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The relationship between workload and length of stay in Singapore

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ABSTRACT

Prior studies link higher workload with longer length of stay (LOS) in the US. Unlike U.S. hospitals, Singaporean hospitals, like other major hospitals in the Asia-Pacific, are partially occupied by patients with non-acute needs due to insufficient alternative facilities. We examined the association between workload and length of stay (LOS) and the impact of workload on 30-day re-hospitalization and inpatient mortality rates in retrospective cohort in this setting. We defined workload as the daily number of patients per physician team. 13,097 hospitalizations of 10,000 patients were included. We found that higher workload was associated with shorter LOS (coefficient, −0.044 [95%CI, −0.083, −0.01]), especially for patients with longer stays (hazard ratios, not significantly greater than 1 before Day 4, 1.04 [95%CI, 1.01, 1.07] at Day 4 and 1.16 [95%CI, 1.10, 1.24] at Day 10), without affecting inpatient mortality (odds ratio (OR), 1.03 [95%CI, 0.99, 1.05]) or 30-day re-hospitalization (OR, 1.01 [95%CI, 0.99, 1.04]). This result differs from studies in the US and may reflect regional differences in the use of acute hospital beds for non-acute needs.

1. Introduction

The Asia-Pacific region, which is home to 61% of the world's population, is experiencing precipitous population ageing. The associated rise in demand for hospital care leads to severe hospital overcrowding in this region [1]. Public acute hospitals in Singapore, which provide 80% of acute care services for the 5.6 million people, are no exception. Their average occupancy rate is 85–95%. High occupancy rate may be associated with increased rate of hospital-acquired infection [2] and mortality [3]. In Singapore, high occupancy rate creates significant challenges to care delivery. For example, gardens, therapeutic area, and tents have been used to accommodate the high volume of patients and the median waiting time for admission was up to 7 h [4]. In addition, with rapid population ageing, the demand for acute hospital beds in Singapore is projected to at least double in the next 25 years. Building new hospitals is one approach to manage the challenge of increasing demand. However, this is expensive and may increase the demand for acute services and hence healthcare cost as "every bed built is a bed filled" without proper constraints on utilization [5].

One alternative approach to addressing increasing acute hospital demand is to explore strategies to reduce the LOS in acute hospitals without worsening patient outcomes. Several strategies have been implemented and evaluated to this end in the U.S. For example, the Prospective Payment System has significantly driven down LOS [6].

Although it is tempting to consider implementing solutions such as payment incentives directly in Singapore to meet its capacity challenges, that would be short-sighted as it does not account for the differences in the healthcare systems. One major difference is that physician workload is very high in the public hospitals in Singapore when compared to the U.S. [7,8]. Prior studies from the U.S. showed that high physician workload drives a longer LOS [9], increased 30-day re-hospitalization rate [10], increased inpatient

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mortality rate [11], and nosocomial infections [2], suggesting that high physician workload reduces efficiency and quality of care. If the findings could also be applied to the Singaporean context, any strategy that increases the already high physician workload would promote longer LOS and thus mitigate the effect of the effort to reduce the LOS.

However, it is possible that the dynamic between physician workload and LOS in the Singaporean context differs from the U.S., for two reasons. First, the overall LOS in Singapore is 20% longer than the US (5.8 days [12] versus 4.8 days [13]), which is partially explained by the use of acute hospitals to deliver non-acute services such as rehabilitation and wound care due to limited capacity in the non-acute sectors[14] (the number of "intermediate or long-term care facilities per 1000 population is 2.49 [15] in Singapore versus 5.33 in the U.S. [16]). There is evidence that the LOS of the patients who only receive non-acute services can potentially be safely reduced [17]. Second, in the absence of a strong incentive to expedite discharge as observed in the U.S., delay in discharge planning may occur, leading to incomplete administrative work that prohibits discharge when patients are medically fit and a bed in the non-acute facility is available [18]. Increased workload may incentivize the physicians to make proactive discharge planning and potentially reduce the LOS as organizational behavior studies show that increase in workload may increase productivity [19–21].

