Author/s:
Elia, S;Moore, Y;Duke, T;Crawford, NW;Tosif, S

Title:
Influenza vaccine administration in a paediatric intensive care unit

Date:
2022-10-01

Citation:
Elia, S., Moore, Y., Duke, T., Crawford, N. W. & Tosif, S. (2022). Influenza vaccine administration in a paediatric intensive care unit. Journal of Paediatrics and Child Health, 58 (10), pp.1766-1770. https://doi.org/10.1111/jpc.16083.

Elia Sonja (Orcid ID: 0000-0002-6368-189X)
Duke Trevor (Orcid ID: 0000-0003-4637-1416)
Tosif Shidan (Orcid ID: 0000-0003-0022-1009)

INFLUENZA VACCINE ADMINISTRATION IN A PAEDIATRIC INTENSIVE CARE UNIT

Sonja Elia[1,2], Yvette Moore[4], Trevor Duke[3,4], Nigel W Crawford[1,2,3], Shidan Tosif [1,2,3]

Original article

Affiliations

[1] Immunisation services, The Royal Children's Hospital, Melbourne Australia, 50 Flemington Rd, Parkville, Victoria, 3052.

[2] Infection and Immunity, Murdoch Children's Research Institute, 50 Flemington Rd, Parkville, Victoria, 3052.

[3]Department of Paediatrics, The University of Melbourne, Grattan Street, Parkville, Victoria, 3010.

[4]Paediatric Intensive Care Unit, The Royal Children's Hospital, 50 Flemington Rd, Parkville, Victoria, 3052.

Corresponding author email

Sonja Elia (Sonja.elia@rch.org.au)

2 Gleneagle Way, Eltham Vic. 3095

Ph: +61 478 875 999

Author's email

Shidan.tosif@rch.org.au, nigel.crawford@mcri.edu.au, trevor.duke@rch.org.au, yetti31@hotmail.com

Conflict of Interest Disclosures (including financial disclosures): All authors have no conflicts of interest to disclose.

Funding Support: No funding was secured for this study.

Clinical trial registration: Royal Children's Hospital human research ethics committee, HREC#49699, https://au.forms.ethicalreviewmanager.com/Project/Index/194494#navigation-tab

Words 2,498

Key words

Immunisation, influenza vaccine, special risk groups, intensive care

ABSTRACT

Aim: We describe the clinical profile of children and outcomes of influenza immunisation for patients in a Paediatric Intensive Care Unit (PICU).

Methods: Over two influenza seasons: 19/04/2018 – 07/08/2018 and 02/05/2019-10/10/2019 an Immunisation nurse and PICU nurse coordinator met weekly and identified patients to receive the influenza vaccine. An inpatient list of PICU patients was screened for eligible patients: greater than 6-months of age, did not have imminent procedures (e.g. surgery) or were not critically unwell, as determined by the treating team, to receive the influenza vaccine. Patients were excluded if they had undergone surgery in the previous 24 hours or were being treated palliatively.

Results: 60 patients in PICU were identified, with 43% (26/60) receiving the vaccine whilst in PICU and 17% (10/60) once discharged from PICU to the general ward environment. The majority of patients immunised were in PICU due to cardiac surgery/cardiology or general medical conditions, such as cerebral palsy or RSV bronchiolitis. There were no reported adverse events following immunisation.

Conclusions: We have demonstrated the suitability and acceptability of children in the PICU receiving the seasonal influenza vaccine and tailored interventions to follow-up once discharged from PICU to optimise protection.

What is already known on this topic

Influenza in children is associated with high rates of hospitalisation and vaccination can reduce the incidence of disease. Patients can be opportunistically immunised whilst in hospital, however this is not routine practice in the paediatric intensive care unit (PICU).

What this paper adds

This paper describes the clinical profile of patients offered influenza immunisation whilst in PICU and demonstrates feasibility of the intervention. By applying the same patient selection process more broadly in a hospital setting, similar or better results may be achieved.

