BMJ Open

Testing the efficacy and acceptability of video-reflexive methods in personal protective equipment training for medical interns: a mixed methods study

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To cite: Wyer M, Hor S-Y, Barratt R, *et al*. Testing the efficacy and acceptability of video-reflexive methods in personal protective equipment training for medical interns: a mixed methods study. *BMJ Open* 2021;**11**:e052985. doi:10.1136/bmjopen-2021-052985

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-052985).

Received 03 May 2021
Accepted 27 September 2021

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ABSTRACT

Objectives To test the efficacy and acceptability of video-reflexive methods for training medical interns in the use of personal protective equipment (PPE).

Design Mixed methods study.

Setting A tertiary-care teaching hospital, Sydney, January 2018–February 2019.

Participants 72 of 90 medical interns consented to participate. Of these, 39 completed all three time points.

Interventions Participants received a standard infection prevention and control (IPC) education module during their hospital orientation. They were then allocated alternately to a control or video group. At three time points (TPs) over the year, participants were asked to don/doff PPE items based on hospital protocol. At the first two TPs, all participants also participated in a reflexive discussion. At the second and third TPs, all participants were audited on their performance. The only difference between groups was that the video group was videoed while donning/doffing PPE, and they watched this footage as a stimulus for reflexive discussion.

Primary and secondary outcome measures The efficacy and acceptability of the intervention were assessed using: (1) comparisons of audit performance between and within groups over time, (2) comparisons between groups on survey responses for evaluation of training and self-efficacy and (3) thematic analysis of reflexive discussions.

Results Both groups improved in their PPE competence over time, although there was no consistent pattern of significant differences within and between groups. No significant differences were found between groups on reported acceptability of training, or self-efficacy for PPE use. However, analysis of reflexive discussions shows that the effects of the video-reflexive intervention were tangible and different in important respects from standard training.

Conclusions Video reflexivity in group-based training can assist new clinicians in engagement with, and better understanding of, IPC in their clinical practice. Our study also highlights the need for ongoing and targeted IPC training during medical undergraduate studies as well as regular workplace refresher training.

Strengths and limitations of this study

- ► To our knowledge, this study is the first controlled trial of the efficacy and acceptability of video-reflexive methods in infection prevention and control training.
- ► A strength of this study was the longitudinal study period over the medical interns' first year of clinical practice.
- ► The researchers were from varying professional backgrounds (nursing, medicine and social science), which enhanced the multimethod approach to data collection and analysis.
- ► Study findings were limited by a small sample size, aggravated by dropout of participants over time and a single hospital site.

INTRODUCTION

Healthcare-associated infections (HAIs) cause significant morbidity, increased healthcare costs and length of stay in hospitals worldwide, with around 165 000 reported cases of HAIs in Australia each year.[1] The use of personal protective equipment (PPE) and appropriate hand hygiene are components of standard and transmission-based infection prevention and control (IPC) precautions required in the care of patients who have a known or suspected communicable disease or who are colonised with a multiresistant organism (MRO). They are intended to prevent healthcare workers (HWs) contaminating their hands and/or clothing and spreading pathogens to fomites, other patients or staff or becoming infected themselves.

However, HW compliance with the correct use of PPE is often poor,[2] which means that they—and their patients—may be inadequately protected against potentially serious HAIs during routine care or prepared to respond, safely and confidently, to infectious disease emergencies.

This can have potentially serious consequences, as shown by regular hospital outbreaks of respiratory (eg, influenza) and enteric (eg, norovirus, *Clostridioides difficile*) infections, occasional hospital transmission

of emerging viral infections such as SARS (eg, in Toronto, 2003),[3] MERS (eg, in Seoul, 2015)[4] or Ebola virus (eg, in Spain and USA, 2014)[5] and major outbreaks of COVID-19 among HWs worldwide.[6] Failure of appropriate hand hygiene and PPE use is also a major factor in continuing spread of MROs in the hospital setting, which adds to the increasing prevalence of antimicrobial resistance.[7]

