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**Assessment of best-selling respirators and masks: Do we have acceptable respiratory protection for the next pandemic?**

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**Background:** COVID-19 pandemic caused a high demand for respiratory protection, caused a scarcity of approved respirators and the production of alternative respiratory protection. To raise public awareness through the scientific community, bestselling respirators and masks in the United States’ leading online retailer, Amazon.com, were evaluated.

**Methods:** Ten respirators and masks, 5 Face Protective Equipment (FPE) and 5 Cloth Face Masks (CFMs), were evaluated compared to the N95 standard. Two groups were established with the intention of comparing all masks together. The fractional efficiency and pressure drop were measured and compared to the National Institute for Occupational Safety and Health (NIOSH) standards. In addition, grading factors for protection, comfort, and affordability were developed that can be used by the scientific community to readily disseminate to consumers for the selection of the appropriate respiratory protection.

**Results:** Two FPE provided acceptable efficiency (>95%) similar to the N95, while the remaining products were below or extremely below NIOSH standards. All products provided pressure drops within NIOSH standards (≤35 mmH2O) ranging from 2.3-10.3 mmH2O. The grading factors show that the CFMs have minimal protection, and the N95 has average comfort and affordability compared to all the products.

**Conclusion:** The N95 remains the best respiratory protection, and in the event of the next airborne pandemic, FPEs could serve as adequate alternative protection against the viral spread.
CoV-2 variant emerges, consumers may resume their practice of wearing non-NIOSH-approved respirators. Therefore, it is important to shed light on the products that consumers purchase and provide relevant data useful to the scientific community for dissemination to the public to aid their choices of consumer respiratory products.

Among the respirators in the market, the N95 is most frequently used for industrial and health care occupations, \(^6\) which under a proper fit, filters \(\geq 95\%\) particles or allows \(\leq 5\%\) penetration, when tested under a flow of 85 LPM. \(^7,8\) Previous studies have used the scanning mobility particle sizer (SMPS) spectrometer to determine the fractional filtration efficiency of NIOSH-approved respirators and non-NIOSH-approved respirators and face coverings. In a study by Joo et al.\(^9\), the N95 respirator (3M 8210) was tested as the reference material using NIOSH standards and demonstrated to have a filtration efficiency, as measured by the SMPS, of above 96%. Brochet et al.\(^10\) tested four NIOSH-approved N95 respirators from three different manufacturers by following NIOSH testing parameters, using an SMPS, and showed that the N95 respirators had efficiency levels greater than 96% when the applied flow rate was 85 LPM and the pressure drop upstream and downstream were within the acceptable value. In another study, Mostofi et al.\(^11\) followed NIOSH testing parameters to determine the filtration efficiency of N95, measured aerosol concentration using an SMPS, and concluded that the initial penetration never exceeded the 5% penetration limit (95% efficiency) at 85 LPM. The study also showed that, when measuring aerosol concentration using an SMPS, the most penetrating particle size (MPPS) was 40 nm.

Studies have addressed the shortage of respiratory protective equipment and measured the effectiveness of different fabric materials for use as alternative protection. \(^12,13\) Rengasamy et al.\(^14\) followed NIOSH testing procedures to measure fractional efficiency of various materials and found that the tested cloth masks and other fabrics had penetration levels between 10% and 90%. Konda et al.\(^15\) tested various single- and two-layer masks developed from the different fabrics and determined a wide range of virus protection efficiency between 5-80% and larger than 80, respectively. Duncan et al.\(^16\) tested a two-layer reusable cloth mask and a multilayered cloth mask and determined that these masks have an efficiency as low as 8% and 30%, respectively. These studies identify that non-certified NIOSH respirators have varying efficiency that could provide minimal respiratory protection.

Respiratory protection has become the norm of our society during the pandemic due to the serious health outcomes of COVID-19 transmission or the face covering mandates put in place by federal or local governments. \(^17,18\) Liang et al.\(^19\) surveyed U.S. consumers regarding face mask protection and found a significant attitude towards purchase due to comfort, fit, and protection. In addition, the study found that consumers want to be in control of their choice of purchase and are most likely to purchase previously acquired products. On the other hand, in a survey study conducted by Saiki et al.\(^20\) on attitudes on mask characteristics, participants surveyed had mixed opinions regarding protection, type of material and aesthetics of masks for purchase, or mask mandates. Therefore, these mixed results show that it is important to investigate different aspects when evaluating face coverings or masks.

