BMJ Open

Outcomes of direct and indirect medical intensive care unit admissions from the emergency department of an acute care hospital: a retrospective cohort study

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ABSTRACT

Objectives: This study aimed to determine if the risk of adverse outcomes (in-hospital and 60-day mortality, intensive care unit (ICU) and total hospital length of stay (LOS)) was greater for medical ICU (MICU) or high dependency unit (HDU) patients indirectly admitted from the emergency department (ED) than for directly admitted patients.

Setting: This study was conducted at a large public acute care hospital in Singapore.

Participants: In this retrospective cohort study, hospital records of patients who were admitted directly from the ED, or initially admitted to the general wards from the ED and subsequently transferred to the MICU/HDU within 24 h, were reviewed. Patients were included if they were: (A) discharged from the MICU/HDU in 2009 and were admitted from the ED and (B) transferred to the MICU/HDU within 24 h of presentation at the ED. Data from 706 patients were analysed; 58.4% were men with a median age of 61 years.

Primary and secondary outcome measures: The following outcomes were compared: in-hospital mortality, 60-day mortality, LOS at the MICU/HDU, as well as total hospital LOS.

Results: Of the 706 patients, 491 (69.5%) were directly admitted to the MICU/HDU. After adjusting for demographics, comorbidities, interventions at the ED and clinical parameters at the ED (heart rate, respiration, oxygen saturation, mean arterial pressure), as well as the Apache II score on arrival at the MICU/HDU, indirectly admitted patients had a higher risk of in-hospital mortality (OR=3.07, 95% CI 1.39 to 6.80), death within 60 days (OR=3.09, 95% CI 1.40 to 6.83) and risk of staying >1 day at the MICU/HDU (OR=2.54, 95% CI 1.48 to 4.36). There was no significant difference in total in-hospital LOS.

Conclusions: Indirectly admitted MICU/HDU patients had generally poorer outcomes. As the magnitude of effect may vary across settings, context-specific studies may be useful for improving outcomes.

Strengths and limitations of this study

- This health services research focused on patient-important outcomes including mortality and length of hospital stay.
- Unlike other studies, this research focused on the effect of indirect admissions (admission to the general wards before transfer to the intensive care unit (ICU)) rather than on the effect of admission delays.
- Only patients admitted to the ICU within 24 h of arrival at the emergency department were included in the study to minimise bias resulting from differences in disease severity/prognosis on presentation.
- While this study confirms other study findings of a detrimental effect of delayed/indirect admission, more importantly it suggests that differences in the magnitude of effect across institutions are due to factors intrinsic to each health facility and that these contributory factors must be addressed at the level of the individual institution.
- Owing to limitations in the data, it was not possible to determine the reason for the initial refusal of indirect medical ICU/high dependency unit admissions.

INTRODUCTION

In recent decades, healthcare has become more and more expensive, triggering calls for cost-effective care in an increasingly cost-conscious and quality-conscious environment. Intensive care unit (ICU) beds are scarce hospital resources reserved for a select subset of hospital patients. Underlying the scarcity of ICU beds is the high start-up and operating cost of the unit as well as the highly specialised training required of the staff. While the total cost of ICU admission varies widely, the daily cost of ICU care per patient is approximately three to four times more than that in the general ward.[1–4] Despite ICU beds comprising only between 1.2–6.3% of all hospital beds, ICU services are estimated to take up 15–20% of the total hospital budget.[5] Given the scarcity of ICU beds, priority is given to patients with serious but potentially reversible conditions who may benefit from more intensive observation and

treatment than is provided in the general ward.[4] [6] To a certain extent, guidelines can reduce the arbitrariness of triaging patients to the ICU. However, the ultimate decision to admit a patient to the ICU depends largely on the individual physician's preference, professional judgement and experience. A benchmarking study found a wide variation across ICUs in the proportion of critical care patients admitted for active critical care treatment versus monitoring alone.[7] Depending on the institution, between 20% and 98% of patients admitted to the ICU required active treatment.[7]

The benefits gained from the ICU as a scarce resource can be maximised not just through the right siting of care, but also by ensuring that critically ill patients are admitted without delay. Numerous factors have been cited for delays in admitting critically ill patients from the emergency department (ED) to the ICU. Commonly implicated factors include the lack of available ICU beds,[8–12] the underlying disease itself,[8] [13] organisational issues[9] and frontline health professionals' inability to recognise the seriousness of the condition.[14] [15] Regardless of the cause, delayed ICU admissions may ultimately have the same detrimental effect on the patient.

