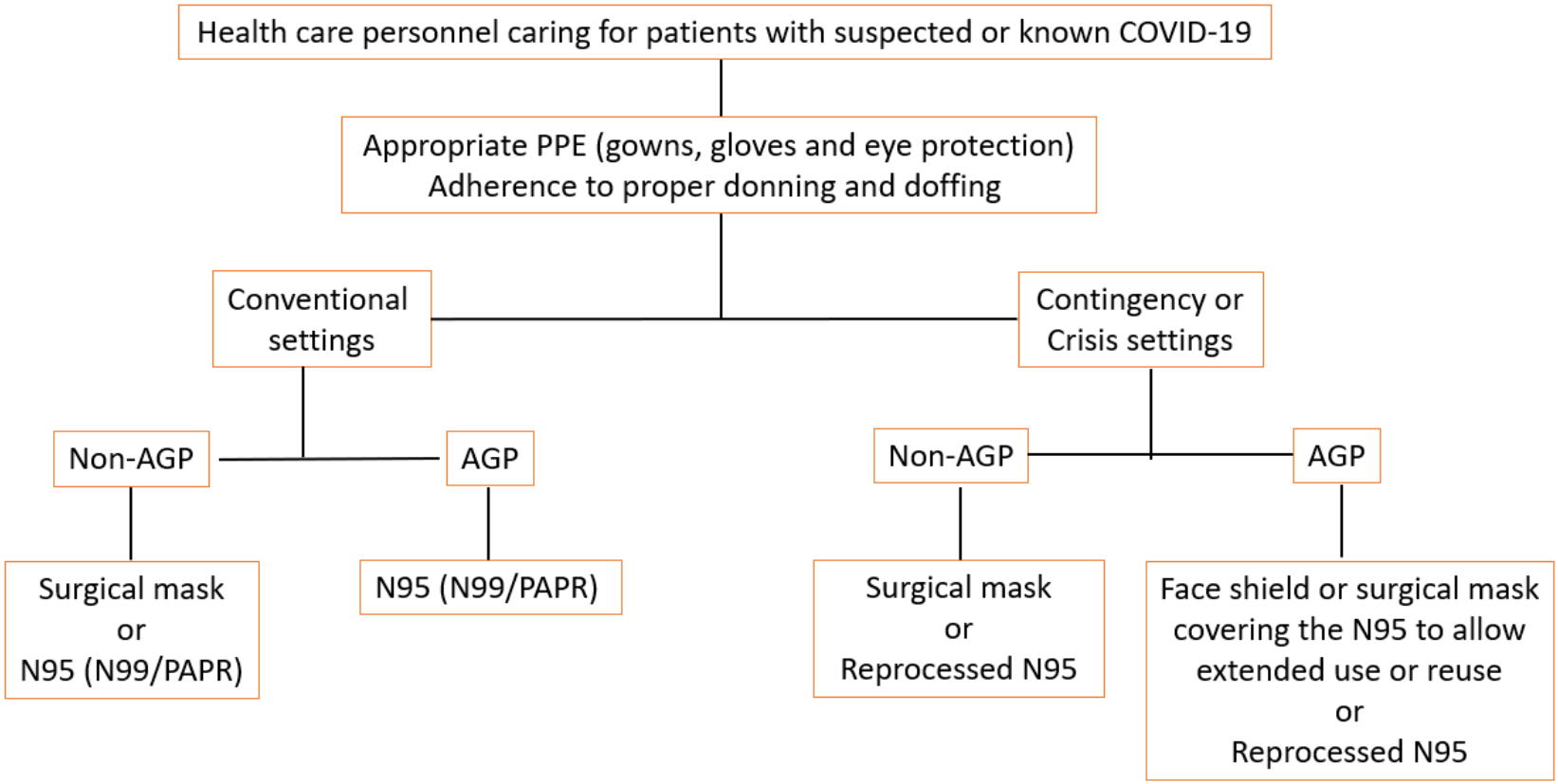
Figure 1. IDSA algorithm for appropriate PPE in conventional and contingency or crisis settings



AGP: aerosol-generating procedures; **PPE**: personal protective equipment

Figure 2. Approach and implications to rating the quality of evidence and strength of recommendations using GRADE methodology *(unrestricted use of figure granted by the U.S. GRADE Network)*