During the COVID-19 pandemic, the U.S. Centers for Disease Control and Prevention (CDC) provided mask guidance for the general public and described the different levels of protection provided by different types of masks and respirators. \(^21\) When wearing masks, CDC recommended those that properly fit over the nose, mouth and chin, have nose wire, and have multiple layers of tightly woven, breathable fabric (for cloth masks) or of non-woven material (for procedure mask). \(^22\) However, information on the protection and breathability of commercially available respirators and masks is not always readily accessible to consumers. This study aimed to assess the fractional filtration efficiencies of different best-selling respirators and fabrics compared to a NIOSH-approved N95 respirator. In addition, this study aims to provide relevant information on protection, breathability and cost of best-selling respirators or masks to the scientific community that can be readily translated to the general population and will aid in selecting alternative respirators for purchase if approved respirators are unavailable. Such information could prove important in the event of the need to wear respiratory protection that is mandatory due to an airborne viral epidemic or pandemic.

**MATERIAL AND METHODS**

**NIOSH respirator efficiency test protocol**

The NIOSH has established respirator efficiency test parameters to determine the approval and certification of respiratory protective equipment. \(^23\) The experimental parameters in the NIOSH test include pre-testing and testing conditions. \(^24,25\) Before testing, filters are preconditioned at 85 \(\pm 5\%\) humidity and 38 \(\pm 2.5\,^\circ\,C\) for 25 \(\pm 1\) hour while sealed in a gas-tight humidity chamber and tested within 10 hours of removal. Challenge aerosols are generated from a 2% NaCl solution with a count median diameter (CMD) of 0.075 \(\pm 0.02\) \(\mu m\) and a geometric standard deviation (GSD) equal to or less than 1.86. The aerosol temperature is set at 25 \(\pm 5\,^\circ\,C\) with a humidity level of 30 \(\pm 10\%\) and is neutralized to the Boltzmann equilibrium state. Finally, a single respirator filter is tested at a system flow rate of 85 \(\pm 4\,LPM\), and the flow should not exceed a pressure drop of 35 mmH\(_2O\) through the respirator.

**Reference respirator**

The N95 (3M, Model No. 8210, Saint Paul, MN, U.S.) was used to obtain baseline results for the fractional filter efficiency in this study. Therefore, the fractional filtration efficiency of all other respirators and masks was compared to the results of the N95 and the NIOSH standards.

**Criteria for selection of alternative filter materials**

The best-selling adult face coverings and masks were chosen from the top online retailer in the U.S., Amazon.com, \(^26\) wherein different products were reviewed to determine consumer use for respiratory protection. The mask selection criterion was based on the 'Best-selling' results from Amazon.com for 'Personal Protective Equipment' and 'Medical Supplies & Equipment'. In addition, five masks were chosen from each subcategory, 'Best Sellers in Face Protective Equipment (PPE)' and 'Best Sellers in Cloth Face Masks (CFMs)'. Therefore, a total of ten masks were chosen for testing. The PPE included KN95's, which are filtering facepiece respirators that are certified by China to have passed their regulatory standard (but not necessarily the NIOSH standard). The mask selection was performed on February 17, 2022, approximately one month after the U.S. reached its highest daily average COVID-19 cases, \(^27\) and before the mask mandate was lifted in the U.S. around March 7, 2022. Adult masks were selected within the top 15 best-selling PPE and CFMs since our testing methods were established based on adult respiratory rates. \(^28\) Table 1 shows the best-selling products tested in this study and their corresponding information on description, seller, and cost. The CFM from Will-Nertpow (MagArt) was listed twice on the best-selling list, but in different quantity packs, a pack of 8 (CFM1) and a pack of 12 (CFM4). Both packs were purchased to evaluate the manufacturer’s quality control.
Filter preparation

