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Personal protective equipment preparedness in intensive care units during the coronavirus disease 2019 pandemic: An Asia-Pacific follow-up survey

Ms. Navya Gullapalli, Final Year Medical Student, Dr. Zheng Jie Lim, ICU Resident, Dr. Kollengode Ramanathan, Senior ICU Consultant, Shailesh Bihari, A/Prof. ICU consultant, Dr. Jumana Haji, ECMO program director, Consultant anesthesia and critical care, Kiran Shekar, A/Prof. Senior ICU consultant, Dr. Wai Tat Wong, Clinical Professional Consultant, Dr. Arvind Rajamani, Senior Staff Specialist, Dr. Ashwin Subramaniam, Senior ICU consultant, Adjunct Senior Lecturer

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Author Statement

-
- Telephone: 0413 900 715

Author			**Author Contribution (CRediT author statement)**
Ms	Navya	Gullapalli	Data curation, Formal analysis, Writing - original draft, Writing - review and editing
Dr	Zheng Jie	Lim	Data curation, Formal analysis, Software, Writing - review and editing
Dr	Kollengode	Ramanathan	Conceptualization, Methodology, Writing - review and editing
A/Prof	Shailesh	Bihari	Writing - review and editing
Dr	Jumana	Haji	Writing - review and editing
A/Prof	Kiran	Shekar	Writing - review and editing
Dr	Wai Tat	Wong	Writing - review and editing
Dr	Arvind	Rajamani	Conceptualization, Methodology, Writing - review and editing
Dr	Ashwin	Subramaniam	Conceptualization, Methodology, Data curation, Supervision, Project administration, Writing - original draft, Writing - review and editing

Title page

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			Email	ORCID ID	Designation	Affiliation
Ms	Navya	Gullapalli	navya.gullapalli@gmail.com	0000-0001-8081-6787	Final Year Medical Student	Monash University, Clayton VIC
Dr	Zheng Jie	Lim	zhengjie.lim@icloud.com	0000-0001-8864-4844	ICU Resident	Ballarat Health Services, Ballarat, Victoria, Australia
Dr	Kollengode	Ramanathan	Ram_ramanathan@nuhs.edu.sg		Senior ICU Consultant	NUH, Singapore
A/Prof	Shailesh	Bihari	biharishailesh@gmail.com	0000-0001-7553-8620	ICU consultant	Flinders university and Flinders Medical center, Bedford Park SA 5042
Dr	Jumana	Haji	drjyhaji@gmail.com	0000-0003-1601-4266	ECMO program director, Consultant anesthesia and critical care	Aster CMI Hospital Bangalore
A/Prof	Kiran	Shekar	Kiran.shekar@health.qld.gov.au		Senior ICU consultant	Adult Intensive Care Services, the Prince Charles Hospital, Brisbane, Queensland, Australia Critical Care Research Group and Centre of Research Excellence for Advanced Cardio-respiratory Therapies Improving OrgaN Support (ACTIONS) University of Queensland, Brisbane, Queensland, Australia and Bond University, Gold Coast, Queensland, Australia
Dr	Wai Tat	Wong	wtwong@cuhk.edu.hk		Clinical Professional Consultant	The Chinese University of Hong Kong
Dr	Arvind	Rajamani	rrarvind@hotmail.com		Senior Staff Specialist	University of Sydney, Nepean Clinical School and Nepean Hospital,

						Kingswood, NSW
Dr	Ashwin	Subramaniam	ashwin.subramaniam@monash.edu	0000-0002-8292-7357	Senior ICU consultant	Frankston Hospital, Frankston, VIC. Adjunct Senior Lecturer, Monash University

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Corresponding author:

- Dr Ashwin Subramaniam
- ashwin.subramaniam@monash.edu
- Telephone: 0413 900 715

Author			**Author Contribution (CRediT author statement)**
Ms	Navya	Gullapalli	Data curation, Formal analysis, Writing - original draft, Writing - review and editing
Dr	Zheng Jie	Lim	Data curation, Formal analysis, Software, Writing - review and editing
Dr	Kollengode	Ramanathan	Conceptualization, Methodology, Writing - review and editing
A/Prof	Shailesh	Bihari	Writing - review and editing
Dr	Jumana	Haji	Writing - review and editing
A/Prof	Kiran	Shekar	Writing - review and editing
Dr	Wai Tat	Wong	Writing - review and editing
Dr	Arvind	Rajamani	Conceptualization, Methodology, Writing - review and editing
Dr	Ashwin	Subramaniam	Conceptualization, Methodology, Data curation, Supervision, Project administration, Writing - original draft, Writing - review and editing

Personal protective equipment preparedness in intensive care units during the coronavirus disease 2019 pandemic: An Asia-Pacific follow-up survey

Abstract

Background: Personal-protective equipment (PPE)-preparedness, defined as adherence to guidelines, healthcare worker (HCW) training, procuring PPE stocks and responding appropriately to suspected cases, is crucial to prevent HCW-infections.

Objective: To perform a follow-up survey to assess changes in PPE-preparedness across six Asia-Pacific countries during the COVID-19 pandemic.

Design: Prospective follow-up cross-sectional, web-based survey between 10/08/2020 to 01/09/ 2020, five months after the initial Phase 1 survey.

Setting: The same six Asia-Pacific countries (Australia, Hong Kong, India, New Zealand, Philippines, and Singapore) that participated in Phase 1.

Participants: Intensivists from 231 ICUs across these six countries.

Main outcome measures: Changes in PPE-preparedness between Phases 1 and 2.

Results: Phase 2 had responses from 132 ICUs (57%). Compared to Phase 1 respondents reported increased use of PPE-based practices such as powered air-purifying respirator (40.2% vs. 6.1%), N95-masks at all times (86.4% vs. 53.7%) and double-gloving (87.9% vs. 42.9%). The reported awareness of PPE stocks (85.6% vs. 51.9%), mandatory showering policies following PPE-breach (31.1% vs. 6.9%) and safety perception amongst HCWs (60.6% vs. 28.4%) improved significantly during Phase 2. Despite reported statistically similar adoption rate of the buddy system in both phases (42.4% vs. 37.2%), there was a

reported reduction in donning/doffing training in Phase 2 (44.3% vs. 60.2%). There were no reported differences HCW training in other areas, such as tracheal intubation, intra-hospital transport and safe waste disposal, between the 2 phases.

Conclusions: Overall reported PPE-preparedness improved between the two survey periods, particularly in PPE use, PPE inventory and HCW perceptions of safety. However, the uptake of HCW training and implementation of low-cost safety measures continued to be low and the awareness of PPE breach management policies were suboptimal. Therefore, the key areas for improvement should focus on regular HCW training, implementing low-cost buddy-system and increasing awareness of PPE-breach management protocols.

