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Assessment of need for lower level acuity critical care services at a tertiary acute care hospital in Canada: A prospective cohort study

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ABSTRACT

Purpose: Critical care beds are commonly described in three levels (highest level 3, lowest level 1). We aimed to describe the actual level of care for patients assigned to level 2 in a tertiary hospital with inadequate level 1 bed capacity.
Materials and methods: Prospective cohort study with daily assessment of level of care. The primary outcome was the proportion of patients who could be triaged to level 1 for the entirety of their ICU stay. Secondary outcomes included the percentage of patients who could receive level 1 care on any given day.
Results: 289 patients originally classified as level 2 were assessed for the primary, and 335 for the secondary outcomes. 14.9% could be level 1 for their entire ICU stay. 20.6%, once appropriate for level 1, remained in that level for the rest of their ICU stay. 23.6% of the assessments were suitable for level 1 on any given day.
Conclusion: In a single centre, 14.9% of level 2 patients could have been cared for in a lower acuity bed for the entirety of their ICU stay. We believe this methodology is reproducible and can help resource allocation with regard to the high demand for critical care beds.

1. Introduction

Intensive Care Units (ICUs) are frequently subcategorized according to different characteristics, such as case mix and acuity of the patients. In acute care hospitals, we commonly identify patients who require an intermediate level of care [1]. Some of these patients do not require active treatment or support for organ dysfunction, but need frequent monitoring in order to prevent deterioration or to provide early intervention in case of deterioration. Such patients have care needs that result in a lower staff workload. Despite these lower levels of care needs, these patients frequently occupy a high acuity critical care bed. In a study done in the United States including 42 ICUs from 40 hospitals and a total of 17,440 patients, 46% were monitoring admissions, and of those, <4% required active treatment [2].

Although data are conflicting, some studies have shown that Intermediate Care Units (IMCUs) may reduce costs and ICU length of stay without increasing mortality [3-6]. Data may be conflicting as opening IMCUs allows for an influx of higher-acuity patients who will occupy the vacant bed and may actually increase hospital costs and ICU length of stay [7]. At the same time, however, with more vacant beds, more high acuity patients can be admitted and cared for in an appropriate setting.

In fact, in order to better allocate resources and optimize care according to patients' needs, the American College of Critical Care Medicine recommends the implementation of IMCUs, with guidelines to promote safe triage of patients to these units [8]. Following this recommendation, 65% of US institutions claim to have at least one IMCU [9]. As per their last guidelines, IMCUs in the US serve as monitoring units for patients requiring more than ward, but less than standard ICU care, without necessarily providing artificial life support [8]. However, critical care remains very heterogeneous in the US and classifications of levels of care in such units varies a lot [1], as evidenced by a recent survey

Abbreviations: ICU, Intensive care unit; IMCU, Intermediate care unit; PACU, Post-Anesthesia care unit; ER, Emergency room; RRT, Rapid response team; REB, Research ethics board; CICU, Cardiology intensive care unit; REDCap, Research electronic data capture; DAD, Discharge abstract database; CI, Confidence interval; DKA, Diabetic ketoacidosis; TISS, Therapeutic intervention scoring system; NEMS, Nine equivalents of nursing manpower use score; NAS, Nursing activities score; IQR, Interquartile range; COPD, Chronic obstructive pulmonary disease.

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about IMCU use, showing that many of these units not only are intensivist-led, but also work as stepdown and even step-up units [9]. In Canada and in the UK, on the other hand, such classification is better described as patients are categorized by levels of acuity (Table S1). In this classification, ranging from most to least acute, level 3 patients are those requiring invasive respiratory support or support to a minimum of two organs; level 2 are high risk postoperative patients or patients receiving single organ support; and level 1 are patients at risk of their condition deteriorating, whose needs can be met in an acute ward with additional support from a critical care team [10,11].

At our institution, a tertiary teaching 627-bed acute care hospital in Toronto, Canada, such categorization of level of care is standard. However, there are few level 1 critical care beds within the hospital, necessitating use of level 2 resources for most of the patients who require more than ward care. With a level 1 demand that is higher than its supply, level 2 beds are commonly used for level 1 patients, resulting in a critical care occupancy rate that frequently surpasses 100%. This leads to patients being cared for in inappropriate environments, such as the emergency department, wards and the post-anesthesia care unit (PACU), with the potential for adverse outcomes [12-14] and delays in discharges at all levels of care. One possible solution to this problem is to create level 1 beds to allow lower level critical care patients to be cared for in such units. It is unknown how often patients assigned to level 2 ICU beds would meet criteria for level 1 care instead. We hypothesized that, at our hospital, up to 20% of patients assigned as level 2 could safely receive care in a level 1 bed for the entirety of their critical care stay.

