Personal protective equipment in the paediatric emergency department during the COVID-19 pandemic: Estimating requirements based on staff numbers and patient presentations

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Objective: To estimate the personal protective equipment (PPE) required in a paediatric ED during the COVID-19 pandemic comparing the use per patient to use per patient zone, based on the NSW Clinical Excellence Commission (CEC) guidelines in place at the time of the study.

Methods: A retrospective case note review of all patients and staff present in the ED of The Children’s Hospital at Westmead, Sydney, Australia in the 24 h period of Sunday 5 April 2020. The primary outcome of PPE estimates was generated from identifying the number of patient contacts and aerosol generating procedures (AGPs) performed per patient as well as the number of staff on shift.

Results: One hundred patients attended the ED (50% of usual) and all were included in the study. For a low-risk community environment allocating PPE per patient contact required 48 face shields, 192 surgical masks, 48 N95 masks and 430 gowns for the day, increasing to 430 face shields, 331 surgical masks, 430 N95 masks and 761 gowns in a high-risk community environment. Allocating PPE using zoning reduces the requirement to 48 face shields, 192 surgical masks, 48 N95 masks and 204 gowns, increasing to 196 face shields, 96 surgical masks, 196 N95 masks and 292 gowns per day in a high-risk community environment.

Conclusion: This study has demonstrated the considerable requirement for PPE in a paediatric ED, which varies according to presentation type and the background prevalence of COVID-19 in the community.

Key words: coronavirus, paediatric emergency medicine, personal protective equipment.
guidance follow these principles. However, some reports suggest that the droplet/airborne theory is oversimplified, with aerosol generation occurring from laryngeal activity such as talking and coughing. There is some evidence to suggest that sneezes and coughs are able to form a turbulent multiphase gas cloud which may travel up to 8 m. The Centre for Disease Control review of the choir practice in Skagit County, Washington concluded that one index patient infected 52 people in a 2.5 h period, an attack rate of 87%, resulting in three hospitalisations and two deaths. The emission of aerosols from the loudness of vocalisation might have been a significant factor.

With small numbers of potential patients, staff can wear individual items of PPE for each patient contact and then discard. However, as the number of patient contacts or potentially infected patients increase, the need for PPE increases. A switch from individual patient contact PPE to staff focused, patient zoning PPE may then more effectively balance the availability of PPE against its need. However, the disadvantage of this includes increased staff discomfort, PPE breaches with long term wear, cross contamination of clean areas (such as store rooms) and cross contamination of colleagues and other patients.

In New South Wales (NSW), the Clinical Excellence Commission (CEC) produced a document outlining the use of PPE in EDs that encompasses the risk of transmission, based on local disease prevalence, the procedure being undertaken and the risk of an individual patient having the disease (epidemiological or clinical risk factors).

The role of children in the spread of COVID-19 is unclear. Studies suggest that the secondary attack rate for children is 4–7.3%, compared to the adult rate of 6.2–21.9%, meaning that exposed children are less likely to become infected than adults. This is supported by literature from population testing in Italy, South Korea and Iceland where children (especially <10 years) had a much lower incidence of positive testing compared to adults. There is no current literature on the risk to adults from infected children, but there is limited evidence from a NSW study in schools suggesting that the risk of spread from children to children and teachers in schools is low. Until recently, it was thought that children have very mild illnesses; however, the identification of paediatric inflammatory multisystem syndrome temporally associated with COVID-19 (PIMS-TS) has renewed interest in the impact of COVID-19 on children.

The aim of this study was to identify the number of staff contacts and AGPs with patients in the paediatric ED over a 24 h period and attribute PPE required according to the NSW CEC guideline and compare this to the PPE required based on staff zone allocations.

**Methods**

A retrospective chart review was performed on all children who presented to the ED of The Children’s Hospital at Westmead (CHW) on Sunday 5 April 2020. CHW is a major referral paediatric hospital in Sydney, Australia with an annual ED attendance of approximately 60 000 patients.

