How much do operational processes affect hospital inpatient discharge rates?

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ABSTRACT

Background The objective of this study is to determine the effect of day of the week, holiday, team admission and rotation schedules, individual attending physicians and their length of coverage on daily team discharge rates.

Methods We conducted a retrospective analysis of the General Internal Medicine (GIM) inpatient service at our institution for years 2005 and 2006, which included 5088 patients under GIM care.

Results Weekend discharge rate was more than 50% lower compared with reference rates whereas Friday rates were 24% higher. Holiday Monday discharge rates were 65% lower than regular Mondays, with an increase in pre-holiday discharge rates. Teams that were on-call or that were on call the next day had 15% higher discharge rates compared with reference whereas teams that were post-call had 20% lower rates. Individual attending physicians and length of attending coverage contributed small variations in discharge rates. Resident scheduling was not a significant predictor of discharge rates.

Conclusions Day of the week and holidays followed by team organization and scheduling are significant predictors of daily variation in discharge rates. Introducing greater holiday and weekend capacity as well as reorganizing internal processes such as admitting and attending schedules may potentially optimize discharge rates.

Keywords day of the week, discharge rate, holiday, operational efficiency, scheduling

Introduction

Improving patient flow in acute care hospitals is an important issue in hospital management and research. Improved patient flow can decrease wait times for care, ease Emergency Department (ED) congestion, and increase the effective capacities of the ICU and inpatient units.1–4 One way to improve patient flow is to remove variation in processes along the care pathway that can block or delay flow.5

One process in particular—patient discharge—has received critical attention because variation and delays in this process create ‘bottlenecks’ that ultimately delay most care pathways, especially new admissions from the ED.6,7

Although the decision to discharge an individual patient from hospital should predominantly be a clinical decision, there may be non-clinical factors that influence decision-making. These may include patient and family preferences,8 physician practice preferences,9 internal hospital inefficiencies,10 post-acute care bed capacity11 and healthcare financing arrangements.12
The impact of non-clinical hospital discharge delays on costs, quality and appropriateness of care has garnered international attention. In the United States where hospitals are reimbursed prospectively, one study found that ~7% of hospital days were judged unnecessary and were due to difficulty finding a bed in a skilled nursing facility. In the UK, where transfer from acute inpatient hospital care to ongoing health and social care is subject to means-testing and user charges, the Community Care Act 2003 was introduced that allowed hospital trusts to charge social service departments (providing ongoing health and social care in the community) for hospital beds unnecessarily ‘blocked’ by people awaiting social services. In Canada, universal health insurance covers medically necessary in- and out-patient hospital services as well as extended health services (certain aspects of long-term residential care and the health aspects of home care and ambulatory care services). Hospitals receive block funding and chronically face budget deficits. There is increasing accountability on hospitals to meet benchmarks on wait times in the ED, for diagnostic imaging, and for selected elective surgeries, all whereas maintaining a balanced budget. Thus, patients occupying acute care beds who are awaiting transfer to a community facility represent a significant challenge in timely acute care hospital discharge.

Although efforts have been made to better coordinate care between acute and post-acute sectors, understanding factors within an acute care hospital’s control should be a top priority, as reducing them may improve efficiency. Several studies have focused on internal hospital operational factors including the day of the week of admission in terms of internal resource availability, team organization and workload, and clinician behaviour to understand how they contribute to variations in discharge. In these studies, the primary outcome measure was length of stay (LOS). An alternative metric to measure the impact of hospital operational factors on the discharge process is daily discharge rate. Daily discharge rate incorporates day of the week explicitly and may highlight other operational factors that exhibit temporal patterns including staffing and scheduling.

The objective of this study was to determine the effect that the following operational factors had on discharge rates: day of the week, holiday status, team admission schedule, resident scheduling, individual attending physicians and the length of attending physician coverage. Our primary outcome measure was mean daily team discharge rate, expressed as the number of team discharges divided by team census on a particular day.

Methods

We conducted a retrospective analysis of the General Internal Medicine (GIM) inpatient service at Toronto General Hospital for two consecutive years, 2005 and 2006. We wanted to determine the effect of day of the week, holiday status, team admission schedule, resident scheduling and attending physician schedule on team discharge rates. University Health Network (UHN) Research Ethics Board approved this study.