In order to explore the potential to reduce LOS and expand our understanding of these issues to an Asian context, we aim to examine the impact of workload on LOS at an acute care hospital in Singapore. Secondarily, we aim to understand the impact of workload on two patient outcome measures, namely 30-day re-hospitalization rate and inpatient mortality rate. We hypothesize that higher workload is associated with shorter LOS, without leading to changes to patient outcome measures. In addition, we anticipate that it is the LOS of the patients receiving non-acute services that are likely to be reduced and these patients, on average, have longer LOS than patients who only receive acute services [14,22]. Thus, we hypothesize that workload has a stronger impact on the discharge of patients whose stays are long but weaker or no impact on the discharge of those whose stays are short.

Although this study is conducted in Singapore, the findings may potentially be generalizable to health systems including Japan [23], Hong Kong [24], Taiwan [25], and South Korea [26], in which a significant proportion of the acute hospital beds are utilized for non-acute medical care or social care.

2. Method

2.1. Site and subjects

Singapore General Hospital (SGH) is the largest acute hospital in Singapore with 1700 inpatient beds, accounting for one-fifth of all acute hospital beds in the country. SGH is the base for multiple US-style residency programs that are accredited by Accreditation Council for Graduate Medical Education International (ACGME-I). It also partners with the Duke-NUS Medical School [27] which offers postgraduate education that leads to M.D. and/or Ph.D. degree, and constitutes the largest academic medical center in Singapore. The Department of Internal Medicine (DIM) in SGH provides care to general internal medicine patients. Service teams are comprised of one consultant, who may be a sub-specialist or a general internist, one to two registrars/fellows (at least post graduate year (PGY) 4), several medical officers/residents (at least PGY 2) and house officers/interns (PGY 1). New admissions are assigned to teams by turns, regardless of the variations in workload across teams.

We included all patients who were older than 18 years and were either admitted to or discharged from DIM from 1 st Jan through 31 st Dec 2013 in the study. We excluded patients whose stays are (1) extremely short (less than 1 day) as they may not have required acute hospitalization or (2) long (greater than the 99th percentile, i.e. 35 days) as these patients likely have extraordinary social or other non-medical issues delaying their discharge.

2.2. Measurement of workload

We defined workload as the number of patients per physician team on a daily basis. We used the average of daily workloads from admission to discharge as the independent variable in the analyses of LOS, inpatient mortality rate and re-hospitalization rate as the unit of analysis was patient. We used daily workload as the independent variable in the Cox proportional hazard model of discharge as the unit of analysis was patient-days [28].

2.3. Statistical analysis

We employed an ordinary least square (OLS) regression to examine the association between workload and LOS. As anecdotal accounts suggest that the rate of discharging patients decreases as workload becomes excessively high, we conducted subgroup analyses for hospitalizations with workload greater than 50th, 75th, 90th and 95th percentiles of the distribution (which corresponds to 27, 29, 30, 31 patients per team), respectively, to examine the potential differences in the direction of the association between workload and LOS as workload becomes excessively high. Assuming admission rate remains constant and discharge patterns could be modified to resemble those on high workload days, the proportion of bed days that can be potentially saved is estimated by the following equation,

$$\begin{aligned}&\text{proportion of bed days that can be saved}\\&=\frac{(2\text{ standard deviations of workload}\times\text{ the association between workload and LOS})\times\text{admission rate}}{\text{current average LOS}\times\text{admission rate}}\\&=\frac{2\text{ standard deviations of workload}\times\text{the association between workload and LOS}}{\text{current average LOS}}.\end{aligned}$$

We used logistic regressions to examine the correlations of the workload with the 30-day re-hospitalization rate and inpatient mortality rate.

