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Research paper

# Short research paper: Personal protective equipment for the care of suspected and confirmed COVID-19 patients – Modelling requirements and burn rate

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## KEYWORDS

COVID-19;  
Personal protective  
equipment;  
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**Abstract** *Background:* The COVID-19 pandemic has caused unprecedented global demand for personal protective equipment (PPE). A paucity of data on PPE burn rate (PPE consumption over time) in pandemic situations exacerbated these issues as there was little historic research to indicate volumes of PPE required to care for surges in infective patients and thus plan procurement requirements.

*Methods:* To better understand PPE requirements for care of suspected or confirmed COVID-19 patients in our Australian quaternary referral hospital, the number of staff-to-patient interactions in a 24-h period for three patient groups (ward-based COVID suspect, ward-based COVID confirmed, intensive care COVID confirmed) was audited prospectively from 1st to 30th April 2020.

*Results:* The average number of staff-to-patient interactions in a 24-h period was:  $13.1 \pm 5.0$  (mean  $\pm$  SD) for stable ward-managed COVID-19 suspect patients;  $11.9 \pm 3.8$  for stable ward-

*Abbreviations:* PPE, personal protective equipment; ICU, intensive care unit; 95%CI, 95% confidence interval.

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managed confirmed COVID-19 patients; and  $30.0 \pm 5.3$  for stable, mechanically ventilated, ICU-managed COVID-19 patients. This data can be used in PPE demand simulation modelling for COVID-19 and potentially other respiratory illnesses.

*Conclusion:* Data on the average number of staff-to-patient interactions needed for the care of COVID-19 patients is presented. This data can be used for PPE demand simulation modelling.

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### Highlights

- Paucity of PPE burn rate (PPE consumption over time) data in pandemic situations exacerbated PPE supply issues during the COVID-19 pandemic.
- Data on the number of staff-to-patient interactions in a 24-h period required for the care of COVID-19 hospital inpatients is presented.
- An approach to PPE demand simulation modelling using this data that can be adapted to other healthcare settings is presented.

## Introduction

In early days of the COVID-19 pandemic, unprecedented global demand and critical supply chain disruptions led to many healthcare systems being unable to provide adequate personal protective equipment (PPE) to frontline healthcare workers [1–3]. A paucity of data on PPE burn rate (PPE consumption over time) in pandemic situations exacerbated these issues as there was little historic research to indicate volumes of PPE required to care for surges in infective patients and thus plan procurement requirements [3].

Simulation modelling is used across many industries to aid contingency planning for different scenarios. With regards to the ongoing COVID-19 pandemic, better understanding of the PPE needed to care for COVID-19 patients through scenario modelling may assist in modelling PPE burn rate in future COVID-19 waves and/or other respiratory pandemics in the future. This may be useful in PPE supply chain management, in returning services/facilities to full operational capacity, and benchmarking local PPE consumption to other services/best practice guidelines.

In this paper, we present data on the number of staff-to-patient interactions in a 24-h period in the care of ward-managed and intensive care unit (ICU) managed suspected and confirmed COVID-19 patients during the first wave of the COVID-19 pandemic in Australia in a quaternary hospital setting. We outline an approach to how this data may be used to inform a patient-centred, best evidence approach to modelling PPE burn rates for care of COVID-19 patients which can be adapted as scenarios and evidence evolves.

## Methods

Westmead Hospital is a 975-bed quaternary hospital in Sydney, Australia. During the first wave of the COVID-19 pandemic in Australia from February–April 2020, it was one of country's major COVID-19 referral centres, treating its first COVID-19 inpatients, and many COVID-19 patients requiring ICU.

To better understand PPE requirements for care of suspected or confirmed COVID-19 patients in our service, the number of staff-to-patient interactions in a 24-h period for three patient groups was audited prospectively from 1st to 30th April 2020:

- stable ward-managed COVID-19 suspect patients (COVID-19 test result pending)
- stable ward-managed confirmed COVID-19 patients
- stable, mechanically ventilated, ICU-managed confirmed COVID-19 patients

In accordance with local protocols during the study period, all COVID-19 suspect and confirmed patients were managed in single rooms under airborne precautions. All staff entering a COVID-19 patient's single room logged their entries on a dedicated log sheet. The number of entries logged was defined as the number of staff-to-patient interactions. In the ward-managed groups, each COVID-19 patient and each complete 24-h period for each patient was numbered sequentially and a random number generator used to select 40 inpatient days per group to audit. In the ICU, three consecutive days for a single patient was audited. During the study period there was no extended use of PPE. Descriptive data analyses were conducted using Microsoft Excel (Redmont, USA).

This study was approved by the Western Sydney Local Health District Human Research Ethics Committee. All aspects of the study complied with the principles of the Declaration of Helsinki. Informed consent was deemed by the Committee to not be applicable to this study.