Setting

This study was conducted on the GIM inpatient service at the UHN’s Toronto General Hospital site, a 400-bed tertiary care centre and teaching hospital located in downtown Toronto, Canada. GIM provides acute, non-surgical health care to a patient population primarily composed of elderly patients with complex, chronic illnesses. GIM receives 98% of its inpatient admissions from the ED, other sources being transfers from other services (CCU, ICU, surgery, etc.) and other institutions. Of all patients requiring admission from the ED, GIM receives the largest share (30–50% of all ED admissions).

During the study period, there were four admitting teams. Each team consisted of one attending physician, one resident and two interns. Each day, the team assigned to be on-call accepted new admissions from 8 AM to 8 AM the following day, at which time they transitioned to post-call status. During weekends, the on-call team was responsible for all admitting duties as well as clinical duties for all GIM admissions. Teams (resident and interns) rotated every 2 months, whereas attending physicians normally rotated on a monthly basis. Attending physician rotations could range from half a month to two consecutive months. Attending physicians were not assigned exclusively to one team.

Data collection

Data was collected from January 15th to December 15th for the 2 years, 2005 and 2006. We excluded the period December 16th–January 14th from our analyses due to Christmas/New Year holiday disruptions to physician team structures. To simplify analyses, we only selected holidays that occurred on a Monday, thus excluding Easter (March 24–29, 2005 and April 13–18, 2006) and Canada Day (June 30–July 4, 2005 and June 30–July 4, 2006) from analysis. The unit of analysis was a day, defined as the 24 h period from 08:00 to 08:00. The time period of 08:00–08:00 was chosen because it better reflects the period when decisions are made and work is completed.
Patient-level data was obtained from UHN’s primary patient care system Electronic Patient Record (EPR). EPR contains information pertaining to sociodemographics, diagnosis, LOS, patient disposition, attending physician, admission and discharge dates and times. Attending physician schedules, team admission schedules, and resident schedules were obtained from team rosters maintained by the GIM residency program. We included all GIM inpatient admissions that were under the care of GIM services during the study period (i.e. patients whose admission or discharge dates were within the study period and patients admitted before the start of the study period and discharged after the end of the study period).

Outcomes

Our primary study outcome was mean daily team discharge rate, expressed as the number of discharges divided by census for a specific team on a particular day. Daily team discharge rate was chosen as opposed to the overall discharge rate because each team effectively acted as an independent unit and it allowed us to look at variations caused by scheduling. Daily team census was measured at 8 AM. To retain a focus on operational factors that can act as bottlenecks in discharge, we excluded discharges with disposition of either death or left against medical advice from daily discharge rate calculations. These visits were however maintained for daily census calculations.

Predictors

Day of the week and holiday status

We examined if day of the week or a holiday period was a predictor of daily team discharge rates. Holiday Mondays included Victoria Day (23 May 2005 and 22 May 2006), Civic Holiday (1 August 1 2005 and 7 August 2006), Labour Day (5 September 2005 and 4 September 2006) and Thanksgiving Day (10 October 2005 and 9 October 2006). A priori, we believed that in anticipation of a Holiday Monday, proactive measures to increase discharge rates would be taken pre-holiday period (either by physician purposeful behaviour or by request of patient and/or patient’s family), or conversely reactive measures would be taken post-holiday period. Fridays, Saturdays, and Sundays immediately preceding a Holiday Monday were defined as pre-holiday days. Tuesdays immediately following a Holiday Monday were defined as post-holiday days. ‘Regular’ weekdays and weekends included all days in the study period except pre-/post-/Holiday Mondays listed above.

Clinical scheduling

We examined whether the scheduling of team admissions, resident scheduling or attending physicians was a predictor of daily team discharge rates. According to the team admission schedule, each day, each team was assigned either pre-call, on-call, post-call, post–post-call or no-call status (team neither pre-call, on-call, post-call nor post–post-call) (Fig. 1). Each call-status was equally likely to occur during the 7 days of the week, with the exception of no-call status, which only occurred on weekends. We anticipated that discharge rates for post-call teams would be significantly decreased since post-call teams were relieved of hospital duties at 12 PM. We hypothesized that there would be an increase in discharge rates for pre-call teams in anticipation of the increased workload of new admissions the following day.

