CSIRO PUBLISHING
Australian Health Review, 2014, 38, 318–324
http://dx.doi.org/10.1071/AH13103

Using capacity alert calls to reduce overcrowding in a major public hospital

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Abstract

Objective. To investigate the efficacy of capacity alert calls in reducing acute hospital overcrowding through addressing rising occupancy, high patient throughput and increased access block.

Methods. Retrospective analysis of 24 months of in-patient, emergency department, and capacity alert call log data from a large metropolitan public hospital in Australia. The analysis explored statistical differences in patient flow parameters between capacity alert call days and other days including a control case set of days with statistically similar levels of occupancy.

Results. The study identified a significant ($P < 0.05$) reduction in occupancy, patient throughput and access block on capacity alert call days. Capacity alert call days reversed rising occupancy trends, with 6 out of 7 flow parameters reporting significant improvement ($P < 0.05$) over the 48 h following the call. Only 3 of these 7 flow parameters were significantly improved 48 h after control case days, confirming value in the alert mechanism and that the results are not a regression toward the mean phenomenon.

Conclusions. Escalation processes that alert and engage the whole hospital in tackling overcrowding can successfully deliver sustained improvements in occupancy, patient throughput and access block. The findings support and validate the use of capacity alert escalation calls to manage overcrowding, but suggest the need to improve the consistency of trigger mechanisms and the efficiency of the processes initiated by the capacity alert call.

What is known about the topic? Hospitals use various capacity management protocols to combat rising occupancy and the resulting poor patient care outcomes. However, there is little or no empirical evidence based on real hospital data to validate the efficacy of these approaches.
What does this paper add? This study suggests that capacity alert call days result in a significant reduction in occupancy, throughput and access block, thereby arresting and reversing rising occupancy trends and returning a greater improvement in patient flow parameters over the following 48 h than is observed on a set of control case days with statistically similar levels of occupancy. The study also identifies aspects of the protocol in need of improvement.
What are the implications for practitioners? The study provides valuable insight into the ability of capacity alert calls to tackle rising occupancy and reduce overcrowding in hospitals. It makes a good case for hospitals to conduct similar reviews of their capacity management protocols to help identify and address suboptimal aspects of the protocols to support delivery of improved patient flow and better patient outcomes.

Received 24 May 2013, accepted 27 January 2014, published online 12 May 2014

Introduction

The management of in-patient capacity in acute hospitals, and achieving a balance between bed access for patients and overcrowding, is acknowledged as an increasing, worldwide concern.[1] High occupancy and overcrowding have been associated with several poor patient outcomes, including increased mortality.[2,3]

Hospital services around the world advocate bed occupancy targets to drive operational capacity management.[4–7] Consequently, they use different protocols to help overcome periods of high occupancy. Popular mechanisms include capacity management plans,[8,9] census alerts[10–12] and peak or critical census policies.[13,14] Although increased discharge rates have been linked to capacity alerts,[15] there is, to the best of our knowledge, little documented evidence empirically validating the efficacy of these approaches. The present study is a step towards filling this void.

The Royal Adelaide Hospital (RAH), South Australia's largest teaching hospital, uses a capacity management and escalation process that entails a four-tier response protocol defining hospital-wide actions triggered by occupancy levels. The most critical level of the capacity alert protocol is Alert-4, triggered when bed occupancy has reached a capacity that may potentially impact the ability to maintain safe and efficient patient care. It also signifies a state where the organisation's ability to maintain appropriate staffing levels is at risk as a result of the increased patient activity. Other factors that may contribute to the decision to call an Alert-4 at high levels of occupancy include a sudden increase in presentations to the emergency department (ED), high patient acuity, workload staffing mismatch due to staff shortages or heavy workload, extended patient length of stay in the hospital and an imbalance between the admission : discharge ratio.

For example, an Alert-4 call would typically be made when, at 0830 hours, the hospital bed demand system reports either that the hospital has no empty beds or predicts that no beds will be available at 1600 hours. An Alert-4 condition is a hospital-wide problem that all functional service units and services are asked to respond to in order to streamline patient admission and discharge planning. As part of the Alert-4 approach, action cards have been developed for specific personnel and services. Services that have Alert-4 action cards include the general manager, director of nursing, patient flow team, service, clinical and nursing directors, switchboard, in-patient pharmacy, allied health, orderlies and cleaning managers. At Alert-4, hospital staff are alerted of the status of RAH occupancy via pager messages, text messages to listed mobile phones and occasionally through the hospital public address system. Some examples of typical responses include the cancellation of elective surgery, prioritising discharges and related pharmacy and/or radiology requests and notifying ambulance services to prioritise transfer patients. Although the protocol is followed with the belief that it helps arrest the rising occupancy and addresses overcrowding, no empirical evidence is available to test this hypothesis. The present study is a step towards filling this void.

