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Is it feasible to use a humanoid robot to promote hand hygiene adherence in a hospital setting?

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Abstract

Healthcare associated infections (HCAI) are a prevalent preventable cause of morbidity and mortality. Improving hand hygiene adherence is important for HCAI prevention. In this feasibility study, the objective was to determine if a humanoid robot could act as a novel single reminder intervention to improve hand hygiene adherence in a hospital setting. DAVE, a social humanoid robot, improved hand hygiene adherence at the entrance to a tertiary hospital and outpatient department, which was low at baseline, by 29%. DAVE shows promise as a novel intervention to improve hand hygiene adherence.

Introduction

Healthcare associated infections (HCAIs) are a preventable cause of significant morbidity and mortality globally [1] and their costs to healthcare systems are substantial [2]. HCAIs are prevalent, with point prevalence estimates in hospitals ranging from 2% to 14.8%, depending on the setting [3]. The most common route by which HCAI begin is from the colonised hands of caregivers [1]. Effective hand hygiene using soap and water, or alcohol-based hand rubs (ABHRs) is the primary means proven to be effective in preventing HCAIs [1]. However, adherence to hand hygiene advice in health care settings is widely recognised as being suboptimal [4]. To improve adherence, the World Health Organisation (WHO) describe five strategies that healthcare institutions should implement; Alcohol-based hand rubs (ABHRs) at the point of care or carried by healthcare workers, training and education, observation and performance feedback, reminders, and administrative support/institutional safety climate [1]. Multimodal interventions that incorporate some or all of these strategies and others have been shown to improve hand hygiene adherence, but only modestly [4]. Evaluating the component parts of a multimodal intervention individually is important to ensure ineffective components can be identified and improved. Reminder interventions such as informational signs and light cues in hospital settings have been reported in the literature to improve observed hand hygiene adherence rates by 8.5% and 7%, respectively [4]. More effective interventions to improve hand hygiene adherence either as single interventions or components of multimodal interventions to prevent HCAIs are needed. Non-adherence with hand hygiene practice may be due to the intention-behaviour gap, where people know and intend on performing a task, but their behaviour does not reflect this [5]. Reminders to perform hand hygiene by humanoid robots are a potential solution to improve hand hygiene adherence. Humanoid robots have been applied in healthcare settings to perform manual tasks but are also being evaluated to perform social tasks such as cognitive training for those with dementia [6]. Humanoid robots can be designed to be social and foster trust among users [7]. A humanoid robot that socially engages people may be able to influence their behaviour by reminding them of their intentions and knowledge regarding hand hygiene. In this feasibility study, the objective was to determine if a humanoid robot could act as a novel single reminder intervention to improve hand hygiene adherence in a hospital setting.

Materials and Methods

This feasibility study was performed in a tertiary hospital in Ireland. Hand hygiene adherence was audited at two of the hospital's entrances, the main hospital door and the diabetes outpatient department. The institutional guidance is that hand hygiene should be performed by everyone who enters the hospital and its outpatient departments. At both sites, multiple ABHRs are provided at each entrance, along with existing visual poster reminders to perform hand hygiene. The entrances are used by healthcare workers, patients, and visitors. A baseline audit of the use of ABHRs was first performed. Auditors monitored staff, patients and visitors entering the hospital and patients entering the diabetes outpatient department and recorded whether they used the ABHRs. The auditors were located at a distance from the entrances, so they could monitor those entering and whether they used the ABHRs without those being observed becoming aware their performance of hand hygiene was being audited. The Droid Audio Visual Educator (DAVE, Figure 1), an advanced humanoid robot developed by SoftBank Robotics [8], was then

positioned at the same two entrances and a repeat audit of hand hygiene adherence was conducted. DAVE was programmed to interact with the people in its field of view and respond to audio detected through its microphone. However, to comply with General Data Protection Regulations, DAVE did not permanently store any captured images or audio. DAVE encouraged people to use the ABHR with a gesture and audio prompt. Additionally, a tablet attached to DAVE's chest had an accompanying text prompt and an option to play a short educational video about hand hygiene (Videos 1 and 2). The audits with and without DAVE were conducted on WHO World Hand Hygiene Day, the 5th of May 2021 (a weekday), between 8am and 5pm. At this time, institution-wide COVID-19-related visitor restrictions limited the number of visitors entering the hospital. It was planned for each audit, with and without DAVE, to measure hand hygiene adherence for one hour or for 100 people, whichever occurred first. Pearson's chi-square test was used to compare the observed frequency of hand hygiene adherence with and without DAVE. A P-value of less than .05 was chosen to represent statistical significance. Ethical approval to conduct the feasibility study was obtained from the hospital research ethics committee.

