

ORIGINAL ARTICLE

Bed management system and inpatient bed availability in a public medical complex in Saudi Arabia: a comparative retrospectively study

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ABSTRACT

Background: This study aims to investigate whether initiating a cross-hospital bed management system makes a difference in the number of admissions and bed occupancy rates at a selected hospital and how, if at all, the average length of stay is reduced in specific hospital departments.

Methods: The study included all sequentially hospitalized patients between June 1, 2016, and June 30, 2019.

Results: The total number of patients who were admitted to a referred medical complex between June 2016 and July 2019 was 20,749. The inpatient days after the initiative show a statistically significant increase compared to inpatient days before the initiative (137,630 vs. 72,930 days, respectively). Additionally, bed occupancy rates (BOR) after the initiative had a significant increase compared to BOR beforehand (50.5% vs. 26.6%, respectively). Following the bed management program, bed turnover rates (BTR) had doubled relative to BTR before (27.7% vs. 13.8%, respectively). Inpatients were more likely to be admitted in medical wards for treatment ($n = 11,976$, 57.8%). The most common reasons for admissions to the medical wards of a referred medical complex were internal medicine diseases ($n = 6,472$), followed by diseases of the cardiovascular system ($n = 3,096$). However, comparing the average length of stay before and after the initiative found no difference.

Conclusion: This study's findings suggest that the number of patients admitted to the hospital were far greater after the bed management initiative began than before it was implemented. Additionally, the increase in BOR and BTR was significant after the initiative was implemented. In contrast, even though the overall length of stay has not changed significantly since the bed management initiative began, when departments are considered separately, a statistically significant reduction in length of stay was only seen in surgical wards since the initiative began.

Keywords: Bed management program, bed occupancy rate, bed turnover rate, length of hospital stay.

Introduction

Healthcare services are perhaps one of the most complex and largest industries in the world while also being the costliest [1]. Because it is an essential component for life, healthcare is threatened by an increasing demand during times of limited financial resources and conflicting social needs. Thus, providing appropriate medical care involves decision-making in terms of planning and managing of healthcare resources.

A hospital's internal dynamics represent a complex, nonlinear structure. Planning and managing a hospital's daily operations require a comprehensive understanding of its system along with detailed information to make informed decisions. An understanding of the dynamics

that govern a hospital system and its flow of patients also requires sophisticated capacity models that consider complexity, uncertainty, variability, and limited

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resources. The most common limited resource is the number of hospital beds. Although public spending on health in Saudi Arabia is remarkably high compared to many high-income countries, the number of hospital beds is considerably lower and the cost of each bed is higher [2,3]. Furthermore, hospitals frequently have more patients than they can handle, resulting in significant scheduling delays and increased queue lengths [4]. Allocation of a bed to a patient with minimum waiting time and a reduction in the number of patients waiting for beds are the main areas of focus. For a complete understanding of a hospital's functioning, it is essential to analyze each department's average length of stay (LOS), waiting times, bed turnover time, and queue length. Well-documented evidence suggests that shorter hospital stays reduce the burden of medical fees and increase hospital bed turnover, thereby increasing hospitals' profit margins and lowering overall social costs [5,6].

Hence, through collaboration with several participating hospitals, the Saudi Ministry of Health (MOH) has designed a generic, nationwide, bed-tracking system for managing cross-hospital patient referral [7]. The system recognizes and complies with the necessity of implementing comprehensive, flexible, and intuitive operational models to support both the planning and management of hospitals' resources, namely hospital beds. The system was designed by considering the user needs and real-life experiences of the participating hospitals. Rapid and accurate information delivery is essential to the success of the system so that patients can get access to clinical beds, workflow in health facilities can be tracked, and future regional bed needs can be forecasted. A variety of clinical indicators are collected, including the number of beds, average circulation, and average time occupied. Despite this, the bed management process and its impact on bed occupancy rates and admissions have received little attention in academic literature, and national protocols for best practices in this area have not yet been investigated. Therefore, this study aims to investigate whether initiating a cross-hospital bed management system makes a difference in the number of admissions and bed occupancy rates at a selected hospital and how, if at all, the average length of stay is reduced in specific hospital departments. By gaining this insight, the hospital administration can devise better strategies to enhance hospital performance and, thus, improve the quality of patient care.

Materials and Methods

MOH bed management program description

The bed management program intends to provide an accurate inventory of clinical beds at MOH hospitals as well as at other governmental and private hospitals throughout the Kingdom. The program also aims to identify the future demands of the Kingdom's regions over the coming years [7].