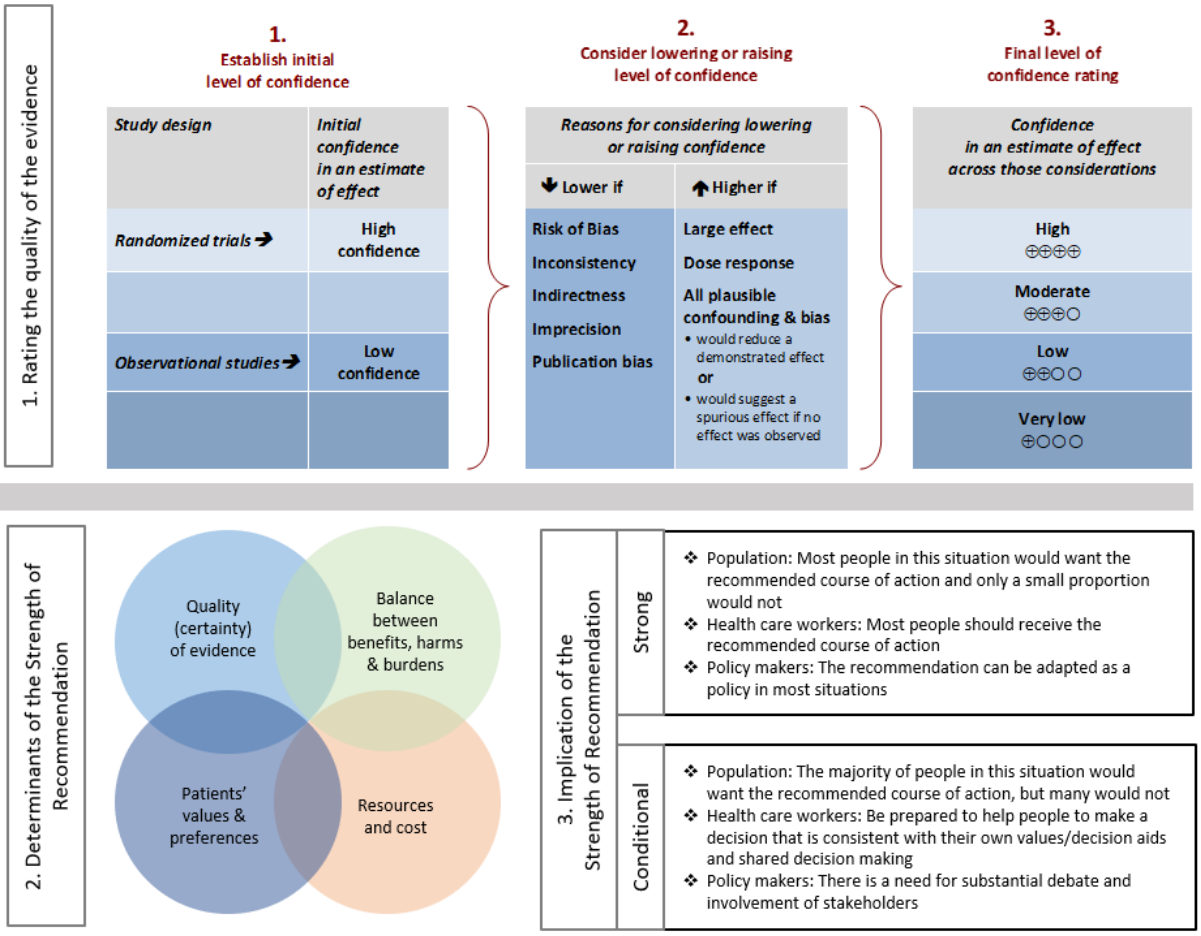


Table 1. GRADE evidence profile, Recommendation 1

Question: N95 medical/surgical mask compared to no PPE (no mask) or infrequent PPE (inconsistent use of mask) in healthcare personnel caring for patients with suspected or known COVID-19

Last reviewed and updated 03/30/2021

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	N95	no PPE	Relative (95% CI)	Absolute (95% CI)	
SARS-CoV-2 infection											
1 [1]	observational studies	not serious [d]	not serious	not serious	not serious	strong association [b]	540/5242 (10.3%)	369/2109 (17.5%)	**OR 0.54** [c] (0.47 to 0.63)	**72 fewer per 1,000** (from 84 fewer to 57 fewer)	⨁⨁⨁◯ MODERATE
SARS-CoV-1 infection											
5 [2-6]	observational studies	not serious	not serious	not serious [a]	not serious	strong association [b]	9/163 (5.5%)	86/234 (36.8%)	**OR 0.12** (0.06 to 0.26)	**302 fewer per 1,000** (from 334 fewer to 236 fewer)	⨁⨁⨁◯ MODERATE