This study aimed to determine if severely ill patients indirectly admitted from the ED to the general wards and subsequently to the medical ICU (MICU) or high dependency unit (HDU) have a greater risk of adverse outcomes than those who were admitted directly from the ED to the MICU or HDU. The main outcomes of interest included in-hospital and 60-day mortality, ICU as well as total hospital length of stay.

METHODS
Plan of investigation
This was a retrospective cohort study conducted in a tertiary level acute care public hospital in Singapore.

In this hospital, after assessing the patient's need for ICU care, the ED physician refers the patient to the intensivist on-call. The intensivist makes his own assessment at the ED and makes the final decision on where to admit the patient. This decision is based mainly on the intensivist's expert judgement as well as his awareness of current ICU bed availability. A bed is then requested in the unit specified by the intensivist.

All patients admitted to the MICU or HDU within 24 h of presentation at the ED between January and December 2009, and who were admitted under the following medical specialties, were eligible for inclusion: general medicine; respiratory medicine; infectious disease; gastroenterology; psychiatry; rheumatology, allergy and immunology; medical oncology; rehabilitation medicine and geriatric medicine. Patients who would have been admitted to the MICU/HDU under the aforementioned specialties, but were admitted to other critical care units because of the unavailability of beds, were likewise included. Patients who were admitted under cardiology, neurology and other surgical specialties were excluded as these specialties manage their own ICU and the nature of intensive care required for these patients would have been different from that required for general MICU patients.

Patients were classified into direct and indirect admissions. Direct admissions comprised patients admitted directly to the MICU/HDU within 24 h of presentation at the ED. Patients who were initially admitted to the wards and subsequently transferred to the MICU/HDU within 24 h of presentation at the ED were considered indirect admissions. A previous study[15] showed that the in-hospital mortality rate for indirectly admitted patients was 44% with a relative risk of 1.41. At a direct to indirect admission ratio of 1:1, confidence level of 95%, power of 80% and minimum effect size of 12.8%, the estimated minimum sample size was 480 patients.

In-hospital mortality, 60-day mortality, MICU/HDU and total in-hospital length of stay were compared between the two groups. Except for deaths within 60 days of admission, data on the independent and dependent variables as well as selected covariates were extracted from the Operations Data Store hospital administrative database, ED, MICU and HDU case notes. Sixty-day mortality was requested from the Ministry of Health, Singapore. Data extraction was performed by one trained research assistant. Data were periodically reviewed by the investigator for completeness and were subjected to logic checks.

Analysis
Analysis was conducted with PASW Statistics Release V.18.0 (IBM, New York). Aside from baseline patient characteristics, the proportion of direct and indirect MICU/HDU admissions relative to total MICU/HDU admissions were generated using descriptive statistics. Outcomes were expressed as dichotomous variables with an MICU/HDU length of stay categorised into <2 and 2+ days, and an in-hospital length of stay categorised into <8 and 8+ days. Possible associations between an admitting unit and each outcome were explored through univariate analysis. Adjusted effect measures between the timing of admission to the MICU/HDU (direct or indirect) and each outcome were analysed using two sets of logistic regression models. The primary analyses included all patients regardless of the reason for admission to the ICU. The secondary analyses excluded patients with hypotension, respiratory failure or those who were intubated—conditions considered as strong indications for ICU admission. In the secondary analyses, the total hospital length of stay and ICU length of stay were analysed as continuous variables using Cox proportional hazard. Interval estimates of ORs for categories of the independent variable and identified covariates were generated. Effect measures were adjusted for the following covariates:

▶ Age.
▶ Gender.
▶ Charlson comorbidity index (CCI) based on a history of the following: acute myocardial infarction, congestive heart failure, peripheral vascular disease,

cerebrovascular disease, dementia, chronic pulmonary disease, connective tissue disease, peptic ulcer disease, mild liver disease, moderate to severe liver disease, hemiplegia, moderate to severe renal disease, any tumour within the past 5 years, metastatic solid tumour, lymphoma, leukaemia, diabetes, diabetes with end organ damage and AIDS.

▶ Acute Physiology and Chronic Health Evaluation II (APACHE II) score on arrival at the MICU/HDU;
▶ Recent (7 days) discharge from the hospital prior to current admission.
▶ Objective parameters on presentation at the ED including heart rate, respiratory rate, oxygen saturation, mean arterial pressure.
▶ Resuscitation efforts at the ED.
▶ Intubation at the ED.
▶ Admission at the MICU versus HDU.

