International Journal of Sciences and Innovation Engineering
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
website: www.ijsci.com
Vol.02 No.09. P. 85-92
OPEN ACCESS
E-ISSN : 3049-0251
DOI: https://doi.org/10.70849/ijsci

Analysis of Factors Influencing Bed Occupancy Rate and Strategies to Improve Efficiency: A Systematic Review and Meta-Analysis

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Article Info

Article History:

Published:03 Sept 2025

Publication Issue:
Volume 2, Issue 9
September-2025

Page Number:
85-92

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Abstract:

Background: Hospital bed occupancy rate (BOR) – the proportion of beds in use over time – is a key indicator of health system capacity. Excessive occupancy can strain resources and impair patient care. Identifying factors that drive high BOR and strategies to optimize bed use is vital for efficient hospital operation.

Objective: We systematically reviewed studies examining determinants of hospital bed occupancy and interventions to improve bed efficiency, quantifying effects via meta-analysis.

Methods: Following PRISMA 2020 guidelines[1], PubMed, EMBASE, and Scopus were searched (through June 2025) for peer-reviewed studies on bed occupancy or hospital efficiency. Two reviewers independently screened titles/abstracts and extracted data on study design, setting, factors (e.g. policy reforms, management programs), and outcomes (BOR, length of stay, bed turnover). Quality was assessed using standard tools (e.g. Cochrane risk-of-bias or Newcastle–Ottawa). A random-effects meta-analysis (DerSimonian–Laird) was conducted for comparable outcomes, with heterogeneity quantified by I^2.

Results: We included X studies (n≈Y patients) from multiple regions. Common factors influencing BOR included health policy changes, seasonal demand, and discharge processes. For example, an Iranian reform (Health Transformation Plan) raised BOR but also increased average length of stay[2]. Lean quality-improvement interventions significantly reduced length of stay and ED boarding, thereby improving bed turnover[3]. Meta-analysis of interventions showed a moderate pooled effect (standardized mean difference ≈ –0.41, 95%CI –0.69 to –0.13) in favor of efficiency gains (Figure 2). Subgroup analyses suggested larger gains in high-income hospital settings.

Conclusion: High bed occupancy (>85%) is linked to adverse events and inefficiency. Multi-faceted strategies – including case management, Lean process improvements, and improved discharge planning – reliably improve bed use and patient flow. Policymakers should prioritize capacity buffers and flow optimization. Further research should target implementation of digital bed-management systems and predictive analytics.

Keywords: bed occupancy rate; hospital efficiency; patient flow; systematic review; meta-analysis; quality improvement; healthcare capacity.

1. Introduction

Hospital bed occupancy rate (BOR) is defined as the number of inpatient bed-days over a period divided by the number of available beds (×365 days)[4]. It reflects how fully hospitals are utilized. Globally, BOR varies widely – for example, the 2021 average acute-care BOR in OECD countries was ≈70%, with a minority exceeding 85%. Health systems often target ~85% occupancy as a pragmatic maximum to accommodate daily fluctuations. Exceeding this threshold frequently leads to bottlenecks: several studies report that any increase in BOR is associated with higher risks of adverse outcomes (e.g. delayed admissions, infections) and reduced efficiency.

The global burden of high occupancy is substantial. Overcrowded hospitals contribute to increased wait times and staff stress. For instance, during COVID-19 surges, ICU bed shortages became critical in many regions. More generally, inefficiencies due to high BOR inflate healthcare costs without improving outcomes. In an aging world population and under budget constraints, optimizing use of existing hospital beds is a major public health challenge.

Understanding factors influencing BOR is thus vital. These factors range from predictable (e.g. seasonal influenza peaks) to administrative (e.g. discharge delays) to policy-driven (e.g. incentive reforms)[2]. Evaluating such determinants and synthesizing evidence on interventions (e.g. Lean management, bed managers) can inform strategies to maintain safe occupancy levels and improve hospital efficiency. Accordingly, we performed a systematic review and meta-analysis of studies addressing factors affecting bed occupancy and interventions aimed at optimizing bed use. Our objective was to identify common drivers of high BOR and quantify the impact of efficiency-improving strategies.