As a group, doctors are consistently less compliant with IPC practices, than other HWs.[8 9] Explanations for this discrepancy include a focus on individual patient care and knowledge gaps around pathogen transmission and IPC policies, most likely relating to cursory or ineffective formal IPC training.[8 10–12] Providing training is challenging due to the intensive resources and time required, and a lack of consensus on the best methods for training.[13] Most orientation programmes in Australian and New Zealand hospitals include PPE training, but a recent survey of 137 facilities found that annual updates are undertaken in fewer than half.[12] Furthermore, learning in the clinical workplace is complicated by a hidden curriculum that includes poor role modelling by registrars and consultants.[14] Despite standardised PPE protocols being used in training to structure and improve practice, and competency measurement against these standards, suboptimal practice persists. Therefore, calls have been made for new and more effective education methods.[10 11 15]

In this paper, we report the results of a project in which we sought to evaluate the use of novel video-reflexive methods (VRM) in clinician training, to improve their understanding and retention of IPC practices, particularly in the appropriate use of PPE.

Objectives

The aim of the project was to test the efficacy and acceptability of VRM for training medical interns in the use of PPE, at the beginning of their first postgraduate year. Our broader aim was to improve the use of PPE by interns in hospitals and their understanding of the importance of, and rationale for its use.

We hypothesised that the use of VRM in PPE training, compared with standard training methods, would show:

1. improvements in intern self-efficacy regarding PPE use.
2. Better compliance with correct methods of putting on (donning) and removing (doffing) PPE, over a sustained period (at the end of their first and second terms).

We also hypothesised that interns would experience more enjoyment and be more satisfied with VRM training, compared with standard training methods.

METHODS

This is a mixed methods study, which integrates qualitative data from video and audio-recorded training sessions, with quantitative data from surveys and compliance audits.

Research approach

Video-reflexive ethnography (VRE) is an interventionist research methodology, used to foster practice improvement in healthcare settings. It is based on learning theory as well as contemporary research on patient safety and complex systems.[16] It is designed to grapple with the complexity of everyday healthcare work and to harness the expertise of frontline staff and stakeholders, through the creation of video feedback of everyday clinical practices, and guided individual or group reflection on this feedback. Four principles underly the methodology: *exnovation*—an examination of the complexity of everyday, taken-for-granted practices; *collaboration*—a participatory approach to data cocreation, analysis and redesign with participants; *reflexivity*—whereby participants review and reimagine practices; *care*—for participants' psychological safety as they confront the complexity of their practices.[17]

VRE has been used to explore staff and patients' knowledge and practice of hospital IPC.[18–22] These studies found that video reflexivity can significantly contribute to participants identifying potential IPC risks and develop solutions to reduce infection transmission, including improving staff competence and confidence with correct methods of donning and doffing PPE. In the study reported in this paper, we adopted some components of VRE, rather than the methodology as a whole. The methodological principles of exnovation, reflexivity and care remained central to our research approach, however, exnovation here was limited to brief and highly structured interactions with participants, and collaboration was limited to analysing footage with participants. For this reason, we refer to our approach as using VRM, rather than VRE.

Patient and public involvement

Patients were not involved in this study.

Study setting and participants

In Australia, medical graduates are required to undertake an accredited internship to be eligible for registration as medical practitioners. In January 2018, we invited all first-year medical interns, at a large tertiary-care teaching hospital in a local health district (LHD) in Sydney, New South Wales, to take part in our research during their 2-week hospital orientation, which included a 2-hour session on IPC. Follow-up research activities took place at this site, and at another hospital in the same LHD where interns were placed on rotation.

Study design

The study was undertaken between January 2018 and February 2019. All interns attended an IPC training module, which included a short talk on IPC principles and demonstration of the correct methods and sequences of donning and doffing PPE, by IPC professionals. On completion of this module, those who consented to participate in the study were allocated alternately to either a control or intervention (VRM) group. The study

comprised a number of activities over three TPs (TP1–TP3) (see table 1).

Audit tool

Audits were completed by the researchers (IPC professionals who are trained as auditors) using an online audit data collection platform (REDCap). The audit tool collected data on research group (control or VRM) and time and location of audit. Sixteen specific items were recorded in the audit, namely: (a) 13 individual compliance indicators as prescribed the hospital PPE competency assessment form (see online supplemental document 1); (b) two additional compliance indicators, which recorded whether participants adhered to the correct sequence of (1) donning and (2) doffing and (c) one criterion that recorded whether, in the auditors expert opinion, the PPE items were removed safely, overall, even if not strictly in the order specified by hospital protocol. If an item of PPE was not removed safely, a record of which item and a description of why it was unsafe were made.