TEXT – 2,820 words

INTRODUCTION

Intensive Care Unit (ICU) healthcare workers (HCWs) are at an increased risk of coronavirus disease-2019 (COVID-19) due to inadequate personal protective equipment (PPE), long-time exposure with infected patients, increased work demand, and more aerosol generating procedures (AGP), among other reasons.[1-3] As per our original survey,[4] PPE-preparedness, defined as adherence to guidelines, HCW training, procuring PPE stocks and responding appropriately to suspected cases, is crucial to prevent HCW-infections.[4] In the early stage of the pandemic (March 25th 2020 and April 6th 2020), a multinational survey was conducted to assess PPE-preparedness in ICUs across six countries in the Asia-Pacific region.[4] Wide variations in PPE-preparedness was observed both between and within countries, with several ICUs reporting suboptimal PPE-training, practice and stock-awareness.[4] There were notable variations in several areas: reported use of negative-pressure room; HCW training; PPE stock-awareness; reported use of high flow nasal oxygenation and non-invasive ventilation, reported use of specialised airway teams, showering policies; and "buddy-systems".[4]

Since then, these six countries have experienced differing trends in the epidemiology of COVID-19 cases and HCW-infection rates. At the time of this survey, while India and the Philippines were in the first wave of infections,[5] Australia was experiencing a second wave in some states.[3] Meanwhile, New Zealand (NZ), Singapore and Hong Kong (HK) had minimal community spread and their majority of cases were imported from overseas travellers.[5-7] Similar international surveys on PPE preparedness during the early pandemic identified unprecedented challenges and lack of forward planning among health systems worldwide.[8]

The aim of this follow-up study was to determine if there have been changes in PPE-preparedness over time, taking into consideration the changing contexts, such as prone-positioning patients with COVID-19, ICU policies for PPE breach and PPE reuse. In this paper, we report a follow-up survey of the same ICUs across six Asia-Pacific countries.[4]

METHODS

Study design

This follow-up survey used the same cross-sectional web-based methodology as our original study.[4] The questionnaire content was based on the EuroNHID project,[9] and was validated after several rounds of consensus-building process between ICU and infectious diseases specialists. As in the original survey, the World Health Organisation (WHO) recommendations were chosen as the reference standard.[10] Our initial survey (defined as Phase 1 henceforth) was conducted between March 25, 2020, and April 06, 2020.[4]

Study setting and population

This survey (defined as Phase 2 henceforth) was distributed to qualified consultant intensivists across the same six countries (Australia, NZ, Singapore, HK Philippines and India), working in hospitals with a 24/7 Emergency/Casualty Department and an ICU capable of mechanically ventilating patients for at least 24 hours. As shown in the supplementary appendix, we made minor amendments to a few questions to make it in line with the ongoing pandemic, namely, asking questions regarding training for prone-positioning patients with COVID-19, ICU policies for PPE breach and PPE reuse. Following ethical approval by the Nepean Blue Mountains Local Health District Human Research Ethics Committee (approval number: 2020/ETH00705, August 6, 2020) the survey was distributed from August 10th, 2020 to September 1st 2020 by email, text message and WhatsApp™ to the intensivists from the same 231 ICUs who had responded to the Phase 1 survey. Two reminders were sent one week apart. As is the initial survey, we only included the first response from each institution. The reason behind this was to avoid the likelihood of multiple intensivists from the same

institution responding to the survey by the snowballing method employed for distribution.[4] Participation was voluntary, with no incentives offered.

Definitions

As per the original survey, we defined PPE-preparedness as adherence to guidelines, HCW training, procuring PPE stocks, and responding appropriately to suspected cases.[4]

Data analysis

Data analysis was conducted by two trained authors. Data was reported as proportions and 95% confidence interval (95%-CI) was calculated. No overlap of 95%-CI between Phase 1 and Phase 2 represents significant results. All values and analyses were calculated using STATA 16.0 (Statacorp, USA).

Study outcomes

This follow-up survey sought to explore any changes in PPE-preparedness between Phase 1 and 2, which included PPE practice, HCW training, PPE inventory and HCW perceptions, differences in practices associated with responding appropriately to suspected cases between Phase 1 and 2, the locations for management of a sick non-intubated patient with COVID-19 and type of non-invasive oxygen therapies and any differences in family visitation policies. Additionally, in Phase 2, we explored the policies and protocols surrounding PPE breach management, training for prone-positioning and PPE reuse.

RESULTS

A total of 132 intensivists out of the 231 ICUs from all the six countries who responded in Phase 1, responded in Phase 2 (57% response rate). The mean response rate in Phase 2 survey

was 63%. Singapore had the highest response rate (6/6, 100%), while Philippines had the lowest (5/16, 31%) (Figure 1).

Changes in PPE-preparedness

PPE use: There was a statistically significant increase in the reported use of all appropriate PPE required to manage patients with COVID-19 across all countries. There were significant increases in the reported use of powered air-purifying respirator (PAPR) in Phase 2 [Phase 1: 6.1% (95%-CI: 3.4-10.0); Phase 2: 40.2% (95%-CI: 31.7-49.0)]; double glove use [Phase 1: 42.9% (95%-CI: 36.4-49.5); Phase 2: 87.9% (95%-CI: 81.1-92.9)]; and in the use of N95 masks at all times [Phase 1: 53.7% (95%-CI: 47.0-60.2); Phase 2: 86.4% (95%-CI:79.3-91.7)]. Caps (131/132, 99.2%), visors (126/132, 95.5%) and goggles (126/132, 95.5%) were reportedly used by almost all ICUs in the Phase 2 survey (Figure 2, Supplementary Table 1). There were no reported differences in N95/P2 mask fit-testing [Phase 1: 27.3% (95%-CI: 21.6-33.5); Phase 2: 30.3% (95%-CI:22.6-38.9)] and the reported use of low-cost observers or "buddy-systems" to check donning and doffing procedures [Phase 1: 37.2% (95%-CI: 31.0-43.8); Phase 2: 42.4% (95%-CI:33.9-51.3)] (Table 1).

HCW Training: Overall, there was a reported significant reduction in HCW training for donning and doffing from 60.2% (95%-CI: 53.5-66.5) in Phase 1 down to 44.3% (95% CI: 35.6-53.2) in Phase 2. There was no reported difference in the other HCW training between the 2 phases in all countries. Phase 2 included an additional question regarding training for prone-positioning patients with COVID-19. 20% (26/132) [range: 0% (0/5) in NZ; 33% (2/6) in Singapore] of ICUs had regular training for prone-positioning. There was no reported difference in the use of specialised intubation teams between the 2 phases (65.8% in Phase 1 [95%-CI: 59.3-71.9] versus 77.9% in Phase 2 [95%-CI: 69.8-84.6]) (Table 2).