To examine if the association between workload a length of stay, if any, is modified by the patient's primary diagnosis, comorbidity index, or ward class (three classes, higher class requires higher copayment rates), we included an interaction term in the above model and performed Wald test on the interaction term. For primary diagnosis, we kept the top ten common diagnoses as they are and combined the remaining cases as other diagnoses (Appendix Table 1). In order to understand whether the variations in LOS associated with workload, if any, are driven by differences in the discharge rate of all patients or a subgroup of patients of particular LOS, we used a Cox proportional hazard model [29] to examine potential interactions between the day of a patient's stay and the association between the daily workload on a given day and discharge occurring on the following day [28]. We specified the model as $\log(HR)=\beta_{WL}WL+\beta_{Day}Day+$

$\beta_{Interaction}(WL \times Day) + \mathbf{X_c}\boldsymbol{\beta_c}$, where *HR* is the hazard ratio of discharge on the following day, *WL* is the daily workload, *Day* is the number of the day of a patient's stay, $WL \times Day$ represents the interaction between workload and day of a patient's stay, and Xc is the matrix of covariates (see the next paragraph). Inpatient mortality was treated as censored observations. We also ran the model without the interaction term to examine the association between daily workload on a given day and the probability of discharge on the following day.

All regressions adjusted for potential confounders including patient characteristics (i.e. age, gender, emergency room triage category, ward class, admitted to ICU or high dependency ward during hospitalization, and the Elixhauser comorbidity measure [30]). Potential day and time effect was controlled for in the least square model and logistic model by including binary variables describing whether admissions or discharges occurred over the weekend or admissions that occurred after hours because a prior study in Singapore showed that these variables would affect LOS [31]. In the Cox model, the potential day and time effect was controlled for by including a categorical covariate that denoted day of the week and a binary variable that represented whether admissions occurred after hours. In addition, admission month fixed effect is adjusted for in all regression models. All regressions were clustered by unique patient.

Finally, we performed robustness tests on our findings. First, we assessed a severity-adjusted workload metric. Specifically, we assigned a weight to each admission equal to the adjusted mortality odds ratio of Elixhauser comorbidity (Appendix Table 2). For patients with multiple comorbidities, we used the highest mortality odd ratio of those comorbidities as the weight. Second, we gave a weight of 2 to the day of admission as new cases typically takes more time than existing cases [11]. Finally, we tested if the findings were sensitive to trimming of short and long stays at different percentiles of the LOS distribution.

3. Results

Excluding 4343 hospitalizations with LOS shorter than 1 day and 1815 hospitalizations with LOS greater than 35 days, 13,097 hospitalizations among 10,000 unique patients met the inclusion criteria. Characteristics of the patients and hospitalizations were summarized in Table 1. The average age of the patients was 67 years and

Table 1
Patient and Hospitalization Characteristics.

