

Epidemiology of paediatric intensive care unit admissions, deaths and organ donation candidacy: A single-centre audit

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ABSTRACT

Introduction: There are limited reports on the epidemiology of paediatric intensive care unit (PICU) admissions, deaths and organ donation candidacy. We aimed to describe PICU admission characteristics and outcomes, determine risk factors for mortality, and perform an independent assessment of missed organ donation opportunities.

Method: We adopted a clinical audit design recruiting consecutive patients admitted to a single-centre multidisciplinary PICU from June 2020 to December 2023. Clinical characteristics and outcomes of survivors and non-survivors were described. Multivariable regression was performed to identify independent risk factors for mortality. Organ donation candidacy was evaluated by an independent team based on the criteria by Singapore's National Organ Transplant Unit.

Results: There were 1766 PICU admissions with mean age $\pm$ standard deviation of 5.9 ± 6.0 years. Surgical admissions accounted for 707/1766 (40%), while the most common medical admission category was respiratory (416/1766; 23.6%). The majority of 983/1766 (55.7%) had a chronic comorbidity and 312/1766 (17.6%) were dependent on at least 1 medical technology device. Mortality occurred in 99/1766 (5.6%). After adjusting for elective admissions and admission category; comorbidity with adjusted odds ratio (aOR) 95% confidence interval (CI) 3.03 (1.54–5.96); higher Pediatric Index of Mortality 3 (PIM 3) score with aOR 1.06 (95% CI 1.04–1.08); and functional status scale with aOR 1.07 (95% CI 1.00–1.13) were associated with mortality. Among non-survivors, organ donor candidacy was 21/99 (21.2%) but successful organ donation occurred in only 2/99 (2.0%).

Conclusion: In this single-centre audit, comorbidities, PIM 3 score and functional impairment were associated with mortality. Efforts are needed to improve paediatric organ donation rates.

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Keywords: children, paediatrics, paediatric intensive care units, PICU, mortality, organ donation, organ transplant

CLINICAL IMPACT

What is New

- This clinical audit identified a substantial population of children with chronic disease and medical technology dependence who were admitted to our paediatric intensive care unit (PICU).
- Presence of chronic disease, higher admission severity score and functional impairment were associated with mortality.
- Among PICU non-survivors, there was a large gap between eligibility and actual organ donation that predominantly stemmed from non-identification of potential organ donors.

Clinical Implications

- Children with chronic disease and functional impairment are vulnerable populations within our PICU, underscoring the need for research in these groups of children to improve outcomes.
- Concrete measures to improve paediatric organ donation rates may include having an independent team screen patients for eligibility when death is anticipated, involving the donor coordinator in family discussions, and establishing an operational workflow for donation after cardiac death.

INTRODUCTION

With advancements in medical care, mortality rates in critically ill patients have decreased substantially.^{1,2} Contemporary studies from developed countries report paediatric intensive care mortality rates of 2–3%^{3,4} in 2014 to 2019, whereas mortality in developing countries can be as high as 50%⁵ as of 2024, indicating large disparities in resources,

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expertise and infrastructure between high- and low-resource countries. Other evident differences include the causes of death—sepsis, multiorgan failure and pneumonia are leading causes of mortality in developing countries,^{6,7} whereas, cardiovascular disease (including congenital heart disease, cardiomyopathy and myocarditis) and neuromuscular disease (including encephalitis/encephalopathy) are more prevalent causes of death in developed countries.^{3,4} Paediatric intensive care unit (PICU) registries are a useful means to track the epidemiology of PICU admissions and mortality characteristics. For example, the Virtual Pediatric Systems registry in the US,⁸ the Australian and New Zealand Pediatric Intensive Care Registry (ANZPICR)⁹ and the Paediatric Intensive Care Audit Network (PICANet)¹⁰ in the UK are established PICU registries with audit, quality improvement and research aims. There is currently a lack of such registry initiatives in other parts of the world including Asia. As a result, reliable year-on-year admission characteristics and mortality data are lacking.