PPE inventory and HCW perceptions: Compared to Phase 1, there was a significant reported improvement in PPE stock adequacy, with most ICUs reporting they had adequate stocks to manage 3 patients with COVID-19 for 1 week from 51.9% in Phase 1 (95%-CI: 45.3-58.5) to 85.6% in Phase 2 (95%-CI:78.4-91.1)] (Table 2). In line with this, there was a reported statistically significant increase in the HCW perception of increased PPE procurement over the past 2 months in all six countries from 14.4% in Phase 1 (95%-CI: 10.1-19.6) to 71.2% in Phase 2 (95%-CI:62.7-78.8)]. The perception of HCW safety had reportedly improved significantly with the majority of respondents in Phase 2 reporting feeling safe (28.4% in Phase 1 [95%CI: 22.6-34.7] versus 60.6% in Phase 2 [95%-CI:51.7-69.0]). However, variations were observed in HCW perceptions regarding PPE practice and likelihood of HCW infections. HK, NZ and the Philippines had a decrease in the number of respondents who felt that PPE practice was optimal in Phase 2, while India had a statistically significant increase (Table 2).

PPE Breach: Policies regarding PPE breach were only explored in Phase 2. The most common policy measure for PPE breach reported by respondents was a mandatory reporting to infectious diseases experts or designated COVID consultants. (38/74, 51%). However, a substantial proportion reported they were either unaware of or that there was no formal policy regarding showering immediately (35/74, 47%), reporting to infectious diseases expert or designated COVID consultants/authorities (30/74, 41%) and retraining for donning and doffing (36/74, 49%) post-PPE breach (Figure 3). There was a reported significant increase from Phase 1 in the number of ICUs with mandatory showering policies if PPE was breached [Phase 1: 6.9% (95%-CI: 4.0-11.0); Phase 2: 31.1% (95%-CI:23.3-39.7)] (Supplementary Table 1).

Location to treat patients with COVID-19 receiving non-invasive oxygen therapies: Location for treating patients with COVID-19 remained relatively similar to Phase 1. However, there was a statistically significant reduction in the use of only negative pressure rooms in Phase 2 (8.6%; 95%-CI: 2.9-19.0) (Supplementary Table 2). In Phase 2, fewer respondents stated that non-invasive oxygen therapies were "not an option" for high-flow nasal cannula (26.4% in Phase 1 [95%-CI: 20.8-32.6] versus 10.6% in Phase 2 [95%-CI: 5.9-17.2]) and non-invasive ventilation (NIV) (45.5% in Phase 1 [95%-CI: 38.9-52.1] versus 21.2% in Phase 2 [95%-CI: 14.6-29.2]). For all forms of non-invasive oxygen therapies, the use of negative pressure rooms with overflow increased, with the largest change seen in NIV [9.1% in Phase 1 (95%-CI: 5.7-13.6) versus 30.3% in Phase 2 (95%-CI:22.6-38.9)] (Table 3).

ICU family visitation: In Phase 2, family visitation rights were limited to mostly remote communication only across all countries, which demonstrated a significant increase from Phase 1 (51.9% in Phase 1 [95%-CI: 45.3-58.5] versus 85.6% in Phase 2 [95%-CI:78.4-91.1]). Very few ICUs reported unchanged visitation policies in Phase 2 (6/132, 4.5%) (Table 1 and 2).

PPE reuse: Policies regarding PPE reuse were explored only in the Phase 2 survey. 51% (67/131) of ICUs reported reuse of face shields after washing with soap and water, while 31% (41/131) of ICUs were advised to reuse N95 masks (Supplementary Table 3).

DISCUSSION

This multinational follow-up survey was done to explore if there were any changes to PPE-preparedness reported by intensivists from six Asia-Pacific countries for the COVID-19 pandemic. The use of N95 masks in ICUs at all times significantly increased in Phase 2. There was an overall improvement in general PPE preparedness across ICUs in the six countries, particularly in the areas of individual PPE practices, visitation policies, PPE stocks and HCW perceptions of safety. No statistically significant differences were observed between the 2 phases in PPE training, except for donning and doffing, where there was a significant reduction in training. Implementation of buddy-system was similar between the 2 phases. There was an increased uptake of non-invasive oxygenation therapies within most ICUs, preferably in negative pressure rooms with overflow and a shift away from invasive mechanical ventilation.

The PPE practices for managing patients with COVID-19 has improved since the start of the pandemic, which is bolstered by various factors. Increased PPE production is one amongst them.[11-14] Across all countries, almost all recommended PPE was used by 80% or more of respondents in the Phase 2 survey. It is encouraging to see an increased use of surface-protective measures, such as shoe covers and neck covers, as SARS-CoV-2 has been shown to cause significant surface contamination, especially in ICUs.[15] The use of N95 masks continued to increase, with 86% of respondents reporting wearing N95/P2 masks at all times, compared to only 54% in Phase 1. This was an expected change as the community spread of the SARS-CoV-2 increased. However, internationally, guidelines continue to be inconsistent regarding the use of masks, with WHO guidelines still recommending N95 masks for AGPs only,[16] and societies such as the Australian and New Zealand Intensive Care Society (ANZICS) recommending N95 while nursing critically ill patients at all times.[17]

Perceptions of safety in HCWs improved across most countries. There has been a significant push for more PPE production, with many countries expanding local manufacturing of PPE, including utilising non-medical manufacturers for PPE production.[12] We found that overall awareness of PPE stock also improved among HCWs. This likely reflects the greater transparency from hospitals and government authorities, which is important for reducing HCW fear and anxiety.[18]

Of concern, there was no significant difference in most aspects of HCW training in Phase 2 compared to Phase 1. This was contrary to the to the intermediate follow-up study that our group conducted in India 1 month after the initial Phase 1 survey, which showed a significant increase in all aspects of HCW training.[19] We postulate the following reasons: either all HCWs were confident about their training;[20] or there was a possible waning of training opportunities as the pandemic peaked. Other plausible causes include probable staff attrition and lack of time in their busy ICUs and PPE fatigue. We observed that less than 50% of the ICUs conducted regular training with a significant drop in PPE donning and doffing in Phase 2. Since inappropriate PPE doffing is associated with increased contamination of HCWs,[21] and full training of HCWs reduces the rate of HCW-infection, it is important that ICUs continue to provide regular training and refresher sessions to maintain appropriate PPE-practices, familiarity and confidence among HCWs.[20, 21]

Despite societal guideline recommendations,[17, 22] low-cost safety measures, such as use of buddy systems continued to be under-utilised. Furthermore, there was still resistance in implementing fit-testing of HCWs with a recent large survey identifying that more than half the survey respondents were fit-tested with N95 masks.[8] Although fit-testing must be part of a respiratory protection program to ensure a safe working environment, there are both legal and moral obligations in implementing these measures.[23] The lack of improvement in HCW

training and minimal use of low-cost safety measures warrants further attention from hospitals and policymakers, as these simple methods can help reduce HCW infections.

