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Brief report

Pilot evaluation of a ward-based automated hand hygiene training system

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A novel artificial intelligence (AI) system (SureWash; GLANTA, Dublin, Ireland) was placed on a ward with 45 staff members for two 6-day periods to automatically assess hand hygiene technique and the potential effectiveness of the automated training system. Two human reviewers assessed videos from 50 hand hygiene events with an interrater reliability (IIR) of 88% (44/50). The IIR was 88% (44/50) for the human reviewers and 80% (40/50) for the software. This study also investigated the poses missed and the impact of feedback on participation (+113%), duration (+11%), and technique (+2.23%). Our findings showed significant correlation between the human raters and the computer, demonstrating for the first time in a clinical setting the potential use of this type of AI technology in hand hygiene training.

The World Health Organization (WHO) guidelines on the effective decontamination of hands of health care workers (HCWs) recommend a 6-pose hand hygiene technique for hand hygiene with either alcohol-based hand rub or handwashing.[1] The need for, and benefits of, hand hygiene technique training and compliance assessment have been identified.[2-4] However, training in hand hygiene requires individual instruction, assessment, and feedback, the provision of which is often logistically challenging. The aim of the pilot study was to assess the suitability of an automated hand hygiene training system.

METHODS

A computer cart fitted with the SureWash system (GLANTA, Dublin, Ireland) automatically measured compliance with the WHO hand hygiene protocol for alcohol-based hand rub and provided training feedback in real time (Fig 1A). The artificial intelligence (AI) software compared the user's hand movements with a database containing examples identified by members of the research team. To pass each pose, the user needed to achieve 1 second of correct technique, or 1 second for each part in a pose with left and right parts.

The HCW using the system sees a live video of her hands on the screen. If feedback is being provided, she also sees a "traffic light" indicator for each pose of the WHO protocol (Fig 1B); the indicator turns from red to green when the software has verified the technique and duration for each pose. Where a pose has a left part and a right part, half of the indicator light changes color as each part is completed. The HCW has a maximum of 90 seconds to complete the protocol. At the end of a session, either by completing all of the poses or by reaching the 90-second limit, a final result is presented with a "pass" or "fail" grade and the time taken to complete the hand hygiene event.

Our evaluation used a quasi-experiment interrupted times series design in 2 phases of 6 days each on a clinical ward with 45 HCWs. In phase 1, a baseline was established by recording videos of hand hygiene events with no feedback provided to the HCWs. In phase 2, on-screen feedback was provided to the HCWs. Ethics approval for the study required that HCW participation be both voluntary and anonymous; consequently, the camera view was restricted to only the hands of the HCW.

Two researchers who were blinded to the study reviewed the videos of each hand hygiene event. If a HCW missed a pose or used incorrect technique, the hand hygiene event was judged a "fail."

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Conflict of interest: H.H. has recent research collaborations with Steris Corporation, Inov8 Science, Pfizer, and Cepheid, and has also recently received lecture and other fees from Novartis, AstraZeneca, and Astellas. G.L. is a director of GLANTA Ltd.

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Fig 1. (A) The SureWash system uses a camera at the top of the system to capture video of the user's hands, which are displayed live on the screen. The tray area prevents the camera from seeing anything that could personally identify the user. (B) The on-screen feedback shows the WHO poses in images 1-6. The green and read indicators alert the user when the pose has been completed successfully.

Interrater reliability (IIR) was assessed based on the percentage of agreement, and Krippendorff's alpha (Kα) was calculated using ReCal software.[5] Jackknife resampling[6] was used to ensure stability of the pass rate comparison in our small sample set. The nonparametric Wilcoxon rank-sum test was used to determine statistical significance between the pass rates. The jackknife resampling and Wilcoxon rank-sum test results were calculated using Matlab (Mathworks, Natick, MA).