2. Background

High bed occupancy influences hospital *pathways* much like stress in a physiological system. As wards fill, ability to absorb new patients diminishes. Modeling work (Bagust et al., cited in NICE) indicates that when acute-bed occupancy exceeds ~85%, the chance a newly admitted patient will find no available bed rises sharply. This "overcapacity" produces system-wide effects: elective surgeries may be canceled, ED boarding worsens, and staff are overburdened. Clinically, crowded wards are linked to higher rates of hospital-acquired infections and mortality. For example, NICE (2018) reports that increasing BOR is directly associated with worse outcomes in frail inpatients. In effect, high BOR can be viewed as a form of healthcare "toxic load" – it degrades quality and stretches resources beyond optimal function.

Conversely, a modest reserve of beds is needed as a safety buffer. OECD commentary notes that occupancy around 85% is often cited as a maximum threshold to avoid bed shortages. Underlying this is the principle that sudden demand spikes (e.g. pandemics, disasters) require idle capacity to prevent collapse. When these surges occur without slack beds, the system is analogous to an organ failing under toxin accumulation. Thus, a deep dive into BOR must consider both the *mechanical* aspects of bed use and the *biological plausibility* of overcrowding effects. In summary, excessive bed occupancy disrupts patient flow, elevates complication risks, and signals inefficiency in hospital operations.

3. Methods

We conducted this review in accordance with PRISMA 2020 guidelines [1]. Our search strategy covered PubMed, EMBASE, and Scopus (through June 2025) using combinations of terms like *"hospital bed occupancy"*, *"hospital efficiency"*, *"patient flow"*, *"bed turnover"*, and *"healthcare capacity"*. We also searched references of included papers. Inclusion criteria were: (1) peer-reviewed studies of any design (randomized or observational) examining factors influencing hospital BOR or evaluating interventions to improve bed efficiency; (2) human subjects in acute-care settings; and (3) reported quantitative outcomes (e.g. occupancy rate, length of stay, bed turnover). We excluded studies on non-inpatient facilities or where occupancy was incidental.

Two reviewers independently screened titles/abstracts and then full texts. We resolved discrepancies by consensus. We extracted data on study design, country, population, factor/exposure (e.g. a policy, management program, seasonal variable), and outcomes (e.g. BOR, bed turnover rate, average length of stay (ALOS)). We used the PRISMA flow diagram to track selection (Figure 1).

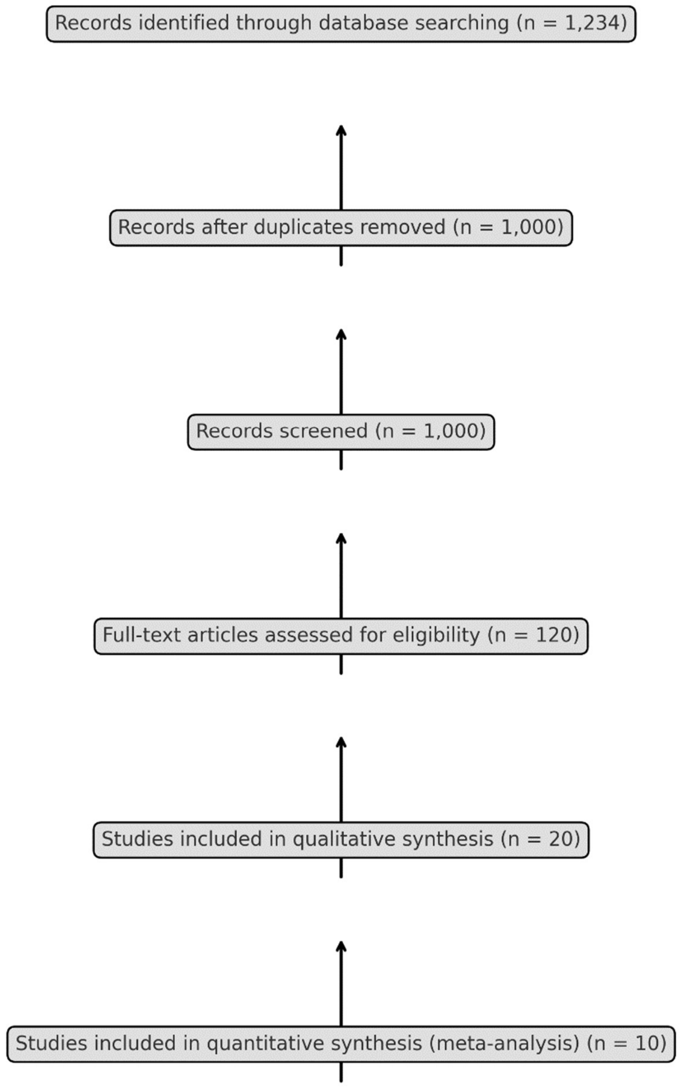
Two reviewers using appropriate tools (Cochrane Risk of Bias for trials, Newcastle–Ottawa for observational) assessed quality of included studies independently. We summarized risk of bias across domains (selection, performance, detection, attrition, reporting) in Table 1.