The present study was undertaken to determine the operational efficacy of the RAH Capacity Alert protocol. Because clear measurable responses are defined around the Alert-4 tier of the protocol, the study focused on this stage of the protocol. Patient flow parameters on Alert-4 call days were compared with non-alert call days (days in our analysis period on which Alert-4 calls were not made) and to a control case subset of non-alert call days on which the hospital operated at similar levels of average occupancy as on Alert-4 call days. The occupancy profile of the 5-day period ranging from 2 days before to 2 days after an Alert-4 call day was analysed, and the impact of Alert-4 and control case days on patient flow parameters over the following 1- and 2-day periods was compared. This analysis also helped identify elements of the protocol that needed be addressed to improve overall impact.

Methods

Retrospective analysis of patient flow data from in-patient and ED databases in the patient management system and the log of Alert-4 calls from the RAH was performed. The study period for patient flow analysis was 24 months (July 2009–June 2011).

Ethics approval for this study was obtained from the RAH Research Ethics Committee.

Patient record data were aggregated into hourly intervals, and these hourly interval 'slots' were used as a common index on which patient flow parameters from different datasets were measured, visualised and compared. Occupancy was calculated as the ratio of occupied beds to census beds (i.e. rated fixed capacity) across hourly intervals to compare patient flow parameters and identify complex interdependencies between them. Daily patient flow was then calculated from this hourly flow information by measuring the following parameters: midnight, minimum, maximum, and average occupancy; average and maximum in-patient admission and discharge rates; time spent at various occupancy levels; average access block (admitted patient's boarding time in ED >8 h) cases per hour; and the change in average occupancy over 1- and 2-day periods.

Data about Alert-4 calls were used to calculate the number of calls made each month, and the spread of these calls over days of the week during the analysis period. Non-alert days were defined as all days on which Alert-4 calls were not made (i.e. lower perceived occupancy and hence lower alert levels). To test whether the changes following an Alert-4 call were attributable to the protocol rather than a natural reduction after a period of high occupancy, a set of control case days was constructed by putting together those non-alert days in the analysis period that exhibited an average occupancy within 1% of the mean average occupancy across Alert-4 days. Statistical evaluation was used to confirm that the control case days represented statistically similar levels of average, peak and minimum occupancy as Alert-4 days (see Table 1). Pearson χ^2 tests of association were used for this analysis.

Daily patient flow was analysed to compare parameters on Alert-4 days with control case days and non-alert days. Alert-4 days that immediately followed another Alert-4 day were excluded from the analysis to avoid the effect of consecutive calls. Consecutive control case days were similarly excluded from the analysis. Statistical relationships were investigated, and anomalies identified with a view to assessing efficiency and consistency in protocol trigger mechanisms. Two-tail two-sample *t*-tests assuming unequal variances were used for this analysis.

Changes to patient flow parameters, and the levels of reduction in occupancy, were also measured at 24 h (1 day after) and 48 h (2 days after) time intervals and compared for both Alert-4 days and control case days. The significance of changes in these parameters was measured with the aim of quantifying the effectiveness of the protocol in addressing the flow bottlenecks that necessitated triggering of the protocol. Two-tail matched paired *t*-tests were used for this analysis.

Matlab (R2011a; Mathworks, Natick, MA, USA) and Microsoft Excel (2007; Microsoft Corporation, Redmond, WA, USA) were used for data preparation and analysis. Although

Table 1. Statistical comparison of flow parameters on Alert-4 days, non-alert days and control case days

Data show mean values with 95% confidence intervals in parentheses. A4, Alert-4 day; Non-AD, non-alert day; CC, control case day