INTRODUCTION

Influenza in children is associated with high rates of hospitalisation and complications, particularly in children with co-morbidities.[1,2] Influenza vaccination reduces the incidence of seasonal influenza and associated burden.[3,4] Children and adolescents with conditions which put them at higher risk, are funded in Australia to receive the annual seasonal influenza vaccine under the National Immunisation Program (NIP)[5], but there is limited data on uptake. A tertiary hospitalImmunisation Serviceoffers immunisation to inpatients and outpatients by providing vaccines opportunistically with episodes of care. This includes patients within special risk groups (SRG's) with underlying medical conditions that make them more vulnerable to becoming unwell or complications from vaccine preventable diseases. Hospitalisation is a risk factor for under-immunisation in children.[6] Immunisation in hospital provides an opportunity to improve vaccine uptake, especially in SRG. Successful programs rely on specific consideration of immunisation by medical staff or the implementation of a routine system for screening and vaccinating.[6,7] Key strategies to improve vaccination in hospital include rapidly identifying that a vaccination is required, addressing concerns over vaccine safety and having access to electronic immunisation records.[8]

Paediatric Intensive Care Unit (PICU) provides specialist care for critically ill children as well as care post-cardiac surgery, liver and cardiac transplantation. Immunisation against influenza is a potentially lifesaving intervention and administration within PICU allows for close monitoring of potential adverse effects. If a decision is made to wait for a patient to leave PICU before vaccination, an immunisation opportunity may be lost. There is however, limited data surrounding the administration of opportunistic influenza vaccine to seriously ill children in the PICU.

This study highlights the clinical profile of patients offered influenza immunisation whilst in PICU, as part of a pilot program targeting this high-risk population. The identification process and outcomes of the influenza immunisation is described. We aim to describe the feasibility of influenza

administration in PICU and help tailor future interventions to streamline vaccination for patients in PICU and hospital wide.

METHODS

A weekly inpatient list of PICU patients was reviewed by the PICU nurse coordinator and a specialist immunisation nurse for eligible patients. Children aged 6 months and older with special risk conditions funded to receive the annual seasonal influenza vaccine under the NIP were identified, over two seasonal influenza periods: 19/04/2018 – 07/08/2018 and 02/05/2019 – 10/10/2019. Patients were eligible if they were greater than 6-months of age, did not have imminent procedures (e.g. surgery) or were not critically unwell, as determined by the treating team, to receive the influenza vaccine. Patients were excluded if they had undergone surgery in the previous 24 hours or were being treated palliatively. Once the patient was identified as eligible for vaccination, the Immunisation nurse would then visit the PICU, consult with the patient (where appropriate for age) and parents and either administer the vaccine at that time, or a plan was made to return for vaccination at a mutually convenient time.

An audit of the PICU database reviewed all patients who received an influenza immunisation whilst admitted in the hospital's PICU during 2018-19. The medical record was reviewed using the electronic medical record (EMR) and PICU database. Data were collected from each eligible patient and recorded in a password protected excel spreadsheet: age, sex, primary admission diagnosis, underlying medical diagnosis(es), routine immunisation status, primary treating medical team, flu vaccine administered (in current year and previous years), days in PICU and hospitalisation days in total, day of administration of vaccine in hospital, reasons for refusal, adverse reactions, readmission rate, survival (alive/deceased). Adverse events following immunisation was defined as any untoward medical occurrence that follows vaccination[5].

The Australian Immunisation Register (AIR) was reviewed for immunisation records at the end of the influenza season, capturing both hospital and primary care vaccinations (where applicable). This study was reviewed and approved by the hospital's human research ethics committee (HREC#49699).

RESULTS

The overall PICU population during the study period was 1,116 patients (490 in 2018; 626 in 2019) with 343 infants less than 6 months of age and therefore excluded from the total population. Of the remaining 773, 123 (16%) a subset was identified at weekly review by the study team for the influenza vaccine (31 in 2018 and 92 in 2019) [see Figure 1]. Majority of patients were male (72

[59%]) with a median age of 49 months (IQR 5-228) (see Table 1). 51% (63/123) had received the influenza vaccine prior to admission. Of the remaining 60 patients who had not received influenza vaccine at time of PICU admission, 43% (26/60) received the vaccine whilst a PICU inpatient. 17% (10/60) received the vaccine during the same admission once discharged from PICU to the general ward environment. A further 7% (4/60) received the vaccine following discharge from hospital (see Table 2). The patient's vaccination status was identified on review of the AIR and compared with date of admissions. Overall, of the total eligible patients, only 20/123 (16%) did not receive the vaccine whilst in hospital or upon discharge during these two influenza seasons.

The reasons for not immunising whilst an inpatient in hospital was due to medical staff determining the patient not appropriate (8), parents refused (9) or no reason provided (3). Patients determined not appropriate to receive immunisation by the medical staff were on extracorporeal membrane oxygenation (ECMO) or 5/8 (63%) with impending surgery. Due to the stressful nature of the intensive care unit admission, parents were not pressed for reasons for refusal, but note that of the 9 patients where the parents refused, only 3/9 (33%) had ever previously received an influenza vaccine.