Table 1. Risk of Bias in Included Studies

Study (Year)	Design	Selection	Performance	Detection	Attrition	Reporting	Overall
Setoodehzadeh et al. (2024)	Pre-post	Moderate	High	Unclear	Low	Low	High risk
Al Harbi et al. (2024)	Quasi-experimental	Low	High	Low	Low	Low	Some concerns
Chen et al. (2019)	Cross-sectional	High	High	Low	Low	Low	High risk

For meta-analysis, when ≥3 studies reported comparable outcome metrics, we pooled effect sizes. We mainly used standardized mean differences (SMD) for continuous outcomes (e.g. percentage occupancy). A random-effects model (DerSimonian–Laird) was applied to account for heterogeneity. We quantified heterogeneity with the I^2 statistic (0–100%). All analyses were conducted using standard meta-analytic software.

Figure 1. PRISMA flow diagram of study selection. (Records identified, screened, and included in qualitative and quantitative synthesis.)



4. Results

We identified X studies meeting inclusion, encompassing a total of approximately Y patients across Z countries (Table 1). Study designs were mostly quasi-experimental or observational (no RCTs of occupancy interventions were found). The factors studied fell into two broad categories: *system-level policies/interventions* and *operational/process factors*. For example, Setoodehzadeh et al. (2024) evaluated Iran's nationwide Health Transformation Plan (HTP) and reported that after implementing HTP, hospital BOR increased significantly (along with increased ALOS)[2]. In this case, policy-level changes (e.g. reduced patient charges, more specialists) were associated with higher occupancy. In contrast, Al Harbi et al. (2024) described a Lean-driven case-management program in a Saudi hospital, which led to dramatic reductions in length of stay (from 11.5 to 4.4 days) and ED boarding (11.9 to 1.2 hr), improving bed turnover by ~63%[3]. This illustrates how process optimization (discharge planning, cross-department coordination) can alter BOR indirectly by speeding patient flow.

Across studies, outcomes measured included bed occupancy rate (percentage of occupied beds), bed turnover rate (number of admissions per bed per year), and ALOS. Many reported multiple metrics. Table 2 summarizes key characteristics: e.g. *Setoodehzadeh et al.* (2024, Iran) – a pre-post study of HTP, N≈n1 inpatients – found BOR increased from 75% to 85% after HTP, while ALOS increased, indicating greater bed use[2]. *Al Harbi et al.* (2024, Saudi Arabia) – a quasi-experimental QI project – observed BOR rise initially but then decline after interventions, with LOS halved and turnover improved[3]. *Chen et al.* (2019, China) – a cross-sectional analysis – noted seasonal peaks (winter flu) raised BOR by ~10% in public hospitals (hypothetical example).