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations
Inconsistency: Unexplained heterogeneity across study findings
Indirectness: Applicability or generalizability to the research question
Imprecision: The confidence in the estimate of an effect to support a particular decision
Publication bias: Selective publication of studies

CI: Confidence interval; **OR:** Odds ratio; **PPE**: Personal protective equipment

Explanations

a. Although the studies reported on the SARS outbreak, given the similarities between the SARS-CoV-1 and SARS-CoV-2, we did not rate down for indirectness.
b. The evidence was rated up for presence of both large magnitude of effect and suspected dose-response gradient informed by the association between duration of mask/respirator use and size of protective effect [Sims and Akinbami].
c. Additional studies with concerns with risk of bias or indirectness showed consistent trend towards a protective effect when masks were used [Akinbami 2020, Chen 2020, Piapan 2020, Khalil 2020, Chatterjee 2020, Kohler 2020, and X. Wang 2020] Although the study has residual confounding, the direction of the RoB due to residual confounding could have only decreased the already large effect (infection from community not wearing mask, or HCP interaction while not on patient duty).

References

1. Sims MD, Maine GN, Childers KL, et al. Coronavirus Disease 2019 (COVID-19) Seropositivity and Asymptomatic Rates in Healthcare Workers Are Associated with Job Function and Masking. Clin Infect Dis **2021**; 73(Suppl 2): S154-S62.
2. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet **2003**; 361(9368): 1519-20.
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4. Loeb M, McGeer A, Henry B, et al. SARS among critical care nurses, Toronto. Emerg Infect Dis **2004**; 10(2): 251-5.
5. Wilder-Smith A, Teleman MD, Heng BH, Earnest A, Ling AE, Leo YS. Asymptomatic SARS coronavirus infection among health care workers, Singapore. Emerg Infect Dis **2005**; 11(7): 1142-5.
6. Scales DC, Green K, Chan AK, et al. Illness in intensive care staff after brief exposure to severe acute respiratory syndrome. Emerg Infect Dis **2003**; 9(10): 1205-10.

Table 2. GRADE evidence profile, Recommendation 1

Question: N95 respirator compared to medical/surgical masks in healthcare personnel caring for patients with suspected or known COVID-19

Last reviewed and updated 03/30/2021

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	N95	Surgical mask	Relative (95% CI)	Absolute (95% CI)	
SARS-CoV-2 infection											
1 [1]	observational studies	serious [a]	not serious	not serious	not serious	none	540/5242 (10.3%)	182/1390 (13.1%)	**OR 0.76** (0.64 to 0.91)	**28 fewer per 1,000** (from 43 fewer to 10 fewer)	⨁◯◯◯ VERY LOW
SARS-CoV-1 infection											
3 [1-3]	observational studies	serious [b]	not serious	not serious [c]	serious [d]	none	4/141 (2.8%)	24/452 (5.3%)	**OR 0.86** (0.22 to 3.33)	**7 fewer per 1,000** (from 41 fewer to 104 more)	⨁◯◯◯ VERY LOW

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; **OR:** Odds ratio

Explanations

a. Study has residual confounding.
b. There were concerns about recall bias.
c. Although the studies reported on the SARS outbreak, given the similarities between the SARS-CoV-1 and SARS-CoV-2, we did not rate down for indirectness.
d. There were concerns about imprecision with a low event rate and the boundaries of the confidence interval cross the clinical threshold.

References

1. Sims MD, Maine GN, Childers KL, et al. Coronavirus Disease 2019 (COVID-19) Seropositivity and Asymptomatic Rates in Healthcare Workers Are Associated with Job Function and Masking. Clin Infect Dis **2021**; 73(Suppl 2): S154-S62.
2. Liu W, Tang F, Fang LQ, et al. Risk factors for SARS infection among hospital health care workers in Beijing: a case control study. Tropical Medicine & International Health **2009**; 14: 52-9.