RESULTS

Baseline characteristics

Table 1 presents the baseline characteristics of direct and indirect admissions. There were 706 patients admitted to the MICU/HDU within 24 h of presentation at the ED in 2009. Of these, more than two-thirds were admitted directly from the ED to the MICU/HDU with the rest having been admitted to the general wards before their subsequent transfer. Compared with indirect admissions, a significantly greater proportion of those directly admitted underwent resuscitation and intubation at the ED. However, those indirectly admitted were older, had more comorbidities and were significantly more likely to be admitted to the MICU than the HDU. Time from ED presentation to MICU/HDU admission was more than four times longer for indirect admissions.

Clinical and laboratory findings of patients on arrival at the ED are presented in table 2. Aside from pneumonia, which was the most common diagnosis at the ED, chronic airway obstruction was among the five leading diagnoses for direct and indirect ICU admissions. Respiratory distress was the most common reason for admission to the ICU. Intubation, hypotension and severe acidosis were other common reasons for admission to the ICU for directly and indirectly admitted patients. The following laboratory parameters were significantly lower for direct ICU admissions: pH, calcium, urea and creatinine; while the following were significantly higher for direct ICU admissions: PaO_2, sodium, haemoglobin and haematocrit.

Main results

Univariate analysis of outcomes by the admitting unit

Regardless of which critical care unit the patient was admitted to (MICU and HDU taken together), direct admissions had a lower in-hospital mortality, lower 60-day mortality, were less likely to stay in the unit for more than 1 day and were less likely to stay in the hospital for more than 1 week.

Looking at results separately for MICU and HDU, patients directly admitted from the ED to the MICU had a lower in-hospital mortality and 60-day mortality, and were less likely to stay in the hospital for more than 1 week than those indirectly admitted (figure 1). For those admitted to the HDU, directly admitted patients likewise had a lower in-hospital mortality and 60-day mortality, but were less likely to stay in the unit for more than 1 day. Among all direct admissions, in-hospital mortality and 60-day mortality were higher for patients admitted to the MICU than for those admitted to the HDU. In addition, MICU patients were

Table 1 Baseline characteristics of patients directly and indirectly admitted to the ICU/MICU

Characteristic	All patients N=706	Direct admissions n=491	Indirect admissions n=215	p Value
Age				
Mean* (SD)	59.72 (17.6)	58.6 (18.3)	62.3 (15.7)	0.006
Median	61	61	62	
Gender, N (%)				
Male	412 (58.4)	288 (58.8)	124 (57.4)	0.808
Female	294 (41.6)	203 (41.3)	91 (42.3)	
Ethnicity, N (%)	470 (66.6)	326 (66.4)	144 (67.0)	0.085
Chinese	104 (14.7)	64 (13.0)	40 (18.6)	
Malay	89 (12.6)	65 (13.2)	24 (11.2)	
Indian	3 (0.4)	2 (0.4)	1 (0.5)	
Eurasian	40 (5.6)	34 (6.9)	6 (2.8)	
Others				
Presented at the ED in the preceding 7 days, N (%)	22 (3.1)	17 (3.5)	5 (2.3)	0.424
Hospitalised in the preceding 7 days, N (%)	30 (4.2)	20 (4.1)	10 (4.7)	0.726
Underwent resuscitation at the ED*, N (%)	34 (4.8)	34 (6.9)	0 (0.0)	0.000
Underwent intubation at the ED*, N (%)	223 (31.6)	223 (45.3)	0 (0.0)	0.000
Admitted to the MICU (vs HDU)*, N (%)	445 (63.8)	296 (60.4)	149 (71.6)	0.005
Charlson comorbidity index*, median	1.0	1.0	2.0	0.000
Hours from arrival at the ED to ICU admission*, median	2.51	1.97	9.20	0.000

*p<0.05.
ED, emergency department; HDU, high dependency unit; ICU, intensive care unit; MICU, medical ICU.

Table 2 Baseline clinical and laboratory findings of patients directly and indirectly admitted to the ICU/MICU

Baseline clinical finding	All patients N=706	Direct admissions n=491	Indirect admissions n=215
Most common presenting diagnoses	Pneumonia Unspecified infection Chronic airway obstruction Asthma Fluid overload	Unspecified infection Pneumonia Asthma Chronic airway obstruction Fluid overload	Pneumonia Chronic airway obstruction Myocardial infarction Diabetes Chronic kidney disease
Most common reasons for ICU admission	Respiratory distress Severe acidosis Intubated patient Hypotension Altered mental state	Severe acidosis Respiratory distress Intubated patient Hypotension Altered mental state	Respiratory distress Urgent dialysis Intubated patient Hypotension Severe acidosis