As most inpatient paediatric deaths occur in the PICU, identification of potential organ donors is most actively conducted in there, which is a pragmatic representation of the potential paediatric organ donor pool.¹¹ Besides being affected by prevailing mortality rates, organ donation in children is also diminished due to medical suitability (e.g. higher prevalence of inborn errors, of metabolism and genetic conditions compared to adults) and parental values and beliefs.¹² Singapore legislation requires parents or legal guardians of minors to give consent during an already stressful period for organ donation.¹³ There are limited reports on organ donation rates and missed donation opportunities in PICUs in Singapore and globally. By leveraging a recently established paediatric ICU registry, this study aimed to (1) describe the epidemiology of PICU admissions, (2) compare characteristics of survivors and non-survivors to identify risk factors for poor outcome, and (3) explore perimortem characteristics to independently determine the number of potential organ donors over the study period.

METHOD

Study design

This study employed an audit design, extracting data from the Singapore Pediatric Intensive Care Registry (SG-PedIC). We chose to perform a clinical audit from the SG-PedIC Registry as our primary aim was to describe the epidemiology of PICU admissions, deaths and organ donation candidacy to inform regarding the current standard of care delivered in our PICU. By adopting an audit design,

all consecutive PICU admissions were included. The registry routinely and prospectively collects data on patient demographics, clinical characteristics, PICU therapies and outcomes from a single-centre PICU at KK Women's and Children's Hospital. This is a tertiary, university-affiliated paediatric centre in Singapore with a multidisciplinary PICU comprising 16 beds (including medical, surgical, oncology, neurosurgical and cardiothoracic surgical subspecialties). It is also the largest paediatric hospital in Singapore, serving the majority of the local paediatric population. As this study was deemed an audit, ethics approval was waived. No generative artificial intelligence (AI) or AI-assisted technologies were used.

All consecutive patients admitted to the PICU between July 2020 and December 2023 (3.5-year period) were included in this study. Patients' characteristics including age, sex, weight, race, presence of comorbidities, admission details, Paediatric Index of Mortality 3 (PIM 3) score, PICU therapies and outcomes were extracted using a standardised case report form. The PIM 3 score that has been validated at our centre was calculated on admission to the PICU.^{14,15} Comorbidities were defined according to the list of chronic complex conditions and the main system affected was reported.^{16,17} The functional status scale was scored on admission to the PICU.¹⁸ Technology dependence was defined according to the list provided by the ANZPICR.⁹ Non-survivors were defined as patients who demised during in-patient admission or who were discharged directly home from the PICU for terminal extubation. Perimortem characteristics and cause of death were examined in non-survivors. In addition to routinely collected registry data, we independently identified potential organ donors based on published criteria; age (at least 2 months and above); and absence of any malignancy, disseminated infection, hepatitis C and HIV (Supplementary Table S1).¹⁹ Patients who were diagnosed with or suspected of having inborn errors of metabolism (IEM) or other genetic conditions were excluded. Once a patient was deemed a potential organ donor, perimortem case notes (up to 72 hours before terminal event) were reviewed to determine if the medical team identified organ donation eligibility and if the topic of organ donation was broached with the patient's parents/legal guardian. Reasons for and against organ donation were identified and summarised.

Statistical analysis

The primary outcome of this audit was PICU mortality. We calculated the standardised mortality ratio by the ratio of the observed deaths to expected deaths based on the PIM 3 score at

admission. Characteristics and PICU therapies of PICU survivors and non-survivors were compared using the Student's t-test or chi-square test for continuous or categorical outcomes, respectively. Multivariable logistic regression was performed to identify independent risk factors for PICU mortality, and adjusted for baseline patient characteristics with significant univariate associations and clinical significance. Analysis was performed on STATA software version 15.1 (StataCorp, College Station, TX, US). All tests were two-tailed and *P* value <0.05 was accepted as statistically significant.

