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Brief Report

Novel approach to deployment of crisis situation supply of N95 respirator models in a healthcare system

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Given supply constraints of N95s in the United States during the COVID-19 pandemic, healthcare facilities have turned to extended use protocols and new sources of N95s. Because fit testing every employee for every new mask is not feasible, our Infection Prevention Department developed a method for rapid deployment of new N95s.
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Given N95 respirators (N95s) supply chain constraints in the United States, many healthcare facilities have turned to extended use protocols and new N95 sources.[1-3] In our healthcare system, these sources have ranged from alternative N95 models obtained through our supply chain to stockpiled federal supplies to donations. With ongoing shortages and the rapidity with which N95s need to be deployed, fit testing each healthcare worker (HCW) for every mask model has not been an option because of logistical and supply constraints.[1] Our Infection Prevention department therefore developed a method for rapid evaluation and deployment of N95s, based on a protocol described by the University of North Carolina.[4] The objective was to obtain facial measurements and perform fit-testing for a subset of HCWs, in order to develop system-wide guidance on which new N95 models were most likely to fit an employee based on prior N95 size and facial features.

METHODS

Due to resource constraints posed by the pandemic, a convenience sample of HCWs was used. Fourteen HCWs, including 7 men and 7 women with racial and age diversity, completed a demographic survey, had facial measurements performed according to the National Institute for Occupational Safety and Health (NIOSH) Bivariate Panel protocol[5] and were fit-tested for the available N95s on 2 days. All N95s tested were approved by NIOSH, except for the KN95 model which is considered an equivalent mask.[6] Emory Healthcare has historically fit-tested every employee using the 3M 1860 respirator in either regular or small size, so each participant's typical 1860 size was used to guide which alternative N95 models were trialed. For those N95s for which a user seal check could be confirmed, participants attempted an OSHA-approved qualitative fit test (QLFT), with success or failure documented. Success and failure percentages were then evaluated for any association with facial size. Statistical analysis was completed using JMP (Version 14.2. SAS Institute Inc., Cary, NC). Not all N95 models and sizes were tested on every participant, due to limited supply. The results of the fit testing were used to create recommendations regarding which models HCWs should prioritize for alternative use.

RESULTS

Of the 14 HCWs who participated, four had prior successful fit-testing on the 3M 1860 small, while ten had previously worn the 3M 1860 regular. Facial length ranged from 104 to 114 mm ($M = 109.75 \pm 4.35$) in those who wore a small and from 111 to 125 mm ($M = 115.9 \pm 4.41$) in those who wore a regular, while facial width ranged from 123 to 146 mm ($M = 137 \pm 10.03$) and 137-153 mm ($M = 142.9 \pm 5.78$), respectively. Of all the masks tested on more than 50% of participants, only the HDX OSFA showed a significant association between face width and length and pass rate ($\chi^2 = 13.64$, $P = .0011$).

Abbreviation: N95, N95 respirator; HCW, healthcare worker; NIOSH, National Institute for Occupational Safety and Health; QLFT, qualitative fit test; OSHA, occupational safety and health administration

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Table 1
N95 fit testing results

Respirator	Total pass rate passed/tested (%)		Pass rate for 1860 standard wearers		Pass rate for 1860S wearers	
HDX H950S	2/6	33%	0/2	0%	2/4	50%
HDX H950M/L	1/6	17%	1/4	25%	0/2	0%
HDX H950V	6/14	43%	5/10	50%	1/4	25%
3M 8110 S	1/2	50%	–	–	1/2	50%
3M 9210	2/3	67%	2/3	67%	–	–
3M 1870	2/3	67%	2/3	67%	–	–
3M 8000	2/5	40%	2/5	40%	–	–
3M 8200	4/4	100%	4/4	100%	–	–
3M 8210	3/4	75%	3/4	75%	–	–
3M 8511	2/3	67%	2/3	67%	–	–
North 7130	8/14	57%	7/10	70%	1/4	25%
Duramask 1895	1/12	8%	0/9	0%	1/3	33%
Alpha ProTech	0/12	0%	0/8	0%	0/4	0%
Inovel 1500 XS*	2/2	100%	0/1	0%	2/2	100%
Inovel 1500S*	2/2	100%	0/10	0%	1/1	100%
Inovel 1500M	8/14	57%	6/10	60%	2/4	50%
Barrier 4270 M/L	7/14	50%	6/10	60%	1/4	25%
Halyard Duckbill Regular	6/12	50%	5/9	56%	1/3	33%
Halyard Duckbill Small*	2/2	100%	–	–	2/2	100%
Affinity Pro M	4/6	67%	1/2	50%	3/4	75%
KN95†	0/7	0%	0/4	0%	0/3	0%

OSFA: one size fits all.
percentage of regular and small 3M 1860 wearers passing alternative N95s fit testing.
*mask only available on second day of testing.
†mask straps broke off as first participants attempted to put the mask on.