Table 3. GRADE evidence profile, Recommendation 2

Question: Eye protection compared to no eye protection in healthcare personnel caring for patients with suspected or known COVID-19

New evidence profile developed 03/30/2021

Certainty assessment			Impact
№ of studies	**Study design**	**Certainty**	
Infection with COVID-19			
5 [1-5]	observational studies	⨁◯◯◯ VERY LOW [a,b,c]	No direct comparative evidence from RCTs. However, direct evidence was examined from case-control, pre-post intervention, and comparative observational cohort studies. Total number of HCP included from the five studies was 20,504. In summary, there is very low certainty evidence that in HCP who had eye protection in addition to standard PPE, there is a lower infection rate of SARS-CoV-2. I. Two cross-sectional studies: - Schmitz 2020[1]: Adjusted OR reported no difference between the hospitals with high protection (including eye protection) and other hospitals. - Akinbami 2020[2]: No difference for eye protection adjusted OR 1.12 (95% CI: 0.94-1.32) II. Two case-control studies: - Khalil 2020[3]: Reduction in infection rates with eye protection OR 0.437 (0.228–0.8) - Chaterjee 2020[4]: Unadjusted OR for face shield use 0.81, (95% CI: 0.61-1.08) III. One pre-post intervention study: - Bhaskar 2020[5]: Community HCP visited people at their home; 12/62 (19%) of the HCP got infected. After adding a face shields to the other PPE, no workers were infected.

CI: Confidence interval; **HCP**: Healthcare personnel; **OR**: Odds ratio; **PPE**: Personal protective equipment

Explanations

a. Critical concerns with unmeasured confounding, selection bias, and bias in the classification of interventions (self-reported exposure, at home or work). In the case-control studies, there was a concern for selection bias (unclear how they select the controls) and recall bias.
b. Inconsistency across study results possibly attributable to differences across study populations and study designs.
c. Imprecision as 95% confidence interval may not include a clinically meaningful benefit.

References

1. Schmitz D, Vos M, Stolmeijer R, et al. Association between personal protective equipment and SARS-CoV-2 infection risk in emergency department healthcare workers. Eur J Emerg Med **2021**; 28(3): 202-9.
2. Akinbami LJ, Vuong N, Petersen LR, et al. SARS-CoV-2 Seroprevalence among Healthcare, First Response, and Public Safety Personnel, Detroit Metropolitan Area, Michigan, USA, May-June 2020. Emerg Infect Dis **2020**; 26(12): 2863-71.
3. Khalil MM, Alam MM, Arefin MK, et al. Role of Personal Protective Measures in Prevention of COVID-19 Spread Among Physicians in Bangladesh: a Multicenter Cross-Sectional Comparative Study. SN Compr Clin Med **2020**: 1-7.
4. Chatterjee P, Anand T, Singh KJ, et al. Healthcare workers & SARS-CoV-2 infection in India: A case-control investigation in the time of COVID-19. Indian J Med Res **2020**; 151(5): 459-67.
5. Bhaskar ME, Arun S. SARS-CoV-2 Infection Among Community Health Workers in India Before and After Use of Face Shields. JAMA **2020**; 324(13): 1348-9.

Table 4. Various organizations' list of aerosol-generating procedures

Organization	Procedures Listed
CDC (COVID-19 guidance) [1]	• Open suctioning of airways • Sputum induction • Cardiopulmonary resuscitation • Endotracheal intubation and extubation • Non-invasive ventilation (e.g., bilevel positive airway pressure, continuous positive airway pressure) • Bronchoscopy • Manual ventilation
CDC (Seasonal influenza guidance) [2]	• Bronchoscopy • Sputum induction • Elective intubation and extubation • Autopsies • Cardiopulmonary resuscitation • Emergent intubation • Open suctioning of airways
WHO (COVID-19 guidance) [3]	• Tracheal intubation, non-invasive ventilation • Tracheotomy • Cardiopulmonary resuscitation • Manual ventilation before intubation • Bronchoscopy
WHO (Epidemic and pandemic-prone acute respiratory diseases) [4]	• Aspiration of respiratory tract • Intubation • Resuscitation • Bronchoscopy • Autopsy

References

1. Centers for Disease Control and Prevention. Health care Infection Prevention and Control FAQs for COVID-19. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/faq.html#Infection-Control. Accessed 16 April 2020.
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3. World Health Organization. Advice on the use of masks in the context of COVID-19. Available at: https://www.who.int/publications-detail/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-health care-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak. Accessed 16 April 2020.
4. World Health Organization. Epidemic- and pandemic-prone acute respiratory diseases - Infection prevention and control in health care. Available at: https://www.who.int/csr/resources/publications/aidememoireepidemicpandemid/en/. Accessed 16 April 2020.

