Letters

RESEARCH LETTER

Correlation Between N95 Extended Use and Reuse and Fit Failure in an Emergency Department

Frontline health care workers are at high risk of contracting severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19).[1] Personal protective equipment (PPE), including N95 respirators (N95s), is essential for prevention of COVID-19. The Centers for Disease Control and Prevention recommends that health care workers dispose of N95s after a single patient encounter. However, it recommends N95 extended use (wearing the same N95 for multiple patient encounters) and limited reuse (storing an N95 between encounters for use over multiple encounters) during critical PPE shortages.[2,3] There are limited data regarding N95 reuse and extended use. Existing studies were conducted in laboratories, not clinical environments.[4,5] Inadequate supplies of N95s have forced many emergency departments to implement various N95 reuse and extended use policies but without empirical evidence of their effectiveness. We examined the prevalence of N95 fit test failure while reusing 2 common types of N95 masks.

Audio

Methods | We performed a cross-sectional study of N95 fit at the University of California, San Francisco (UCSF) emergency department from April 4 to April 6, 2020. We enrolled a convenience sample of health care workers (physicians, nurses, nurse practitioners, physician assistants, and patient care technicians) on their clinical shifts when the researchers were present. All had passed a standard Occupational Safety and Health Administration–mandated N95 fit test within the last 1 to 2 years. We performed a qualitative fit test of dome-shaped (3M 1860) and duckbill (Kimberly-Clark 46727 or Halyard 46867) N95s (**Figure**) during various stages of extended use/reuse using a standardized hood and 3M FT-32 bitter testing solution. If participants could taste the solution, they failed the fit test and were fit with a new N95. We recorded health care worker characteristics, mask type, shifts used, and donnings/doffings. Our primary outcome was N95 fit test failure.

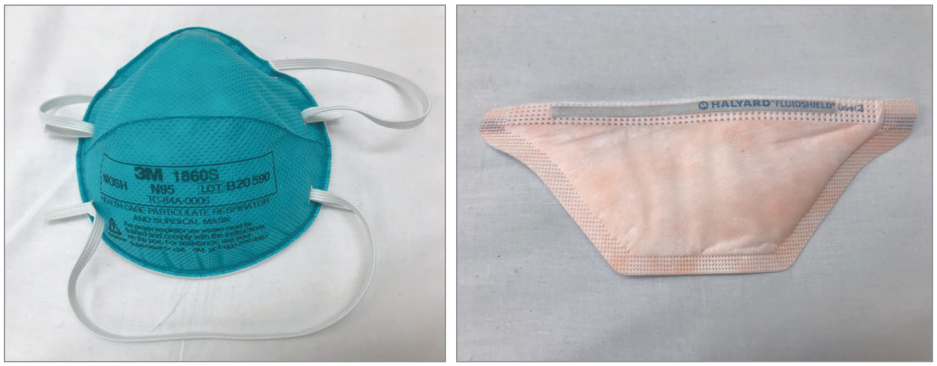
Medians for continuous variables were compared using the Wilcoxon log-rank test. Proportions for categorical variables were compared using the Fisher exact test. For comparisons, a 2-sided $\alpha < .05$ was considered statistically significant. Given the high failure rate of duckbill masks, we conducted a sensitivity analysis to examine the association between the amount of wear time and fit test failure in only dome-shaped masks. Data were analyzed using Stata version 16 (StataCorp). This study was categorized as exempt by the UCSF institutional review board.

Results | Among 68 participants, 66.2% were women and 48.5% were nurses. Dome-shaped N95s were used by 51 of 68 (75.0%); 17 of 68 (25.0%) used duckbill N95s. Overall, 38.2% of participants failed the fit test; 12 of 17 (70.6%) duckbill masks failed, compared with 14 of 51 (27.5%) dome-shaped masks. Among wearers of dome-shaped masks, fit test failure was associated with increased number of shifts worn (median, 4 shifts [interquartile range {IQR}, 3-5] vs 2 shifts [IQR, 1-3]; $P < .001$), increased donnings/doffings (median, 15 [IQR, 13-18] vs 8 [IQR, 4-12]; $P < .001$), and increased hours worn (14 [IQR, 10-30] vs 12 [IQR, 6-16]; $P = .048$) (**Table**).

Discussion | This study found duckbill N95s had a high failure rate. Failure of dome-shaped masks was associated with increased use. N95 failure may contribute to SARS-CoV-2 transmission despite PPE use and deserves further study. Based on these preliminary data, health systems should closely evaluate N95 fit during extended use or reuse and limit duckbill mask use if alternatives are available.

Limitations include the study's cross-sectional design; a cohort study is needed to determine directionality. The duration of wear and number of donnings/doffings were self-reported and may not be precise or accurate estimates. Precise time of failure was not measured. Prior studies have shown an inherent N95 fit failure rate,[6] which may have affected

Figure. N95 Mask Types



Left, Dome-shaped. Right, Duckbill.

Table. Characteristics of Participants and Prevalence of Fit Failure (Dome-Shaped Masks Only)

Characteristics	Total (N = 51)	Fit pass (n = 37)	Fit fail (n = 14)	*P* value
Sex, No. (%)				
Women	33 (100)	23 (69.7)	10 (30.3)	.74[a]
Men	18 (100)	14 (77.8)	4 (22.2)	
Health care worker type, No. (%)				
Nurse	27 (100)	20 (74.1)	7 (25.9)	
Physician	11 (100)	7 (63.6)	4 (36.4)	.77[a]
PCT/APP/other[b]	13 (100)	10 (76.9)	3 (23.1)	
Hours mask worn, median (IQR)	12 (6-18)	12 (6-16)	14 (10-30)	.048[c]
Shifts mask worn, median (IQR)	3 (2-4)	2 (1-3)	4 (3-5)	<.001[c]
Donnings/doffings, median (IQR)	10 (5.5-15.5)	8 (4-12)	15 (13-18)	<.001[c]
Shifts mask worn, No. (%)				
1	11 (100)	11 (100)	0	<.001[a]
2	12 (100)	11 (91.7)	1 (8.3)	
3	13 (100)	10 (76.9)	3 (23.1)	
>3	15 (100)	5 (33.3)	10 (66.7)	

Abbreviations: APP, advanced practice provider; IQR, interquartile range; PCT, patient care technician.

[a] By Fisher exact test.

[b] Advanced practice provider includes nurse practitioners and physician assistants. Other includes registration clerks and pharmacists.

[c] By 2-sample Wilcoxon rank-sum test.

outcomes. This observational study was subject to confounding (eg, mask quality, unobserved characteristics of wearer). Shifts worn, hours worn, and donnings/doffings are likely correlated: because of the low number of failures, multivariable adjustment was not performed. This study was designed to detect mask failure based on qualitative fit testing. Failed fit tests may not necessarily result in increased rates of infection.

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