	Mean/Proportion	95% Confidence Interval
Patient Characteristics (N = 10,000)		
Age, y	66.6	66.3–66.9
Female, %	51.8	51–52.7
Hospitalization Characteristics (N = 13,097)		
Inpatient mortality, %	16.7	16.1–17.4
Readmitted within 30 days, %	19	18.3–19.7
Admitted to ICU/ICA/HD, %	3.8	3.5–4.1
Admitted over the weekend, %	28.8	28–29.6
Admitted after hours, %	48.7	47.9–49.6
Triage*, Category 3, %	23.8	23.1–24.5
Category 2, %	52.9	52–53.7
Category 1, %	23.3	22.6–24.1
Elixhauser comorbidity conditions[a]		
Congestive heart failure, %	0.4	0.3–0.5
Cardiac arrhythmias, %	1	0.8–1.2
Valvular disease, %	0.8	0.7–1
Pulmonary circulation disorders, %	0.3	0.2–0.4
Peripheral vascular disorders, %	0.8	0.7–1
Hypertension (combined), %	19.4	18.7–20.1
Paralysis, %	0.3	0.2–0.4
Other neurological disorders, %	2	1.7–2.2
Chronic pulmonary disease, %	2.7	2.5–3
Diabetes, uncomplicated, %	0.9	0.7–1.1
Diabetes, complicated, %	0.7	0.5–0.8
Hypothyroidism, %	0.7	0.5–0.8
Renal failure, %	0.3	0.2–0.4
Liver disease, %	1.7	1.5–1.9
Peptic ulcer disease excluding bleeding, %	0.4	0.3–0.5
AIDS, %	0	0–0.1
Lymphoma, %	0.3	0.2–0.4
Metastatic cancer, %	1.7	1.5–2
Solid tumor without metastasis, %	3.9	3.6–4.2
Rheumatoid arthritis/collagen vascular diseases, %	0.2	0.1–0.3
Coagulopathy, %	2.6	2.4–2.9
Obesity, %	0.1	0.1–0.2
Weight loss, %	0.1	0.1–0.2
Fluid and electrolyte disorders, %	12.9	12.3–13.5
Blood loss anemia, %	0.3	0.2–0.4
Deficiency anemia, %	10.7	10.2–11.2
Alcohol abuse, %	0.4	0.3–0.5
Drug abuse, %	0.1	0–0.1
Psychoses, %	0.6	0.4–0.7
Depression, %	1	0.8–1.1

*Every patient admitted from the Emergency Department in Singapore is triaged based on the following categories:
Category 1: serious cases requiring immediate medical attention (e.g. myocardial infarction).
Category 2: patients are unable to move on their own and in severe distress. But the patients are not in danger of imminent collapse (e.g. asthma).
Category 3: patients have acute symptoms but are still able to move on their own (e.g. high fever).
Category 4: patients do not require acute care.

Table 2
The association between average workload during a patient's stay and the length of stay.

Dependent Variable	Coefficients of the workload (95%CI)			
	Full sample	Subgroups by team workload#		
		≥27 patients (50th percentile)	≥29 patients (75th percentile)	≥ 31 patients (95th percentile)
Length of stay	−0.04* (−0.08, −0.01)	−0.39*** (−0.47,−0.31)	−0.90*** (−1.04,−0.77)	−0.48*** (−0.67,−0.30)
N	10916	5455	2728	552

This model adjusted for the following potential confounders: age and gender of the patients, emergency room triage category, admitted to ICU or high dependency ward during hospitalization, and the Elixhauser comorbidity measure, whether admissions or discharges occurred over the weekend, and whether admissions occurred after hours. The model is also clustered by patients.
Abbreviation: CI, confidence interval.
* $p < 0.05$.
*** $p < 0.001$.

Table 3
Correlation of average workload during a patient's stay with 30-day re-hospitalization rate, and inpatient mortality rate.

Dependent Variable	Odds ratio of the workload (95%CI)			
	Full sample	Subgroups of hospitalizations by workload#		
		≥50th percentile	≥75th percentile	≥95th percentile
30-day re-hospitalization rate	1.01 (0.99,1.04)	1.00 (0.93,1.08)	0.90 (0.75,1.08)	0.90 (0.40,1.98)
N	10916	5431	2709	548
Inpatient mortality rate	1.03 (0.99,1.05)	1.01 (0.95,1.07)	1.05 (0.94,1.18)	0.90 (0.56,1.44)
N	13097	6510	3198	622

This model adjusted for the following potential confounders: age and gender of the patients, emergency room triage category, admitted to ICU or high dependency ward during hospitalization, and the Elixhauser comorbidity measure, whether admissions or discharges occurred over the weekend, and whether admissions occurred after hours.
Abbreviation: CI, confidence interval.

