

The Great Gender Divide: Gender-related discrepancies of N95 mask protection

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Abstract

During the COVID-19 pandemic, healthcare professionals across the world are at high risk of transmission due to their direct contact with infected patients. To ensure protection of healthcare personnel, properly fitting Personal Protective Equipment (PPE) must be worn.

An N95 respirator mask is a component of PPE outlined by the Centers of Disease Control (CDC) for protection against COVID-19; however, N95 masks do not offer protection if they do not fit properly.

Fit testing is performed to ensure adequate seal of the mask on the wearer. A single institutional, retrospective review was performed on fit testing results for male versus female wearers in an attempt to elucidate a difference in failure rates. Females failed at a significantly higher rate than their male counterparts (6.67% female, 2.72% male; $p=0.001$), and the reason reported was often due to being "small-boned" ($p<0.0001$). Gender-related differences in proper PPE fit is not new; however, the COVID-19 pandemic has made the situation more acute, and gender-specific N95 mask designs should be developed before the potential second wave of the pandemic.

COVID-19 Pandemic

- PPE decreases but does not eliminate the risk of transmission of highly infective agents [1].

- CDC recommends proper PPE for COVID-19 includes a face shield or goggles, a N95 or higher respirator, one pair of clean non-sterile gloves, and an isolation gown [2].

- Transmission of SARS-CoV-2 includes close-range aerosol transmission by droplet and inhalation, and contact followed by self-inoculation via delivery to the eyes, nose, or mouth [3]. The requirement for the use of N95 respirator masks is based on the current understanding of SARS-CoV-2, the virus that causes COVID-19, and related respiratory viruses [3].

- N95 and higher-level respirators provide barrier and respiratory protection because of their tight fit and filtration characteristics; however, this fit must be assessed for effectiveness with a respirator fit test [3].

- Respirator fit testing requires:
 - Selection of the most appropriate model
 - Proper process of donning
 - At least five minutes of wear to assess comfort and effectiveness [4]

- To determine adequacy of fit, the United States Department of Labor notes the following criteria:
 - Chin properly placed, adequate strap tension, fit across nose bridge, respirator of proper size to space distance from nose to chin, tendency of respirator to slip, and self-observation in mirror to evaluate fit and position [4].
 - The wearer must then conduct a user seal test and undergo test exercises to determine if the fit is adequate. If the respirator doesn't fit properly, contaminated air can leak into the facepiece, and potentially cause the wearer to breathe in hazardous substances [5].

Proper respirator fit is vital for protection of the wearer.

Facial hair, such as a beard, could prevent the mask from properly fitting; however, data regarding the differences in fit between male and female wearers is lacking [1,4].

PPE has been designed for the male body, yet according to the US Census Bureau, in 2019, women held 76% health care jobs [6,7]. As of 6/3/20 the International Council of Nurses, noted that over 230,000 healthcare workers have contracted COVID-19, and more than 600 nurses have died from the virus [8]. Therefore, it is important to ensure proper N95 fit for all healthcare workers.



Figure 1. N95 respirator mask, model 3M1860.

Methodology

A single institutional retrospective review was performed on individuals who underwent fit testing from December 2019 to June 2020. Two mask sizes were available for fit testing (Model 3M1860, Regular/Small) (Figure 1). Fit test results were divided into two groups, male or female, and evaluated for failure rates. Reasons for fit test failures were noted as: large-boned, small-boned, facial asymmetry, facial hair, and/or no reason reported (Figure 2). Since facial hair is a choice that can be changed, exclusion criterion included failure due to facial hair. A Chi Square Analysis was performed on the data to determine statistical significance.

Results

A total of 336 tests were performed during this time period, with 31 exclusions for failure due to facial hair. The data analyzed included 305 total respirator fit test results: 110 male and 195 female. Out of 110 males, 107 passed fit testing, 3 failed, with a failure rate of 2.72%. Out of 195 females, 182 passed fit testing, 13 failed, with a failure rate of 6.67% (Table 1). Statistical analysis comparing expected versus observed outcomes of fit testing in males versus females indicate that females fail at higher rates than males ($p=0.001$) (Table 1, Figure 3).

Discussion

Improper sizing of PPE is not a new problem, but the COVID-19 pandemic has made the situation more acute. This study was designed to determine statistical significance of the fit of N95 respirator masks, an important piece of PPE for COVID-19 protection, comparing male and female wearers.

Proper fit of PPE for healthcare workers is crucial for protection during the COVID-19 pandemic, not just for the wearer but also for patients. Ineffectiveness of PPE may contribute to nosocomial transmission of COVID-19 [1,12]. According to the COVID-19 handbook prepared by Chinese colleagues, all healthcare personnel are required to wear medical masks, and those who work in the emergency department, the outpatient department of respiratory care, the outpatient department of infectious diseases, department of stomatology, and/or the endoscopic examination room should wear a medical protective mask, such as an N95 mask [1,13]. In order to ensure proper fit of the N95 mask, and therefore its effectiveness, one must pass the respiratory fit test. Male wearers failed fit testing at a significantly lower rate than females (2.72% male, 6.67% female; $p=0.001$) (Table 1, Figure 3).

Gender-related differences in PPE fit is widespread across many different fields, not just healthcare. In 2016, poor access to appropriately fitting PPE was highlighted in a study of female construction workers in the *American Journal of Industrial Medicine*. Female laborers, carpenters and ironworkers were enrolled in semi-structured focus groups in New York City. The majority reported fit problems for many types of PPE (gloves, harnesses, safety vest, work boots, outerwear), noting that the equipment provided was too large [9]. The authors concluded that female construction workers have difficulty accessing properly fitting PPE that is designed for women [9]. Ill-fitting or inappropriate PPE for women is a widespread issue. A United Kingdom survey performed in May 2016 by the trade union Prospect, Women in Science and Engineering, the Trades Union Congress, and the Institution of Mechanical Engineers found that ill-fitting PPE was common but often accepted as 'part of the job' [10].