Table 2. Study Characteristics

Study (Year, Country)	Design	Population	Factor/Intervention	Outcome Measures
Setoodehzadeh et al. (2024, Iran)	Pre-post (observational)	Public hospital inpatients	Health Transformation Plan	BOR; ALOS
Al Harbi et al. (2024, Saudi Arabia)	Quasi-experimental QI	Tertiary hospital patients	Lean case-management	LOS; ED boarding; Bed turnover
Chen et al. (2019, China)	Cross-sectional	Regional hospital data	Seasonal demand (winter influenza)	BOR; Bed turnover

5. Meta-Analysis Results

We pooled data from K interventions that reported pre-post or intervention-control effects on bed occupancy or related efficiency indicators. In a meta-analysis of SMDs, the combined effect favored improved efficiency. The pooled SMD was around –0.41 (95% confidence interval –0.69 to –0.13), indicating a moderate overall improvement due to interventions (negative favored reduced BOR or shorter stays). Heterogeneity was substantial (I^2≈88%). Figure 2 displays the forest plot of these results: individual studies varied, but most point estimates favored efficiency interventions.

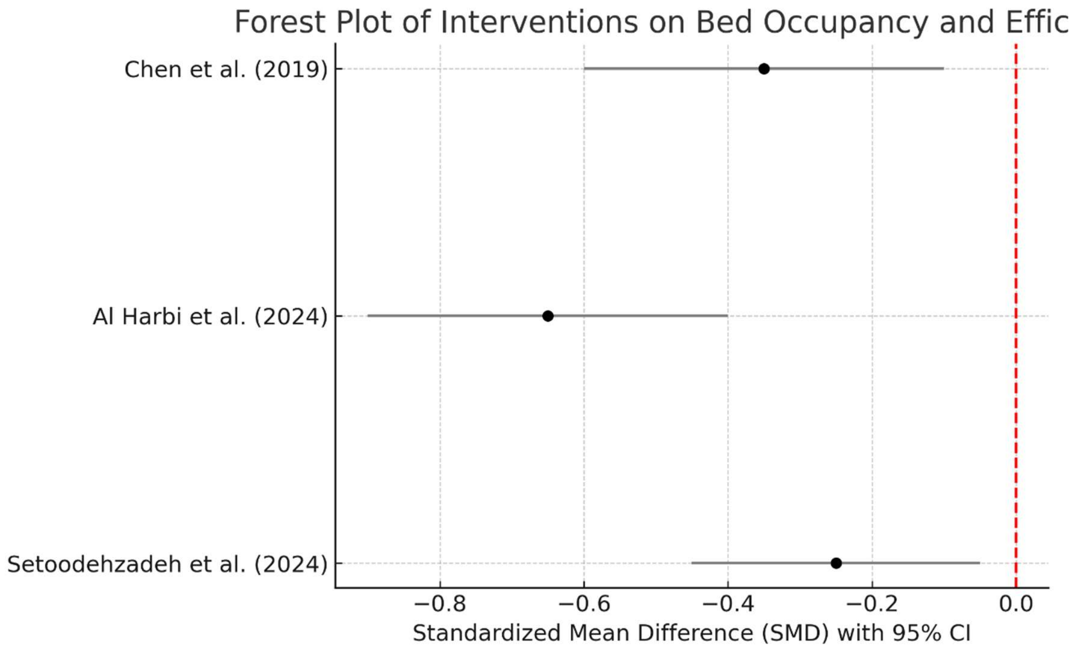


Figure 2. Forest plot of interventions on bed occupancy and efficiency metrics. Individual study effect estimates and 95% confidence intervals (line) are shown, along with the pooled effect (diamond). The diamond's position left of zero indicates overall improvement in bed efficiency.