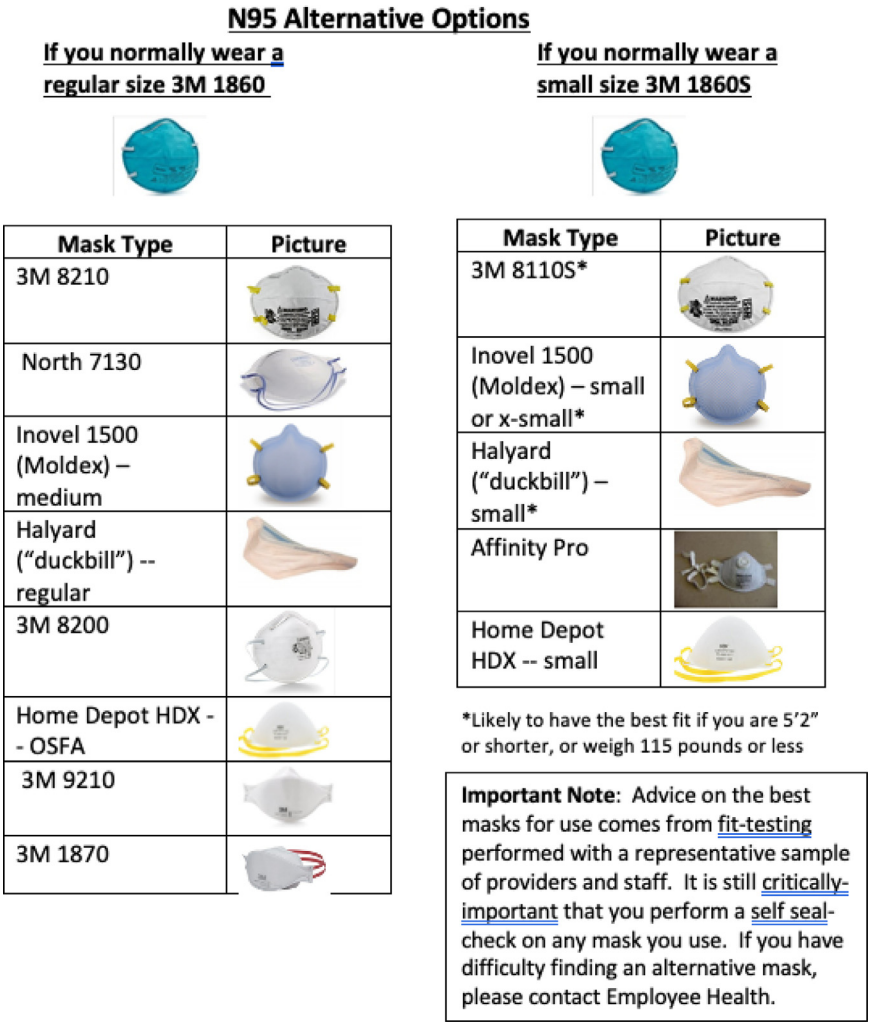

Fig 1. Reference document sent to healthcare workers.

Twenty-one N95s were tested on at least some participants, with four models tested on everyone and another three models tested on all 1860 small wearers. The masks that were not tested on all participants were in low supply, not available until the second day of testing, or appeared defective. Of the models tested on all 1860 small wearers, at least 50% of participants passed the QLFT on 3, while an additional 4 models achieved at least a 50% pass rate in a subset of participants. For those tested on all 1860 regular wearers, at least 50% of participants passed on 4 models, with an additional 6 models reaching the 50% pass threshold in a subset (Table 1). There were 3 masks with a failure rate >90% (Duramask 1895, Alpha ProTech, and KN95).

Four participants failed fit-testing in >70% of the masks that they attempted. When masks with >90% failure were removed from analysis, only 1 participant remained in this category; they were an outlier with facial width and length more than one standard deviation below the mean.

DISCUSSION

The findings from this study highlight both the need for a thorough vetting of N95s provided to healthcare facilities prior to deployment, and the ability to use a small HCW sample to provide universal guidelines.

Even if a mask has NIOSH approval or equivalent, this does not guarantee that a majority of HCWs will be able to successfully fit-test; we identified 3 mask types for which an overwhelming majority of providers failed. These masks were therefore transitioned to use for patients and providers in situations where it is not possible to practice social distancing.

At least six models were past their expiration dates or had no expiration date labeled. Prior research has suggested that this may not necessarily impact the efficacy of filtration,[7] but in this sample, the elastic of several of these expired models had degraded and so it was critical that the masks were examined prior to deployment.

The Infection Prevention department used these findings to develop guidance documents to accompany deployment of select N95 models and sizes to healthcare units (Fig 1). Only N95 models that worked for at least 50% of participants were included, and additional guidance was given based on the outlier from the 1860 small group. Given that most HCWs will not have the ability to perform facial measurements, height and weight were used as proxies to suggest small or extra-small masks that might provide the best fit.

Overall there was no clear correlation between facial measurements and mask fit, but there may be a role for using measurements to guide recommendations in providers who are unable to achieve a self seal-check. The four participants with the smallest percentages of successful QLFTs were all outliers – 1 had the smallest facial width and length measurements, one had the second longest facial length and the longest facial width, and the other two had measurements that were at or below the mean for their regular 3M 1860 group and so may have benefitted from trialing smaller masks.

While individual qualitative or quantitative fit testing of N95s is always preferred, this method offers a safe alternative when faced with contingency or crisis capacity situations such as the current pandemic.

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