Letter to the Editor re: Beard Length and the Efficacy of an Aviator Oxygen Mask

Dear Editor:

A recent article by French & Wagner[1] concludes "facial hair of any length has no effect on reducing a contemporary aviator mask effectiveness in maintaining adequate blood oxygenation." Facial hair in aircrew can be an emotive topic, but a sound evidence base is required to challenge established understanding and recommendations.

The study in question was conducted in a normobaric, reduced-oxygen environment using a Collins Sweep-On 2000 mask with the pressure-demand regulator in "normal" (air-mix) mode. As there was no ambient pressure change, the regulator would have mixed oxygen and ambient air in proportions to deliver a ground-level breathing gas mix. The ambient air being mixed contained a reduced oxygen concentration in this experimental setup, so the breathing gas would have contained a fraction of oxygen (FO_2) below that intended by the manufacturer. Combined, these experimental limitations mean that the system was not representative of real-world performance at 30,000-ft (9144 m) pressure altitude.

At lower altitudes, pressure-demand regulators deliver an air-mix with oxygen partial pressure that is greater than sea-level equivalent air. At ground level, a significant inward leak due to poor mask seal may, therefore, not result in an inspired gas mix sufficient to cause hypoxia. Assuming a typical demand regulator delivery performance of FO_2 of 0.35 at ground level, it can be calculated that the inspired gas would remain >0.21 FO_2 despite an inward leak of over 10% from the reduced-oxygen ambient air in this study. Without knowledge of the exact air-mix ratio, particularly considering the nonstandard air-mix, the threshold size of detectable leak cannot be calculated. Civilian standards typically require a minimum FO_2 of 0.95 above 35,000 ft (10668 m).[2] Detection is further affected by the limitations of peripheral oxygen-saturation monitoring[3] and characteristics of the oxyhaemoglobin dissociation curve, which allows peripheral oxygen saturation to be maintained even with an FO_2 below 0.21.

With regard to smoke and fume protection, the authors challenge the need for quantitative fit-testing for protection, instead employing a 5-s static smelling salt exposure. Aircrew masks are required to provide protection during head movement; typical approved qualitative fit tests require specific movements during a total exposure greater than 7 min.[4] Quantitative fit tests assure an inboard leak of no greater than 10%,[4,5] and military mask standards require less than 2% or 5% admixture (UK Ministry of Defense. Certification Specifications for Airworthiness. Part: 01: Fixed Wing Combat Air Systems. Report No. DEF STAN 00-970 Part 13; 2022) (Five Eyes Air Force Interoperability Council. Minimum physiological requirements for aircrew demand breathing systems. Document No. AIR-STD-4039 ED. 1(2); 2020). Only quantitative fit-testing can provide this level of assurance.

Previously published studies in aviation and nonaviation settings have shown that beards present a significant risk of inward mask leak.[6–8] Only a single unpublished trial (the authors cite a university news article) are in line with French & Wagner's findings. Methodological limitations in both studies mean that inboard ambient air leaks of between 10% and 50% may have gone undetected. This degree of inboard leak would not protect against hypoxia at altitudes in excess of 25,000–30,000 ft (7620–9144 m) or noxious fumes. The evidence presented by this study is not sufficiently robust to support the authors' conclusions, and incorrect application of the reported findings may lead to significant flight safety hazards.

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In Response:

The established "understanding and recommendations" the reviewer references in his opening paragraph derive from the 1980 Federal Aviation Administration (FAA) Advisory Circular. The FAA does not prohibit beards; the Advisory Circular only contends that pilots could be impaired in an emergency if they had beards.

We have two main issues with this established "understanding":

- There are no peer-reviewed studies demonstrating that aviation emergency masks leak enough from beards to impair pilot ability to safely fly the aircraft. Our study showed that bearded pilots do not become hypoxic at altitude while using aviation masks, and thus beards would not compromise their performance.
- The FAA's lack of a definitive stance on disallowing beards leaves airlines in a precarious legal position. If the FAA believes there is evidence that passenger safety is at risk from pilots with beards, it should prohibit beards immediately. The fact that they have not done so means that there must not be sufficient evidence. The lack of a definitive stance by the FAA means that the airlines could be held legally culpable for any incidents where bearded pilot performance might be blamed. This also leaves the FAA culpable for why they have not banned beards if they believe beards could impair pilot performance.