The masks were preconditioned according to NIOSH standards at 85 ± 5% humidity at 38 ± 2.5°C for 25 ± 1 hours using a humidity chamber (MEMMERT HCP50115V, Schwabach, Germany) and tested within 10 hours of removal from the humidity chamber. The respirator or fabric was then mounted to a disc with a 4-inch inseam using beeswax (EricX Light, Chancheng, China) to secure the test materials. The mixing chamber was connected to the exposure setup through the HEPA filter attached to the mixing chamber. The respirator or fabric material attached to the disc was positioned in the cross-section of a custom-made exposure chamber (34.6 cm × 21.9 cm). Then the aerosol concentration was measured upstream and downstream of the respirator or mask using an SMPS (TSI Model 3998 SMPS Spectrometer, Shoreview, MN, U.S.). The aerosol particles were measured upstream of the filter and were consistent within NIOSH standards with a CMD of 0.075 ± 0.02 μm, GSD < 1.86, temperature 25 ± 5°C, and relative humidity 30 ± 10%. The pressure of the exposure chamber upstream of the respirator was ~14.7 psi, measured by a differential pressure gauge (Magnehelic, Michigan City, Indiana, U.S.), ensuring atmospheric pressure was maintained.

Airflow was achieved through the exposure chamber by a vacuum pump (Welch-Ilmvac 2585B-50, Niles, IL, U.S.) operated at 85 LPM, controlled by a valve (SMC vacuum regulator, Yorba Linda, CA, U.S.), and measured by a flow meter (Alicat Scientific, Tucson, AZ, U.S.). A HEPA filter (Global Life Sciences Solutions 0.2 μm PTFE, Buckinghamshire, UK) was used to remove the remaining salt particles before entering the flow meter. The resistance within the exposure setup system was determined by measuring the pressure drop across the respirator or mask using a differential pressure meter (TSI Model 5825 DP-CALC Micromanometer, Shoreview, MN, U.S.).

Experimental setup

The experimental setup for the filter efficiency test is shown in Figure 1. A 5-stage desiccant air drying system (Speedaire, Niles, Illinois, U.S.) supplied particle-free air to a heater and ionizer, each controlled by mass flow control meters (Alicat Scientific, Tucson, AZ, U.S.). The heater (Vulcan Electric Company, Porter, ME, U.S.), regulated by a Triac variable voltage supply (Dart Controls, Algonquin, IL), was used to dry the salt particles at the desired temperature of 25 ± 5°C. The ionizer (Simco-Ion Technology Group, Alameda, CA) was used to achieve the Boltzmann equilibrium state. The heated and ionized air was supplied to a mixing chamber before the exposure chamber (Hoffman Enclosures Inc., Anoka, MN, U.S.). A six-jet atomizer (TSI Model 9306 Six-jet Atomizer, Shoreview, MN, U.S.) was used with a 2% NaCl solution to generate salt aerosols that flowed toward the mixing chamber. The mixing chamber was connected to the filter exposure chamber and included a HEPA filter (Global Life Sciences Solutions 0.2 μm PTFE, Buckinghamshire, UK) before passing the aerosol through the chamber to remove excess flow from the system.

The six-jet atomizer was operated with one jet at a standard pressure of 25 psi and a flow rate of 6.6 LPM. The airflow through the heater and ionizer was set at 55 LPM and 32 LPM, respectively. The combined flow rate of the atomizer, heater, and ionizer measured 93.6 LPM, greater than the system flow rate of 85 LPM. The excess pressure was relieved through the HEPA filter attached to the mixing chamber. The respirator or fabric material attached to the disc was positioned in the cross-section of a custom-made exposure chamber (34.6 cm × 21.9 cm). Then the aerosol concentration was measured upstream and downstream of the respirator or mask using an SMPS (TSI Model 3998 SMPS Spectrometer, Shoreview, MN, U.S.). The aerosol particles were measured upstream of the filter and were consistent within NIOSH standards with a CMD of 0.075 ± 0.02 μm, GSD < 1.86, temperature 25 ± 5°C, and relative humidity 30 ± 10%. The pressure of the exposure chamber upstream of the respirator was ~14.7 psi, measured by a differential pressure gauge (Magnehelic, Michigan City, Indiana, U.S.), ensuring atmospheric pressure was maintained.

Table 1
The best-selling respirators and masks on Amazon.com

| Item name | Mask name | Mask description | Seller (Location) | Package cost ($) |
|-----------|-----------|------------------|------------------|-----------------|
| N95       | 3M N95    | 3M 50051138464573 8210 N95 Particulate Respirators, 20/Dispensers (Pack of 20) | U.S. | 27.16 |

*Cost at the time of purchase.