Baseline laboratory	Direct admissions (n=491)			Indirect admissions (n=215)			p Value
	N	Result	SD	N	Result	SD	
Arterial pH	424	7.2	0.19	81	7.3	0.15	0.000
PaO_2 (mm Hg)	419	152.9	125.55	72	104.8	59.51	0.002
Sodium (mmol/dL)	482	136.1	6.3	204	134.3	6.79	0.001
Potassium (mmol/dL)	481	4.6	1.33	203	4.5	1.25	0.149
Calcium (mmol/dL)	324	1.4	0.5	78	1.7	0.65	0.000
Glucose (mmol/dL)	378	12	8.22	150	10.6	6.25	0.057
Urea (mmol/dL)	480	13	12.71	204	19.05	19.22	0.000
Creatinine (μmol/dL)	480	297.3	354.59	200	405.7	415.59	0.001
Bicarbonate (mmol/dL)	418	20.5	10.36	78	19.2	9.61	0.307
Haemoglobin (g/dL)	482	12.6	3.06	205	11.4	2.97	0.000
Haematocrit (%)	482	37.4	9.14	205	34.1	8.9	0.000
Total white cells (×10^9/L)	474	14.3	10.28	205	13.3	9.96	0.238

ICU, intensive care unit; MICU, medical ICU.

more likely than HDU patients to stay in the unit for more than 1 day.

Multivariate results

1. All patients
   A. In-hospital mortality: Patients admitted to the general wards before subsequent transfer to the MICU/HDU had a threefold increased risk of in-hospital death (table 3(1)). In-hospital mortality was likewise significantly associated with increasing age and with resuscitation at the ED. None of the other covariates were significantly associated with in-hospital death.
   B. Death within 60 days of admission: The risk of dying within 60 days of admission was three times higher for indirectly admitted patients. Increasing age and resuscitation at the ED were likewise associated with increased 60-day
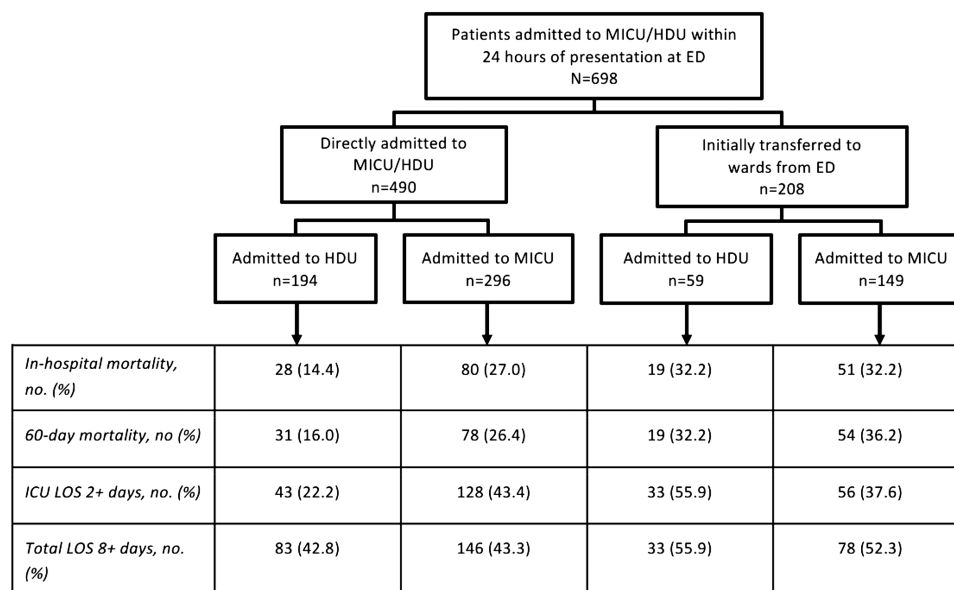
Figure 1 Outcomes of direct and indirect admissions, by unit (HDU, high dependency unit; ICU, intensive care unit; MICU, medical ICU; ED, emergency department; LOS, length of stay).

Table 3 Adjusted results for the effect of indirect MICU/HDU admissions on selected outcomes (all patients)