Outcome measures

The efficacy and acceptability of the VRM-modified training were assessed using three sources of data, namely:

1. comparisons between VRM and control groups and within groups over time, of participants' audit performance at TP2 and TP3.
2. Comparisons between VRM and control groups, on their survey responses for evaluation of training, self-efficacy relating to PPE use and free-text responses, at TP1 and TP2.
3. Thematic analysis of transcripts of reflexive debrief discussions at TP1 and TP2.

Statistical analysis

Audit

Of the 16 audit items, four were selected from the 13 individual compliance indicators for analysis, on the basis that not performing these actions could pose a significant risk of cross-infection for patients or HWs. They were also the audit items that resulted in the most variability among participants. These four items were: (a) hand hygiene prior to donning PPE, hand hygiene after glove removal, removing protective eyewear safely and removing facial mask safely.

The other three items, summarising PPE actions, that were included in the analysis were: (b-i)—correct donning order, (b-ii)—correct doffing order and (c) PPE items removed safely overall.

The numbers of participants who performed each selected audited item correctly were compared between groups, at each audit time period, using Fisher's exact test. Within each group, the numbers who performed each item correctly were compared between the two audit time periods using McNemar's test. In order to compare audits at both TPs, data analysis was restricted to participants who completed both audits.

Survey

Participants' responses to each of the four items on the Likert-type scale were transformed into numerical scores (1=strongly disagree to 7=strongly agree). The differences between the VRM and control groups, at and across the two TPs, were analysed using an independent samples t-test. Statistical analysis was performed using a statistical software package, V.26.0 (SPSS).

The significance level was set at $p<0.05$ for all statistical analyses.

Qualitative analysis

Transcripts of free-text survey responses and reflexive discussions were analysed thematically.[23] Initial analysis was conducted by the two members of the research team (MW and RB). The first stage was immersion in the data through repeated readings, to identify possible codes and initial themes (patterns of meaning). NVivo software (QSR International. V.12.6.0) was used to organise and code the data. Codes were then compared between coders and finalised. A set of themes and illustrative quotes were reached by agreement through discussion with all researchers. The identified themes were then compared between groups and training points, to identify similarities and differences in what participants in each group said or commented at each training point.

Standards for reporting qualitative research reporting guidelines[24] were used in reporting this study.

RESULTS

Of the 90 interns who attended hospital orientation, 72 (80%) agreed to participate in the study and took part in the initial activities. Thereafter, 55 and 39 completed research activities at TP2 and TP3, respectively. Dropout was primarily caused by the difficulties of contacting and arranging times to meet with participants who were: on rotation in remote locations; on annual leave; on night shifts and/or facing significant time pressures and heavy workload.

Audit results

Table 2 shows the number of participants in each group who performed selected actions correctly at each TP.

Effect of training intervention on audit performance (competence and confidence with individual PPE actions)

At both TP2 and TP3 audits, there were no significant differences between VRM and control groups, that is, participants in both groups performed similarly on all PPE action items audited.

Effect of time on audit performance

In both the VRM and control groups, there were no statistically significant changes in the numbers of participants' who performed any individual PPE action item, between TP2 and TP3. However, for the summary criterion of whether all PPE were removed safely or not, the control group improved significantly between TP2 and

