Forecasting the Growing Demand for Inpatient Beds Using Hospital Efficiency Indicators

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ABSTRACT
The quality of inpatient services in hospitals is strongly influenced by the efficiency of bed utilization, which is measured using key indicators such as Bed Occupancy Rate (BOR), Average Length of Stay (AvLOS), Turnover Interval (TOI), and Bed Turnover (BTO). Preliminary findings at Majalengka District Hospital showed that BOR remained below the optimal standard, AvLOS showed a gradual increase, TOI continued to decline, and BTO was excessively high. These patterns indicate the need to project inpatient bed requirements for the years 2025–2029. This study aimed to predict inpatient bed requirements based on inpatient service efficiency indicators. A descriptive quantitative study with a prospective approach was conducted. Secondary data on inpatient activities from 2022–2024 were collected using purposive sampling. Linear regression analysis was applied to predict inpatient days and patient discharges, while BOR and TOI calculations were used to estimate the number of beds required. The findings indicate that inpatient bed utilization at Majalengka District Hospital during 2022–2024 was still inefficient. Although the number of beds decreased, inpatient days and patient discharges continued to rise, reflecting increasing demand for inpatient services. Based on the standard BOR of 75–85% and TOI of 1–3 days, the projected bed requirement ranges from 167–292 beds in 2025 and increases to 212–368 beds by 2029. In conclusion, inpatient bed requirements at Majalengka District Hospital are expected to continue increasing, highlighting the need for regular evaluation and strategic planning of bed capacity.
Keywords: prediction; bed requirement; efficiency; hospital

INTRODUCTION
Hospitals are healthcare institutions that provide comprehensive individual health services, including outpatient care, inpatient care, and emergency services [1]. Among the various units within a hospital, the inpatient care unit holds a particularly important role, as it accommodates patients who require intensive treatment or prolonged observation until their clinical condition allows for discharge. Beyond clinical management, inpatient services also involve administrative processes such as patient registration, which is carried out by medical record personnel. Registration is a crucial component of service delivery because it ensures that complete and accurate patient information is collected. These data, derived from patient medical records, are subsequently used to generate hospital statistics that support managerial decision-making. With accurate statistical calculations, hospital management can determine the number of beds required to meet service demands effectively [2].

Hospital beds are essential facilities that support patient care, and their planning must be optimized to prevent shortages or inefficiencies. This requires hospital management to conduct regular reviews and evaluations of bed utilization efficiency in each inpatient ward [3]. Bed utilization cannot be assessed solely through raw numerical data; instead, it must be analyzed using inpatient service indicators such as Bed Occupancy Rate (BOR), Average Length of Stay (AvLOS), Turnover Interval (TOI), and Bed Turnover (BTO), each of which reflects a different dimension of ideal bed use [4].

Preliminary findings at Majalengka District Hospital based on 2024 inpatient service data showed a BOR of 72.52%, an AvLOS of 3 days, a TOI of 1 day, and a BTO of 90.63 cycles. The BOR was slightly below the ideal Barber Johnson standard of 75%–85%, although it still met the Ministry of Health standard of 60%–85%. The suboptimal BOR may be influenced by inaccuracies in bed allocation [5]. The AvLOS of 3 days meets the Barber Johnson standard of 3–12 days but falls below the Ministry of Health standard of 6–9 days. From a medical perspective, a low AvLOS may indicate suboptimal quality of care due to shorter treatment duration, whereas from an economic perspective, it may reduce the financial burden on patients [5].

The TOI of 1 day meets both Barber Johnson and Ministry of Health standards of 1–3 days. However, the BTO of 90.63 cycles far exceeds the Barber Johnson standard (>30 cycles) and the Ministry of Health standard (40–50 cycles). Excessively high BTO contributes to low TOI, indicating that the number of patients exceeds available beds, resulting in rapid bed turnover without adequate intervals. This situation increases the risk of nosocomial infections because beds are reused repeatedly without sufficient downtime [6].

