# In The Wild Study with "WallBo" - A Robotic Handwashing Buddy with School Children During a Pandemic

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In this paper we present a potentially impactful use-case using our social robotic platform- "WallBo" a robotic buddy to improve handwashing for children in schools. We report our initial results from the first in-the-wild one-week study in a Scottish school with 16 pupils. The 1:1 interaction with WallBo resulted in 86.25% handwashing compliance, a 33.25% improvement from the baseline handwashing technique pre-WallBo training. We have also highlighted some challenges we faced carrying out a real-life study during COVID-19 pandemic.

CCS Concepts: • **Human-centered computing** → **Empirical studies in interaction design**; **User interface design**.

Additional Key Words and Phrases: Child-robot interaction, handwashing, interaction design, COVID-19

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## 1 INTRODUCTION

Social robots have great potential to serve an impactful role during the COVID-19 pandemic. Some researchers have studied the impact of social robots with adults for example in clinical care areas, promoting physical distancing, and reducing the contagion rate etc [1]. In this paper we present a use-case for a social robot - "WallBo" that can act as a persuasive agent to effect positive change on children's handwashing behaviour. More recently, in the context of COVID-19, handwashing is regarded as one of the most effective measures to prevent the spread of the virus between/from children to the most vulnerable populations [2]. Existing practices for improving handwashing behaviour face three major challenges: **(i)** they are resource intensive, **(ii)** complex to measure/monitor compliance at scale, and **(iii)** children often lack interest/motivation and know-how to wash their hands regularly. Hence there is need for an interdisciplinary and innovative approach for influencing sustainable handwashing behaviour. We propose a **novel** method for hand hygiene intervention by developing a social robot "WallBo- handwashing Buddy" to improve handwashing compliance and measure its impact by systematic empirical studies. This paper presents initial findings from our first deployment of the "WallBo" robotic buddy to improve handwashing for children in a Scottish school and describe some challenges in carrying out such studies in schools under COVID-19 circumstances.


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## 2 BACKGROUND

Previous hand hygiene intervention programs mostly focus on educating people about health, germs and disease - often using tools such as games, videos, posters, leaflets and charts [3]. Evidence suggests the disruption of the physical and social setting where the handwashing behaviour should take place by placing eye-catching cues and visual reminders for children can lead to more successful interventions [4]. In essence, the intervention needs to be surprising, simple, attractive and engaging to children as its target users. Previous research in child-robot interaction has shown that robots in education could motivate children to learn better [5, 6]. A robot can tirelessly offer tutoring experiences that are on a equal with, and often exceed, the effectiveness of computer/screen-based tutoring systems [7].

Handwashing education and training in schools is an effective way of reaching children and teaching them the habit of handwashing at a young age [8]. This research builds on our previous pilot study (pre-COVID) where WallBo was deployed in a rural village school in India showed a **significant** 40% increase in handwashing compliance [9]. In this research, we investigated the impact on handwashing compliance on Scottish school children and other factors to be considered in future trials using "WallBo" during a pandemic.

## 3 STUDY DESIGN

The study was conducted in a primary school in an economically deprived area of Glasgow, UK. The school was selected by Glasgow city council. The class suitable for the intervention was decided by the headschool teacher looking at practical arrangements and restrictive access for researchers due to COVID-19 pandemic. The study was carried out for one week (5 days, 22nd – 26th March 2021) under COVID-19 circumstances. This was a Wizard of Oz study (WoZ) where the researcher sitting in the same classroom could see the pupils at the solitary handwashing station and controlled the robot's behaviour. On Day 1 we recorded their baseline handwashing technique. WallBo was introduced on days 2-4 when 1:1 sessions were conducted with the pupils while handwashing. The researchers had to improvise during the study and could not introduce a control condition as they were given access to only one classroom where everybody could see what the robot was doing.

### 3.1 Participants

The school enrolls children primarily from immigrant families from south Asian and Romanian ethnic minorities. The study was carried out P3 (Primary 3) class with 16 pupils aged 6-7 years (12 Boys, 4 girls). All parents provided written informed consent for their child to be video recorded. The study was approved by the ethics committee at the University of Glasgow (approval number 200200012), Glasgow City Council Educational Services ethics committee, and the school authorities. All participants were provided random IDs and no personal identifications were collected.

### 3.2 WallBo- Robotic platform

The WallBo robotic platform has been designed and created by researcher Dr Amol Deshmukh at the University of Glasgow as a **low-cost**, **portable** platform for encouraging handwashing for children in schools [10]. WallBo is designed with a hand shaped to elicit a symbolic meaning relevant to handwashing. As evidence shows childlike voices to be most effective in child-robot interaction studies [11], this is what we incorporated into our speech design. WallBo displayed the 10 steps of handwashing on the small screen and verbally communicated the 10 steps of handwashing and the pupils were following WallBo's instructions at the handwashing station in the classroom (See Fig. 1 Left).

Fig. 1. WallBo giving 1:1 instructions to the pupil near handwashing station about 10 steps of handwashing (left), WallBo (right)

### 3.3 Data collection

Data was collected in the form of videos of handwashing on Day 1 (Baseline, no WallBo) and Days 2-4 (During 1:1 intervention with WallBo). The video data was collected using a camera trap positioned on top of handwashing station (see Fig. 1 for illustration of the setup). The handwashing data was scored based on the number of handwashing steps completed, see Appendix Fig. 3.

## 4 RESULTS AND DISCUSSION

### 4.1 Handwashing Compliance

We measured the 10 handwashing steps based on WHO handwashing technique (See Appendix Fig. 3) [12]. Each handwashing video was given a score from 1-10 (one point for each of the handwashing step completed).