We also examined whether resident scheduling was a predictor of daily team discharge rates. Residents are scheduled for durations of 2 months. We anticipated that there would be differences in team discharge rates for three distinct periods during the 2 months: first week, last week and all remaining weeks. We hypothesized that in the first week of the 2 month period, teams were newly acquainted with their patients and as a result, would be less likely to discharge them compared with remaining weeks. In contrast, in the last week of the 2 months, teams were well acquainted with their patients and would be more likely to discharge them compared with other weeks.
Finally, we examined whether individual attending physicians had different daily team discharge rates and whether the length of coverage assigned to an attending affected discharge rates. We anticipated no major difference in aggregate daily discharge rate among the different attending physicians during the course of the study period; however, we hypothesized that there would be differences in discharge rates for physicians attending for shorter periods (i.e. ≤15 days) versus longer coverage periods (i.e. ≥30 days). Physicians who are attending for short periods may be less inclined to be actively involved in discharge planning. In addition, physicians nearing their end of their coverage period may be less motivated to discharge patients. To account for the length of attending service and proximity to end of service coverage for each day of the study period, we calculated the numbers of days since the start of team coverage and the numbers of days till the end of team coverage for each of the four attending physicians on service.

Statistical analyses
Preliminary analysis of the data included the calculation of descriptive statistics to summarize GIM patient admission and service characteristics. We reported medians and interquartile ranges for continuous variables and proportions for categorical variables. All regression analyses used a linear mixed random effects model with the number of discharges by a team on a day treated as a Poisson random variable. In all analyses, we accounted for the effects of clustering of the four team outcomes within a day by including a random effect for day. All analyses also included a six-degree-of-freedom natural spline fitted to the calendar time variable to account for seasonal fluctuation and correlation between outcomes on adjacent days.

In four separate univariable regressions, we assessed the relationship between discharge rate and each of the predictor variables (type of day, team admission schedule, resident scheduling and the length of attending physician coverage). We also ran a model with a random effect for the attending physician; this allowed each attending physician to have a discharge rate that is either higher or lower than the average. Finally, we fitted a model with all four predictors and the random effect for attending physician. We report the rate ratios and 95% confidence intervals, compared with a reference group for categorical predictors, and per 30 days for attending physician coverage. We also report the standard deviation between log-rate ratios for individual attending physicians. All statistical analyses were performed using R (version 2.8.0; R Foundation for Statistical Computing, Vienna, Austria); and two-tailed P < 0.05 was considered statistically significant in all analyses.

Results
Patient and service characteristics
During the 648-day study period, there were 5088 patients under the care of GIM services (Table 1). About 98% of patients were admitted from the ED, 2% were directly admitted. The median age of patients was 68 years and 48% were women. Patient dispositions following GIM care during the study period included: discharge home (72%), transfer to other facility including other acute care facilities, rehabilitation, long-term care, respite care, complex continuing care (14%), in-hospital death (7%), transfer to another inpatient service within UHN (6%) and lastly left against medical advice (2%). The overall median LOS was 5 days. Measured at 8 AM, daily median GIM census was 66 patients. On a daily basis, both the median number of admissions and discharges to and from GIM services was 7 patients. At the team level, median daily census was 16 patients, median number of daily discharges was one patient, and median daily team discharge rate was 9% of team census.

Day of the week and holiday status
The day of the week accounted for a significant amount of variation in discharge rates in both unadjusted and adjusted models (Fig. 2 and Table 2). Wednesday was chosen as the
reference. For regular weekends, both Saturday and Sunday had significantly lower (by 50% $P < 0.001$, and 71% $P < 0.001$, respectively) adjusted rates of discharge relative to Wednesday. For regular weekdays, whereas Monday, Tuesday and Thursday had similar adjusted discharge rates relative to Wednesday (8, 5 and 6% lower, respectively), Friday had significantly higher discharges (by 24% $P = 0.001$) relative to Wednesday.