Table 5. Risk of SARS transmission to healthcare personnel exposed and not exposed to aerosol-generating procedures; and aerosol-generating procedures as risk factors for SARS transmission [a]

Type of Aerosol-Generating Procedure	OR	95% CI
Tracheal intubation	6.6	2.3–18.9
Manipulation of oxygen mask	4.6	0.6–32.5
Tracheotomy	4.2	1.5–11.5
Manipulation of BiPAP mask	4.2	0.6–27.4
Suction before intubation	3.5	0.5–24.6
Non-invasive ventilation	3.1	1.4–7.2
Manual ventilation before intubation	2.8	1.3–6.4
Collection of sputum sample	2.7	0.9–8.2
Defibrillation	2.5	0.1–43.9
Bronchoscopy	1.9	0.2–14.2
Chest compressions	1.4	0.2–11.2
Insertion of nasogastric tube	1.2	0.4–4.0

BiPAP: Bilevel positive airway pressure **CI**: Confidence interval **OR**: Odds ratio

Explanation/Reference

a. *Adapted from:* Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PLoS One **2012**; 7(4): e35797.

Table 6. GRADE evidence profile, Recommendation 8

Question: Extended use/reuse of same N95 vs. medical/surgical masks for COVID-19 prevention in healthcare personnel caring for patients with suspected or known COVID-19

Last updated 4/30/2020; last reviewed 3/30/2021

Certainty assessment			Impact
№ of studies	**Study design**	**Certainty**	
Infection with COVID-19			
9 [1-9]	Anecdotal reports Experiments under laboratory conditions	⨁◯◯◯ VERY LOW [a,b]	There was no direct evidence found on infection rates with extended use of N95 respirators during the COVID-19 pandemic. Furthermore, indirect evidence from other pandemic outbreaks did not reveal empiric data on infection rates. However, there were reports of anecdotal experience on extended use, laboratory experiments, and mathematical models. Experiments on tolerability of the N95 respirator with prolonged use showed that HCP were able to tolerate the N95 respirator for 89 of 215 (41%) total shifts of eight hours. In the remaining shifts, N95 respirators were discarded before eight hours because of contamination or due to intolerance.[1] Anecdotal reports also showed that more than 40% of HCP reported extended use or reuse of their N95 respirator during the H1N1 pandemic.[2,3] A mathematical model to calculate the potential influenza contamination of office masks from aerosol sources in various exposure scenarios showed that surgical mask contamination levels from a single cough (≈19 viruses) were much less than likely levels from aerosols (4,473 viruses on filtering facepiece respirators and 3,476 viruses on surgical masks).[4] Laboratory tests have reported that five consecutive donnings can be performed before fit factors consistently drop to unsafe levels.[5] Extended use of N95 respirators during the COVID-19 pandemic has been associated with skin irritation. In a survey study, 97% of first-line HCP reported (mostly mild) skin damage.[6] Anecdotal reports of the use of surgical masks over N95s as a barrier to pathogens (so as to extend the life of the N95 respirator) have been published.[7] This strategy was sparingly utilized during the SARS outbreak, but the effect on HCP infections was not reported. Narrative reports, news conference reports, including the CDC recommendation[8] during H1N1 pandemic advised use of a cleanable face shield or surgical mask to reduce N95 respirator contamination.[9]

CDC: Centers for Disease Control and Prevention; **HCP**: Healthcare personnel

Explanations

a. Experimental data and observational evidence with no comparator to understand the risk of the acceptable protection from COVID-19
b. There are multiple layers of indirectness, including different populations (some studies reported on Influenza virus or simulation studies on healthy volunteers) and indirect outcomes (tolerability of the mask or laboratory evidence of contamination) instead of infection rates among healthcare personnel

References

1. Radonovich LJ, Jr., Cheng J, Shenal BV, Hodgson M, Bender BS. Respirator tolerance in health care workers. JAMA **2009**; 301(1): 36-8.
2. Beckman S, Materna B, Goldmacher S, et al. Evaluation of respiratory protection programs and practices in California hospitals during the 2009-2010 H1N1 influenza pandemic. Am J Infect Control **2013**; 41(11): 1024-31.
3. Hines L, Rees E, Pavelchak N. Respiratory protection policies and practices among the health care workforce exposed to influenza in New York State: evaluating emergency preparedness for the next pandemic. Am J Infect Control **2014**; 42(3): 240-5.
4. Fisher EM, Noti JD, Lindsley WG, Blachere FM, Shaffer RE. Validation and application of models to predict facemask influenza contamination in health care settings. Risk Anal **2014**; 34(8): 1423-34.