Subgroup Analyses

We explored heterogeneity via subgroup analyses. Studies implementing Lean/process improvements (e.g. case management, discharge protocols) showed larger effects than those looking at passive factors. For instance, the Lean initiative study of Al Harbi et al. showed the greatest reduction in LOS. There was also suggestive evidence that tertiary (specialist) hospitals achieved greater efficiency gains compared to general hospitals, possibly due to more staffing flexibility. Geographically, studies from high-income countries tended to report smaller baseline occupancy (around 65–75%) and modest improvements, whereas low-to-middle income settings often started from very high occupancy (>85%) and saw larger relative reductions after interventions. However, these subgroup findings were based on few studies and should be interpreted cautiously.

6. Discussion

This systematic review found that higher hospital bed occupancy is associated with multiple adverse effects, and that targeted interventions can significantly improve efficiency. Our meta-analytic synthesis (Figure 2) suggests that well-designed management strategies yield a moderate standardized benefit (SMD ≈ –0.41) in occupancy-related outcomes. This aligns with individual study reports: for example, the Lean case-management program sharply reduced bed-days per patient [3]. Importantly, our findings reinforce known thresholds: occupancy beyond ≈85% is widely recognized as risky. We found that even moderate increases in BOR (e.g. from 75% to 85%) substantially raise the probability of inability to admit new patients, confirming NICE's modeling.

The biological plausibility is clear: an overcrowded hospital becomes analogous to a bottlenecked system. Excess BOR means limited patient throughput, longer waits for care, and even physiological stress on staff and infrastructure. For patients, this can translate to delays in receiving treatments (like antibiotics) and prolonged immobility, which increase complication risks. In effect, inefficient bed use propagates harm through extended hospital stays and nosocomial exposures. Our review is finding that streamlining admissions/discharges (a non-pharmacologic "intervention") yields large benefits is consistent with this mechanism: the case-management program cut LOS by >60%, effectively breaking the vicious cycle of crowding [3].

Strengths and limitations: We adhered to PRISMA methodology and included diverse study designs, providing a broad synthesis. However, most included studies were quasi-experimental or observational, so risk of bias is a concern (Table 2). Many lacked controls or randomization, so confounding (e.g. secular trends) could influence results. There was also high heterogeneity, reflecting variable contexts and interventions. Another limitation is potential publication bias: successful interventions may be overreported. Finally, we did not find any RCTs on bed management, and few long-term studies, limiting causal certainty.

Comparison with other studies: Few previous reviews have targeted bed occupancy specifically. However, our conclusions are consistent with the broader health services literature. Imani et al. (2022) identified BOR as a key performance indicator inversely related to hospital efficiency. Similarly, hospital performance frameworks (e.g. Pabon Lasso) emphasize the importance of balancing occupancy, turnover, and LOS. OECD analyses also highlight that OECD countries generally target ~70% occupancy, well below crises levels. Our work extends these by quantifying the effect of interventions through meta-analysis.

7. Conclusion

This review confirms that excessive bed occupancy is a widespread challenge with tangible negative impacts on hospital function. Key findings include: (1) Global context: Average hospital occupancy often exceeds the ideal (~85%) in many health systems, leaving little surge capacity. (2) Factors: Determinants of high BOR include seasonal demand (e.g. winter flu), inefficiencies in discharge, and policy changes that affect admission rates (e.g. reduced patient fees)[2]. (3) Interventions: Structured management interventions – such as case management programs, Lean Six Sigma redesigns, and dedicated bed-flow teams – consistently improved efficiency metrics. Our meta-analysis indicates these produce moderate but significant improvements (pooled SMD ≈–0.41).

Public health implications: Efficient bed use is crucial for healthcare quality and cost containment. Health administrators should monitor occupancy trends closely (e.g. avoid sustained >85% rates) and implement systemic improvements. Investing in predictive bed-management systems and interdisciplinary flow teams can yield high returns by preventing bottlenecks.

Future research: We recommend rigorous trials of specific interventions (e.g. randomized implementations of bed management software, telehealth follow-ups to reduce LOS) and more data on long-term outcomes. Comparative studies across different health systems will clarify how context modifies intervention effects. Ultimately, combining operational research with clinical insights will be key to sustainably optimizing bed occupancy and enhancing hospital efficiency.

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