Management of PPE breaches needs further attention as 40-50% of respondents reported either not being aware of or not having a formal policy on reporting, showering or retraining for donning and doffing after a PPE breach (Figure 3). Although there was an increase in showering after PPE breach, it was only mandated in around 30% of ICUs. It is equally concerning to note that 60% of Indian and Philippine ICUs reported reusing N95 masks, contrary to WHO, Centers of Disease Control and Prevention and ANZICS recommendations, and may display a need for additional N95 masks in these areas.[16, 17, 24]

In the early stages of the pandemic, there was hesitancy with using non-invasive oxygenation therapies, due to risk of aerosol transmission, with preference for early intubation. Intubation in patients with COVID-19 has been associated with increased barotrauma and mortality.[25] Studies have found high-flow nasal oxygen (HFNO) to be at low risk of bio-aerosol dispersion contrary to previous concerns and effective in reducing the need for intubation and mechanical ventilation.[26-29] Hence, it is encouraging to see that in Phase 2 there was an increase in their use, particularly NIV and HFNO, shifting away from early intubation that was witnessed in Phase 1. Appropriate PPE is essential to balance against the unknown risk of airborne transmission.[26] With the increased production of PPE and improved PPE practices, it has likely helped to make these forms of non-invasive oxygenation therapies a safer option for use in ICUs than was initially possible.

The study had several strengths. One, we included a range of ICUs in various countries at varying stages of the COVID-19 pandemic, which allowed for assessment of PPE preparedness across diverse landscapes with differing COVID-19 burdens. Two, a robust process was followed to design and validate the survey questionnaire. Three, the Phase 2

survey, distributed five months after initial the survey, provided sufficient time for changes in PPE practices to be implemented by hospitals and thus changes could be assessed effectively.

There were several limitations. While the study overall had a moderate mean response rate of 63%, there was marked variation in response rates of individual countries. Particularly Philippines and NZ both had low response rates and small sample sizes, which may restrict applicability of results there. Although, we sent the follow-up survey to the same ICUs that responded in Phase 1 to ensure consistency between the two phases, we were not sure what fraction of response come from the same person in that ICU between the first and second survey. Inherent to any survey, response bias may be present. The responses were self-reported and were not further independently checked to confirm if they aligned with their ICU protocols/practices. Although some additional AGPs such as prone positioning was added in the Phase 2 survey, there were still many AGPs including cardiopulmonary resuscitation, tracheostomy and bronchoscopy which were not assessed, mainly to keep response time manageable. Further research into rates of HCW infection may be beneficial to determine this association.

CONCLUSION

This follow-up survey found that ICUs in the six Asia-Pacific countries demonstrated reported improvements in their overall PPE-preparedness. There was a reported increased uptake in PPE practices, awareness regarding PPE stocks and more refined visitation policies resulting in an improved perception of safety amongst HCWs. There was a reported trend towards increased use of less-invasive respiratory therapies and shift away from early invasive mechanical ventilation. However, the reported uptake of HCW training and implementation of low-cost safety measures continued to be low and awareness of PPE breach management polices was suboptimal. We suggest that further attention be given to

HCW training and implementation of inexpensive measures to help reduce HCW infection rates.

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TABLES AND FIGURES

Legends

Table 1: Low-cost measures to ensure PPE safety

Table 2: Management and training strategies for COVID-19 patients; perceptions of safety in HCW

Table 3: Non-invasive oxygenation therapies

Figure 1: Overall response rate comparison between Phase 1 and Phase 2

Figure 2: Individual PPE practices (all countries)

Figure 3: Measure after PPE breach

Supplementary Appendix: The Survey

Supplementary Table 1: Individual PPE practices

Supplementary Table 2: Location for managing COVID patients requiring ICU admission

Supplementary Table 3: PPE reuse (Phase 2 only)

Table 1: Low-cost measures to ensure PPE safety

		Australia n/N (%, 95%-CI)	Hong Kong n/N (%, 95%-CI)	India n/N (%, 95%-CI)	New Zealand n/N (%, 95%-CI)	Philippines n/N (%, 95%-CI)	Singapore n/N (%, 95%-CI)	Total n/N (%, 95%-CI)
Measures to ensure safety								
N95/P2 mask fit-testing	Phase 1	16/68 (23.5, 14.1-35.4)	12/12 (100.0, 73.5-100.0)	13/115 (11.3, 6.2-18.6)	9/14 (64.3, 35.1-87.2)	7/16 (43.8, 19.8-70.1)	6/6 (100.0, 54.1-100.0)	63/231 (27.3, 21.6-33.5)
	Phase 2	10/47 (21.3, 10.7-35.7)	11/11 (100.0, 71.5-100.0)	5/58 (8.6, 2.9-19.0)	5/5 (100.0, 47.8-100.0)	3/5 (60.0, 14.7-94.7)	6/6 (100.0, 54.1-100.0)	40/132 (30.3, 22.6-38.9)
Mandatory use of a "buddy"	Phase 1	35/68 (51.5, 39.0-63.8)	2/12 (16.7, 2.1-48.4)	32/115 (27.8, 19.9-37.0)	9/14 (64.3, 35.1-87.2)	5/16 (31.3, 11.0-58.7)	3/6 (50.0, 11.8-88.2)	86/231 (37.2, 31.0-43.8)
	Phase 2	31/47 (70.0, 50.7-79.1)	1/11 (0.9, 0.2-41.3)	14/58 (24.1, 13.9-37.2)	4/5 (80.0, 28.4-99.5)	2/5 (40.0, 5.3-85.3)	4/6 (66.7, 22.3-95.7)	56/132 (42.4, 33.9-51.3)
Showering at end of shift	Phase 1	16/68 (23.5, 14.1-35.4)	1/12 (8.3, 0.2-38.5)	59/115 (51.3, 41.8-60.7)	9/14 (64.3, 35.1-87.2)	10/16 (62.5, 35.4-84.8)	2/6 (33.3, 4.3-77.7)	97/231 (42.0, 35.5-48.6)
	Phase 2	3/47 (6.4, 1.3-17.5)	0/11 (0.0, 0.0-28.5)	36/58 (62.1, 48.4-74.5)	1/5 (20.0, 0.5-71.6)	4/5 (80.0, 28.4-99.5)	2/6 (33.3, 4.3-77.7)	46/132 (34.8, 26.8-43.6)
Showering if PPE breach	Phase 1	10/68 (14.7, 7.3-25.4)	2/12 (16.7, 2.1-48.4)	**3/115 (2.6, 0.5-7.4)**	1/14 (7.1, 0.2-33.9)	0/16 (0.0, 0.0-20.6)	0/6 (0.0, 0.0-45.9)	**16/231 (6.9, 4.0-11.0)**
	Phase 2	13/47 (27.7, 15.6-42.6)	1/11 (0.9, 0.2-41.3)	**22/58 (37.9, 25.5-51.6)**	0/5 (0.0, 0.0-52.2)	2/5 (40.0, 5.3-85.3)	3/6 (50.0, 11.8-88.2)	**41/132 (31.1, 23.3-39.7)**
The values listed in bold, represent no overlap of 95%-CI between Phase 1 and Phase 2, and are significant results.								