According to the MOH:

“The electronic program of the Bed Management Program is basically intended to get the clinical indicators (the actual bed capacity, average bed

circulation per month, average bed occupation, etc.) at 100-bed hospitals (or more), with particular emphasis on the bed capacity at ICUs” [7].

The system also calculates the number of patients admitted to and discharged from hospitals over the prior 24 hours as well as the number of patients hospitalized (both Saudis and non-Saudis). The system then calculates the number of patients who have spent more than 30 days in the hospital, along with those who exceeded the expected duration of stay (based on diagnosis-related groupings and the International Classification of Diseases-10) and the waiting time required to be assigned a clinical bed in normal and emergency cases [7]. Unfortunately, due to a lack of data, the latter variables were omitted from the study.

Both the bed management program and its electronic program (bm.moh.gov.sa) have been already adopted in some regions, and it will be expanded to cover all regions over the next year. Therefore, it offers daily and instant data on bed occupancy, the average length of stays, the average number of beds in circulation, and the average waiting time needed to get a bed in normal and emergency cases. In Figure 1, a conceptual map of the bed management system is presented.

Study area

This study area was Jeddah city, which is the largest city in Makkah Province and Saudi Arabia's commercial capital, with a population of about four million people (as of 2017). The metropolitan area of the city is divided into 137 districts and has a population density of around 2,500 individuals per square kilometer. [8] This present study focused on the King Abdullah Medical Complex in Jeddah, which will be referred to as “a referred medical complex” in this study. This complex is located in the north of Jeddah, covers an area of 266,000 square meters, and has a main 500-bed hospital with a planned total capacity of 1,100 beds.

Study design, setting, and sample selection

This was an analytical, retrospective, cross-sectional study that included all patients who were admitted in a referred medical complex (having a capacity of 500 beds) in Jeddah, Saudi Arabia, between 2016 and 2019. The hospital joined the MOH bed management program in January 2018. The study included all sequentially hospitalized patients between January 1, 2018, and June 30, 2019. As part of the pre-initiative comparison, admissions between July 1, 2016, and December 31, 2017, were considered.

Measures

The patients' admissions records are linked to the hospital's “InterSystems TrakCare HIS.” Data were obtained directly from the hospital *TrakCare* system, which contains admissions information. Patients who were admitted for at least 1 day were eligible to be included in this study. Admissions data included the date of admission, length of stay, and date of discharge for all patients. The overall description of hospital-bed

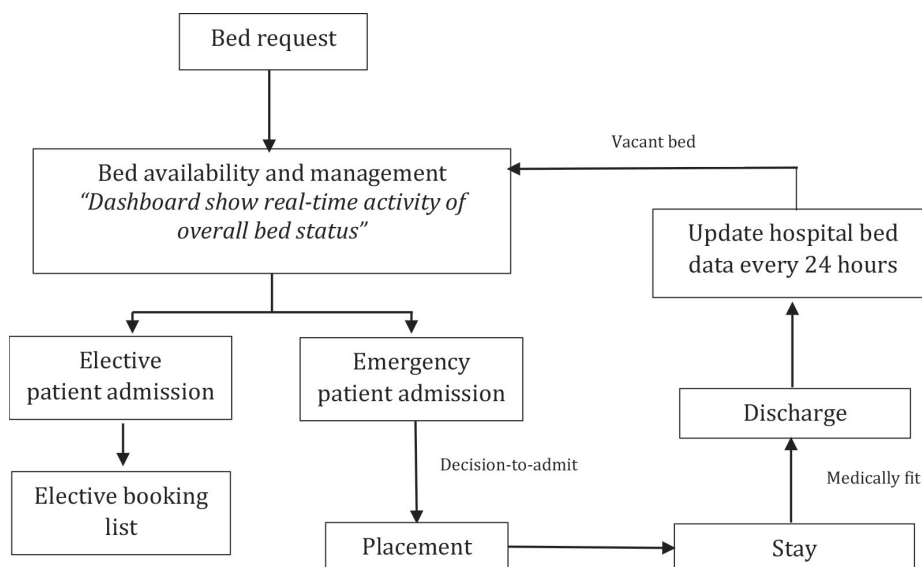


Figure 1. Conceptual map of the bed management system.

management was assessed using the following indicators: number of beds; patients discharged over a specific period of time (e.g., 1 year); and total number of inpatient days (i.e., the overall number of days that all the patients were hospitalized). The BOR [(the total number of inpatient days for a given period/available beds \times number of days in the period) \times 100] was calculated as an outcome of interest [9]. The total number of days included in this study period is 1,094 (with 548 days located in the pre-initiative period versus 545 days in the post-initiative period). The bed turnover rate (BTR) (total number of admission in one year /active beds) was calculated as a proxy of productivity of hospital beds and it represents the number of patients treated per bed in a defined period [10]. The average LOS (i.e., the average number of days that a patient remained in the hospital) is also calculated as an indicator of the use of medical services. To test the impact of the MOH bed management program on improving bed occupancy, data were categorized into before and after the initiative.

