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Complete List of Authors:	Howard, Michael; Northland District Health Board, Emergency Medicine Chambers, Charlotte; Association of Salaried Medical Specialists, Policy and Research Mohr, Nicholas; The University of Iowa Roy J and Lucille A Carver College of Medicine, Department of Emergency Medicine
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TITLE

New Zealand Emergency Department COVID-19 Preparedness Survey

AUTHORS

Michael J. Howard MD PhD
Charlotte Chambers PhD
Nicholas M. Mohr MD MS

Author Affiliations:

1. Department of Emergency Medicine, Whangarei Hospital, Northland District health Board, Whangarei, New Zealand, michaelhowardmd@gmail.com
2. Director of Policy and Research, Association of Salaried Medical Specialists, Wellington, New Zealand, charlotte.chambers@asms.org.nz
3. Department of Emergency Medicine, University of Iowa Carver College of Medicine, Iowa City, Iowa, nicholas.mohr@iowa.edu

Corresponding Author:

Michael J. Howard MD PhD, Whangarei Hospital Emergency Department, Northland District Health Board, Private Bag 9742 Maunu Road, Whangarei, 0148 New Zealand
michaelhowardmd@gmail.com

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ABSTRACT

Objective

Our objective was to assess the level of COVID-19 preparedness of emergency departments (EDs) in Aotearoa New Zealand (NZ) through the views of emergency medicine specialists working in district health boards around the country. Given the limited experience NZ hospitals have had with SARS-CoV-2, a comparison of current local practice with recent literature from other countries identifying known weaknesses may help prevent future healthcare worker infections in NZ.

Methods

We conducted a cross-sectional survey of NZ emergency specialists in November 2020 to evaluate preparedness of engineering, administrative policy, and personal protective equipment (PPE) use.

Results

A total of 137 surveys were completed (32% response rate). More than 10% of emergency specialists surveyed reported no access to negative pressure rooms. N95 fit testing had not been performed in 15 (12%) of respondents. Most specialists (77%) work in EDs that cohort COVID-19 patients, about one-third (34%) do not use spotters during PPE doffing, and most (87%) do not have required space for physical distancing in non-patient areas. Initial PPE training, simulations and segregating patients were widespread but appear to be waning with persistent

low SARS-CoV-2 prevalence. PPE shortages were not identified in NZ EDs, yet 13% of consultants do not plan to use respirators during aerosol generating procedures on COVID-19 patients.

Conclusions
New Zealand emergency specialists identified significant gaps in COVID-19 preparedness, and they have a unique opportunity to translate lessons from other locations into local action. These data provide insight into weaknesses in hospital engineering, policy, and PPE practice in advance of future SARS-CoV-2 endemic transmission.

Strengths and limitations of this study

- Survey responses specifically identified existing breakdowns in engineering, administrative policy and personal protective equipment in New Zealand emergency departments, potentially increasing healthcare worker nosocomial infection risk upon reintroduction of SARS-CoV-2
- Survey included emergency specialists from all 20 of New Zealand's district health boards but the electronic convenience sample may not be representative of all ED consultants in NZ
- Some survey questions asked respondents to recall experiences or project how they would practice if they were caring for a COVID-19 patient
- Those motivated to respond may feel they have more or less access to protective policies and equipment than non-respondents

KEYWORDS
COVID-19, Cross-Sectional Studies, Emergency Service, Hospital, Infection Control, Infectious Disease Transmission, Patient-to-Professional

INTRODUCTION

The Aotearoa New Zealand (NZ) healthcare system was as unprepared for the coronavirus disease 2019 (COVID-19) pandemic as many nations, yet NZ has successfully eliminated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).(1, 2) The decision to implement aggressive public health infection elimination practices hinged on NZ's ability to rapidly and effectively close its borders thus limiting COVID-19 impact to approximately 2600 cases and 26 deaths.(3, 4) As a result, NZ's Emergency Departments (EDs) have had little experience caring for COVID-19 patients and disparate efforts towards infection control preparedness may leave heath care workers (HCWs) vulnerable to endemic SARS-CoV-2 transmission.(5-8)

The Hierarchy of Control offers an algorithm to assess preparedness of a health system, scalable to departmental, hospital and nationwide recommendations.(8-10) Once elimination is established but eradication remains impossible there must be appropriate resources to institute and sustain substitution of the threat (typically by vaccination or other therapies). Even as vaccine-based immune protection expands there are still uncertainties requiring multiple controls to prevent transmission of SARS-CoV-2. Questions about viral variants that evade host immune responses, vaccine safety and efficacy in vulnerable groups (ie. young children, immunocompromised, elderly), and the impact of vaccine hesitancy indicate we will need to maintain layers of protection for some time into the future.(11) In addition to vaccination, pandemic ED response should continue focus on proven non-pharmaceutical interventions such as engineering (often through changes in ED physical layout, ventilation and bed allocation), administrative policy (infection prevention and control, workflow changes, training, resources), and transmission-based PPE. These practices demand equity, and the failure to maintain high-

quality controls has resulted in healthcare worker (HCW) infections, disability and death.(8, 12-14).

The July-August 2020 outbreak in Melbourne, Victoria, Australia revealed deficiencies in hospital level infection prevention and control (IPC) in a health system comparable to that of Aotearoa New Zealand.(15, 16). Unfortunately, this outbreak in long-term care facilities and subsequent nosocomial spread in tertiary hospitals resulted in significant SARS-CoV-2 infections in HCWs. The Australian response affords insight into system preparedness improvements to adopt in other health systems.(8, 17, 18) The New Zealand Emergency Department COVID-19 (NZEDC19) Preparedness Survey of emergency consultants was designed to identify and address weaknesses in local NZ emergency department policy, engineering, and PPE to provide proactive recommendations for system improvement.

METHODS

This study was a cross-sectional web-based assessment of COVID-19 pandemic preparedness of EDs in NZ via survey of ED senior medical officers (ED SMOs) from the EDs of all NZ District Health Boards (DHBs).

Questionnaire Design. A 27-item questionnaire was framed around the hierarchy of control model with questions on engineering (negative flow isolation rooms, shared/cohorted patient areas, segregated patient flow, physical distancing), administrative controls (policies for rostering, training, simulations, treatments, and breaches), and personal protective equipment (supply, fit testing, use and re-use).(8, 10, 19) A series of Likert scale questions evaluated individual stress, wellness and risk assessment. Questions were adapted from a published survey

of preparedness in intensive care units (ICUs) of Australasia and the prospective COVID Evaluation of Risk in Emergency Departments (COVERED) Project in the U.S.(20, 21) The questionnaire was validated using established survey methodology, after several rounds of consensus building process between ED, microbiology and infectious disease specialists.(22)

Survey Distribution. The survey was distributed by email to 422 members of the Association of Salaried Medical Specialists (ASMS) identified as having emergency medicine as their designated department of work using Survey Monkey (San Mateo CA, USA) between 26 October 2020 and 23 November 2020. Two e-mail reminders were sent. Participation was voluntary. The study was considered exempt from the institutional review board by the NZ Health and Disabilities Ethics Committees.

Data Analysis. The data analysis was primarily descriptive and reported as percentages of valid responses. Diverging stacked Likert scales are used to display emergency specialist opinion results. The survey and raw data are included as a supplemental appendix.

Patient and Public Involvement. Patients or members of the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

One-hundred thirty-seven surveys were completed (32% response rate). All (100%) of 20 NZ DHBs were represented by at least 2 returned surveys. Nine (6.6%) respondents did not identify a DHB.

Engineering: The majority of respondents have access to negative flow or negative pressure patient care rooms (Table 1). Most (115, 83%) report 4 or fewer such rooms in their ED, but 14 (12 %) ED specialists reported no access to negative flow rooms for COVID-19 patient care. Most respondents worked in EDs that have some beds separated only by curtains with shared air circulation where patients may be cohorted.

Most (n=101, 74%) surveyed emergency consultants work in EDs which can create physical separation of care areas for high (HIS) index of suspicion patients segregated from those for presumed low index of suspicion (LIS) patients. Emergency consultants from multiple DHBs commented that ED segregated flow or "streaming" can be changed with COVID-19 prevalence and alert level.

Table 1: Summary table of select NZEDC19 Preparedness Survey answers

CONTROL	SPECIFIC HIERARCHY OF CONTROL QUESTION	N	%
ENGINEERING	Have negative flow/pressure rooms in ED	123	88%
	Have cohorted beds in ED	99	77%
	Segregated COVID/non-covid patients in ED	101	74%
	Rostered to see both COVID/non-COVID as needed	70	60%
	Unable to meet physical distance requirements at office	94	70%
	Unable to meet physical distance requirements at workstation	118	87%
	Unable to meet physical distance requirements at break rooms	92	71%
POLICY	Intubate LIS patient in negative pressure	6	4%
	Intubate HIS patient in negative pressure	88	64%
	Dedicated intubation teams ICU/anaesthesia	57	47%
	Intubation of HIS/COVID with video laryngoscopy	98	71%
	Use HFNC for hypoxic COVID-19 patients	53	50
	Use NIV for hypoxic COVID-19 patients	101	86%
	Use NIV with in-line expiration viral filter	19	16%
	No PPE training	3	2%
	PPE group training in-person with observed practice	66	37%
	PPE individual training in-person with observed practice	40	23%
	Simulation training of intubation in COVID-19 patient	93	70%
	Simulation training of NIV in COVID-19 patient	61	46%
	Simulation training of self-proning in COVID-19 patient	17	13%
	Not monitored during donning PPE	39	30%
	Not monitored during doffing PPE	44	34%
PPE	Not N95 fit tested by time of this survey	15	12%
	Fit tested by qualitative method (odour or taste)	82	60%
	Fit tested by quantitative method (machine sampling)	41	30%
	Wear N95 for HIS/COVID patient not receiving AGP	61	48%
	Wear N95 or PAPR for AGP of HIS/COVID patient	110	87%
	N95 masks unavailable	6	6%
	Re-use N95 masks without sterilization	12	11%
	Re-use N95 masks after sterilization	3	3%
	Elastomeric respirators unavailable	63	66%
	PAPRs unavailable	79	82%

Most respondents did not feel they could meet minimum physical distancing requirements for patient care in their workplace and disagree or strongly disagree that physical distancing is possible (Figure 1).

Administrative controls: Rostering ED consultants into either strictly "COVID" or "non-COVID" teams is not common and the majority (n=70, 60%) see these patient populations during their work period. Almost all (98%) of NZ ED consultants report having training for proper transmission-based PPE use with 60% having had in-person sessions being observed donning and doffing by the instructor. In practice, NZ emergency specialists report donning observation is rarely (18%) mandatory and about a third (30%) do not have an observer present. Only 16% report mandatory observation during removal while a third (34%) are not usually observed doffing PPE. Greater than half the NZ emergency consultant workforce surveyed are not aware of an official breach-of-PPE policy in their hospital ED or breach criteria.(23) Although they report access to showers, approximately 75% of NZ ED SMOs report no policy for showering after a recognized breach, after shifts, or at home.

Simulation training is common in NZ for patient intubation (93, 70%). Less common simulations are performed for non-invasive ventilation (61, 46%) and are rare for patient self-proning (17, 13%).

Greater than half (54%) of specialists report HFNC availability, but 14% would not use this technology at all. Half (55%) of ED specialists say they can utilize NIV (CPAP/BiPAP) but only 16% report using viral expiration filters, a low-cost recommended infection control adaptation. NIV is not used outside negative pressure rooms and only 4% report need to transfer to ICU for this modality. The majority of specialists report wide discretion in their ability to apply NIV to

COVID-19 patients and just 15% reserve it only for patients with comorbidities (COPD, CHF, etc.) known to benefit.

Sixty-four percent of consultants would intubate HIS/COVID-19 patients in a negative pressure room. Very few (4%) would intubate patients screened as LIS/non-COVID-19 patients under negative pressure.

The lack of adequate staffing levels during the pandemic is cited as the greatest concern for two-thirds of respondents. Having adequate PPE and adequate testing capacity if a future wave of COVID-19 occurred in NZ were less concerning for respondents (Figure 2).

Personal protective equipment: New Zealand emergency consultants report few shortages of consumable PPE and have had little experience with reusing PPE, except washable face shields and goggles (Table 1). Low reuse of N95 masks either without sterilization (9%) and after sterilization (2%) further supports that respondents felt PPE supplies were adequate. Few respondents reported use of elastomeric respirators (2%) and powered air-purifying respirators (PAPRs) (2%).(24, 25)

Only 89% of respondents had been fit tested for N95 masks at the time of this survey, leaving approximately one in ten of ED consultants surveyed (11%) having not been fit tested by November 2020. Half of these (7/15) were from one hospital.

Best practice for ED consultant use of transmission based PPE was assessed in different clinical scenarios as shown in (Table 2). Only 83% of respondents reported they would use N95 respirators in the context of aerosol generating procedures (AGP), with an additional 4% protected with elastomeric or PAPR. Thirteen percent of respondents would not use a respirator

(N95 mask, elastomeric mask or PAPR) for a HIS/COVID-19 patient receiving an AGP. Five consultants (4%) report using only a surgical mask during AGPs for HIS/COVID-19 patients.

Table 2: PPE chosen by EDSMOs ED Consultants for various clinical scenarios.

PPE	Non-patient care	Tea room	Toilet	LIS	HIS	HIS + AGP
Face shield	1%	0%	2%	4%	71%	75%
Safety glasses/goggles	1%	0%	1%	12%	79%	76%
Surgical masks	31%	9%	10%	61%	71%	34%
Reusable fabric masks	2%	1%	1%	2%	6%	5%
N-95 masks/respirators	0%	0%	1%	6%	48%	83%
Elastomeric respirators	0%	0%	0%	0%	3%	2%
Papr	0%	0%	0%	0%	1%	2%
Disposable surgical hat	0%	0%	1%	2%	25%	29%
Reusable surgical hat	0%	0%	1%	4%	7%	7%
Disposable gown	0%	0%	1%	13%	87%	84%
Impermeable suit	0%	0%	0%	2%	6%	7%
Gloves	2%	0%	1%	52%	90%	83%
Double gloves	0%	0%	0%	1%	21%	25%
Foot coverings	0%	0%	0%	1%	16%	13%

Low (LIS) or high (HIS) index of suspicion for COVID-19. Aerosol generating procedure (AGP). Non-patient care areas include areas in ED for charting, making telephone calls, etc.

PPE practice preferences vary when caring for either a High or Low Index of Suspicion patient while not performing an AGP. For a HIS/COVID-19 patient without an AGP consultants report N95 use of 48%, the rest using surgical mask alone or over N95. When seeing a LIS patient and no AGP, 6% report using an N95 respirator. Two-thirds (69%) wear some type of mask seeing LIS patients and one third of emergency consultants surveyed see LIS patients in their ED without a mask. While working outside of direct patient care but still in the hospital one third of ED SMOs wear a surgical or reusable fabric mask. Toilets may present a unique risk for droplet and possibly faecal-airborne transmission yet only 10% report using masks in toilets.(26, 27)

A summary rank-ordered list by ED consultants' assessment of their most likely source of exposure to COVID-19 identified "wearing inadequate PPE for patients not suspected of COVID-19 infection", followed by "contracting it from fellow staff members" or "accidental doffing exposure" as the top three most likely routes of nosocomial infection. Consultants were less concerned about inadequate N95 mask fit testing or the lack of appropriate training or PPE for co-workers such as housekeeping staff (Table 3).

Table 3: Rank the most likely reason that you think puts you at risk of exposure to COVID-19 at work? (1 for most likely, 8 for least likely)

Rank	Risk	Mean	C.I.
1	Wearing inadequate PPE for patient not suspected of COVID-19 infection	2.93	0.38
2	Contracting it from a fellow staff member in the ED	3.06	0.38
3	Accidental PPE doffing exposure	3.53	0.39
4	Wearing inadequate PPE for patient(s) suspected of COVID-19 infection	3.67	0.35
5	Not being able to access adequate PPE	4.44	0.48
6	Inadequate mask fit testing for staff	5.62	0.41
7	Cleaners have been provided inadequate training and/or inadequate PPE	5.66	0.32
8	Not applicable- I do not fear risk of COVID-19 exposure at work	6.57	0.57

DISCUSSION

This study assesses the preparedness of EDs around Aotearoa New Zealand for the eventual reintroduction of SARS-CoV-2 (28). Survey results identify weaknesses in local NZ hospital infection control practices which have been cited as risks in prior outbreaks in other countries(5, 8, 13). Our results reveal incomplete ED engineering upgrades such that 12% of NZ emergency consultants report no access to negative flow rooms for AGPs, continued use of cohorted bed bays possibly collocates infected and non-infected patients in areas of shared air circulation, and crowded work environments are inconsistent with recommendations for physical distancing. Results also indicate variations in pandemic specific administrative policy, adherence and practice. In particular, only a third of specialists reported routine monitoring of donning and

doffing of PPE. Only two-thirds would intubate a high index of suspicion (HIS) patient in a negative pressure room. High flow nasal cannula (HFNC) for hypoxic COVID-19 patients would be utilized by only half of ED consultants in this survey. Finally, infection control through PPE availability and proper use may be compromised by the finding that about one-tenth of ED consultants reported not being fit tested for N95 masks. Although reported N95 mask shortages were rare, only 87% of respondents would use a respirator in the high risk setting of a HIS/COVID-19 patient receiving an AGP.

When elimination of SARS-CoV-2 fails and adequate community-wide immunity has not been established it is these proven step-wise controls that are needed to curb nosocomial spread and prevent health-care system compromise. Cited as primary are engineering controls which decrease SARS-CoV-2 transmission by modifications to hospital ventilation, bed allocation, streaming patients and physical distancing of staff. A minimum requirement would provide enough adequately ventilated negative pressure rooms, or at least negative directional airflow, to allow for treatment of multiple respiratory isolation patients requiring AGPs. Negative flow dilutes contaminated air breathed by HCWs caring for patients with airborne transmissible infections. DHBs should prioritise ED patient areas with a greater number of room air changes per hour (ideally 6-12 ACH), and greater proportion of fresh (vs recycled) air or consider portable HEPA filter units if airflow is inadequate.(7, 18) The finding that 12% of consultants report no access to at least one negative flow room for AGPs, mostly in smaller peripheral hospitals, suggests NZ DHBs have not equitably upgraded all EDs.

Control of bed-allocation during a COVID-19 surge reiterates issues common to emergency systems chronically plagued by over-crowding and limited resources.(29) Somewhat unique to a respiratory pandemic, patients with suspected COVID-19 may compromise the capacity to

protect other patients from exposure. Because of this, single rooms to isolate suspected cases or protect vulnerable non-infected patients become a premium. The delay between clinical suspicion and confirmatory testing can further prolong lengths of stay such that available, rapid SARS-CoV-2 testing must be a priority.(30) Our results show most NZ suspected COVID-19 patients are streamed to separate ED areas or wards away from others where possible. In the Australian model, HCWs are to be rostered such that they minimize intermingling between COVID and Non-COVID teams.(8, 18, 31) A majority (92%), of NZ consultants work in EDs that stream HIS/COVID-19 patients but most (64%) report being rostered to alternate seeing both HIS and LIS patients. Smaller EDs and limited rosters were often cited as the reason in the comments.

In some instances there may be pressure to cohort patients in multiple bed bays with shared air circulation. In this study, three quarters of NZ specialists report having ED patients cohorted with only curtains separating beds. Based on overseas experience, large numbers of COVID-19 patients in confined spaces may create a high density of aerosols and cause HCWs to stay longer as they attend each patient increasing their risk. Best practice reduces patient density to one per room (even if in a 2 or 4 bed bay) and mandates airborne PPE for staff in these situations.(8, 32, 33) Conversely, use of multi-bed bays to cohort presumed Non-COVID patients risks misidentifying the asymptomatic or presymptomatic patients as safe to collocate with other uninfected individuals(30). Well ventilated or HEPA filtered areas may decrease this risk but evidence is limited(34).

Although much attention is directed toward patient-to-HCW transmission, literature has identified HCW transmission to patients and to other HCWs and many of these nurses or doctors had no symptoms reiterating the importance of maintaining physical distancing and mask

wearing in non-clinical areas when SARS-CoV-2 is circulating.(35, 36) Ranking this risk second in Table 2 suggests most NZ ED specialists may be aware of this concern. Despite recommendations to maintain physical distancing in non-clinical work areas most (86%) of NZ specialists disagreed that their ED workstations were engineered for adequate room (Figure 1). This illustrates how the lack of resources, physical space or personnel can undermine administrative efforts to protect staff and patients from exposures.

Administrative policy involves institution of rules that change how health care workers behave, it alters work flow and implements infection control protocols. Success may depend on dissemination of guidelines, staff confidence in recommendations, or practice (real life or simulation). This can be undermined by poor messaging, mistrust or when case counts are low and the risk no longer justifies the effort. Vaccination may also create a sense that these other controls are not needed.

Initial training for PPE use was universal (97%) but ongoing interval training was not common nor was mandatory observation during donning or doffing as recommended in the literature.(16) Training (baseline and refreshers) and monitoring policy for PPE use (spotters) for all clinical and non-clinical staff is not standardized across DHBs (Table 1). Simulations to practice skills (such as intubation and NIV use) and accommodate for PPE are variably applied in NZ(16). Experience in other countries has shown HCW PPE breaches, exposures and infections cause large numbers of staff furloughs, worsening nurse to patient ratios and causing the remaining staff to experience high workloads.(8, 31, 37) Maintaining a healthy skilled workforce is paramount to offset predicted inadequate staffing. A proactive approach should be used to support infected and furloughed staff wellbeing, with dedicated nursing and medical staff monitoring physical and mental health and providing support. Given the gravity of HCW

infection and the system failure it implies, every suspected healthcare associated infection should trigger a bundle of immediate infection control measures.(38)

Among the strongest recommendations in the literature regarding prevention of HCW nosocomial infection is to "decant" or decrease overcrowding of COVID-19 patients in EDs and wards.(8) Ensuring a manageable workload through adequate staffing ratios by anticipating the increased care required for these infectious respiratory failure patients is paramount. This may also prevent the added fatigue HCWs face secondary to PPE compliance, doffing observation, and decontamination of providers and work environment. These additional tasks are not being calculated into traditional bedside severity scores and underestimate nursing ratios.

Only two thirds of NZ ED specialists (64%) would intubate HIS/COVID-19 patients in a negative pressure/flow room. Allowing for the roughly 12% who reported no access to this engineering control, it suggests a quarter of NZ ED consultants would depart from recommended practice. It is possible the difference represents consultants who do not intubate and or intend to transfer care before that indication arises.