	A4	Non-AD	*P*-value[A]	CC	*P*-value[B]	1 day post-A4	*P*-value[C]	2 days post-A4	*P*-value[D]	1 day post-CC	*P*-value[E]	2 days post-CC	*P*-value[F]
Midnight occupancy (%)	104.1 (103.1–105.1)	97.3 (96.8–97.7)	<0.05	103.8 (103.3–104.3)	0.60	103.6 (102.3–104.9)	0.16	102.6 (101.3–103.9)	<0.05	103.9 (103.4–104.4)	0.42	103.5 (102.4–104.6)	0.34
Minimum occupancy (%)	100.5 (99.4–101.6)	94.1 (93.7–94.5)	<0.05	100.7 (100.3–101.0)	0.74	99.5 (98.2–100.8)	<0.05	98.7 (97.4–100.0)	<0.05	100.1 (99.2–101.0)	0.06	98.4 (97.1–99.7)	<0.05
Maximum occupancy (%)	109.6 (108.6–110.6)	101.9 (101.4–102.4)	<0.05	109.3 (108.8–109.7)	0.49	108.5 (107.2–109.8)	<0.05	107.4 (106.0–108.7)	<0.05	109.2 (108.5–109.8)	0.43	108.6 (107.4–109.7)	0.16
Average occupancy (%)	104.9 (103.9–105.9)	97.9 (97.5–98.3)	<0.05	104.7 (104.5–104.9)	0.70	103.9 (102.6–105.1)	<0.05	102.9 (101.6–104.2)	<0.05	104.5 (103.7–105.2)	0.30	103.4 (102.3–104.5)	<0.05
Average admission rate (patients/h)	4.9 (4.7–5.1)	4.2 (4.1–4.2)	<0.05	4.9 (4.7–5.1)	0.86	4.5 (4.3–4.7)	<0.05	4.5 (4.3–4.7)	<0.05	4.9 (4.6–5.1)	0.45	4.5 (4.2–4.7)	<0.05
Average discharge rate (patients/h)	5.0 (4.8–5.2)	4.2 (4.1–4.2)	<0.05	4.8 (4.5–5.1)	0.36	4.8 (4.5–5.1)	0.15	4.7 (4.3–5.0)	0.07	5.0 (4.8–5.2)	0.22	5.1 (4.7–5.4)	0.16
Access block cases (cases/day)	28.8 (26.4–31.3)	22.3 (21.7–22.8)	<0.05	26.7 (24.7–28.6)	0.18	27.4 (25.2–29.5)	0.15	26.0 (23.6–28.4)	<0.05	28.2 (25.1–31.3)	0.21	27.3 (25.0–29.6)	0.34
Average occupancy (%)													
1 day	1.0%	0.1%	<0.05	0.2%	0.12								
2 days	2.0%	0.2%	<0.05	1.3%	0.34								

[A] *P*-values were calculated from two-sample *t*-tests between Alert-4 days and non-alert days.
[B] *P*-values were calculated from two-sample *t*-tests between Alert-4 days and control case days.
[C] *P*-values were calculated from matched paired *t*-tests between Alert-4 days and 1 day after.
[D] *P*-values were calculated from matched paired *t*-tests between Alert-4 days and 2 days after.
[E] *P*-values were calculated from matched paired *t*-tests between control case days and 1 day after.
[F] *P*-values were calculated from matched paired *t*-tests between control case days and 2 days after.

data accuracy and quality issues typically arise, no significant concerns were raised. However, some concerns were raised regarding the volume and penetration of Alert 4 data, and these have been addressed in the Limitations section. Statistical significance in all tests was set at $P < 0.05$.

Results

Occupancy levels for Alert-4 days compared with control case days and other non-alert days are shown in Fig. 1. In general, the Alert-4 days appeared at the peaks of the occupancy data. However, there were many instances of higher occupancy recorded on control case days and non-alert day than on days when Alert-4 had been called. This was especially noticed for the period between mid-September 2009 and mid-December 2009 when the hospital frequently operated at and above 100% capacity levels.

In total, across the 2-year analysis period, there were 66 Alert-4 call days. Analysing the spread of Alert-4 calls across days of the week (see Table 2) showed that Alert-4 calls were mostly made early in the week, with maximum calls being triggered on Tuesdays, followed closely by Wednesdays and Mondays. There was a strong correlation (correlation coefficient $\rho = 0.87$) between day of the week average occupancy and the frequency of Alert-4 calls. Analysis across the months showed a similar strong correlation ($\rho = 0.72$), with anomalies observed in October and November 2009, where no calls were made although mean occupancy was high. With the exception of September 2009, the mean average occupancy across the call days was also markedly higher than the mean average occupancy for that month.

Figure 2 shows the time spent at various occupancy levels and the variance in average occupancy across the 5-day period centred on an Alert-4 call day. This analysis revealed that hospitals spent significantly more time at higher levels of occupancy on Alert-4 days and that Alert-4 days successfully resulted in reversing the trend of rising average occupancy.