Data of hospital departments in which patients were admitted were also available. Demographic data (e.g., age, gender, and nationality) were collected and served as the principal descriptive component of the study. All data identifying beneficiaries, physicians, and institutions were encrypted to ensure privacy.

Ethics approval

Before carrying out the research, an ethics application was submitted to the MOH in Saudi Arabia (KSA:H-02-J-002) and the Human Research Ethics Committee at the University of Western Australia (RA/4/20/6317). The proposal was reviewed and approval was granted to continue with the research. The extracted data were then coded to ensure the confidentiality and privacy of all patients. The data set was saved in a password-protected computer and was only accessible by the research team.

Data analysis

For analyzing the data, the “Statistical Package for the Social Sciences” (SPSS Inc., Chicago, IL), version 21, was used. The data were first screened for the presence of any entry errors and outliers. Descriptive statistics were undertaken and categorical data (e.g., gender and nationality) were reported as frequency, percentage, and continuous variables (e.g., age and number of admissions as mean and standard deviation). For inferential analysis, the bivariate analysis, chi-square test, and *t*-tests were run to explore any statistically significant ($p < 0.05$) association between explanatory categorical and continuous variables, with the dependent variable admissions outcome “pre-initiative” or “post-initiative”.

Results

Inpatient characteristics

The total number of patients who were admitted to a referred medical complex between June 2016 and July 2019 was 20,749. Of these, more males were admitted to the hospital (58% males vs. 42% females) (Table 1). The average age of the inpatients was 50.4 years (± 20.8). Of those admitted to the hospital, 33% were before the initiative and 67% after. Table 1 represents the difference in inpatient characteristics before and after the initiative.

Hospital admission characteristics

The inpatient days after the initiative show a statistically significant increase compared to inpatient days before the initiative (137,630 vs. 72,930 days, respectively; $p = 0.004$). Additionally, bed occupancy rates after the initiative had a significant increase compared to bed occupancy rate beforehand (50.5% vs. 26.6%, respectively; $p = 0.001$; Table 2). Following the bed management program, bed turnover rates had doubled

relative to bed turnover rate before (27.7% vs. 13.8%, respectively; $p = 0.164$; Table 2). Hospital admitted cases ($n = 6,900$) between June 2016 and December 2017 had statistical differences in relation to admitted cases ($n = 13,840$) between January 2018 and July 2019. Whereas a higher number of patients were more likely to be discharged after the initiative than beforehand (13,563 vs. 6,899; $p=0.001$). However, comparing the average length of stay before and after the initiative found no difference (Table 3).

Hospital admissions per department

Inpatients were more likely to be admitted in medical wards for treatment ($n = 11,976$, 57.8%). The most common reasons for admissions to the medical wards of a referred medical complex were internal medicine diseases ($n = 6,472$), followed by diseases of the cardiovascular system ($n = 3,096$). Regardless of the department, the number of patients admitted to the hospital were far greater after the initiative than beforehand ($p < 0.001$; Figure 2). In contrast, there has only been a statistically significant ($p = 0.001$) reduction in the length of hospital stays in the general surgical wards since the bed management initiative began (Table 4).

Discussion

This study, conducted at a referred medical complex in Jeddah, gathered data on patients who were admitted for at least 1 day; the data included the date of admission, LOS, BOR, BTR, and date of discharge for all patients. To the best of our knowledge, this was the first hospital-based observational study that aimed to explore whether initiating a cross-hospital bed management system makes a difference in the number of admissions and BOR at a selected hospital and how, if at all, the average LOS is reduced in specific hospital departments. Our results are

similar to those reported in previous studies showing that, generally, males tend to have higher all-cause admission rates (particularly acute and life-threatening conditions) than females [11-13]. Studies indicate that men in their 60s are more likely to be admitted for cardiovascular conditions and neoplasms, but less likely to be admitted for injuries, musculoskeletal disorders, and sex-specific reasons [14,15]. Although admission rates for both genders have generally increased since initiating a bed management system, the same gender-based admission gap was evident. The study also found that the average age of admission in Saudi Arabia was younger than that observed in developed countries, such as the United States, Australia, or Denmark [14,16,17]. Hospital admissions are a fundamental component of the healthcare system that may be particularly vulnerable to population age and where gender differences are evident.