RESULTS

A total of 1766 patients were admitted to the PICU during the study period. The mean age of patients was 5.9 (± 6.0) years (Table 1). Among them, 997/1766 (56.5%) were male, 946/1766 (53.6%) were Chinese and 514/1766 (29.1%) were elective admissions. Surgical admissions accounted for 707/1766 (40%) of total admissions, while the most common medical admission category was respiratory at 416/1766 (23.6%). The main sources of admission were the general inpatient ward/intermediate care unit at 550/1766 (31.1%), operating theatre at 541/1766 (30.6%) and emergency department at 487/1766 (27.6%).

The majority of patients who were admitted also had preexisting comorbidities at 983/1766 (55.7%), with cardiovascular and neurological/neuromuscular comorbidities being most prevalent in our study population.

Respiratory support was the most common PICU therapy required by patients (invasive mechanical ventilation in 777/1766 [44.0%] and non-invasive respiratory support in 560/1766; 31.7%), whereas cardiovascular support was required in 484/1766 (27.4%) (Table 2). Non-survivors had increased frequency of use of all PICU support therapies, except non-invasive respiratory support. The mean length of PICU stay of our study population was 7 (± 26.6) days, though 137/1766 (7.8%) patients had a prolonged PICU stay of more than 2 weeks. Patients admitted for more than 2 weeks were sicker (PIM 3 score mean standard deviation [SD] 5.4 [± 11.0]% vs. 2.6 [± 6.9]; *P*<0.001); more likely to have an underlying chronic condition (100/137 [73.0%] vs. 884/1626 [54.4%]; *P*≤0.001); be technology dependent (48/137 [35.0%] vs. 264/1629 [16.2%]; *P*<0.001); and have a poorer functional state (functional status scale, mean [SD] 10.8 [± 5.1] versus [vs] 8.2 [± 3.6]; *P*<0.001). When excluding these long stayers, the mean length of PICU stay was 3.6 (± 2.5) days.

Table 1. Comparison of characteristics of survivors and non-survivors admitted to the paediatric intensive care.

Patient characteristics	Total (n=1766)	Survivors (n=1667)	Non-survivors (n=99)	<i>P</i> value
Age, years	5.9 (6.0)	5.9 (5.9)	5.6 (6.0)	0.647
Age group, no. (%)				0.209
Infant (1 month to <1 year)	544 (30.8)	506 (30.3)	38 (38.3)	
Child (1 year to <10 years)	739 (41.9)	706 (42.3)	33 (33.3)	
Adolescent (10 to <18 years)	445 (25.2)	418 (25.0)	27 (27.2)	
Adult (>18 years)	37 (2.1)	36 (2.1)	1 (1.0)	
Weight, mean (SD), kg	35.8 (568.9)	36.6 (585.5)	21.8 (22.9)	0.801
PIM 3 score, mean (SD), %	2.7 (7.3)	2.3 (5.2)	12.1 (22.5)	<0.001
Male, no. (%)	997 (56.5)	946 (56.8)	52 (52.5)	0.403
Race, no. (%)				0.147
Chinese	946 (53.6)	901 (54.1)	44 (44.4)	
Malay	521 (29.5)	485 (29.1)	36 (36.3)	
Indian	147 (8.3)	135 (8.1)	12 (12.1)	
Others	150 (8.5)	144 (8.6)	7 (7.0)	
Any comorbidities, no. (%)	983 (55.7)	918 (55.2)	65 (65.6)	0.042
Neurological/neuromuscular	297 (16.8)	279 (16.7)	18 (18.1)	0.709

Table 1. Comparison of characteristics of survivors and non-survivors admitted to the paediatric intensive care. (Cont'd)

