A model respiratory personal protective programme for the New Zealand healthcare industry

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ABSTRACT

In the absence of advice from the workplace regulator, a model respiratory protection programme for healthcare workers is presented based in healthcare and wider industry experience. Hospital and other healthcare institutions can use this as a basis for their programmes in preparation for the next infective disease outbreak.

In the current COVID pandemic, personal protective equipment (PPE) has been a presented as a solution for the respiratory protection of healthcare workers (HCWs), imperfectly applied because of logistics and supply problems. The real problem, however, lies elsewhere, in that PPE is seldom deployed correctly: its is only one component of a health protection system.

Although WorkSafe New Zealand[1] recommends a respiratory protection programme, no guidance is given on how to design one, despite the existence of an Australian/New Zealand Standard[2] and the development of specific guidelines in Australia.[3] We trust that our experiences in applying the basic principles of respiratory protection in industrial settings will prove to have direct applicability to the health sector. In the absence of advice from the workplace regulator, we offer these thoughts to promote better understanding of the problem so that HCWs achieve adequate protection.

The statutory duties imposed on a person in control of a business unit (PCBU) by the Health and Safety at Work Act 2015 [4] (The Act) lies at the heart of the problem: they have a primary duty of care and must, so far as is reasonably practicable, provide and maintain a work environment that is without health and safety risks. Under the provisions of the Act, work risks are to be managed by identifying, assessing and controlling hazards. Hazards can be assessed against standards, for chemicals in air there are workplace exposure standards (WES's) which should not be exceeded.[5] In healthcare there are a number of chemical exposures including waste anaesthetic gases, cytotoxic agents and electrosurgical smoke, but the principal hazard resides in infectious agents, for which exposure standards have not been set, but the same control principles apply.

With regard to the latter, the Health and Safety (General Risk and Workplace Management) Regulations 2016 [6] draw on a long established and empirically proven occupational health and safety principle, the 'hierarchy of control'.[7] The hazard should be either eliminated, impracticable for biological exposures unless a vaccine is available, or isolated in a suitable facility with specially trained staff, for example a nosocomial or intensive care unit. If the hazard remains then it must be minimised by, in order of importance, engineering controls, safe work practices, and, failing all else, by the use of PPE, which attempts to control any residual risk.

The implications are that a safe workplace, particularly in complex industries such as healthcare, requires a health and safety system underpinning the optimal combination of an appropriately engineered work environment, safe work practices, the

use of the most effective PPE, monitoring of the work environment and finally, adequate information and training. The efficacy of such programmes should be subject to periodic audit.

For HCWs in some circumstances, PPE may be the only effective hazard control mechanism, blood or body fluid exposures being an example. With airborne hazards, engineering solutions must not be overlooked, and remain a cornerstone of the healthcare risk management model. An example is the best practice requirements for operating theatre ventilation are effective at managing the risks from waste anaesthetic gas and electrosurgical smoke.

Ventilation can help to manage biological hazards. As an example, the risk of occupational conversion of tuberculosis status is much reduced in clinical areas with appropriate ventilation.[8]

If ventilation fails to control the hazard, then respiratory protective equipment (RPE) is the final option, simply because it is least likely to prove effective, largely because of human behaviour or environmental factors, a seminal example being the use of PPE in the hot and humid conditions of the freezing works, which has actually been shown to increase the risk of leptospirosis in meat workers.[9] The associated costs of human leptospirosis due to time absent from work and treatment have also been calculated to be $4.42 US million per annum (95% probability interval: 2.04–8.62) million).[10] The possible costs of SARS-CoV-2 is likely to be much greater.

Modelling of SARS-CoV-2 virus transmission is complex, but a key finding of a study by Jones[11] was that droplet, inhalation and contact routes contribute respectively 35%, 57% and 8.2% of the probabability of infection, on average, without the use of PPE. While the virus emission rates remain uncertain, Jones concludes "that inhalation exposure is likely to contribute meaningfully to the risk of COVID-19 among HCP providing care to infectious patients, motivating the use of respirators to prevent occupationally acquired infection".