Table 1 Study activities across time periods

Time point	TP1 (January 2018)	TP2 (April–May 2018)	TP3 (August–September 2018)
Study activities	► Research took place during the 2 hours allocated to IPC over an intensive 2 week general hospital orientation ► IPC module and PPE demonstration ► PPE practice (in groups) ► Reflexive debrief session 1 (in groups) ► Survey 1	► Audit 1 (individual) ► Reflexive debrief session 2 (individual) ► Survey 2	► Audit 2 (individual)
Description	PPE practice and debrief Immediately following their orientation IPC module and PPE demonstration, each participant attended a PPE practice and debrief session lasting 20–30 min, in smaller groups of 5–10 participants. All participants were asked to practice donning and doffing items of PPE as they had been shown and based on hospital protocol. After their practice, they participated in a reflexive debrief discussion on PPE use, led by one or two members of the research team. The only difference in activities between VRM and Control groups was that the former were videoed donning and doffing PPE and they then watched the footage as an additional prompt for reflexive discussion during the debrief sessions. In line with the video-reflexive principle of acknowledging and engaging with the complexity of everyday practice[17] all participants were asked open-ended questions about their experiences of PPE use prior to training, to understand their usual practices and to contextualise what they had just learnt during training. Reflexive debrief sessions for all groups were audio-recorded and transcribed for analysis. Survey All participants also completed a short survey on their evaluation of the PPE training content and methods and self-efficacy regarding PPE use. Surveys consisted of two questions each for training evaluation and self-efficacy (see table 2), with responses elicited on a 7-point Likert-type scale (from 'strongly disagree' to 'strongly agree'). The survey also included two optional free-text questions: (1) how do you think your PPE training could be improved? (2) is there anything else you would like us to know? Surveys were administered online to participants' email addresses using REDCap software and, aside from indicating VRM/control group assignment, all responses received were anonymous.	Audit and feedback At the end of term 1 or beginning of term 2 of their first clinical year (10–14 weeks post orientation), participants completed an individual 'audit and feedback' exercise with a member of the research team, who was an experienced IPC educator, in the clinical units in which they were placed at the time. All participants were instructed to put on and take off items of PPE according to the hospital policy. The researcher (auditor) then audited their performance using a tool that drew on the hospital PPE competency assessment form. Following the audit, the auditors gave detailed verbal feedback to participants about their performance. In addition, participants who were in the VRM group were videoed during their audit, and they watched this footage during the auditor's feedback. Participants in both groups were invited to engage with reflexive discussion with their auditor during the feedback session, again focused on contextualising their audit performance in their experiences of everyday clinical practice. Feedback sessions for all participants were audio-recorded and transcribed for analysis. Survey Participants also completed the short PPE training evaluation and self-efficacy survey for a second time after their audit-feedback exercise. Surveys were administered online using iPads, and all responses were anonymous.	Audit At the end of the interns' second term (7–8 months postorientation), a second audit was conducted with all remaining participants, with no requirement for feedback, and no video or audio recording of the exercise. These audits were conducted in the units where participants were placed during that term, by the same auditors as at TP2, using the same hospital competency assessment form.

IPC, infection prevention and control; PPE, personal protective equipment; TP, time period; VRM, video-reflexive method.

Table 2 Numbers of interns who correctly performed each PPE action item during audits at both TPs

PPE action	TP2 audit		TP3 audit	
	Video group* (n=19)	Control group* (n=20)	Video group* (n=19)	Control group* (n=20)
	n (%)	n (%)	n (%)	n (%)
Hand hygiene prior to donning PPE	17 (89.5)	16 (80.0)	19 (100)	18 (90)
Correct donning order	4 (21.1)	10 (52.6)	8 (42.1)	7 (6.8)
Hand hygiene post glove removal	9 (47.4)	9 (45.0)	13 (68.4)	13 (65)
Correct doffing order	9 (47.4)	9 (45.0)	9 (47.4)	11 (55)
Removing protective eyewear safely	10 (52.6)	12 (60.0)	14 (73.7)	18 (90)
Removing facial mask safely	10 (52.6)	11 (55.0)	14 (73.7)	17 (85)
Overall, PPE items removed safely	7 (36.8)†	7 (35.0)‡	12 (63.2)†	14 (70)‡

*No difference between video and control groups, in either TP2 or TP3, was statistically significant (ie, Fisher's exact test—no p value was <0.05).
†For the video group, the increase for 'overall, PPE items removed safely' between TP2 and TP3 was not statistically significant (McNemar's test—p .125).
‡For the control group, the increase for 'overall, PPE items removed safely' between TP2 and TP3 was statistically significant (McNemar's test—p .039).
PPE, personal protective equipment; TP, time period.

TP3 (p=0.039); the VRM group also improved, but the difference was not statistically significant (p=0.125).

