

Are Australian medical interns adequately prepared for the optimal use of personal protective equipment?

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Research article

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Abstract

Background

The current COVID-19 pandemic has demonstrated that personal protective equipment (PPE) is essential, to prevent the acquisition and transmission of infectious diseases, yet its use is often sub-optimal in the clinical setting. Training and education are important to ensure and sustain the safe and effective use of PPE by medical interns, but current methods are often inadequate in providing the relevant knowledge and skills. The purpose of this study was to explore new graduates' experiences of the use of PPE and identify opportunities for improvement in medical student education and training programmes, to improve occupational and patient safety.

Methods

This study was undertaken in 2018 in a large tertiary-care teaching hospital in XXXX, Australia, to explore medical interns' self-reported experiences of PPE use, at the beginning of their first postgraduate year. Focus groups were conducted immediately after theoretical and practical PPE training, during hospital orientation. Transcripts of recorded discussions were analysed, using a thematic approach that drew on the COM-B (capability, opportunity, motivation - behaviour) framework for behaviour.

Results

80% of 90 eligible interns participated. Many interns had not previously received formal training in the specific skills required for optimal PPE use and had developed potentially unsafe habits. Their experiences as medical students in clinical areas contrasted sharply with recommended practice taught at hospital orientation and impacted on their ability to cultivate correct PPE use.

Conclusions

Undergraduate teaching should be consistent with best practice PPE use, and include practical training that embeds correct and safe practices.

Background

Healthcare-associated infections are among the most frequent preventable causes of adverse patient events, resulting in increased lengths of stay and morbidity(1, 2) and contributing to spread of antimicrobial resistance(3). Healthcare workers can transmit pathogens and are themselves at risk of occupationally acquired infectious diseases including emerging/exotic viral infections such as COVID-19. The use of personal protective equipment (PPE) is a critical infection prevention and control (IPC) practice(4). PPE protects the wearer and contributes to preventing further transmission, yet is often inappropriately used, especially by doctors(5, 6). Many doctors feel that they have inadequate knowledge and practical skills, in IPC, generally, and PPE use, specifically(7), suggesting an unmet need for teaching undergraduates about its importance(8). Mann and Wood found that around 50% of medical students

thought their course should have had a greater emphasis on IPC(9), while John et al. reported that 92.5% of medical students made procedural errors when removing PPE during training(10). In another study, Saudi Arabian medical students scored poorly on survey questions relating to PPE knowledge (average scores 3.8 ± 1.9 out of 9 points)(11). In Hong Kong, the SARS outbreak exposed deficiencies in medical students' PPE skills, which prompted changes in undergraduate IPC education(12).

Practical PPE skills are not always formally assessed at undergraduate level(10) and are often learnt via role modelling during clinical placements. The hidden curriculum therefore plays an important role in the clinical learning environment(13). In relation to PPE use, interns may be influenced by the PPE practices of their role models – senior registrars and consultants – which can be suboptimal(14). An understanding of the intern's experiences and knowledge of the use of PPE at the beginning of their careers can help to inform undergraduate training and identify opportunities to enhance their skills in the clinical context.

Previous studies have used qualitative methods to investigate the influence of informal and hidden curricula in medical education(15, 16); others have used self-reported surveys or observation(17, 18) - often focused on hand hygiene - to examine IPC knowledge and behaviours of medical students or junior doctors. In this qualitative study, we used focus groups to explore interns' experience and behaviours related to the use of PPE. In this paper we report our analysis of these discussions.

Methods

Setting and participants

This sub-study is nested within a larger study, involving a trial of novel methods of medical intern training, in the use of PPE, undertaken in 2018 at a large tertiary-care teaching hospital in xxxx.

All the interns attending their 2-week orientation course in January 2018 were approached as a convenience sample for the study. This type of non-probability sampling uses a population that is easily available (Bryman, 2016). For the main study, interns were informed, in advance, about the research by the Director or Prevocational Education and Training, and subsequently approached by researchers, during orientation, to participate.