Investigating the performance of patient flow parameters on Alert-4 days compared with non-alert days (see Table 1) revealed that Alert-4 days were characterised by significantly ($P < 0.001$) higher levels of occupancy, higher patient admission and discharge rates and increased ED access block. It was also observed that Alert-4 days resulted in reduced average occupancy levels over the following 24 and 48 h, a trend that was significantly different from that observed on non-alert days. However, when analysing control case days (see Table 1), the reduction in average occupancy levels over 24 and 48 h tended to be lower, although not significantly different, from values observed on Alert-4 days.

Statistical analysis of the differences in flow parameters in the 48 h following Alert-4 days (see Table 1) revealed that minimum, maximum and average occupancy levels and the average admission rate were significantly improved (reduced) in the 1 day after analysis period, and reductions in midnight occupancy and access block became significant in the 2 day after analysis period. Although reduced, the average discharge rate was not significantly different 2 days after an Alert-4 call. In contrast, none of the above flow parameters significantly improved in the 1 day after period following a control case day. In fact, a rise was observed in the average admission and discharge rates and levels of access block. In the 2 days after analysis period following a control case day, significant reductions were observed only in minimum and average occupancy levels and the average admission rate.

Discussion

The key purpose behind this analysis was to investigate the efficacy of capacity escalation alert processes that are used by

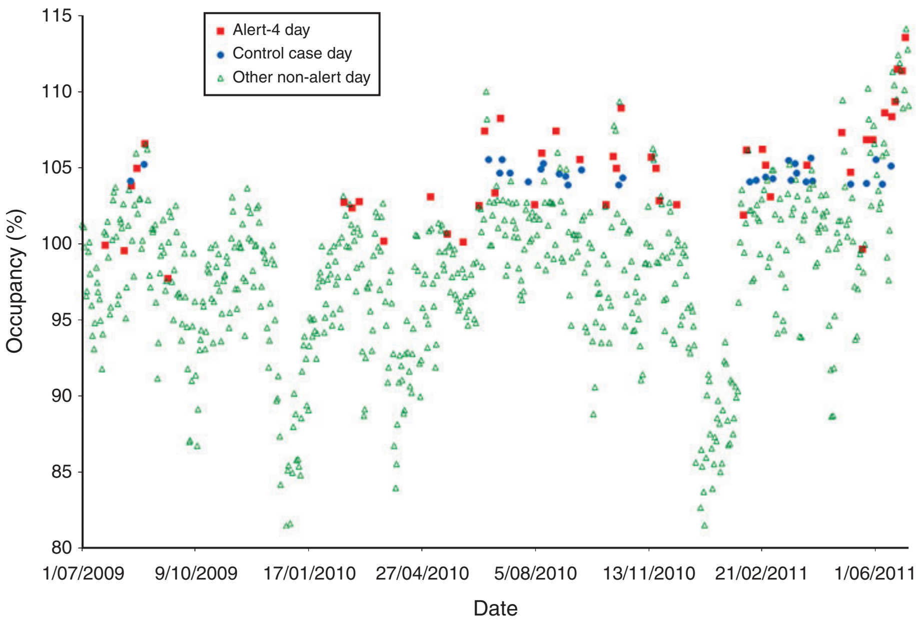

Fig. 1. Occupancy levels of Alert-4 days compared with control case and other non-alert days. Squares indicate Alert-4 days; circles indicate control case days; triangles indicate non-alert days.