There is advice to the contrary. The World Health Organization (WHO)[12] notes the complexity of transmission routes, SARS-CoV-2 being primarily transmitted by droplet and contact routes. Although there have been no reports of the latter the WHO advice is that "fomite transmission is considered a likely mode of transmission for SARS-Cov-2 given consistent findings about environmental contamination in the vicinity of infected cases and the fact that other coronaviruses and respiratory viruses can transmit this way". The WHO therefore recommends droplet and contact precautions when caring for COVID 19 patients. Airborne precautions are recommended during aerosol generating procedures, the use of N95, filtering face piece (FFP)2 or FFP3 respirators.

The situation with respiratory protective equipment, RPE, is therefore complex and requires thorough analysis and the development of an 'in-depth' protection programme. Experience with viral haemorrhagic fever has shown that 'standard precautions', the suite of infection prevention and control measures, must be allied to the use of PPE, and the combination treated as an ensemble: training, for example in donning and doffing, is crucial to success.[13]

Having decided that RPE is necessary to reduce residual risk, appropriate equipment must be selected. Up to now, N95 respirators and surgical masks have been the most widely discussed options.

N95 masks are available in different sizes and contours, and designed to fit closely around the nose and mouth. They are electrostatically charged to filter out particulate matter, but not virus droplets. Half face respirators with filters are also available and comply with a standard, having an assigned protective factor (APF) of 10, meaning that no more than one-tenth of the contaminants to which the worker is exposed leak or pass through into the mask.[14]

Surgical masks are loose fitting, have no APF and are not considered to be RPE: they cannot be fit tested.[15] Both the N95 respirator and surgical mask are useful for containing exhaled air, however the surgical mask does allow more lateral escape.[16] The other options, finding more frequent application in the healthcare industry, are the filtering face piece types, the half face air purifying respirator or the powered air-purifying respirator, the latter having an APF of up to 1,000 and being used during high-risk aerosol-generating procedures.[17]

We advocate an RPE programme, so what should this include? Howie[18] sets out a number of steps to construct an effective programme, these being:

- risk assessment
- hazard substitution (if practicable)
- technical controls
- identification of those remaining vulnerable
- information and informed consent to risk
- select respiratory protective equipment (RPE) adequate to control residual risk
- involve wearers in RPE selection and match RPE to wearer
- fit testing (to determine the RPE that gives the maximum protection)
- test RPE in use (ie, the wearer can still achieve the required work task) including compatibility with other pieces of ppe or task equipment (gowns, eye loupes etc)
- train wearers, supervise in use (eg donning and doffing)
- minimise wear periods
- maintain and audit RPE

As alluded to above, Howie further qualifies the use of respiratory PPE by pointing out that manufacturers stated NPFs are many orders of magnitude greater than the workplace protection measured in the workplace, the assigned protective factor. The protection offered by RPE, and indeed all PPE, degrades when in real use, as shown for leptospirosis but also likely to occur in healthcare—particularly, for example, when subject to the hurly burly of physically intensive work such as might occur during resuscitation, high-intensity nursing or some orthopaedic procedures.

In our experience as occupational health physicians either working in, or offering advice to, district health boards, it is our considered opinion, shared by Agius[19] and others, that the use of surgical masks has little place in a respiratory PPE programme for HCWs. Surgical masks may have some use in diffusing the exhaled cough jet stream,[16] that is they are better placed on the patient rather than the staff member, but have no place as RPE, as they cannot be fit tested, a view re-iterated by the manufacturer.[20]

Having said that, there have been several trials comparing infection rates in healthcare workers using surgical masks and or N95 respirators, but a meta analysis showed no difference,[21] the authors suggesting that compliance with N95 masks may have been a problem. The effect sizes were also small and the samples not large enough to say if there was any difference at all.

The risk does nevertheless need to be managed. Modelling data shows that the inhalation route of exposure is likely to be important, that respirators may be needed, and that PPE is part of a suite of protective measures. The implications of the limited filtering capacity of the P2 respirators including the N95 are that a choice of the higher grade of disposable respirator, or even the more complex respirators such as the air purifying respirator or the powered air purifying respirator should be available for high-risk procedures, or failing that, the higher grade of disposable filtering face piece respirator. These have been used successfully in previous viral epidemics[21] providing that training is effective. Although available and quite widely used in industry, these appear to have had limited availability to HCWs in New Zealand.

