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## Adherence to standard medication infusion concentrations and its impact on paediatric intensive care patient outcomes

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### ABSTRACT

**Aim:** To review compliance with the DERS, and to evaluate the impact on daily fluid balances as a standard outcome in paediatric intensive care.

**Method:** A prospective audit of patients admitted to our tertiary level PICU over a 10 day period. The audit tool collated information on patient's weight, diagnosis, medication infusions, whether standard concentrations were selected, daily fluid balance, target fluid balance, and renal support including use of diuretics.

**Results:** Seventy-seven (84%) of patients weighed less than 10 kg. On average, there were 7 medication infusions per patient and 98% of the medication infusions adhered to standard concentrations for medication infusions and DERS. In 2% of medication infusions staff opted not to use the DERS, or selected non-standard concentration, and 2% of patients had no labels on the syringe. 90% of patients had a minimal positive balance of 0.5 mL/kg/h, averaged over 24 h; 48% of patients received renal support and 16% of patients were 24 h post cardiac surgery, where a negative fluid balance was recorded. It is standard practice post cardiac surgery to receive diuretics. Standard concentrations did not have a significant impact on patients' daily fluid balance.

**Conclusions:** The use of standard concentrations and short infusions in PICU using DERS is feasible & achievable as demonstrated by high compliance, and does not have a negative impact on patient outcome, especially fluid balance.

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### 1. Background

Calculations using “rule of six” and the preparation of individualised medication infusions have been a source of medication errors, especially for high-alert medications, in paediatrics.<sup>1</sup> The Institute for Safe Medication Practices (ISMP) medication safety alert<sup>2</sup> advises to avoid preparing medication infusions using the “rule of six”, and advocates the use of standard concentrations for medications as a medication safety initiative. Standard concentrations for medication infusions are when a medication is prepared

exactly the same; e.g. morphine 5 mg in 50 mL of 5% glucose, where as an individualised concentration is when morphine 0.5 mg/kg in 50 mL of 5% glucose, the latter uses the “rule of six” principles. Providing standard concentrations for medication infusions improves and assists medication libraries for infusion devices in the paediatric intensive care unit (PICU) and aims to minimise administration errors.<sup>3–5</sup> In Canada and the United States, standard concentrations for medication infusions are a requirement for accreditation for the hospital.<sup>6,7</sup> The Australian Commission on Safety and Quality in Health Care (ACSQHC)<sup>8</sup> have not proposed or adopted this in their national medication standards. However, vigorous application of standard concentrations for continuous medication infusions using dose error reduction software (DERS) for infusion devices improves medication safety and has been standard practice in our PICU since 2008. In November 2014 the DERS

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drug library for Lady Cilento Children's Hospital (LCCH) infusion devices was revised and updated for PICU patients, to include a bedside medication guide and pre-printed medication infusion labels for over 100 standard concentrations for medication infusions, previously this was limited to inotropes, opioids and sedative agents. There are 127 medication profiles that have a standard concentration for medication infusions out of the existing 213 medication profiles in DERS, these include but are not limited to high-risk medications. ACSQHC define high-risk medications as medications that have a low therapeutic index, medications that have high risk when administered the wrong route or when system errors occur.<sup>8</sup> Examples of high-risk medication categories listed by ACSQHC are opioids and sedative agents, electrolytes, insulin, chemotherapy, and anti-infectives.<sup>8</sup> The 86 medications profiles with no standard concentration are mainly antimicrobials, or short infusion considered less than 15 min, where dose of medication is considered important and this is reflected in DERS. Although there is evidence that standard concentrations for medication infusions improve medication safety in the PICU, this approach has not been universally adopted in the 6 PICUs in Australia and New Zealand.