Personal Protective Equipment places a barrier between the HCW and the infectious agent (the principal example being respirators and other masks) and are considered the final and least effective control measure because it relies on consistent individual action at the point of care.(10) PPE should be implemented through clear guidelines and be current with peer reviewed literature and expert recommendations.(20, 39-41) The NZ Ministry of Health (MoH) last updated PPE recommendations 22 September 2020 and these do not promote use of N95 respirators outside of AGPs for HIS/COVID-19 patients.

This study shows that shortages of N95 masks, and one key reason for limiting their use, have largely resolved and improved supplies allow hospitals to stop contingency and crisis practices (e.g. decontaminating N95s and using surgical masks in place of respiratory protection). The scientific community has acknowledged literature demonstrating transmission through inhalation of small airborne particles is a significant mode of SARS-CoV-2 virus transmission.(38, 41-43) These studies demonstrate aerosols produced through breathing, talking, coughing and yelling can remain in air and viable for long periods of time, travel long distances within a room and sometimes farther depending on ventilation. The experience in The Royal Melbourne Hospital City Campus outbreak noted that "aerosol generating behaviour" (AGB) in infected patients appeared to be linked to transmission events(8). Patients shouting, vigorous coughing, cognitive impairment and combative behaviour, actions common in ED patients, should mandate airborne precautions.(37, 41)

Fit testing of N95 respirators in line with other nations' health and safety legislation was late to be initiated in NZ, and for at least 15 consultants (11%) was still not available at the time of this survey.(16, 20) Small peripheral facilities, as was the case for negative flow rooms, appear to be less prepared.

In the scenario-based PPE questions (Table 2), the finding that up to 13% of NZ ED consultants would not choose an N95 respirator, elastomeric or PAPR in the context of an aerosol generating procedure (AGP) for a HIS/COVID-19 patient was unexpected and raises concern. Given the low prevalence of SARS-CoV-2 in NZ, the probability of an HIS patient being infected is low, but not zero. Some ED consultants may argue N95s are not necessary due to elimination efforts or may believe they are still in short supply. But the omission of this recommended PPE could be interpreted as a purposeful disregard of evidence based pandemic IPC practice or a deliberate

ignorance of why these policies exist. In a pandemic, an individual's choice to forgo personal protection does not just take the risk for themselves, but for the community of others on their health care team, the other patients they care for, and their families and close contacts. Instituting and maintaining a standardized observer system and breach protocols should remedy this issue and may help promote a culture of staff safety, risk and adverse event reporting and staff support. NZ has enjoyed near SARS-CoV-2-free medical practice but sporadic reintroduction has occurred with HCW infection and risking transmission during aerosol generating procedures is an unconscionable breach of infection prevention and control even if vaccinated.(14) This will have to change as SARS-CoV-2 is reintroduced.

Some professional organizations have gone one step further and simplified the practice. The Australasian and New Zealand College of Anaesthesia in conjunction with the Infection Control Expert Group (ICEG) recently recommend wearing airborne precaution PPE for care of all patients with high risk of SARS-CoV-2, irrespective of the community transmission.(39)

CONCLUSION

These survey results from NZ ED consultants identify potential risks of failure in the hierarchy of infection controls currently in place to prevent nosocomial spread of SARS-CoV-2 or future emerging infections. Our findings show that engineering upgrades to respiratory pandemic standards are not prevalent, administrative COVID-19 policy has not adapted to scientific advances seen in policy from other healthcare systems (ie. Australia), and PPE current practice reveals high variability suggesting poor dissemination of guidelines, low confidence in recommendations, or little practice because of low prevalence. NZ's public health success in SARS-CoV-2 elimination and the promise of protective immunity through vaccines has allowed

for a relaxation of other layers of infection control even as evidence-based practice supporting them has evolved. As New Zealand borders reopen and crowded and under resourced emergency departments and their frontline health care workers face endemic COVID-19, it would be prudent to use lessons learned elsewhere to identify local ED weaknesses and better prepare them to protect their patients and care givers in this approaching phase of the pandemic.

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Ethics Statement: A waiver of ethical approval was received from Health and Disability Ethics Committee from the New Zealand Ministry of Health

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Figure Legends:

Figure 1: Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?

Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following:

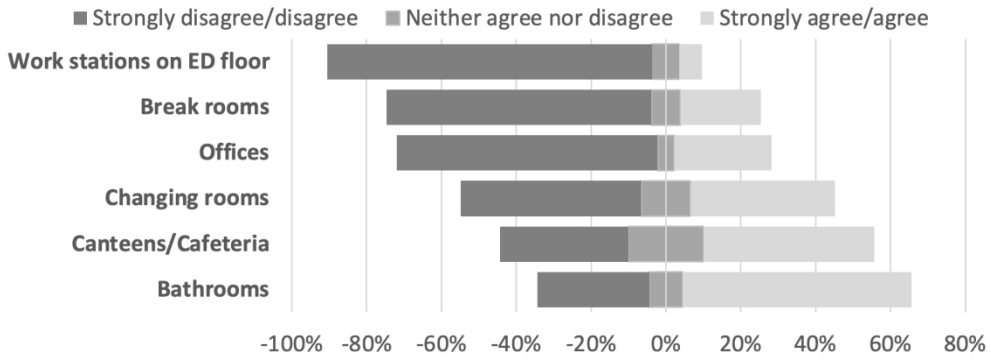


Figure 1: Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?

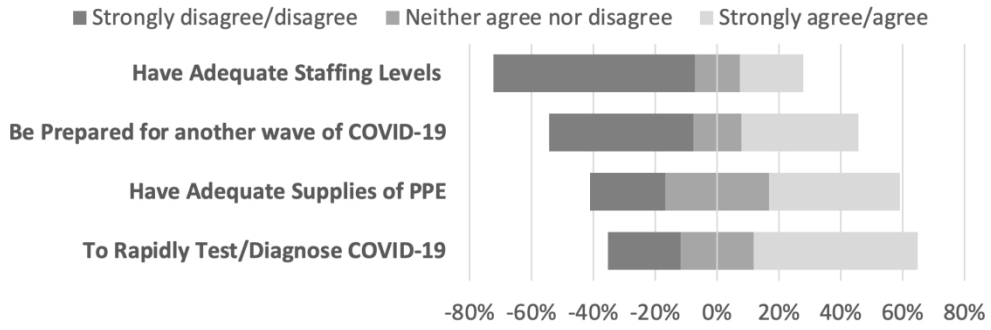


Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following:

Introduction

The NZED COVID-19 Preparedness Survey focuses on your safety and well-being during the COVID-19 pandemic.

The questions are peer-reviewed and created with the help of emergency specialists and infectious disease experts focused on health care worker safety and well-being.

We hope the results from this research will enable dialogue as to best infection control measures, and assist with standardising local protocols with the aim of minimising risk of nosocomial COVID-19 infections in the Emergency Department (ED).

ASMS understands that your commitment to the welfare of your patients and colleagues is predicated on your ability to focus on providing the best medical care in the safest possible work environment. We understand this requires practice and preparation.

Please take this opportunity to relate the current and proposed practices in your ED and share your opinions and thoughts.

If you have any questions regarding this research, please do not hesitate to contact Dr Charlotte Chambers at ASMS: CC@asms.nz

Thank you for your time.

Emergency Department (ED) Facility Characteristics

1. **Where is your primary place of work?**

2. **Do you have any negative pressure beds in your ED and if so, how many?**

For the purposes of this survey, a negative pressure or negative flow bed is defined as any bed in single or multiple rooms with minimum of 6 air changes per hour with or without an ante room.

- We don't have any negative pressure beds in our ED
- 1-4
- 5-9
- 10-14
- 15-19
- 20 or more
- Other (please specify)

3. **How many beds in your ED at the time of this survey are in shared rooms for cohorted patients**

For the purposes of this survey shared rooms are defined as large rooms with multiple curtained beds

- 1-4
- 5-9
- 10-14
- 15 or more
- I'm not sure
- None
- Other (please specify)

4. **When you have either confirmed COVID-19 patients or high index of suspicion (HIS) patients entering your ED do you treat them in a separate area (separate flow/segregated ED)?**

- ◯ Yes
- ◯ No
- ◯ Not applicable
- ◯ I'm not sure
- ◯ Other (please specify)

5. **Some EDs may be segregated into COVID and Non-COVID areas for patient care. How would you expect to be personally rostered in your ED?**

- ◯ We don't have a segregated ED
- ◯ I will be treating COVID patients only
- ◯ I will be treating Non-COVID patients only
- ◯ I will see both, alternating between them as needed
- ◯ I'm not sure
- ◯ Comment:

6. **Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Not applicable
Offices	◯	◯	◯	◯	◯	◯
Work stations on ED floor	◯	◯	◯	◯	◯	◯
Break rooms	◯	◯	◯	◯	◯	◯
Bathrooms	◯	◯	◯	◯	◯	◯
Changing rooms	◯	◯	◯	◯	◯	◯
Canteens/Cafeteria	◯	◯	◯	◯	◯	◯

Comments:

PPE training and fit testing

1. **What type of training have you had in the use of PPE at your current place of employment?**

Please select all that apply from the following:

- [ ] None - I have not completed any online training or employer required/directed training
- [ ] Self-taught using online training (video, reading material)
- [ ] In-person group demonstration in which I only watched
- [ ] In-person group session in which I practiced putting PPE on and removing it properly
- [ ] In-person individual demonstration in which I only watched
- [ ] In-person individual session in which I was observed putting PPE on and removing it properly
- [ ] Other (please specify)

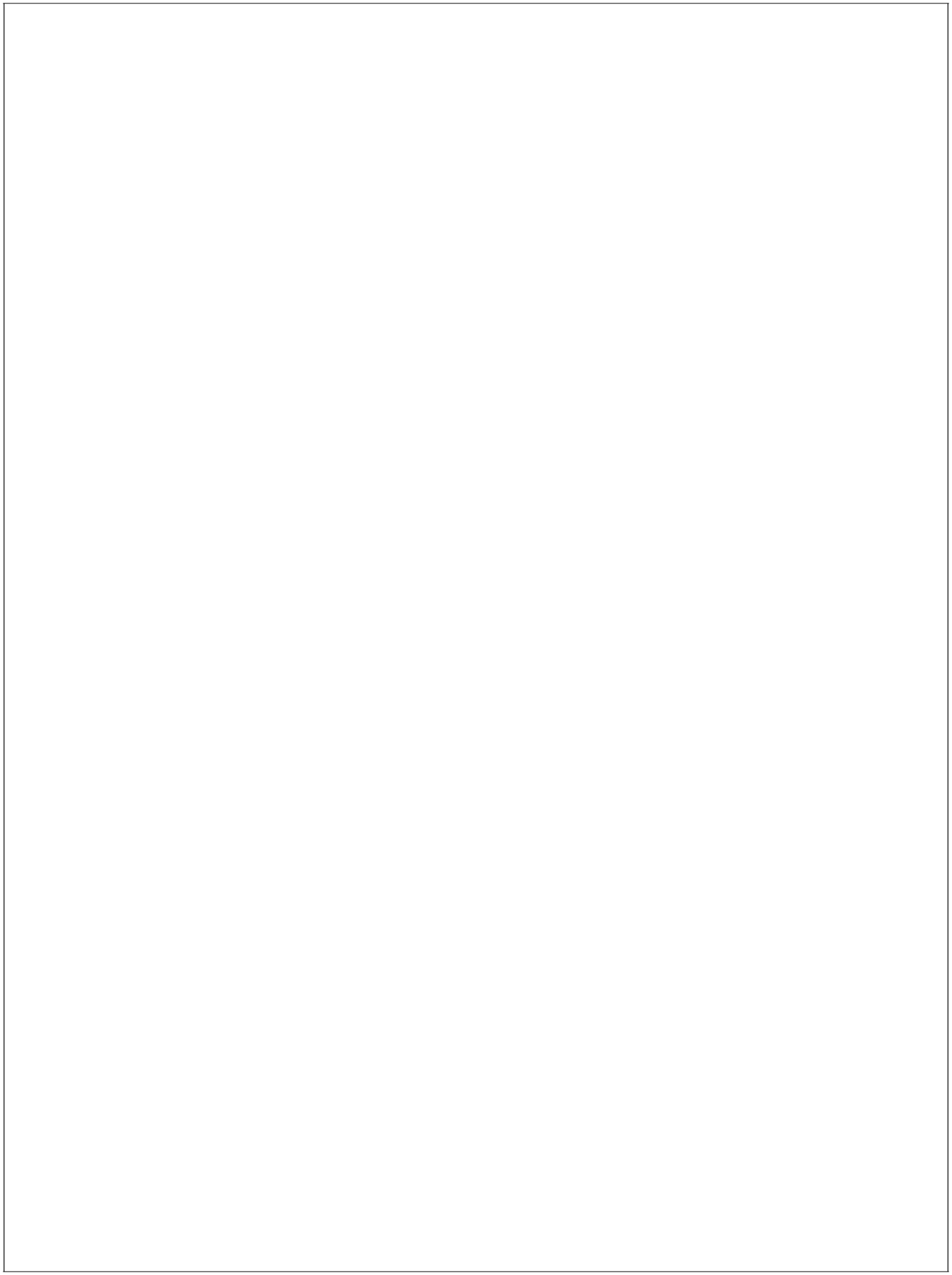
2. **Approximately, how frequently are you trained in any of the following activities?**

	Upon request	Never	Once	Annually	I'm not sure
Training for donning and doffing PPE	○	○	○	○	○
Simulation sessions on intubating COVID patients	○	○	○	○	○
Simulation session for non-invasive ventilation (NIV: CPAP, HFNC)	○	○	○	○	○
Simulation sessions on awake/self prone positioning of COVID patients	○	○	○	○	○
Simulation sessions on transporting COVID patients	○	○	○	○	○

Other (please specify)

3. If you have been fit tested with a N-95 mask/respirator within the last 12 months, what method was used to determine fit?

- ○ Not applicable; I have not been fit tested within the last 12 months
- ○ Qualitative (odour or taste detection in hood)
- ○ Quantitative (machine sampling via tubing)
- ○ I'm not sure
- ○ Other (please specify)



PPE Scenarios

1. **What personal precautions are you currently using in the following settings?**

Please select all that apply from the following:

	When in your ED but not providing patient care (charting, making telephone calls)	When in your Break/Tea Room (eating, conversing with colleagues)	When in your ED providing care for a non-COVID-19 low index of suspicion (LIS) patient	When in your ED providing care for COVID-19 HIS or confirmed patient	When within 2m of an aerosol-generating procedure for a confirmed or HIS COVID-19 case	When using the bathroom facilities
Standard precautions (handwashing, distancing from others)	☐	☐	☐	☐	☐	☐
Face shield	☐	☐	☐	☐	☐	☐
Safety glasses/goggles	☐	☐	☐	☐	☐	☐
Surgical masks	☐	☐	☐	☐	☐	☐
Reusable fabric masks	☐	☐	☐	☐	☐	☐
N-95 masks/respirators	☐	☐	☐	☐	☐	☐
Elastomeric respirators	☐	☐	☐	☐	☐	☐
Powered air-purifying respirator systems (PAPR CAPR)	☐	☐	☐	☐	☐	☐
Disposable surgical hat	☐	☐	☐	☐	☐	☐
Reusable surgical hat	☐	☐	☐	☐	☐	☐
Standard disposable isolation gown	☐	☐	☐	☐	☐	☐
Full-body impermeable suit	☐	☐	☐	☐	☐	☐
Gloves	☐	☐	☐	☐	☐	☐
Double gloves	☐	☐	☐	☐	☐	☐
Foot coverings	☐	☐	☐	☐	☐	☐

Other (please specify):

2. **Does your ED have a formal policy on showering/shampooing after caring for COVID-19 patients?**

	Mandatory	Not mandatory	Not practical as we have limited facilities	We don't have shower facilities	Not aware of a formal policy
Immediately after every single patient-contact episode	○	○	○	○	○
Only if PPE was breached	○	○	○	○	○
At the end of the shift	○	○	○	○	○
After reaching home	○	○	○	○	○

Comment:

3. **In your ED, is PPE donning monitored by an observer prior to care for COVID-19 patients?**

- ○ Yes, all the time (mandatory)
- ○ Yes, some of the time (ad-hoc)
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

4. **In your ED, is PPE doffing (removal) monitored by an observer to identify breaks in doffing technique after care for COVID-19 patients?**

- ○ Yes, all of the time (mandatory)
- ○ Yes, some of the time (ad-hoc)
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

Policies and practices for patients with suspected COVID-19

1. **For endotracheal intubation, which of the following (if any) is your ED using all or most of the time for patients with:**

Please select all that apply from the following:

	Low Index of Suspicion for COVID-19	High Index of Suspicion/Confirmed COVID-19
Negative pressure bed (bed with minimum of 6 air changes per hour)	☐	☐
Video laryngoscopy	☐	☐
Intubation barrier protection (e.g., intubating boxes , intubating bags, etc.)	☐	☐
Intubation barrier protection with integrated suction (e.g., intubating boxes connected to suction; negative pressure hood)	☐	☐
Intubation response teams (with dedicated staff)	☐	☐
Intubation through a supraglottic device (e.g., intubating LMA, etc.)	☐	☐
None of these	☐	☐

Other (please specify)

2. **Does your ED have a dedicated intubation team for confirmed or suspected COVID-19 patients?**

- ○ Yes, consisting of ICU/Anaesthesia responding to ED
- ○ Yes, consisting of ICU/ED formalised
- ○ Yes, ED only
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

3. **For patients with confirmed or suspected COVID-19, is your ED practice/protocol that patients will be treated with high-flow nasal cannula (HFNC), if needed?**

- ◯ Yes
- ◯ No
- ◯ I'm not sure
- ◯ We don't have a formal protocol
- ◯ Comment:

4. **For ED patients with confirmed or suspected COVID-19, is your ED practice/protocol that patients will be treated with non-invasive positive pressure ventilation (NIV, including CPAP or BiPAP), if needed?**

- ◯ Yes, in any area in the ED
- ◯ Yes, only in a negative flow/pressure room in ED
- ◯ Yes, only with in-line or expiration viral filter in negative flow/pressure room in ED
- ◯ Yes, only after transfer to the ICU if appropriate
- ◯ No
- ◯ We don't have a formal protocol
- ◯ Other (please specify)

5. **For confirmed or suspect COVID-19 ED patients, under what circumstances might NIV (including CPAP or BiPAP) be used in your ED?**

Please select from the following:

- ☐ Any patient with respiratory failure that I think will benefit from NIV if indicated (NIV: CPAP/BiPAP)
- ☐ Only patients that have other co-morbidities known to benefit from NIV (eg. COPD, CHF, OSA)
- ☐ Only patients who have a "Do Not Intubate" or a "Do Not Resuscitate" order
- ☐ Only when mechanical ventilators are scarce
- ☐ Other (please specify)

PPE Breaches

1. **Please select from the following scenarios what constitutes a 'Breach in PPE' in your Emergency Department**

	Breach	Not a breach	Not aware of formal policy
Inadequate face protection	○	○	○
Inadequate eye protection	○	○	○
Improper donning/doffing	○	○	○
Exposure of skin due to a glove or gown tear	○	○	○
Inadequate shoe cover	○	○	○
Direct contact of skin to any secretion	○	○	○
Needle stick	○	○	○
Poor mask fit	○	○	○

Other (please specify)

2. **What measures have been advised by your hospital/ED administration when a PPE breach has been identified?**

	Mandatory	Optional	Not aware of a formal policy
Shower immediately	○	○	○
Report to ID/designated authorities	○	○	○
Retraining given for donning or doffing	○	○	○
Quarantine with testing protocol	○	○	○

Other (please specify)

PPE supply and re-use

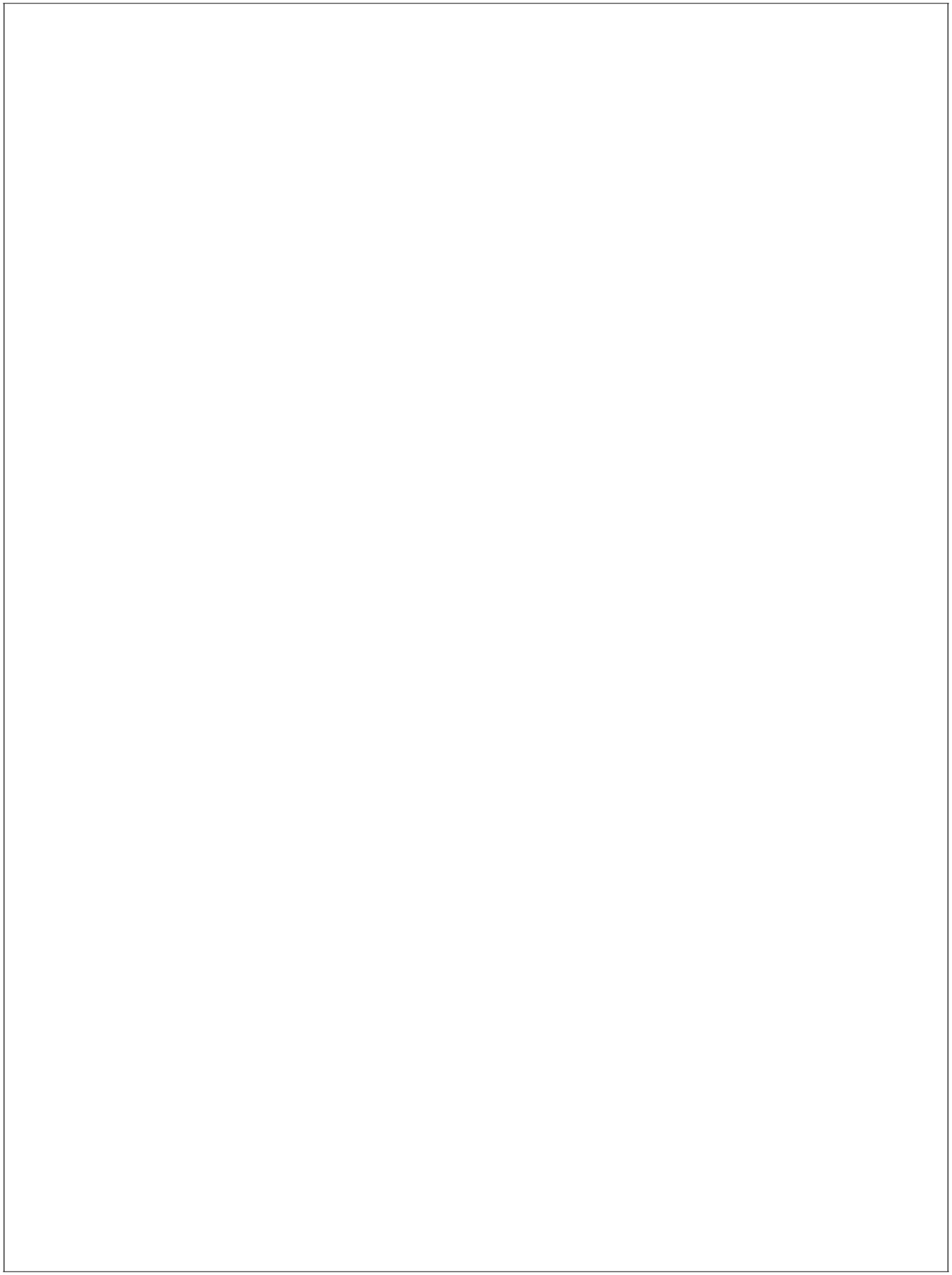
1. **At the time of this survey, please select from the following any PPE that is out of stock or otherwise unavailable for clinical use in your ED:**

