

A New Age of Auscultation:
Novel Technology to Combat High-Consequence Pathogens

Mia J. Biondi¹, Aidan Nikiforuk², Todd Cutts², Robert Kozak¹, Steven Theriault² & James E. Strong¹

¹Special Pathogens Program, ²Applied Biosafety Research Program; National Microbiology Laboratory, Public Health Agency of Canada, 1015 Arlington Street, Winnipeg, Manitoba, R3E 3R2

Abstract

Background

Recent outbreaks of emerging diseases have brought to light challenges faced by the medical community in balancing safe, but effective care. One such challenge identified by clinicians during the 2014 Ebola outbreak in West Africa, was the inability to use a stethoscope to auscultate due to exposure risk. With several imported cases treated in the US and Europe, there was a need to develop novel alternatives for auscultation. In one instance, the 3M Littmann 3200 was used to record sound clips, followed by wireless transmission to a team station outside the isolation room. Unfortunately, this method is time-consuming, only records short segments, and does not afford the bedside clinician the ability to auscultate based on assessment findings. We sought to investigate technological alternatives to both the traditional stethoscope and the Littmann 3200 for use in high-containment settings.

Methods

We evaluated the ease of use and sound quality of the ThinkLabs One digital stethoscope with a Bluetooth transmitter and wireless headphones. This set-up allows the nurse to listen in real-time, as well as record, for clinicians to review outside the isolation room. The assessing nurse recorded systems sounds in the absence of personal protective equipment (PPE), with the use of a PAPR, and in a pressurized suit (used in Containment Level 4). Recorded sounds were then blindly assessed by clinicians of differing backgrounds including Nurse Practitioners and physicians with specialty training. We also assessed the sound quality when using the stethoscope within multiple protective layers (Ziploc bags), such that the stethoscope could be used for several patients within an Ebola treatment unit without being exposed to the virus.

To evaluate whether we would be able to re-use the ThinkLabs after decontamination, we treated with clinically relevant pathogens, more resistant to decontamination than Ebola (Mycobacterium, MRSA). Several aerosol-based methods were used, followed by functional tests on the stethoscope.

Conclusions

Our work determined that the sound quality of the ThinkLabs is on par with, if not superior to, the Littmann 3200. Additionally, we demonstrate that the ambient noise of the PAPR or CL4 suit has little effect on the quality of recorded sounds. In order to translate this device to the field, we needed to find a way to use the stethoscope for multiple patients without risking transfer. We show that the addition of up to ten Ziploc bags has little to no affect on sound quality. Finally, after testing aerosol-based methods for decontamination and assessing functionality post-aerosol, we show that these gases do not erode circuitry, and therefore the ThinkLabs can be used repeatedly. Our findings demonstrate that the ThinkLabs One Digital Stethoscope allows for adequate auscultation, without compromising safety, and could be an option for healthcare organizations to consider during emergency preparedness planning.