Table 2: Management and training strategies for COVID-19 patients; perceptions of safety in HCW

		Australia n/N (%, 95%-CI)	Hong Kong n/N (%, 95%-CI)	India n/N (%, 95%-CI)	New Zealand n/N (%, 95%-CI)	Philippines n/N (%, 95%-CI)	Singapore n/N (%, 95%-CI)	Total n/N (%, 95%-CI)
Regular training for aerosol-generating activities in COVID-19 patients								
Tracheal intubation training	Phase 1	40/68 (58.8, 46.2-70.6)	4/12 (13.6, 9.9-65.1)	21/115 (18.3, 11.7-26.5)	11/14 (78.6, 49.2-95.3)	4/16 (25.0, 7.3-52.4)	3/6 (50.0, 11.8-88.2)	83/231 (35.9, 29.7-42.5)
	Phase 2	27/46 (58.7, 43.2-73.0)	2/11 (18.2, 2.3-51.8)	7/58 (12.1, 5.0-23.3)	1/5 (20.0, 0.5-71.6)	1/5 (20.0, 0.5-71.6)	3/6 (50.0, 11.8-88.2)	41/131 (31.3, 23.5-40.0)
Intra-hospital transport training	Phase 1	15/68 (22.1, 12.9-33.8)	1/12 (8.3, 0.2-38.5)	19/115 (16.5, 10.3-24.6)	7/14 (50.0, 23.0-77.0)	4/16 (25.0, 7.3-52.4)	1/6 (16.7, 0.4-64.1)	47/231 (20.3, 15.3-26.1)
	Phase 2	14/47 (29.8, 17.3-44.9)	0/11 (0.0, 0.0-28.5)	10/58 (17.2, 8.6-29.4)	0/5 (0.0, 0.0-52.2)	2/5 (40.0, 5.3-85.3	3/6 (50.0, 11.8-88.2)	29/132 (22.1, 15.4-30.2)
PPE donning and doffing training	Phase 1	54/68 (79.4, 67.9-88.3)	9/12 (75.0, 42.8-94.5)	48/115 (41.7, 32.6-51.3)	14/14 (100.0, 76.8-100.0)	10/16 (62.5, 35.4-84.8)	4/6 (66.7, 22.3-95.7)	**139/231 (60.2, 53.5-66.5)**
	Phase 2	30/46 (65.2, 49.8-78.6)	5/11 (45.5, 16.7-76.6)	19/58 (32.8, 21.0-46.3)	0/5 (0.0, 0.0-52.2)	1/5 (20.0, 0.5-71.6)	3/6 (50.0, 11.8-88.2)	**58/131 (44.3, 35.6-53.2)**
PPE waste disposal training for cleaners	Phase 1	25/68 (36.8, 25.4-49.3)	4/12 (13.6, 9.9-65.1)	43/115 (37.4, 28.5-46.9)	6/14 (42.9, 17.7-71.1)	9/16 (56.3, 29.9-80.2)	2/6 (33.3, 4.3-77.7)	89/231 (38.5, 32.2-45.1)
	Phase 2	12/46 (26.1, 14.3-41.1)	4/11 (36.4, 10.9-69.2)	17/58 (29.3, 18.1-42.7)	1/5 (20.0, 0.5-71.6)	3/5 (60.0, 14.7-94.7)	3/6 (50.0, 11.8-88.2)	40/131 (30.5, 22.8-39.2)
Specialised COVID intubation team	Phase 1	52/68 (76.5, 64.6-85.9)	5/12 (41.7, 15.2-72.3)	69/115 (60.0, 50.4-69.0)	13/14 (92.9, 66.1-99.8)	11/16 (68.8, 41.3-89.0)	2/6 (33.3, 4.3-77.7)	152/231 (65.8, 59.3-71.9)
	Phase 2	39/46 (84.8, 71.1-93.7)	5/11 (45.5, 16.7-76.6)	46/58 (79.3, 66.6-88.8)	4/5 (80.0, 28.4-99.5)	5/5 (100.0, 47.8-100.0)	3/6 (50.0, 11.8-88.2)	102/131 (77.9, 69.8-84.6)
Prone-positioning COVID patients *	Phase 2	15/47 (32%)	0/11 (0%)	8/58 (14%)	0/5 (0%)	1/5 (20%)	2/6 (33%)	26/132 (20%)
Awareness of PPE stock adequacy to manage 3 confirmed COVID patients in ICU for at least 1 week								
Aware of PPE stock and able to care for 3 COVID patients for 1 week	Phase 1	**36/68 (52.9, 40.4-65.2)**	11/12 (91.7, 61.5-99.8)	**49/115 (42.6, 33.4-52.2)**	12/14 (85.7, 57.2-98.2)	7/16 (43.8, 19.8-70.1)	5/6 (83.3, 35.9-99.6)	**120/231 (51.9, 45.3-58.5)**
	Phase 2	**40/47 (85.1, 71.7-93.8)**	11/11 (100.0, 71.5-100.0)	**49/58 (84.5, 72.6-92.7)**	4/5 (80.0, 28.4-99.5)	3/5 (60.0, 14.7-94.7)	6/6 (100.0, 54.1-100.0)	**113/132 (85.6, 78.4-91.1)**
Family/NOK visitation								
Remotely, no exceptions	Phase 1	**36/68 (52.9, 40.4-65.2)**	11/12 (91.7, 61.5-99.8)	74/115 (64.3, 54.9-73.1)	13/14 (92.9, 66.1-99.8)	13/16 (81.3, 54.4-96.0)	5/6 (83.3, 35.9-99.6)	**152/231 (65.8, 59.3-71.9)**
	Phase 2	**42/47 (89.4, 76.9-96.5)**	11/11 (100.0, 71.5-100.0)	48/58 (82.8, 70.6-91.4)	4/5 (80.0, 28.4-99.5)	5/5 (100.0, 47.8-100.0)	5/6 (83.3, 35.9-99.6)	**115/132 (87.1, 80.2-92.3)**
Perceptions of safety reported by intensivists (Highly Agree)								
I feel very safe	Phase 1	20/68 (29.4, 19.0-41.7)	6/12 (50.0, 21.1-78.9)	**26/115 (22.6, 15.3-31.3)**	8/12 (66.7, 34.9-90.1)	1/16 (6.3, 0.2-30.2)	4/6 (66.7, 22.3-95.7)	**65/229 (28.4, 22.6-34.7)**
	Phase 2	25/47 (53.2, 38.1-67.9)	10/11 (90.9, 58.7-99.8)	**36/58 (62.1, 48.4-74.5)**	2/5 (40.0, 5.3-85.3)	1/5 (20.0, 0.5-71.6)	6/6 (100.0, 54.1-100.0)	**80/132 (60.6, 51.7-69.0)**
PPE practice is suboptimal to prevent healthcare	Phase 1	21/68 (30.9, 20.2-43.3)	0/12 (0.0, 0.0-26.5)	**65/115 (56.5, 47.0-65.7)**	2/12 (16.7, 2.1-48.4)	3/16 (18.8, 4.0-45.6)	0/6 (0.0, 0.0-45.9)	**91/229 (39.7, 33.4-46.4)**
	Phase 2	14/47	1/11	**11/58**	3/5	1/5	0/6	**30/132**

