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# Improved hand hygiene technique and compliance in healthcare workers using gaming technology

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## SUMMARY

**Background:** In 2009, the World Health Organization recommended the use of a 'multi-faceted, multi-modal hand hygiene strategy' (Five Moments for Hand Hygiene) to improve hand hygiene compliance among healthcare workers. As part of this initiative, a training programme was implemented using an automated gaming technology training and audit tool to educate staff on hand hygiene technique in an acute healthcare setting.

**Aim:** To determine whether using this automated training programme and audit tool as part of a multi-modal strategy would improve hand hygiene compliance and technique in an acute healthcare setting.

**Methods:** A time-series quasi-experimental design was chosen to measure compliance with the Five Moments for Hand Hygiene and handwashing technique. The study was performed from November 2009 to April 2012. An adenosine triphosphate monitoring system was used to measure handwashing technique, and SureWash (Glanta Ltd, Dublin, Ireland), an automated auditing and training unit, was used to provide assistance with staff training and education.

**Findings:** Hand hygiene technique and compliance improved significantly over the study period ( $P < 0.0001$ ).

**Conclusion:** Incorporation of new automated teaching technology into a hand hygiene programme can encourage staff participation in learning, and ultimately improve hand hygiene compliance and technique in the acute healthcare setting.

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## Introduction

Although Semmelweis discovered the link between unwashed hands and hospital-acquired infections in the 1800s,<sup>1</sup> the healthcare profession still struggles with hand hygiene compliance in the 21st Century.<sup>2,3</sup>

In 2009, the World Health Organization (WHO) recommended the use of a 'multi-faceted, multi-modal hand hygiene

strategy' (Five Moments for Hand Hygiene) to improve hand hygiene compliance among healthcare staff. It provided a strategy to assist with hand hygiene, recommending interventions such as healthcare worker (HCW) training and education, monitoring of alcohol hand rub usage, auditing of hand hygiene practices with feedback, reminders in the work place, and increased availability of handwash sinks and alcohol-based hand rubs at point of care. The importance of cultivating an environment where senior management support a culture of patient safety was also stressed.

This paper describes the use of automated teaching technology (SureWash, Glanta Ltd, Dublin, Ireland) combined with adenosine triphosphate (ATP) as part of a multi-modal

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approach to educate all grades of HCWs on hand hygiene technique and compliance.

## Literature review

Healthcare-associated infections (HCIs) remain a concern in Europe and worldwide.<sup>4</sup> It is also an accepted fact internationally that hand hygiene is linked to prevention of HCIs,<sup>1,5–7</sup> and is the most effective intervention to reduce infection rates.<sup>8–10</sup> However, HCWs' compliance with hand hygiene is still far from perfect.<sup>2,11</sup>

A Cochrane review of the evidence relating to those interventions found to be most effective was undertaken by Gould *et al.*<sup>12</sup> They found a dearth of evidence regarding the best methods to employ due to the poor design of the majority of published papers. However, others have argued that research demonstrates that practice improves when staff are educated and audited, with feedback provided.<sup>10,13</sup> It is evident that levels of hand hygiene decrease once interventions cease.<sup>3,11,12</sup>

Numerous research papers have attempted to explain why people do not wash their hands.<sup>12,14–17</sup> The unanswered question remains, what can be done to ensure that HCWs are convinced once and for all that 'clean hands save lives'?<sup>12,16,17</sup>

There is agreement among behavioural researchers that an individual's experience of an effect from not washing their hands is of greater importance than formal education in improving hand hygiene behaviour.<sup>17,18</sup> This would imply that HCWs need to personally experience an effect from not washing their hands in order to ensure sustained practice change. Nicol *et al.* noted that HCWs themselves agreed that a personal experience or experimental learning was more powerful in changing their practice.<sup>18</sup> However, the Cochrane review by Gould *et al.* found that, in practice, HCWs are trained rather than educated in hand hygiene.<sup>12</sup>

The authors attempted to improve hand hygiene compliance in their acute care private hospital, and identified poor technique as a second issue. Unable to provide the individualized training needed to tackle this, ATP and gaming technology were used to capture the imagination of HCWs with the aim of improving both hand hygiene compliance and technique.