Several previous studies have reported discrepancies between available beds and inpatient service needs. The first study, which used Ministry of Health standards to calculate bed requirements per ward, found that many wards did not meet efficiency standards and required additional beds due to increased inpatient days [2]. The second study, also using Ministry of Health indicators such as BOR, LOS, TOI, and BTO, reported that bed requirements continued to rise in subsequent years due to increasing inpatient days, length of stay, and patient discharges [7]. The third study, which used Barber Johnson indicators (BOR, TOI, AvLOS, and BTO), found that bed utilization remained inefficient, with indicators falling outside the efficient zone, indicating the need for additional beds in the following year [8].

However, these studies were conducted in different hospitals with varying patient characteristics, service capacities, and visitation trends. Moreover, previous research typically used either Ministry of Health standards or Barber Johnson indicators independently, whereas the present study integrates both approaches to predict inpatient bed requirements. This study was conducted at Majalengka District Hospital, where no prior research has examined bed requirement projections for the 2025–2029 period.

Therefore, this study aims to provide a more accurate and context-specific estimation of bed needs based on current service conditions and trends at Majalengka District Hospital. The findings are expected to offer practical contributions to hospital management, particularly in decision-making related to bed capacity expansion and resource allocation. With accurate projections, the hospital can plan inpatient services more efficiently and enhance the sustainability and quality of healthcare delivery in the coming years.

METHODS
This study was conducted at Majalengka District Hospital (RSUD Majalengka) over a four-month period from January to April 2025. The research setting included inpatient service units within the hospital, where historical service data from previous years were systematically reviewed.

The research employed a quantitative approach with a descriptive design and a prospective orientation. This design was selected to enable forward-looking analysis based on historical inpatient service data, allowing the prediction of future bed requirements.

The study population consisted of inpatient service activity data from RSUD Majalengka covering the period 2022–2024, representing 11 inpatient wards. The sample was restricted to seven general inpatient wards, while specialized units such as the ICU, NICU, Perinatology, and Isolation wards were excluded due to their distinct clinical characteristics. Sampling was conducted using purposive sampling, a method based on predetermined criteria and specific considerations [9].

The variables examined in this study included: inpatient days, number of beds, patient discharges and predicted bed requirements. Data were collected through observation of secondary inpatient service records. Variable measurement involved: linear regression equations to predict inpatient days and patient discharges for the years 2025–2029; BOR and TOI formulas to calculate the number of beds required based on predicted service volumes and standards used was BOR 75%–85% and TOI 1–3 days. A descriptive quantitative analysis was performed. Linear regression was used to generate predictions for inpatient days and patient discharges for the 2025–2029 period. These predicted values were subsequently applied to BOR and TOI calculations to determine the projected number of beds required in accordance with national and international efficiency standards.

RESULTS

Calculating inpatient service indicators for 2022–2024

The data used as the basis for calculating inpatient service indicators were obtained from the Inpatient Service Activity Records for the years 2022–2024. Based on Table 1, the indicators that met the ideal Ministry of Health standards were BOR in 2024 and TOI in 2022–2024. Meanwhile, the indicators that met the Barber Johnson standards were AvLOS in 2022–2024, TOI in 2022–2024, and BTO in 2022–2024. However, the BTO values exceeded the ideal threshold, indicating a very high frequency of bed use at Majalengka District Hospital.

Presenting the Barber Johnson Graph

After calculating the inpatient service indicators, the next step was to compute the Barber Johnson Graph coordinates for each indicator (Figure 1). Based on Table 2, each indicator value was converted into X- and Y-axis coordinates to facilitate visualization in the Barber Johnson Graph, which is used to assess bed utilization efficiency at Majalengka District Hospital. The graph shows that all four indicators for 2022–2024 intersect at a point located outside the efficient zone, indicating that bed utilization at Majalengka District Hospital during this period was not optimal.

Predicting inpatient days and patient discharges for 2025–2029

Historical data on bed availability, inpatient days, and total patient discharges were used as the basis for predicting future values (Table 3). These data were used to predict inpatient days and patient discharges for 2025–2029 using linear regression (trend analysis).