- [ ] Reusable face shields
- [ ] Disposable face-shields (single use)
- [ ] Safety glasses/goggles
- [ ] Surgical masks
- [ ] Reusable fabric masks
- [ ] N-95 masks/respirators
- [ ] Elastomeric respirators
- [ ] Powered air- purifying respirator systems (PAPR, CAPR, etc.)
- [ ] Disposable surgical hat
- [ ] Reusable surgical hat
- [ ] Standard disposable isolation gown
- [ ] Full-body impermeable suit
- [ ] Gloves
- [ ] Foot coverings
- [ ] Other (please specify)

2. **Have you ever re-used PPE equipment according to any of the following scenarios?**

	Yes	No	I'm not sure
We re-use N-95 masks without sterilization	○	○	○
We re-use N-95 masks after sterilization	○	○	○
We re-use face shields without washing with cleaning solution	○	○	○
We re-use face shields after washing with cleaning solution provided	○	○	○
We re-use goggles without washing with cleaning solution	○	○	○
We re-use goggles after washing with cleaning solution provided	○	○	○

Other (please specify)



Your views

1. **Which of the following best describes your level of confidence in your ED's PPE protocol?**

	During Level 4 Lockdown	At the time of this survey
I am/was confident that our PPE protocol will keep me completely safe	☐	☐
I think my ED's protocol put me at risk and that I should have better PPE than is available, or use PPE more often than required by protocol	☐	☐
I think my ED's PPE protocol is too restrictive, and I feel that I can safely practice without wearing PPE every time that it is required by protocol	☐	☐
I am/was unsure about the safety of our PPE protocol and feel neither safe or unsafe	☐	☐
I am/was not aware of a PPE protocol in my ED	☐	☐

Other (please specify)

2. **At the time of the initial COVID-19 outbreak in New Zealand (during level 4 lockdown), please consider how you felt about the following:**

	Never	Rarely	Sometimes	Often	Always
I worried that family members or other close contacts were at risk of exposure to COVID-19 because of my work	○	○	○	○	○
I worried that I was at risk of exposure to COVID-19 because of my work	○	○	○	○	○
I worried about the level of preparedness of my hospital and ED	○	○	○	○	○
I worried about the supply of adequate and appropriate PPE in my ED	○	○	○	○	○
I felt anxious and stressed because of COVID-19	○	○	○	○	○

Other (please specify)

3. **Please answer the following questions regarding your views on how prepared your ED would be if there was another wave of COVID-19 in New Zealand**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Our ED is prepared and ready for another wave of COVID-19	☐	☐	☐	☐	☐
Our ED would have adequate staffing levels if there was another wave of COVID-19	☐	☐	☐	☐	☐
Our ED would have adequate supplies of appropriate PPE if there was another wave of COVID-19	☐	☐	☐	☐	☐
We would be able to rapidly test and in a timely manner diagnose possible cases of COVID-19	☐	☐	☐	☐	☐

Other (please specify)

4. **Do you feel you are at risk of infection from COVID-19 at work?**

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
○	○	○	○	○

Other (please specify)

5. **If you feel you are at risk of COVID-19 infection AT WORK, please rank the most likely reason that you think would put you at risk of exposure to COVID-19?**

Please select 1 for the most likely reason through to 8 as the least likely.

- ☐ Not applicable- I do not fear risk of COVID-19 exposure at work
- ☐ Not being able to access adequate PPE
- ☐ Wearing inadequate PPE for patient(s) not suspected of COVID-19 infection
- ☐ Wearing inadequate PPE for patient(s) suspected of COVID-19 infection
- ☐ Contracting it from a fellow staff member in the ED
- ☐ Accidental PPE doffing exposure
- ☐ Cleaners have been provided inadequate training and/or inadequate PPE
- ☐ Inadequate mask fit testing for staff

6. We would be grateful to hear your thoughts on any other aspects regarding the level of preparedness of your ED or the impact of COVID-19

Table 1:

Physical Plant of Emergency Departments		
How many negative pressure beds in your ED?	**%**	**n**
We don't have any negative pressure beds in our ED	12%	16
1-4	83%	115
5-9	4%	6
10-14	1%	2
How many cohorted beds in your ED?		
1-4	19%	24
5-9	21%	27
10-14	13%	17
15 or more	24%	31
I'm not sure	2%	2
None	21%	27
How would you be rostered for COVID patients in your ED?		
We don't have a segregated ED	28%	32
I will be treating COVID patients only	2%	2
I will be treating Non-COVID patients only	7%	8
I will see both, alternating between them as needed	60%	70
I'm not sure	3%	4
Would you treat COVID/HIS patients in a separate area of your ED?		
Yes	74%	101
No	26%	35

Table 2:

Policy for working with COVID patients		
Do you have dedicated intubation teams in either ICU/Anaesthesia/ED?		
	%	**n**
Yes, consisting of ICU/Anaesthesia responding to ED	20%	24
Yes, consisting of ICU/ED formalised	8%	10
Yes, ED only	6%	7
No	62%	74
I'm not sure	3%	4
For COVID/HIS patients, do you treat with high-flow nasal cannula (HFNC) if needed?		
Yes	50%	53
No	15%	16
I'm not sure	18%	19
We don't have a formal protocol	16%	17
For COVID/HIS patients, when do you use NIV (including CPAP or BiPAP)?		

Any patient with respiratory failure that I think will benefit from NIV if indicated	80%	79
Only patients that have other co-morbidities known to benefit from NIV	15%	15
Only patients who have a "Do Not Intubate" or a "Do Not Resuscitate" order	1%	1
Only when mechanical ventilators are scarce	4%	4

Table 3:

PPE use, training and availability						
Approximately, how frequently are you trained in any of the following activities?						
	Upon request		**Never**		**Once**	
Training for donning and doffing PPE	33%	43	6%	8	48%	64
Simulation sessions on intubating COVID patients	25%	33	17%	23	45%	60
Simulation session for non-invasive ventilation (NIV: CPAP, HFNC)	23%	31	42%	55	23%	30
Simulation sessions on awake/self prone positioning of COVID patients	5%	7	80%	106	8%	10
Simulation sessions on transporting COVID patients	10%	14	63%	85	19%	26
What type of training have you had in the use of PPE ?						
None - I have not completed any online training or employer required/directed training	2%	3				
Self-taught using online training (video, reading material)	21%	37				
In-person group demonstration in which I only watched	13%	23				
In-person group session in which I practiced putting PPE on and removing it properly	37%	66				
In-person individual demonstration in which I only watched	5%	8				
In-person individual session in which I was observed putting PPE on and removing it properly	23%	40				
How was N95 fit tested?						
Not applicable; I have not been fit tested within the last 12 months	12%	15				
Qualitative (odour or taste detection in hood)	59%	74				
Quantitative (machine sampling via tubing)	26%	33				

I'm not sure	2%	3				
At the time of this survey, please select from the following any PPE that is out of stock or otherwise unavailable for clinical use in your ED:						
Reusable face shields	18%	17				
Disposable face-shields (single use)	17%	16				
Safety glasses/goggles	6%	6				
Surgical masks	2%	2				
Reusable fabric masks	39%	37				
N-95 masks/respirators	6%	6				
Elastomeric respirators	66%	63				
Powered air- purifying respirator systems (PAPR, CAPR, etc.)	82%	79				
Disposable surgical hat	30%	29				
Reusable surgical hat	49%	47				
Standard disposable isolation gown	2%	2				
Full-body impermeable suit	75%	72				
Gloves	2%	2				
Foot coverings	46%	44				
Have you ever re-used PPE equipment according to any of the following scenarios?						
	Yes		**No**		**I'm not sure**	
We re-use N-95 masks without sterilization	11%	12	85%	94	4%	4
We re-use N-95 masks after sterilization	3%	3	88%	96	9%	10
We re-use face shields without washing with cleaning solution	3%	3	86%	96	11%	12
We re-use face shields after washing with cleaning solution provided	56%	63	32%	36	12%	14
We re-use goggles without washing with cleaning solution	9%	10	77%	82	14%	15
We re-use goggles after washing with cleaning solution provided	75%	85	14%	16	11%	13

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	N/A
Bias	9	Describe any efforts to address potential sources of bias	2
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	N/A
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	5
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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TITLE

New Zealand Emergency Department COVID-19 Preparedness: A Cross-sectional Survey and Narrative View

AUTHORS

Michael J. Howard MD PhD
Charlotte N. L. Chambers, PhD MSc
Nicholas M. Mohr MD MS

Author Affiliations:
1. Department of Emergency Medicine, Whangarei Hospital, Northland District Health Board, Whangarei, New Zealand, michaelhowardmd@gmail.com
2. Director of Policy and Research, Association of Salaried Medical Specialists, Wellington, New Zealand, charlotte.chambers@asms.org.nz
3. Department of Emergency Medicine, University of Iowa Carver College of Medicine, Iowa City, Iowa, nicholas-mohr@iowa.edu

Corresponding Author:
Michael J. Howard MD PhD, Whangarei Hospital Emergency Department, Northland District Health Board, Private Bag 9742 Maunu Road, Whangarei, 0148 New Zealand
michaelhowardmd@gmail.com

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ABSTRACT

Objective

Our objective was to assess the level of COVID-19 preparedness of emergency departments (EDs) in Aotearoa New Zealand (NZ) through the views of emergency medicine specialists working in district health boards around the country. Given the limited experience NZ hospitals have had with SARS-CoV-2, a comparison of current local practice with recent literature from other countries identifying known weaknesses may help prevent future healthcare worker infections in NZ.

Methods

We conducted a cross-sectional survey of NZ emergency specialists in November 2020 to evaluate preparedness of engineering, administrative policy, and personal protective equipment (PPE) use.

Results

A total of 137 surveys were completed (32% response rate). More than 12% of emergency specialists surveyed reported no access to negative pressure rooms. N95 fit testing had not been performed in 15 (12%) of respondents. Most specialists (77%) work in EDs that cohort COVID-19 patients, about one-third (34%) do not use spotters during PPE doffing, and most (87%) do not have required space for physical distancing in non-patient areas. Initial PPE training,

simulations and segregating patients were widespread but appear to be waning with persistent low SARS-CoV-2 prevalence. PPE shortages were not identified in NZ EDs, yet 13% of consultants do not plan to use respirators during aerosol generating procedures on COVID-19 patients.

Conclusions
New Zealand emergency specialists identified significant gaps in COVID-19 preparedness, and they have a unique opportunity to translate lessons from other locations into local action. These data provide insight into weaknesses in hospital engineering, policy, and PPE practice in advance of future SARS-CoV-2 endemic transmission.

Strengths and limitations of this study

- Survey responses specifically identified existing breakdowns in engineering, administrative policy and personal protective equipment in New Zealand emergency departments, potentially increasing healthcare worker nosocomial infection risk upon reintroduction of SARS-CoV-2
- Respondents included emergency specialists from all 20 of New Zealand's district health boards but the electronic convenience sample may not be representative of all ED consultants in NZ
- Some survey questions asked respondents to recall experiences or project how they would practice if they were caring for a COVID-19 patient
- Those motivated to respond may feel they have more or less access to protective policies and equipment than non-respondents

KEYWORDS
COVID-19, Cross-Sectional Studies, Emergency Service, Hospital, Infection Control, Infectious Disease Transmission, Patient-to-Professional

INTRODUCTION

The Aotearoa New Zealand (NZ) healthcare system was as unprepared for the coronavirus disease 2019 (COVID-19) pandemic as many nations, yet NZ successfully eliminated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).(1, 2) The decision to implement aggressive public health infection elimination practices hinged on NZ's ability to rapidly and effectively close its borders thus limiting COVID-19 impact to approximately 2600 cases and 26 deaths.(3, 4) As a result, NZ's Emergency Departments (EDs) have had little experience caring for COVID-19 patients and disparate efforts towards infection control preparedness may leave heath care workers (HCWs) vulnerable to nosocomial SARS-CoV-2 transmission.(5-8)

The Hierarchy of Control offers an algorithm to assess preparedness of a health system, scalable to departmental, hospital and nationwide recommendations.(8-10) Once elimination is established but eradication remains impossible there must be appropriate resources to institute and sustain substitution of the threat (typically by vaccination or other therapies). Even as vaccine-based immune protection expands there are still uncertainties requiring multiple controls to prevent transmission of SARS-CoV-2. Questions about viral variants that evade host immune responses, vaccine safety and efficacy in vulnerable groups (ie. young children, immunocompromised, elderly), and the impact of vaccine hesitancy indicate we will need to maintain layers of protection for some time into the future.(11) In addition to vaccination, pandemic ED response should continue focus on proven non-pharmaceutical interventions such as engineering (often through changes in ED physical layout, ventilation and bed allocation), administrative policy (infection prevention and control (IPC), workflow changes, training, resources), and transmission-based PPE. These practices demand equity, and the failure has resulted in healthcare worker (HCW) infections, disability and death.(8, 12-14)

The July-August 2020 outbreak in Melbourne, Victoria, Australia revealed deficiencies in hospital level IPC in a health system comparable to that of NZ.(15, 16) Unfortunately, this outbreak in long-term care facilities and subsequent nosocomial spread in tertiary hospitals resulted in significant SARS-CoV-2 infections in HCWs. The Australian response affords insight into improvements to adopt in other health systems.(8, 17, 18) The New Zealand Emergency Department COVID-19 (NZEDC19) Preparedness Survey of emergency consultants was designed to identify and address weaknesses in local NZ emergency department policy, engineering, and PPE to provide proactive recommendations for system improvement.

METHODS

This study was a cross-sectional web-based assessment of COVID-19 pandemic preparedness of EDs in NZ via survey of ED senior medical officers (ED SMOs) from the EDs of all NZ District Health Boards (DHBs).

Questionnaire Design. A 27-item questionnaire was framed around the hierarchy of control model with questions on engineering (negative flow isolation rooms, shared/cohorted patient areas, segregated patient flow, physical distancing), administrative controls (policies for rostering, training, simulations, treatments, and breaches), and personal protective equipment (supply, fit testing, use and re-use).(8, 10, 19) Likert scale questions evaluated consultant ability to physically distance and respond to a future surge. Questions were adapted for the ED from a published survey of preparedness in intensive care units (ICUs) of Australasia and the prospective COVID Evaluation of Risk in Emergency Departments (COVERED) Project in the U.S.(20, 21) These questions were previously validated by those investigators using established

survey methodology.(22) ED specific modifications of our survey were checked for clarity and vernacular specific to NZ with at least 2 test surveys of ED, microbiology and infectious disease specialists, and of a primary investigator from each of the studies mentioned above.

Survey Distribution. The survey was distributed by email to 422 members of the Association of Salaried Medical Specialists (ASMS) identified as having emergency medicine as their designated department of work using Survey Monkey (San Mateo CA, USA) between 26 October 2020 and 23 November 2020. Two e-mail reminders were sent. Participation was voluntary. The study was considered exempt from the institutional review board by the NZ Health and Disabilities Ethics Committees.

Data Analysis. The data analysis was primarily descriptive and reported as percentages of valid responses. Diverging stacked Likert scales are used to display emergency specialist opinion results. The survey is included as a supplementary file'.

Patient and Public Involvement. Patients or members of the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

One-hundred thirty-seven surveys were completed (32% response rate). All (100%) of 20 NZ DHBs were represented by at least 2 individual SMO surveys. Surveys were returned from 24 emergency departments representing smaller regional to major urban tertiary hospitals. Nine (6.6%) respondents did not identify a DHB.

Engineering: The majority of respondents have access to negative flow or negative pressure patient care rooms (Table 1). Most (115, 83%) report 4 or fewer such rooms in their ED, but 14 (12 %) ED specialists reported no access to negative flow rooms for COVID-19 patient care. Most respondents (99, 77%) worked in EDs that have some beds separated only by curtains with shared air circulation where patients may be cohorted. Most (101, 74%) surveyed emergency consultants work in EDs which can create physical separation of care areas for high index of suspicion (HIS) patients segregated from those for presumed low index of suspicion (LIS) patients. Emergency consultants from multiple DHBs commented that ED segregated flow or "streaming" can be changed with COVID-19 prevalence and alert level.

Table 1: Summary table of select NZEDC19 Preparedness Survey answers

CONTROL	SPECIFIC HIERARCHY OF CONTROL QUESTION	N	%
ENGINEERING	Have negative flow/pressure rooms in ED	123	88%
	Have cohorted beds in ED	99	77%
	Segregated COVID/non-covid patients in ED	101	74%
	Rostered to see both COVID/non-COVID as needed	70	60%
	Unable to meet physical distance requirements at office	94	70%
	Unable to meet physical distance requirements at workstation	118	87%
	Unable to meet physical distance requirements at break rooms	92	71%
POLICY	Intubate LIS patient in negative pressure	6	4%
	Intubate HIS patient in negative pressure	88	64%
	Dedicated intubation teams ICU/anaesthesia	57	47%
	Intubation of HIS/COVID with video laryngoscopy	98	71%
	Use HFNC for hypoxic COVID-19 patients	53	50%
	Use NIV for hypoxic COVID-19 patients	101	86%
	Use NIV with in-line expiration viral filter	19	16%
	No PPE training	3	2%
	PPE group training in-person with observed practice	66	37%
	PPE individual training in-person with observed practice	40	23%
	Simulation training of intubation in COVID-19 patient	93	70%
	Simulation training of NIV in COVID-19 patient	61	46%

	Simulation training of self-proning in COVID-19 patient	17	13%
	Not monitored during donning PPE	39	30%
	Not monitored during doffing PPE	44	34%
PPE	Not N95 fit tested by time of this survey	15	12%
	Fit tested by qualitative method (odour or taste)	82	60%
	Fit tested by quantitative method (machine sampling)	41	30%
	Wear N95 for HIS/COVID patient not receiving AGP	61	48%
	Wear N95 or PAPR for AGP of HIS/COVID patient	110	87%
	N95 masks unavailable	6	6%
	Re-use N95 masks without sterilization	12	11%
	Re-use N95 masks after sterilization	3	3%
	Elastomeric respirators unavailable	63	66%
	PAPRs unavailable	79	82%

Most respondents (118, 87%) did not feel they could meet minimum physical distancing requirements in their workplace and disagree or strongly disagree that physical distancing is possible (Figure 1).

Administrative controls: Policy rostering ED consultants into either strictly "COVID" or "non-COVID" teams is not common and the majority (n=70, 60%) see these patient populations during shifts. Almost all (98%) of NZ ED consultants report having training for proper transmission-based PPE use with 60% having had in-person sessions being observed donning and doffing by the instructor. In practice, NZ emergency specialists report donning observation is rarely (18%) mandatory and about a third (30%) do not have an observer present. Only 16% report mandatory observation during removal while a third (34%) are not usually observed doffing PPE. Greater than half of the NZ emergency consultant workforce surveyed are not aware of an official breach-of-PPE policy in their hospital ED or breach criteria.(23) Simulation training is common in NZ for patient intubation (93, 70%). Less common simulations are

performed for non-invasive ventilation (61, 46%) and are rare for patient self-proning (17, 13%). Only half (54%) of specialists report HFNC availability, but 14% would not use this technology at all. Half (55%) of ED specialists say they can utilize NIV (CPAP/BiPAP) but only 16% report using viral expiration filters, a low-cost recommended infection control. NIV is not used outside negative pressure rooms and only 4% transfer to ICU for this modality. The majority of specialists report wide discretion in their ability to apply NIV to COVID-19 patients and just 15% reserve it only for patients with comorbidities (COPD, CHF, etc.) known to benefit. Sixty-four percent of consultants would intubate HIS/COVID-19 patients in a negative pressure room. Very few (4%) would intubate patients screened as LIS/non-COVID-19 patients under negative pressure. The lack of adequate staffing levels during the pandemic is cited as the greatest concern for two-thirds of respondents. Having adequate PPE and adequate testing capacity if a future wave of COVID-19 occurred in NZ were less concerning for respondents (Figure 2).

Personal protective equipment: New Zealand emergency consultants report few shortages of consumable PPE and have had little experience with reusing PPE, except washable face shields and goggles (Table 1). Low reuse of N95 masks either without sterilization (9%) and after sterilization (2%) further supports that respondents felt PPE supplies were adequate. Few respondents reported use of elastomeric respirators (2%) and powered air-purifying respirators (PAPRs) (2%).(24, 25) Only 89% of respondents had been fit tested for N95 masks at the time of this survey, leaving approximately 11% of ED consultants surveyed having not been fit tested by November 2020. Half of these (7/15) were from one hospital.

Best practice for ED consultant use of transmission based PPE was assessed in different clinical scenarios as shown in (Table 2). Only 83% of respondents reported they would use N95

respirators in the context of aerosol generating procedures (AGP), with an additional 4% protected with elastomeric mask or PAPR. Thirteen percent of respondents would not use a respirator (N95 mask, elastomeric mask or PAPR) for a HIS/COVID-19 patient receiving an AGP.

Table 2: PPE chosen by EDSMOs ED Consultants for various clinical scenarios.

PPE	Non-patient care	Tea room	Toilet	LIS	HIS	HIS + AGP
Face shield	1%	0%	2%	4%	71%	75%
Safety glasses/goggles	1%	0%	1%	12%	79%	76%
Surgical masks	31%	9%	10%	61%	71%	34%
Reusable fabric masks	2%	1%	1%	2%	6%	5%
N-95 masks/respirators	0%	0%	1%	6%	48%	83%
Elastomeric respirators	0%	0%	0%	0%	3%	2%
PAPR	0%	0%	0%	0%	1%	2%
Disposable surgical hat	0%	0%	1%	2%	25%	29%
Reusable surgical hat	0%	0%	1%	4%	7%	7%
Disposable gown	0%	0%	1%	13%	87%	84%
Impermeable suit	0%	0%	0%	2%	6%	7%
Gloves	2%	0%	1%	52%	90%	83%
Double gloves	0%	0%	0%	1%	21%	25%
Foot coverings	0%	0%	0%	1%	16%	13%

Low (LIS) or high (HIS) index of suspicion for COVID-19. Aerosol generating procedure (AGP). Non-patient care areas include areas in ED for charting, making telephone calls, etc.