## Intervention

A baseline audit of HCWs' compliance with the Five Moments for Hand Hygiene<sup>10</sup> was carried out between November and December 2009.

In January 2011, a multi-faceted approach to hand hygiene<sup>3,10</sup> was implemented. This involved monthly hand hygiene audits of the Five Moments for Hand Hygiene, the design of new posters, increased supplies of alcohol hand rubs, and the use of ATP to demonstrate visually and numerically the level of contamination on the hands of staff in clinical areas. Commitment from management at the highest level was essential, and thus hand hygiene audit results were provided not just to ward and department managers, but also to the hospital executive team and board.

In early 2010, compliance with the Five Moments for Hand Hygiene improved to 58%, but this had decreased to 29% by the end of 2010. The audits also identified another issue, as ATP used to assess the level of hand contamination identified poor

handwashing technique. Visual observation of HCWs using alcohol hand rubs confirmed a similar problem. The individualized training and assessments needed to improve practice were not feasible within available resources. As such, SureWash, a mobile computer-based unit using gaming technology, was purchased. SureWash, a mobile stand-alone computer system, guides the user through the seven steps of hand hygiene,<sup>10</sup> demonstrating each position and allowing the user to practice. Next, it video audits the user as they move through all the steps, and provides them with an instant percentage score.

In February 2011, an advertising campaign about SureWash was carried out in the hospital through e-mails and general hospital mail. The unit was set up outside the staff canteen, and all those entering the canteen were encouraged to try it. Fob watches were provided as spot prizes. An information leaflet was designed and copies were left in the canteen, at nurses' stations, in staff meeting rooms etc.

The SureWash unit was deployed to each ward and department for periods of one week at a time. Once all departments had been reached, the unit was redeployed to each area. Over a 12-month period, it spent two weeks in each unit. All HCWs were asked to use the unit for hand hygiene training and to practice their handwashing technique. This training was in addition to the annual hand hygiene training provided to all HCWs by the infection prevention control (IPC) team.

Throughout the study period, random audits of HCWs' handwashing technique were undertaken using ATP to ascertain if any improvements in technique had occurred. Monthly hand hygiene audits continued. All patient areas of the hospital were included in the study, and all HCWs working in clinical areas were included. ATP testing was only carried out after handwashing with soap and water. Administration staff working in non-clinical areas such as consultant secretaries and office-based staff were not included.

## Methods

### Hand hygiene audits

The monthly hand hygiene audits of the Five Moments for Hand Hygiene were performed using an audit tool based on the WHO audit tool. Verbal feedback was provided directly to staff during the audits. Reports detailing results by HCWs' grade and department were provided monthly to each ward manager, hospital executive team and board. The audits were performed by IPC nurses who completed a recognized training course on the use of the audit tool. The course was designed to ensure that auditors nationally were using the tool accurately, and competence was only confirmed following reliability testing. There was no change in the auditing method or in the lead auditor for the duration of the study.

### Adenosine triphosphate

In conjunction with these audits, ATP was used in the clinical area during spot audits and also at regular intervals outside the staff canteen. HCWs were selected at random and asked to wash their hands with soap and water. Once the hands were completely dry, the swab was rubbed against the tips of each finger, in between each finger and then in an S-shape along the palm of one hand. The swab was then placed in the monitor and

the results recorded. An explanation of the score achieved was given and the results were discussed, highlighting improvements in technique to achieve cleaner hands and thus a better ATP result. Using ATP in this way personalized the results and increased the emotional impact of poor handwashing technique for HCWs.

The ATP monitoring system (Hygiene International, Watford, UK) chosen was SystemSURE Plus (Trafalgar Scientific, Leicester, UK) due to its ability to provide a zero baseline and its ease of use in the clinical setting. When ATP is brought into contact with the reagent in the Ultrasp testing device, light is emitted in direct proportion to the amount of ATP present. As ATP is the universal energy molecule found in all animal, plant, bacteria, yeast and mould cells, residues contain large amounts of ATP. After cleaning, all sources of ATP should be significantly reduced. Thus the higher the reading, the more contamination present. The manufacturer recommended a score <25 as a pass.