The aim of this study was to determine the proportion of critical care patients who could be triaged to a level 1 bed for the entirety or for some portion of their ICU stay; to identify diagnostic groupings and surgical procedures that are associated with assignment to level 1 care; and to assess the frequency of agreement regarding triage level between nurses and physicians caring for patients.

2. Materials and methods

2.1. Study design and setting

We conducted a prospective cohort study with daily assessments of ICU patients for their level of care required, from April 2nd to May 18th, 2018. The trial protocol appears in the Supplement. The study was conducted at Sunnybrook Health Sciences Centre, a 627-bed acute care teaching hospital in Toronto, Canada. The following adult critical care units were studied: a 13-bed trauma and neurosurgical level 2 unit, an 8-bed medical-surgical level 2 unit, a 14-bed cardiovascular surgical unit, a 24-bed level 3 trauma and medical-surgical unit, the emergency room (ER) and the PACU. For this study, all 59 intensivist-led critical care beds in the hospital, plus the ER and PACU locations where critical care patients are cared for when these units are full, were studied. Of note, the number of existing level 1 beds at our hospital is fixed at 9 (6 medical and 3 neurosurgical). Critical care services admit patients irrespective of bed availability in our units. Bed assignments are usually suggested by the primary team or emergency physician, or by consulting the critical care service through the Rapid Response Team (RRT). Given the lack of level 1 beds, patients who are potentially level 1 are commonly assigned to (and accepted by) the critical care team.

We defined level 2 patients as those requiring detailed observation or intervention, including support for a single failed organ system, and level 1 as those without new organ dysfunction but at risk of acute deterioration and requiring more than ward care. At our hospital, and in the provincial definitions, the nurse to patient ratio is 1:1, 1:2 and 1:3 for levels 3, 2 and 1, respectively, and level 1 units are not intensivist-led, but advice and support are granted through the RRT. Staffing or bed structure are not flexible, which means that when patients change their level of acuity, they move to a different unit.

Because this study was performed as a Quality Improvement assessment, it was considered exempt from the requirement of having a formal Research Ethics Board (REB) review.

2.2. Subjects

All patients in level 2 areas and patients in other hospital areas, such as level 3 units, ER and PACU, identified as receiving level 2 care during the study period were included. Ward patients admitted by the critical care team were included only when physically present at one of the ICUs. We excluded patients requiring level 3 care, patients admitted to an existing level 1 unit, and patients treated in the cardiovascular surgical unit for cardiac surgical procedures.

2.3. Data collection

Data were collected prospectively by 3 trained critical care nurses, and managed using the REDCap electronic data capture tool hosted at Sunnybrook Health Sciences Centre [15]. The data collectors received a 1-week training followed by 1 week of data collection and data entry for training purposes (these data were not included in the analysis).

Admission data such as demographics, diagnostic grouping and reason for ICU admission were collected after critical care admission. Subsequently, daily data such as level of acuity, as identified by both attending physician and the patient's nurse, and reasons to be classified as level 1 or level 2, were collected. Charlson Comorbidity Index for all discharged patients was collected retrospectively from the Discharge Abstract Database (DAD), except for patients who were not discharged from the hospital up to one month after the conclusion of the study period who had those data censored. If a patient was discharged from the ICU and subsequently readmitted, the readmission was counted as a new index admission. The ICU length of stay included the time spent in a level 1 unit, if that was the case.

On a daily basis, the patients' nurses and attending physicians were separately asked to identify the most appropriate level of care for each identified patient, according to a pre-specified description of these levels (Table S1). These data were collected until discharge to the ward or an existing level 1 unit, or death.

The primary outcome was the percentage of level 2 patients who could have completed their entire critical care stay in a notional level 1 unit based on agreement on a lower acuity level by both the ICU nurse and physician assessments. The patient was considered level 1 when independently classified as such by both assessors or when classified as level 1 by one and ward by the other. In case of discordant classification between nurses and physicians, the highest level of acuity was the one considered (e.g. if a patient was classified as level 1 by the physician and level 2 by the nurse, that patient was considered level 2). If a patient was classified as level 1 during the entire critical care stay but had missing days of assessment, that patient was not considered meeting the criteria for level 1 for the entirety of their stay. Similarly, if the reason for admission was something that would have precluded that patient from going to a level 1 unit (e.g. transient treatment with a vasopressor), but by the time of first assessment was classified as level 1, that patient was also not considered level 1 for the entirety of their stay.