Adjusted rates of discharge on Holiday-Monday were significantly lower than regular Mondays with Holiday-Monday discharge rates being 65% lower than rates on a regular Monday ($P < 0.001$). Discharge rates on a pre-holiday Friday were 27% higher than rates on a regular Friday ($P = 0.04$). Although pre-holiday Saturday and Sunday had rates that were higher than their corresponding regular weekend days, these increases were not statistically significant (Saturday: 40% higher, $P = 0.06$; and Sunday: 34% higher, $P = 0.22$). In contrast, discharge rates on a post-holiday Tuesday were similar to regular Tuesdays ($P = 0.17$).

**Clinical scheduling**

Following type of day, team admission schedule ranked as the next most important predictor of variation in discharge rates in both unadjusted and adjusted models. Post–post call teams were chosen as the reference. Relative to post–post call teams, pre-call and on-call teams had significantly higher (by 17 and 15%, respectively) adjusted rates of discharge ($P < 0.001$, $P = 0.002$, respectively), whereas post-call and no-call teams had significantly lower (by 20 and 27%, respectively) adjusted rates of discharge ($P < 0.001$, $P = 0.005$, respectively).

Resident scheduling was not a predictor of discharge rates in either unadjusted or adjusted models. Weeks other than the first or last weeks of resident rotation were chosen as the reference. Adjusted discharge rates during the first and last weeks of resident rotation schedule were similar to middle weeks ($P = 0.65$ and $P = 0.67$, respectively).

Individual attending physicians and their length of scheduled coverage was a predictor of discharge rates in the adjusted model. There were 28 different attending physicians that covered the four teams during the study period. There was a small but significant random effect for the attending physicians in the adjusted model, wherein attending physicians had discharge rates that ranged from 8% below average to 4% above average ($P = 0.006$). Length of attending physician coverage ranged from a minimum of 14 consecutive days to a maximum of 64 consecutive days. There was a small but significant increase in adjusted rates of daily discharge as the term length (days from start of attending coverage) increased (by 10% per 30 days attending, $P = 0.04$). Proximity to end of term coverage (days till end of attending coverage) was not a significant predictor of daily discharge rate ($P = 0.84$).

**Discussion**

**Main finding of this study**

We found that discharge rates within a GIM inpatient service were affected by the day of the week, holiday status, team admission schedule, individual attending physicians and their length of attending coverage. Adjusted discharge rate ratios and 95% confidence intervals for the majority of predictors were virtually identical to the unadjusted discharge rate ratios, confirming that the effects of the predictors are independent of each other. Weekend discharge rate was significantly lower than weekday discharge rate. More discharges occurred on Fridays than other days, possibly to compensate for reduced weekend discharges. Holiday Monday discharge rates were significantly lower than regular Mondays with increases in pre-holiday discharge rates. More discharges occurred when a team was either pre-call or on-call status, and significantly less discharges occurred for teams on post-call status. Resident scheduling was not a significant predictor of team discharge rates. Individual attending physicians had small but significant variation in team
discharge rates, and as the length of attending coverage increased, so did the rate of discharge.

**What is already known on this topic**

We investigated the effect of weekends and holidays on discharge rates because it has received considerable attention as a source of hospital inefficiency.27,28 Although discharges and discharge rates should be predominately clinical decision, there is significant variation caused by hospital processes. Understanding these variations may be key to improving efficiency. A study by Carey et al.13 to quantify delays in care for general medicine inpatients found that nearly 25% of unnecessary patient-days involved an inability to access medical services on a weekend day. The data on weekends reported here are consistent with and extend findings from previous studies that have evaluated the effect of weekends on patient flow. It has been previously shown that discharge rates are significantly higher on Fridays and lower over the weekends and that these results are independent of clinical indicators of risk.29 One explanation for this phenomenon is that availability of hospital resources including physicians and hospital staff are decreased on weekends. To avoid the weekend, patients were preferably discharged on Friday. A similar explanation may be used to explain increased pre-holiday discharges relative to their regular counterpart days. Reduced weekend capacity also applies to many community resources and post-acute care institutions making it unfeasible to discharge patients that require home care or transfer to other institutions on weekends. Patient and family preferences may also be relevant in determining the day of week of discharge.