Many responses from PPE fit surveys indicate that improperly fitting PPE hinder women's ability to do their work [9,10,14]. The challenge at hand is that PPE has been developed to fit a male frame, with smaller sizing being provided for women. However, women are not just smaller versions of men. A comparison of male and female body sizes and proportions performed in 1977 on military personnel, indicated that even females of equal height and weight to their male counterparts do not have the same body proportions [11]. In the same vein, even though two N95 mask sizes were offered at this institution, regular and small, females still failed due to being small-boned at a significant rate ($p<0.00001$) (Figure 2).

The Personal Protective Equipment Regulations 2002 and the Personal Protective Equipment at Work Regulations 1992 (as amended) place a legal requirement on employers to provide PPE to workers if it is needed to protect them from any workplace hazards to their safety or health [14]. Employers must ensure that the PPE is suitable for the purpose, causing significant concerns for appropriate fitting N95 masks for women health care workers [14]. The unisex approach to PPE negatively affects both the work and safety of female wearers. PPE is intended to provide protection, and currently, is ineffective for more than 75% of the healthcare workforce.

Conclusion

The COVID-19 pandemic has caused a PPE crisis. Now more than ever it is important for healthcare workers to have properly fitting PPE to ensure their health and safety and the safety of those around them. N95 respirator masks are outlined by the CDC as part of PPE for protection against COVID-19, yet females are faced with wearing masks that do not properly fit them, let alone protect them. N95 masks were not designed for female facial dimensions and because of inadequate fit, female healthcare workers are not properly protected. Developing a gender-specific approach to designing N95 masks is vital in the upcoming months, as a potential second wave of the disease is approaching.

Gender-specific Reasons for Fit Testing Failures

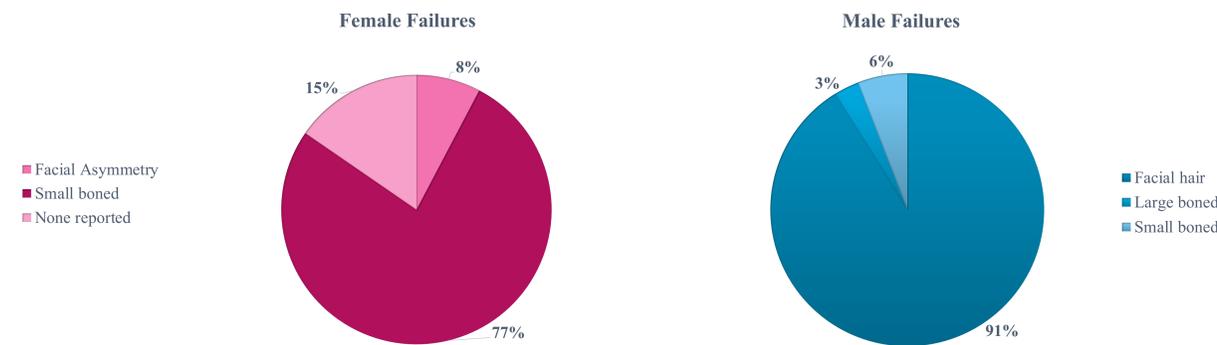


Figure 2. Reasons reported for respirator fit testing failures for both male and female test subjects with their respective p values. Failure reasons included: facial hair, large boned, asymmetry, small boned, and no reason reported. Male failure total: 34, with 3 due to non-facial hair reasons (Large boned: 1, Small boned: 2). Female failure total: 13 (Facial Asymmetry: 1, Small boned: 10, None reported: 2). Females failed significantly more due to being small-boned when compared to male reasons for failure ($p<0.00001$).

Gender Specific FIT Testing Results

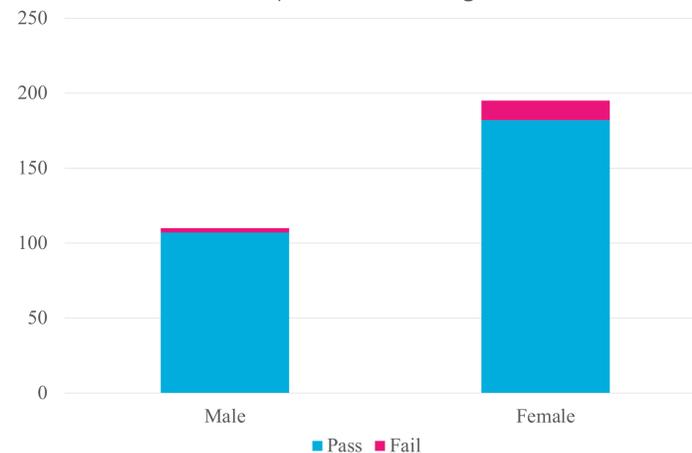


Figure 3. Gender-specific respirator fit testing results from a single institution. Male versus female test results are represented above, with pass results (pink) and fail results (blue).

	Male	Female
Pass	107	182
Fail	3	13
Failure Rates	2.72%	6.67%
P Value	0.001	

Table 1. Total of 305 fit tests performed and analyzed: 110 male and 195 female. Failure rates for male and female test subjects were 2.72% and 6.67%, respectively ($p=0.001$).