52% of them were female. Inpatient mortality was 16.7%. Among the 10,910 discharges, 2073 (19%) of the patients experienced re-hospitalizations within 30 days. The mean and median LOS of the 13,097 hospitalizations was 5.9 days and 3.3 days respectively. Over the one-year study period, daily workload averaged 27 patients per team (SD = 3, range = 19–34). Table 2 showed the coefficients of workload in the regression on LOS. Controlled for potential confounders and clustered by unique patient, higher workload was significantly associated with shorter LOS. On average, the LOS is shorter by −0.044 (95%CI, −0.083, −0.01) days for every one extra patient per physician team (i.e. about half a day for every 10 extra patients per physician team). In subgroup analyses of hospitalizations with average workload equal to or greater than 50th, 75th, and 95th percentiles of the all hospitalizations respectively (27, 29, and 31 patients respectively), we found that higher workload was consistently associated with shorter LOS (Table 2). If the discharge pattern could be modified to resemble those on days with workload of 2 standard deviations above the average, 4% (95% CI = 1%, 8%) of hospital bed days could potentially be saved in the department. There is no evidence that primary diagnosis, comorbidity index, or ward class modify the association between workload and LOS (results not shown).

Table 3 showed the results of the logistic regressions of the workload on 30-day re-hospitalization rates and inpatient mortality rates. The odds ratios of the workload were not significantly different from 1 in either the full sample analyses or subgroup analyses of hospitalizations with high workloads.

Table 4 highlights the associations between daily workload and discharge for all discharges and discharges that occurred on particular days of stay. On average, the hazard ratio of discharge with one additional patient per team was 1.05 (95% CI, 1.02–1.07), indicating that higher daily workload is associated with higher probability of discharge on the following day. This finding is consistent with the negative association between average workload across the patient's stay and LOS. Daily workload is not significantly associated with discharges that occurred before the 4th day of stay. Higher workload is significantly associated with higher likelihood of discharge for discharges that occurred after the 4th day of stay, and the hazard ratio increased from 1.04 (95% CI, 1.01–1.07) in Day 4–1.16 (95% CI, 1.10–1.24) in Day 10.

The direction and significance of all the findings were robust to different metrics of workload and winsorization levels of the dataset (Appendix Tables 3–6).

4. Discussion

In our study of general medicine patients at an acute care hospital in Singapore, we found that higher workload was associated with reduced LOS, without increases in 30-day re-hospitalization rate or inpatient mortality rate. In addition, we found that higher workload has stronger association with the discharge of patients with longer stays.

Although increased workload might be hypothesized to lead to delay in providing services and potentially increase inpatient mortality rate, 30-day re-hospitalization rate or LOS as noted in prior studies [9–11], higher workload may also incentivize physicians to make proactive discharge planning and potentially speed up appropriate discharges [19–21]. The negative correlation between workload and LOS suggests that the latter mechanism is dominant in our context. Moreover, the correlations between the workload and LOS remain significantly negative in subgroup analyses of hospitalizations during high workload days while the correlations of the workload with re-hospitalization rate or mortality rate are not statistically significant. However, these findings do not suggest that directly increasing physicians' workload (e.g., by reducing the number of teams) will reduce LOS. This is because doing so may lead to a workload that surpassed the turning point of the plausible inverted U shaped relationship between workload and productivity [20]. This would not only reduce productivity but would promote physician burnout [32] and compromise the quality and safety of care.

Our findings are in contradistinction to earlier studies from U.S. showing positive correlations of workload with LOS, re-hospitalization, and inpatient mortality. This may be due to the differences in acuity of hospitalized patients between the two countries. We posit that, unlike the majority of U.S. hospitals, there are many patients in our acute hospitals who only received non-acute services for a few days before discharge [14]. Moreover, there is no incentive to discharge non-acute patients which is as strong as the Prospective Payment System in the US. Therefore, patients with non-acute needs may linger when workload is low, and when workload is high, teams are motivated to discharge them rapidly. Our finding that increased workload has a stronger association with discharge of patients with longer LOS supports our supposition. Policy makers may consider incentivizing policies that promote early discharge of non-acute patients (e.g. increase peer-monitoring by sharing the data on each team's census, number of admissions and LOS among all the teams) [33].