Design

After an IPC lecture and demonstration of how to don and doff (put on and remove) PPE safely, based on Australian guidelines (NHMRC, 2019), participating interns were randomly allocated to one of two groups to practice donning and doffing routine PPE - gloves, gown, mask and eye protection. These practice sessions were then followed by focus group discussions in which participants reflected on their training and compared what they had learnt with their previous practical experiences using PPE. As part of the larger study design, the intervention groups were videoed during their PPE practice and then shown their own footage during their focus group session. Semi-structured and open-ended questions were used to

stimulate group discussion and interaction among participants. Focus groups allow researchers to understand people's perceptions in a more natural setting than one-on-one interviews, while at the same time providing a platform for participants to learn from each other and thus have a positive experience of the research process(19). There were eight focus group discussions (four video and four non-video) lasting 20–30 minutes each, which were audio-recorded and transcribed by an independent transcription service, for analysis. Full details of the overall study methods will be reported separately.

In this sub-study, transcripts of focus group audio recordings were downloaded into NVivo qualitative data analysis software; QSR International Pty Ltd. Version 12.6.0. Using an iterative deductive/inductive process, two researchers initially coded data, independently, using the COM-B model(21) as a theoretical framework. The following behavioural conditions for appropriate PPE use in clinical practice were used for coding: *capability* (knowledge and skills), *opportunity* (structural and environmental factors) and *motivation* (attitudes, habits, and decision-making). In this context, examples of *capability* include knowledge of when to use PPE, and skills and self-efficacy in donning and doffing PPE; examples of *opportunity* include access to PPE and social norms of the clinical unit; and examples of *motivation* include prompts for PPE use and the personal desire to protect oneself. In the second stage of data analysis, the COM-B themes were re-examined to identify overarching themes to describe the factors that impacted on participants' appropriate PPE use in routine clinical practice.

Results

72 interns out of the 90 who were invited to participate consented to be part of the study (80% response). Initial coding of behavioural conditions according to the COM-B framework can be seen in Table 1.

Table 1
Themes matched to COM-B categories

COM-B category	Themes
Capability	♣ Skills in donning and doffing PPE
Psychological capability	♣ Understanding PPE principles
	♣ Knowledge of PPE protocols/processes
	♣ Undergraduate learning about PPE
	♣ Prior clinical teaching about PPE
Motivation	♣ Unconscious habit – e.g. unconsciously doffing PPE as learned in operating theatre
Automatic motivation	♣ Beliefs about benefits of PPE for self-protection
Reflective motivation	
Opportunity	♣ PPE availability/access
Physical opportunity	♣ Range of PPE sizes and different products
Social opportunity	♣ Facility design
	♣ Peer behaviour
	♣ Clinical team norms
	♣ Role models
	♣ Time constraints to don and doff PPE
	♣ Interference with clinical assessment

Similar factors were described by both videoed and non-videoed groups, and therefore we combined these groups in our analysis. At Stage 2 analysis, two overarching themes were developed to describe factors that were likely to impact on interns' safe and correct PPE use in clinical practice. These were: a) adequacy of prior knowledge and skills for practice; and b) using PPE in the real world. Within the COM-B framework, theme a) corresponded with *capability/motivation*, and theme b) with *opportunity*. Below, we describe these themes in more detail.

Theme A: Adequacy of prior knowledge and skills for practice.

All participants indicated that they had received basic education on the use of PPE at medical school, and some had received additional PPE education or training during clinical placement (e.g. several who had worked in the operating theatres had been taught how to don sterile gloves and gown). This prior learning had provided some PPE knowledge and skills which, after their brief IPC/PPE orientation training, participants recognised was not necessarily adequate for safe PPE use. They reported that preparation for medical school practical exams included an emphasis on hand hygiene before patient contact, so

they automatically performed hand hygiene prior to donning PPE. However, although they were taught that PPE is important, correct methods of donning and doffing were not necessarily demonstrated or explained. As one participant described it: “We get told *what* to put on, but no one's been, like, this is *how* you put it on...” (Focus Group 1 [FG1], *emphasis added*.)