PPE practice preferences vary when caring for either a High or Low Index of Suspicion patient while not performing an AGP. For a HIS/COVID-19 patient without an AGP consultants report N95 use of 48%, the rest using surgical mask alone or over N95. When seeing a LIS patient and no AGP, 6% report using an N95 respirator. Two-thirds (69%) wear some type of mask seeing LIS patients and one third of emergency consultants surveyed see LIS patients in their ED without a mask. While working outside of direct patient care but still in the hospital one third of

ED SMOs wear a surgical or reusable fabric mask. Toilets may present a unique risk for droplet and possibly faecal-airborne transmission yet only 10% report using masks in toilets.(26, 27)

A summary rank-ordered list by ED consultants' assessment of their most likely source of exposure to COVID-19 identified "wearing inadequate PPE for patients not suspected of COVID-19 infection", followed by "contracting it from fellow staff members" or "accidental doffing exposure" as the top three most likely routes of nosocomial infection. Consultants were less concerned about inadequate N95 mask fit testing or the lack of appropriate training or PPE for co-workers such as housekeeping staff (Table 3).

Table 3: Rank the most likely reason that you think puts you at risk of exposure to COVID-19 at work? (1 for most likely, 8 for least likely)

RANK	RISK	MEAN	95% C.I.
1	Wearing inadequate PPE for patient(s) not suspected of COVID-19	2.9	2.6-3.3
2	Contracting it from a fellow staff member in the ED	3.1	2.7-3.4
3	Accidental PPE doffing exposure	3.5	3.1-3.9
4	Wearing inadequate PPE for patient(s) suspected of COVID-19 infection	3.7	3.3-4.0
5	Not being able to access adequate PPE	4.4	4.0-4.9
6	Inadequate mask fit testing for staff	5.6	5.2-6.0
7	Cleaners have been provided inadequate training and/or inadequate PPE	5.7	5.3-6.0
8	Not applicable- I do not fear risk of COVID-19 exposure at work	6.6	6.0-7.1

Confidence interval (C.I.)

DISCUSSION

This study assesses the preparedness of EDs around Aotearoa New Zealand for the eventual reintroduction of SARS-CoV-2. (28) Survey results identify weaknesses in local NZ hospital infection control practices which have been cited as risks in prior outbreaks in other countries.(5, 8, 13) Eight months following declaration of the pandemic in March 2020, these responses from NZ ED specialists reveal incomplete ED engineering upgrades to provide them negative flow rooms or portable HEPA filtration, the continued use of curtained patient bed bays with shared circulation and crowded work environments inconsistent with recommendations for physical

distancing. Results also indicate variations in pandemic specific administrative policy, adherence and practice. In particular, inconsistent monitoring of donning and doffing of PPE as well as limited adoption of recommended treatments such as HFNC and NIV. Although reported N95 mask shortages were rare, not all respondents would use a respirator in the high risk setting of a HIS/COVID-19 patient receiving an AGP. Finally, infection control through PPE may be compromised by the finding that about one-tenth of ED consultants reported not being fit tested for N95 masks as late as November 2020. NZ guidelines for PPE were slow to accept airborne transmission stating: "The route of transmission of SARS-CoV-2 continues to be an area of debate in the medical and scientific community" as recently as August 2020. When elimination of SARS-CoV-2 fails and adequate community-wide immunity has not been established it is these proven layers of inhalation dose reduction that are needed to curb nosocomial spread and prevent health-care capacity compromise.

Engineering controls should provide enough adequately ventilated negative pressure rooms, or at least negative directional airflow, to allow for treatment of multiple respiratory isolation patients. Negative flow dilutes contaminated air breathed by HCWs caring for patients with airborne transmissible infections. DHBs should prioritise ED patient areas with a greater number of room air changes per hour (ideally 6-12 ACH), and greater proportion of fresh (vs recycled) air or consider portable HEPA filter units if airflow is inadequate.(7, 18) The finding that 12% of consultants report no access to at least one negative flow room, mostly in smaller peripheral hospitals, suggests NZ DHBs have not equitably upgraded all EDs.

Control of bed-allocation during a COVID-19 surge reiterates issues common to emergency systems chronically plagued by over-crowding and limited resources.(29) Somewhat unique to a

respiratory pandemic, patients with suspected COVID-19 may compromise the capacity to protect other patients from exposure. Because of this, single rooms to isolate suspected cases or protect vulnerable non-infected patients become a premium. The delay between clinical suspicion and confirmatory test results can further prolong lengths of stay such that available, rapid SARS-CoV-2 testing must be a priority.(30) Our results show most NZ suspected COVID-19 patients are streamed to separate ED areas or wards away from others where possible. Although recommended as an important ICP control, placing patients in LIS or HIS streams relying only on an unvalidated pre-triage screening set of questions and not rapid antigen or nucleic testing ignores the lessons learned from asymptomatic spread in this pandemic. In some instances there may be pressure to cohort patients in multiple bed bays with shared air circulation. In this study, three quarters of NZ specialists report having ED patients cohorted with shared ventilation and only curtains separating beds. Based on overseas experience, large numbers of COVID-19 patients in confined spaces may create a high density of aerosols and cause HCWs to stay longer as they attend each patient increasing their risk. Best practice reduces patient density to one per room (even if in a 2 or 4 bed bay) and mandates airborne PPE for staff in these situations.(8, 31, 32) Conversely, use of multi-bed bays to cohort presumed Non-COVID patients risks misidentifying the asymptomatic or presymptomatic patients as safe to collocate with other uninfected individuals.(30) This has resulted in verified nosocomial infections in 39% of uninfected roommates by whole-genome sequencing confirmation of cluster association (33, 34) Masking of patients and well ventilated or HEPA filtered areas may decrease this risk but evidence is limited.(35)

Although much attention is directed toward patient-to-HCW transmission, literature has identified HCW transmission to patients and to other HCWs and many of these nurses or doctors

had no symptoms reiterating the importance of maintaining physical distancing and mask wearing in non-clinical areas when SARS-CoV-2 is circulating.(36, 37) Ranking this risk second in Table 2 suggests most NZ ED specialists may be aware of this concern. Despite recommendations to maintain physical distancing in non-clinical work areas most (86%) of NZ specialists disagreed that their ED workstations were engineered for adequate room (Figure 1). This illustrates how the lack of resources, physical space or personnel can undermine administrative efforts to protect staff and patients from exposures.

Administrative policy involves institution of rules that change how health care workers behave, it alters work flow and implements infection control protocols. Success may depend on dissemination of guidelines, staff confidence in recommendations, or practice. This can be undermined by poor messaging, mistrust or when case counts are low and the risk no longer justifies the effort. Vaccination may also create a sense that these other controls are not needed. Initial training for PPE use was universal (97%) but ongoing interval training was not common nor was mandatory observation during donning or doffing as recommended in the literature.(16) Training (baseline and refreshers) and monitoring policy for PPE use (spotters) for all clinical and non-clinical staff is not standardized across DHBs (Table 1). Simulations to practice skills (such as intubation and NIV use) and accommodate for PPE are variably applied in NZ.(16) Experience in other countries has shown HCW PPE breaches, exposures and infections cause large numbers of staff furloughs, worsening nurse to patient ratios and causing the remaining staff to experience high workloads.(8, 38, 39) Maintaining a healthy skilled workforce is paramount to offset predicted inadequate staffing. A proactive approach should be used to support infected and furloughed staff wellbeing, with dedicated nursing and medical staff

monitoring physical and mental health and providing support. Given the gravity of HCW infection and the system failure it implies, every suspected healthcare associated infection should trigger a bundle of immediate infection control measures.(40)

Among the strongest recommendations in the literature regarding prevention of HCW nosocomial infection is to "decant" or decrease overcrowding of COVID-19 patients in EDs and wards.(8) Ensuring a manageable workload through adequate staffing ratios by anticipating the increased care required for these infectious respiratory failure patients is paramount. This may also prevent the added fatigue HCWs face secondary to PPE compliance, doffing observation, and decontamination of providers and work environment. These additional tasks are not being calculated into traditional bedside severity scores and underestimate nursing ratios.

Personal Protective Equipment places a barrier between the HCW and the infectious agent (the principal example being respirators and other masks) and are considered the final and least effective control measure because it relies on consistent individual action at the point of care.(10) PPE should be implemented through clear guidelines and be current with peer reviewed literature and expert recommendations.(20, 34, 41, 42) The NZ Ministry of Health (MoH) last updated PPE recommendations August 2021 and these do not promote use of N95 respirators outside of HIS/COVID-19 patients receiving AGPs or during lockdowns but still allow surgical masks to be used caring for HIS/COVID-19 patients at lower community prevalence.(42)

The scientific community has acknowledged transmission through inhalation of small airborne particles as a significant mode of SARS-CoV-2 virus transmission.(34, 40, 43, 44) These studies demonstrate aerosols produced through breathing, talking, coughing and yelling can remain in air and viable for long periods of time, travel long distances within a room and sometimes farther

depending on ventilation. The experience in The Royal Melbourne Hospital City Campus outbreak noted that "aerosol generating behaviour" (AGB) in infected patients appeared to be linked to transmission events.(8) Patients shouting, vigorous coughing, cognitive impairment and combative behaviour, actions common in ED patients, should mandate airborne precautions equivalent to AGPs.(34, 38) Yet fit testing of N95 respirators, in line with other nations' health and safety legislation, was late to be initiated in NZ, and for at least 15 consultants (11%) was still not available at the time of this survey.(16, 20) Small peripheral facilities, as was the case for negative flow rooms, appear to be less prepared.

In the scenario-based PPE questions (Table 2), the finding that up to 13% of NZ ED consultants would not choose an N95 respirator, elastomeric or PAPR in the context of an aerosol generating procedure (AGP) for a HIS/COVID-19 patient was unexpected and raises concern. Given the low prevalence of SARS-CoV-2 in NZ, the probability of an HIS patient being infected is low, but not zero. Some ED consultants may argue N95s are not necessary due to elimination efforts or may believe they are still in short supply. But the omission of this recommended PPE could be interpreted as a purposeful disregard of evidence based pandemic IPC practice or a deliberate ignorance of why these policies exist. In a pandemic, an individual's choice to forgo personal protection does not just take the risk for themselves, but for the community of others on their health care team, the other patients they care for, and their families and close contacts. Instituting and maintaining a standardized observer system and breach protocols should remedy this issue and may help promote a culture of staff safety, risk and adverse event reporting and staff support.

NZ has enjoyed near SARS-CoV-2-free medical practice but sporadic reintroduction has occurred with HCW infection and risking transmission during aerosol generating procedures is

an unconscionable breach of infection prevention and control even if vaccinated.(14) This will have to change as SARS-CoV-2 is reintroduced.

Our survey has several limitations. It was a cross-sectional study and relied on voluntary, self-reported data from ED consultants only. Email addresses were obtained from ASMS (n=422) and were not verified as still active. Although the rate of returned surveys from 137 ED consultants was 32%, all 20 DHBs representing 25 EDs returned surveys increasing the representativeness of the sample. Respondent characteristics were not collected to protect individual anonymity and promote candour. COVID-19 NZ ED presentations were variable by hospital location and respondent experience with direct patient care was not included in survey design. COVID-19 infection prevention and control policies and practices may vary significantly among different types of facilities and/or those in different DHBs. Despite these limitations, this study may be useful to EDs or other acute care settings throughout the Australasian-Pacific region where elimination was successful but now need to examine their preparedness as endemic Delta Variant spread becomes imminent.

CONCLUSION

These survey results from NZ ED consultants identify potential risks of failure in the hierarchy of infection controls currently in place to prevent nosocomial spread of SARS-CoV-2 or future emerging infections. Our findings show that engineering upgrades to respiratory pandemic standards are not prevalent, administrative COVID-19 policy has not adapted to scientific advances seen in policy from other healthcare systems (ie. Australia), and PPE current practice reveals high variability suggesting poor dissemination of guidelines, low confidence in recommendations, or little practice because of low prevalence. NZ's public health success in

SARS-CoV-2 elimination and the promise of protective immunity through vaccines has allowed for a relaxation of other layers of inhalation dose reduction even as evidence-based practice supporting them has evolved. As New Zealand borders reopen and crowded and under resourced emergency departments face endemic COVID-19, it would be prudent to use lessons learned elsewhere to identify local ED weaknesses and better prepare them to protect their patients and care givers in this approaching phase of the pandemic.

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Ethics Statement: A waiver of ethical approval was received from Health and Disability Ethics Committee from the New Zealand Ministry of Health

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Figure Legends:

Figure 1: Are you able to meet minimum physical distancing requirements in certain non-clinical areas of the ED?

Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following:

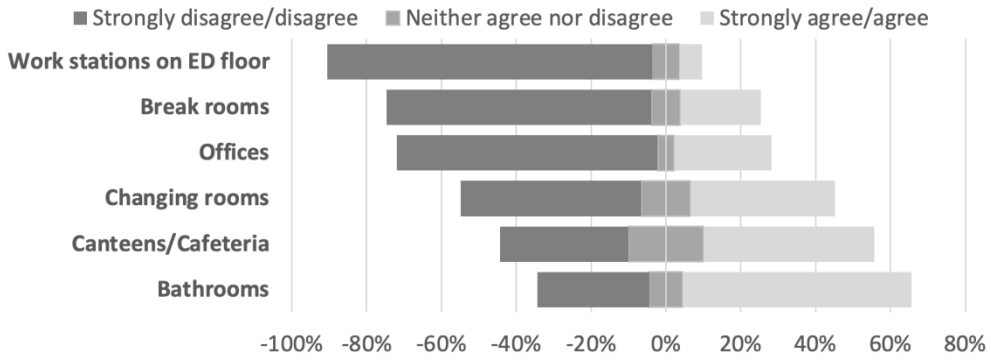


Figure 1: Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?

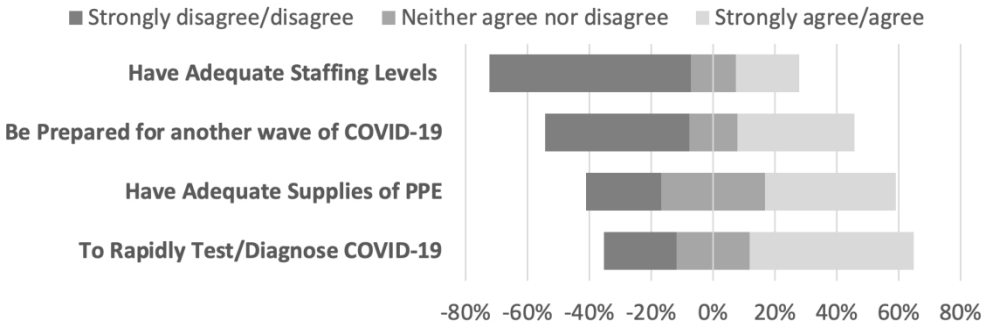


Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following:

Introduction

The NZED COVID-19 Preparedness Survey focuses on your safety and well-being during the COVID-19 pandemic.

The questions are peer-reviewed and created with the help of emergency specialists and infectious disease experts focused on health care worker safety and well-being.

We hope the results from this research will enable dialogue as to best infection control measures, and assist with standardising local protocols with the aim of minimising risk of nosocomial COVID-19 infections in the Emergency Department (ED).

ASMS understands that your commitment to the welfare of your patients and colleagues is predicated on your ability to focus on providing the best medical care in the safest possible work environment. We understand this requires practice and preparation.

Please take this opportunity to relate the current and proposed practices in your ED and share your opinions and thoughts.

If you have any questions regarding this research, please do not hesitate to contact Dr Charlotte Chambers at ASMS: CC@asms.nz

Thank you for your time.

Emergency Department (ED) Facility Characteristics

1. **Where is your primary place of work?**

2. **Do you have any negative pressure beds in your ED and if so, how many?**

For the purposes of this survey, a negative pressure or negative flow bed is defined as any bed in single or multiple rooms with minimum of 6 air changes per hour with or without an ante room.

- We don't have any negative pressure beds in our ED
- 1-4
- 5-9
- 10-14
- 15-19
- 20 or more
- Other (please specify)

3. **How many beds in your ED at the time of this survey are in shared rooms for cohorted patients**

For the purposes of this survey shared rooms are defined as large rooms with multiple curtained beds

- 1-4
- 5-9
- 10-14
- 15 or more
- I'm not sure
- None
- Other (please specify)

4. **When you have either confirmed COVID-19 patients or high index of suspicion (HIS) patients entering your ED do you treat them in a separate area (separate flow/segregated ED)?**

- ◯ Yes
- ◯ No
- ◯ Not applicable
- ◯ I'm not sure
- ◯ Other (please specify)

5. **Some EDs may be segregated into COVID and Non-COVID areas for patient care. How would you expect to be personally rostered in your ED?**

- ◯ We don't have a segregated ED
- ◯ I will be treating COVID patients only
- ◯ I will be treating Non-COVID patients only
- ◯ I will see both, alternating between them as needed
- ◯ I'm not sure
- ◯ Comment:

6. **Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Not applicable
Offices	◯	◯	◯	◯	◯	◯
Work stations on ED floor	◯	◯	◯	◯	◯	◯
Break rooms	◯	◯	◯	◯	◯	◯
Bathrooms	◯	◯	◯	◯	◯	◯
Changing rooms	◯	◯	◯	◯	◯	◯
Canteens/Cafeteria	◯	◯	◯	◯	◯	◯

Comments:

PPE training and fit testing

1. **What type of training have you had in the use of PPE at your current place of employment?**

Please select all that apply from the following:

- [ ] None - I have not completed any online training or employer required/directed training
- [ ] Self-taught using online training (video, reading material)
- [ ] In-person group demonstration in which I only watched
- [ ] In-person group session in which I practiced putting PPE on and removing it properly
- [ ] In-person individual demonstration in which I only watched
- [ ] In-person individual session in which I was observed putting PPE on and removing it properly
- [ ] Other (please specify)

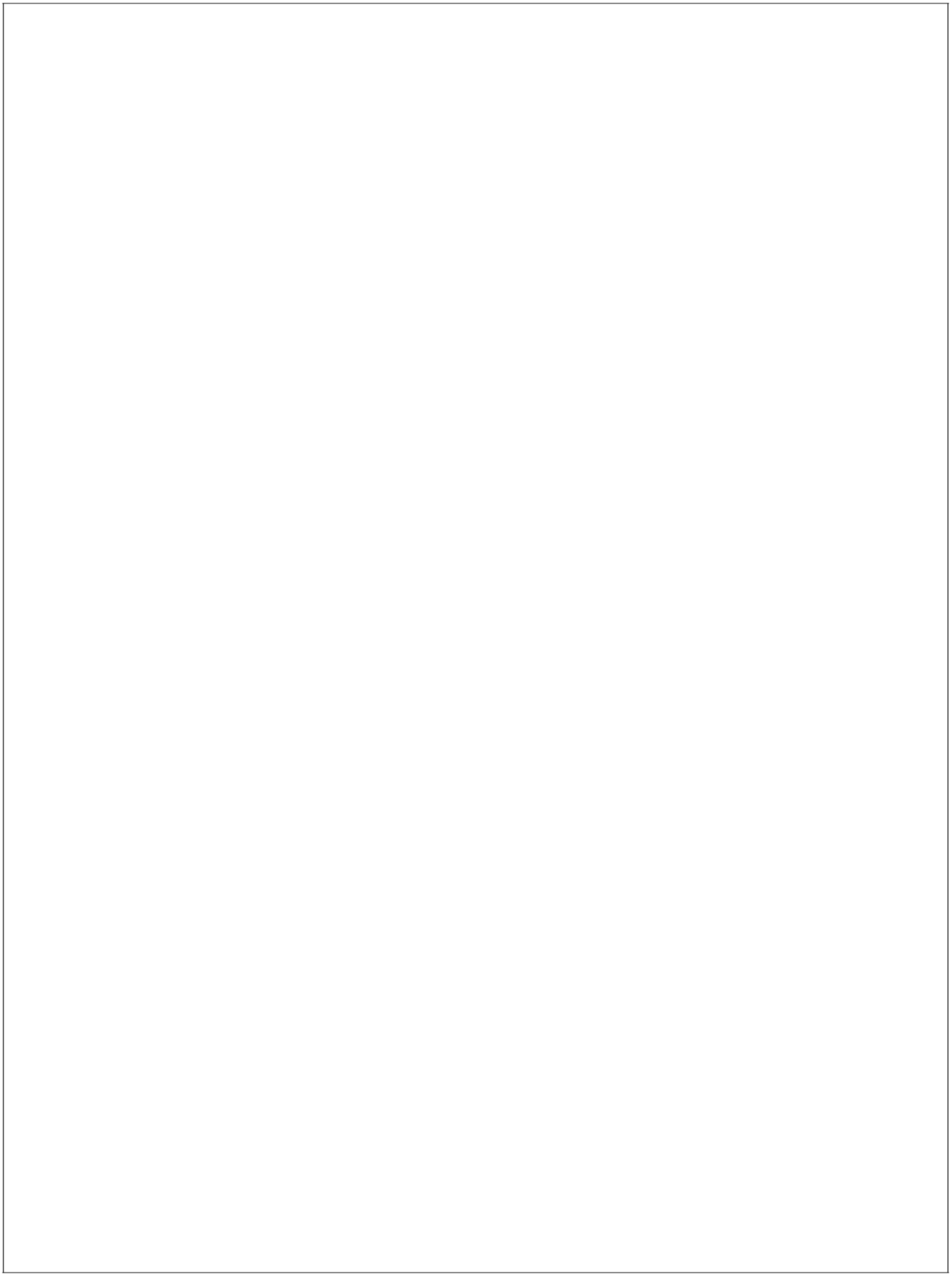
2. **Approximately, how frequently are you trained in any of the following activities?**

	Upon request	Never	Once	Annually	I'm not sure
Training for donning and doffing PPE	○	○	○	○	○
Simulation sessions on intubating COVID patients	○	○	○	○	○
Simulation session for non-invasive ventilation (NIV: CPAP, HFNC)	○	○	○	○	○
Simulation sessions on awake/self prone positioning of COVID patients	○	○	○	○	○
Simulation sessions on transporting COVID patients	○	○	○	○	○

Other (please specify)

3. If you have been fit tested with a N-95 mask/respirator within the last 12 months, what method was used to determine fit?