Even if LOS can be reduced with policies that encourage discharge of patients with non-acute needs, the reduction in LOS may not be sustainable. It is possible that as hospital beds become available, patients who would not have been admitted when the hospitals were full are now admitted (Appendix Fig. 1). These are patients in the 'grey zone'. Some of them have healthcare needs that are not life-threatening (e.g. deranged blood sugar levels) and may be treated by the primary care physicians or the specialists in outpatient settings. Others have non-medical needs (e.g. lack of support at home due to caregiver burnout) [34]. When these people present to the emergency department, they may get admitted when hospital beds are available and alternatives are not available or less accessible [35–37]. Thus, a sustainable reduction in the use of acute hospital beds depends on the availability and affordability of alternative non-acute services. The deficiency in non-acute services calls for a combined effort from the government and market to provide sufficient financial support [38,39] and quality services [40].

This study has several limitations. First, we used the number of patients per team to estimate the physician workload although ideally the estimator should account for the different amount of time and effort allocated to various tasks including inpatient care, outpatient clinics, education and research as well as different time spent on each patient [41]. However, we suspect that the number of patients per team is a reasonable reflection of physicians' perception of workload as it is associated with the time spent on rounds (e.g., for a typical patient mix, a one-page rounding list is half as concerning for time management as a list with two pages). In addition, a systematic search of studies of physician workload consistently used the total number of patients as a primary metric [9,10]. A second limitation is that this is an observational study, and as such there are omitted variables and associations cannot be interpreted as causal relationships. One omitted variable is the size of the team, which could potentially confound the association. A plausible reverse causal story would be that during a particular period of time, patients tend to have shorter LOS than usual and discharge of these patients result in perceivable increase in the hospital bed availability, leading to increased admissions and workload [42]. This is essentially a calendar effect though, which is partially controlled for by the month, day and time variables. Future studies can examine the association exogenous shock to workload (e.g. flu season) and LOS to tease out the causal relationship. Finally, our study did not investigate how the quicker discharge was achieved for patients with prolonged stays during days with high workload and future research that incorporates qualitative and quantitative investigations into the discharge planning and decision processes are needed to elucidate the exact mechanisms.

To conclude, this study demonstrated a different dynamic between workload and LOS in a US-style teaching hospital in Singapore compared with the U.S., which may reflect systemic differences in the use of acute hospital beds for non-acute services and incentives for discharge. With a rapidly aging population it will be

Table 4
Interactions between day of the patient's stay and the association between workload and discharge.

Time[#]	No interaction	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
		Hazard ratio of discharge (95% confidence interval)								
Workload	1.05^{**} (1.01,1.08)	0.98 (0.94,1.03)	1.02 (0.99,1.06)	1.04^{*} (1.01,1.07)	1.06^{***} (1.03,1.10)	1.08^{***} (1.04,1.12)	1.10^{***} (1.06,1.15)	1.12^{***} (1.07,1.18)	1.14^{***} (1.08,1.21)	1.16^{***} (1.10,1.24)
N	84859	84859	84859	84859	84859	84859	84859	84859	84859	84859

This model adjusted for the following potential confounders: age and gender of the patients, emergency room triage category, admitted to ICU or high dependency ward during hospitalization, and the Elixhauser comorbidity measure, day of the week, and whether admissions occurred after hours.

Abbreviation: CI, confidence interval.

[#] It begins with Day 2 instead of Day 1 because patients who stayed for less than 24 h were excluded from our analysis.

[*] $p < 0.05$.

[**] $p < 0.01$.

[***] $p < 0.001$.

especially important to be aware of the changing need for types of service so as to achieve sustainable reduction in the LOS of acute hospital without risking the safety of care.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.healthpol.2018.04.002.

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