The secondary outcomes were the number and percentage of patients who could have completed some portion of their critical care stay in a level 1 unit without return to level 2 or 3 during the study period; the number and percentage of patients on any individual day who could have been cared for in a level 1 unit; the agreement between nursing and medical staff assessments on the level of care required each day; and specific medical diagnostic or surgical categories of patients who could have been reliably triaged to level 1.

Only patients with admission dates after the first study date and discharge dates by the last study date were included for analysis of the primary outcome. All patients admitted to level 2 critical care as described above were included for analysis of the secondary outcomes.

2.4. Statistical analysis

We summarized continuous variables as medians and interquartile ranges (IQR) and tested differences between groups using Wilcoxon rank-sum test. Categorical data is presented as frequencies and percentages and groups were compared by χ^2 –test or Fisher's exact test. We calculated the proportion of patients who could have been triaged to a level 1 facility for the entirety of their critical care stay and the 95% confidence interval (CI); the proportion of patients who could have received care in a level 1 bed and then stay at that level for the rest of their critical care stay (during the study period); the percentage of assessments deemed suitable for level 1; and the total number of beds per day that could have been level 1 on each day of the study, and reported it as median and interquartile ranges (IQR). We used kappa statistics to quantify the agreement in classification between nurses and physicians. We used logistic regression analysis to identify patients' characteristics and type of admission diagnosis that were associated with a patient reclassified as level 1 for their entire stay.

Assuming that 20% of patients could be classified as level 1 for their entire stay, a sample size of 200 allowed for a 95% confidence interval with a margin of error of 5.5%.

3. Results

We were able to collect data on 45 of 47 study days (96%). A total of 980 assessments of 335 patients were included in the analysis. Of those patients, 46 were not considered for the primary outcome because they were admitted before or discharged after the study period, resulting in 289 patients included in the primary analysis (Fig. 1). We identified missing data collection for 38 patients, totalling 59 missing assessments.

Table 1 shows the patients' baseline characteristics. Most of the patients were medical, admitted for monitoring, with a low Charlson Comorbidity Index.

Of the 289 patients included for the primary outcome, 43 (14.9%, 95%CI 10.8–19%) were classified as level 1 for the entirety of their critical care stay (Table 2). These patients classified as level 1 had a median critical care length of stay of 1 day (IQR 1–2), as compared to 4 days (IQR 2–6, $p < 0.0001$) for the remaining population. Some patients were not classified as level 1 for the entirety of their critical care stay, but were identified as being appropriate for level 1 care for a portion of their critical care stay. Of the 335 patients included for the secondary outcomes, 69 (20.6%), once classified as level 1, remained appropriate for level 1 for the rest of the critical care stay, until discharged to the ward or until the end of the study period, with a median critical care length of stay of 5 days (IQR 4–9), of which 1 (IQR 1–2) was a level 1 day. Another 40 patients (11.9%) had at least one day they were identified as appropriate for level 1. Hospital mortality data was available for 323 patients and was 12.4%. It seems to be lower among patients who were classified as level 1 for their entire stay, but we did not achieve a statistically significant difference (Table 2). As shown in Figs. 2 and 3, a median of 5 patients (IQR 3–7) were appropriate for level 1 each day of the week (23.6%, 95% CI 20.9–26.2%, of the assessments originally classified as level 2 could have been level 1).

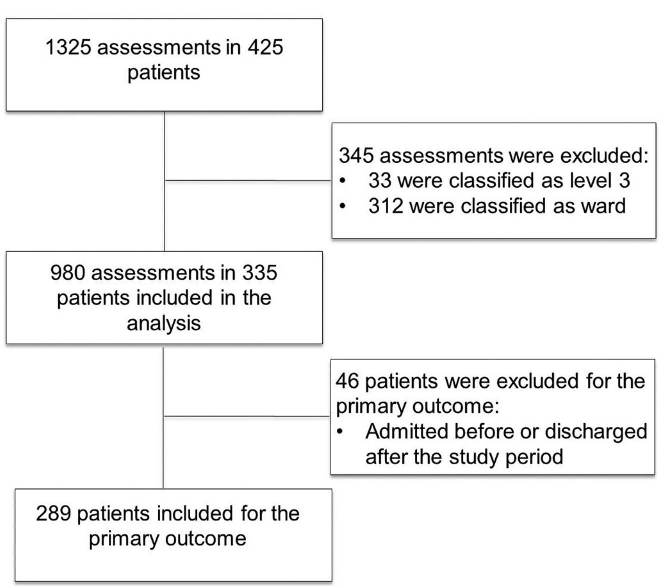

Fig. 1. Flow chart showing number of assessments and patients included.