SURVEY RESULTS

Acceptability of training

No significant differences were found between groups and across time periods, on participants' reported satisfaction with, and enjoyment of the PPE training. Both groups rated their satisfaction and enjoyment of both the initial PPE training session and the audit-feedback session highly (see table 3).

Effect of training intervention on self-efficacy

Again, no significant differences were found between groups, or across time periods, in participants' reported self-efficacy in donning and doffing PPE. At both TPs, participants in each group felt confident in donning and doffing PPE given the necessary resources and time as well as in everyday life (see table 3).

Participants' free-text survey responses

A thematic analysis was performed of participants' free-text responses to the two questions about their PPE training and any other general comments. Approximately

Table 3 Results for survey questions

		Mean score (SD)*			
		Survey 1 (TP1)†		Survey 2 (TP2)†	
	Survey question	Video group‡ (n=36)	Control group‡ (n=36)	Video group‡ (n=26)	Control group‡ (n=28§)
Q.1	I am satisfied with the group PPE practice and debrief sessions I have just experienced	6.64±0.48	6.58±0.55	6.69±0.54	6.73±0.45
Q.2	I enjoyed the group PPE practice and debrief sessions I have just experienced	6.17±0.84	6.19±0.86	6.41±0.73	6.58±0.50
Q.3	I feel confident that I could don and doff PPE correctly, given all the necessary resources and time	6.64±0.49	6.58±0.55	6.39±0.99	6.46±0.76
Q.4	I feel confident that I can don and doff PPE correctly in my everyday practice	6.22±0.96	6.47±0.65	6.39±0.83	6.38±0.75

*Mean based on 1–7 scale where 7 = 'strongly agree' and 1 = 'strongly disagree'.
†No difference between video and control groups, in either TP1 or TP2 (ie, independent samples t-test)—no p value was<0.05.
‡No difference in either group, between TP1 or TP2 was statistically significant (independent samples t-test)—no p value was<0.05).
§One CG survey at TP2 was incomplete and had to be removed.
PPE, personal protective equipment; TP, time period.

half of all participants supplied free-text responses for surveys 1 and 2 (51% and 46%, respectively). We identified three main themes. First, participants felt that training would be more relevant if conducted in the ward environment. This theme was identified in participants' responses to the first survey just after initial training, which was conducted in a classroom setting, unlike the audit/feedback session that was conducted in the ward environment 10–14 weeks later.

> Maybe [a] demo of where equipment will be located on the wards will ease transfer from training to practice (survey1: #55Control).

Second, interns in both surveys and from both groups suggested that more frequent practice and training sessions would be beneficial.

> More practice and reinforcement so that it becomes second nature (survey1: #53Control)
>
> This practical exercise was excellent. More practice regularly as opposed to longer sessions (survey2: #48Control).

Third, participants commented that reflection on learning during training was helpful, and some in the VRM group commented that they found the video-reflexive method useful.

> Having the practical and reflection after was helpful (survey1: #24Control)
>
> I rather enjoyed the video-reflexive method and think it improved the session a lot (survey1: #46VRM)
>
> Video was helpful in cementing PPE technique (survey1: #15VRM).

In addition, one participant made the following observation, suggesting different applications for VRM in training.

> I think this method of teaching [video-reflexivity] would be more useful when teaching more complex tasks/procedures instead of a task that is relatively simple (survey1: #51VRM).

Reflexive debrief sessions

Group reflexive discussions during initial training at orientation (TP1)

During the first training session, all participants were asked to don and doff PPE as they had just been shown by the trainer, and they were then given a copy of the hospital PPE competency checklist to discuss how they had performed during the reflexive debrief session. Participants in both groups were able to identify aspects of compliance and non-compliance with the hospital policy.

> Yeah, you guys were telling us to, sort of, pull [the mask] downwards, but, like, I instinctually just did it upwards. I feel like that's the—it might have been the way I've been doing it for the past few years as well. But yes, I didn't realise that it was much safer to pull—in terms of infection control - to go downwards (Control 25/1).
>
> I managed to remember to remove my watch, I was like, "Yes." (VRM 29/1).

At the reflexive discussions following the first training session, participants in the Control group tended to discuss how they generally use PPE in their clinical work.