Factor	OR (95% CI)	Factor	OR (95% CI)
(1) *Outcome: in-hospital mortality*		Yes	0.62 (0.22 to 1.77)
Admission to the ICU		No (Ref)	–
Indirect	3.07 (1.39 to 6.80)	Gender	
Direct (Ref)	–	Female	0.93 (0.49 to 1.78)
Charlson comorbidity index	0.95 (0.80 to 1.14)	Male (Ref)	–
Age	1.02 (1.01 to 1.04)	Heart rate at the ED	
Hospitalisation within the past 7 days		70–109	0.71 (0.28 to 1.81)
Yes	1.15 (0.30 to 4.39)	110–129 or 50–69	0.58 (0.23 to 1.47)
No (Ref)	–	140+ or <55 (Ref)	–
Cardiopulmonary resuscitation		Respiratory rate at the ED	
Yes	37.38 (6.89 to 202.70)	12–24	0.65 (0.17 to 2.47)
No (Ref)	–	<12 or >24 (Ref)	–
Intubation at the ED		Oxygen saturation at the ED	
Yes	0.90 (0.33 to 2.51)	<98	1.40 (0.75 to 2.61)
No (Ref)	–	98–100 (Ref)	–
Gender		Mean arterial pressure at the ED	
Female	0.85 (0.45 to 1.61)	70–109	0.86 (0.34 to 2.18)
Male (Ref)	–	110–129 or 50–69	0.66 (0.24 to 1.78)
Heart rate at the ED		130+ or <50 (Ref)	–
70–109	0.78 (0.31 to 1.96)	Apache on arrival at the ICU	
110–129 or 50–69	0.64 (0.26 to 1.60)	0–9	2.25 (0.63 to 8.02)
140+ or <55 (Ref)	–	10–14	0.53 (0.16 to 1.77)
Respiratory rate at the ED		15–19	1.21 (0.44 to 3.33)
12–24	0.80 (0.22 to 2.95)	20–24	1.07 (0.38 to 3.05)
<12 or >24 (Ref)	–	25–29	0.81 (0.24 to 2.78)
Oxygen saturation at the ED		30+ (Ref)	–
<98	1.71 (0.92 to 3.17)	Where patient was admitted	
98–100 (Ref)	–	ICU	1.10 (0.47 to 2.54)
Mean arterial pressure at the ED		HDU (Ref)	–
70–109	1.31 (0.51 to 3.37)	(3) *Outcome: total in-hospital length of stay*	
110–129 or 50–69	1.00 (0.37 to 2.75)	*(8+ days vs 0–7 days)*	
130+ or <50 (Ref)	–	Admission to the ICU	
Apache on arrival at the ICU		Indirect	0.80 (0.34 to 1.88)
0–9	2.08 (0.60 to 7.29)	Direct (Ref)	–
10–14	0.54 (0.17 to 1.71)	Charlson comorbidity index	1.02 (0.85 to 1.24)
15–19	0.88 (0.32 to 2.39)	Age	1.03 (1.01 to 1.05)
20–24	0.83 (0.30 to 2.31)	Hospitalisation within the past 7 days	
25–29	0.78 (0.24 to 2.56)	Yes	0.85 (0.18 to 3.92)
30+ (Ref)	–	No (Ref)	–
Where patient was admitted		Intubation at the ED	
ICU	0.98 (0.42 to 2.26)	Yes	1.08 (0.40 to 2.89)
HDU (Ref)	–	No (Ref)	–
(2) *Outcome: death within 60 days of admission*		Gender	
Admission to the ICU		Female	1.53 (0.79 to 2.94)
Indirect	3.09 (1.40 to 6.83)	Male (Ref)	–
Direct (Ref)	–	Heart rate at the ED	
Charlson comorbidity index	1.00 (0.84 to 1.19)	70–109	1.05 (0.37 to 3.03)
Age	1.03 (1.01 to 1.05)	110–129 or 50–69	0.42 (0.16 to 1.15)
Hospitalisation within the past 7 days		140+ or <55 (Ref)	–
Yes	1.12 (0.29 to 4.30)	Respiratory rate at the ED	
No (Ref)	–	12–24	1.19 (0.31 to 4.46)
Cardiopulmonary resuscitation		<12 or >24 (Ref)	–
Yes	51.39 (9.25 to 285.62)	Oxygen saturation at the ED	
No (Ref)	–	<98	1.05 (0.55 to 1.98)
Intubation at the ED		98–100 (Ref)	–
		Mean arterial pressure at the ED	