### Table 2 Univariate and multivariate analysis of operational factors on team discharge rates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate analysis (unadjusted)</th>
<th>Multivariate analysis (adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discharge Rate Ratio 95% CI P value</td>
<td>Discharge Rate Ratio 95% CI P value</td>
</tr>
<tr>
<td>Day of the week</td>
<td></td>
<td></td>
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<tr>
<td>Holiday Monday</td>
<td>0.32 (0.20–0.49, &lt;0.001)</td>
<td>0.32 (0.21–0.51, &lt;0.001)</td>
</tr>
<tr>
<td>Monday</td>
<td>0.90 (0.81–1.00, 0.05)</td>
<td>0.92 (0.83–1.02, 0.11)</td>
</tr>
<tr>
<td>Post-holiday Tuesday</td>
<td>1.12 (0.89–1.43, 0.34)</td>
<td>1.13 (0.89–1.44, 0.32)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>0.95 (0.86–1.05, 0.31)</td>
<td>0.95 (0.86–1.05, 0.35)</td>
</tr>
<tr>
<td>Wednesday*</td>
<td>1 —</td>
<td>1 —</td>
</tr>
<tr>
<td>Thursday</td>
<td>0.93 (0.85–1.03, 0.19)</td>
<td>0.94 (0.85–1.03, 0.19)</td>
</tr>
<tr>
<td>Pre-holiday Friday</td>
<td>1.54 (1.25–1.89, &lt;0.001)</td>
<td>1.57 (1.28–1.93, &lt;0.001)</td>
</tr>
<tr>
<td>Friday</td>
<td>1.24 (1.13–1.37, &lt;0.001)</td>
<td>1.24 (1.13–1.37, &lt;0.001)</td>
</tr>
<tr>
<td>Pre-holiday Saturday</td>
<td>0.62 (0.44–0.86, 0.004)</td>
<td>0.70 (0.50–0.98, 0.04)</td>
</tr>
<tr>
<td>Saturday</td>
<td>0.45 (0.39–0.51, &lt;0.001)</td>
<td>0.50 (0.43–0.57, &lt;0.001)</td>
</tr>
<tr>
<td>Pre-holiday Sunday</td>
<td>0.36 (0.24–0.55, &lt;0.001)</td>
<td>0.39 (0.26–0.6, &lt;0.001)</td>
</tr>
<tr>
<td>Sunday</td>
<td>0.27 (0.23–0.32, &lt;0.001)</td>
<td>0.29 (0.25–0.34, &lt;0.001)</td>
</tr>
<tr>
<td>Attending physician coverage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days from start of coverage†</td>
<td>1.01 (0.93–1.10, 0.76)</td>
<td>1.10 (1.00–1.20, 0.04)</td>
</tr>
<tr>
<td>Days to end of coverage†</td>
<td>1.02 (0.94–1.12, 0.58)</td>
<td>1.01 (0.92–1.11, 0.84)</td>
</tr>
<tr>
<td>Team admitting schedule</td>
<td></td>
<td></td>
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<tr>
<td>Pre-call</td>
<td>1.15 (1.06–1.25, 0.001)</td>
<td>1.17 (1.07–1.27, &lt;0.001)</td>
</tr>
<tr>
<td>On-call</td>
<td>1.06 (0.97–1.15, 0.21)</td>
<td>1.15 (1.05–1.25, 0.002)</td>
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<tr>
<td>Post-call</td>
<td>0.75 (0.69–0.82, &lt;0.001)</td>
<td>0.80 (0.74–0.87, &lt;0.001)</td>
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<tr>
<td>No-call</td>
<td>0.40 (0.32–0.49, &lt;0.001)</td>
<td>0.73 (0.58–0.91, 0.005)</td>
</tr>
<tr>
<td>Post–post-call*</td>
<td>1 —</td>
<td>1 —</td>
</tr>
<tr>
<td>Resident rotation schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First week</td>
<td>0.94 (0.81–1.09, 0.427)</td>
<td>0.98 (0.88–1.09, 0.651)</td>
</tr>
<tr>
<td>Last week</td>
<td>1.08 (0.94–1.24, 0.298)</td>
<td>1.02 (0.92–1.13, 0.668)</td>
</tr>
<tr>
<td>Not first or last week*</td>
<td>1 —</td>
<td>1 —</td>
</tr>
<tr>
<td>Random effect of attending</td>
<td>SD = 0.054</td>
<td>SD = 0.061</td>
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</tbody>
</table>