- ○ Not applicable; I have not been fit tested within the last 12 months
- ○ Qualitative (odour or taste detection in hood)
- ○ Quantitative (machine sampling via tubing)
- ○ I'm not sure
- ○ Other (please specify)



PPE Scenarios

1. **What personal precautions are you currently using in the following settings?**

Please select all that apply from the following:

	When in your ED but not providing patient care (charting, making telephone calls)	When in your Break/Tea Room (eating, conversing with colleagues)	When in your ED providing care for a non-COVID-19 low index of suspicion (LIS) patient	When in your ED providing care for COVID-19 HIS or confirmed patient	When within 2m of an aerosol-generating procedure for a confirmed or HIS COVID-19 case	When using the bathroom facilities
Standard precautions (handwashing, distancing from others)	☐	☐	☐	☐	☐	☐
Face shield	☐	☐	☐	☐	☐	☐
Safety glasses/goggles	☐	☐	☐	☐	☐	☐
Surgical masks	☐	☐	☐	☐	☐	☐
Reusable fabric masks	☐	☐	☐	☐	☐	☐
N-95 masks/respirators	☐	☐	☐	☐	☐	☐
Elastomeric respirators	☐	☐	☐	☐	☐	☐
Powered air-purifying respirator systems (PAPR CAPR)	☐	☐	☐	☐	☐	☐
Disposable surgical hat	☐	☐	☐	☐	☐	☐
Reusable surgical hat	☐	☐	☐	☐	☐	☐
Standard disposable isolation gown	☐	☐	☐	☐	☐	☐
Full-body impermeable suit	☐	☐	☐	☐	☐	☐
Gloves	☐	☐	☐	☐	☐	☐
Double gloves	☐	☐	☐	☐	☐	☐
Foot coverings	☐	☐	☐	☐	☐	☐

Other (please specify):

2. **Does your ED have a formal policy on showering/shampooing after caring for COVID-19 patients?**

	Mandatory	Not mandatory	Not practical as we have limited facilities	We don't have shower facilities	Not aware of a formal policy
Immediately after every single patient-contact episode	○	○	○	○	○
Only if PPE was breached	○	○	○	○	○
At the end of the shift	○	○	○	○	○
After reaching home	○	○	○	○	○

Comment:

3. **In your ED, is PPE donning monitored by an observer prior to care for COVID-19 patients?**

- ○ Yes, all the time (mandatory)
- ○ Yes, some of the time (ad-hoc)
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

4. **In your ED, is PPE doffing (removal) monitored by an observer to identify breaks in doffing technique after care for COVID-19 patients?**

- ○ Yes, all of the time (mandatory)
- ○ Yes, some of the time (ad-hoc)
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

Policies and practices for patients with suspected COVID-19

1. **For endotracheal intubation, which of the following (if any) is your ED using all or most of the time for patients with:**

Please select all that apply from the following:

	Low Index of Suspicion for COVID-19	High Index of Suspicion/Confirmed COVID-19
Negative pressure bed (bed with minimum of 6 air changes per hour)	☐	☐
Video laryngoscopy	☐	☐
Intubation barrier protection (e.g., intubating boxes , intubating bags, etc.)	☐	☐
Intubation barrier protection with integrated suction (e.g., intubating boxes connected to suction; negative pressure hood)	☐	☐
Intubation response teams (with dedicated staff)	☐	☐
Intubation through a supraglottic device (e.g., intubating LMA, etc.)	☐	☐
None of these	☐	☐

Other (please specify)

2. **Does your ED have a dedicated intubation team for confirmed or suspected COVID-19 patients?**

- ○ Yes, consisting of ICU/Anaesthesia responding to ED
- ○ Yes, consisting of ICU/ED formalised
- ○ Yes, ED only
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

3. **For patients with confirmed or suspected COVID-19, is your ED practice/protocol that patients will be treated with high-flow nasal cannula (HFNC), if needed?**

- ◯ Yes
- ◯ No
- ◯ I'm not sure
- ◯ We don't have a formal protocol
- ◯ Comment:

4. **For ED patients with confirmed or suspected COVID-19, is your ED practice/protocol that patients will be treated with non-invasive positive pressure ventilation (NIV, including CPAP or BiPAP), if needed?**

- ◯ Yes, in any area in the ED
- ◯ Yes, only in a negative flow/pressure room in ED
- ◯ Yes, only with in-line or expiration viral filter in negative flow/pressure room in ED
- ◯ Yes, only after transfer to the ICU if appropriate
- ◯ No
- ◯ We don't have a formal protocol
- ◯ Other (please specify)

5. **For confirmed or suspect COVID-19 ED patients, under what circumstances might NIV (including CPAP or BiPAP) be used in your ED?**

Please select from the following:

- ☐ Any patient with respiratory failure that I think will benefit from NIV if indicated (NIV: CPAP/BiPAP)
- ☐ Only patients that have other co-morbidities known to benefit from NIV (eg. COPD, CHF, OSA)
- ☐ Only patients who have a "Do Not Intubate" or a "Do Not Resuscitate" order
- ☐ Only when mechanical ventilators are scarce
- ☐ Other (please specify)

PPE Breaches

1. **Please select from the following scenarios what constitutes a 'Breach in PPE' in your Emergency Department**

	Breach	Not a breach	Not aware of formal policy
Inadequate face protection	○	○	○
Inadequate eye protection	○	○	○
Improper donning/doffing	○	○	○
Exposure of skin due to a glove or gown tear	○	○	○
Inadequate shoe cover	○	○	○
Direct contact of skin to any secretion	○	○	○
Needle stick	○	○	○
Poor mask fit	○	○	○

Other (please specify)

2. **What measures have been advised by your hospital/ED administration when a PPE breach has been identified?**

	Mandatory	Optional	Not aware of a formal policy
Shower immediately	○	○	○
Report to ID/designated authorities	○	○	○
Retraining given for donning or doffing	○	○	○
Quarantine with testing protocol	○	○	○

Other (please specify)

PPE supply and re-use

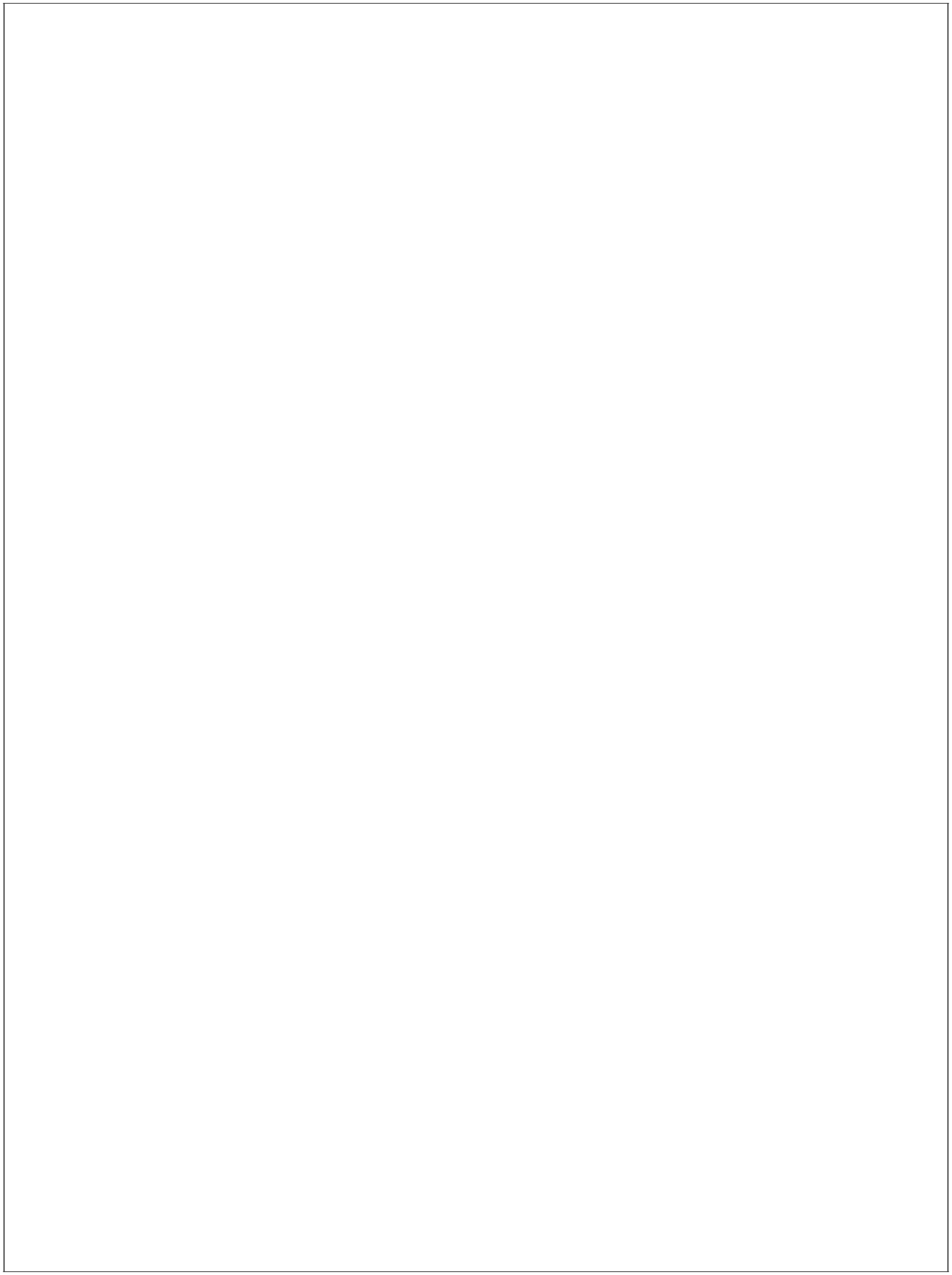
1. **At the time of this survey, please select from the following any PPE that is out of stock or otherwise unavailable for clinical use in your ED:**

- [ ] Reusable face shields
- [ ] Disposable face-shields (single use)
- [ ] Safety glasses/goggles
- [ ] Surgical masks
- [ ] Reusable fabric masks
- [ ] N-95 masks/respirators
- [ ] Elastomeric respirators
- [ ] Powered air- purifying respirator systems (PAPR, CAPR, etc.)
- [ ] Disposable surgical hat
- [ ] Reusable surgical hat
- [ ] Standard disposable isolation gown
- [ ] Full-body impermeable suit
- [ ] Gloves
- [ ] Foot coverings
- [ ] Other (please specify)

2. **Have you ever re-used PPE equipment according to any of the following scenarios?**

	Yes	No	I'm not sure
We re-use N-95 masks without sterilization	○	○	○
We re-use N-95 masks after sterilization	○	○	○
We re-use face shields without washing with cleaning solution	○	○	○
We re-use face shields after washing with cleaning solution provided	○	○	○
We re-use goggles without washing with cleaning solution	○	○	○
We re-use goggles after washing with cleaning solution provided	○	○	○

Other (please specify)



Your views

1. **Which of the following best describes your level of confidence in your ED's PPE protocol?**

	During Level 4 Lockdown	At the time of this survey
I am/was confident that our PPE protocol will keep me completely safe	☐	☐
I think my ED's protocol put me at risk and that I should have better PPE than is available, or use PPE more often than required by protocol	☐	☐
I think my ED's PPE protocol is too restrictive, and I feel that I can safely practice without wearing PPE every time that it is required by protocol	☐	☐
I am/was unsure about the safety of our PPE protocol and feel neither safe or unsafe	☐	☐
I am/was not aware of a PPE protocol in my ED	☐	☐

Other (please specify)

2. **At the time of the initial COVID-19 outbreak in New Zealand (during level 4 lockdown), please consider how you felt about the following:**

	Never	Rarely	Sometimes	Often	Always
I worried that family members or other close contacts were at risk of exposure to COVID-19 because of my work	○	○	○	○	○
I worried that I was at risk of exposure to COVID-19 because of my work	○	○	○	○	○
I worried about the level of preparedness of my hospital and ED	○	○	○	○	○
I worried about the supply of adequate and appropriate PPE in my ED	○	○	○	○	○
I felt anxious and stressed because of COVID-19	○	○	○	○	○

Other (please specify)

3. **Please answer the following questions regarding your views on how prepared your ED would be if there was another wave of COVID-19 in New Zealand**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Our ED is prepared and ready for another wave of COVID-19	☐	☐	☐	☐	☐
Our ED would have adequate staffing levels if there was another wave of COVID-19	☐	☐	☐	☐	☐
Our ED would have adequate supplies of appropriate PPE if there was another wave of COVID-19	☐	☐	☐	☐	☐
We would be able to rapidly test and in a timely manner diagnose possible cases of COVID-19	☐	☐	☐	☐	☐

Other (please specify)

4. **Do you feel you are at risk of infection from COVID-19 at work?**

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
○	○	○	○	○

Other (please specify)

5. **If you feel you are at risk of COVID-19 infection AT WORK, please rank the most likely reason that you think would put you at risk of exposure to COVID-19?**

Please select 1 for the most likely reason through to 8 as the least likely.

- ☐ Not applicable- I do not fear risk of COVID-19 exposure at work
- ☐ Not being able to access adequate PPE
- ☐ Wearing inadequate PPE for patient(s) not suspected of COVID-19 infection
- ☐ Wearing inadequate PPE for patient(s) suspected of COVID-19 infection
- ☐ Contracting it from a fellow staff member in the ED
- ☐ Accidental PPE doffing exposure
- ☐ Cleaners have been provided inadequate training and/or inadequate PPE
- ☐ Inadequate mask fit testing for staff

6. We would be grateful to hear your thoughts on any other aspects regarding the level of preparedness of your ED or the impact of COVID-19

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	N/A
Bias	9	Describe any efforts to address potential sources of bias	2
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	N/A
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	5
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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TITLE

New Zealand Emergency Department COVID-19 Preparedness: A Cross-sectional Survey and Narrative View

AUTHORS

Michael J. Howard MD PhD
Charlotte N. L. Chambers, PhD MSc
Nicholas M. Mohr MD MS

Author Affiliations:
1. Department of Emergency Medicine, Whangarei Hospital, Northland District Health Board, Whangarei, New Zealand, michaelhowardmd@gmail.com
2. Director of Policy and Research, Association of Salaried Medical Specialists, Wellington, New Zealand, charlotte.chambers@asms.org.nz
3. Department of Emergency Medicine, University of Iowa Carver College of Medicine, Iowa City, Iowa, nicholas-mohr@iowa.edu

Corresponding Author:
Michael J. Howard MD PhD, Whangarei Hospital Emergency Department, Northland District Health Board, Private Bag 9742 Maunu Road, Whangarei, 0148 New Zealand
michaelhowardmd@gmail.com

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ABSTRACT

Objective

Our objective was to assess the level of COVID-19 preparedness of emergency departments (EDs) in Aotearoa New Zealand (NZ) through the views of emergency medicine specialists working in district health boards around the country. Given the limited experience NZ hospitals have had with SARS-CoV-2, a comparison of current local practice with recent literature from other countries identifying known weaknesses may help prevent future healthcare worker infections in NZ.

Methods

We conducted a cross-sectional survey of NZ emergency specialists in November 2020 to evaluate preparedness of engineering, administrative policy, and personal protective equipment (PPE) use.

Results

A total of 137 surveys were completed (32% response rate). More than 12% of emergency specialists surveyed reported no access to negative pressure rooms. N95 fit testing had not been performed in 15 (12%) of respondents. Most specialists (77%) work in EDs that cohort COVID-19 patients, about one-third (34%) do not use spotters during PPE doffing, and most (87%) do not have required space for physical distancing in non-patient areas. Initial PPE training,

simulations and segregating patients were widespread but appear to be waning with persistent low SARS-CoV-2 prevalence. PPE shortages were not identified in NZ EDs, yet 13% of consultants do not plan to use respirators during aerosol generating procedures on COVID-19 patients.

Conclusions
New Zealand emergency specialists identified significant gaps in COVID-19 preparedness, and they have a unique opportunity to translate lessons from other locations into local action. These data provide insight into weaknesses in hospital engineering, policy, and PPE practice in advance of future SARS-CoV-2 endemic transmission.

Strengths and limitations of this study

- Survey responses specifically identified existing breakdowns in engineering, administrative policy and personal protective equipment in New Zealand emergency departments, potentially increasing healthcare worker nosocomial infection risk upon reintroduction of SARS-CoV-2
- Respondents included emergency specialists from all 20 of New Zealand's district health boards but the electronic convenience sample may not be representative of all ED consultants in NZ
- Some survey questions asked respondents to recall experiences or project how they would practice if they were caring for a COVID-19 patient
- Those motivated to respond may feel they have more or less access to protective policies and equipment than non-respondents

KEYWORDS
COVID-19, Cross-Sectional Studies, Emergency Service, Hospital, Infection Control, Infectious Disease Transmission, Patient-to-Professional

INTRODUCTION

The Aotearoa New Zealand (NZ) healthcare system was as unprepared for the coronavirus disease 2019 (COVID-19) pandemic as many nations, yet NZ successfully eliminated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).(1, 2) The decision to implement aggressive public health infection elimination practices hinged on NZ's ability to rapidly and effectively close its borders thus limiting COVID-19 impact to approximately 2600 cases and 26 deaths.(3, 4) As a result, NZ's Emergency Departments (EDs) have had little experience caring for COVID-19 patients and disparate efforts towards infection control preparedness may leave heath care workers (HCWs) vulnerable to nosocomial SARS-CoV-2 transmission.(5-8)

The Hierarchy of Control offers an algorithm to assess preparedness of a health system, scalable to departmental, hospital and nationwide recommendations.(8-10) Once elimination is established but eradication remains impossible there must be appropriate resources to institute and sustain substitution of the threat (typically by vaccination or other therapies). Even as vaccine-based immune protection expands there are still uncertainties requiring multiple controls to prevent transmission of SARS-CoV-2. Questions about viral variants that evade host immune responses, vaccine safety and efficacy in vulnerable groups (ie. young children, immunocompromised, elderly), and the impact of vaccine hesitancy indicate we will need to maintain layers of protection for some time into the future.(11) In addition to vaccination, pandemic ED response should continue focus on proven non-pharmaceutical interventions such as engineering (often through changes in ED physical layout, ventilation and bed allocation), administrative policy (infection prevention and control (IPC), workflow changes, training, resources), and transmission-based PPE. These practices demand equity, and the failure has resulted in healthcare worker (HCW) infections, disability and death.(8, 12-14)

The July-August 2020 outbreak in Melbourne, Victoria, Australia revealed deficiencies in hospital level IPC in a health system comparable to that of NZ.(15, 16) Unfortunately, this outbreak in long-term care facilities and subsequent nosocomial spread in tertiary hospitals resulted in significant SARS-CoV-2 infections in HCWs. The Australian response affords insight into improvements to adopt in other health systems.(8, 17, 18) The New Zealand Emergency Department COVID-19 (NZEDC19) Preparedness Survey of emergency consultants was designed to identify and address weaknesses in local NZ emergency department policy, engineering, and PPE to provide proactive recommendations for system improvement.

METHODS

This study was a cross-sectional web-based assessment of COVID-19 pandemic preparedness of EDs in NZ via survey of ED senior medical officers (ED SMOs) from the EDs of all NZ District Health Boards (DHBs). In order to encourage anonymous participation only DHB of employment was requested; respondent characteristics (sex, age, years of practice, ED location) were not gathered for the study sample.

Questionnaire Design. A 27-item questionnaire was framed around the hierarchy of control model with questions on engineering (negative flow isolation rooms, shared/cohorted patient areas, segregated patient flow, physical distancing), administrative controls (policies for rostering, training, simulations, treatments, and breaches), and personal protective equipment (supply, fit testing, use and re-use).(8, 10, 19) Likert scale questions evaluated consultant ability to physically distance and respond to a future surge. Questions were adapted for the ED from a

published survey of preparedness in intensive care units (ICUs) of Australasia and the prospective COVID Evaluation of Risk in Emergency Departments (COVERED) Project in the U.S.(20, 21) These questions were previously validated by those investigators using established survey methodology.(22) ED specific modifications of our survey were checked for clarity and vernacular specific to NZ with at least 2 test surveys of ED, microbiology and infectious disease specialists, and of a primary investigator from each of the studies mentioned above.

Survey Distribution. The survey was distributed by email to 422 members of the Association of Salaried Medical Specialists (ASMS) identified as having emergency medicine as their designated department of work using Survey Monkey (San Mateo CA, USA) between 26 October 2020 and 23 November 2020. Two e-mail reminders were sent. Participation was voluntary. The study was considered exempt from the institutional review board by the NZ Health and Disabilities Ethics Committees.

Data Analysis. Raw data was summarized in Excel and basic descriptive statistics were reported as percentages of valid responses. Diverging stacked Likert scales are used to display emergency specialist opinion results. The survey is included as a supplementary file although not all question responses were resulted here due to length limitations.

Patient and Public Involvement. Patients or members of the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

One-hundred thirty-seven surveys were completed (32% response rate). All (100%) of 20 NZ DHBs were represented by at least 2 individual SMO surveys. Surveys were returned from 24 emergency departments representing smaller regional to major urban tertiary hospitals. Nine (6.6%) respondents did not identify a DHB.

Engineering: The majority of respondents have access to negative flow or negative pressure patient care rooms (Table 1). Most (115, 83%) report 4 or fewer such rooms in their ED, but 14 (12 %) ED specialists reported no access to negative flow rooms for COVID-19 patient care. Most respondents (99, 77%) worked in EDs that have some beds separated only by curtains with shared air circulation where patients may be cohorted. Most (101, 74%) surveyed emergency consultants work in EDs which can create physical separation of care areas for high index of suspicion (HIS) patients segregated from those for presumed low index of suspicion (LIS) patients. Emergency consultants from multiple DHBs commented that ED segregated flow or "streaming" can be changed with COVID-19 prevalence and alert level.