Table 1
Patient's baseline characteristics.

	Population (n = 335)
Gender (male) - n(%)	206 (61.7)
Age (years) - median (IQR)[a]	65 (50–78)
Charlson Comorbidity Index - n(%)	
Score 0 or 1	221 (68.4)
Score 2	52 (16.1)
Score 3 or 4	27 (8.4)
Score ≥ 5	23 (7.1)
Admission diagnosis n(%)	
Medical	193 (57.6)
Sepsis	55 (28.5)
Ischemic stroke	30 (15.5)
Intracranial hemorrhage	15 (7.8)
COPD[b] or asthma exacerbation	11 (5.7)
DKA[c]	9 (4.7)
Gastrointestinal bleed	9 (4.7)
Other	64 (33.1)
Surgical	57 (17)
Neurosurgical	23 (40.4)
Gastrointestinal	8 (14)
Whipple or liver resection	7 (12.3)
Other	19 (33.3)
Trauma	85 (25.4)
Reason for ICU admission n(%)	
Monitoring/risk of deterioration	144 (43)
Acute invasive ventilation[e]	48 (14.3)
Acute NIV[d] or high flow oxygen	41(12.2)
Use of vasopressor or inotrope	30 (9)
High risk post-operative	26 (7.8)
Other	46 (13.7)

Missing data: gender and age, 1 patient; Charlson Comorbidity Index, 12 patients.
[a] IQR, Interquartile Range.
[b] COPD, Chronic Obstructive Pulmonary Disease.
[c] DKA: diabetic ketoacidosis.
[d] NIV, non-invasive ventilation.
[e] Patient admitted as level 3 and subsequently downgraded to level 2.

Table 3 shows the level of agreement between nurses and physicians on the classification of levels of acuity. The overall concordance was 77.3% (Kappa = 0.50 95% CI 0.45, 0.55), considered moderate. As seen in Table 4, when both physicians and nurses agreed that the patient was appropriate to receive level 1 care, the most frequent reasons were frequency of monitoring (27.3%), suctioning requirements (23.3%), and risk of condition deterioration (13%). When classified as level 2, the most frequent reason was vasopressor requirement (14.6%; Table S2 in Supplement).

Table 5 shows patients stratified by outcome. Level 1 admissions were more likely to be surgical (32.6%) and less likely to be trauma (11.6%) as compared to level 2 patients (15% and 27.7%, $p = 0.006$). 55.8% of the level 1 patients were medical, and among them, the most frequent diagnosis was ischemic stroke (33.3%). In regard to the reason for critical care admission, level 1 patients had more admissions for monitoring purposes (60.5 versus 43.1%, p 0.03).

A logistic regression analysis considering patients classified as level 1 for their entire stay and age, Charlson Co-morbidity Index, gender and admission group showed that an increase in age by 10 years is associated with a decrease in odds of being classified as level 1 for the entire critical care stay; and surgical and medical admission groups being

Table 2
Outcomes.

Primary outcome (n = 289)	n (%)	95% CI	Mortality*/n available (%)
Level 1 for the entire critical care stay	43 (14.9)	(10.8–19.0)	1/41 (2.4)
Secondary outcomes (n = 335)			
Level 1 for part of critical care stay	109 (32.5)	(27.5–37.6)	
Remained level 1 once classified as such	69 (20.6)	(16.3–24.9)	10/66 (15.2)
Multiple moves that included days of level 1	40 (11.9)	(8.5–15.4)	7/36 (19.4)
Never classified as level 1	183 (54.6)	(49.3–60.0)	22/180 (12.2)

CI, Confidence Interval.
* Hospital Mortality from Discharge Abstract Database (DAD), p-value comparing the 4 groups = 0.08.

more likely to be admitted to level 1 for the entire critical care stay as compared to trauma.