Continued

Table 3 Continued

Factor	OR (95% CI)
70–109	1.66 (0.66 to 4.17)
110–129 or 50–69	1.75 (0.68 to 4.51)
130+ or <50 (Ref)	–
Apache on arrival at the ICU	
0–9	1.72 (0.36 to 8.14)
10–14	1.34 (0.45 to 3.96)
15–19	0.72 (0.25 to 2.07)
20–24	2.00 (0.70 to 5.74)
25–29	1.26 (0.36 to 4.42)
30+ (Ref)	–
Where patient was admitted	
ICU	1.65 (0.68 to 4.01)
HDU (Ref)	–
(4) *Outcome: ICU/MICU length of stay (2+ vs 0–1 day)*	
Admission to the ICU	
Indirect	2.54 (1.48 to 4.36)
Direct (Ref)	–
Charlson comorbidity index	0.85 (0.76 to 0.96)
Age	1.01 (1.00 to 1.03)
Hospitalisation within the past 7 days	
Yes	1.87 (0.69 to 5.07)
No (Ref)	–
Cardiopulmonary resuscitation	
Yes	1.95 (0.36 to 10.52)
No (Ref)	–
Intubation at the ED	1.93 (1.02 to 3.68)
Intubated	–
Not intubated (Ref)	
Gender	1.36 (0.89 to 2.07)
Female	–
Male (Ref)	
Heart rate at the ED	1.83 (0.92 to 3.67)
70–109	1.62 (0.82 to 3.21)
110–129 or 50–69	–
140+ or <55 (Ref)	
Respiratory rate at the ED	0.90 (0.35 to 2.35)
12–24	–
<12 or >24 (Ref)	
Oxygen saturation at the ED	1.94 (1.28 to 2.93)
<98	–
98–100 (Ref)	
Mean arterial pressure at the ED	1.07 (0.58 to 1.97)
70–109	1.01 (0.53 to 1.92)
110–129 or 50–69	–
130+ or <50 (Ref)	
Where patient was admitted	
ICU	1.39 (0.80 to 2.43)
HDU (Ref)	–

ED, emergency department; HDU, high dependency unit; ICU, intensive care unit; MICU, medical ICU.

mortality (table 3(2)). There were no other significant predictors of 60-day mortality.

C. Total in-hospital length of stay (<8 vs 8+ days): After excluding patients who died during hospitalisation from the analysis, increasing age was the only variable associated with total in-hospital

length of stay of 8 days or more (table 3(3)). There was no significant difference in the total in-hospital length of stay for direct and indirect MICU/HDU admissions.

D. MICU/HDU length of stay (<2 vs 2+ days): As with total in-hospital length of stay, patients who died during hospitalisation were excluded from the analysis. The risk of staying two or more days in the MICU/HDU was 2.5 times higher for indirectly admitted patients (table 3 (4)). Older patients, those with fewer comorbidities (lower CCI), with low oxygen saturation (<98%) and those who were intubated at the ED were also more likely to stay for two or more days in the MICU/HDU.

2. All patients excluding those admitted to the ICU for hypotension, respiratory failure or who were intubated

A. In-hospital mortality: Of the 706 patients in the study, only 197 remained in the analysis after excluding patients with hypotension, respiratory failure or who were intubated. None of the factors tested, including direct/indirect admission, were significantly associated with in-hospital mortality (table 4(1)).

B. Death within 60 days of admission: With 197 patients included in the analysis, none of the factors included in the logistic regression model were significantly associated with mortality within 60 days of admission (table 4(2)).

C. Total in-hospital length of stay: After further excluding patients who died during hospitalisation, 178 patients remained in the analysis. Using Cox proportional hazards, lower CCI was the only variable associated with total in-hospital length of stay (table 4(3)). There was no significant difference in the total in-hospital length of stay for direct and indirect MICU/HDU admissions.

D. MICU/HDU length of stay: As with total in-hospital length of stay, patients who died during hospitalisation were excluded from the analysis. Results of Cox proportional hazards show that none of the factors, including direct/indirect admission, were significantly associated with MICU/HDU length of stay (table 4(4)).

DISCUSSION

In this study, one-third of patients were indirectly admitted to the MICU/HDU. A multicentre study in the USA and Europe on patients with pneumonia revealed a similar indirect admission rate of 30.5%.[16] A Brazilian study reported that 68.8% of admissions to the ICU were delayed as a result of indirect admissions to the ward,[17] while a study from the UK found that 17.6% of ICU admissions were indirect transfers.[18] However, the wide disparity in figures across settings may be related to the lack of a standard definition for indirect admission or admission delays.

Table 4 Adjusted results for the effect of indirect MICU/HDU admissions on selected outcomes (all patients excluding those admitted to the ICU for hypotension, respiratory failure or who were intubated)