Table 1: Summary table of select NZEDC19 Preparedness Survey answers

CONTROL	SPECIFIC HIERARCHY OF CONTROL QUESTION	N	%
ENGINEERING	Have negative flow/pressure rooms in ED	123	88%
	Have cohorted beds in ED	99	77%
	Segregated COVID/non-covid patients in ED	101	74%
	Rostered to see both COVID/non-COVID as needed	70	60%
	Unable to meet physical distance requirements at office	94	70%
	Unable to meet physical distance requirements at workstation	118	87%
	Unable to meet physical distance requirements at break rooms	92	71%
POLICY	Intubate LIS patient in negative pressure	6	4%
	Intubate HIS patient in negative pressure	88	64%
	Dedicated intubation teams ICU/anaesthesia	57	47%
	Intubation of HIS/COVID with video laryngoscopy	98	71%
	Use HFNC for hypoxic COVID-19 patients	53	50%

	Use NIV for hypoxic COVID-19 patients	101	86%
	Use NIV with in-line expiration viral filter	19	16%
	No PPE training	3	2%
	PPE group training in-person with observed practice	66	37%
	PPE individual training in-person with observed practice	40	23%
	Simulation training of intubation in COVID-19 patient	93	70%
	Simulation training of NIV in COVID-19 patient	61	46%
	Simulation training of self-proning in COVID-19 patient	17	13%
	Not monitored during donning PPE	39	30%
	Not monitored during doffing PPE	44	34%
PPE	Not N95 fit tested by time of this survey	15	12%
	Fit tested by qualitative method (odour or taste)	82	60%
	Fit tested by quantitative method (machine sampling)	41	30%
	Wear N95 for HIS/COVID patient not receiving AGP	61	48%
	Wear N95 or PAPR for AGP of HIS/COVID patient	110	87%
	N95 masks unavailable	6	6%
	Re-use N95 masks without sterilization	12	11%
	Re-use N95 masks after sterilization	3	3%
	Elastomeric respirators unavailable	63	66%
	PAPRs unavailable	79	82%

Most respondents (118, 87%) did not feel they could meet minimum physical distancing requirements in their workplace and disagree or strongly disagree that physical distancing is possible (Figure 1).

Administrative controls: Policy rostering ED consultants into either strictly "COVID" or "non-COVID" teams is not common and the majority (n=70, 60%) see these patient populations during shifts. Almost all (98%) of NZ ED consultants report having training for proper transmission-based PPE use with 60% having had in-person sessions being observed donning and doffing by the instructor. In practice, NZ emergency specialists report donning observation is rarely (18%) mandatory and about a third (30%) do not have an observer present. Only 16%

report mandatory observation during removal while a third (34%) are not usually observed doffing PPE. Greater than half of the NZ emergency consultant workforce surveyed are not aware of an official breach-of-PPE policy in their hospital ED or breach criteria.(23) Simulation training is common in NZ for patient intubation (93, 70%). Less common simulations are performed for non-invasive ventilation (61, 46%) and are rare for patient self-proning (17, 13%). Only half (54%) of specialists report HFNC availability, but 14% would not use this technology at all. Half (55%) of ED specialists say they can utilize NIV (CPAP/BiPAP) but only 16% report using viral expiration filters, a low-cost recommended infection control. NIV is not used outside negative pressure rooms and only 4% transfer to ICU for this modality. The majority of specialists report wide discretion in their ability to apply NIV to COVID-19 patients and just 15% reserve it only for patients with comorbidities (COPD, CHF, etc.) known to benefit. Sixty-four percent of consultants would intubate HIS/COVID-19 patients in a negative pressure room. Very few (4%) would intubate patients screened as LIS/non-COVID-19 patients under negative pressure. The lack of adequate staffing levels during the pandemic is cited as the greatest concern for two-thirds of respondents. Having adequate PPE and adequate testing capacity if a future wave of COVID-19 occurred in NZ were less concerning for respondents (Figure 2).

Personal protective equipment: New Zealand emergency consultants report few shortages of consumable PPE and have had little experience with reusing PPE, except washable face shields and goggles (Table 1). Low reuse of N95 masks either without sterilization (9%) and after sterilization (2%) further supports that respondents felt PPE supplies were adequate. Few respondents reported use of elastomeric respirators (2%) and powered air-purifying respirators (PAPRs) (2%).(24, 25) Only 89% of respondents had been fit tested for N95 masks at the time of

this survey, leaving approximately 11% of ED consultants surveyed having not been fit tested by November 2020. Half of these (7/15) were from one hospital.

Best practice for ED consultant use of transmission based PPE was assessed in different clinical scenarios as shown in (Table 2). Only 83% of respondents reported they would use N95 respirators in the context of aerosol generating procedures (AGP), with an additional 4% protected with elastomeric mask or PAPR. Thirteen percent of respondents would not use a respirator (N95 mask, elastomeric mask or PAPR) for a HIS/COVID-19 patient receiving an AGP.

Table 2: PPE chosen by EDSMOs ED Consultants for various clinical scenarios.

PPE	Non-patient care	Tea room	Toilet	LIS	HIS	HIS + AGP
Face shield	1%	0%	2%	4%	71%	75%
Safety glasses/goggles	1%	0%	1%	12%	79%	76%
Surgical masks	31%	9%	10%	61%	71%	34%
Reusable fabric masks	2%	1%	1%	2%	6%	5%
N-95 masks/respirators	0%	0%	1%	6%	48%	83%
Elastomeric respirators	0%	0%	0%	0%	3%	2%
PAPR	0%	0%	0%	0%	1%	2%
Disposable surgical hat	0%	0%	1%	2%	25%	29%
Reusable surgical hat	0%	0%	1%	4%	7%	7%
Disposable gown	0%	0%	1%	13%	87%	84%
Impermeable suit	0%	0%	0%	2%	6%	7%
Gloves	2%	0%	1%	52%	90%	83%
Double gloves	0%	0%	0%	1%	21%	25%
Foot coverings	0%	0%	0%	1%	16%	13%

Low (LIS) or high (HIS) index of suspicion for COVID-19. Aerosol generating procedure (AGP). Non-patient care areas include areas in ED for charting, making telephone calls, etc.

PPE practice preferences vary when caring for either a High or Low Index of Suspicion patient while not performing an AGP. For a HIS/COVID-19 patient without an AGP consultants report

N95 use of 48%, the rest using surgical mask alone or over N95. When seeing a LIS patient and no AGP, 6% report using an N95 respirator. Two-thirds (69%) wear some type of mask seeing LIS patients and one third of emergency consultants surveyed see LIS patients in their ED without a mask. While working outside of direct patient care but still in the hospital one third of ED SMOs wear a surgical or reusable fabric mask. Toilets may present a unique risk for droplet and possibly faecal-airborne transmission yet only 10% report using masks in toilets.(26, 27)

A summary rank-ordered list by ED consultants' assessment of their most likely source of exposure to COVID-19 identified "wearing inadequate PPE for patients not suspected of COVID-19 infection", followed by "contracting it from fellow staff members" or "accidental doffing exposure" as the top three most likely routes of nosocomial infection. Consultants were less concerned about inadequate N95 mask fit testing or the lack of appropriate training or PPE for co-workers such as housekeeping staff (Table 3).

Table 3: Rank the most likely reason that you think puts you at risk of exposure to COVID-19 at work? (1 for most likely, 8 for least likely)

RANK	RISK	MEAN	95% C.I.
1	Wearing inadequate PPE for patient(s) not suspected of COVID-19	2.9	2.6-3.3
2	Contracting it from a fellow staff member in the ED	3.1	2.7-3.4
3	Accidental PPE doffing exposure	3.5	3.1-3.9
4	Wearing inadequate PPE for patient(s) suspected of COVID-19 infection	3.7	3.3-4.0
5	Not being able to access adequate PPE	4.4	4.0-4.9
6	Inadequate mask fit testing for staff	5.6	5.2-6.0
7	Cleaners have been provided inadequate training and/or inadequate PPE	5.7	5.3-6.0
8	Not applicable- I do not fear risk of COVID-19 exposure at work	6.6	6.0-7.1

Confidence interval (C.I.)

DISCUSSION

This study assesses the preparedness of EDs around Aotearoa New Zealand for the eventual reintroduction of SARS-CoV-2. (28) Survey results identify weaknesses in local NZ hospital infection control practices which have been cited as risks in prior outbreaks in other countries.(5,

8, 13) Eight months following declaration of the pandemic in March 2020, these responses from NZ ED specialists reveal incomplete ED engineering upgrades to provide them negative flow rooms or portable HEPA filtration, the continued use of curtained patient bed bays with shared circulation and crowded work environments inconsistent with recommendations for physical distancing. Results also indicate variations in pandemic specific administrative policy, adherence and practice. In particular, inconsistent monitoring of donning and doffing of PPE as well as limited adoption of recommended treatments such as HFNC and NIV. Although reported N95 mask shortages were rare, not all respondents would use a respirator in the high risk setting of a HIS/COVID-19 patient receiving an AGP. Finally, infection control through PPE may be compromised by the finding that about one-tenth of ED consultants reported not being fit tested for N95 masks as late as November 2020. NZ guidelines for PPE were slow to accept airborne transmission stating: “The route of transmission of SARS-CoV-2 continues to be an area of debate in the medical and scientific community” as recently as August 2020. When elimination of SARS-CoV-2 fails and adequate community-wide immunity has not been established it is these proven layers of inhalation dose reduction that are needed to curb nosocomial spread and prevent health-care capacity compromise.

Engineering controls should provide enough adequately ventilated negative pressure rooms, or at least negative directional airflow, to allow for treatment of multiple respiratory isolation patients. Negative flow dilutes contaminated air breathed by HCWs caring for patients with airborne transmissible infections. DHBs should prioritise ED patient areas with a greater number of room air changes per hour (ideally 6-12 ACH), and greater proportion of fresh (vs recycled) air or consider portable HEPA filter units if airflow is inadequate.(7, 18) The finding that 12% of

consultants report no access to at least one negative flow room, mostly in smaller peripheral hospitals, suggests NZ DHBs have not equitably upgraded all EDs.

Control of bed-allocation during a COVID-19 surge reiterates issues common to emergency systems chronically plagued by over-crowding and limited resources.(29) Somewhat unique to a respiratory pandemic, patients with suspected COVID-19 may compromise the capacity to protect other patients from exposure. Because of this, single rooms to isolate suspected cases or protect vulnerable non-infected patients become a premium. The delay between clinical suspicion and confirmatory test results can further prolong lengths of stay such that available, rapid SARS-CoV-2 testing must be a priority.(30) Our results show most NZ suspected COVID-19 patients are streamed to separate ED areas or wards away from others where possible. Although recommended as an important ICP control, placing patients in LIS or HIS streams relying only on an unvalidated pre-triage screening set of questions and not rapid antigen or nucleic testing ignores the lessons learned from asymptomatic spread in this pandemic. In some instances there may be pressure to cohort patients in multiple bed bays with shared air circulation. In this study, three quarters of NZ specialists report having ED patients cohorted with shared ventilation and only curtains separating beds. Based on overseas experience, large numbers of COVID-19 patients in confined spaces may create a high density of aerosols and cause HCWs to stay longer as they attend each patient increasing their risk. Best practice reduces patient density to one per room (even if in a 2 or 4 bed bay) and mandates airborne PPE for staff in these situations.(8, 31, 32) Conversely, use of multi-bed bays to cohort presumed Non-COVID patients risks misidentifying the asymptomatic or presymptomatic patients as safe to collocate with other uninfected individuals.(30) This has resulted in verified nosocomial infections in 39% of uninfected roommates by whole-genome sequencing confirmation of cluster association (33,

34) Masking of patients and well ventilated or HEPA filtered areas may decrease this risk but evidence is limited.(35)

Although much attention is directed toward patient-to-HCW transmission, literature has identified HCW transmission to patients and to other HCWs and many of these nurses or doctors had no symptoms reiterating the importance of maintaining physical distancing and mask wearing in non-clinical areas when SARS-CoV-2 is circulating.(36, 37) Ranking this risk second in Table 2 suggests most NZ ED specialists may be aware of this concern. Despite recommendations to maintain physical distancing in non-clinical work areas most (86%) of NZ specialists disagreed that their ED workstations were engineered for adequate room (Figure 1). This illustrates how the lack of resources, physical space or personnel can undermine administrative efforts to protect staff and patients from exposures.

Administrative policy involves institution of rules that change how health care workers behave, it alters work flow and implements infection control protocols. Success may depend on dissemination of guidelines, staff confidence in recommendations, or practice. This can be undermined by poor messaging, mistrust or when case counts are low and the risk no longer justifies the effort. Vaccination may also create a sense that these other controls are not needed. Initial training for PPE use was universal (97%) but ongoing interval training was not common nor was mandatory observation during donning or doffing as recommended in the literature.(16) Training (baseline and refreshers) and monitoring policy for PPE use (spotters) for all clinical and non-clinical staff is not standardized across DHBs (Table 1). Simulations to practice skills (such as intubation and NIV use) and accommodate for PPE are variably applied in NZ.(16)

Experience in other countries has shown HCW PPE breaches, exposures and infections cause large numbers of staff furloughs, worsening nurse to patient ratios and causing the remaining staff to experience high workloads.(8, 38, 39) Maintaining a healthy skilled workforce is paramount to offset predicted inadequate staffing. A proactive approach should be used to support infected and furloughed staff wellbeing, with dedicated nursing and medical staff monitoring physical and mental health and providing support. Given the gravity of HCW infection and the system failure it implies, every suspected healthcare associated infection should trigger a bundle of immediate infection control measures.(40)

Among the strongest recommendations in the literature regarding prevention of HCW nosocomial infection is to "decant" or decrease overcrowding of COVID-19 patients in EDs and wards.(8) Ensuring a manageable workload through adequate staffing ratios by anticipating the increased care required for these infectious respiratory failure patients is paramount. This may also prevent the added fatigue HCWs face secondary to PPE compliance, doffing observation, and decontamination of providers and work environment. These additional tasks are not being calculated into traditional bedside severity scores and underestimate nursing ratios.

Personal Protective Equipment places a barrier between the HCW and the infectious agent (the principal example being respirators and other masks) and are considered the final and least effective control measure because it relies on consistent individual action at the point of care.(10) PPE should be implemented through clear guidelines and be current with peer reviewed literature and expert recommendations.(20, 34, 41, 42) The NZ Ministry of Health (MoH) last updated PPE recommendations August 2021 and these do not promote use of N95 respirators outside of

HIS/COVID-19 patients receiving AGPs or during lockdowns but still allow surgical masks to be used caring for HIS/COVID-19 patients at lower community prevalence.(42)

The scientific community has acknowledged transmission through inhalation of small airborne particles as a significant mode of SARS-CoV-2 virus transmission.(34, 40, 43, 44) These studies demonstrate aerosols produced through breathing, talking, coughing and yelling can remain in air and viable for long periods of time, travel long distances within a room and sometimes farther depending on ventilation. The experience in The Royal Melbourne Hospital City Campus outbreak noted that "aerosol generating behaviour" (AGB) in infected patients appeared to be linked to transmission events.(8) Patients shouting, vigorous coughing, cognitive impairment and combative behaviour, actions common in ED patients, should mandate airborne precautions equivalent to AGPs.(34, 38) Yet fit testing of N95 respirators, in line with other nations' health and safety legislation, was late to be initiated in NZ, and for at least 15 consultants (11%) was still not available at the time of this survey.(16, 20) Small peripheral facilities, as was the case for negative flow rooms, appear to be less prepared.

In the scenario-based PPE questions (Table 2), the finding that up to 13% of NZ ED consultants would not choose an N95 respirator, elastomeric or PAPR in the context of an aerosol generating procedure (AGP) for a HIS/COVID-19 patient was unexpected and raises concern. Given the low prevalence of SARS-CoV-2 in NZ, the probability of an HIS patient being infected is low, but not zero. Some ED consultants may argue N95s are not necessary due to elimination efforts or may believe they are still in short supply. But the omission of this recommended PPE could be interpreted as a purposeful disregard of evidence based pandemic IPC practice or a deliberate ignorance of why these policies exist. In a pandemic, an individual's choice to forgo personal protection does not just take the risk for themselves, but for the community of others on their

health care team, the other patients they care for, and their families and close contacts. Instituting and maintaining a standardized observer system and breach protocols should remedy this issue and may help promote a culture of staff safety, risk and adverse event reporting and staff support. NZ has enjoyed near SARS-CoV-2-free medical practice but sporadic reintroduction has occurred with HCW infection and risking transmission during aerosol generating procedures is an unconscionable breach of infection prevention and control even if vaccinated.(14) This will have to change as SARS-CoV-2 is reintroduced.

Our survey has several limitations. It was a cross-sectional study and relied on voluntary, self-reported data from ED consultants only. Email addresses were obtained from ASMS (n=422) and were not verified as still active. Although the rate of returned surveys from 137 ED consultants was 32%, all 20 DHBs representing 25 EDs returned surveys increasing the representativeness of the sample. Respondent characteristics were not collected to protect individual anonymity and promote candour. COVID-19 NZ ED presentations were variable by hospital location and respondent experience with direct patient care was not included in survey design. COVID-19 infection prevention and control policies and practices may vary significantly among different types of facilities and/or those in different DHBs. Despite these limitations, this study may be useful to EDs or other acute care settings throughout the Australasian-Pacific region where elimination was successful but now need to examine their preparedness as endemic Delta Variant spread becomes imminent.

CONCLUSION

These survey results from NZ ED consultants identify potential risks of failure in the hierarchy of infection controls currently in place to prevent nosocomial spread of SARS-CoV-2 or future

emerging infections. Our findings show that engineering upgrades to respiratory pandemic standards are not prevalent, administrative COVID-19 policy has not adapted to scientific advances seen in policy from other healthcare systems (ie. Australia), and PPE current practice reveals high variability suggesting poor dissemination of guidelines, low confidence in recommendations, or little practice because of low prevalence. NZ's public health success in SARS-CoV-2 elimination and the promise of protective immunity through vaccines has allowed for a relaxation of other layers of inhalation dose reduction even as evidence-based practice supporting them has evolved. As New Zealand borders reopen and crowded and under resourced emergency departments face endemic COVID-19, it would be prudent to use lessons learned elsewhere to identify local ED weaknesses and better prepare them to protect their patients and care givers in this approaching phase of the pandemic.

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Ethics Statement: A waiver of ethical approval was received from Health and Disability Ethics Committee from the New Zealand Ministry of Health

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Figure Legends:

Figure 1: Are you able to meet minimum physical distancing requirements in certain non-clinical areas of the ED?

Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following:

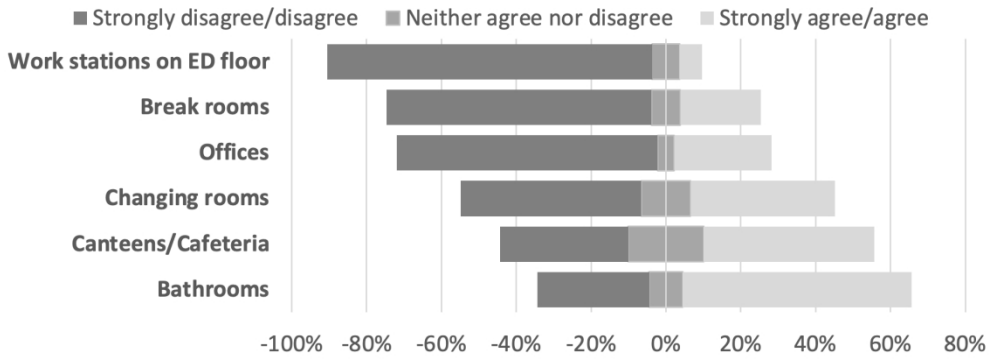


Figure 1: Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?

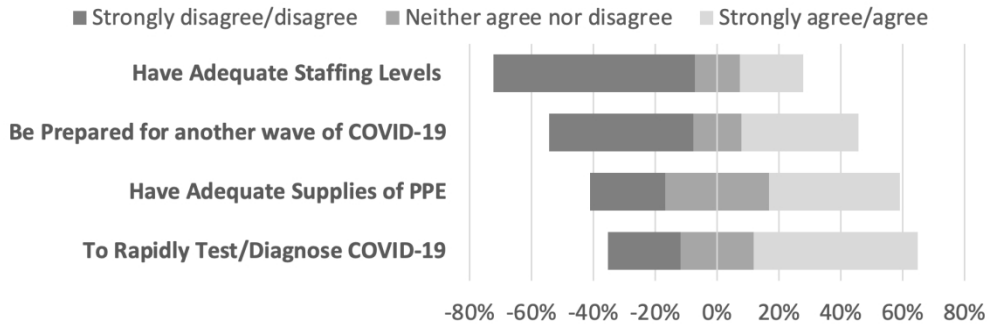


Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following:

Introduction

The NZED COVID-19 Preparedness Survey focuses on your safety and well-being during the COVID-19 pandemic.

The questions are peer-reviewed and created with the help of emergency specialists and infectious disease experts focused on health care worker safety and well-being.

We hope the results from this research will enable dialogue as to best infection control measures, and assist with standardising local protocols with the aim of minimising risk of nosocomial COVID-19 infections in the Emergency Department (ED).

ASMS understands that your commitment to the welfare of your patients and colleagues is predicated on your ability to focus on providing the best medical care in the safest possible work environment. We understand this requires practice and preparation.

Please take this opportunity to relate the current and proposed practices in your ED and share your opinions and thoughts.

If you have any questions regarding this research, please do not hesitate to contact Dr Charlotte Chambers at ASMS: CC@asms.nz

Thank you for your time.

Emergency Department (ED) Facility Characteristics

1. **Where is your primary place of work?**

2. **Do you have any negative pressure beds in your ED and if so, how many?**

For the purposes of this survey, a negative pressure or negative flow bed is defined as any bed in single or multiple rooms with minimum of 6 air changes per hour with or without an ante room.