The mask in our normobaric hypoxia chamber combined ambient air with enough oxygen to allow a normoxic mix. The mask operates the same in hypobaric conditions. The reviewer's comment about the mask valves is irrelevant to our study on the mask seal. The air-pressure-filled hoses create a very tight seal leaving indented seal imprints on participants' faces within minutes.

Regarding our participants not smelling ammonia within our test period of about 5 s at chin level while masked, we suggest the reviewer confirm, as we did, that ammonia that close when unmasked will trigger a powerful response in less than 0.5 s.

Regarding the three references that the reviewer claimed document beards causing aviation masks to leak:

- Naber's study was conducted 54 yr ago with outdated mask technology. Moreover, in the conclusion on page 2, the authors admitted that there was "no conclusive evidence that beards cause serious injury."[1]
- Stobbe et al. was a literature review focusing on the methods and findings of 14 Occupational Safety and Health Administration (OSHA) type respirators and included one study with an aviation type mask. This one study was only presented at a 1979 convention in Las Vegas. It only involved four participants tested in nonaviation conditions and was not published in a peer-reviewed journal.[2]
- The reviewer missed the point of Floyd et al.: These authors were making the point that even with OSHA's stringent testing for lethal molecules, some respirators fit adequately on bearded individuals. They suggested OSHA should relax their position on beards because of this.[3]

The author presents assumptions without solid evidence and ignores the issue we addressed with our study, finding that the mask's seal is adequate to protect pilots with beards of any length in a hypoxic environment.

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From the Editor-in-Chief

The research article by French and Wagner published in the April issue of *Aerospace Medicine and Human Performance* has generated quite some interest.[1] Two Letters to the Editor have been received and published, including the one that appears here.[2,3]

As the Editor-in-Chief, I wanted to make a few comments about the process that the article and the two subsequent letters to the editor represent. In essence, the entire point of scientific publication is encapsulated in this. Researchers present the results of their experimental method and the conclusions they've drawn from them in a published article for the wider scientific community to see. Other researchers with different perspectives or experiences can then engage in a critique of that work via the journal's Letter to the Editor process. Each letter is sent to the original authors for their comment, and we always publish the two side-by-side for the benefit of the wider readership.

The beauty of this process is that it fosters academic discussion and debate, which can then generate subsequent experiments taking into account all of the issues raised, which should get nearer to the true answer posed by the original research question. Historically, this has been the entire point of scientific publication: to generate discussion and discourse, highlight design and methodological limitations, challenge conclusions drawn, encourage the design of comprehensive, rigorous follow-on experiments, and ultimately move the body of scientific knowledge and understanding forward.

Richard Feynman, the 1965 Nobel Laureate in Physics, once said, "Scientific knowledge is a body of statements of varying degrees of certainty—some most unsure, some nearly sure, none *absolutely* certain."[4] Out of this uncertainty comes opportunity. The scientific method involves replicating others' studies or finetuning them to compensate for any limitations identified by the original authors or others. No single paper in general represents the sum total of evidence. Indeed, there are exceedingly few instances where a single paper on a topic is the first and last word on any particular matter. Rather, the full understanding of a topic evolves over time, due to continued research and experimentation. Scientific discovery and understanding is an iterative process.

As Editor-in-Chief, I encourage every reader to critically review the articles that we publish. In stimulating debate and discussion, our journal will continue to thrive and the field of aerospace medicine will continue to move forward. That is in everyone's interests. In particular, I encourage any of you interested in the particular topic represented by the original article here and the subsequent letters to the editor to think about how to design an experiment that adequately addresses the question and takes into account the limitations discussed. The results of such experiments are likely to further our understanding on this topic. This is the process by which we move closer to full understanding of any scientific topic, and particularly so in the aerospace medicine field with all its inherent complexities.

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