In order to estimate potential PPE use per patient, an initial search was obtained from the electronic medical records (Cerner FirstNet, Kansas City, MO, USA) to identify the patients. Data were then extracted manually by study investigators using a standardised instrument. Data were entered into a database (Access; Microsoft, Redmond, WA, USA) for processing. Data entry was double checked by a second investigator for 25% of cases. The number of contacts was estimated from documented observations, clinical reviews and procedures. Throat examination was included if documented in the examination notes. If multiple procedures were performed at the one time, then this was included as one contact. Radiology staff were captured by the request for a mobile X-ray and clerical staff by their standard practice of initial clerking and admission clerking.

Primary outcomes were the location of the patient in the ED, the number of patient contacts by HCWs and the number of AGPs performed. Secondary outcomes were patient demographics, diagnoses and the type of procedures performed.

AGPs (encompassing high risk procedures) were classified as per Australasian College for Emergency Medicine and Safe Airway Society and the throat examination was included as per Royal College of Paediatrics and Child Health UK. The Australian and New Zealand Intensive Care Society guideline includes ‘procedures on screaming children’ as an AGP; however, this would not be recorded and therefore was not assessed as part of this study. ‘Coughing/sneezing/expectorating’ as defined by Safe Airway Society were also not retrieved from the electronic medical records (EMR) for the same reason.

**Figure 1.** Clinical Excellence Commission, NSW. Personal protective equipment (PPE) use at different risk levels.

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At the time of the study, the ED at CHW had been divided into three zones: Cold – no infective symptoms; Warm – fever with infective symptoms such as diarrhoea or vomiting; and Hot – fever with no source and/or respiratory symptoms or high-risk epidemiological criteria for COVID-19. For the purpose of the study, warm and hot patients were combined and labelled Non-Cold. Gastrointestinal symptoms have been well described in children with COVID-19 and staff caring for these patients should wear the same PPE as they would for Hot Zone patients.23

To estimate potential PPE use per staff member, the medical and nursing staff rosters for Sunday 5 April were accessed and the number of staff present and their allocated locations recorded. Staff were all assumed to have three meal/rest breaks per shift that would require a change of mask and gown if worn.

The amount of PPE (goggles/face shields, surgical masks, N95 masks and gowns) required was then estimated based on the NSW CEC recommendations (24 April 2020_v3), calculations being made for each community risk level (low, medium and high)10 (Fig. 1). For eye wear, the number of goggles was calculated per staff member working, as these could be wiped down in between patients and meal/rest breaks. The number of face shields was estimated against the number of AGPs, as generally staff would use the better droplet protection of the face shields when performing AGPs and some of the N95 masks were not fluid resistant. As ED activity had reduced by almost 50% during the COVID-19 pandemic, estimates were then calculated for 50% and 100% increase in attendances by multiplying results assuming the same percentage of non-cold versus cold presentations.

| TABLE 1. Demographics and numbers of contacts and procedures |
|---------------------------------------------------------------|
|                                                             |
| Cold zone | Non-cold zone | Total |
| Number of patients | 54 | 46 | 100 |
| Male | 26 | 23 | 49 |
| Median age/months (IQR) | 42 (23–132) | 30 (8–111) | 49 |
| Triage category 1–3 | 27 | 27 | 54 |
| Median time to be seen by doctor/nurse practitioner (min) (IQR) | 20 (10–53) | 15 (10–27) |
| Median ED length of stay (min) (IQR) | 111 (73–143) | 157 (78–236) |
| Number of patients admitted | 10 | 19 | 29 |
| Number of triage nurse contacts | 54 | 46 | 100 |
| Number of clinical initiative nurse contacts | 19 | 20 | 39 |
| Number of clerk contacts | 64 | 66 | 130 |
| Number of ED nurse contacts | 88 | 115 | 203 |
| Number of nurse procedures | 31 | 43 | 74 |
| Number of nurse AGPs | 2 | 24 | 26 |
| Number of ED doctor/nurse practitioner contacts | 94 | 90 | 184 |
| Number of doctor/nurse practitioner procedures | 6 | 3 | 9 |
| Number of doctor/nurse practitioner AGPs | 3 | 19 | 22 |
| Number of non-ED doctor contacts | 15 | 12 | 27 |
| Number of child and family health nurse contacts | 0 | 0 | 0 |
| Number of assistant in nursing contacts | 1 | 2 | 3 |
| Number of assistant in nursing procedures | 6 | 2 | 8 |
| Number of PICU/COVID-19 response/rapid response contacts | 0 | 3 | 3 |
| Number of mental health team contacts | 0 | 0 | 0 |
| Number of allied health contacts | 0 | 0 | 0 |
| Number of mobile radiology contacts | 0 | 1 | 1 |
| Number of porter contacts | 7 | 13 | 20 |
| Number of security contacts | 0 | 0 | 0 |