Until then, many participants had been unaware of the risks of self-contamination during doffing or the rationale for the doffing steps that were taught. For example, most interns had been unaware that a critical step in doffing PPE safely was to perform hand hygiene *after* the removal of gloves (because of the potential to contaminate their hands(20)), as the following quotes suggest:

“I’ve never washed my hands right after taking off the gloves.” (FG4)

“We didn’t wash our hands after we took our gloves off.” (FG6)

Some interns had already developed incorrect and unsafe habits of PPE use. For example, some had previously tied their gowns at the front – where gown ties could become contaminated - and so risked contaminating their hands when doffing. One participant described his thoughts about the order of donning, during orientation PPE practice:

“I was much more conscious of what I was doing, because when you’re on the ward, you’re just like, yeah, yeah, yeah... You think you’re doing it automatically, but now you [need to] think in steps.” (FG2)

Participants also recognised that their lack of understanding of correct donning and doffing of protective masks had led to unsafe mask use. For example, some removed their masks upwards, over their face and hair, potentially contaminating themselves:

“But yes, I didn’t realise that it was much safer to pull [the mask] ... downwards.” (FG1)

There was also a notable knowledge gap in the use of eye protection, with many interns erroneously having believed that their own spectacles were an acceptable alternative to protective eyewear.

“I would have my glasses on as well, so I would be like, I’m good.” (FG3)

For several interns, aspects of their PPE behaviour had been learnt in operating theatres, during surgical placements, which subsequently influenced their use of PPE in the wards. At orientation and during this study, PPE removal was taught according to current Australian guidelines(20), namely: remove gloves first, followed by hand hygiene, then remove eye protection, gown and mask (in that order). However, participants noted that they had made a habit of removing their masks first, due to their experience in theatre:

“I think it’s just habitual [to remove the mask first]... when you’re going into theatre, you put the mask on then the scrubs...” (FG5)

Also, many participants noted that they instinctively removed gown and gloves together in one motion as they had been taught to do in theatre:

"I'd actually take it [...] off like in theatres. Like I'd pull the gown off and then take it off with the gloves and pull it off as one unit." (FG7)

Finally, participants demonstrated a mixed understanding of the items of PPE required for transmission-based precautions. Although some correctly identified the PPE required for contact, droplet and airborne modes of transmission, others expressed confusion about which type of mask to wear for various disease scenarios.

"And like I said, there's a lot of misunderstanding about what each mask is used for. They just think this [N95] is the better mask. Use this mask, rather than, like, what is its actually for".(FG8)

Theme B: Using PPE in the real world

Participants frequently referred to the differences between 'real-life' PPE use and how it was demonstrated at orientation. Factors contributing to these differences included the physical environment and resources, the behavioural norms of the clinical area where they worked and the expectations of their roles as junior doctors.

As taught in orientation training, the first step in donning PPE is to remove jewellery to allow for effective cleaning of hands and arms below the elbow. Interns noted that this varied between wards, some of which were more compliant than others.

"Obviously in surgery, you don't have [jewellery] in surgical scrubs, but on the ward, everyone wears their watches and rings and stuff." (FG2)

A commonly cited reason for non-compliance with removing jewellery on the ward was a requirement to use a watch for patient examination. There was also the practical barrier of finding a suitable, safe place for it when removed.

"I actually physically take everything off, you know, and sit it on the sink. And hope that it's still there when I go back." (FG5)

"[Removing jewellery is] difficult on a ward where you're going to lose your watch, yeah." (FG5)

Other environmental barriers that impacted on PPE behaviour was the variability and availability of some PPE items in clinical areas. Different gowns and masks were available in different clinical settings, so could be unfamiliar. Participants particularly noted that goggles or protective eyewear were difficult to locate in wards and even when eye protection was available, it was not always suitable:

"None of these goggles fit over my glasses." (FG4)

As medical students, participants had come to accept, as “normal”, that certain PPE items were never available on wards and, even if they were, they were rarely used anyway.

