immunity, preventive and social strategies should be used in a timely fashion to reduce community spread, morbidity, and mortality,[7,8] and to protect the medical and nursing community at large.

Declarations of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2021.01.007.

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doi: 10.1016/j.bja.2021.01.007
Advance Access Publication Date: 18 January 2021

Trends in personal protective equipment use by clinicians performing airway procedures for patients with coronavirus disease 2019 in the USA from the intubateCOVID registry

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Keywords: aerosol-generating procedures; COVID-19; personal protective equipment; respiratory failure; tracheal intubation

Editor—Healthcare providers involved in aerosol-generating procedures, such as tracheal intubation, have been recognised as a group at high risk of infection from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1,2] Paramount to protecting healthcare providers, adequate personal protective equipment (PPE) use reduces viral transmission and potential coronavirus disease 2019 (COVID-19).[2,3] Adherence to published standards for PPE has been shown to be high, yet not universal.[4,5] Importantly, variations in PPE over time have not been established. Information on patterns of PPE use among providers may help to identify opportunities to increase adherence to national guidelines and inform ongoing responses to the pandemic. Here, we analyse data from a voluntary registry of COVID-19 airway providers in the USA and aim to characterise trends in PPE adherence and respirator use among registry participants during airway procedures.

We analysed data from the US component of the international intubateCOVID registry (www.intubatecovid.org/info).[1] Briefly, intubateCOVID is a voluntary, web-based registry containing self-reported records of airway procedures performed by healthcare providers for patients with confirmed or suspected COVID-19 across 33 countries and 42 states in the USA. The registry was determined to be a quality improvement project by the University of Pennsylvania Institutional Review Board, and as such did not require human subjects review or written informed consent. We restricted the present analysis to providers who recorded an airway procedure in which they either directly performed an intubation or managed the tracheal tube in cases of a tracheostomy or tube exchange at an institution in the USA from March 7, 2020 to October 20, 2020.

For each airway procedure reported into the registry, provider characteristics (e.g. age) and training, details of the procedure including hospital location and indication, and PPE used were collected. For each airway procedure, providers reported whether the following components of PPE were used: eye protection (visor/goggles), hat, gown, plastic apron, gloves, surgical face mask, N95 filtering facepiece respirator (FFR), N100 FFR, powered air purifying respirator (PAPR), clear plastic drape or intubating box. Participants were permitted to indicate use of multiple respirator types for each intubation. For the present analysis, we defined compliance with Centers for