Experimental Design

Stethoscope Selection Validation



Results

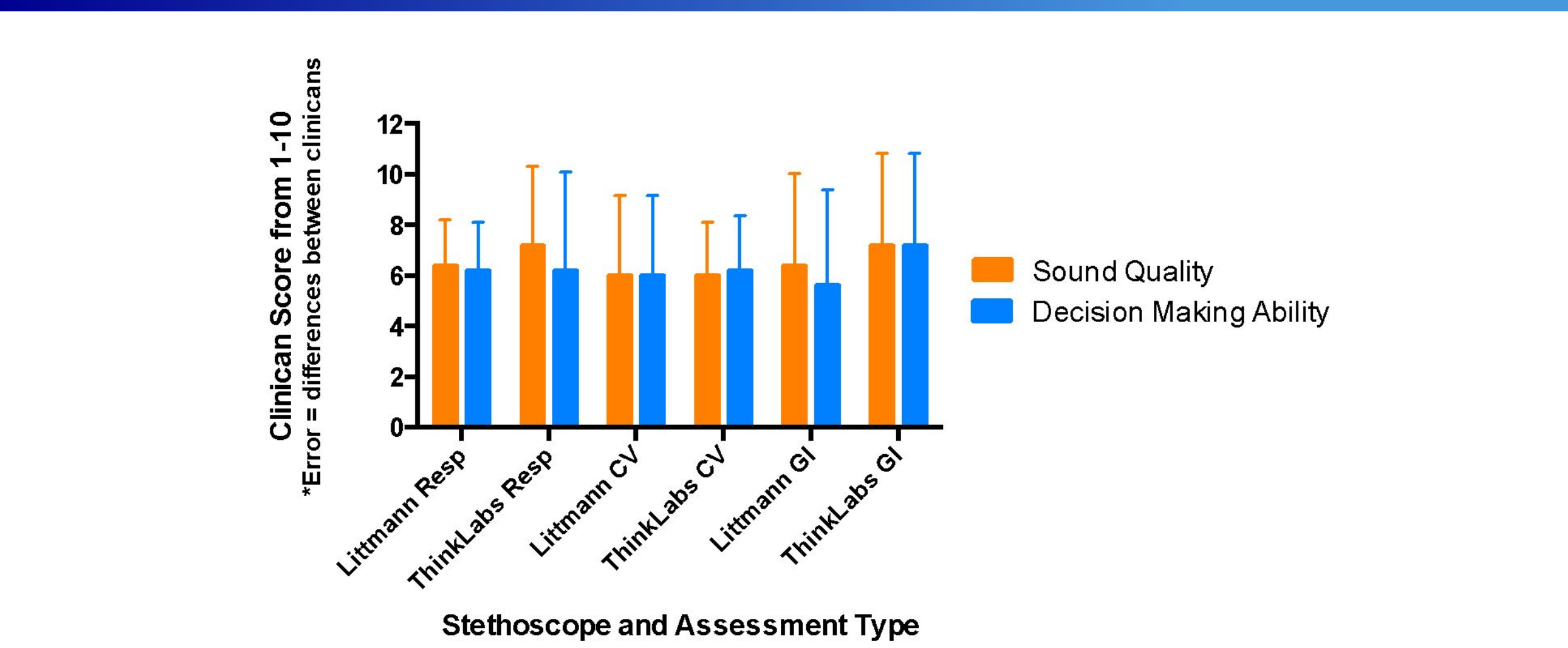


Figure 1. Mean scoring for system assessments comparing the 3M Littmann 3200 to the ThinkLabs One digital stethoscope.