The masks are ordered based on their order from Amazon.com at the time of purchase.

Filter preparation

The masks were preconditioned according to NIOSH standards at 85 ± 5% humidity at 38 ± 2.5°C for 25 ± 1 hours using a humidity chamber (MEMMERT HCP50115V, Schwabach, Germany) and tested within 10 hours of removal from the humidity chamber. The respirator or fabric was then mounted to a disc with a 4-inch inseam using beeswax (EricX Light, Chancheng, China) to secure the test materials and prevent fine particles from passing between the material edges and the disc holder. The application of beeswax prevents leakage and withstands test system conditions. A disc with a 4-inch inseam was chosen because the 4-inch inseam was the best fit for the mounting of N95. The masks under the FPE category (FPE1-FPE5) were tested without any modifications. However, unlike the N95s and KN95 respirators, the masks under the CFM category were not tested in the original configuration and were cut to a 5-inch diameter sample to prevent leakage between the disc and the exposure chamber. Despite reducing the masks in the CFM category to accommodate the exposure chamber size, the masks were not stretched and represented similar exposure areas as the N95 and KN95s respirators.

Experimental setup

The experimental setup for the filter efficiency test is shown in Figure 1. A 5-stage desiccant air drying system (Speedaire, Niles, Illinois, U.S.) supplied particle-free air to a heater and ionizer, each controlled by mass flow control meters (Alicat Scientific, Tucson, AZ, U.S.). The heater (Vulcan Electric Company, Porter, ME, U.S.), regulated by a Triac variable voltage supply (Dart Controls, Algonquin, IL), was used to dry the salt particles at the desired temperature of 25 ± 5°C. The ionizer (Simco-Ion Technology Group, Alameda, CA) was used to achieve the Boltzmann equilibrium state. The heated and ionized air was supplied to a mixing chamber before the exposure chamber (Hoffman Enclosures Inc., Anoka, MN, U.S.). A six-jet atomizer (TSI Model 9306 Six-jet Atomizer, Shoreview, MN, U.S.) was used with a 2% NaCl solution to generate salt aerosols that flowed toward the mixing chamber. The mixing chamber was connected to the filter exposure chamber and included a HEPA filter (Global Life Sciences Solutions 0.2 μm PTFE, Buckinghamshire, UK) before passing the aerosol through the chamber to remove excess flow from the system.

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Airflow was achieved through the exposure chamber by a vacuum pump (Welch-Ilmvac 2585B-50, Niles, IL, U.S.) operated at 85 LPM, controlled by a valve (SMC vacuum regulator, Yorba Linda, CA, U.S.), and measured by a flow meter (Alicat Scientific, Tucson, AZ, U.S.). A HEPA filter (Global Life Sciences Solutions 0.2 μm PTFE, Buckinghamshire, UK) was used to remove the remaining salt particles before entering the flow meter. The resistance within the exposure setup system was determined by measuring the pressure drop across the respirator or mask using a differential pressure meter (TSI Model 5825 DP-CALC Micromanometer, Shoreview, MN, U.S.).

Humidity and
temperature were measured in the exposure chamber upstream of the filter using a data logger (HOBO temperature/RH, Bourne, MA, U.S.).

**Fractional efficiency and pressure drop**

The particle penetration value is a percentage determined by the ratio of the downstream concentration to the upstream concentration. The fractional filter efficiency was calculated by measuring 3 upstream and 3 downstream samples. The average of the upstream and downstream samples was used to calculate the fractional efficiency. The scan time for each sample was 60 seconds. Each test was conducted using new respirators or masks from the same package. For statistical significance, three individual masks of the same kind were tested. To determine the fractional filter efficiency of the filter material, the following equation was used:

\[ \text{Fractional Filter Efficiency} = \frac{1 - \text{Average downstream concentration}}{\text{Average upstream concentration}} \times 100 \]  

(1)

The initial and final pressure drop values were measured, where the initial value was measured before the experiment and the final value was measured after 6 minutes when the 3 upstream and downstream samples were completed. The average fractional efficiency and pressure drop (resistance) from the three samples (n=3) for all the respirators were calculated and plotted. The goal was to determine the minimum efficiency and the MPPS for each PFE and CFMs compared to the NIOSH-approved N95 respirator. Two plots were constructed for the filter efficiency and pressure drop, one comparing PFE to the N95 and the other comparing CFMs to the N95. The PFE and CFMs were plotted in separate groups for readability and clarity with the intention of comparing all masks together using side-by-side figures.