Factor	OR (95% CI)	Factor	OR (95% CI)
(1) *Outcome: in-hospital mortality*		Respiratory rate at the ED	
Admission to the ICU		12–24	0.31 (0.00 to –)
Indirect	10.67 (0.76 to 149.39)	<12 or >24 (Ref)	–
Direct (Ref)	–	Oxygen saturation at the ED	
Charlson comorbidity index	0.72 (0.32 to 1.64)	98–100	0.63 (0.05 to 8.69)
Age	0.99 (0.91 to 1.07)	<98 (Ref)	–
Hospitalisation within the past 7 days		Mean arterial pressure at the ED	
No	1.09 (0.05 to 22.43)	70–109	0.16 (0.00 to 5.91)
Yes (Ref)	–	110–129 or 50–69	0.02 (0.00 to 1.30)
Gender		130+ or <50 (Ref)	–
Female	0.50 (0.41 to 6.05)	Apache on arrival at the ICU	
Male (Ref)	–	0–9	1.13 (0.02 to 76.15)
Heart rate at the ED		10–14	0.00 (0.00 to –)
70–109	0.43 (0.01 to 12.67)	15–19	1.79 (0.12 to 26.97)
110–129 or 50–69	0.35 (0.01 to 14.94)	20–24	0.93 (0.07 to 12.44)
140+ or <55 (Ref)	–	25–29	0.27 (0.01 to 15.54)
Respiratory rate at the ED		30+ (Ref)	–
12–24	0.07 (0.00 to –)	Where patient was admitted	
<12 or >24 (Ref)	–	ICU	2.00 (0.07 to 59.39)
Oxygen saturation at the ED		HDU (Ref)	–
98–100 (Ref)	2.24 (0.08 to 63.61)	(3) *Outcome: total in-hospital length of stay*	
<98		Admission to the ICU	
Mean arterial pressure at the ED		Indirect	1.06 (0.51 to 2.22)
70–109	0.05 (0.00 to 5.41)	Direct (Ref)	–
110–129 or 50–69	0.01 (0.00 to 1.66)	Charlson comorbidity index	0.76 (0.59 to 0.96)*
130+ or <50 (Ref)	–	Age	1.00 (0.97 to 1.02)
Apache on arrival at the ICU		Hospitalisation within the past 7 days	
0–9	0.23 (0.00 to 26.07)	Yes	2.09 (0.57 to 7.72)
10–14	0.00 (0.00 to –)	No (Ref)	–
15–19	2.35 (0.13 to 41.91)	Gender	
20–24	0.16 (0.01 to 4.95)	Female	0.76 (0.39 to 1.49)
25–29	0.90 (0.02 to 48.44)	Male (Ref)	–
30+ (Ref)	–	Heart rate at the ED	
Where patient was admitted		70–109	0.62 (0.18 to 2.15)
ICU	4.50 (0.14 to 142.83)	110–129 or 50–69	1.46 (0.40 to 5.33)
HDU (Ref)	–	140+ or <55 (Ref)	–
(2) *Outcome: death within 60 days of admission*		Respiratory rate at the ED	
Admission to the ICU		12–24	2.58 (0.27 to 24.38)
Indirect	10.30 (0.83 to 128.02)	<12 or >24 (Ref)	–
Direct (Ref)	–	Oxygen saturation at the ED	
Charlson comorbidity index	1.09 (0.53 to 2.24)	98–100	0.71 (0.31 to 1.62)
Age	1.01 (0.93 to 1.10)	<98 (Ref)	–
Hospitalisation within the past 7 days		Mean arterial pressure at the ED	
No	1.09 (0.05 to 22.43)	70–109	0.78 (0.24 to 2.54)
Yes (Ref)	–	110–129 or 50–69	0.64 (0.19 to 2.20)
Gender		130+ or <50 (Ref)	–
Female	0.22 (0.02 to 2.19)	Apache on arrival at the ICU	
Male (Ref)	–	0–9	0.96 (0.22 to 4.30)
Heart rate at the ED		10–14	1.24 (0.45 to 3.38)
70–109	1.42 (0.05 to 39.37)	15–19	0.57 (0.20 to 1.64)
110–129 or 50–69	0.33 (0.01 to 11.56)	20–24	0.65 (0.24 to 1.82)
140+ or <55 (Ref)	–	25–29	0.84 (0.21 to 3.32)
		30+ (Ref)	–

Continued

Table 4 Continued	
Factor	**OR (95% CI)**
Where patient was admitted	
ICU	1.10 (0.42 to 2.91)
HDU (Ref)	–
(4) *Outcome: ICU/MICU length of stay*	
Admission to the ICU	
Indirect	0.94 (0.65 to 1.36)
Direct (Ref)	–
Charlson comorbidity index	1.01 (0.93 to 1.10)
Age	1.00 (0.99 to 1.00)
Hospitalisation within the past 7 days	
No	1.05 (0.45 to 2.46)
Yes (Ref)	–
Gender	
Female	1.16 (0.83 to 1.61)
Male (Ref)	–
Heart rate at the ED	
70–109	0.90 (0.50 to 1.63)
110–129 or 50–69	0.77 (0.42 to 1.41)
140+ or <55 (Ref)	–
Respiratory rate at the ED	
12–24	2.98 (0.38 to 23.14)
<12 or >24 (Ref)	–
Oxygen saturation at the ED	
98–100	1.06 (0.73 to 1.52)
<98 (Ref)	–
Mean arterial pressure at the ED	
70–109	1.00 (0.58 to 1.72)
110–129 or 50–69	0.91 (0.50 to 1.64)
130+ or <50 (Ref)	–
Where patient was admitted	
ICU	0.93 (0.62 to 1.39)
HDU (Ref)	–

ED, emergency department; HDU, high dependency unit; ICU, intensive care unit; MICU, medical ICU.