Normalized Comparison of Sound Quality in Various PPE

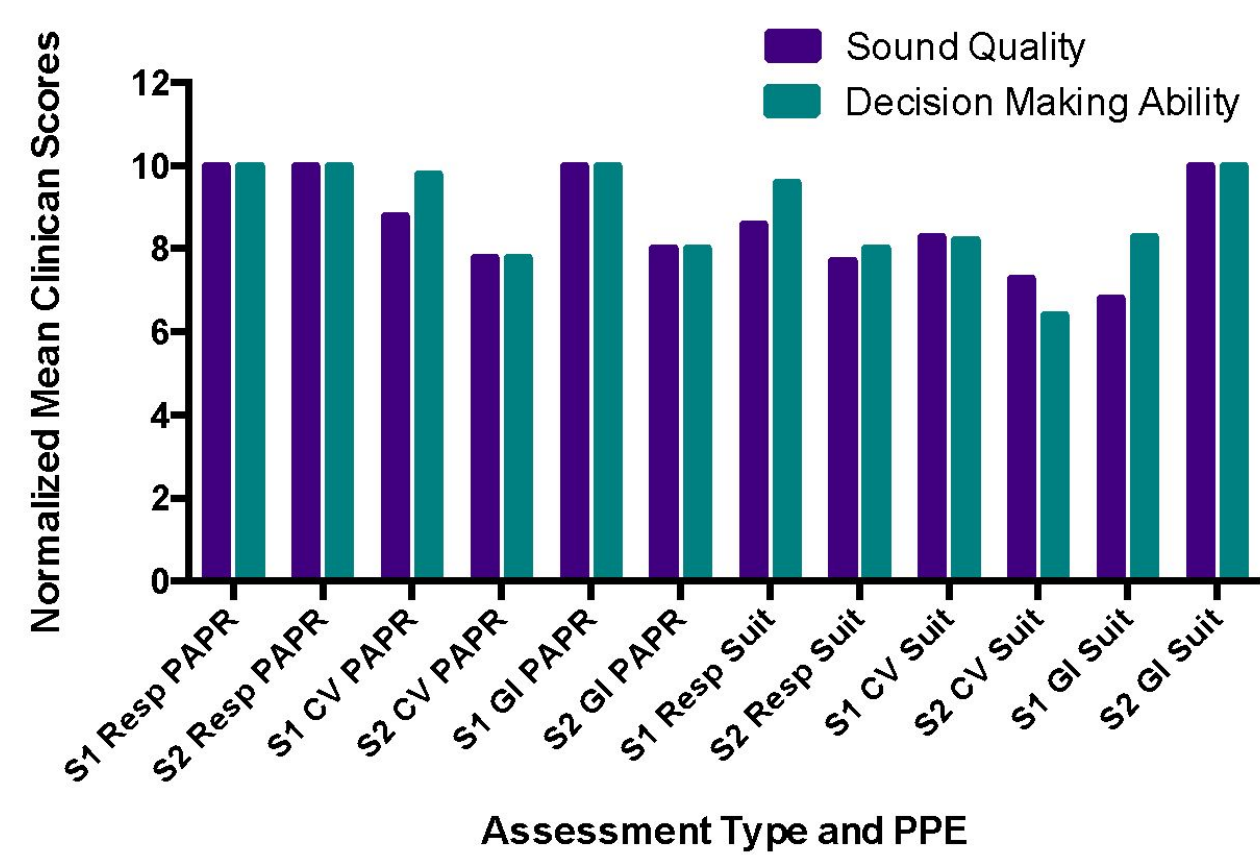


Figure 2. Normalized mean scoring for systems assessments in a PAPR and CL4 suit on subject 1 (S1) and 2 (S2). Normalization was completed for each evaluator's scores per assessment type, individually for each subject. Therefore a 10.0 indicates the same score as the absence of PPE.

Table 1. Mean sound quality scores for Resp, CV, and GI, with the ThinkLabs One in varying number of layers (Ziplocs).

Protective Layers	Resp	CV	GI
10	8.6	7.6	7.4
9	7.4	8.4	6.8
8	7.8	7.8	6.8
7	7.8	8.4	5.8
6	7.4	8.6	5.6
5	7.4	8.4	5.8
4	6.8	8.4	6.0
3	7.8	7.6	6.2
2	7.0	7.8	6.2
1	7.2	7.4	5.4
0	7.2	7.8	5.0

Decontamination of the ThinkLabs One

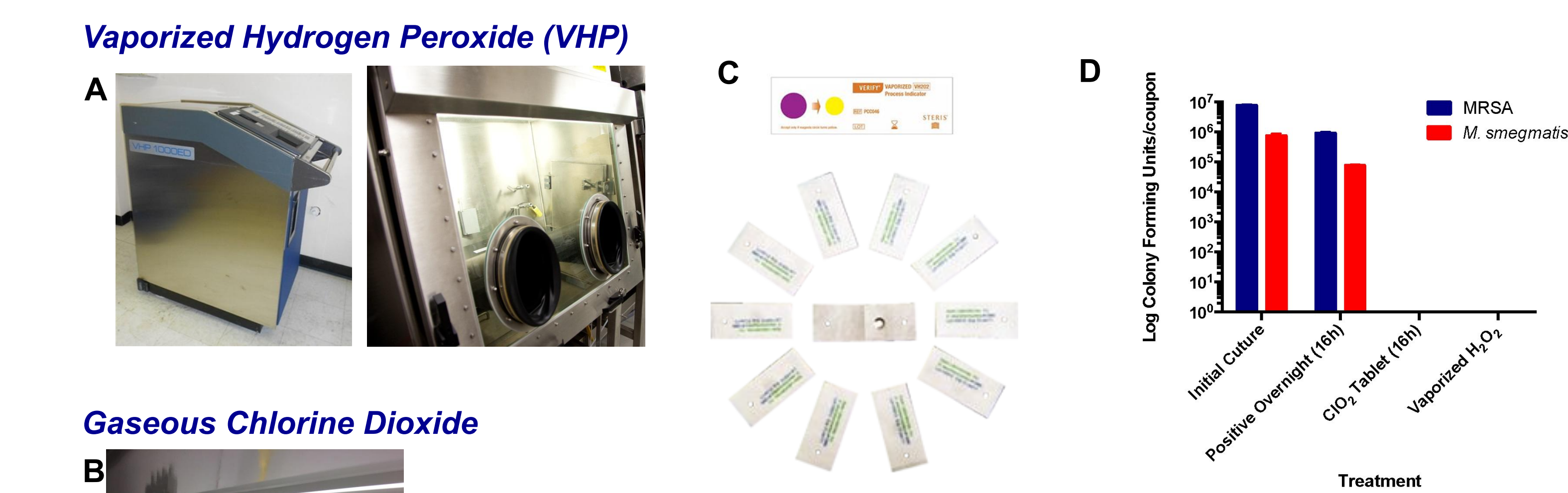


Figure 3. The ThinkLabs One was placed in a Class III cabinet with contaminated disk. A) VHP was generated by the Steris VHP 1000 ED for four hours and vented overnight. B) A 5g Chlorine Dioxide tablet was dissolved in sterile water placed into disposable container, after which the lid was removed inside cabinet overnight at ambient temperature. C) and D) Cabinet indicators for pathogens were negative indicating sterilization. Both stethoscopes were tested on a healthy adult, with no difference in sound quality (data not shown).

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