The ATP testing provided a physical measurement of the level of contamination on HCWs' hands after washing. The numerical score helped HCWs recognize the effect of poor technique. ATP was not used after application of alcohol hand rub as the alcohol in the rub reacts with the reagent, making the test inaccurate.

### Reminders

Posters displaying hand hygiene technique and information about the Five Moments for Hand Hygiene were placed at key locations throughout the hospital. These included above all handwash sinks, in all clinical rooms, at entry and exit points to wards and departments, and on the back of toilet doors in all staff and public toilets.

### Alcohol hand rubs

Alcohol hand rubs were already located at the entry and exit points to all wards. As part of the intervention, these units were also placed at the end of all patient beds and on portable blood pressure monitoring devices following feedback from staff.

### Measurement of impact of interventions

A time-series quasi-experimental design was considered an appropriate method to measure the impact of the interventions on hand hygiene technique and compliance. This design is similar to a pre–post test design but with multiple pre-tests and multiple post-tests. The advantage of this approach is that it provides greater confidence that the change in the dependent variable was caused by the manipulation and was not just a random fluctuation.<sup>19</sup>

Auditing of HCWs' compliance with the Five Moments for Hand Hygiene was ongoing each month. Percentage compliance was correlated for each quarter of 2010, and compared with percentage compliance in 2011 and then separately for the first quarter of 2012 to assess sustainability.

Measurement of technique was calculated based on random audits of HCWs' technique using ATP and a mobile handwash sink. Four audits were performed before implementation of SureWash and four were performed after implementation of SureWash. The mobile sink, Hygieneus (Patron, Dublin, Ireland), had a refillable water container that provided hot

water for up to 50 handwashing episodes. It had a timed 30-s water dispensing system providing water to wet hands, then a 30-s period without water and then 30 s with water for rinsing hands. This unit was placed outside the hospital staff canteen, and all HCWs entering the restaurant were asked to participate. Participation was encouraged by providing a fob watch to all HCWs who volunteered.

All those who agreed to take part were asked to wash their hands at the portable sink using soap and water and then dry them with paper towel. Hands were swabbed using the ATP monitor as described above. Numerical results were recorded and the percentage of scores >25 (fail) and <25 (pass) were correlated.

Rates of compliance with the Five Moments for Hand Hygiene and ATP pass rates throughout 2010 were compared with rates in 2011 and the first quarter of 2012 using homogeneity tests. The *P*-value was computed using 10,000 Monte Carlo simulations.

## Results

HCWs' compliance with the Five Moments for Hand Hygiene increased from a baseline of 20% to 58% in early 2010. Unfortunately, the rates dropped gradually during the remainder of 2010 (Figure 1). In the first quarter of 2011, rates increased significantly to 86% and remained >80% for the rest of the year. The figure for the first quarter of 2012 was 80.7% (Figure 1).

In the 12 months prior to the implementation of SureWash, the rate of compliance with the Five Moments for Hand Hygiene was recorded as 42% (204 of 491 moments audited). In the 12 months following implementation, the compliance rate was recorded as 84% (618 of 735 moments audited) (Table 1). This was a significant increase ( $P < 0.0001$ ).

Handwashing technique, as measured by ATP results, showed a month-on-month improvement over the two years (Figure 2). The mean pass rate prior to implementation of SureWash was 52% (94 staff had scores <25). This increased to 79% (201 staff had scores <25) in the year following implementation ( $P < 0.0001$ ).