The treating team of patients vaccinated is summarised in Table 3. Children immunised included; following cardiac surgery, those with underlying conditions such as, congenital heart disease, cerebral palsy or acute infection (e.g. RSV bronchiolitis). Patients with cerebral palsy were also included under Developmental medicine and those with tracheostomies were admitted under ENT or respiratory. Nephrology patients were either renal failure or kidney transplantation. Of the eligible patients, the highest uptake of vaccination occurred under Developmental medicine, General surgical and the Metabolic teams, with 100% of identified patients vaccinated. There were no adverse events reported following immunisation in PICU. Twenty-one patients were readmitted to PICU but unrelated to timing of the influenza vaccine. Of these, one patient on immunosuppressive treatment was admitted to PICU positive for influenza disease, diagnosed 2 months post influenza vaccination.

DISCUSSION

Every encounter with a health service is an opportunity to review immunisation status and provide necessary vaccines. Patients in PICU were specifically selected, as children with illness or comorbidities place them at highest mortality risk from influenza. Most infants/children had medical conditions which qualified them for a funded influenza vaccine. It is important to note that

influenza vaccine is now funded under the NIP for all children from 6 months to 5 years of age, as well as older patients with specified medical risk conditions. This is a recognition of the significant rate of influenza admissions amongst otherwise healthy young children[5]. Missed opportunities for immunisation in the hospital setting are often attributable to the child being unwell at presentation.[9] However, in this PICU patient cohort, which includes children with complex medical conditions, immunisation was safely administered. Providing vaccines whilst in the PICU presents a safe environment to immunise, as the patient is often closely monitored with 1:1 nursing care, to better support any potential patient instability.

Staff often consider it inappropriate for children to be vaccinated prior to discharge from hospital[6], yet this study demonstrates the successful opportunistic immunisation of unwell inpatients. This intervention of identifying eligible PICU patients resulted in 43% receiving an influenza vaccine. This proportion of patients vaccinated is significantly improved compared to data collected in 2015 of ward vaccines administered, where no patients in PICU received influenza vaccine. If this result can be achieved in the PICU, then identifying influenza vaccine eligible patients more broadly in the hospital setting may achieve similar or better results.

Previous studies have identified hospital admissions as an opportunity to identify children requiring immunisation and to offer catch-up immunisation when needed. A study of 1000 preschool aged children admitted to hospital in the UK found 142 children (14.2%) had missed a scheduled immunisation and 41 were due a scheduled immunisation[10]. Of 43 children offered vaccination, there was 65% uptake. In another study, 65.4% (172/263) of hospitalised children were under-vaccinated on presentation to hospital to two tertiary paediatric hospitals in India[11]. A study of 2329 children aged between 0-2 years found immunisations were delayed greater than or equal to 2 months in 18% (355) of children[12]. Successful administration of rotavirus vaccine has also been shown in neonatal intensive care units[13,14].

Hospital staff play an integral role in ensuring optimal immunisation rates. Whilst not every hospital may have a dedicated Immunisation service, having keen nursing and medical staff (immunisation champions) specifically targeting special risk group patients for additional vaccines is both innovative and productive.

The study team was limited in capacity as the specialist immunisation nurse and PICU nurse coordinator only met weekly and therefore identified a small subset of potential patients. This is the reason that only 123 patients were identified out of the total population of 773. The number of eligible patients could have been increased if screening occurred more often. For this reason, the

model was changed in 2020, with the PICU nurse coordinator identifying patients for influenza immunisation every day during multidisciplinary ward rounds.

We conclude that a model of opportunistic immunisation can be applied to selected children in PICU and inpatients in hospital settings, as a strategy for safely immunising higher risk children. Future research examining in more detail the family circumstances and rationale for refusal would be useful in developing supports to improve uptake in this subgroup.

ACKNOWLEDGEMENTS

The authors thank the Immunisation service and Paediatric Intensive Care Unit nursing and medical staff. All authors have indicated they have no conflicts to declare relevant to this study.

