



A novel personal protective equipment for filovirus outbreaks: a usability study under simulated field conditions

*Esther Sterk¹, Birgit Schramm², Eugenia Riccio¹, Martin Gabut¹, Luca Fontana³, Michel André Rochat⁴, Gregoire Castella⁴, Iza Ciglenecki¹, Iona Crumley¹, **Claire Dorion**¹

¹Médecins Sans Frontières (MSF), Geneva, Switzerland; ²Epicentre, Paris, France; ³World Health Organization, Geneva, Switzerland; ⁴École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

*claire.dorion@geneva.msf.org

Introduction

The 2014 West Africa Ebola outbreak underlined inadequacies of current personal protective equipment (PPE), such as being uncomfortable and hot, causing excessive sweating and rapid exhaustion, and limiting interactions between health workers and patients. The smartPPE development project responded to the urgent need for a more comfortable, simpler, and sustainable PPE solution for filovirus-outbreak front-line workers. A one-piece, reusable smartPPE with ventilation system was developed to address these challenges. We assessed ease-of-use, comfort, functionality, and perceived doffing-safety of the smartPPE prototype compared with currently used PPE (current-PPE) under simulated field conditions.

Methods

In June 2023, we conducted a mixed-methods crossover usability study in a controlled high-heat/high-humidity indoor site in Brindisi, Italy. Ten test users (three female, seven with filovirus-front-line experience) assessed smartPPE and current-PPE in four guided sessions covering donning, (emergency) doffing, clinical tasks, and heavy physical WATSAN activities. User feedback was collected through structured questionnaires. Temperature, humidity, session duration, and vital signs were measured, and perceived exertion was assessed using Borg-scores (scale 6–20).

Ethics

This study was approved by the MSF Ethics Review Board.

Results

Median temperature and humidity were higher inside current-PPE than inside smartPPE (difference: 2.3°C [IQR 1.8–3.0] and 12.6 percentage points [8.8–19.6], respectively). Users endured heavy work sessions for significantly longer in smartPPE than in current-PPE (80.0 min [IQR 75–84] vs 49.5 min [45–56]). Median increases in body temperature (1.1°C [IQR 0.7–1.6] vs 0.7°C [0.3–0.9]; $p < 0.001$) and respiratory rate (3.5 rpm [1–5] vs 1.5 rpm [0–3]; $p = 0.034$), and reductions in O₂ saturation (–2% [–5 to –1] vs –1.5% [–3 to 0]; $p = 0.027$) were higher with current-PPE than with smartPPE. Peripheral vision was similarly rated, but hearing was compromised with smartPPE at ≥ 5 m. Median exertion-scores were lower for smartPPE (clinical tasks 8.5 [IQR 7–11] vs 15.5 [14–16] $p < 0.01$; heavy physical activities 14 [13–17] vs 18 [17–20] $p = 0.035$). All users preferred smartPPE for overall and thermal comfort, breathing, and doffing-safety; nine (90%) favoured it for non-verbal communication, eight (80%) for vision or longer-interval heavy WATSAN activities, six (60%) for longer-interval patient care, six (60%) for short-term clinical activities, and six (60%) for emergency doffing. Reported concerns were airflow obstruction while bending, hearing difficulties attributed to ventilation noise, and adjustments for headgear, ventilation, and suit fitting.

Conclusion

Test users confirmed the usability of smartPPE and favoured it, especially for doffing-safety, longer-interval clinical or physical work, and improved non-verbal interactions, whereas hearing was challenged by the ventilation. Adjustments are currently underway before design freeze. Stakeholder commitment will be crucial to ensure production at scale.

Conflicts of interest

All authors declare no competing interests.