- We don't have any negative pressure beds in our ED
- 1-4
- 5-9
- 10-14
- 15-19
- 20 or more
- Other (please specify)

3. **How many beds in your ED at the time of this survey are in shared rooms for cohorted patients**

For the purposes of this survey shared rooms are defined as large rooms with multiple curtained beds

- 1-4
- 5-9
- 10-14
- 15 or more
- I'm not sure
- None
- Other (please specify)

4. **When you have either confirmed COVID-19 patients or high index of suspicion (HIS) patients entering your ED do you treat them in a separate area (separate flow/segregated ED)?**

- ◯ Yes
- ◯ No
- ◯ Not applicable
- ◯ I'm not sure
- ◯ Other (please specify)

5. **Some EDs may be segregated into COVID and Non-COVID areas for patient care. How would you expect to be personally rostered in your ED?**

- ◯ We don't have a segregated ED
- ◯ I will be treating COVID patients only
- ◯ I will be treating Non-COVID patients only
- ◯ I will see both, alternating between them as needed
- ◯ I'm not sure
- ◯ Comment:

6. **Do you feel able to meet minimum physical distancing requirements in the non-clinical staff areas of your ED?**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Not applicable
Offices	◯	◯	◯	◯	◯	◯
Work stations on ED floor	◯	◯	◯	◯	◯	◯
Break rooms	◯	◯	◯	◯	◯	◯
Bathrooms	◯	◯	◯	◯	◯	◯
Changing rooms	◯	◯	◯	◯	◯	◯
Canteens/Cafeteria	◯	◯	◯	◯	◯	◯

Comments:

PPE training and fit testing

1. **What type of training have you had in the use of PPE at your current place of employment?**

Please select all that apply from the following:

- [ ] None - I have not completed any online training or employer required/directed training
- [ ] Self-taught using online training (video, reading material)
- [ ] In-person group demonstration in which I only watched
- [ ] In-person group session in which I practiced putting PPE on and removing it properly
- [ ] In-person individual demonstration in which I only watched
- [ ] In-person individual session in which I was observed putting PPE on and removing it properly
- [ ] Other (please specify)

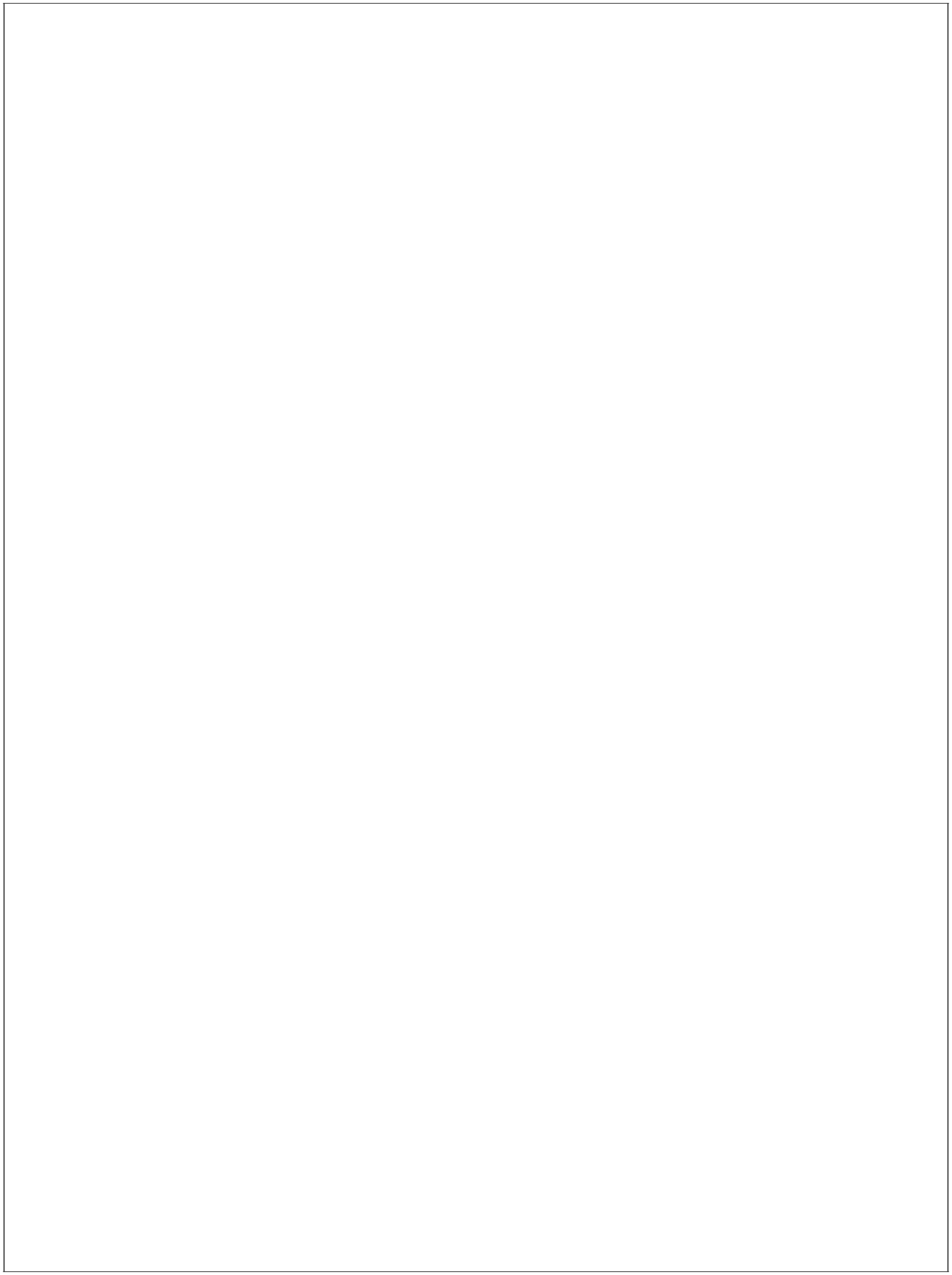
2. **Approximately, how frequently are you trained in any of the following activities?**

	Upon request	Never	Once	Annually	I'm not sure
Training for donning and doffing PPE	○	○	○	○	○
Simulation sessions on intubating COVID patients	○	○	○	○	○
Simulation session for non-invasive ventilation (NIV: CPAP, HFNC)	○	○	○	○	○
Simulation sessions on awake/self prone positioning of COVID patients	○	○	○	○	○
Simulation sessions on transporting COVID patients	○	○	○	○	○

Other (please specify)

3. If you have been fit tested with a N-95 mask/respirator within the last 12 months, what method was used to determine fit?

- ○ Not applicable; I have not been fit tested within the last 12 months
- ○ Qualitative (odour or taste detection in hood)
- ○ Quantitative (machine sampling via tubing)
- ○ I'm not sure
- ○ Other (please specify)



PPE Scenarios

1. **What personal precautions are you currently using in the following settings?**

Please select all that apply from the following:

	When in your ED but not providing patient care (charting, making telephone calls)	When in your Break/Tea Room (eating, conversing with colleagues)	When in your ED providing care for a non-COVID-19 low index of suspicion (LIS) patient	When in your ED providing care for COVID-19 HIS or confirmed patient	When within 2m of an aerosol-generating procedure for a confirmed or HIS COVID-19 case	When using the bathroom facilities
Standard precautions (handwashing, distancing from others)	☐	☐	☐	☐	☐	☐
Face shield	☐	☐	☐	☐	☐	☐
Safety glasses/goggles	☐	☐	☐	☐	☐	☐
Surgical masks	☐	☐	☐	☐	☐	☐
Reusable fabric masks	☐	☐	☐	☐	☐	☐
N-95 masks/respirators	☐	☐	☐	☐	☐	☐
Elastomeric respirators	☐	☐	☐	☐	☐	☐
Powered air-purifying respirator systems (PAPR CAPR)	☐	☐	☐	☐	☐	☐
Disposable surgical hat	☐	☐	☐	☐	☐	☐
Reusable surgical hat	☐	☐	☐	☐	☐	☐
Standard disposable isolation gown	☐	☐	☐	☐	☐	☐
Full-body impermeable suit	☐	☐	☐	☐	☐	☐
Gloves	☐	☐	☐	☐	☐	☐
Double gloves	☐	☐	☐	☐	☐	☐
Foot coverings	☐	☐	☐	☐	☐	☐

Other (please specify):

2. **Does your ED have a formal policy on showering/shampooing after caring for COVID-19 patients?**

	Mandatory	Not mandatory	Not practical as we have limited facilities	We don't have shower facilities	Not aware of a formal policy
Immediately after every single patient-contact episode	○	○	○	○	○
Only if PPE was breached	○	○	○	○	○
At the end of the shift	○	○	○	○	○
After reaching home	○	○	○	○	○

Comment:

3. **In your ED, is PPE donning monitored by an observer prior to care for COVID-19 patients?**

- ○ Yes, all the time (mandatory)
- ○ Yes, some of the time (ad-hoc)
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

4. **In your ED, is PPE doffing (removal) monitored by an observer to identify breaks in doffing technique after care for COVID-19 patients?**

- ○ Yes, all of the time (mandatory)
- ○ Yes, some of the time (ad-hoc)
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

Policies and practices for patients with suspected COVID-19

1. **For endotracheal intubation, which of the following (if any) is your ED using all or most of the time for patients with:**

Please select all that apply from the following:

	Low Index of Suspicion for COVID-19	High Index of Suspicion/Confirmed COVID-19
Negative pressure bed (bed with minimum of 6 air changes per hour)	☐	☐
Video laryngoscopy	☐	☐
Intubation barrier protection (e.g., intubating boxes , intubating bags, etc.)	☐	☐
Intubation barrier protection with integrated suction (e.g., intubating boxes connected to suction; negative pressure hood)	☐	☐
Intubation response teams (with dedicated staff)	☐	☐
Intubation through a supraglottic device (e.g., intubating LMA, etc.)	☐	☐
None of these	☐	☐

Other (please specify)

2. **Does your ED have a dedicated intubation team for confirmed or suspected COVID-19 patients?**

- ○ Yes, consisting of ICU/Anaesthesia responding to ED
- ○ Yes, consisting of ICU/ED formalised
- ○ Yes, ED only
- ○ No
- ○ I'm not sure
- ○ Other (please specify)

3. **For patients with confirmed or suspected COVID-19, is your ED practice/protocol that patients will be treated with high-flow nasal cannula (HFNC), if needed?**

- ◯ Yes
- ◯ No
- ◯ I'm not sure
- ◯ We don't have a formal protocol
- ◯ Comment:

4. **For ED patients with confirmed or suspected COVID-19, is your ED practice/protocol that patients will be treated with non-invasive positive pressure ventilation (NIV, including CPAP or BiPAP), if needed?**

- ◯ Yes, in any area in the ED
- ◯ Yes, only in a negative flow/pressure room in ED
- ◯ Yes, only with in-line or expiration viral filter in negative flow/pressure room in ED
- ◯ Yes, only after transfer to the ICU if appropriate
- ◯ No
- ◯ We don't have a formal protocol
- ◯ Other (please specify)

5. **For confirmed or suspect COVID-19 ED patients, under what circumstances might NIV (including CPAP or BiPAP) be used in your ED?**

Please select from the following:

- ☐ Any patient with respiratory failure that I think will benefit from NIV if indicated (NIV: CPAP/BiPAP)
- ☐ Only patients that have other co-morbidities known to benefit from NIV (eg. COPD, CHF, OSA)
- ☐ Only patients who have a "Do Not Intubate" or a "Do Not Resuscitate" order
- ☐ Only when mechanical ventilators are scarce
- ☐ Other (please specify)

PPE Breaches

1. **Please select from the following scenarios what constitutes a 'Breach in PPE' in your Emergency Department**

	Breach	Not a breach	Not aware of formal policy
Inadequate face protection	○	○	○
Inadequate eye protection	○	○	○
Improper donning/doffing	○	○	○
Exposure of skin due to a glove or gown tear	○	○	○
Inadequate shoe cover	○	○	○
Direct contact of skin to any secretion	○	○	○
Needle stick	○	○	○
Poor mask fit	○	○	○

Other (please specify)

2. **What measures have been advised by your hospital/ED administration when a PPE breach has been identified?**

	Mandatory	Optional	Not aware of a formal policy
Shower immediately	○	○	○
Report to ID/designated authorities	○	○	○
Retraining given for donning or doffing	○	○	○
Quarantine with testing protocol	○	○	○

Other (please specify)

PPE supply and re-use

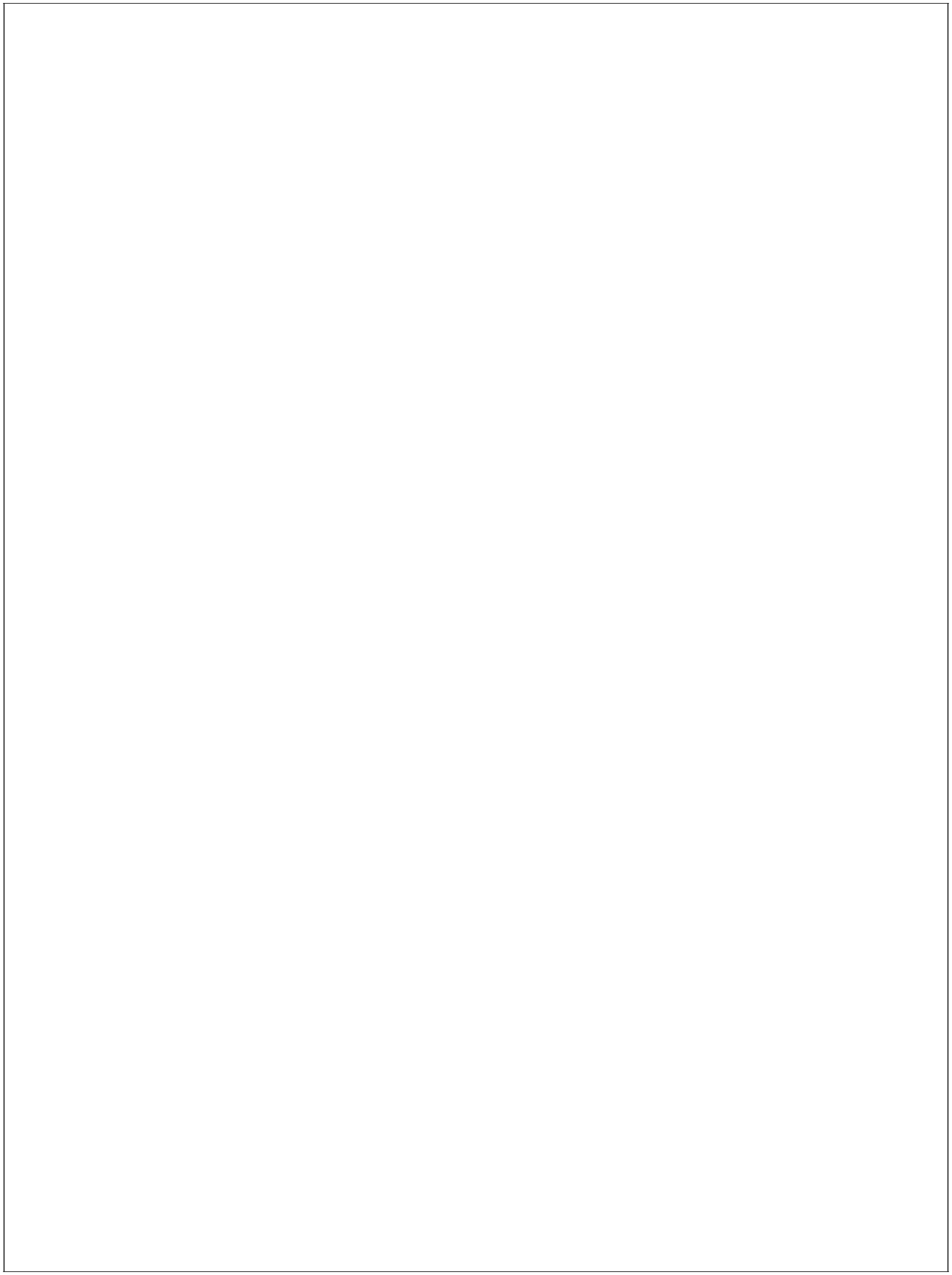
1. **At the time of this survey, please select from the following any PPE that is out of stock or otherwise unavailable for clinical use in your ED:**

- [ ] Reusable face shields
- [ ] Disposable face-shields (single use)
- [ ] Safety glasses/goggles
- [ ] Surgical masks
- [ ] Reusable fabric masks
- [ ] N-95 masks/respirators
- [ ] Elastomeric respirators
- [ ] Powered air- purifying respirator systems (PAPR, CAPR, etc.)
- [ ] Disposable surgical hat
- [ ] Reusable surgical hat
- [ ] Standard disposable isolation gown
- [ ] Full-body impermeable suit
- [ ] Gloves
- [ ] Foot coverings
- [ ] Other (please specify)

2. **Have you ever re-used PPE equipment according to any of the following scenarios?**

	Yes	No	I'm not sure
We re-use N-95 masks without sterilization	○	○	○
We re-use N-95 masks after sterilization	○	○	○
We re-use face shields without washing with cleaning solution	○	○	○
We re-use face shields after washing with cleaning solution provided	○	○	○
We re-use goggles without washing with cleaning solution	○	○	○
We re-use goggles after washing with cleaning solution provided	○	○	○

Other (please specify)



Your views

1. **Which of the following best describes your level of confidence in your ED's PPE protocol?**

	During Level 4 Lockdown	At the time of this survey
I am/was confident that our PPE protocol will keep me completely safe	☐	☐
I think my ED's protocol put me at risk and that I should have better PPE than is available, or use PPE more often than required by protocol	☐	☐
I think my ED's PPE protocol is too restrictive, and I feel that I can safely practice without wearing PPE every time that it is required by protocol	☐	☐
I am/was unsure about the safety of our PPE protocol and feel neither safe or unsafe	☐	☐
I am/was not aware of a PPE protocol in my ED	☐	☐

Other (please specify)

2. **At the time of the initial COVID-19 outbreak in New Zealand (during level 4 lockdown), please consider how you felt about the following:**

	Never	Rarely	Sometimes	Often	Always
I worried that family members or other close contacts were at risk of exposure to COVID-19 because of my work	○	○	○	○	○
I worried that I was at risk of exposure to COVID-19 because of my work	○	○	○	○	○
I worried about the level of preparedness of my hospital and ED	○	○	○	○	○
I worried about the supply of adequate and appropriate PPE in my ED	○	○	○	○	○
I felt anxious and stressed because of COVID-19	○	○	○	○	○

Other (please specify)

3. **Please answer the following questions regarding your views on how prepared your ED would be if there was another wave of COVID-19 in New Zealand**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Our ED is prepared and ready for another wave of COVID-19	☐	☐	☐	☐	☐
Our ED would have adequate staffing levels if there was another wave of COVID-19	☐	☐	☐	☐	☐
Our ED would have adequate supplies of appropriate PPE if there was another wave of COVID-19	☐	☐	☐	☐	☐
We would be able to rapidly test and in a timely manner diagnose possible cases of COVID-19	☐	☐	☐	☐	☐

Other (please specify)

4. **Do you feel you are at risk of infection from COVID-19 at work?**

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
○	○	○	○	○

Other (please specify)

5. **If you feel you are at risk of COVID-19 infection AT WORK, please rank the most likely reason that you think would put you at risk of exposure to COVID-19?**

Please select 1 for the most likely reason through to 8 as the least likely.

- ☐ Not applicable- I do not fear risk of COVID-19 exposure at work
- ☐ Not being able to access adequate PPE
- ☐ Wearing inadequate PPE for patient(s) not suspected of COVID-19 infection
- ☐ Wearing inadequate PPE for patient(s) suspected of COVID-19 infection
- ☐ Contracting it from a fellow staff member in the ED
- ☐ Accidental PPE doffing exposure
- ☐ Cleaners have been provided inadequate training and/or inadequate PPE
- ☐ Inadequate mask fit testing for staff

6. We would be grateful to hear your thoughts on any other aspects regarding the level of preparedness of your ED or the impact of COVID-19

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	N/A
Bias	9	Describe any efforts to address potential sources of bias	2
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	N/A
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	5
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

TITLE

New Zealand Emergency Department COVID-19 Preparedness: A Cross-sectional Survey and Narrative View

AUTHORS

Michael J. Howard MD PhD
Charlotte N. L. Chambers, PhD MSc
Nicholas M. Mohr MD MS

Author Affiliations:
1. Department of Emergency Medicine, Whangarei Hospital, Northland District Health Board, Whangarei, New Zealand, michaelhowardmd@gmail.com
2. Director of Policy and Research, Association of Salaried Medical Specialists, Wellington, New Zealand, charlotte.chambers@asms.org.nz
3. Department of Emergency Medicine, University of Iowa Carver College of Medicine, Iowa City, Iowa, nicholas-mohr@iowa.edu

Corresponding Author:
Michael J. Howard MD PhD, Whangarei Hospital Emergency Department, Northland District Health Board, Private Bag 9742 Maunu Road, Whangarei, 0148 New Zealand
michaelhowardmd@gmail.com

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ABSTRACT

Objective

Our objective was to assess the level of COVID-19 preparedness of emergency departments (EDs) in Aotearoa New Zealand (NZ) through the views of emergency medicine specialists working in district health boards around the country. Given the limited experience NZ hospitals have had with SARS-CoV-2, a comparison of current local practice with recent literature from other countries identifying known weaknesses may help prevent future healthcare worker infections in NZ.

Methods

We conducted a cross-sectional survey of NZ emergency specialists in November 2020 to evaluate preparedness of engineering, administrative policy, and personal protective equipment (PPE) use.

Results

A total of 137 surveys were completed (32% response rate). More than 12% of emergency specialists surveyed reported no access to negative pressure rooms. N95 fit testing had not been performed in 15 (12%) of respondents. Most specialists (77%) work in EDs that cohort COVID-19 patients, about one-third (34%) do not use spotters during PPE doffing, and most (87%) do not have required space for physical distancing in non-patient areas. Initial PPE training,

simulations and segregating patients were widespread but appear to be waning with persistent low SARS-CoV-2 prevalence. PPE shortages were not identified in NZ EDs, yet 13% of consultants do not plan to use respirators during aerosol generating procedures on COVID-19 patients.

Conclusions
New Zealand emergency specialists identified significant gaps in COVID-19 preparedness, and they have a unique opportunity to translate lessons from other locations into local action. These data provide insight into weaknesses in hospital engineering, policy, and PPE practice in advance of future SARS-CoV-2 endemic transmission.

Strengths and limitations of this study

- Survey responses specifically identified existing breakdowns in engineering, administrative policy and personal protective equipment in New Zealand emergency departments, potentially increasing healthcare worker nosocomial infection risk upon reintroduction of SARS-CoV-2
- Respondents included emergency specialists from all 20 of New Zealand's district health boards but the electronic convenience sample may not be representative of all ED consultants in NZ
- Some survey questions asked respondents to recall experiences or project how they would practice if they were caring for a COVID-19 patient
- Those motivated to respond may feel they have more or less access to protective policies and equipment than non-respondents

KEYWORDS
COVID-19, Cross-Sectional Studies, Emergency Service, Hospital, Infection Control, Infectious Disease Transmission, Patient-to-Professional

INTRODUCTION

The Aotearoa New Zealand (NZ) healthcare system was as unprepared for the coronavirus disease 2019 (COVID-19) pandemic as many nations, yet NZ successfully eliminated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).(1, 2) The decision to implement aggressive public health infection elimination practices hinged on NZ's ability to rapidly and effectively close its borders thus limiting COVID-19 impact to approximately 2600 cases and 26 deaths.(3, 4) As a result, NZ's Emergency Departments (EDs) have had little experience caring for COVID-19 patients and disparate efforts towards infection control preparedness may leave heath care workers (HCWs) vulnerable to nosocomial SARS-CoV-2 transmission.(5-8)

The Hierarchy of Control offers an algorithm to assess preparedness of a health system, scalable to departmental, hospital and nationwide recommendations.(8-10) Once elimination is established but eradication remains impossible there must be appropriate resources to institute and sustain substitution of the threat (typically by vaccination or other therapies). Even as vaccine-based immune protection expands there are still uncertainties requiring multiple controls to prevent transmission of SARS-CoV-2. Questions about viral variants that evade host immune responses, vaccine safety and efficacy in vulnerable groups (ie. young children, immunocompromised, elderly), and the impact of vaccine hesitancy indicate we will need to maintain layers of protection for some time into the future.(11) In addition to vaccination, pandemic ED response should continue focus on proven non-pharmaceutical interventions such as engineering (often through changes in ED physical layout, ventilation and bed allocation), administrative policy (infection prevention and control (IPC), workflow changes, training, resources), and transmission-based PPE. These practices demand equity, and the failure has resulted in healthcare worker (HCW) infections, disability and death.(8, 12-14)

The July-August 2020 outbreak in Melbourne, Victoria, Australia revealed deficiencies in hospital level IPC in a health system comparable to that of NZ.(15, 16) Unfortunately, this outbreak in long-term care facilities and subsequent nosocomial spread in tertiary hospitals resulted in significant SARS-CoV-2 infections in HCWs. The Australian response affords insight into improvements to adopt in other health systems.(8, 17, 18) The New Zealand Emergency Department COVID-19 (NZEDC19) Preparedness Survey of emergency consultants was designed to identify and address weaknesses in local NZ emergency department policy, engineering, and PPE to provide proactive recommendations for system improvement.