In predicting inpatient days for 2025–2029 (Table 4 and Table 5),
Constant (a):

$$a = \frac{\sum y}{n} = \frac{134.180}{3} = 44.726{,}67$$

Slope (β):

$$\beta = \frac{\sum xy}{\sum x^2} = \frac{6.992}{2} = 3.496$$

In predicting inpatient discharges for 2025–2029 (Table 6 and Table 7),
Constant (a):

$$a = \frac{\sum y}{n} = \frac{46.880}{3} = 15.626{,}67$$

Slope (β):

$$\beta = \frac{\sum xy}{\sum x^2} = \frac{2.357}{2} = 1.178{,}5$$

Table 1. Calculation results of inpatient indicators in 2022–2024 at Majalengka District Hospital and ideal standards

Indicator	Year	Value	Ideal standard (Barber Johnson)	Ideal standard (Ministry of Health)
BOR	2022 2023 2024	53.96% 58.78% 72.55%	75%–85%	60%–85%
AvLOS	2022 2023 2024	2.76 days 2.61 days 3.00 days	3–12 days	6–9 days
TOI	2022 2023 2024	2.5 days 1.92 days 1.10 days	1–3 days	1–3 days
BTO	2022 2023 2024	65.34 cycles 78.52 cycles 90.63 cycles	>30 cycles	40–60 cycles

Table 2. Coordinate calculations for the Barber Johnson graph

Indicator	Year	Value	X-Axis	Y-Axis
BOR	2022 2023 2024	53.96% 58.78% 72.55%	10 – 5.39 = 4.61 10 – 5.87 = 4.13 10 – 7.25 = 2.75	53.96 ÷ 10 = 5.39 58.78 ÷ 10 = 5.87 72.55 ÷ 10 = 7.25
AvLOS	2022 2023 2024	2.76 days 2.61 days 3.00 days	0 0 0	2.76 2.61 3.00
TOI	2022 2023 2024	2.5 days 1.92 days 1.10 days	2.5 1.92 1.10	0 0 0
BTO	2022 2023 2024	65.34 cycles 78.52 cycles 90.63 cycles	365 ÷ 65.34 = 5.42 365 ÷ 78.52 = 4.64 366 ÷ 90.63 = 4.03	365 ÷ 65.34 = 5.42 365 ÷ 78.52 = 4.64 366 ÷ 90.63 = 4.03

Table 3. Historical data for 2022–2024

Year	Available beds	Inpatient days	Total patient discharges
2022	214 beds	42,149	14,410
2023	200 beds	42,910	15,703
2024	186 beds	49,121	16,767

Table 4. Determining variables X and Y

Year	Inpatient days (Y)	X	X^2	XY
2022	42,149	–1	1	–42,149
2023	42,910	0	0	0
2024	49,121	1	1	49,121
Total	134,180	0	2	6,992

Table 5. Predicted inpatient days for 2025–2029

Year	X	Equation (Y = a + βX)	Predicted inpatient days
2025	2	44,726,67 + (3,496 × 2)	51,719
2026	3	44,726,67 + (3,496 × 3)	55,215
2027	4	44,726,67 + (3,496 × 4)	58,711
2028	5	44,726,67 + (3,496 × 5)	62,207
2029	6	44,726,67 + (3,496 × 6)	65,703