“I don’t ... usually find [protective eyewear] on the wards and most times when we do, everyone just wears the mask and gloves and gown, no-one wears goggles.” (FG7)

Participants identified that senior doctors are looked to as role models, but may not always model best practice, as described by the following participant:

“When you’re a student who’s a bit less experienced, you’re just following what the rest of the team is doing and basing it off that... [but] they’re not often the best models to follow.” (FG1)

Frequently, as the most junior member of the team, the intern was often required to remain outside of the room during ward rounds, to write in the patient notes, which limited opportunities to practice donning and doffing skills. They also identified time pressure during ward rounds as a challenge to optimal PPE use, describing a lack of time for all team members to correctly don PPE.

“I was in a rush doing ward rounds, so I just follow suit.” (FG3)

“When you’re on wards you’re definitely pressured to do it faster because you want to go in. Whereas today [during the training] I was like, oh, I’ve got all the time in the world to go in and do it correct.” (FG6)

Discussion

This study used a qualitative study design with focus group discussion to investigate interns’ knowledge and experiences of the use of routine PPE at the start of their internship. Previous research has used similar methods to explore the hidden curriculum in medical undergraduate learning(15). We developed two overarching themes from the data which described likely influences on interns’ safe and correct PPE use, namely a) interns’ previous knowledge and skills in PPE use (*capability and motivation*) and b) how actual clinical contexts affect their PPE use (*opportunity*). Participants’ comments suggested that different approaches to learning are needed. Classroom education needs to include more detailed explanation of the logic of PPE use, for standard and transmission-based precautions. But, in addition, greater emphasis on practical and reflective learning in situ is required, during student placements, to ensure that interns can practice IPC safely once qualified.

The first theme illustrated discrepancies and gaps between correct PPE use and junior doctors’ behaviours, learnt during undergraduate placements. It showed a potential for personal risk to the clinician, if incorrect PPE was used or it was put on or taken off incorrectly. An important finding, not previously described, was that the habit of removing gown and gloves together, in one action, in the theatre environment, impacted on PPE behaviour during routine care. However, in consultation with the IPC team, we reasoned that the risk of self-contamination was no different between the method used in theatre and doffing gown and gloves separately (as per policy for routine care). Furthermore, this method is endorsed by the Centres for Disease Control(22). Another potential occupational risk, identified by

participants, was that they rarely used goggles, safety glasses or visors and several mistakenly believed their own glasses would protect their eyes from splash. This is a common misconception, as reported previously(23), and consistent with previous reports of low rates (27–40%) of compliance with eye protection by medical staff(5). However, eye protection over and above prescription glasses is still needed, when a risk of eye contamination with blood or respiratory secretions is anticipated, to prevent blood-borne(23) or respiratory viral infection(24).

In our study there was also a worrying knowledge deficit related to protective masks, which protect clinical staff from infections transmitted via respiratory droplets, such as influenza, meningococcal disease or via smaller aerosolised particles. For example, not all participants knew that they could be exposed to airborne infection such as pulmonary tuberculosis unless they wore a properly fitted N95/P2 respirator. An understanding of appropriate facial protection has implications during emerging infectious disease outbreaks when transmission routes are unknown and both droplet (including eye protection) and airborne precautions (including N95/P2 respirator) may be required. The current COVID-19 pandemic has led to a greater use of N95/P2 respirators among healthcare workers than usual, which has identified a need for training in PPE skills(25). The knowledge deficit identified in this study aligns with that of Peres et al(26), in which surveys of advanced medical students and junior doctors found that 59% of respondents had inadequate knowledge about PPE. Potential self-contamination, due to errors in PPE doffing, has been demonstrated in a number of studies which has implications for pathogen transmission not only to clinicians, themselves, but also to the environment and patients(27, 28). The current COVID-19 outbreak has highlighted the importance of correct PPE use to protect frontline workers(29).

Education and training designed for medical interns at the start of their clinical practice cannot assume that interns arrive with an understanding of appropriate PPE principles and practice. Instead, education and training programs should acknowledge and identify interns' prior misconceptions and inappropriate practice, in order to address and correct them. These findings provide some indication of what those misconceptions and inappropriate practices might include.