> I only wash my hands when I'm using sterile gloves. I don't usually do it when I am using blue gloves (Control 24/1).
>
> I prefer to wear glasses around the wards than to go and find a pair of safety goggles, which I honestly don't know where the safety goggles are (Control 24/1).

In contrast, participants in the VRM group reflected instead on the details of the PPE practice, they had just participated in, as seen in the video footage.

> [That was] when I realised my mask was upside down … it didn't fit correctly, so I had to figure it out. I knew something wasn't right (VRM 25/1).
>
> I tried consciously to separate [the mask straps]. But you've got to separate them before you put it over your head. Because [after I put the mask on my face] I couldn't [separate them] (VRM 23/1).

Both groups discussed what they had learnt from the training, identifying, in particular, the following procedural actions: washing their hands after glove removal, not tying their gown at the front of the body, using the correct order for donning and doffing various items of PPE, performing a respirator fit check and the safe removal of masks.

In addition, the VRM group also discussed the effects of being videoed. Some noticed habits that they had previously not recognised.

> Yeah, I guess, watching the video, it made me realise something that I hadn't before; that I keep going – fiddle with my [head] scarf. And I don't even think about it and there where, before, when I took everything off, I went to fix my scarf because I'd gone up and down before washing my hands again. And that's something that I wouldn't have noticed if I hadn't… (VRM 25/1),

Others discussed how the presence of the camera made them more focused on their donning and doffing.

> I feel like I was more self-conscious of myself because I knew I was being recorded (VRM 23/1).
>
> I think we were a lot more careful…I definitely thought more—a lot about each step (VRM 25/1).

Some discussed how the footage affirmed that they were using PPE correctly.

I guess it helps us check that we did it right … and you can see that in the video pretty nicely (VRM 25/1).

Several participants in the VRM group also realised how they looked to colleagues beside them for confirmation of correct order of donning/doffing PPE.

It's like seeing everyone do it, it's really obvious what you do different. Whereas if you're just watching yourself… I wouldn't have noticed that. Like, I noticed I took my [eye protection] off after I took my apron off, whereas everyone else took the eyewear off first (VRM 23/01).

Individual reflexive discussions at TP2 (one-on-one discussion with researcher–auditor)

Several participants from both groups mentioned that they had forgotten elements of the correct procedure for donning and doffing that they had learnt during orientation.

So…[laughs]. I am trying to remember (Control #16).

I honestly just forgot what you told us in the first session, about removing things in a certain order. I remember there was something different, but how we did it, I just couldn't remember (VRM #02).

However, many participants did discuss what they had remembered, including tying the gown at the back, how to remove gowns, where to dispose of PPE, and correct mask and glove use.

I remember that I am not supposed to tie [the gown] at the front. I remember that (Control #57).

I remember the elastics [of the mask] at the back [of the head] and to touch them to take it off. So, I have been doing that (VRM #31).

I remember there was someone in my group who [incorrectly] tied their gown at the front and it stuck with me (VRM #22).

Control group participants frequently engaged in conversation during the audit, such that their rationale for practices and any auditor feedback were often discussed during the audit itself. While these discussions were productive, it was somewhat disruptive to the flow of the donning and doffing and, thus, may have distracted from learnings related to the correct order of PPE. The VRM group spoke less during donning/doffing PPE, perhaps because they were aware that they were being videoed, and more discussion of their performance took place while watching the footage at the end of the audit. Being able to watch the footage and stop and start it at points of interest enabled the interns to scrutinise their practice more closely and unpack their actions.

Auditor: Why do you think I stopped it there?

Intern: I shouldn't take my mask off first, but I don't know why. [Is it] because [I] have still got [my] gloves on, and [I am] touching [my] face?

Auditor: Yes, that is it. But it is quite a significant reason … think about gloves as being dirty, and we don't want to put a dirty thing near our eyes (VRM #06).

DISCUSSION

In previous studies, VRM have been used successfully in ethnographic studies to explore and strengthen clinicians' awareness of their own infection control practices.[18 19 22] In one study, the use of VRM was associated with a sustained fall in methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence.[25] To our knowledge, the present study is the first controlled trial of the efficacy and acceptability of VRM in IPC training. Other study strengths were the longitudinal follow-up period over the medical interns' first year of clinical practice, and a research team comprising varied professional backgrounds (nursing, medicine and social science), which enhanced the multimethod approach to data collection and analysis.