Patient characteristics	Total (n=1766)	Survivors (n=1667)	Non-survivors (n=99)	P value
Cardiovascular	303 (17.1)	279 (16.7)	24 (24.2)	0.054
Respiratory	104 (5.8)	96 (5.7)	8 (8.0)	0.340
Renal	27 (1.5)	25 (1.5)	2 (2.0)	0.682
Gastrointestinal	84 (4.7)	80 (4.8)	4 (4.0)	0.730
Haematology/immunology	47 (2.6)	45 (2.7)	2 (2.0)	0.683
Metabolic	66 (3.7)	63 (3.7)	3 (3.0)	0.703
Genetic/congenital	185 (10.4)	171 (10.2)	14 (14.1)	0.220
Neoplastic	180 (10.1)	169 (10.1)	11 (11.1)	0.756
Technology dependent, no. (%)	312 (17.6)	288 (17.3)	24 (24.2)	0.077
Elective, no. (%)	514 (29.1)	506 (30.4)	9 (9.0)	<0.001
Admission category, no. (%)				<0.001
Cardiac surgical	274 (15.5)	262 (15.7)	12 (12.1)	
Cardiac medical	131 (7.4)	118 (7.0)	13 (13.1)	
Trauma	48 (2.7)	40 (2.4)	8 (8.0)	
Respiratory	416 (23.6)	388 (23.3)	28 (28.2)	
Neurological	148 (8.3)	139 (8.3)	9 (9.0)	
Surgical (non-cardiac)	385 (21.8)	379 (22.7)	6 (6.0)	
Other medical diagnoses	361 (20.4)	338 (20.3)	23 (23.2)	
Admission source, no. (%)				<0.001
Operating theatre	541 (30.6)	531 (31.9)	10 (10.1)	
Emergency department	487 (27.6)	460 (27.6)	27 (27.2)	
General ward/intermediate care unit	550 (31.1)	517 (31.0)	33 (33.3)	
Neonatal department	44 (2.4)	39 (2.3)	5 (5.0)	
Inter-hospital transfers	89 (5.0)	71 (4.2)	18 (18.1)	
Others	53 (3.0)	47 (2.8)	6 (6.0)	
Admission functional status scale, mean (SD)	8.3 (3.8)	8.3 (3.7)	9.4 (4.5)	0.003
Mental status	1.1 (0.6)	1.1 (0.6)	1.3 (0.8)	0.007
Sensory functioning	1.2 (0.6)	1.1 (0.6)	1.3 (0.6)	0.037
Communication	1.2 (0.7)	1.2 (0.7)	1.4 (0.7)	0.099
Motor functioning	1.4 (1.0)	1.4 (1.0)	1.7 (1.2)	0.001
Feeding	1.6 (0.9)	1.5 (0.9)	1.8 (1.0)	0.029
Respiratory status	1.6 (1.2)	1.6 (1.2)	1.8 (1.4)	0.083

PIM 3: Pediatric Index of Mortality 3

Table 2. Comparison of intensive care therapies in survivors and non-survivors.

Intensive care therapies	Total (n=1766)	Survivors (n=1667)	Non-survivors (n=99)	P value
Inotrope, no. (%)	484 (27.4)	402 (24.1)	82 (82.8)	<0.001
Adrenaline	295 (16.7)	220 (13.2)	75 (75.8)	<0.001
Noradrenaline	247 (14.0)	186 (11.2)	61 (61.6)	<0.001
Milrinone	242 (13.7)	212 (12.7)	30 (30.3)	<0.001
Vasopressin	62 (3.5)	19 (1.1)	43 (43.4)	<0.001
Dopamine	32 (1.8)	21 (1.3)	11 (11.1)	<0.001
Dobutamine	12 (0.7)	7 (0.4)	5 (5.1)	<0.001
Continuous renal replacement therapy, no. (%)	43 (2.4)	20 (1.2)	23 (23.2)	<0.001
Continuous veno-venous haemodialysis	42 (2.4)	19 (1.1)	23 (23.2)	<0.001
Peritoneal dialysis	4 (0.2)	2 (0.1)	2 (2.0)	<0.001
ECMO, no. (%)	59 (3.3)	28 (1.6)	31 (31.3)	<0.001
Non-invasive respiratory support, no. (%)	560 (31.7)	533 (31.9)	27 (27.2)	0.329
Continuous positive airway pressure	455 (25.8)	443 (26.6)	12 (12.1)	0.001
Bilevel positive airway pressure	326 (18.5)	306 (18.4)	20 (20.2)	0.646
High flow nasal cannula	47 (2.7)	46 (2.8)	1 (1.0)	0.293
Mechanical ventilation, no. (%)	777 (44.0)	684 (41.0)	93 (93.9)	<0.001
Duration	3.0 (12.0)	2.4 (10.5)	13.6 (24.3)	<0.001
High frequency ventilation	51 (2.8)	29 (1.7)	22 (22.2)	<0.001
Nitric oxide	42 (2.3)	26 (1.5)	16 (16.1)	<0.001
Intracranial pressure monitor, no. (%)	45 (2.5)	38 (2.2)	7 (7.0)	0.003
ICU stay, mean (SD), days	7.0 (26.6)	6.4 (26.5)	15.6 (27.8)	<0.001
Prolonged ICU stay, no. (%)	137 (7.8)	114 (6.8)	23 (23.2)	<0.001