The second theme (b) captured the challenges faced by junior doctors, if they attempt to use PPE appropriately when working in clinical areas. Other team members who use PPE incorrectly, if at all, make it difficult for junior doctors to do so safely. This concurs with Cresswell and Monrouxe's(30) finding that social pressures experienced by medical students and junior doctors are a barrier to optimal IPC practice. This illustrates the tension between what students have learnt in the classroom and what they are subsequently taught through the hidden curriculum in the clinical setting. Senior medical staff can have a major influence on the use of PPE by junior medical staff, but there is a paucity of appropriate peer and/or senior role modelling(30).

However, frontline leadership can have a positive influence. Peponis *et al*(31) reported that real-time peer feedback significantly increased compliance with eye protection (from 25 to 44%, $p = 0.0004$) and

protective masks (3 to 16%, $p < 0.0001$) by members of a trauma team. Others have shown leadership can improve hand hygiene compliance and central-line associated bacteraemia rates(32).

Our study also highlighted some of the practical challenges in implementing PPE policy in the clinical space. Interns described their being expected to scribe outside patients' room, on ward rounds, as a constraint on learning PPE skills. Another challenge was time pressure during ward rounds, as previously reported(33, 34). There were also potential policy conflicts in relation to other clinical skills. For example, interns reported that they could not comply with a no jewellery requirement when they needed to use their watches for a clinical assessment. Consistent with findings from other studies(5, 6), poor access to suitable PPE within clinical areas was an environmental barrier, contributing to lack of opportunity to develop appropriate skills. Unavailability of the correct sizes of gowns or masks increases the risk of self-contamination(27).

The Behaviour Change Wheel(21) that accompanies the COM-B model would suggest that these barriers to ongoing skill maintenance and development are more appropriately addressed by systemic organisational change, rather than relying on education or training. For instance, ensuring that appropriate PPE stocks are available, providing physical locations for staff to place items for temporary safekeeping, encouraging use of fob (rather than wrist-) watches for use in clinical assessment. Organisations also have a responsibility to ensure that senior medical staff fulfil their accepted professional responsibility to be role models of appropriate clinical practice, including correct PPE use(35).

The limitations of this study are that the findings are confined to the experiences and practices of one cohort of interns within one local health district. Exploring interns' preparedness for optimal PPE use in other institutions and at other times, such as during the COVID-19 pandemic and afterwards, may identify different issues regarding their skills, knowledge and clinical experiences.

Conclusions

This study has identified gaps in the knowledge and skills of medical interns related to optimal use of PPE and highlighted missed opportunities in the clinical area to reinforce safe practice. Junior medical staff are sometimes taught sub-optimal PPE use as medical students, by poor role models and leaders, and are likely to perpetuate these practices as their careers progress. As junior doctors, they are more likely to work autonomously and be less exposed to peer support for PPE use than nursing staff. They see more patients, within a working day, as they move between different wards and departments, and so may be unwitting vectors of pathogen transmission within a facility(36).

Education and training in IPC, including appropriate use of PPE, for new doctors is important to minimise transmission of infection and prevent occupationally acquired infectious disease. Although many organisations provide generic IPC education at orientation for all clinical staff, including interns, the content and delivery of this training may not target gaps in the prior knowledge and poor habits developed through prior experiences of PPE use by junior doctors, and does not routinely recognise the

informal and hidden curriculum in medical education. Educators should incorporate these factors in training and education, by promotion of appropriate use of PPE that is situated in the everyday contexts of medically-orientated routine care such as ward rounds, and would provide multiple opportunities for reinforcing relevant donning and doffing skills. Our findings also indicate that organisations should incorporate interventions to address the contextual opportunity barriers, that go beyond education and training, in order to improve appropriate PPE use by junior doctors, and thereby reduce the risks of healthcare-associated infections for patients as well as staff.

Abbreviations

PPE personal protective equipment

IPC infection prevention and control

Declarations

Ethical approval

This study was approved by the Western Sydney Local Health District Human Research Ethics Committee (Ref. 5409).

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available as individual privacy could be compromised but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

All authors made substantial contributions to conception and design, and/or acquisition, analysis and interpretation of data. All authors have been involved in drafting and/or critically revising the manuscript for important intellectual content. All authors read and approved the final manuscript.

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