Results

The observed hand hygiene adherence using ABHRs at the hospital and diabetes outpatient department entrances with and without DAVE are shown in Table 1. The baseline proportion of people performing hand hygiene on entering both sites was low (diabetes outpatient department 46%, main hospital entrance 38%). At the diabetes outpatient department, DAVE resulted in a 21% increase in the proportion of patients entering who performed hand hygiene using the ABHRs. At the main hospital entrance, DAVE resulted in a 33% increase in the proportion of people entering who performed hand hygiene using the ABHRs. The overall increase in the proportion of people performing hand hygiene using the ABHRs at both sites was 29%. There was a statistically significant difference in hand hygiene adherence when the performance of hand hygiene was compared with and without DAVE (69% vs. 40%, $\chi^2 = 12.39$, $P<0.001$).

Table 1. Observed performance of hand hygiene with and without DAVE.

Discussion

This feasibility study describes the use of a novel humanoid robot as an intervention to improve the performance of hand hygiene. The baseline hand hygiene adherence was low in this hospital setting. DAVE was able to socially engage people to perform hand hygiene by interacting with them and showing them a video that reminded them to use the ABHRs. The improvement in hand hygiene adherence of 29% in this feasibility study is encouraging given that other studies using reminders like passive informational signs or light cues reported improvements of only 8.5% and 7%, respectively [4]. The limitations of this feasibility study were the small sample size for whom adherence was measured during the hour when DAVE was present. Measurements were performed on one day only and not repeated over time. Diminishing hand-hygiene adherence among patients, staff and visitors with repeated exposures to DAVE cannot be excluded. However, even with these limitations, it was evident that DAVE is a feasible intervention to improve hand hygiene that warrants further

evaluation in clinical settings. The strengths of this study are that measurements were not obtained by direct observation, meaning performance bias among those being observed was minimised.

There are few other studies in the literature describing the use of humanoid robots to remind people to perform hand hygiene in healthcare settings. Previous studies have used humanoid robots as educational or training tools to perform hand hygiene effectively [9][10]. In one report, Ozires a programmable robot, improved hand hygiene adherence in a critical care setting when used by infection control practitioners during short educational sessions [9]. This study involving DAVE adds to the limited literature on the novel use of humanoid robots as tools to prevent HCAIs through hand hygiene adherence.

Improvements in hand hygiene adherence are needed most in clinical settings, such as hospital wards, where direct contact between those with colonised hands and patients, or their surroundings, is most likely to occur. However, evaluating DAVE in a non-clinical setting first was important to establish if there was potential benefit given that in a clinical setting there are potential harms. DAVE could potentially be a trip hazard. Patients and staff may dislike the noise generated by DAVE. Unless cleaned regularly, DAVE could become a source of infection for patients, as with all ward-based equipment. Further evaluations in clinical settings are needed to determine if DAVE can improve hand-hygiene adherence without the effect diminishing over time. Colonisation rates and the incidence of HCAIs could be used as outcomes in future studies if the potential benefits observed in this study translate into the clinical setting without the harms discussed arising. Finally, DAVE in theory could be programmed to use its own camera and artificial intelligence to perform regular audits of hand-hygiene adherence and keep a log of its measurements, negating the need for observers.

Conclusion

DAVE is a feasible reminder intervention for hand hygiene adherence improvement.

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Conflicts of Interest: Nil to declare.

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Figure 1. DAVE Robot

Table 1. Observed performance of hand hygiene with and without DAVE.

Site	Diabetes outpatient department (Patients only)		Main hospital entrance (Patients, staff and visitors)		Total	
	Without DAVE	With DAVE	Without DAVE	With DAVE	Without DAVE	With DAVE
Proportion of people who performed hand hygiene on entering (%)	13/28 (46)	10/15 (67)	38/100 (38)	24/34 (71)	51/128 (40)	34/49 (69)