ECMO: extracorporeal membrane oxygenation; ICU: intensive care unit

There were a total of 99/1766 (5.6%) deaths in this population (mortality rate for each calendar year ranged 5.1–6.8% with no statistical difference between years). The standardised mortality ratio was 2.1. There were no differences in demographics between survivors and non-survivors. However, compared to survivors, non-survivors were more likely to have an underlying comorbidity (65/99 [65.6%] vs 918/1667 [55.2%]; $P=0.042$), higher PIM 3 (mean [SD] 12.1% [± 22.5] vs 2.3% [± 5.2], $P<0.001$), and higher admission functional status scale (mean [SD] 9.4 [± 4.5] vs 8.3 [± 3.7]; $P=0.003$). There were also differences in admission categories and source of admission between survivors and non-survivors (Table 1). In the multivariable regression model, after adjusting for elective admissions and

admission category, the presence of comorbidities (adjusted odds ratio [aOR] 3.03, 95% confidence interval [CI] 1.54–5.96), PIM 3 (aOR 1.06, 95% CI 1.04–1.08) and admission functional status scale (aOR 1.07, 95% CI 1.00–1.13) were independently associated with PICU mortality (Table 3). Among the non-survivors, the main causes of death include central nervous system infarction/haemorrhage/hypertension (17/99; 17.1%) and pneumonia/chronic lung disease (15/99; 15.1%) (Table 4). There were also 30/99 (30.3%) of patients who required coroner's referral. Most deaths occurred on maximal support 38/99 (39.1%) while brain death occurred in 6/99 (6.2%) of the patients. Majority (51/99; 52.0%) of patients who died had existing limitation of care orders.

Table 3. Multivariable logistic regression for paediatric intensive care mortality.

Covariate	Univariate		Multivariate	
	OR (95% CI)	P value	aOR (95% CI)	P value
Comorbidities	1.55 (1.01–2.38)	0.043	3.03 (1.54–5.96)	0.001
PIM 3 score	1.06 (1.04–1.08)	<0.001	1.06 (1.04–1.08)	<0.001
Admission functional status scale	1.06 (1.02–1.11)	0.004	1.07 (1.00–1.13)	0.039
Elective	0.23 (0.11–0.46)	<0.001	0.42 (0.14–1.31)	0.134
Admission category Ref: Surgical (non-cardiac)				
Cardiac surgery	2.89 (1.07–7.81)	0.036	5.46 (1.55–19.26)	0.008
Cardiac medical	6.96 (2.59–18.71)	<0.001	3.23 (0.77–13.60)	0.110
Trauma	12.63 (4.17–38.24)	<0.001	11.09 (2.02–60.94)	0.006
Respiratory	4.56 (1.87–11.13)	0.001	2.72 (0.78–9.53)	0.117
Neurological	4.09 (1.43–11.70)	0.009	4.30 (1.07–17.35)	0.040
Other medical diagnoses	4.30 (1.73–10.68)	0.002	2.99 (0.83–10.76)	0.094

aOR: adjusted odds ratio; CI: confidence interval; OR: odds ratio; PIM 3: Pediatric Index of Mortality 3

Table 4. Perimortem characteristics of non-survivors.