worker infection		(29.8, 17.3-44.9)	(0.9, 0.2-41.3)	**(19.0, 9.9-31.4)**	(60.0, 14.7-94.7)	(20.0, 0.5-71.6)	(0.0, 0.0-45.9)	**(22.7, 15.9-30.8)**
PPE stock is at least 2 months behind	Phase 1	**47/68 (69.1, 56.7-79.8)**	**9/12 (75.0, 42.8-94.5)**	**68/115 (59.1, 49.6-68.2)**	5/12 (41.7, 15.2-72.3)	10/16 (62.5, 35.4-84.8)	1/6 (16.7, 0.4-64.1)	**140/229 (61.1, 54.5-67.5)**
	Phase 2	**6/47 (12.8, 4.8-25.7)**	**1/11 (0.9, 0.2-41.3)**	**5/58 (8.6, 2.9-19.0)**	1/5 (20.0, 0.5-71.6)	0/5 (0.0, 0.0-52.2)	0/6 (0.0, 0.0-45.9)	**13/132 (9.8, 5.3-16.3)**

The values listed in bold, represent no overlap of 95%-CI between Phase 1 and Phase 2, and are significant results.
COVID – coronavirus disease; PPE – personal protective equipment; NOK – next-of-kin
* Training for Prone-positioning of COVID patients was only asked in Phase 2