RESULTS

The IIR agreement between each human reviewer and the computer was 88% (44 of 50), Kα = 0.74 and 80% (40 of 50), Kα = 0.56, respectively. The IIR agreement between human reviewers was 88% (44 of 50), Kα = 0.76. In phase 2, using the real-time on-screen feedback resulted in a 113% increase in participation (from 16 to 34). The pass rate for the hand hygiene events increased from 62.5% (95% confidence interval [CI], 62.8-62.2) in phase 1 to 64.7% (95% CI, 64.6-64.9) in phase 2, a small but statistically significant difference ($P < .005$ at 95% confidence). The time taken to complete the hand hygiene event increased from 47.4 seconds to 52.5 seconds between phase 1 and 2, but this difference was not statistically significant. The system also provided information on which poses were most frequently missed (pose 6, thumbs and pose 5, fingertips) and the average time spent in each pose (Fig 2).

DISCUSSION

The Kα values in the pilot study showed substantial agreement ($\alpha = 0.61$-0.80)[7] and moderate agreement ($\alpha = 0.41$-0.60)[7] between each reviewer and the software, respectively. These initial results strongly suggest that the SureWash software is capable of reliably measuring hand hygiene technique; however, studies with larger sample sizes are needed to verify this. Assessment of the videos required significant concentration by the reviewers, who found that after 20 minutes, fatigue significantly compromised accuracy. Consequently, very large sample sizes and perfect agreement are very unlikely with human reviewers.

The pilot study was set in a busy clinical ward, and participation was voluntary. In this context, the 113% increase in participation in phase 2 demonstrates the positive impact of real-time feedback. This is similar to the reported impact of feedback in other studies.[8,9] We feel that selection bias and the Hawthorne effect affected the pass rates in both phases of the study, 62.5% and 64.7%, respectively, which are higher than those reported in other studies.[4] The additional information on pose failures and time spent in poses can be used to guide follow-up training and communication to HCWs.

This is the first study to use automated image analysis for hand hygiene quality assessment in a clinical setting. Despite the study's small size, our findings suggest that video analysis is a powerful and scalable new technology for hand hygiene training that will reduce the associated workload on Infection Control teams. Future studies will involve larger cohorts and will address the self-selection issue by tracking individual progress.

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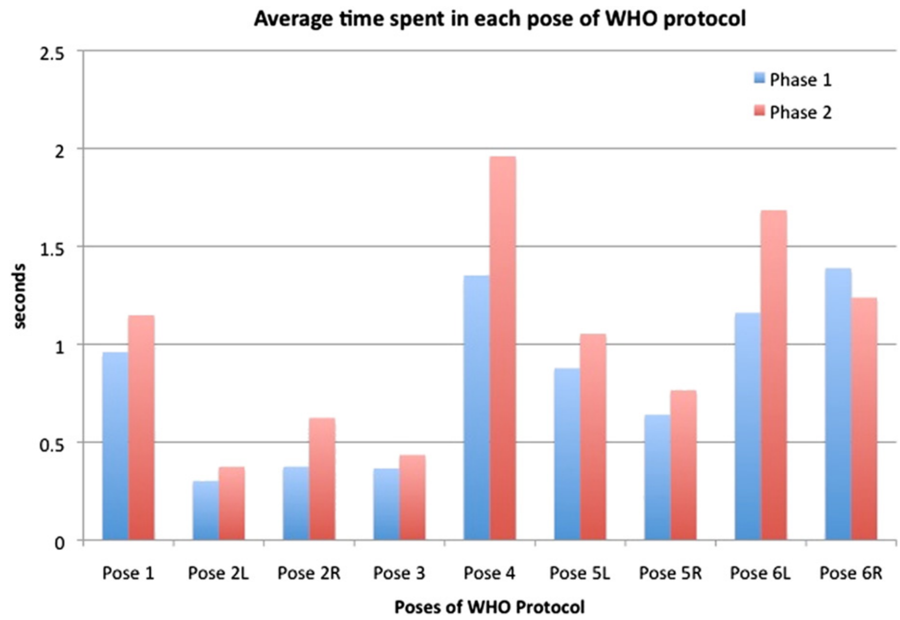

Fig 2. Bar chart showing the average time spent by HCWs between each pose of the WHO hand hygiene protocol in each of the 2 study phases. Pose 1: palm to palm; pose 2 (left and right): rub palm over dorsum with fingers interlaced; pose 3 (left and right): rub palm to palm with fingers interlaced; pose 4 (left and right): rub backs of the fingers onto opposing palm with fingers interlocked; pose 5 (left and right): rub finger tips on opposing palm; pose 6 (left and right): rotate thumb while clasped in palm.

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