Table 6. Determining variables X and Y

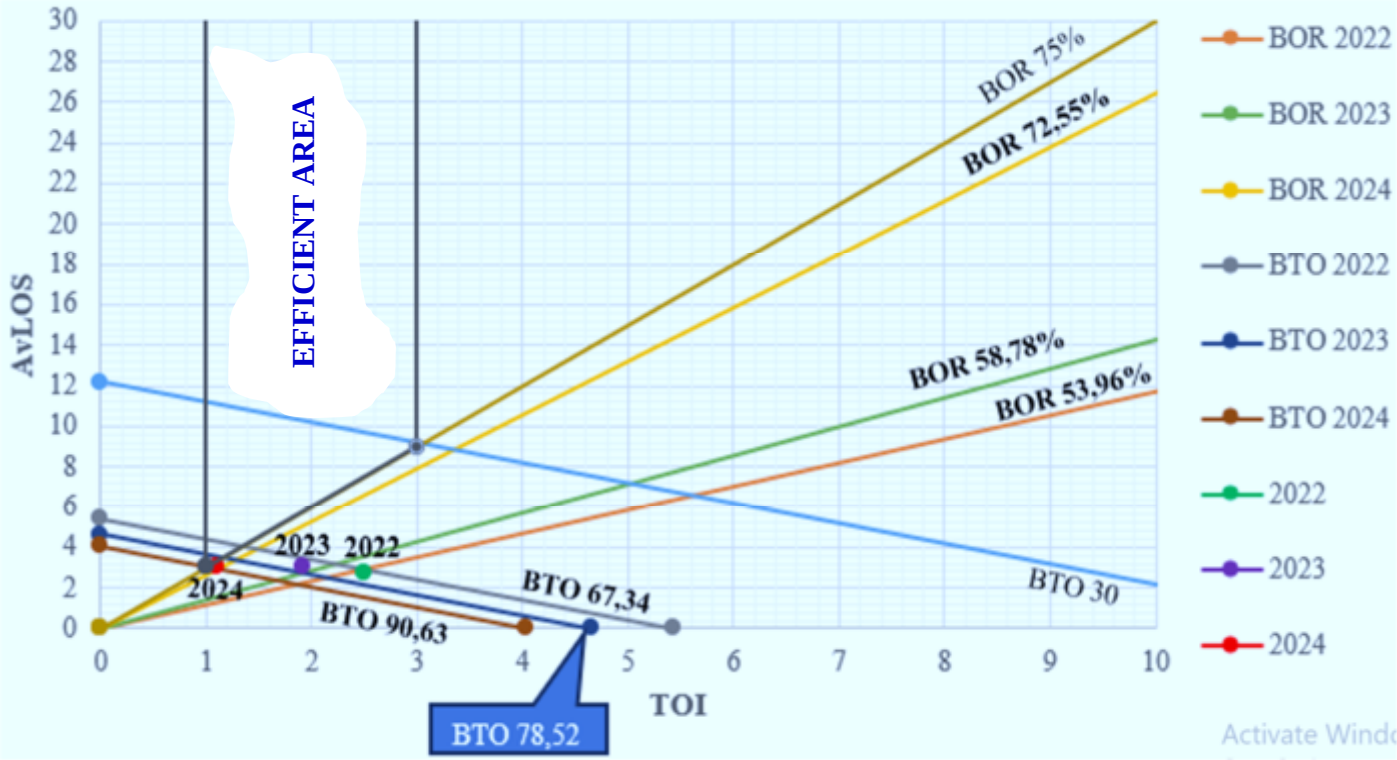
Year	Patient Discharges (Y)	X	X^2	XY
2022	14,410	–1	1	–14,410
2023	15,703	0	0	0
2024	16,767	1	1	16,767
Total	46,880	0	2	2,357

Table 7. Predicted patient discharges for 2025–2029

Year	X	Equation (Y = a + βX)	Predicted Discharges
2025	2	15,626,67 + (1,178,5 × 2)	17,984
2026	3	15,626,67 + (1,178,5 × 3)	19,162
2027	4	15,626,67 + (1,178,5 × 4)	20,341
2028	5	15,626,67 + (1,178,5 × 5)	21,519
2029	6	15,626,67 + (1,178,5 × 6)	22,698

Table 8. Predicted inpatient bed requirements

Year	BOR 75%	BOR 85%	TOI 1 day	TOI 3 days
2025	189 beds	167 beds	192 beds	292 beds
2026	202 beds	178 beds	204 beds	309 beds
2027	214 beds	189 beds	229 beds	346 beds
2028	227 beds	200 beds	229 beds	346 beds
2029	240 beds	212 beds	243 beds	368 beds



Predicting bed requirements for 2025–2029

Bed requirement predictions were calculated using BOR standards (75%–85%) and TOI standards for 1–3 days (Table 8). Using BOR (75–85%) and TOI (1–3 days) standards, the number of beds required increases each year. In 2025, the requirement ranges from 167–292 beds, rising to 212–368 beds by 2029. This indicates a consistent upward trend in inpatient facility needs over time.