Table 3: Non-invasive oxygenation therapies

			Australia n/N (%, 95%-CI)	Hong Kong n/N (%, 95%-CI)	India n/N (%, 95%-CI)	New Zealand n/N (%, 95%-CI)	Philippines n/N (%, 95%-CI)	Singapore n/N (%, 95%-CI)	Total n/N (%, 95%-CI)
Low-flow oxygen <6L/min	Not an option – will intubate immediately	Phase 1	2/68 (2.9, 0.4-10.2)	0/12 (0.0, 0.0-26.5)	26/115 (22.6, 15.3-31.3)	0/14 (0.0, 0.0-23.2)	3/16 (18.8, 4.0-45.6)	0/6 (0.0, 0.0-45.9)	31/231 (13.4, 9.3-18.5)
		Phase 2	1/47 (2.1, 0.1-11.3)	0/11 (0.0, 0.0-28.5)	5/58 (8.6, 2.9-19.0)	0/5 (0.0, 0.0-52.2)	0/5 (0.0, 0.0-52.2)	0/6 (0.0, 0.0-45.9)	6/132 (4.5, 1.7-9.6)
	Neutral rooms with overflow	Phase 1	32/68 (47.1, 34.8-59.6)	0/12 (0.0, 0.0-26.5)	**57/115 (49.6, 40.1-59.0)**	5/14 (35.7, 12.8-64.9)	6/16 (37.5, 15.2-64.6)	3/6 (50.0, 11.8-88.2)	103/231 (44.6, 38.1-51.2)
		Phase 2	21/47 (44.7, 30.2-59.9)	0/11 (0.0, 0.0-28.5)	**14/58 (24.1, 13.9-37.2)**	2/5 (40.0, 5.3-85.3)	2/5 (40.0, 5.3-85.3)	2/6 (33.3, 4.3-77.7)	41/132 (31.1, 23.3-39.7)
	Negative pressure rooms with overflow	Phase 1	26/68 (38.2, 26.7-50.8)	3/12 (25.0, 5.5-57.2)	**10/115 (8.7, 4.2-15.4)**	7/14 (50.0, 23.0-77.0)	2/16 (12.5, 1.6-38.3)	0/6 (0.0, 0.0-45.9)	**48/231 (20.8, 15.7-26.6)**
		Phase 2	22/47 (46.8, 32.1-61.9)	1/11 (9.1, 0.2-41.3)	**33/58 (56.9, 43.2-69.8)**	3/5 (60.0, 14.7-94.7)	2/5 (40.0, 5.3-85.3)	3/6 (50.0, 11.8-88.2)	**64/132 (48.5, 39.7-57.3)**
	Negative pressure rooms only	Phase 1	8/68 (11.8, 5.2-21.9)	9/12 (75.0, 42.8-94.5)	22/115 (19.1, 12.4-27.5)	2/14 (14.3, 1.8-42.8)	5/16 (31.3, 11.0-58.7)	3/6 (50.0, 11.8-88.2)	49/231 (21.2, 16.1-27.1)
		Phase 2	3/47 (6.4, 1.3-17.5)	10/11 (90.9, 58.7-99.8)	4/58 (6.9, 1.9-16.7)	0/5 (0.0, 0.0-52.2)	1/5 (20.0, 0.5-71.6)	1/6 (16.7, 0.4-64.1)	19/132 (14.4, 8.9-21.6)
High Flow Nasal Cannula oxygenation	Not an option – will intubate immediately	Phase 1	18/68 (26.5, 16.5-38.6)	8/12 (66.7, 34.9-90.1)	**30/115 (26.1, 18.3-35.1)**	1/14 (7.1, 0.2-33.9)	1/16 (6.3, 0.2-30.2)	3/6 (50.0, 11.8-88.2)	**61/231 (26.4, 20.8-32.6)**
		Phase 2	5/47 (10.6, 3.5-23.1)	5/11 (45.5, 16.7-76.6)	**4/58 (6.9, 1.9-16.7)**	0/5 (0.0, 0.0-52.2)	0/5 (0.0, 0.0-52.2)	0/6 (0.0, 0.0-45.9)	**14/132 (10.6, 5.9-17.2)**
	Neutral rooms with overflow	Phase 1	11/68 (16.2, 8.4-27.1)	1/12 (8.3, 0.2-38.5)	41/115 (35.7, 26.9-45.1)	1/14 (7.1, 0.2-33.9)	2/16 (12.5, 1.6-38.3)	1/6 (16.7, 0.4-64.1)	**57/231 (24.7, 19.3-30.8)**
		Phase 2	2/47 (4.3, 0.5-14.5)	0/11 (0.0, 0.0-28.5)	10/58 (17.2, 8.6-29.4)	0/5 (0.0, 0.0-52.2)	1/5 (20.0, 0.5-71.6)	0/6 (0.0, 0.0-45.9)	**13/132 (9.8, 5.3-16.3)**
	Negative pressure rooms with overflow	Phase 1	17/68 (25.0,15.3-37.0)	2/12 (16.7, 2.1-48.4)	**5/115 (4.3, 1.4-9.9)**	8/14 (57.1, 28.9-82.3)	3/16 (18.8, 4.0-45.6)	1/6 (16.7, 0.4-64.1)	**36/231 (15.6, 11.2-20.9)**
		Phase 2	22/47 (46.8, 32.1-61.9)	0/11 (0.0, 0.0-28.5)	**32/58 (55.2, 41.5-68.3)**	4/5 (80.0, 28.4-99.5)	3/5 (60.0, 14.7-94.7)	1/6 (16.7, 0.4-64.1)	**62/132 (47.0, 38.2-55.8)**
	Negative pressure rooms only	Phase 1	22/68 (32.3, 21.5-44.8)	1/12 (8.3, 0.2-38.5)	39/115 (33.9, 25.3-43.3)	4/14 (28.6, 8.4-58.1)	10/16 (62.5, 35.4-84.8)	1/6 (16.7, 0.4-64.1)	77/231 (33.3, 27.3-39.8)
		Phase 2	18/47 (38.3, 24.5-53.6)	6/11 (54.5, 23.4-83.3)	10/58 (17.2, 8.6-29.4)	1/5 (20.0, 0.5-71.6)	1/5 (20.0, 0.5-71.6)	5/6 (83.3, 35.9-99.6)	41/132 (31.1, 23.3-39.7)
Non-invasive ventilation	Not an option – will intubate immediately	Phase 1	**31/68 (45.6, 33.5-58.1)**	10/12 (83.3, 51.6-97.9)	**44/115 (38.3, 29.4-47.8)**	4/14 (28.6, 8.4-58.1)	11/16 (68.8, 41.3-89.0)	5/6 (83.3, 35.9-99.6)	**105/231 (45.5, 38.9-52.1)**
		Phase 2	**9/47 (19.1, 9.1-33.3)**	8/11 (72.7, 39.0-94.0)	**6/58 (10.3, 3.9-21.1)**	2/5 (40.0, 5.3-85.3)	1/5 (20.0, 0.5-71.6)	2/6 (33.3, 4.3-77.7)	**28/132 (21.2, 14.6-29.2)**
	Neutral rooms with overflow	Phase 1	7/68 (10.3, 4.2-20.1)	0/12 (0.0, 0.0-26.5)	34/115 (29.6, 21.4-38.8)	1/14 (7.1, 0.2-33.9)	1/16 (6.3, 0.2-30.2)	1/6 (16.7, 0.4-64.1)	**44/231 (19.0, 19.2-24.7)**
		Phase 2	1/47 (2.1, 0.1-11.3)	0/11 (0.0, 0.0-28.5)	9/58 (15.5, 7.3-27.4)	0/5 (0.0, 0.0-52.2)	1/5 (20.0, 0.5-71.6)	0/6 (0.0, 0.0-45.9)	**11/132 (8.3, 4.2-14.4)**
	Negative pressure	Phase 1	7/68 (10.3, 4.2-20.1)	1/12 (8.3, 0.2-38.5)	**5/115 (4.3, 1.4-9.9)**	7/14 (50.0, 23.0-77.0)	1/16 (6.3, 0.2-30.2)	0/6 (0.0, 0.0-45.9)	**21/231 (9.1, 5.7-13.6)**

	rooms with overflow	Phase 2	10/47 (21.3, 10.7-35.7)	0/11 (0.0, 0.0-28.5)	**25/58 (43.1, 30.2-56.8)**	3/5 (60.0, 14.7-94.7)	2/5 (40.0, 5.3-85.3)	0/6 (0.0, 0.0-45.9)	**40/132 (30.3, 22.6-38.9)**
	Negative pressure rooms only	Phase 1	23/68 (33.8, 22.8-46.3)	1/12 (8.3, 0.2-38.5)	32/115 (27.8, 19.9-37.0)	2/14 (14.3, 1.8-42.8)	3/16 (18.8, 4.0-45.6)	0/6 (0.0, 0.0-45.9)	61/231 (26.4, 20.8-32.6)
		Phase 2	27/47 (57.4, 42.2-71.7)	3/11 (27.3, 6.0-61.0)	15/58 (25.9, 15.3-39.0)	0/5 (0.0, 0.0-52.2)	1/5 (20.0, 0.5-71.6)	4/6 (66.7, 22.3-95.7)	50/132 (37.9, 29.6-46.7)
The values listed in bold, represent no overlap of 95%-CI between Phase 1 and Phase 2, and are significant results.									