## Results

The average number of staff-to-patient interactions in a 24-h period was:  $13.1 \pm 5.0$  (mean  $\pm$  standard deviation) (95% confidence interval [95%CI] 11.5–14.6) for stable ward-managed COVID-19 suspect patients;  $11.9 \pm 3.8$  (95%CI 10.7–13.1) for stable ward-managed confirmed COVID-19

patients; and  $30.0 \pm 5.3$  (95%CI 24.0–36.0) for the stable, mechanically ventilated, ICU-managed COVID-19 patient.

## Discussion

The data presented has been used by the authors AK, NP and RS in conjunction with national guidelines to inform creation of an Excel based simulation model to calculate PPE burn rate for the care of COVID-19 and other patients. The model has simple parameters and methodology. To estimate PPE burn in a 24-h period for the care of an individual patient, the average number of close-contact staff interactions in a 24-h period in each group was multiplied by PPE requirements set out in national guidelines from the Australian Government. As of 12th November 2020 this involved contact and droplet precautions including: one long-sleeved (preferably fluid-resistant) gown, a surgical mask, eye protection and non-sterile gloves when in direct contact with a patient [4]. Using this information with the projected number of patients in each group, the model is able to quickly estimate PPE required for patient care and compare it to actual consumption of PPE (e.g. as monitored through stocktakes). A simplified COVID-19 calculator on which the model is based is presented in Online Supplement 1. A similar approach has now been applied to the entire quaternary hospital facility covering patients (COVID-19 or otherwise) in all clinical areas from theatres to outpatient clinics.

Our approach has proved locally useful for service planning (e.g. determining if there will be enough PPE to maintain theatre capacity if there is a second surge of COVID-19 patients), procurement management, and providing a data-based benchmark to identify instances of PPE over/under use (e.g. insufficient staff training leading to underuse of appropriate PPE per national guidelines) to guide targeted intervention.

Most research on PPE consumption in pandemic situations has focussed on total stock consumed, as opposed to PPE burn rate to care for individual patients [5,6]. For example, use of facial PPE (surgical masks, respirators and goggles) in the Vancouver Coastal Health system during the H1N1 influenza pandemic in 2009 increased 130% compared to the previous influenza season [5]. During the 2013 MERS-CoV pandemic, PPE use in the Johns Hopkins Aramco Healthcare hospital system also increased significantly with surgical facemask demand increasing almost 250% and N95 respirator demand increasing by 955% [6]. While useful for establishing broad understanding of the potential increases in PPE burn rate in pandemic situations, these data do not facilitate a patient-centred, dynamic modelling approach which can accommodate changing scenarios, guidelines or different PPE requirements for different patients.

Our patient-centred approach to simulation modelling of PPE burn rate can be easily adapted to different scenarios and guidelines as evidence for COVID-19 transmission evolves [7]. This facilitates rapid estimation of PPE burn rate for the care of current COVID-19 patients, scenario analyses for PPE burn rate in surges of COVID-19 cases (with potential cost saving potential through rationalisation of procurement), and detection of potential cases of PPE over and underuse in clinical areas (e.g. if there is a

discrepancy between modelled predictions and observed stock movement).

The dataset presented has inherent limitations, including focus on a single centre, which limits direct applicability to other healthcare settings, and limited data in the ICU cohort. The modelling approach, however, is designed to be tailored to local settings when applied. Furthermore, the model does not account for some factors which may alter PPE burn rate such as patient cohorting which may reduce PPE demand.

Our approach, however, has strengths including: providing prospective audit data on the number of staff-to-patient interactions needed for the care of COVID-19 patients; simple parameters of the model allowing for easy user understanding and modification to suit local settings; and a patient centred, flexible approach to modelling to different scenarios and guidelines.

International data has suggested that frontline healthcare workers have a significantly increased risk of contracting COVID-19 compared to the general population [7,8]. As the current pandemic continues, a data-driven, modelled approach determining PPE burn rate may help protect frontline healthcare workers, particularly as healthcare services return to normal operations.

## Ethics

This study was approved by the Western Sydney Local Health District Human Research Ethics Committee. All aspects of the study complied with the principles of the Declaration of Helsinki. Informed consent was deemed by the Committee to not be applicable to this study.

## Authorship statement

Andrew W. Kam – conceptualization, methodology, software, validation, formal analysis, investigation, data curation, writing (original draft), project administration.

Nicole King – methodology, validation, investigation, writing (review and editing).

Ashima Sharma – methodology, validation, investigation, writing (review and editing).

Nicole Phillips – conceptualization, methodology, validation, writing (review and editing), project administration.

Vineet Nayyar – conceptualization, methodology, validation, writing (review and editing), project administration.

Ramon Z. Shaban – conceptualization, methodology, validation, writing (original draft), project administration, supervision.

## Conflict of interest

AWK, NP and RZS have established intellectual property protection for PPE Predict, a simulation model software that was developed using data from this manuscript. This software is not commercially active. RZS is a senior editor of *Infection, Disease and Health* but had no role to play in

the peer review or editorial decision-making whatsoever. The authors have no other conflicts to declare.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.idh.2021.04.001>.

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