DISCUSSION

Inpatient service indicator calculations for 2022–2024 at Majalengka District Hospital

The calculation of the Bed Occupancy Rate (BOR) for 2022 and 2023 shows that both values remained below the Ministry of Health standard of 60–85%. However, in 2024, the BOR increased significantly, reaching 72.55%. This improvement was influenced by a rise in the number of hospitalized patients as well as the temporary closure of several inpatient rooms due to construction and renovation activities, which reduced the number of available beds and consequently increased the BOR. The surge in patient visits, particularly among BPJS participants also contributed to the higher utilization of inpatient beds [10]. Other studies similarly report that increases in BOR are often associated with improvements in hospital service quality, including physical changes such as the renovation of inpatient rooms [11]. Although the BOR at Majalengka District Hospital is approaching the ideal standard, bed utilization efficiency still requires improvement because the AvLOS remains low and the BTO remains high, indicating the need for further evaluation of bed capacity in the coming years.

The AvLOS at Majalengka District Hospital remains below the Ministry of Health standard of 6–9 days. This suboptimal value may be influenced by the types of cases treated at the hospital, where most inpatients present with mild to moderate conditions. Severe cases do occur but are often referred to hospitals with more advanced diagnostic equipment, such as MRI, which is not yet available at Majalengka District Hospital. This referral pattern affects the average length of stay because cases requiring longer treatment durations are not managed on-site. AvLOS values below six days may also be associated with high rates of patient discharge due to death from chronic diseases, improper documentation of referrals, or patients leaving against medical advice, all of which indicate the need to improve inpatient care quality [12]. Other studies have shown that non-ideal AvLOS values are influenced by disease types, inpatient volume, and treatment duration. Low AvLOS may also reflect suboptimal service planning or clinical decision-making [7]. A low AvLOS indicates that patients are discharged relatively quickly, and therefore the hospital must ensure that patients receive optimal care before discharge.

Over the past three years, the TOI indicator has consistently met the Ministry of Health standard of 1–3 days. However, in 2024, the TOI value declined and warrants attention. This decline was caused by an increase in the total number of hospitalized patients and a reduction in available beds, resulting in shorter waiting times to prepare beds for the next patient. Consequently, beds may not have been adequately cleaned or disinfected, increasing the risk of nosocomial infections. Although this situation may provide financial benefits to the hospital, it poses risks to patient safety due to insufficient bed turnover intervals. The increased workload on healthcare staff may also compromise patient safety and satisfaction [13]. Other studies indicate that BOR values that meet ideal standards influence TOI, as higher BOR tends to reduce TOI. Maintaining optimal TOI requires effective organizational management, including workload adjustments, clear task distribution, and community outreach to balance bed demand [12]. The decline in TOI at Majalengka District Hospital highlights the need to evaluate bed readiness, staff workload distribution, and sterilization procedures to maintain TOI within optimal limits without compromising service quality.

The BTO values over the past three years have exceeded the ideal threshold of 40–50 cycles, indicating high bed turnover. This high BTO reflects frequent bed use by multiple patients within short intervals. The elevated BTO is attributed to an increase in inpatient volume while the number of available beds decreased due to renovation activities. From an economic perspective, high bed utilization increases hospital revenue. However, from a clinical standpoint, this condition may compromise patient safety and reduce patient satisfaction because beds may not be adequately sterilized due to staff workload, increasing the risk of nosocomial infections [5]. Other studies also show that although high BTO can be financially advantageous, excessively high values increase staff workload, reduce cleaning time, elevate infection risk, and lower patient satisfaction [14].

Barber Johnson Graph analysis at Majalengka District Hospital

The analysis of the Barber Johnson Graph shows that the BOR and BTO lines, along with the AvLOS and TOI points for 2022–2024, intersect at a single point located outside the efficient zone. This indicates that bed utilization at Majalengka District Hospital during this period was not efficient. Although the indicators form an intersection point, the values do not meet the ideal standards and therefore do not fall within the efficient zone. The efficient zone is characterized by the intersection of TOI within 1–3 days, BOR at 75%, and AvLOS at 12 days [15]. Nonetheless, there is a positive development: the intersection point in 2024 is closer to the efficient zone compared to previous years, suggesting that the hospital has made efforts to improve service performance. However, further evaluation and strategic planning are required to ensure that all indicators fall within the efficient zone. These findings align with previous research showing that intersection points outside the efficient zone indicate suboptimal bed utilization. The closer the BOR line is to the Y-axis, the higher the BOR value; conversely, the farther it is, the lower the BOR. Additionally, the closer the BTO line is to the axis, the higher the number of patient discharges (alive or deceased) [5].