Of the various independent variables considered in this study, indirect admission to intensive care was identified as one of the few which were independently associated with in-hospital mortality, death within 60 days of admission, and length of stay at the MICU/HDU. Other researchers had similar findings suggesting poor outcomes for patients indirectly admitted or whose admission was delayed.[8 11 12 14–17 19–24]

Establishing the magnitude of the problem as well as its consequences is an important first step towards planning for improvements. Planning specific interventions will require identification of the underlying reasons for indirect admissions and delays. While a full ICU is often implicated for delays,[8–12] other reasons such as procedural standards and staffing issues,[9] as well as the diagnosis and prognosis of the patient,[8 13] have been cited as reasons for refusal of admission. Inability to recognise the severity of the patient's condition has likewise been cited as a cause of delays in ICU admission.[14 15] A study which compared direct and indirect admissions noted that patients whose admission to the ICU were delayed were more likely to have been initially assessed by junior staff or less experienced intensivists.[8 23] In a survey of ICU physicians in Italy, 86% of the respondents acknowledged having admitted patients inappropriately, with 33% attributing this to clinical doubt and 25% to assessment error.[25]

The long list of possible causes of indirect ICU admissions and delays makes it a challenge to prioritise interventions because each cause calls for a different solution. To address the perennial problem of a full ICU, aside from the intuitive but operationally complex solution of increasing the number of beds, other recommendations include increasing the availability of intermediate or step-down care[8] or alternative care areas for patients who require stabilisation;[13] deployment of medical emergency teams or intensive care outreach services for ward patients becoming critically ill;[13 18 26 27] and use of various models to expand physician coverage to provide critical care in the ED.[28] Other factors and proposed interventions include the development of ward care pathways for conditions which frequently lead to ICU admissions[15] and the development of predictive models and physiological early warning scores to identify incipient severe outcomes.[16 18] Bringing in some elements of intensive care such as ventilators to the general wards may not be enough to improve outcomes for critically ill patients. Tang found a significantly higher risk-standardised mortality among patients who were mechanically ventilated in the wards compared with the ICU.[29]

To enhance triage decisions, resources such as clinical guidelines are available for emergency physicians and intensivists to complement their professional judgement. Examples include the American College of Critical Care Medicine's Guidelines for ICU Admission, Discharge, and Triage,[4] as well as Guidelines on Admission to and Discharge from the ICU and HDU of the UK Department of Health.[30] The performance and accuracy of tools such as the Emergency Severity Index have been assessed.[31] While, to a certain extent, existing tools minimise the subjectivity of patient assessments, there is a need to continuously improve the performance of these tools.

With regard to limitations of this research, as this was a retrospective study, it was not possible to determine the reason for the initial refusal of indirect MICU/HDU admissions. While the lack of ICU beds is perhaps the most commonly cited reason in the literature,[8–12] for this study the proportion of indirect admissions due to the unavailable MICU/HDU beds cannot be ascertained.

Differentiating direct from indirect admissions based solely on where the patient was initially admitted may introduce bias if no criterion is specified for the upper limit of the interval between arrival at the ED and admission to the MICU/HDU. There is no universally accepted duration which determines that a patient's condition is not expected to deteriorate to a point that transfer to the MICU/HDU becomes necessary soon after admission to the general ward. However, for this study, the 24 h upper

limit from ED presentation to MICU/HDU admission was used as it was considered a reasonable interval during which a non-critical patient admitted to the general ward is expected to remain stable.

In the multivariate analysis, MICU and HDU patients were analysed as a single group as analysing them separately would have substantially reduced the sample size. While the magnitude of effects may differ between the two groups, bivariate results suggested similar directions of effect for MICU and HDU patients analysed separately.

This study validates previously published findings that indirect ICU admissions or delays lead to adverse patient outcomes. While the direction of effect may be consistent across settings, variations in the magnitude of effect may be affected by factors such as differences in ICU bed capacity, the profile of patients served, organisational procedures and standards, as well as physician characteristics. For this reason, the estimated risk of adverse outcomes in one setting will not necessarily apply to another, thus highlighting the usefulness of conducting similar studies in one's own context. These self-assessments enable emergency and ICU departments to customise improvements based on their unique situations. It also facilitates performance monitoring by providing a baseline measure of the adverse consequences of indirect admissions, against which future results may be compared.

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