*Reference variable.
†Per 30 days.
What this study adds

Our study introduces daily team discharge rate, expressed as the number of discharges divided by census for a specific team on a particular day. Although daily discharge rate explicitly incorporates day of the week trends, there are implicit factors operating at many different levels that influence its value. Likelihood of discharge is affected by the composition of the ultimate discharge destinations of the current patient census (home versus transfer to another facility). Similarly, the proportion of team census considered ‘long-stay’ will also affect daily team discharge rate.

Our study further highlights the importance of considering full utilization of hospital capital designed to operate 7 days a week. Bell and Redelmeier\(^{30}\) found that even conservative growth in weekend service can achieve an increase in procedure volumes of \(\sim 15\%\). Our study also showed that team organization and scheduling is a significant predictor of daily team discharge rates. Teams discharged a significantly greater proportion of their patients during pre-call and on-call days and significantly fewer on post-call days. Clinically, pre-call teams have patients that have had at least 3 days of diagnostic and therapeutic care and therefore would be expected to be more ready for discharge than post-call teams that have a larger proportion of their patient census consisting of new patients with active clinical issues.

A plausible non-clinical explanation for increased pre-/on-call discharges is that in anticipation of increased workload/census due to new admissions, teams purposefully discharged more of their patients. Although in our admission system, we get a ‘bolus’ of patients on average every 4 days, other systems have been proposed that have daily admission rates. If our traditional ‘bolus’ admitting system in place was replaced with ‘drip’ admissions, workload would be more manageable and discharges would occur in a more uniform and predictable manner.\(^{31}\)

We also compared team discharge rates in the first week, last week and remaining weeks of a resident rotation schedule and found no substantive differences. This finding may be in part because of attending physician scheduling. Since attending physicians lead team decision-making but do not follow the resident rotation schedule, similar rates of discharge during the course of the resident rotation schedule may not be surprising. A study by Smith \(et\ al.\)\(^{32}\) did find that the last 3 days of the month was an independent predictor of LOS. Lastly, we observed that individual attending physicians had small but significant differences in discharge rates and found that attending physicians with shorter coverage periods tended to have lower discharge rates compared with attending physicians with longer coverage periods. Physicians who attend for longer periods of time may be more invested in discharge processes and discharge planning. Further study is required to investigate optimum scheduling and durations of attending coverage to improve efficiency.

Limitations of this study

This study has several limitations. It took place in one large teaching institution with resident and attending physician staffing, and as a consequence, may be less generalizable to other community hospitals. Nonetheless, clinical scheduling policies and availability of resources on weekends and holidays affect all hospitals. Also, we excluded the period December 16th–January 14th from our analyses due to Christmas/New Year holiday disruptions to physician team structures and holidays not landing on a Monday. Therefore, although our results may underestimate the impact of holidays on discharge rates, they still reveal important trends in discharge rate during holidays.

Conclusion

In conclusion, our findings suggest that day of the week, holiday status and team admission schedule significantly influenced daily discharge rates. Individual attending physicians and their length of coverage have a small influence in discharge rate. Introducing greater holiday and weekend capacity as well as reorganizing internal processes such as admitting and attending schedules may potentially optimize discharge rates. Discharge rate, expressed as the number of discharges divided by census on a particular day, may be a useful metric to measure the impact of operational factors on the discharge process. One particular benefit of discharge rate is that it can be used to actively monitor and improve operations in more real-time as opposed to lagging indicators of performance. Further study in other inpatient settings is required to confirm the appropriateness of discharge rate as a performance metric of discharge efficiency.

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