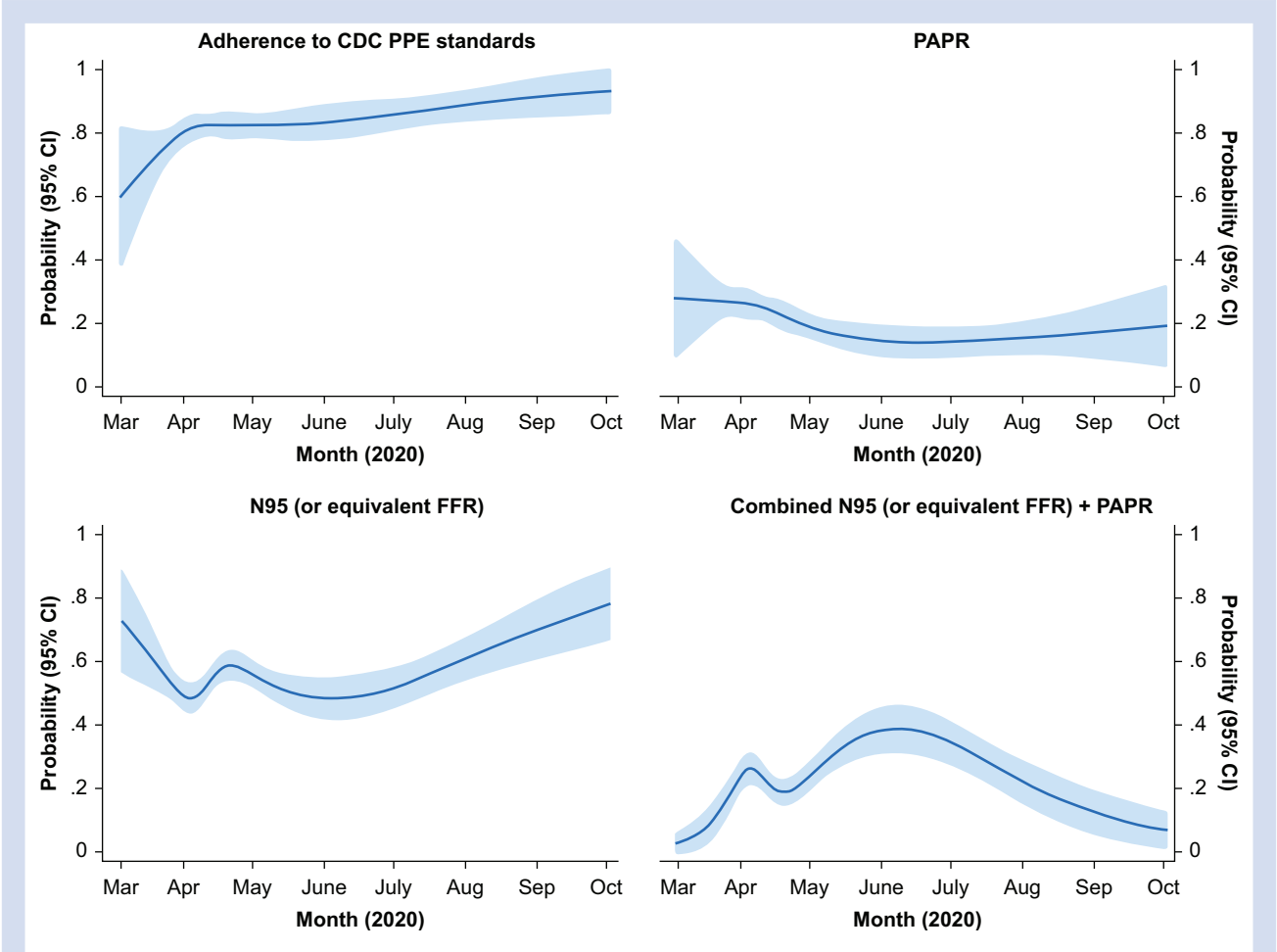

Fig 1. Adherence to US Centers for Disease Control and Prevention (CDC) PPE standards and respiratory use over time for 1570 airway procedures. Restricted cubic spline modelling shows the probability (dark blue lines) of adherence to CDC PPE standards (upper left), probability of wearing a PAPR (upper right), N95/equivalent FFR (lower left), combined N95/equivalent FFR + PAPR (lower right) for airway procedures over the study period from March 6, 2020 to October 20, 2020. 95% Confidence intervals (CI) are shown in light blue. PPE, personal protective equipment; FFR, filtering facepiece respiratory; PAPR, powered air-purifying respirator.

Disease Prevention and Control (CDC) PPE standards as wearing a gown, respirator, eyewear, and gloves.[6] For participants who indicated PAPR use, we considered this device to meet CDC requirements for both respirator and eyewear use.

We summarised provider and airway procedure characteristics as frequencies and proportions for categorical variables and mean and standard deviation (SD) for continuous variables. We used restricted cubic splines with 5 knots to graph the association between time and the probability with 95% confidence intervals of (1) adherence to CDC PPE standards and (2) respirator type. All analyses were performed using Stata 15.0 (StataCorp LLC, College Station, TX, USA).

Between March 7, 2020 and October 20, 2020, 513 providers from more than 220 different institutions self-reported a total of 1570 airway procedures in which they either performed the intubation or managed the tracheal tube (in cases of tracheostomy or tube exchange). The majority of providers had primary training in anaesthesiology (n=486, 94.7%) and were an attending physician (n=373, 72.7%). The mean provider age was 42.1 (9.3) yr. Airway procedures were most commonly performed for respiratory failure (n=1076, 68.5%) and occurred in the ICU (n=1012, 64.5%).

Self-reported PPE use met CDC minimum standards in 1301 (82.0%) of recorded airway procedures; wearing an apron instead of a gown was the most common reason for CDC PPE standards not being met. Adherence to CDC PPE standards was lowest in March 2020 (~60%) and gradually improved over time (Fig. 1). A respirator was used in 1555 (99%) of airway procedures. An N95 was the most frequently used type of respirator (n=856, 54.5%) with increased use from July 2020 through October 2020. PAPR use varied over time, with the highest use in April 2020 and a decrease in use starting in May 2020. Concurrent use of an N95 and PAPR was reported in 353 (22.5%) of airway procedures with peak use in June and July 2020.

More than one of six airway procedures performed for suspected or confirmed COVID-19 did not adhere to CDC PPE standards, consistent with the average adherence previously published from the international data of the intubateCOVID registry.[1] Here, we add to this work and report on the trends of PPE use and adherence across a 7 month period in the USA. Adherence was lowest at the start of the pandemic in March 2020, most commonly because of lack of gowning, and improved over time. Increases in adherence to PPE standards could potentially relate to increasing availability of PPE over the course of the pandemic and to effective local strategies to disseminate and implement guidance and training.

We observed that more than 20% of airway procedures involved concurrent use of an N95 respirator (or equivalent FFR) plus a PAPR. Wearing multiple types of respirators has been shown to increase particle exclusion in simulated settings over individual use.[7] However, the extra steps and complexity related to the removal of multiple respirators may increase the risk of healthcare provider contamination during PPE doffing.[8] Current CDC guidance recommends either N95 or PAPR alone as adequate respiratory protection in high-risk settings[6]; it is possible that avoidance of such combined use may support efforts to ensure adequate PPE supply within a given hospital setting without meaningfully increasing risks to individuals involved in airway procedures.

This work should be interpreted in the context of its limitations. As the study data were self-reported by providers, our findings could be biased by selective reporting if clinicians were more likely to enter data on certain types of cases, such as those in which PPE may have been inadequate. Moreover, we describe data from US providers that may not be generalisable to other countries.

In summary, we observed that airway procedures over the course of the pandemic continue to be performed with PPE regimens that diverge from recommendations, highlighting continued opportunities for improvement in safe airway management.

Funding

American Society of Anesthesiologists, International Anesthesia Research Society, Anesthesia Patient Safety Foundation, and Difficult Airway Society.

Declarations of interest

The authors declare that they have no conflict of interest.

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doi: 10.1016/j.bja.2021.01.019
Advance Access Publication Date: 2 February 2021