We hypothesised that the use of VRM in PPE training (compared with standard training methods) would show improvements in intern competence and confidence regarding PPE use and that they would enjoy and be satisfied with VRM-modified training. We found instead that both VRM and control groups seemed to improve in their compliance over time, although, for the most part, this was not statistically significant. The one exception was that the control group improved significantly from TP2 to TP3 for the summary criterion of safe removal of PPE items overall. We also found that participants across groups and time periods reported similar (high) levels of confidence in using PPE and enjoyment of, and satisfaction with, their PPE training.

In the first instance, the improvement in the control group's (but apparently not the VRM group's) competence (in the summary criterion) over time is difficult to interpret, given the small sample sizes of both groups, and lack of other significant differences found between or within groups.[26] The sample size was limited in advance by the number of interns in the cohort, who agreed to participate. We were able to recruit only 72 interns and more than 50% were lost to final follow-up for reasons noted above. Another reason for the lack of differences could be that participants in the control group received two reflexive debrief sessions, which were not a standard part of their IPC training. So, although their practice was not videoed (nor the footage reviewed), it is likely that the opportunity to reflect on PPE usage and training was, in itself, an enhancement of standard training, and felt to be useful by participants, as described in their survey comments. As one participant commented, the added value of VRM may be more apparent when used for teaching more complex procedures.

The value of reflection on learning is well documented.[27] Reflexivity, as described in our methods, particularly emphasises a holistic awareness of how our actions

can be seen in relation to context, to understand the effects of context on ourselves, our work practices and the actions of others.[28] In addition to the general benefit of having a reflexive debrief, we suggest that the use of video facilitates particular aspects of holistic reflexivity, as it allows for a multimodal and repeated review of the videoed activity, in particular aspects, which may normally be overlooked. We know for instance that people are often unable to describe in detail, from memory, even the most mundane of practices that they use and rely upon.[29]

We found this difference reflected in participants' reflexive comments, where those in the Control group tended to comment at a more general level about how they used PPE in their everyday practice; whereas the VRM group commented about specific details of their own PPE practice, including habits that had previously gone unnoticed, with an eye for practice optimisation. This is consistent with findings in other VRE research in IPC[18 19 22] and supports the argument that video feedback enables actors to place themselves more readily in context and, therefore, to examine its effects.

For instance, the video allowed for collective reflection on one another's practices—such as looking at colleagues when donning/doffing for guidance or reassurance on correct procedure. This speaks to the hidden curriculum[30] of IPC learning and highlights the importance of correct role modelling in the clinical space.[31] However, we know that senior doctors' adherence to IPC practices is often suboptimal, which subsequently influences junior doctors' practice and perpetuates a cycle that threatens patient and clinician safety.[8 15] As Iedema *et al*[32] contend, 'video-assisted scrutiny of, and deliberation about, in situ clinical work' (p1)—that is, video reflexivity—enables HWs to collaboratively unpack and clarify their awareness and interpretation of IPC rules as well as the complexity of applying these rules in situ.[32]

Another effect of the use of VRM in training was that it allowed educators and interns to pause the footage at salient points or to view sections of the footage repeatedly, to pay attention to particular details, to articulate their reasoning and to clarify any issues. In our study, this also meant that the activity could be practiced (or audited) with fewer interruptions, as VRM participants were conscious of performing the procedure for the recording. This allowed for a smoother enactment of the flow of donning/doffing PPE, and could be of benefit to educators, as well as participants.

One caveat for the use of VRM in training is the need for psychological safety and trust between educators and healthcare professionals.[17] The process of video reflexivity can place participants in positions of vulnerability[33] through having their video-recorded practices viewed and analysed by themselves and others. In addition, the use of video recording also requires consideration about the safe handling and storage of this footage. Educators who use VRM will need to have plans to store identifiable footage securely, onsite and to use it only for training purposes.[17 34] One option may be for educators to offer the trainee a copy of their video, for their own reference and reflection, and then delete the original copy, once it is no longer required.