Perimortem characteristics	No. (%) n=99
Limitation of care order	51 (52.0)
Any CPR in ICU	37 (37.3)
CPR as terminal event	20 (20.8)
Mode of death	
Brain death	6 (6.2)
Death with maximal support	38 (39.1)
Death with therapy limited but not withdrawn	23 (23.7)
Death with therapy withdrawn (but not brain dead)	30 (30.9)
Cause of death	
CNS infarction/haemorrhage/hypertension	17 (17.1)
Pneumonia/chronic lung disease	15 (15.1)
Cardiac failure/congenital heart disease	10 (10.1)
Sepsis/multiorgan dysfunction	10 (10.1)
Pulmonary hypertension	5 (5.0)
Malignancy	4 (4.0)
Others	8 (8.0)
Coroner's referral	30 (30.3)
Organ donation	2 (2.1)

CNS: central nervous system; CPR: cardiopulmonary resuscitation; ICU: intensive care unit

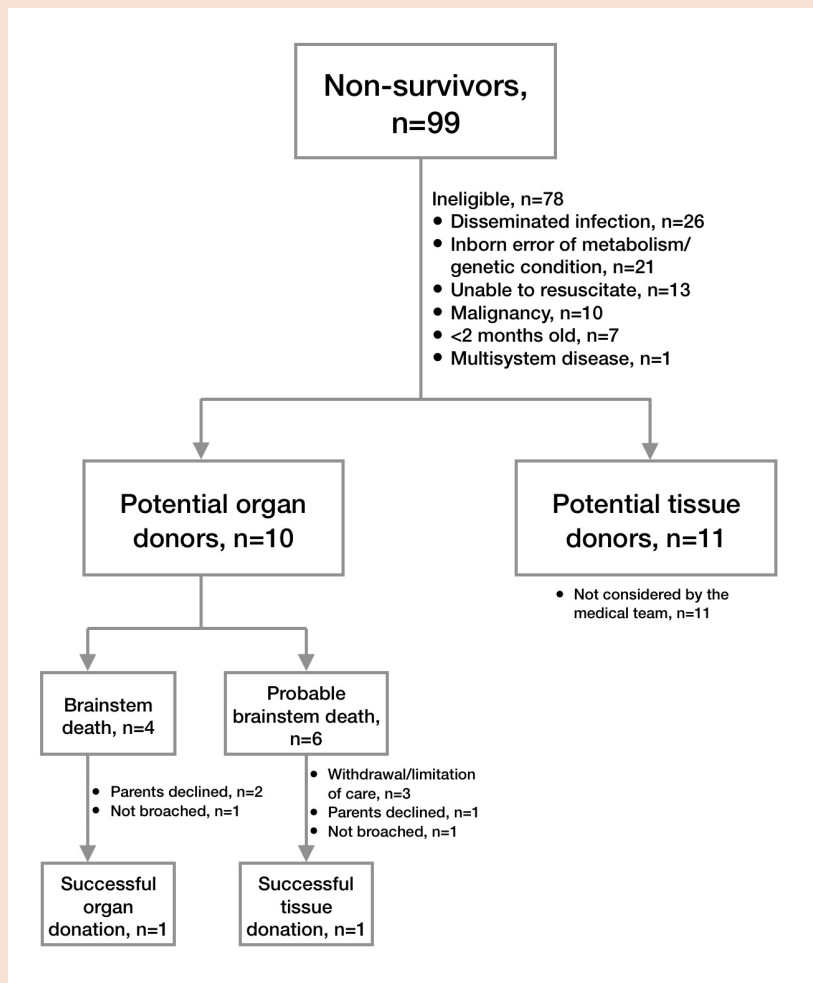
Among non-survivors, 78/99 (76.8%) were deemed ineligible for organ donation—the most common reasons for ineligibility were disseminated infection (26/78; 33.33%) and presence or suspicion of IEM/genetic conditions (21/78; 26.9%) (Fig. 1). Of the remaining 21 patients who were independently deemed to be potential organ donors, 4 met brainstem death criteria but only 1 went on to donate organs after brainstem death certification. Six patients had severe neurological prognosis with incomplete brainstem death criteria—among these only 1 went on to donate their tissue after cardiac death. The medical team did not consider the others 11/21 (52.4%) who were potential tissue donors.

