WVU HSC Center for Inhalation Toxicology

Response to Conclusions Made by: Fischer et al., Sci. Adv. 10.1126/sciadv.abd3083 (2020)

In the recent publication by Fischer et al, an inexpensive and easily operable setup was developed for the rapid evaluation of mask performance during speech, sneezing or coughing. The authors tested 14 materials/masks and reported a normalized expelled droplet count outside the mask as an index of the filtration efficiency of the mask/material. It was reported that fleece gaiters performed the worst among the tests. The authors further concluded that fleece gaiters not only offer very little protection, but also "…*disperse the largest droplets into a multitude of smaller droplets*…". We challenge this notion from the following scientific perspectives:

1) The fundamental issue is about the material (polyester fleece), not the style of mask (gaiter vs traditional over the ear mask). Moreover, the study did not investigate the same fleece material in both mask styles. Thus, it cannot be concluded that one style performs "better" than another.

2) Droplet size was not directly measured in this study. Rather, light scattering combined with algorithms were used to *estimate* droplet size. A more rigorous approach is necessary to convincingly demonstrate that dispersion is occurring through this material.

3) When droplets pass through mask pores created by fibrous materials, four outcomes have been consistently demonstrated in the literature (**FIGURE 1**): inertial impaction, interception, diffusion and electrostatic attraction. Dispersion is not one of these. Thus, the notion that a large droplet is split into two smaller droplets AND both droplets continue in exhaled air is not substantiated.

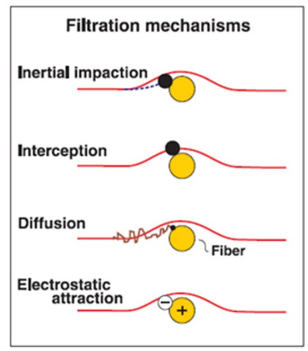

FIGURE 1: Filtration mechanisms of fibrous materials. Source: https://www.cdc.gov/niosh/docs/2014-102/default.html

4) The resolution limit of the system is the pixel size, which was reported to be 120 μm x 120 μm. Thus, the smallest droplet size estimated was 120 μm. Typically, the upper limit of "respirable" particles and droplets is 10 μm.

5) Direct particle size measures were not made. Even if the size estimates and claim of dispersion are entertained, the droplet measures were ≥ 200 μm. These would quickly fall from suspension. More importantly, they are not respirable.

6) Respirable aerosols are typically characterized by discrete phases: nucleation, condensation and mechanically generated (**FIGURE 2**). In our aerosol research, a considerable amount of directed and sustained force is necessary to *decrease* aerosol size and maintain that experimental atmosphere. This is not present in exhaled air moving through a fleece gaiter.

7) The above statement by Fischer et al has generated a tremendous amount of attention, and despite lacking scientific credibility, has resulted in the withdraw of the WVU Gaiters being distributed across campus. Our position is that the comment by Fischer et al was unwarranted speculation. Further it requires direct droplet measurements to validate their claim. As such, we tested the WVU Gaiters.

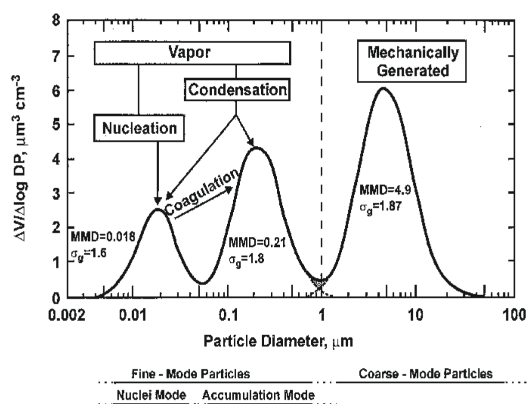

FIGURE 2: Particle size mode shifts. The tendency is for particle size to increase from left to right. Source: https://www.researchgate.net/publication/298434201_Particulate_Air_Pollution_and_Health_Emerging_Issues_and_Research_Needs_Related_to_the_Development_of_Air_Quality_Standards

Test Results of WVU Gaiters

1) The WVU Gaiter is 100% polyester, 130 gram interlocked material. Only new, unopened gaiters were tested. Material characteristics of the gaiter used by Fischer et al was not reported. Thus, we cannot determine how the two relate.

2) Quantitative Fit Testing was performed with the TSI PortaCount Respirator Fit Tester 8038. The principle of operation is that a room is filled with saline droplets. Air is sampled in the room and inside the mask, the number of droplets is counted. The droplet difference between the two sides reflects the fit of the mask and its effectiveness as a filter.