Having provided adequate RPE, it must be incorporated into a programme, starting with fit testing. As far as we can determine from our own experience and our occupational physician colleagues there were no comprehensive RPE with an adequate “fit testing programme” as recommended by the New Zealand Australian Standard prior to the pandemic,[2] these programmes should have been in place well in advance of any epidemic, again in our opinion ‘normalised’ into the healthcare worker induction and ongoing certification programmes, as required for cardio pulmonary resuscitation, and, as with clinical skills, subject to audit.

Behavioural measures are also essential. As the risk of contamination when doffing the high-end equipment, or indeed any RPE emphasises the need for training, we would endorse Howie’s[18] and the CDC’s[22] recommendation of a “change supervisor” (themselves wearing appropriate PPE) to assist—and insist on observing the correct technique.

There are some very valuable occupational health lessons to be learned from the New Zealand COVID-19 response, the

emphasis on surgical masks and N95 respirators also obscured other hazard control issues. For example facilities should be designed so that cross contamination is minimised by careful attention to detail, for example sound design of patient flow and the provision of negative pressure areas to meet the expected clinical demand.

Work practice controls must be improved through attention to information and training, the effect of possible failure having been demonstrated in at least one district health board.[23] The evidence supports this: well equipped and practised high care units provided better protection for HCWs than found in the less prepared general healthcare and home settings.

Our model of a good respiratory protection programme therefore draws heavily upon Australian practice, in particular the Queensland Workcover guidance,[3] to ensure compliance with the relevant standards including:

- correctly selecting appropriate RPE (that is the right type of RPE for the identified risk to staff)
- medical screening of RPE users
- training in the correct use and maintenance of RPE
- ensuring RPE is correctly used, that is supervision
- fit testing and fit checking
- inspection, maintenance and repair of RPE
- correct storage
- keeping records
- audit

To be effective, as with all complex medical procedures, an adequate respiratory protection programme requires that the HCW is deployed in a safe environment, using appropriate equipment and techniques, and has the resources and training to apply those techniques to their everyday practice. This should be considered as a component of staff welfare, which, in an audit of DHB plans, was the most poorly addressed.[24] We should also bear in mind that, in the run up to the Rugby World Cup 'well prepared' acute care providers were significantly less likely to respond to an infectious disease outbreak.[25] We need to give them the confidence to do so.

Competing interests:
Nil.

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www.nzma.org.nz/journal-articles/a-model-respiratory-personal-protective-programme-for-the-new-zealand-healthcare-industry

REFERENCES:

1. WorkSafe. [Internet]. [cited 2020 August 11th]. Respiratory Protective Equipment. [1 screen] Available from: http://worksafe.govt.nz/topic-and-industry/personal-protective-equipment-ppe/respiratory-protective-equipment/advice-for-businesses/
2. Standards Australia/Standards New Zealand. Respiratory Protection Standards. Standard No.: AS/NZS 1715:2009.
3. WorkCover Queensland. [Internet]. [cited 2020 August 11th]. Respiratory protective equipment] [1 screen] Available from: http://www.worksafe.qld.gov.au/injury-prevention-safety/managing-risks/personal-protective-equipment-ppe/respiratory-protective-equipment-RPE
4. Health and Safety at Work Act 2015 (NZ).
5. WorkSafe. Workplace exposure standards and biological exposure indices. 11th ed. Wellington: WorkSafe New Zealand; 2019. Available from: http://worksafe.govt.nz/topic-and-industry/work-related-health/monitoring/exposure-standards-and-biological-exposure-indices/ [Accessed 11th August 2020].
6. The Health and Safety (General Risk and Workplace Management) Regulations 2016 (NZ).
7. Soule RD. Industrial Hygiene Engineering Controls. In: Clayton GD, Clayton, FE, eds. Patty's Industrial Hygiene and Toxicology. 3rd ed. New York: John Wiley and Sons; 1978:707–771.
8. Du CR, Wang SC, Yu MC, Chiu TF, Wang JY, Chuang PC, et al. Effect of ventilation improvement during a tuberculosis outbreak in underventilated university buildings. Indoor Air. 2020; 30(3):422–32.
9. Dreyfus A, Benschop J, Collins-Emerson J, Wilson P, Baker MG, Heuer C. Sero-prevalence and risk factors for leptospirosis in abattoir workers in New Zealand. Int J Environ Res Public Health. 2014; 11(2):1756–75.
10. Sanhueza JM, Baker MG, Benschop J, et al. Estimation of the burden of leptospirosis in New Zealand. Zoonoses Public Health. 2020; 67(2):167–76.
11. Jones RM. Relative contributions of transmission routes for COVID-19 among healthcare personnel providing patient care. Occup Environ Hygiene 2020; 1–6. Available from: http://www.tandfonline.com/doi/full/10.1080/15459624.2020.1784427 [Accessed 11th August 2020].
12. World Health Organisation. Transmission of SARS-CoV-2: implications for infection prevention precautions. Geneva; 2020 Aug 9th: World Health Organisation. Available from: http://www.who.int/publications/i/item/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations [Accessed 2nd September 2020].
13. Raj D, Hornsey E, Perl TM. Personal protective equipment for viral hemorrhagic fevers. Curr Opin Infect Dis. 2019; 32(4):337–47.
14. U.S. Food and Drug Administration. [Internet]. [cited 2020 August 11th]. N95 Respirators, Surgical Masks, and Face Masks. [1 screen]. Available from: http://www.fda.gov/medical-devices/personal-protective-equipment-infection-control/n95-respirators-surgical-masks-and-face-masks
15. Ha JF. The COVID-19 pandemic, personal protective equipment and respirator: A narrative review. Int J Clin Pract. 2020:e13578.
16. Hui DS, Chow BK, Chu L, et al. Exhaled air dispersion during coughing with and without wearing a surgical or N95 mask. PLoS One. 2012; 7(12):e50845. doi:10.1371/journal.pone.0050845.
17. Chen Q, et al. Rapid ramp-up of powered air-purifying respirator (PAPR) training for infection prevention and control during the COVID-19 pandemic. Br J Anaesth 2020; 125(1):e171–e176.
18. Howie RM. Respiratory Protective Equipment. Occup Environ Med 2005; 62:423–428.
19. Agius R. Covid-19 and Health at Work. Occup Med (Lond) 2020; 70(5):349–51.
20. 3M Personal Safety Division. Respiratory Protection for Airborne Exposures to Biohazards. StPaul: 3M; 2020. Total number of pages. Technical data bulletin No.: 174. Available from: http://multimedia.3m.com/mws/media/409903O/respiratory-protection-against-biohazards.pdf [Accessed 2nd September 2020].
21. Long Y, Hu T, Liu L, Chen R, Guo Q, Yang L, Cheng Y, Huang J, Du L. Effectiveness of N95 respirators versus surgical masks against influenza: A systematic review and meta-analysis 12 February 2020 DOI: 10.1111/jebm.12381
22. Centers for Disease Control and Prevention. For U.S. Healthcare Settings: Donning and Doffing Personal Protec-

tive Equipment (PPE) for Evaluating Persons Under Investigation (PUIs) for Ebola Who Are Clinically Stable and Do Not Have Bleeding, Vomiting, or Diarrhea. Atlanta; 2018: Centers For Disease Control and Prevention. Available from: http://www.widernet.org/ebolapocketlibrary/EbolaPocketLibrary_2019/Web/www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance-clinically-stable-puis.html [Accessed 11th Aug 2020].

23. Waitemata District Health Board. Incident Review Report: COVID-19 Staff Infections Waitakere Hospital. Auckland; 2020:Waitemata District Health Board. Available from: http://www.waitematadhb.govt.nz/assets/Documents/news/media-releases/2020/Waitemata-DHB-Incident-Review-Report-WTK-Hospital-April-2020.pdf [Accessed 11th August 2020].

24. Al-Shaqsi S, Gauld R, McBride D, et al. The State of Healthcare Disaster Plans in New Zealand and the Sultanate of Oman: An International Comparative Analysis. Advances in Emergency Medicine 2014; http://dx.doi.org/10.1155/2014/758728

25. Al-Shaqsi S, McBride D, Gauld R, et al. Are we ready? Preparedness of acute care providers for the Rugby World Cup 2011 in New Zealand. Emerg Med J. 2013; 30(8):611–4.