4. Discussion

We found that 14.9% of patients cared for in a level 2 bed at our institution could have received all of their care in a level 1 bed, and 23.6% of assessments on average showed patients suitable for care in a level 1 bed. Our a priori estimate of the number of patients who could complete their critical care stay in a notional level 1 bed was higher than our actual finding (20% versus 14.9%), and this evaluation was adequately powered as we exceeded our a priori sample size calculation (289 versus 200).

Our study has a number of limitations that may have impacted our results, over or underestimating our findings. First, we chose to define a level 1 patient based on physicians' and nurses' opinions. It's possible that some of them based their views on the reality of current practice considering a context where the lack of level 1 beds is well identified, and therefore underestimating the number of patients triaged as level 1. It may also be true that the pressure of not having enough level 2 beds could have made some physicians or nurses classify a less sick level 2 patient as appropriate for level 1, which could have overestimated our findings. In order to minimize this limitation, we provided a list of specific criteria for classification of level of acuity (Table S1), but some patients might have been misclassified. An example of this is that we believe that most patients with a diagnosis of diabetic ketoacidosis (DKA) could be cared for in a level 1 bed. However, out of the 9 DKA patients we found in our sample, only 3 were classified as level 1. Furthermore, a significant number of patients (65 out of 425, or 15.3%) were classified as suitable for a ward bed from the first assessment despite being admitted as level 2; this could be due to the fact that the first assessment may have been the day after admission. Not knowing what would have been the triage decision in regard to the level of acuity at the time of the first assessment by the critical care team is a limitation of this study. It's unclear which level of acuity these patients would have met at that time, and we believe that many of some short stay patients could have potentially been level 1, causing our results to be an underestimate of the true rates. However, this could also overestimate level 1 classifications, since it allows time for improvement, or for patient's trajectory to become clear. As an attempt to decrease the effect of this limitation on our results, we checked the main reason for the critical care admission. If the reason was something considered inappropriate for level 1 (e.g. use of vasopressor or invasive mechanical ventilation), we did not consider that patient as being level 1 for the entirety of their stay, even if classified as such. We also believe, based on the study design and as a consequence of not being able to assess patients in real time, that we may have failed to capture some short stay patients that were discharged to the ward straight from the ER or PACU before the research team had a chance to assess them, underestimating our findings.

To avoid bias, we designed our study to assess nurses' and physicians' opinions separately. We found a moderate to high concordance at 77.3%, which seems reasonable. However, since the assessments

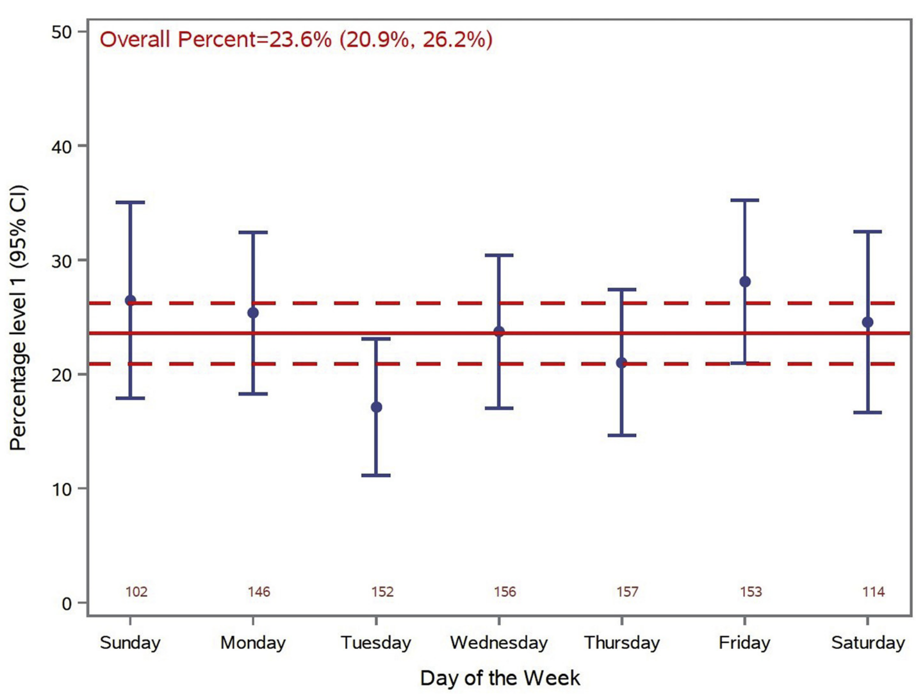

Fig. 2. Percentage of level 2 beds occupied by level 1 patients by day of the week.