3) The WVU Gaiter scored a "1" on the N95 and non N95 fit test. A score of 100 is necessary for a passing score for an N95 test. This reflects that the WVU Gaiter does not provide the user appreciable protection from small respirable aerosols (~50 nm – 1 μm).

4) The materials testing provided information regarding the filtration efficiency of the WVU Gaiter fabric. The material scored a fit factor of 3 on the non N95 fit test. This indicates that the material itself filtered out about 2/3 of the particles when all the flow was passed through the material. When we doubled up the material (2 layers) the filtration efficiency was not appreciably improved.

5) Next, we made direct droplet size measurements with three instruments that make such measures via distinctly different principles. First, an Aerodynamic Particle Sizer (APS, 3321 TSI) was used. The APS device excels at measuring condensation phase particles and larger, from 500 nm – 20 μm. The APS indicated there was no difference in droplet size after filtration through the WVU Gaiter material (735 nm was the count median droplet diameter on both sides of the material). Second, an Electrical Low Pressure Impactor (ELPI+, Dekati) was used. The ELPI indicated there was a nominal drop in droplet size after filtration through the WVU Gaiter material (68 nm vs 60 nm was the count median droplet diameter on both sides of the material). Third, a Scanning Mobility Particle Sizer (SMPS, 3938, TSI) was used. The SMPS indicated there was a nominal increase in droplet size after filtration through the WVU Gaiter material (47 nm vs 58 nm was the count median droplet diameter on both sides of the material).

SUMMARY - CONCLUSION

This was one test day of the WVU Gaiter, with multiple tests and materials. The WVU Gaiter does not provide filtration/respiratory protection to the user from inhaled aerosols. However, it does afford some opposition to the spread of exhaled droplets. Assuming a good fit, it will provide a respiratory containment approximately comparable to a common over the ear cloth mask.

Because we made direct droplet size measurements, we have evidence that refutes the notion advanced by Fischer et al that fleece gaiters disperse large droplets into many smaller droplets.

Considered together, the WVU Gaiter: 1) does no harm, 2) is unquestionably better than no mask, and 3) provides reasonable containment that contributes to the opposition of droplet transmission between two people in close proximity. We see no reason to stop distributing the WVU Gaiter.

Test Results of WVU Mask vs Gaiter

1) The WVU Gaiter (single layer, 100% polyester) was compared against the WVU mask (two-layer, 100% cotton).

2) Two tests were performed with the TSI PortaCount Respirator Fit Tester 8038:
   a) Quantitative Fit Testing.
   b) Material Filtration Efficiency Testing.

3) The WVU mask scored a fit factor of 1. The WVU gaiter scored a 1. This indicates the mask and gaiter do not provide the user appreciable protection from small respirable aerosols.

4) The WVU mask scored a 2 for the Material test. This indicates the WVU mask is filtering ~50% of the droplets passing through it. The WVU gaiter scored in the range of 2-3 for the Material test.

Since the mask and gaiter leak around their substantial gaps, they will provide very little protection for the user from small aerosols. In contrast, during the higher airflows during coughing, talking, etc. and the close proximity of the face to the mask or gaiter, they should provide a measure of filtration and velocity dissipation/redirection for droplets expelled from the user of the mask. This offers a significant level of protection for persons in proximity to the user. The mask and gaiter performed similarly in terms of filtration and are comparable to other cloth-type masks we have tested.

Related Information –Additional Observation

When the polyester WVU gaiter material is rubbed together, we saw an increase in counts measured with the PortaCount device. This may be why the authors of the recent article (Fischer et al) observed larger count numbers with their gaiter. The friction from rubbing the face against the gaiter creates shear forces that may be generating excess particles from the fleece material itself. Additional studies are being performed to further explore this possibility.

Related Information – Combination Test

1) The substantial gaps in masks and gaiters indicated above are different between the two devices. Therefore, we tested if combining a surgical mask with the gaiter would improve performance. Our rationale was that the gaiter would press the surgical mask against the face, thereby removing gaps and forcing more air to be filtered. The WVU gaiter was used with one of the disposable surgical masks distributed with the package after COVID testing being performed on Campus. Tests were performed on two individuals as we speculated that head size/circumference would influence the gaiter fit.

2) For the Fit tests, a fit factor of 3 (~66% of particles filtered) was achieved for the smaller headed individual and 5 (~80% of particles filtered) for the larger headed person.

This combination of mask + gaiter provides a much-improved level of protection for the user and for persons in proximity to the user. This does add some heat stress to the user, but it is estimated that it would be tolerable/wearable for multiple hours of low-effort activities (such as attending class). If this is pursued, we recommend ordering gaiters of smaller size to fit individuals with smaller heads. We also anticipate that would improve the filtration efficiency of the combo for smaller headed individuals

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