REFERENCES

1. Kaczmarek MC, Ware RS, Coulthard MG, McEniery J, Lambert SB. Epidemiology of Australian Influenza-related Paediatric Intensive Care Unit Admissions 1997-2013. *PLoS One* 2016 **Mar 29**;11(3).
2. Hauge SH, Bakken IJ, de Blasio BF, Haberg SE. Risk conditions in children hospitalized with influenza in Norway, 2017-2019. BMC Infectious Diseases. 2020;20(769).
3. Chung JR, Flannery B, Gaglani M, Smith ME, Reis EC, Hickey RW et al. Patterns of influenza vaccination and vaccine effectiveness among young US children who receive outpatient care for acute respiratory tract illness. *JAMA Network*. 2020;174(7):705-713.
4. Bernhard RR, Knuf M. The burden of seasonal and pandemic influenza in infants and children. *Eur J Pediatr.* 2014;**173**:265-76.
5. Australian Government Department of Health. *Australian Immunisation Handbook*. Canberra: National Capital Press. Retrieved from https://immunisationhandbook.health.gov.au/resources/handbook-tables/list-specified-medical-conditions-associated-with-increased-risk-of-0 (Accessed September 2020)
6. Mihalek AJ, Kysh L, Pannaraj PS. Pediatric Inpatient Immunizations: A Literature Review. *Hosp. Pediatr.* 2019;**9**(7):550-59.
7. Elia S, Perrett K, Newall F. Providing opportunistic immunisations for at-risk inpatients in a tertiary paediatric hospital. *J Spec Pediatr Nurs.* 2017; **Jan 22**(1).
8. Shingler S, Hunter K, Romano A, Graham D. Opportunities taken: the need for and effectiveness of secondary care opportunistic immunisation. *J Paediatr Child health*.2012; **48**(3):242-46.

9. Crawford N. Minimising missed opportunities to vaccinate. *J Paediatr Child Health.* 2008; **44**:315-16.
10. Conway SP. Opportunistic immunisation in hospital. *Arch Dis Child*. 1999;81:422-425.
11. Albaugh N, Mathew J, Choudhary R, Sitaraman S, Tomar A, Bajwa IK et al. Determining the burden of missed opportunities for vaccination among children admitted in healthcare facilities in India: a cross-sectional study. *BMJ Open*. 2021;11(3):e046464.
12. Bell LM, Pritchard M, Anderko R, Levenson R. A Program to Immunize Hospitalized Preschool-aged Children: Evaluation and Impact. *Pediatrics*. 1997;100(2):192-196
13. Hiramatsu H, Suzuki R, Nagatani A, Boda H, Miyata M, Hattori F et al. Rotavirus Vaccination Can Be Performed Without Viral Dissemination in the Neonatal Intensive Care unit. *J Infect Dis*. 2018; 217(4):589-596.
14. Monk HM, Motsney AJ, Wade KC. Safety of rotavirus vaccine in the NICU. Pediatrics. 2014;133(6):e1555-e1560.

Table 1. Demographic details of patient subset (123)

Age (months) median(Range)	49 (5 -228)
Gender (females) n (%)	51 (41%)
Routine immunisation status (up to date)	117 (95%)
Primary Treating team (n)	36
- Cardiac surgery/Cardiology	33
- General Medicine	13
- Respiratory Medicine	9
- Developmental Medicine	8
- General Surgical	5
- Neurology	4
- Metabolic	4
- ENT	11

- Other	
Previously received flu vaccine (Yes) n (%)	69 (56%)
Length of stay in PICU (Days) Median (range)	5 (1-134)
Length of stay overall (Days) Median (range)	14 (1-670)[a]