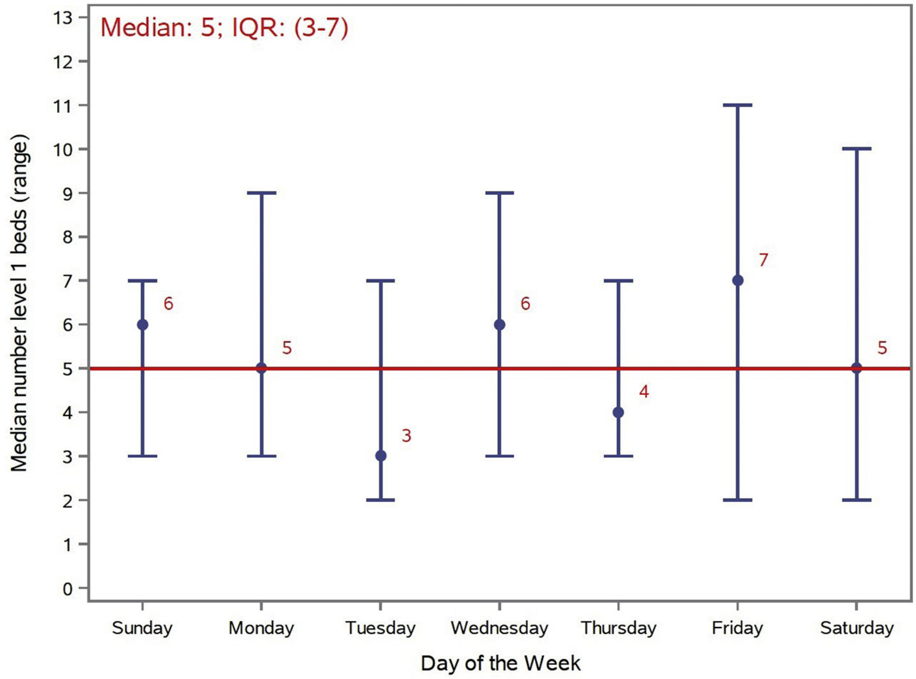

Fig. 3. Number of level 2 beds occupied by level 1 patients by day of the week.

were not performed concurrently, this may have increased discordance, since patients' conditions can fluctuate with time. Considering that we classified patients according to the highest level of care attributed to them by the nurse or physician, our results are conservative. However, we did not address the issue of ways to improve concordance, and we acknowledge this as a limitation. Another limitation is the fact that we did not collect the number of participating nurses and physicians or their identifying information. Therefore, we did not have the information to allow for clustering of the assessments by individual.

It's important to emphasize that there are some workload measurement tools, such as the Therapeutic Intervention Scoring System (TISS) [16,17], the Nine equivalents of nursing manpower use score (NEMS) [18], and the Nursing activities score (NAS) [19], that have been validated and could have been used in order to classify patients according to their care needs and define the appropriate nurse to patient ratio. We anticipated, however, that these scoring systems would have practical issues such as unfamiliarity among our team, need for specific training, and difficult use. In fact, it's questionable if these tools are still in accordance with the advancements attained in nursing care in the most recent years [20]. Severity scores for patients in IMCUs have shown to have poor calibration, and therefore were not used in this study either [21,22]. For these reasons, we chose to define the level of acuity for our patients based solely on physicians' and nurses' opinions, which reflects the reality of our daily decisions. We recognize that the main limitation of our study relates to the generalizability of our results since it represents data from a single centre. However, the methodology we used is pragmatic and easy to reproduce in other hospitals who we feel are very likely to struggle with the same challenges.

Some system issues should be emphasized as we advocate for the creation of level 1 beds. At our hospital, the 3 different levels of acuity are geographically separated, and there's no staffing flexibility. This means that patients have to move to another unit when they change their level of acuity, which may unnecessarily increase workload in case of triage misclassification. At the same time, since level 1 units in our service are not intensivist-led, by increasing the number of these beds, we should probably expect an increment in the volume of RRT consults. Furthermore, we did not focus on outcomes of our triage classification. In face of our reported low mortality for level 1 patients, however, we believe that our triage decisions would have been safe to our patients.