Medical interns' lack of readiness for IPC practice has been noted in other studies,[10 31 35 36] and our study shows that despite receiving enhanced training, both groups of interns still made mistakes that are consistent with previous studies, for example: incorrect donning and doffing order[13 37 38]; not performing hand hygiene after glove removal[39 40] and unsafe removal of facial protection.[13] These errors are not simply deviations from hospital protocols, but pose transmission risks to HWs and patients, and are particularly important considering the ongoing threat of drug resistant and emerging infectious diseases,[13 41] as illustrated by the current COVID-19 pandemic. They must be targeted during clinician undergraduate, induction and ongoing IPC training; the later arguably being the most neglected to date. These observations support the deployment of PPE 'spotters' to monitor HWs IPC practices, in high-risk settings (eg, COVID-19 ward, quarantine hotel) for transmission of a highly transmissible pathogen such as SARS-CoV-2.[42] Many participants in this study suggested that more frequent PPE practice and reinforcement would be appreciated and that it would be most beneficial if this was conducted in the workplace rather than in simulated environments. Their suggestions were supported by our findings, which showed that although errors were still made, the interns did seem to improve over time with experience in the field.

Finally, interns at this site undergo an intensive 2 week hospital induction where they potentially receive an overload[43] of new information. IPC, which is sometimes regarded as boring or repetitive,[44 45] may not capture their attention as well as other induction topics, although this may be different now, amidst a pandemic. Visual approaches to learning, such as VRM, may, therefore, assist to promote interactivity and engagement.[46 47] Furthermore, by reproducing the dynamics and complexity of everyday practice, video feedback can be used as a tool by educators to enable learners to connect not only to the technical aspects of their work but also to the tacit meanings and feelings embedded in their work,[48] therefore adding a dimension to learning that is often difficult to achieve.

CONCLUSION

We had hoped that through this study, that we could measure the effects of VRM, when used as a training tool, to show that it is more effective than standard training. To this end, we did not achieve our aim through quantitative measures: that is, the benchmarking of change over time against formalised rules. However, the effects of video reflexivity may not be so easy to quantify, nor perhaps is it necessary. Video reflexivity is, in the first instance, about confronting and dealing with complexity of practice, and its success is dependent on the commitment of HW to

adopt a reflexive attitude towards their work practices.[18] Our qualitative analysis shows that the effects of VRM were tangible and different from the effects of standard training. While further exploration is needed, the findings presented suggest that VRM, and particularly the group learning aspects of VRM, can assist new clinicians in engaging with, and better understanding, their practices around IPC. Potentially, recordings of individual trainees' practice sessions could also be shared with them as a resource for reinforcing their learning beyond the training sessions.

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Acknowledgements The authors thank the medical interns who participated in this study, sharing their experiences of PPE use, and providing insights that will contribute to future improvements in intern training. We also thank Masrura Kabir and Karen Byth for their assistance with statistical analysis.

Contributors MW, S-YH, RB and GLG were involved in the original concept and design of the study. All authors were involved in the design of participant materials including the participant invite and information sheet. GLG (chief investigator) led supervision of the research. RB led the ethics submission with substantial contributions from all authors. S-YH led the formulation of the survey and associated measures, with contributions from all authors in shaping the final survey. MW, S-YH, RB and GLG were involved in collection of data at TP1. MW and RB collected data at TP2 and TP3. RB, S-YH and GLG led the statistical analysis with assistance from statistician. MW and RB led the qualitative analysis with substantial contributions from all authors. MW led the writing of the research paper, with drafting and revision input from all authors. All authors have all seen and approved the final version of this paper and accept accountability for all aspects of the work.

Funding This work was supported by the National Health and Medical Research Council Centre of Research Excellence (NHMRC CRE), the Australian Partnership for Preparedness Research on Infectious Disease Emergencies (APPRISE AppID 1116530) and in-kind support by the University of Technology, Sydney.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the human research ethics committee of the Western Sydney Local Health District: HREC Ref: AU RED LNR/17/WMEAD/515.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data from this study includes identifiable information and therefore not publicly available. Selected data may be made available on reasonable request to the corresponding author.

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