DISCUSSION

In this single-centre audit of PICU admissions, we report a mortality rate of 5.6% and a standardised mortality ratio of 2.1. We identified the presence of comorbidities, higher PIM 3 score and functional impairment to be independently associated with mortality. The most common causes of death were neurological and respiratory. Of those who died, approximately 21% were eligible to donate their organs/tissue but only 2% went on to successfully donate their organs/tissue.

At 5.6%, the mortality rate reported in this study is slightly higher than those reported from developed countries including the US (1.9–3.4%),³ Australia/New Zealand (2.6%),²⁰ UK (5.1%)²¹ and Japan (2.1%).⁴ The number of predicted deaths based on the PIM 3 score was lower, yielding a standardised mortality ratio of 2.1. This may indicate

Fig. 1. Breakdown of the organ donation process.



that PICU management and quality of care fell behind expected norms or may be contributed by deaths occurring in patients with existing limitation of care orders. However, there are additional considerations in interpreting the standardised mortality ratio. The PIM 3 score was derived from critically ill children admitted to PICUs from 2010–2011 in Australia, New Zealand, Ireland and the UK via the ANZPICR and PICANet registries, and its performance in predicting mortality may require recalibration in different regions.^{15,22} Our hospital also runs an active rapid response team (intra-hospital) and transport service (inter-hospital), which provides advice to referring physicians on stabilising potential PICU candidates before transfer—this may artificially lower the PIM 3 score, which is calculated based on variables obtained once the patient is admitted to the PICU. Physiological variables for the calculation of PIM 3 may also be unavailable for some children (e.g. partial pressure of arterial oxygen), and given that PIM 3 relies on default imputation in which missing observations are given a value considered “normal”

for that variable, this could have artificially lowered the score.¹⁴ Lastly, though it is possible that a different severity of illness scores (e.g. PRISM²³) may yield a more accurate predicted mortality rate in our unit, it was beyond the scope of the current study to compare the predictive ability of these commonly used scores in the PICU.

Higher mortality was observed in patients with existing chronic comorbidities, which is consistent with previous reports.²⁴ These patients may have existing organ dysfunction and/or reduced cardiopulmonary reserve, potentially increasing their risk of death¹⁶ or may be admitted with existing limitation of care orders. Though slightly different from comorbidity per se, we observed that patients who had a higher functional status scale score (functionally impaired) also had a higher mortality rate. These patients were more likely to have a prolonged PICU stay, although the difference between these 2 groups of patients may not be clinically apparent. However, patients who were technology dependent (e.g. required long-term assisted feeding, home non-invasive respiratory

support or long-term vascular device) did not have a significantly higher mortality rate. With advances in medical care, there is likely an increasing population of patients with chronic diseases, functional impairment and technology dependence who may be admitted to PICU.²⁴ Data from this audit indicates that this population is vulnerable in the PICU, and further research is required to study their needs.