Table 2. Characteristics of Alert-4 days

Month	Mean average occupancy across month (%)	No. calls	Mean average occupancy across call days (%)	No. calls Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
July 2009	98.28	1	99.95	0	0	1	0	0	0	0
August 2009	101.58	4	103.80	0	0	2	0	1	1	0
September 2009	98.27	1	97.81	0	1	0	0	0	0	0
October 2009	94.77	0	0.00	0	0	0	0	0	0	0
November 2009	98.94	0	0.00	0	0	0	0	0	0	0
December 2009	91.65	0	0.00	0	0	0	0	0	0	0
January 2010	91.86	0	0.00	0	0	0	0	0	0	0
February 2010	99.08	2	102.60	0	0	0	2	0	0	0
March 2010	97.20	2	101.53	0	0	1	1	0	0	0
April 2010	92.75	0	0.00	0	0	0	0	0	0	0
May 2010	98.21	2	101.93	0	0	1	1	0	0	0
June 2010	100.31	5	104.75	0	1	1	3	0	0	0
July 2010	101.50	2	106.10	0	1	0	0	1	0	0
August 2010	102.36	3	105.37	0	1	1	1	0	0	0
September 2010	98.80	1	105.57	0	1	0	0	0	0	0
October 2010	100.22	5	106.05	0	0	2	2	0	1	0
November 2010	99.32	6	104.80	0	2	2	1	0	1	0
December 2010	93.31	2	101.46	0	0	1	1	0	0	0
January 2011	88.76	0	0.00	0	0	0	0	0	0	0
February 2011	102.34	7	104.76	0	3	1	0	1	2	0
March 2011	101.03	1	104.92	0	0	1	0	0	0	0
April 2011	100.02	1	105.25	0	0	0	0	0	1	0
May 2011	102.63	10	106.82	1	2	4	1	1	1	0
June 2011	107.67	11	111.44	0	2	2	3	2	1	1
Total		66		1	14	20	16	6	8	1
Mean		2.75		0.04	0.58	0.83	0.67	0.25	0.33	0.04
Average occupancy across day of week (%)				95.89	99.44	100.6	100.3	99.66	97.73	94.76

acute hospitals to assist the management of high in-patient occupancy levels and overcrowding. The findings validate the protocol strategies and highlight areas that need to be addressed to further enhance their usefulness in improving hospital performance.

Our analysis of the Alert-4 stage of the capacity alert protocol used at the RAH reveals a strong correlation between mean occupancy levels and the frequency of alert calls across the weeks and months of analysis. Closer analysis of the 5-day window centred on Alert-4 call days shows that the triggering of the Alert-4 protocol successfully reverses the trend of rising occupancy. However, there were several periods within the study that were observed to have high occupancy levels but were managed without Alert-4 calls. Data recorded in the Alert-4 call register were checked manually to explore other recorded causes for Alert-4 calls. Commentary did not accompany all Alert-4 calls, and the available notes pointed to predicted demand surges, ED being over capacity and a single instance of an 'internal disaster' at a neighbouring hospital as causes for the Alert-4 calls. No recorded information was available to suggest alternative measures that were used to overcome high occupancy when Alert-4 calls were not made. However, discussions with capacity management experts at the hospital suggest individual flow manager perceptions of need and concern about Alert-4 fatigue (i.e. the protocol losing its effectiveness if it was initiated too frequently) as possible reasons for the calls not being made on some high occupancy days. Although not documented, other confounding factors contributing to the decision whether to make an Alert-4 call include the triggering of other instinctive capacity management initiatives, such as ambulance diversion, cancellation of surgery and seasonal flow considerations.

Patient flow characteristics of Alert-4 days compared with non-alert days validate the decision-making process behind the triggering of a call. Significantly higher levels of occupancy, patient throughput and access block levels were reported on Alert-4 days compared with non-alert days. Underlying processes triggered as part of an Alert-4 call also seem effective given that Alert-4 days lead to a significant reduction in average occupancy over the next 2 days compared with non-alert days. However, analysis of control case days reveals statistically similar levels of average reduction in occupancy. This suggests that part of the reduction in occupancy comes from processes such as increased discharge rounds, surgery cancellation and capacity flexing, which can be instinctively initiated at high occupancy levels. Thus, although Alert-4 calls may escalate the return to normal operational levels, processes defined by the Alert-4 protocol need to be improved to deliver more significant improvements in patient flow when triggered.

Closer analysis of the 5-day window centred on Alert-4 call days revealed that the triggering of the Alert-4 protocol successfully reversed the trend of rising occupancy. Analysing the change in patient flow parameters over the 48 h following