Since the bed management program was introduced at a 500-bed hospital, the bed occupancy rate increased by 23.9%. Similar studies in Malaysia, Iran, and Tunisia found higher BOR (61%, 65.9%, and 58.1%, respectively) [18-20]. However, the conventionally suggested benchmark for hospital BOR is between 80% and 85%, signifying that the mean BOR of 50.5% in the present study was still relatively low [21]. Generally, the BTR of our hospital was very low compared to other studies where the BTR was observed to be between 34 and 96 patients per bed per year [9,22]. Unfortunately, this result demonstrates a low level of productivity and a high level of inefficiency. Hence, improving the efficiency of patient care will benefit the hospital in terms of productivity and enhance the patient experience. Delays and inefficiencies in the admission/discharge process not only affect the patients' ability to receive the appropriate level of care in a timely manner, but can also affect their expectations of and satisfaction levels with all aspects of their care.

Table 1. Characteristics of patients admitted to a referred hospital in Jeddah between 2016 and 2019 ($n=20,749$) and within hospital admission groups.

Patients' characteristics	Total n (%) or mean \pm SD	Hospital admission n (%) or mean \pm SD		p -value
		Preinitiative	Postinitiative	
Total	20,749	6,906(33.3)	13,843(66.7)	-
Age ^a	50.4 \pm 20.8	51.7 \pm 20	49.7 \pm 21	0.001*
Gender	Males	4,170(20)	7,888(38)	0.001*
	Females	2,730(13)	5,941(29)	
Nationality	Saudi	5,225(25)	10,938(53)	0.001*
	Non-Saudi	1,675(8)	2,891(14)	

^at-test used for comparisons.

* $p < 0.05$ deemed significant.

SD, standard deviation.

Table 2. Inpatient days and bed occupancy in a referred hospital in Jeddah between 2016 and 2019 and before and after bed management intervention.

Variables	Total	Comparative groups n (%)		p -value
		Preinitiative	Postinitiative	
Inpatient days, n (%)	210,560 (100)	72,930 (34.6)	137,630 (65.3)	0.004
Bed occupancy rate	38.5	26.6	50.5	0.001*
Bed turnover rate	44.3	16.7	27.7	0.164*

*Independent t-test.

Table 3. Year of admission and discharge of patients admitted to a referred hospital in Jeddah between 2016 and 2019 (n = 20,749) and within hospital admission groups.

Hospital admissions and discharges		Total n (%) or mean±SD ^b	Hospital admission n (%)		p-value
			Preinitiative	Postinitiative	
Year of admission	2016	2,048	2,048 (9.9)	-	0.001*
	2017	4,852	4,852 (23.4)	-	
	2018	5,852	-	5,852 (28.2)	
	2019	7,988	-	7,988 (38.5)	
Year of discharge ^a	2016	1,966	1,966 (9.5)	-	0.001*
	2017	4,779	4,779 (23.1)	-	
	2018	5,835	150 (0.7)	5,685 (27.4)	
	2019	7,882	4 (0.0)	7,878 (38)	
Length of Stay (in days) ^b	2016	10.8 ± 32.2	10.6 ± 32.0	10 ± 24.7	0.16
	2017	10.5 ± 32			
	2018	10 ± 27.8			
	2019	10 ± 22.2			

^aThe cases discharged in 2020 were not included.

^bMean ± standard deviation.

^cChi-square test and t-test.

*p < 0.05 deemed significant.

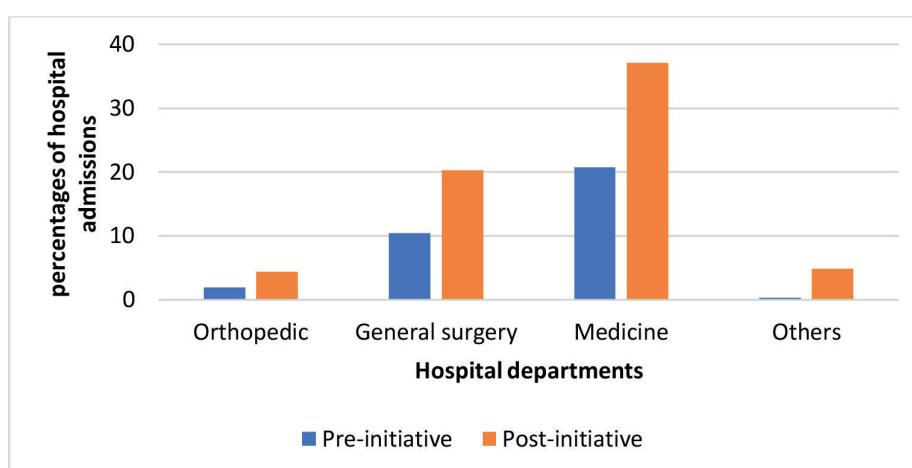


Figure 2. Distribution of hospital admissions by departments in a referred hospital in Jeddah between 2016 and 2019 (n = 20,749). *p < 0.05 deemed significant.

Table 4. Distribution of hospital length of stay at different departments in a referred hospital in Jeddah between 2016 and 2019 (n = 20,749).

Department's ward	Length of stay mean ± SD		p-value
	Preinitiative	Postinitiative	
Orthopedics	8.9 ± 12.7	9.7 ± 13.3	0.323
General surgery	10 ± 24.2	8.3 ± 18.8	0.002*
Medicine	11.1 ± 36.6	11.6 ± 29.44	0.443
Others	5.8 ± 9.8	5.0 ± 8.9	0.495

*p < 0.05, deemed significant.

In this study, the average overall LOS in days is relatively high than that observed in a different city (Hail General Hospital = 2.8-4.7 days) within Saudi Arabia [23] and in several developed countries [24]. Although the bed management program in this study has generally improved the admission rates across the hospital departments, a significant reduction in the LOS was only found in the general surgical wards. The LOS may also be related to the month of the year or the day of the week

of the admission/discharge date; for example, patients admitted on Thursday were not discharged until Sunday.

Study limitations

This study was conducted over a 3-year period and the number of cases was high (20,749 inpatients). However, the study has some limitations that should be addressed. First, the analyses of the patient process related to admission, BOR, BTR, and LOS were based on data

from a single hospital. As there are differences in the admission process and treatment plans between hospitals, generalizability was limited; thus, it is important to collect and analyze data from multiple hospitals using the Pabon Lasso model [25]. Additionally, cross-sectional data cannot be used to infer causality as temporality is not known. Furthermore, the hospital's environmental factors and the number of healthcare professionals, which were not considered in the analysis, may influence the study results. Hospital environmental factors such as lay-out, facilities, room features, hospital design, and numbers of healthcare workers (staff-to-patient ratios) might affect patient turnover.

Lesson learned and recommendations

The successful implementation of our bed management system suggests possible that significant improvements in the bed turnover process are possible if the organization has the commitment and the appropriate tools to achieve that goal. If the bed management system is used consistently and correctly, it can facilitate coordination and collaboration and drive significant process efficiency. Continuously improving the patient experience requires continuous dedication to objectively analyzing data, holding staff accountable for their performance, and striving for improvement. Additionally, considering the global pandemic and the rapidly growing population, Saudi Arabia urgently needs additional hospital beds and intensive care units. Further assessment measures should be taken to ensure that the Saudi health system surge capacity is prepared in a time of crisis. Additionally, the study recommends the implementation of a rapid discharge plan to shorten the hospital stays, which in turn will reduce the medical costs and improve the BTR.

Conclusion

This study's findings suggest that the number of patients admitted to the hospital were far greater after the bed management initiative began than before it was implemented. Additionally, the increase in BOR was statistically significant after the initiative was implemented. In contrast, even though the overall length of stay has not changed significantly since the bed management initiative began, when departments are considered separately, a statistically significant reduction in length of stay was only seen in surgical wards since the initiative began.

Authors' contributions

K.H.A., E.K., and M.T. meet the criteria for authorship as stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals as they all participated in the conception of the study, the analyses and interpretation of the study's results, the drafting or critical revision of the manuscript, and the final approval of the version to be published. All the authors agree to be accountable for all the aspects of the work. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

The authors have no conflict of interest to report.

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Consent for publication

Patient consent was waived as the research involves minimal risk as the review of subjects' medical records is for limited information. The information is not sensitive in nature. There is an extremely low probability of harm to subjects' status.

Ethics approval

Before carrying out the research, an ethics application was submitted to the MOH in Saudi Arabia (KSA:H-02-J-002) and the Human Research Ethics Committee at the University of Western Australia (RA/4/20/6317). The proposal was reviewed and approval was granted to continue with the research. The extracted data were then coded to ensure the confidentiality and privacy of all patients. The data set was saved in a password-protected computer and was only accessible by the research team.

Institutional Review Board statement

This research study was conducted retrospectively using the data obtained for clinical purposes.

Data availability statement

The datasets analyzed during this study are available from the corresponding author upon reasonable request.

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