**Quality and grading factors**

Filter evaluation has also been performed using the Quality Factor that combined the effect of penetration and pressure drop:

\[ \text{Quality Factor} = \frac{\ln(1,P)}{\Delta P} \]  

(2)

Where \( P \) is the fractional penetration (1 - fractional efficiency) and \( \Delta P \) is the pressure drop (mmH₂O).

The general public is unfamiliar with NIOSH standards and expectations of suitable respiratory protection against viruses. In addition, consumers are not necessarily interested in wearing masks for protection. However, other social and political factors might have an influence. Therefore, a grading factor was calculated for three important factors: protection (efficiency), comfort (breathing resistance or pressure drop), and affordability (cost) for each respirator and mask. These factors can be readily translated to the public through the scientific community and were used due to the availability of data and may represent some of the important factors that consumers consider before purchasing respiratory protection. Consumers have expressed intent to purchase based on protection or comfort.

The grading factors were calculated as a percent value, where high values around 100% are better compared to lower values. The Protection Grading Factor (PGF) was calculated from the following equation:

\[ \text{Protection Grading Factor (PGF)} = \frac{\text{Minimum Efficiency (95%)}}{\text{Highest Cost (5$)}} \times 100 \]  

(3)

where the Minimum Efficiency represents the efficiency at MPPS, and the 95% value was chosen based on the NIOSH standard for the minimum efficiency required for respiratory protection.

The Comfort Grading Factor (CGF) was calculated from the following equation:

\[ \text{Comfort Grading Factor (CGF)} = \left(1 - \frac{\text{Resistance (mmH}_2\text{O)}}{35 \text{ mmH}_2\text{O}}\right) \times 100 \]  

(4)

where the Resistance represents the respirator or mask pressure drop, and the 35 mmH₂O value was chosen based on NIOSH standard for the maximum acceptable pressure drop through the respirator or mask. The ratio was subtracted from 1 to obtain a value closer to 100%.

The Affordability Grading Factor (AGF) was calculated from the following equation:

\[ \text{Affordability Grading Factor (AGF)} = \left(1 - \frac{\text{Respirator or Mask Cost ($)}}{\text{Highest Cost ($)}}\right) \times 100 \]  

(5)

where the cost of the Respirator or Mask Cost ($) was calculated based on the data provided in Table 1, by dividing the package cost by the number of items included in the package to represent the item’s unit cost. The Highest Cost ($) was chosen for the mask, with the highest

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**Fig 1.** Experimental setup for fractional filter efficiency determination.
item cost calculated as $3.33 for CFM5. Finally, the PGF, CFG, and AGF values were plotted to show differences between respirators and masks compared to the N95.

RESULTS AND DISCUSSION

Fractional efficiency and resistance (Pressure drop)

The fractional efficiency for FPE and CFMs is shown in Figure 2. The N95 respirator efficiency was 97% at an MPSS of 40 nm and a pressure drop of 6.1 mmH2O. These results are similar to previous studies that evaluated the NIOSH N95 respirator.9,24 For the FPE items (Fig 2-A), efficiency and MPSS results varied, which are: 86% and 0.055 μm, 98% and 0.048 μm, 88% and 0.048 μm, 89% and 0.188 μm, and 98% and 0.025 μm, for FPE 1 through 5, respectively. Compared to the N95, FPE2 and FPE5 had a slightly higher efficiency, but only FPE2 had a similar MPPS value. Items labeled FPE1, FPE3 and FPE4 were below NIOSH standard (95%) for all particle sizes below 0.45 μm. In addition, the variability (standard deviation) was high for these three items, showing poor quality control, compared to the N95, FPE2 and FPE5, which had low variability indicating high-quality control. For the CFM items (Fig 2-B), efficiency and MPSS results varied, 26% and 0.23 μm, 33% and 0.29 μm, 11% and 0.29 μm, 25% and 0.25 μm, and 30% and 0.15 μm, for CFMs 1 through 5, respectively. All items were below the 95% NIOSH efficiency standard and were extremely low. Compared to the N95, the MPPS values were higher than the nanoparticle range (<0.01 μm). The quality control for the Will-Nertpow (CFM1 and CFM4) was high with similar measured efficiency and MPPS. These results show the inadequacy of the CFMs to protect against the virus or any airborne particles.

Finally, the pressure drop for FPE and CFMs is shown in Figure 3. The pressure drop varied from 2.3 to 10.3 mmH2O, where all FPE and CFMs were within the NIOSH standard of 35 mmH2O. FPE5 efficiency

Fig 2. The fractional efficiency of (A) face protective equipment (FPE) and (B) cloth face masks (CFMs) at different particle sizes. The y-axis error bars represent the standard deviation.
and resistance values were 98% and 3.7 mmH2O, which are better than those of the N95 at 97% and 6.1 mmH2O. Most of the CFMs, except the CFM1, had pressure drop values that were similar or lower than the N95 but had poor efficiency values. The N95 showed an 8% change in differential pressure, where CFM2 was the only lower pressure change at 7%. In contrast, CFM1 and FPE5 showed the highest pressure drop change of 135% and 68%, respectively. However, the FPE5 initial and final pressure drop values (3.7 and 6.1 mmH2O, respectively) remained below the N95 values (6.1 and 6.6 mmH2O, respectively) during the 6 minutes of exposure.

The KN95 respirators are marketed to have an overall efficiency of 95%. However, the FPE2 and FPE5 were the only KN95 tested to report efficiencies higher than 95%. The discrepancy regarding the efficiencies of different KN95s in this study has been observed in other studies that performed tests according to NIOSH standards. Brochot et al.11 observed high variability in the efficiency of four different KN95-type respirators from different manufacturers, with the efficiencies being lower than the NIOSH-approved N95. The authors also reported high MPPS values (>0.15 μm). However, similar to this study, pressure drop values were within the NIOSH standard (6-13 mmH2O). Rengasamy, et al.8 tested three different cloth masks and found that the average penetration levels of the tested cloth masks ranged from 74-90% for larger particle sizes. Therefore, the average filtration efficiency level for the cloth masks was from 10-26%. Compared to Rengasamy et al., CFM3 provided similar low efficiency results while the remaining cloth masks reported higher efficiencies but still much lower than the N95.

Adequate respiratory protection adds breathing resistance (pressure drop), and the N95 is designed to achieve acceptable breathing patterns at low pressure drop (≤35 mm H2O) according to NIOSH standards. However, healthcare professionals have expressed difficulty breathing while wearing an N95 respirator for protection.25-27 Kim et al.28 tested the breathing resistance of subjects wearing N95 respirators and determined that the pressure drop varied between 6 and 9 mmH2O. Therefore, since wearing an N95 with low resistance (~6 mmH2O) compared to the maximum NIOSH standard (≤35 mmH2O) could present difficulty in breathing, these masks need to maintain a low resistance and small change in pressure drop during usage. Maintaining low-pressure drop changes is conceivable in healthcare settings due to the low exposure and sterile nature of the environment. Despite that all FPE and CFM are within NIOSH pressure drop standards, based on the consumers’ demanding needs for lower resistance, only the FPE5 is a plausible replacement due to the lower resistance compared to the N95 and high efficiency. However, the FPE5’s high pressure drop increase (68%) in 6 minutes could be an indication that the FPE5 would exceed the N95 resistance levels beyond 6 minutes of exposure. The remaining masks fall short due to low efficiency or higher pressure drop than the N95. Especially, the CFMs that had the highest pressure drop change (i.e., CFM1, CFM3, and CFM4), which show that breathing can potentially become difficult during usage.

**Quality and grading factors**

The Quality and Grading Factors for FPE and CFMs are shown in Figure 4. For the Quality Factor, the N95 had the highest value at 58%/mmH2O, followed by the FPE, while the CFMs had values 10 times lower than the N95 on average. Eninger et al.7 measured the Quality Factor for the N95 using NIOSH standards and determined the same value as this work. For protection grading factor (efficiency), the N95, FPE2 and FPE5 exceeded the expectations recommended by NIOSH. The remaining FPE were below standard, and the CFMs values were extremely low (12-26%). For comfort grading factor (breathing resistance), the N95 was close to the average (83%) of the FPE and CFMs combined. In addition, if we consider CFM2 an outlier, the comfort values were linear and inversely proportional to protection values for both the FPE (R² = 0.95) and CFMs (R² = 0.93). This is not surprising compared to the N95 and high efficiency.
CONCLUSION