METHODS

This study was a cross-sectional web-based assessment of COVID-19 pandemic preparedness of EDs in NZ via survey of ED senior medical officers (ED SMOs) from the EDs of all NZ District Health Boards (DHBs). In order to encourage anonymous participation only DHB of employment was requested; respondent characteristics (sex, age, years of practice, ED location) were not gathered for the study sample.

Questionnaire Design. A 27-item questionnaire was framed around the hierarchy of control model with questions on engineering (negative flow isolation rooms, shared/cohorted patient areas, segregated patient flow, physical distancing), administrative controls (policies for rostering, training, simulations, treatments, and breaches), and personal protective equipment (supply, fit testing, use and re-use).(8, 10, 19) Likert scale questions evaluated consultant ability to physically distance and respond to a future surge. Questions were adapted for the ED from a

published survey of preparedness in intensive care units (ICUs) of Australasia and the prospective COVID Evaluation of Risk in Emergency Departments (COVERED) Project in the U.S.(20, 21) These questions were previously validated by those investigators using established survey methodology.(22) ED specific modifications of our survey were checked for clarity and vernacular specific to NZ with at least 2 test surveys of ED, microbiology and infectious disease specialists, and of a primary investigator from each of the studies mentioned above.

Survey Distribution. The survey was distributed by email to 422 members of the Association of Salaried Medical Specialists (ASMS) identified as having emergency medicine as their designated department of work using Survey Monkey (San Mateo CA, USA) between 26 October 2020 and 23 November 2020. Two e-mail reminders were sent. Participation was voluntary. The study was considered exempt from the institutional review board by the NZ Health and Disabilities Ethics Committees.

Data Analysis. Raw data was summarized in Excel and basic descriptive statistics were ~~The data analysis was primarily descriptive and~~ reported as percentages of valid responses. Diverging stacked Likert scales are used to display emergency specialist opinion results. The survey is included as a supplementary file ~~.~~although not all question responses were resulted here due to length limitations.

Patient and Public Involvement. Patients or members of the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

One-hundred thirty-seven surveys were completed (32% response rate). All (100%) of 20 NZ DHBs were represented by at least 2 individual SMO surveys. Surveys were returned from 24 emergency departments representing smaller regional to major urban tertiary hospitals. Nine (6.6%) respondents did not identify a DHB.

Engineering: The majority of respondents have access to negative flow or negative pressure patient care rooms (Table 1). Most (115, 83%) report 4 or fewer such rooms in their ED, but 14 (12 %) ED specialists reported no access to negative flow rooms for COVID-19 patient care. Most respondents (99, 77%) worked in EDs that have some beds separated only by curtains with shared air circulation where patients may be cohorted. Most (101, 74%) surveyed emergency consultants work in EDs which can create physical separation of care areas for high index of suspicion (HIS) patients segregated from those for presumed low index of suspicion (LIS) patients. Emergency consultants from multiple DHBs commented that ED segregated flow or "streaming" can be changed with COVID-19 prevalence and alert level.

Table 1: Summary table of select NZEDC19 Preparedness Survey answers

CONTROL	SPECIFIC HIERARCHY OF CONTROL QUESTION	N	%
ENGINEERING	Have negative flow/pressure rooms in ED	123	88%
	Have cohorted beds in ED	99	77%
	Segregated COVID/non-covid patients in ED	101	74%
	Rostered to see both COVID/non-COVID as needed	70	60%
	Unable to meet physical distance requirements at office	94	70%
	Unable to meet physical distance requirements at workstation	118	87%
	Unable to meet physical distance requirements at break rooms	92	71%
POLICY	Intubate LIS patient in negative pressure	6	4%
	Intubate HIS patient in negative pressure	88	64%
	Dedicated intubation teams ICU/anaesthesia	57	47%
	Intubation of HIS/COVID with video laryngoscopy	98	71%

	Use HFNC for hypoxic COVID-19 patients	53	50%
	Use NIV for hypoxic COVID-19 patients	101	86%
	Use NIV with in-line expiration viral filter	19	16%
	No PPE training	3	2%
	PPE group training in-person with observed practice	66	37%
	PPE individual training in-person with observed practice	40	23%
	Simulation training of intubation in COVID-19 patient	93	70%
	Simulation training of NIV in COVID-19 patient	61	46%
	Simulation training of self-proning in COVID-19 patient	17	13%
	Not monitored during donning PPE	39	30%
	Not monitored during doffing PPE	44	34%
PPE	Not N95 fit tested by time of this survey	15	12%
	Fit tested by qualitative method (odour or taste)	82	60%
	Fit tested by quantitative method (machine sampling)	41	30%
	Wear N95 for HIS/COVID patient not receiving AGP	61	48%
	Wear N95 or PAPR for AGP of HIS/COVID patient	110	87%
	N95 masks unavailable	6	6%
	Re-use N95 masks without sterilization	12	11%
	Re-use N95 masks after sterilization	3	3%
	Elastomeric respirators unavailable	63	66%
	PAPRs unavailable	79	82%

Most respondents (118, 87%) did not feel they could meet minimum physical distancing requirements in their workplace and disagree or strongly disagree that physical distancing is possible (Figure 1).

Administrative controls: Policy rostering ED consultants into either strictly "COVID" or "non-COVID" teams is not common and the majority (n=70, 60%) see these patient populations during shifts. Almost all (98%) of NZ ED consultants report having training for proper transmission-based PPE use with 60% having had in-person sessions being observed donning and doffing by the instructor. In practice, NZ emergency specialists report donning observation is rarely (18%) mandatory and about a third (30%) do not have an observer present. Only 16%

report mandatory observation during removal while a third (34%) are not usually observed doffing PPE. Greater than half of the NZ emergency consultant workforce surveyed are not aware of an official breach-of-PPE policy in their hospital ED or breach criteria.(23) Simulation training is common in NZ for patient intubation (93, 70%). Less common simulations are performed for non-invasive ventilation (61, 46%) and are rare for patient self-proning (17, 13%). Only half (54%) of specialists report HFNC availability, but 14% would not use this technology at all. Half (55%) of ED specialists say they can utilize NIV (CPAP/BiPAP) but only 16% report using viral expiration filters, a low-cost recommended infection control. NIV is not used outside negative pressure rooms and only 4% transfer to ICU for this modality. The majority of specialists report wide discretion in their ability to apply NIV to COVID-19 patients and just 15% reserve it only for patients with comorbidities (COPD, CHF, etc.) known to benefit. Sixty-four percent of consultants would intubate HIS/COVID-19 patients in a negative pressure room. Very few (4%) would intubate patients screened as LIS/non-COVID-19 patients under negative pressure. The lack of adequate staffing levels during the pandemic is cited as the greatest concern for two-thirds of respondents. Having adequate PPE and adequate testing capacity if a future wave of COVID-19 occurred in NZ were less concerning for respondents (Figure 2).

Personal protective equipment: New Zealand emergency consultants report few shortages of consumable PPE and have had little experience with reusing PPE, except washable face shields and goggles (Table 1). Low reuse of N95 masks either without sterilization (9%) and after sterilization (2%) further supports that respondents felt PPE supplies were adequate. Few respondents reported use of elastomeric respirators (2%) and powered air-purifying respirators (PAPRs) (2%).(24, 25) Only 89% of respondents had been fit tested for N95 masks at the time of

this survey, leaving approximately 11% of ED consultants surveyed having not been fit tested by November 2020. Half of these (7/15) were from one hospital.

Best practice for ED consultant use of transmission based PPE was assessed in different clinical scenarios as shown in (Table 2). Only 83% of respondents reported they would use N95 respirators in the context of aerosol generating procedures (AGP), with an additional 4% protected with elastomeric mask or PAPR. Thirteen percent of respondents would not use a respirator (N95 mask, elastomeric mask or PAPR) for a HIS/COVID-19 patient receiving an AGP.

Table 2: PPE chosen by EDSMOs ED Consultants for various clinical scenarios.

PPE	Non-patient care	Tea room	Toilet	LIS	HIS	HIS + AGP
Face shield	1%	0%	2%	4%	71%	75%
Safety glasses/goggles	1%	0%	1%	12%	79%	76%
Surgical masks	31%	9%	10%	61%	71%	34%
Reusable fabric masks	2%	1%	1%	2%	6%	5%
N-95 masks/respirators	0%	0%	1%	6%	48%	83%
Elastomeric respirators	0%	0%	0%	0%	3%	2%
PAPR	0%	0%	0%	0%	1%	2%
Disposable surgical hat	0%	0%	1%	2%	25%	29%
Reusable surgical hat	0%	0%	1%	4%	7%	7%
Disposable gown	0%	0%	1%	13%	87%	84%
Impermeable suit	0%	0%	0%	2%	6%	7%
Gloves	2%	0%	1%	52%	90%	83%
Double gloves	0%	0%	0%	1%	21%	25%
Foot coverings	0%	0%	0%	1%	16%	13%

Low (LIS) or high (HIS) index of suspicion for COVID-19. Aerosol generating procedure (AGP). Non-patient care areas include areas in ED for charting, making telephone calls, etc.

PPE practice preferences vary when caring for either a High or Low Index of Suspicion patient while not performing an AGP. For a HIS/COVID-19 patient without an AGP consultants report

N95 use of 48%, the rest using surgical mask alone or over N95. When seeing a LIS patient and no AGP, 6% report using an N95 respirator. Two-thirds (69%) wear some type of mask seeing LIS patients and one third of emergency consultants surveyed see LIS patients in their ED without a mask. While working outside of direct patient care but still in the hospital one third of ED SMOs wear a surgical or reusable fabric mask. Toilets may present a unique risk for droplet and possibly faecal-airborne transmission yet only 10% report using masks in toilets.(26, 27)

A summary rank-ordered list by ED consultants' assessment of their most likely source of exposure to COVID-19 identified "wearing inadequate PPE for patients not suspected of COVID-19 infection", followed by "contracting it from fellow staff members" or "accidental doffing exposure" as the top three most likely routes of nosocomial infection. Consultants were less concerned about inadequate N95 mask fit testing or the lack of appropriate training or PPE for co-workers such as housekeeping staff (Table 3).

Table 3: Rank the most likely reason that you think puts you at risk of exposure to COVID-19 at work? (1 for most likely, 8 for least likely)

RANK	RISK	MEAN	95% C.I.
1	Wearing inadequate PPE for patient(s) not suspected of COVID-19	2.9	2.6-3.3
2	Contracting it from a fellow staff member in the ED	3.1	2.7-3.4
3	Accidental PPE doffing exposure	3.5	3.1-3.9
4	Wearing inadequate PPE for patient(s) suspected of COVID-19 infection	3.7	3.3-4.0
5	Not being able to access adequate PPE	4.4	4.0-4.9
6	Inadequate mask fit testing for staff	5.6	5.2-6.0
7	Cleaners have been provided inadequate training and/or inadequate PPE	5.7	5.3-6.0
8	Not applicable- I do not fear risk of COVID-19 exposure at work	6.6	6.0-7.1

Confidence interval (C.I.)

DISCUSSION

This study assesses the preparedness of EDs around Aotearoa New Zealand for the eventual reintroduction of SARS-CoV-2. (28) Survey results identify weaknesses in local NZ hospital infection control practices which have been cited as risks in prior outbreaks in other countries.(5,

8, 13) Eight months following declaration of the pandemic in March 2020, these responses from NZ ED specialists reveal incomplete ED engineering upgrades to provide them negative flow rooms or portable HEPA filtration, the continued use of curtained patient bed bays with shared circulation and crowded work environments inconsistent with recommendations for physical distancing. Results also indicate variations in pandemic specific administrative policy, adherence and practice. In particular, inconsistent monitoring of donning and doffing of PPE as well as limited adoption of recommended treatments such as HFNC and NIV. Although reported N95 mask shortages were rare, not all respondents would use a respirator in the high risk setting of a HIS/COVID-19 patient receiving an AGP. Finally, infection control through PPE may be compromised by the finding that about one-tenth of ED consultants reported not being fit tested for N95 masks as late as November 2020. NZ guidelines for PPE were slow to accept airborne transmission stating: “The route of transmission of SARS-CoV-2 continues to be an area of debate in the medical and scientific community” as recently as August 2020. When elimination of SARS-CoV-2 fails and adequate community-wide immunity has not been established it is these proven layers of inhalation dose reduction that are needed to curb nosocomial spread and prevent health-care capacity compromise.

Engineering controls should provide enough adequately ventilated negative pressure rooms, or at least negative directional airflow, to allow for treatment of multiple respiratory isolation patients. Negative flow dilutes contaminated air breathed by HCWs caring for patients with airborne transmissible infections. DHBs should prioritise ED patient areas with a greater number of room air changes per hour (ideally 6-12 ACH), and greater proportion of fresh (vs recycled) air or consider portable HEPA filter units if airflow is inadequate.(7, 18) The finding that 12% of

consultants report no access to at least one negative flow room, mostly in smaller peripheral hospitals, suggests NZ DHBs have not equitably upgraded all EDs.

Control of bed-allocation during a COVID-19 surge reiterates issues common to emergency systems chronically plagued by over-crowding and limited resources.(29) Somewhat unique to a respiratory pandemic, patients with suspected COVID-19 may compromise the capacity to protect other patients from exposure. Because of this, single rooms to isolate suspected cases or protect vulnerable non-infected patients become a premium. The delay between clinical suspicion and confirmatory test results can further prolong lengths of stay such that available, rapid SARS-CoV-2 testing must be a priority.(30) Our results show most NZ suspected COVID-19 patients are streamed to separate ED areas or wards away from others where possible. Although recommended as an important ICP control, placing patients in LIS or HIS streams relying only on an unvalidated pre-triage screening set of questions and not rapid antigen or nucleic testing ignores the lessons learned from asymptomatic spread in this pandemic. In some instances there may be pressure to cohort patients in multiple bed bays with shared air circulation. In this study, three quarters of NZ specialists report having ED patients cohorted with shared ventilation and only curtains separating beds. Based on overseas experience, large numbers of COVID-19 patients in confined spaces may create a high density of aerosols and cause HCWs to stay longer as they attend each patient increasing their risk. Best practice reduces patient density to one per room (even if in a 2 or 4 bed bay) and mandates airborne PPE for staff in these situations.(8, 31, 32) Conversely, use of multi-bed bays to cohort presumed Non-COVID patients risks misidentifying the asymptomatic or presymptomatic patients as safe to collocate with other uninfected individuals.(30) This has resulted in verified nosocomial infections in 39% of uninfected roommates by whole-genome sequencing confirmation of cluster association (33,

34) Masking of patients and well ventilated or HEPA filtered areas may decrease this risk but evidence is limited.(35)

Although much attention is directed toward patient-to-HCW transmission, literature has identified HCW transmission to patients and to other HCWs and many of these nurses or doctors had no symptoms reiterating the importance of maintaining physical distancing and mask wearing in non-clinical areas when SARS-CoV-2 is circulating.(36, 37) Ranking this risk second in Table 2 suggests most NZ ED specialists may be aware of this concern. Despite recommendations to maintain physical distancing in non-clinical work areas most (86%) of NZ specialists disagreed that their ED workstations were engineered for adequate room (Figure 1). This illustrates how the lack of resources, physical space or personnel can undermine administrative efforts to protect staff and patients from exposures.

Administrative policy involves institution of rules that change how health care workers behave, it alters work flow and implements infection control protocols. Success may depend on dissemination of guidelines, staff confidence in recommendations, or practice. This can be undermined by poor messaging, mistrust or when case counts are low and the risk no longer justifies the effort. Vaccination may also create a sense that these other controls are not needed. Initial training for PPE use was universal (97%) but ongoing interval training was not common nor was mandatory observation during donning or doffing as recommended in the literature.(16) Training (baseline and refreshers) and monitoring policy for PPE use (spotters) for all clinical and non-clinical staff is not standardized across DHBs (Table 1). Simulations to practice skills (such as intubation and NIV use) and accommodate for PPE are variably applied in NZ.(16)

Experience in other countries has shown HCW PPE breaches, exposures and infections cause large numbers of staff furloughs, worsening nurse to patient ratios and causing the remaining staff to experience high workloads.(8, 38, 39) Maintaining a healthy skilled workforce is paramount to offset predicted inadequate staffing. A proactive approach should be used to support infected and furloughed staff wellbeing, with dedicated nursing and medical staff monitoring physical and mental health and providing support. Given the gravity of HCW infection and the system failure it implies, every suspected healthcare associated infection should trigger a bundle of immediate infection control measures.(40)

Among the strongest recommendations in the literature regarding prevention of HCW nosocomial infection is to "decant" or decrease overcrowding of COVID-19 patients in EDs and wards.(8) Ensuring a manageable workload through adequate staffing ratios by anticipating the increased care required for these infectious respiratory failure patients is paramount. This may also prevent the added fatigue HCWs face secondary to PPE compliance, doffing observation, and decontamination of providers and work environment. These additional tasks are not being calculated into traditional bedside severity scores and underestimate nursing ratios.

Personal Protective Equipment places a barrier between the HCW and the infectious agent (the principal example being respirators and other masks) and are considered the final and least effective control measure because it relies on consistent individual action at the point of care.(10) PPE should be implemented through clear guidelines and be current with peer reviewed literature and expert recommendations.(20, 34, 41, 42) The NZ Ministry of Health (MoH) last updated PPE recommendations August 2021 and these do not promote use of N95 respirators outside of

HIS/COVID-19 patients receiving AGPs or during lockdowns but still allow surgical masks to be used caring for HIS/COVID-19 patients at lower community prevalence.(42)

The scientific community has acknowledged transmission through inhalation of small airborne particles as a significant mode of SARS-CoV-2 virus transmission.(34, 40, 43, 44) These studies demonstrate aerosols produced through breathing, talking, coughing and yelling can remain in air and viable for long periods of time, travel long distances within a room and sometimes farther depending on ventilation. The experience in The Royal Melbourne Hospital City Campus outbreak noted that "aerosol generating behaviour" (AGB) in infected patients appeared to be linked to transmission events.(8) Patients shouting, vigorous coughing, cognitive impairment and combative behaviour, actions common in ED patients, should mandate airborne precautions equivalent to AGPs.(34, 38) Yet fit testing of N95 respirators, in line with other nations' health and safety legislation, was late to be initiated in NZ, and for at least 15 consultants (11%) was still not available at the time of this survey.(16, 20) Small peripheral facilities, as was the case for negative flow rooms, appear to be less prepared.

In the scenario-based PPE questions (Table 2), the finding that up to 13% of NZ ED consultants would not choose an N95 respirator, elastomeric or PAPR in the context of an aerosol generating procedure (AGP) for a HIS/COVID-19 patient was unexpected and raises concern. Given the low prevalence of SARS-CoV-2 in NZ, the probability of an HIS patient being infected is low, but not zero. Some ED consultants may argue N95s are not necessary due to elimination efforts or may believe they are still in short supply. But the omission of this recommended PPE could be interpreted as a purposeful disregard of evidence based pandemic IPC practice or a deliberate ignorance of why these policies exist. In a pandemic, an individual's choice to forgo personal protection does not just take the risk for themselves, but for the community of others on their

health care team, the other patients they care for, and their families and close contacts. Instituting and maintaining a standardized observer system and breach protocols should remedy this issue and may help promote a culture of staff safety, risk and adverse event reporting and staff support. NZ has enjoyed near SARS-CoV-2-free medical practice but sporadic reintroduction has occurred with HCW infection and risking transmission during aerosol generating procedures is an unconscionable breach of infection prevention and control even if vaccinated.(14) This will have to change as SARS-CoV-2 is reintroduced.

Our survey has several limitations. It was a cross-sectional study and relied on voluntary, self-reported data from ED consultants only. Email addresses were obtained from ASMS (n=422) and were not verified as still active. Although the rate of returned surveys from 137 ED consultants was 32%, all 20 DHBs representing 25 EDs returned surveys increasing the representativeness of the sample. Respondent characteristics were not collected to protect individual anonymity and promote candour. COVID-19 NZ ED presentations were variable by hospital location and respondent experience with direct patient care was not included in survey design. COVID-19 infection prevention and control policies and practices may vary significantly among different types of facilities and/or those in different DHBs. Despite these limitations, this study may be useful to EDs or other acute care settings throughout the Australasian-Pacific region where elimination was successful but now need to examine their preparedness as endemic Delta Variant spread becomes imminent.

CONCLUSION

These survey results from NZ ED consultants identify potential risks of failure in the hierarchy of infection controls currently in place to prevent nosocomial spread of SARS-CoV-2 or future

emerging infections. Our findings show that engineering upgrades to respiratory pandemic standards are not prevalent, administrative COVID-19 policy has not adapted to scientific advances seen in policy from other healthcare systems (ie. Australia), and PPE current practice reveals high variability suggesting poor dissemination of guidelines, low confidence in recommendations, or little practice because of low prevalence. NZ's public health success in SARS-CoV-2 elimination and the promise of protective immunity through vaccines has allowed for a relaxation of other layers of inhalation dose reduction even as evidence-based practice supporting them has evolved. As New Zealand borders reopen and crowded and under resourced emergency departments face endemic COVID-19, it would be prudent to use lessons learned elsewhere to identify local ED weaknesses and better prepare them to protect their patients and care givers in this approaching phase of the pandemic.

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Figure Legends:

Figure 1: Are you able to meet minimum physical distancing requirements in certain non-clinical areas of the ED?

Figure 2: If there were another wave of COVID-19 in NZ, what are your views regarding your ability to do the following: