reg.predict([[2023]])
Out[19]: array([2061.])

In [20]: lin_reg.predict([[2027]])
Out[20]: array([-6984.33333333])
```

Figure 6: Predicts 2023 and 2027

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From the picture above, it can be explained that in 2003 the beds used will reach 2061, while in 2027 it will produce -6984,333, this is because COVID-19 has now been declared endemic.

5. CONCLUSION

By using regression and forecasting methods, we can claim bed data used in handling covid 19 patients, then with the forecasting method, we can predict Bed Occupancy Rate in 2023 and 2027

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