The discrepancy in the filtration efficiencies for different KN95s proves that the KN95 is not always an appropriate replacement for NIOSH-approved N95s. It is difficult to determine which KN95s possess filtration efficiencies of 95% or higher across all particle sizes without proper testing. The filtration efficiency of different KN95s from different manufacturers varies greatly at the most penetrable particle size. However, this study shows that KN95 respirators are a better option than cloth masks. Based on this study, the KN95 is expected to provide at least 86% protection. Therefore, the KN95 remains a better source of respiratory protection than washable cloth masks. For adequate respiratory protection, consumers are encouraged to wear KN95s when the N95 is not available. These findings are important because they demonstrate which among the best-selling respiratory protection on Amazon.com, the largest online retailer in the U.S., were the better choices by consumers. Given that the online retailer provides access to all purchase history, it is highly probable that consumers will return to their previous purchasing habits, in the event of a new pandemic or epidemic, a new variant, and an increase or surge in disease cases that constitute federal and local mask mandates. Unless consumers will be provided better information to make informed decisions on their purchases, the general public will continue to use cloth masks that do not provide sufficient respiratory protection. It is highly recommended that health authorities or agencies (e.g., CDC) provided more information to the public about the levels of protection and breathability of cloth masks by citing findings of relevant published studies on publicly accessible communication media, such as via agency websites and social media platforms, and public service announcements via television or radio.

ACKNOWLEDGMENTS

We want to thank Ms Vivien Coombs for drawing Figure 1 in the manuscript and helping with preconditioning the respirators and masks before the experiments.

Study limitations

The study measured efficiency based on maximum value and did not consider leakage due to the lack of fit test. However, consumers do not perform any fit tests before choosing products, and a respirator or mask fit depends on the individual. Therefore, consumers should consider that protection values could be lower based on how well the respirator or mask is fitted. In addition, the grading factors developed in this study do not necessarily reflect the important factors that consumers consider while purchasing respiratory protection. The definition of comfort may not necessarily refer to breathing resistance but could refer to the type of material used to fabricate the mask or the comfort around the ears or nose. In addition, the cost might not be a factor to consider compared to safety. However, individuals acquiring masks due to government mandates may consider the cost an important factor. Future work should evaluate the grading factors proposed in this study and the percentage of consumers that purchase from Amazon.com using surveys. A description of the different parameters measured in the study and overall efficiency results, pressure drop, standard values and other factors will be provided so that the consumers can better understand their choices. Such information may help consumers select better quality masks of well-performing respiratory protection products. Finally, this study focused only on adult alternative masks, but many of the best-selling masks on Amazon.com were children’s masks. Therefore, to determine if the public is protected from the spread of COVID-19, all ages must be considered in future studies.

CONCLUSION

The discrepancy in the filtration efficiencies for different KN95s proves that the KN95 is not always an appropriate replacement for NIOSH-approved N95s. It is difficult to determine which KN95s possess filtration efficiencies of 95% or higher across all particle sizes without proper testing. The filtration efficiency of different KN95s from different manufacturers varies greatly at the most penetrable particle size. However, this study shows that KN95 respirators are a better option than cloth masks. Based on this study, the KN95 is expected to provide at least 86% protection. Therefore, the KN95 remains a better source of respiratory protection than washable cloth masks. For adequate respiratory protection, consumers are encouraged to wear KN95s when the N95 is not available. These study findings are important because they demonstrate which among the best-selling respiratory protection on Amazon.com, the largest online retailer in the U.S., were the better choices by consumers. Given that the online retailer provides access to all purchase history, it is highly probable that consumers will return to their previous purchasing habits, in the event of a new pandemic or epidemic, a new variant, and an increase or surge in disease cases that constitute federal and local mask mandates. Unless consumers will be provided better information to make informed decisions on their purchases, the general public will continue to use cloth masks that do not provide sufficient respiratory protection. It is highly recommended that health authorities or agencies (e.g., CDC) provided more information to the public about the levels of protection and breathability of cloth masks by citing findings of relevant published studies on publicly accessible communication media, such as via agency websites and social media platforms, and public service announcements via television or radio.

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