Figure 1: Overall response rate comparison between Phase 1 and Phase 2

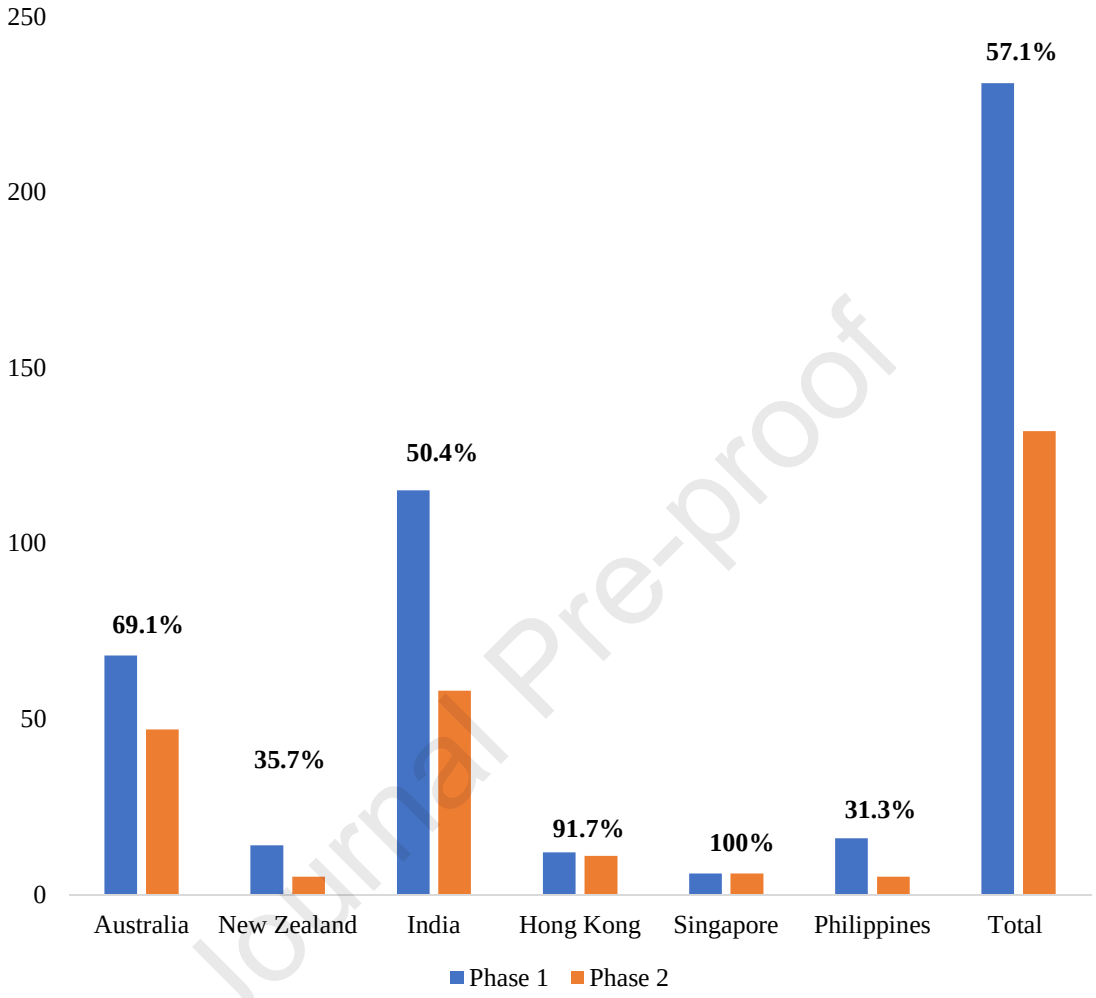
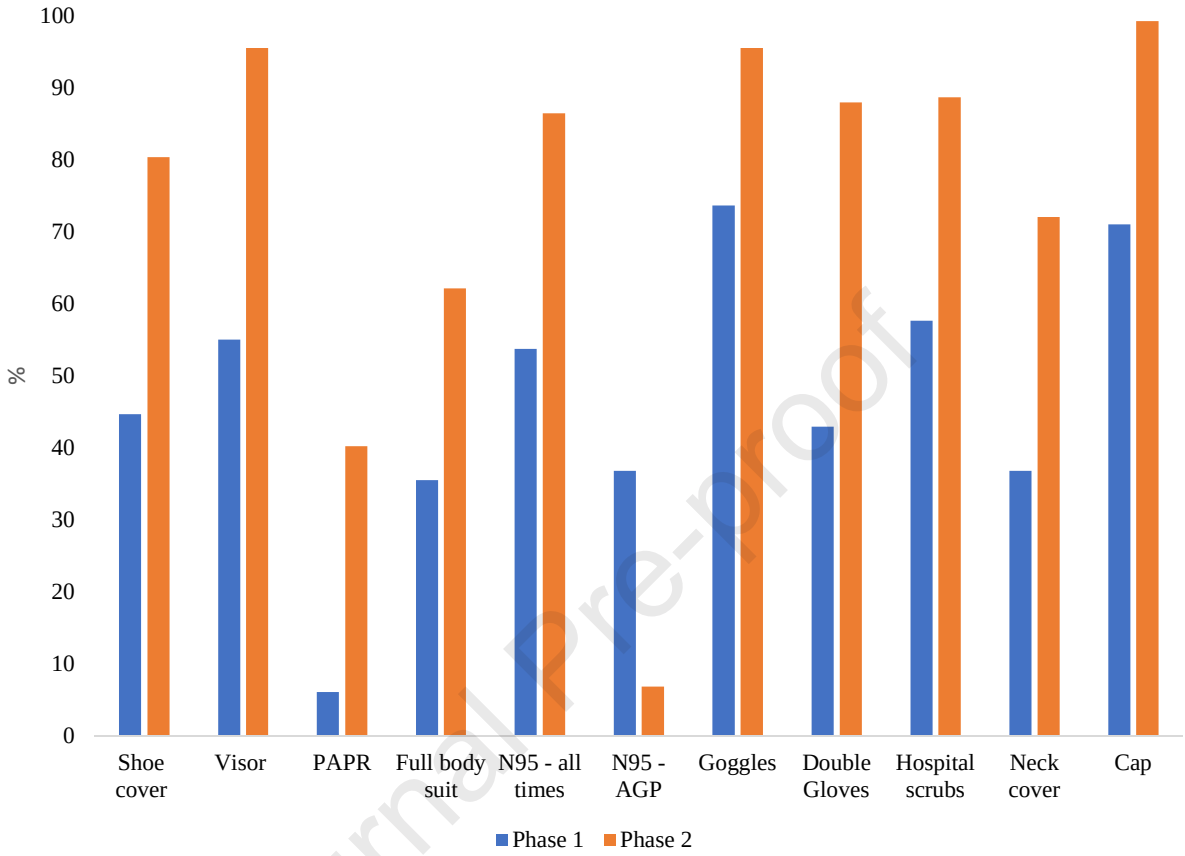


Figure 2: Individual PPE practices (all countries)



AGP – aerosol generating procedures; PAPR - powered air-purifying respirator

Figure 3: Measure after PPE breach