Our study was designed as a Quality Improvement project, influenced by the fact that we currently face an unacceptably high occupancy rate on our critical care service and based on our belief, confirmed by our results, that a significant portion of our patients could have their care delivered in a lower level of acuity bed. While the critical care occupancy rate at our hospital is often above 100%, to be optimal, it should be between 75 and 85% [23]. The challenges we face with high occupancy rates are not restricted to our hospital [24-26] and the expectation is that they will get worse over time [27,28]. Considering the concern that mortality may increase with ICU strain [29], appropriate allocation of available critical care resources is important. Categorizing patients by

Table 3
Nurses' and physicians' agreement on acuity levels (from 980 assessments).

Physicians and nurses agree	Frequency (%)
Level 2	59.3
Level 1	18
Total agreement	77.3
Physicians and nurses disagree	
Level 2 as highest level	17,1
Level 1 as highest level	5.6
Overall disagreement	22.7

Kappa = 0.50, 95% CI 0.45, 0.55.

Table 4
Reasons for level 1 classification when physicians and nurses agreed (n = 176).

Frequency of monitoring	27.3%
Suctioning frequency	23.3%
Risk of condition deterioration	13%
NIV or high flow oxygen with low risk of deterioration	5.7%
Insulin infusion	4%
Other (both agree on the same reason)	3.4%
Other (nurse and physician give different reason)	23.3%

NIV, noninvasive ventilation.

Table 5
Patients stratified by outcome.

	Population analysed for the primary outcome (n = 289)		p value
	Combination of different levels (n = 246)	Level 1 for the entire stay (n = 43)	
Gender (male) - n(%)	153 (62.4)	26 (60.5)	0.80
Age (years) - median (IQR)[a]	66 (50–78)	60 (37–71)	0.19
Charlson Comorbidity Index - n(%)			0.66
Score 0 or 1	166 (69.1)	30 (73.2)	
Score 2	39 (16.3)	6 (14.6)	
Score 3 or 4	18 (7.5)	1 (2.4)	
Score ≥ 5	17 (7.1)	4 (9.8)	
Admission diagnosis n(%)			0.006
Medical	141 (57.3)	24 (55.8)	
Sepsis	40 (16.3)	4 (9.3)	0.24
Ischemic stroke	20 (8.1)	8 (18.6)	0.05
Intracranial hemorrhage	14 (5.7)	0	0.24
COPD[b] or asthma exacerbation	9 (3.6)	1 (2.3)	1.00
DKA[c]	6 (2.4)	3 (7)	0.14
Gastrointestinal bleed	7 (2.9)	1 (2.3)	1.00
Other	45 (18.3)	7 (16.3)	0.75
Surgical	37 (15)	14 (32.6)	
Neurosurgical	12 (4.9)	6 (14)	0.04
Gastrointestinal	7 (2.4)	1 (2.3)	1.00
Whipple or liver resection	4 (1.6)	3 (7)	0.07
Other	14 (5.7)	4 (9.3)	0.32
Trauma	68 (27.7)	5 (11.6)	
Reason for ICU admission n (%)			0.004
Monitoring/risk of deterioration	106 (43.1)	26 (60.5)	0.03
Acute invasive ventilation	32 (13)	0	0.007
Acute NIV[d] or high flow oxygen	33 (13.4)	3 (7)	0.24
Use of vasopressor or inotrope	27 (11)	0	0.02
High risk post-operative	18 (7.3)	6 (13.9)	0.14
Other	30 (12.2)	8 (18.6)	0.25

Missing data: gender and age, 1 patient; Charlson Comorbidity Index, 6 in combination of different levels and 2 in level 1 for the entire stay.
[a] IQR, Interquartile Range.
[b] COPD, Chronic Obstructive Pulmonary Disease.
[c] DKA: diabetic ketoacidosis.
[d] NIV, noninvasive ventilation.

levels of acuity and subsequently creating level 1 beds may be a less expensive and effective solution to deal with the burden of critical illness.

5. Conclusion

In a single centre, 14.9% of patients receiving level 2 critical care could have been cared for in a level 1 bed for the entirety of their critical care stay. Considering all assessments completed for patients admitted to a level 2 bed, 23.6% could have received level 1 care instead. We believe that the methodology we used is reproducible in other hospitals to achieve similar local and actionable data, and that this may contribute to dealing with the high demand for critical care beds.

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Conflict of interests

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2019.06.004.

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