Prediction of inpatient days and patient discharges for 2025–2029

The number of beds at Majalengka District Hospital has decreased and fluctuated frequently each year, reducing the accuracy of inpatient indicator calculations. This fluctuation is due to temporary closures of inpatient rooms during construction and renovation. Despite the reduction in beds, BOR, AvLOS, and BTO values have increased. Accurate bed allocation is essential to improving BOR [5]. In addition, inpatient days and patient discharges have increased annually, indicating improvements in bed management efficiency. The increase in inpatient days may be due to a rise in chronic or long-term conditions requiring extended hospitalization. Meanwhile, the increase in patient discharges may reflect the rapid recovery of patients with mild to moderate conditions, allowing for earlier discharge and maintaining high discharge numbers within the same period [10]. Predictions for inpatient days and patient discharges from 2025 to 2029 show an upward trend, indicating increasing inpatient service demands and higher staff workload. If not managed properly, this may reduce service quality, compromise patient safety, and decrease operational efficiency. Therefore, strategic planning—particularly forecasting bed requirements for the next five years—is essential [8].

Prediction of inpatient bed requirements for 2025–2029

The predicted bed requirements at Majalengka District Hospital are expected to increase from 2025 to 2029, in line with rising inpatient days and patient discharges. Although bed demand is increasing, capacity expansion can be planned gradually by improving bed utilization efficiency through BOR and TOI indicators. The hospital may choose to plan bed requirements based on BOR standards of 75–85% or TOI standards of 1–3 days, depending on operational needs and optimal service capacity. Effective bed planning is crucial for improving service coverage and efficiency. Poor planning leads to inefficiencies in service delivery [10]. Other studies emphasize that proper bed management is essential because it affects service quality, efficiency, and effectiveness. One factor contributing to inefficiency is the unavailability of beds due to repairs or renovations [3]. Renovation activities may render some beds inactive, reducing inpatient capacity. Without proper bed allocation, this may increase BOR, delay services, and make it difficult for patients to obtain beds. Other studies also note that suboptimal bed allocation can lead to overload or shortages [16]. Conversely, excessive bed numbers may result in unused beds and inefficient utilization [17-21]. Therefore, bed adjustments must align with service needs and patient visit trends.

Study limitations

This study has several limitations. First, the data used were limited to the most recent three years, which may not fully represent long-term trends. Second, external factors such as BPJS policy changes, population growth, disease outbreaks, referral pattern shifts, and construction or renovation activities were not included in the analysis, even though they may affect bed availability. Information regarding construction and renovation was obtained from staff reports and not analyzed quantitatively. Third, the study focused only on general inpatient wards and excluded ICU, NICU, Perinatology, and Isolation units due to their distinct service characteristics.

CONCLUSION

The inpatient bed requirements at Majalengka District Hospital are projected to increase annually in line with the rising number of inpatient days and patient discharges. Based on the BOR standard of 75%–85% and the TOI standard of 1–3 days, the estimated bed requirement is expected to grow from 167–292 beds in 2025 to 212–368 beds in 2029. The analysis of BOR, AvLOS, TOI, BTO, and the Barber Johnson Graph indicates that bed utilization at the hospital remains inefficient. Therefore, regular evaluation and strategic planning of bed capacity are necessary, including adjusting the number of beds, improving service quality, maintaining cleanliness in inpatient areas, and managing healthcare workers' workload to ensure efficiency and sustain the quality of inpatient care.

Ethical consideration, competing interest and source of funding

-This study received ethical approval from the Health Research Ethics Committee of Poltekkes Kemenkes Tasikmalaya under approval number PP.06.02/F.XXVI.17/0098/2025. All research procedures adhered to ethical principles, including confidentiality of data, responsible data handling, and fairness toward all parties involved.
-There is no conflict of interest related to this research,
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