Table 2. Influenza vaccine uptake

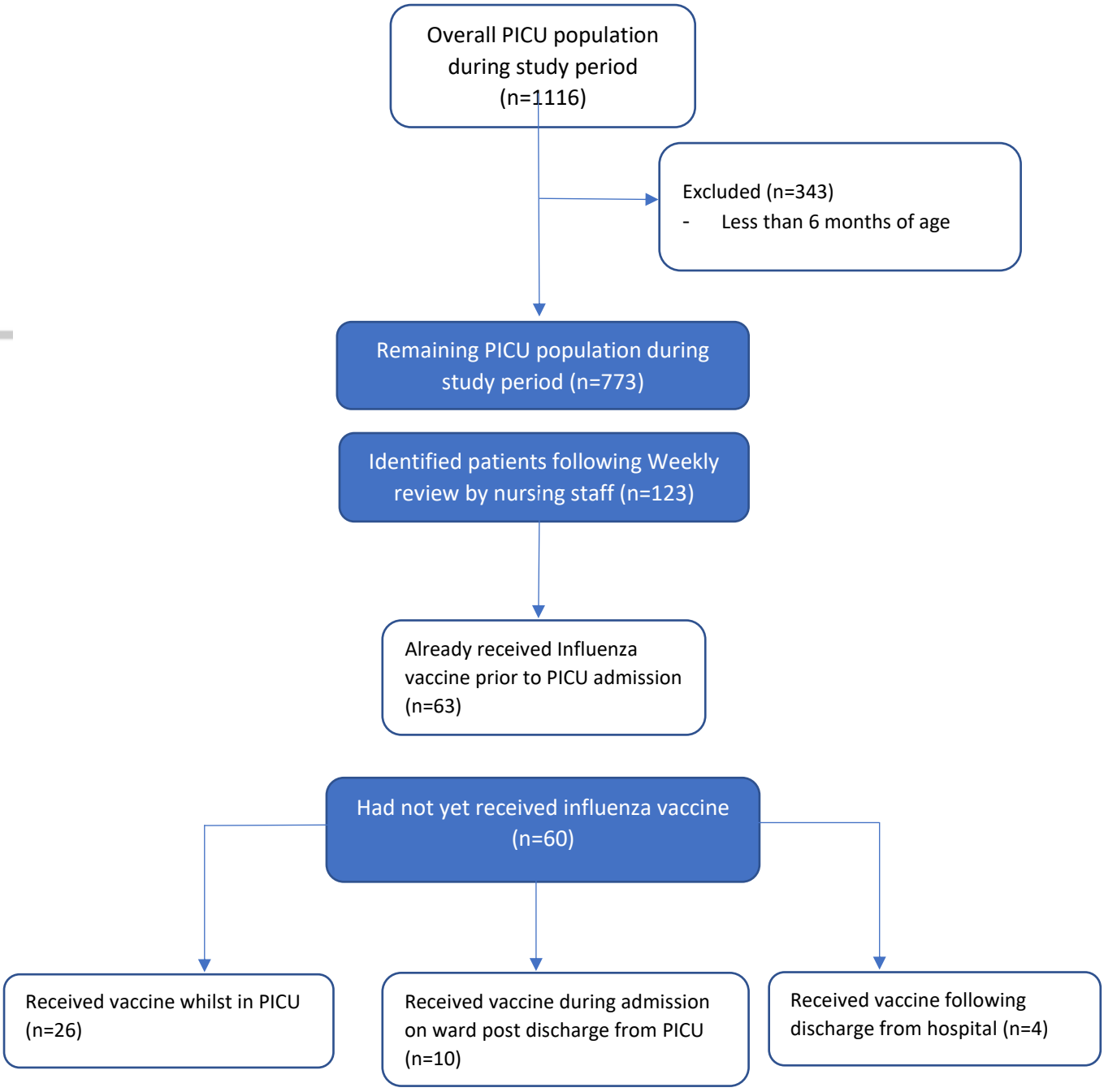
Influenza vaccine given during admission - n (%)	
- PICU	26 (43%)
- General ward	10 (17%)
Influenza vaccine administered prior to admission – n (%)	
- GP	33 (27%)
- Drop in immunisation centre	29 (24%)
- General ward	1 (1%)
Influenza vaccine administered after discharge – n (%)	4 (7%)
Influenza vaccine not given during admission – n (%)	20 (16%)

Table 3. Vaccinated patient's treating team and underlying medical diagnoses

Treating Team	Underlying medical diagnosis	(n)	Primary admission diagnosis
Cardiology	Ex-premature infant, congenital heart disease	1	Congestive cardiac failure
	Goldenhar syndrome	1	Heart transplant rejection
	Congenital heart disease	1	Pulm hypertension, myocarditis
	Congenital heart disease	1	Poor oral intake, malaise
	DILV, Hypoplastic RV, TGA, PDA	1	None
	Cardiomyopathy	7	cardiomyopathy
	Congenital heart disease	1	truncus arteriosus
	Ex premature neonate	1	Aortic stenosis
	Hypoplastic left heart syndrome	3	Fontan completion/ Norwood
	Tetralogy of fallot	1	RSV infection
	None	1	Myocarditis
	Stokes-Adams syncope	1	Insertion of pacemaker
	ASD/VSD	10	ASD/VSD repair
Developmental medicine	Genetic syndrome: epilepsy, cardiac abnormality, Intellectual disability	1	Sepsis