*4.1.1 Pre-WallBo Handwashing compliance.* We scored the handwashing technique from videos gathered from Day 1 (baseline, pre-WallBo training). We analysed 62 handwashing occurrences and observed only a mere 53% handwashing compliance, with most pupils not performing steps 4-8. However, this result needs to be treated with caution as the children had access to only one handwashing station in the classroom and were rushed to wash their hands quickly due the queue before going out/coming in the classroom during breaks. Due to COVID-19 children are made to wash their hands 4-5 times a day.

*4.1.2 WallBo 1:1 session.* Each of the 16 pupils during 1:1 handwashing session with WallBo (See Fig. 1) were independently analysed. Each session was about a 1 minute long. The measurements were carried out two times to reduce human error, **(i)** on-line by the researcher observing near the handwashing on a score sheet and **(ii)** off-line by watching/scoring the videos of the recorded session. The error rate was 12% between the on-line and off-line video analysis. We report the more accurate video analysis results here. We observed an average of **86.25% handwashing compliance** on all the 10 steps carried out, with (25%) n=4 pupils getting a perfect 10/10. All pupils completed steps 1, 2, 9, and 10, however, some pupils struggling a little with Step 7: Rubbing the tips of your fingers on the palm (56.25% compliance) and Step 8: Cleaning wrists (68.75% compliance) may be due to lack of motor skills due to their young age given they are slightly complex steps to perform (See Fig. 2). This result also coincides with the study by Öncü et al. where the most missed areas when washing hands in children were fingertips and palmar surfaces [13]. Perhaps a better/clearer demonstration and repetition for steps 7 and 8 can help to aid pupils to develop their motor skills and complete these steps better.

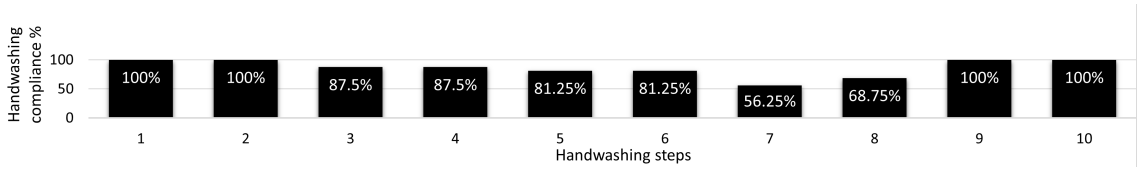


Fig. 2. During 1:1 with WallBo: Handwashing Compliance Graph, N=16

## 5 LIMITATIONS AND FUTURE WORK

The study was conducted under severe COVID-19 restrictions and the 2 researchers were only allowed access to one classroom, where they were required to adhere to strict social distancing protocols. We acknowledge the small number of participants and gender imbalance for this study, and in the future trials we are aiming to study a greater number of pupils if feasible due to COVID-19.

We also acknowledge several uncontrollable confounds that arose due to the real-world setting of this study [14, 15], such as the fact that classes were running in parallel in the same classroom where the handwashing station is located. Furthermore, the presence of researchers during the intervention might have influenced the results and for the next trials we will attempt deploy WallBo autonomously at most times and record the interactions using camera traps to analyse the results off-line. From this trial we cannot say conclusively if the pupils still carried out the 10 handwashing steps learned in their normal handwashing routines and if the handwashing compliance sustained and we will investigate these factors in the next trial, however the initial results seem promising.

We are working towards developing the autonomous technology for accurately recognising the steps of handwashing using computer vision (deep learning techniques) and automatic prompting of behaviours from WallBo during handwashing. We also plan to refine the next trial with 1:1 handwashing sessions pre/during/post interactions with WallBo to determine the changes to handwashing compliance more accurately and understand how these change over a longer-term period of 2 weeks (in order to measure sustainability and novelty effects [16] of the intervention). We shall also investigate with control condition how verbal (handwashing step-by-step instructions) Vs non-verbal actions (handwashing steps displayed on the screen) from WallBo influences handwashing compliance.

## 6 CONCLUSION

In this pilot study we presented preliminary results from handwashing compliance pre/during WallBo intervention. We observed an overall **86.25% handwashing compliance** during 1:1 session with WallBo (N=16) a **33.25% improvement** from the baseline handwashing technique pre-WallBo training. WallBo has a great potential to serve a supportive role in large scale health interventions as an agent of positive handwashing behaviour change and a promising use-case for social robots in the context COVID-19 pandemic and beyond.

## 7 ACKNOWLEDGEMENTS

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## A TABLE 1 - HANDWASHING KNOWLEDGE QUESTIONS

| | **Question** | **Add-on (for clarification needed)** |
|---|---|---|
| 1 | What is the best way of getting rid of germs from our hands? | What are your favourite parts? |
| 2 | When should we wash our hands? | |
| 3 | When you wash your hands, what do you do? What steps do you take? | |
| 4 | Why do you use soap? What does soap do? | |
| 5 | Do you like washing your hands, or do you not like washing your hands | |
| 6 | Do you remember who taught you how to wash your hands? | What person told you how? |

## B 10 STEPS OF HANDWASHING

**Figure 3: 10 handwashing steps**


| 10 Handwashing steps verbal instructions from WallBo |
|---|
| 1. Turn on the water and wet your hands with warm water |
| 2. Put soap onto your hands |
| 3. Rub your hands together. |
| 4. Use one hand to rub the back of the other hand and clean in between the fingers. Do the same with the other hand |
| 5. Rub your hands together and clean in between your fingers. |
| 6. Rub your thumb using your other hand. Do the same with the other thumb. |
| 7. Rub the tips of your fingers on the palm of your other hand. Do the same with the other hand. |
| 8. Clean your wrists. |
| 9. Rinse your hands with water. |
| 10. Dry your hands completely with a disposable towel. |