Despite advances in medical therapy, organ transplant remains the definitive, life-saving treatment for patients with irreversible or end-stage organ disease.²⁵ In Singapore, organ donation is governed by the Human Organ Transplant Act²⁶ and the Medical (Therapy, Education and Research) Act (MTERA),²⁷ and is mainly applied to adults aged 21 years old and above.²⁸ Paediatric organ donation may be applied for via MTERA, but it requires consent from the patient's parents/guardian and is often hindered by cultural and personal beliefs.¹² Here, we demonstrated that while 21% of our patients were deemed potential organ/tissue donors, up to 60% of these patients were not approached by the medical team. A single-centre retrospective study conducted in 2014 in the UK²⁹ has similarly shown that up to 54% of their neonatal patients who died were potential donors. A more recent multicentre retrospective study conducted in 2019 in the UK³⁰ had also reported that the majority of potential paediatric organ donors were not approached by the medical team. Both studies agree that with proper identification of potential organ donors and by approaching families respectfully, this niche group of patients may potentially augment nationwide donor pools. One concrete way to improve identification of organ donors is to have an independent team of medical staff screen patients for eligibility when death is anticipated, similar to how potential donors are screened in non-paediatric hospitals in Singapore. This differs from the current practice, in which transplant eligibility is determined by the medical team that is also in charge of the patient's treatment (a suggested workflow is provided in Supplementary Fig. S1). Once eligibility is established, family discussions should include the donor coordinator, who is a resource person on organ donation. Organ donation may be beneficial to families by providing an option to give meaning to the loss of a child's life, and if this is aligned with the values of the family, the managing team should incorporate their decision into the care plans.¹² Ideally, discussions on organ donation should be part of end-of-life care for dying patients of all ages.^{12,30} Nonetheless, such conversations remain a challenge to clinicians, especially when

families experience a sudden demise and such discussions may seem insensitive and even offensive, if done at the wrong time.

Organ donation after circulatory death (DCD)³¹ involves initiating organ donation after circulatory death is confirmed and has been shown to increase donor pools in countries such as Spain,³² US,³³ UK³⁴ and Canada.³⁵ This is a potential way of increasing the paediatric pool of organ donors as well as for adults.³⁶ Though the current legislation (i.e. MTERA) in Singapore allows for DCD and the first paediatric DCD in Singapore was reported in 2016,³⁷ national guidelines with an operational framework for carrying out DCD have only just been established following a pilot³⁸ and the guidelines were published in 2024.^{39,40} Given that the largest proportion of cases with missed opportunities for tissue/organ donation in this audit were cases of DCD, we anticipate that donation rates may improve with the publication of this guideline/framework and with experience. Organ transplant in Singapore remains a sensitive issue in a relatively conservative culture. More work needs to be done to increase the awareness of the benefits of organ donation for both recipient and donor among the general public, in order to effect a change in beliefs and values even prior to an ICU encounter.³⁸

Though this is to our knowledge the first audit of a large database of critically ill children in Singapore, there are several limitations. The SG-PedIC registry was initially established in a single centre but has only recently become a national-level registry that includes the only other restructured hospital admitting paediatric patients in Singapore, the National University Hospital, in 2024. As such, national-level data were not available to be included in this report and data from this single-centre audit may have limited generalisability. Another limitation of this study was that cause of death was not captured in the registry in approximately 30% of deaths that were referred to the coroners. In determining organ donation eligibility, we have taken a simplistic approach that may have reduced the number of eligible donors—we did not consider organ-specific criteria (Supplementary Table S1) and we excluded all malignancies even though some malignancies may still be considered for organ donation. Lastly, despite minimal missing quantitative data, qualitative data of communication details on organ donation between health-care providers and patients' families may have been missed. As such, more granular details on the reasons for not considering organ donation candidacy by medical staff and the reasons for declining organ donation by parents were not available.

CONCLUSION

This single-centre audit of a multidisciplinary PICU reports a mortality rate of 5.6% and identifies the presence of comorbidities, higher PIM 3 score and functional impairment to be associated with mortality. To improve outcomes of the PICU, research is required to study the needs of patients with chronic diseases and functional impairment. We also found that close to 60% of potential organ donors were missed by the medical team indicating that more effort is needed to improve paediatric organ/tissue donation rates at our unit, which may include independent screening for eligibility, involvement of the donor coordinator in family discussions and establishing an operational workflow for donation after cardiac death.

Ethics statement

As this study was deemed an audit, ethics approval was waived.

Declaration

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Supplementary materials

Table S1. Summary of general and organ specific screening criteria.

Fig. S1. Suggested workflow and timeframe to identify potential organ donors and initiate organ donation processes.

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