	Cerebral palsy, chronic lung disease, central hypoventilation syndrome	1	Cellulitis
	Cerebral palsy	5	Pneumonia / LRTI
	Cerebral palsy	1	Pressure wound breakdown
	Autism spectrum disorder	1	Asthma
ENT	Laryngomalacia	1	Parainfluenza type 3
	Dev delay, difficult airway	1	OSA despite CPAP
	Trache, TOF	1	Increased WOB, desats
General Medicine	Cerebral palsy	3	Pneumonia / LRTI
	None	1	Acute asthma exacerbation
	None	1	Meningitis
	Congenital heart disease: double outlet single ventricles, malposed great arteries, necrotising enterocolitis	1	Sepsis
	CP - GMFCS V, NON VERBAL	1	Aspiration and hypoxaemia
	Ex-premature, CLD	4	Respiratory tract infection
	None	1	Viral illness
	Genetic syndrome	1	Pneumonia
	None	1	Increasing lethargy and irritability
	Genetic syndrome, hypotonia, developmental delay	1	Respiratory tract infection
	Pierre-Robin sequence	1	Asthma exacerbation
	None	5	Viral illness
	None	1	Pneumonia
	Congenital myopathy	1	Pneumonia
	Laryngomalacia	1	Bronchiolitis
	None	1	Complex febrile seizure
	Developmental delay	1	Osteoporosis
	Trisomy 21, ALL in remission	1	RSV infection
General surgery	Undiagnosed neuromuscular condition	1	Bilateral osteotomies
	Scoliosis	1	Spinal fusion
	CDH, poor weight gain, pulm hypoplasia	1	Bowel obstruction
	Hirschprungs disease	1	RSV bronchiolitis
	Oesophageal atresia	1	Surgery for colonic repair
	None	1	Multi trauma
	Paraganglioma	1	None
	Pallister Killian Syndrome	1	Cleft lip and palate repair
Metabolic	Genetic syndrome, hypotonia, developmental delay, failure to thrive, hypertrophic cardiomyopathy	1	Viral illness
	Pompe's disease	1	Resp decompensation
	Propionic acidemia	1	Vomiting, unsteady
	cardiomyopathy	1	Viral illness
Neurology	None	1	Head injury
	None	1	Pneumonia with pleural effusion
	AESD	1	Status Epilepticus
	None	1	Multiple system trauma
Respiratory medicine	Neuromuscular disorder, bipap dependence, intellectual disability	1	LRTI
	Tracheostomy	2	LRTI
	None	3	Pneumonia, pleural effusion

	Cerebral palsy	1	Airway obstruction
	Neuromuscular scoliosis	1	Rhinovirus infection
	None	1	CDH, Pulm HT
	PRS	1	Apnoeas, tachypnoeic
	Pulm arterial hypertension	1	CLD
Other	Crohn's disease	1	Fever, headache, diarrhoea
	ALL	1	Sepsis
	JML	1	Respiratory distress
	None	1	Bilateral syndactyly repair
	Renal transplant	2	Lethargy, fever, resp illness
	Kidney injury	1	Sepsis, resp illness



INFLUENZA VACCINE ADMINISTRATION IN A PAEDIATRIC INTENSIVE CARE UNIT

Sonja Elia[1,2], Yvette Moore[4], Trevor Duke[3,4], Nigel W Crawford[1,2,3], Shidan Tosif [1,2,3]

Original article

Affiliations

[1] Immunisation services, The Royal Children's Hospital, Melbourne Australia, 50 Flemington Rd, Parkville, Victoria, 3052.

[2] Infection and Immunity, Murdoch Children's Research Institute, 50 Flemington Rd, Parkville, Victoria, 3052.

[3]Department of Paediatrics, The University of Melbourne, Grattan Street, Parkville, Victoria, 3010.

[4]Paediatric Intensive Care Unit, The Royal Children's Hospital, 50 Flemington Rd, Parkville, Victoria, 3052.

Corresponding author email

Sonja Elia (Sonja.elia@rch.org.au)

2 Gleneagle Way, Eltham Vic. 3095

Ph: +61 478 875 999

Author's email

Shidan.tosif@rch.org.au, nigel.crawford@mcri.edu.au, trevor.duke@rch.org.au, yetti31@hotmail.com

Conflict of Interest Disclosures (including financial disclosures): All authors have no conflicts of interest to disclose.

Funding Support: No funding was secured for this study.

Clinical trial registration: Royal Children's Hospital human research ethics committee, HREC#49699, https://au.forms.ethicalreviewmanager.com/Project/Index/194494#navigation-tab

Words 2,498