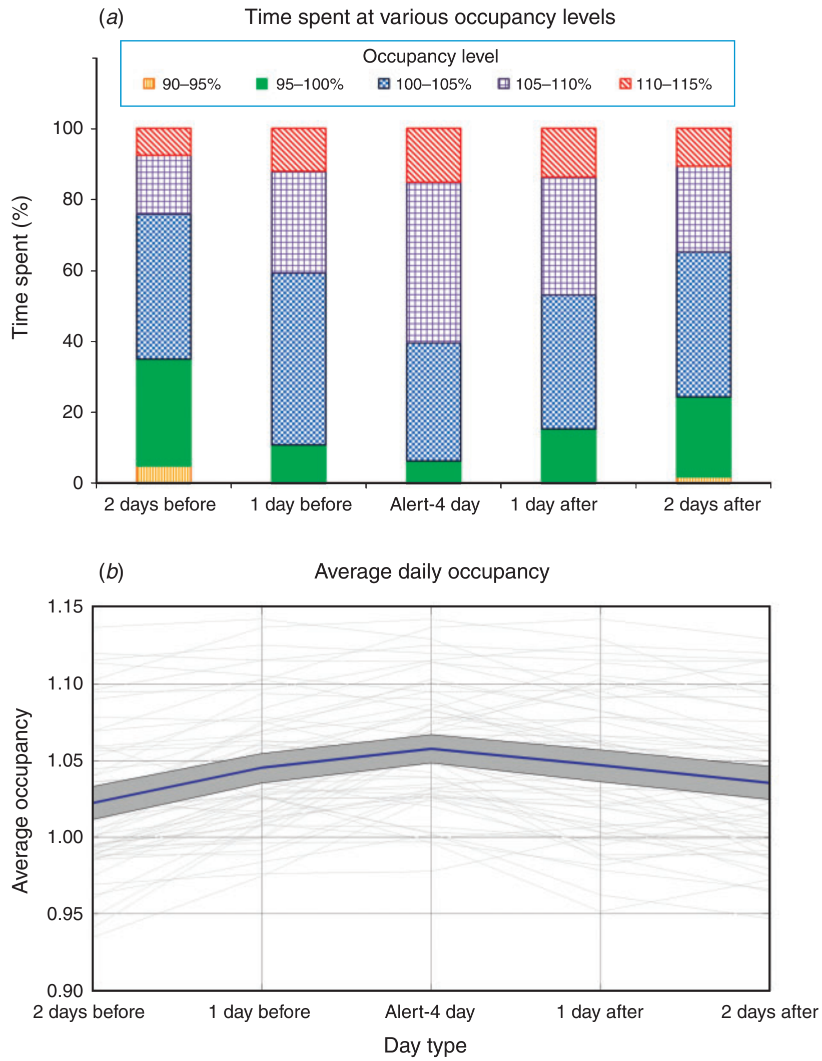

Fig. 2. Occupancy profile showing (a) the time spent at various occupancy levels and (b) the average daily occupancy for the 5-day period centred on an Alert-4 call day.

Alert-4 call days confirmed that the reduction in occupancy and other flow parameters was significant ($P < 0.05$). However, it was observed that significant reductions were not recorded for some parameters in the 1 day following the Alert-4 call, and that the reduction in average discharge rates was not significant even 2 days after the Alert-4 call day. In contrast, improvements in patient flow that follow control case days were less pronounced. Patient throughput and access block levels actually increased over the 24 h following control case days, and significant reductions over 48 h were only observed for minimum and average occupancy, and the average admission rate. This corroborates the need and usefulness of the Alert protocol, but reiterates the need for better-defined triggers and procedures, more efficient processes and better capture of information to drive further improvements in patient flow when the Alert-4 protocol is triggered.

The present study has shown the efficacy of capacity alert escalation plans in controlling rising occupancy, managing throughput and reducing access block, proving that escalation processes that engage the whole hospital during periods of high occupancy can successfully help reverse trends of rising occupancy levels and deliver sustained improvements in patient flow. The findings support the use of ‘Alert’ status escalation calls to manage overcrowding, but suggest that the efficacy could be enhanced by improving consistency of occupancy level triggers for Alert calls and continuous revising of processes supporting escalation processes to improve their effect in reducing occupancy levels within 48 h after a call. Identifying and addressing suboptimal aspects of the protocols would lead to improved patient flow and contribute to better patient care outcomes.

Limitations

The present study assessed the impact of a single capacity alert process at one hospital and in one state that may be seen to have a particular demographic and climatic profile. This should be considered when applying the findings to other hospital service settings. Further, the data used in this analysis did not capture the level of penetration of the series of actions that underscore the

Alert-4 call and hence the impact that particular actions may have had. These are potential areas for extending this analysis.

Conclusions

Hospitals are frequently faced with situations where the medical and health needs of the population exceed available resources. Hospital services adopt a variety of capacity management protocols to address the resulting periods of high occupancy and increased patient throughput. This study analysed the efficacy of the capacity management and escalation Alert process undertaken at the Royal Adelaide Hospital. Our findings suggest that the capacity alert escalation calls are an effective tool in the hospital's arsenal for controlling and reversing the effects of increased occupancy. They also reveal that consistency in protocol trigger mechanisms and an improvement in processes initiated by an Alert-4 call may help raise the effectiveness of the protocol and thus improve patient flow through the health service.

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