Perceived barriers to adoption of standard concentration for medication infusions in paediatrics has been its impact on fluid balance, however this is not supported in the literature. A positive fluid balance is seen as a major predictor of clinical outcome for patients in and after intensive care. Several studies<sup>9,10</sup> found that having positive fluid balance in ICU increased patients' mortality risk, and this is particularly important for postoperative management of congenital heart disease patients.<sup>11</sup> Holliday and Segar<sup>12</sup> identified the 4/2/1 rule; (4 mL/kg for the first 10 kg + 2 mL for kg 11–20 kg + 1 mL/kg for every kg above 20 = hourly rate) for maintenance fluid rates for children and this standard has been adopted internationally for hourly and daily requirements in paediatrics. We investigated the use of standard concentrations for medications infusions in our paediatric intensive care and its impact on patients' daily fluid balance as a clinical outcome.

## 2. Method

The LCCH is a paediatric tertiary teaching hospital in Brisbane, Queensland. In 2015, there were 2097 patients admitted to the PICU. Ethics approval was obtained, and a prospective audit of admitted patients was conducted over 10 days between November 2015 and April 2016. All PICU patients could be selected, however patients not receiving intravenous therapy were excluded, and all PICU admissions were selected on the ten days of the audit. The 10 days were selected at random, and data were collected only when the pharmacist and nurse educator were available. A clinical information system (CIS, metavision<sup>®</sup> Version 5.46) assisted prescribers with selection of standard concentrations for medications that match the DERS, and the PICU pharmacist and clinical nurse educator collected the required data from the same CIS and infusion devices at the patient bedside. The use of a CIS and DERS with standard concentrations for medication infusions has been standard practice in our PICU since 2008. The pharmacist and nurse educator collected adherence to standard concentrations for medication infusions at each patient bedside. Patients' daily target fluid balance is documented in the CIS during morning ward rounds and each patient's actual fluid balances is cumulated daily in the CIS. We compared the actual and target fluid balance for each patient. Information collected was the patient's weight, presenting diagnosis for PICU admission, medication infusions, whether standard concentrations for medication infusions were selected, whether the medication infusion label matched the medication infusion prescribed, the patient's actual daily fluid balance, the patient's target fluid balance, whether renal support was indicated and if diuretics

**Table 1**  
Medication Infusions.

Medication categories	Medication	Number of infusions
Opioids (77)	Morphine	55
	Fentanyl	13
	Hydromorphone	1
	Methadone	2
	Ketamine	6
Sedation (81)	Midazolam	27
	Dexmedetomidine	45
	Propofol	8
	Thiopentone	1
Inotropes (96)	Adrenaline	10
	Noradrenaline	25
	Dopamine	20
	Dobutamine	4
	Milrinone	37
Paralysing agent (21)	Cisatracurium	20
	Vecuronium	1
Cardiovascular (9)	Sodium nitroprusside (SNP)	2
	Esmolol	1
	Glycerol trinitrate (GTN)	1
	Epoprostenol	1
	Alprostadil	4
Electrolytes (70)	Potassium	33
	Calcium	27
	Bicarbonate	3
	Sodium chloride 3%	2
	Glucose 50%	5
Anticoagulants (161)	Heparin	29
	Alteplase	1
	Defibrotide	1
	Hep saline	130
Fluids and PN (77)	Fluids	48
	Parental Nutrition (PN)	14
	Lipids	15
Endocrine & metabolic (12)	Insulin	10
	Arginine	1
	Octrotide	1
Bloods product (8)	Cryoprecipitate	2
	Albumin 20%	3
	Albumin 4%	3
Diuretics (22)	Furosemide	22
Other (3)	Naloxone	1
	Cyclosporin	1
	Tranexamic acid	1

were required. Note this is standard practice in the post operative period for congenital heart disease patients. This was collected using an in house data collection form.

Data analysis compared the target and actual fluid balance for each patient audited. Assessment of compliance with DERS, and whether standard concentrations for medication infusions was selected on the infusion pumps and CIS.

A telephone survey of the other dedicated PICUs in Australian & New Zealand was undertaken by the nurse educator to assess if; other sites currently use DERS for their infusion devices, if DERS compliance was regularly reviewed, whether standard concentration medication infusions were used, if yes for which medications, and whether they would like to expand standard concentrations for their medication infusions.

## 3. Results

Ninety-two patients were audited over the 10 days between November 2015 and April 2016, when the PICU pharmacist and nurse educator were available. Majority of the patients 77 (84%)

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