AGP, aerosol generating procedure; IQR, interquartile range; PICU, Paediatric Intensive Care Unit.
Data were analysed using SPSS version 22.0 (IBM, Armonk, NY, USA) to obtain simple frequencies and descriptives.

Results

One hundred patients attended the ED on Sunday 5 April and all were included in the study (representing approximately 50% of usual presentations). Table 1 describes the primary and secondary numerical outcomes, divided by Cold and Non-Cold status. Overall, in the Cold Zone there were 198 contacts with HCWs, 37 general procedures and five AGPs. In the Non-Cold Zone there were 219 contacts with HCWs, 46 procedures and 43 AGPs. Table S1 describes the presenting complaints, divided by Zone.

Documented AGPs were COVID-19 swab (n = 14), throat swab/nasopharyngeal aspirates (n = 1), removal of nasal foreign body (n = 2), throat examination (n = 19), acute airway management/ventilation (n = 6) and nebulisation (n = 6). The most common nursing AGP was a COVID-19 swab and the most common medical AGP was throat examination. AGPs on Cold Zone patients were removal of nasal foreign body, COVID-19 swab and throat examination. Fourteen patients met the COVID-19 testing criteria and had negative swabs.

ED staffing on that day showed 39 nurses and 22 doctors and nurse practitioners (NPs). The day shift had 16 nurses including the Nurse Unit Manager (NUM) and Clinical Nurse Educator (CNE) and eight doctors, the evening had 10 nurses and 11 doctors/NPs and the night 13 nurses and four doctors. As this was a weekend, senior medical staff was reduced compared to a week day.

Estimated PPE requirements for each of the three levels of risk of infection and transmission based on staff roles and zone allocations are described in Table S2 and based on patient contacts and procedures in Table S3. Table 2 summarises these results and then provides an extrapolation of 50% and 100% increase in ED attendances.
Fifteen patients presented with a primary respiratory problem, with 10 of those being Category 3 or above, indicating they would meet the CEC criteria for ‘interaction with a patient with respiratory distress or significant cough’ and hence require contact, droplet and airborne precautions. For this group, there were three clinical initiative nurse (CIN) contacts, 17 clerk contacts, 38 ED nursing contacts, 16 nursing procedures, 19 AGPs, 29 doctors/NPs contacts and two doctor/NP procedures. In low and moderate risk environments this would increase the number of face shields, gowns and N95 masks required by 88, as every contact becomes equivalent to an AGP. Only one of these patients met testing criteria for COVID-19.

Discussion

This study has demonstrated that in the paediatric ED, even in a region with a low level of infection, a considerable amount of PPE is required in a 24 h period and that as presentations increase or community prevalence increases, the need for PPE will increase considerably.

With a small number of ED presentations and a low regional risk level, single-use PPE for individual patients makes practical and economic sense. However, in the paediatric ED, fever or respiratory symptoms are common presenting symptoms, resulting in almost 50% of patients need isolating in the Non-Cold Zone and require PPE when being assessed and managed. As presentations increase zone-based PPE becomes increasingly necessary for conservation of PPE. There is still however considerable daily PPE requirements despite zone-based PPE.

As the pandemic progresses, PPE utilisation in the ED will require more thought and research. Reducing the need for PPE might occur from being able to reclassify patients as cold on presentation or the use of reliable rapid testing to reclassify patients as cold. Unfortunately, COVID-19 is difficult to exclude clinically at presentation in children, rapid tests are not yet readily available and conventional polymerase chain reaction only has 70% sensitivity in identifying disease. Other savings may be made by reducing patient contact in the ED, through telehealth solutions in or before ED to reduce attendances and by reducing total ED length of stay. Grouping patient contacts episodes and having flexible roles is another solution. For example, with the same set of PPE, the doctor can take a history, perform an examination, do a set of observation, perform a COVID-19 swab and collect a urine specimen by in out catheter. Unfortunately, procedures on children often involve at least two HCWs, increasing PPE consumption.

Information on the cost of public hospital PPE is not freely available. Newmarch Nursing Home was spending $21 000 daily on PPE, which included 2000 gowns, 12 000 gloves, 50 sets of goggles, 400 shoe covers and 30 face shields. In total Anglicare Sydney had spent $650 000 on PPE in the 31 days to 16 May 2020.

This study has not considered the possibility of parents and carers in the ED having asymptomatic COVID-19. To protect staff and other carers would result in an extra 100 surgical masks/day. This study also did not consider the possible benefit of all HCWs wearing a surgical mask to prevent asymptomatic transmission to or from the wearer, approximately 50 surgical masks a day. During the study CHW ED clerks were not required to wear PPE, so another 36 surgical masks/day would be required to protect them.

It was not possible to quantify the cleaners’ use of PPE in this study but this adds considerably to requirements as rooms need specific cleaning after patients leave. Curtains do not require cleaning, so keeping patients zoned in open wards rather than single rooms saves PPE by reducing cleaning requirements, although the downside is the increased risk of spreading the virus to staff, other patients and their families.

This study is limited by its retrospective nature and relying on documentation in the EMR to identify all patient contacts and AGPs. It is likely that these have been underestimated, from inaccurate documentation; however, this may be offset by grouping patient contact episodes. We were unable to identify the number of cleaning contacts from the EMR and some staff groups were not required in the timeframe but need to be included in estimation, for example, child and family health nurses and the mental health teams. Mental health teams may be at particular unrecognised risk as they often spend prolonged time with patients and families with an inability to physical distance to maintain rapport with them. The study was not preformed prospectively as the aim was to record anticipated PPE usage, rather than actual PPE utilised. There was no guarantee that staff would follow the PPE guidelines in place at the time.

In Australia, health administrators now have to balance the costs of purchasing and using PPE against the potential benefit to staff and patients, particularly as the disease prevalence is currently low in some states. However, when outbreaks do occur, the devastating impact of COVID-19 on staff, patients and the community make this an emotive issue. Novel solutions may be required to conserve PPE which could include COVID-19 facilities in the major cities, rather than each facility having its own zoning approach. From an ED perspective we need to ensure there is a whole of hospital approach to the care of potential COVID-19 patients. This might include ensuring rapid testing, early risk reclassification and ensuring adequate inpatient beds so there is no COVID-19 access block. Administrators also need to consider the benefits for all staff (and possibly patients and visitors) in healthcare facilities to wear surgical masks in low-risk regions to try and mitigate the risk of asymptomatic transmission.

Conclusion

This study demonstrates the considerable requirement for PPE in a paediatric ED, which varies according to presentation type and the background prevalence of COVID-19 in the community.

Competing interests

None declared.
Data availability statement
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting information
Additional supporting information may be found in the online version of this article at the publisher’s web site:
Table S1. Presenting complaints by zone.
Table S2. Estimated PPE requirements for 24 h based on staff roles, zone allocations and facility risk level.
Table S3. Estimated PPE requirements for 24 h based on patient contacts and procedures and facility risk level.