## Discussion

The study hospital is a tertiary referral acute care private hospital in Ireland with a well-established IPC programme. In 2010, the hospital commenced the implementation of a multi-modal hand hygiene programme. This intervention initially improved the compliance rate by 20% (Figure 1). However, this improvement declined gradually from 58% at the beginning of 2010 to 29% by the fourth quarter of 2010 (Figure 1). Nicol *et al.* found that successful programmes needed to connect with individuals on an emotional level to ensure sustained improvement.<sup>18</sup>

The use of ATP to demonstrate contamination levels on HCWs' hands in the clinical area did assist with technique improvements (Figure 2), but the need for increased training on correct technique was also highlighted. WHO recommends that education and audit of HCWs' handwashing technique and alcohol hand rub application should be included in hand hygiene education programmes.<sup>10</sup> However, the IPC team did not have the resources to increase the frequency of their education sessions. With over 1000 staff working in the

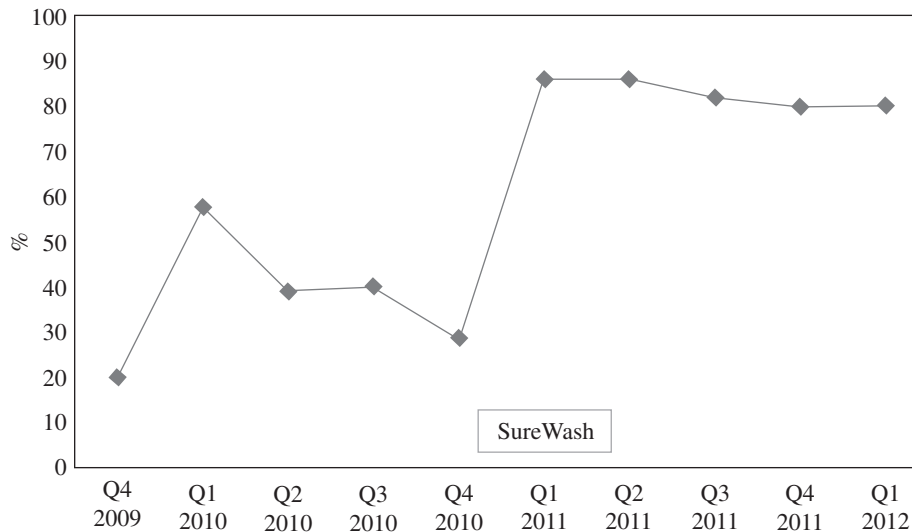


Figure 1. Percentage compliance with the World Health Organization's Five Moments for Hand Hygiene.

hospital, provision of this type of one-to-one training and audit was not feasible.

The implementation of SureWash used gaming technology to demonstrate and audit technique became an essential part of the IPC programme. It provided the much needed focus on technique training and allowed HCWs the opportunity to practice at a time that suited them. This training was available 24 h/day, 365 days/year. In the first eight months, 287 h of audit and training were recorded. The usage levels did not reduce over time. Regardless of the department where SureWash was placed, HCWs used the unit and practiced their technique in equal numbers, although nursing staff and doctors recorded better technique initially than untrained workers.

Following one week in each area, reports were run detailing the numbers and grades of HCWs who used the unit. Reports run from the unit demonstrated that individual HCWs returned again and again until they achieved 100%. The gaming design of SureWash provided an individual, experimental, fun way to learn the correct handwashing technique. Behavioural science has identified the need for individual experimental learning.<sup>19</sup> Research has identified that this individual experience is essential if behaviour is to be changed in the long term.<sup>12,18</sup> This individual experience of the impartial computerized response to incorrect technique was a powerful educational tool for HCWs.

The quarterly audits of technique using ATP showed a significant increase in the proportion of HCWs reaching

acceptable ATP scores after washing. This was an indication of the improvements in their technique (Figure 2), and evidence that SureWash was having a positive impact.

What was surprising and unexpected was the sudden and sustained improvement in compliance with the Five Moments for Hand Hygiene that occurred at the same time (Figure 1). Improved compliance rates achieved in early 2010 had dwindled to 29% in the last quarter of 2010 (Figure 2). However, rates rose to >80% for the first time in March 2011, and remained consistently >80% for the rest of the year (Figure 2). This indicates that the SureWash system, although tackling technique, increased overall awareness of hand hygiene.

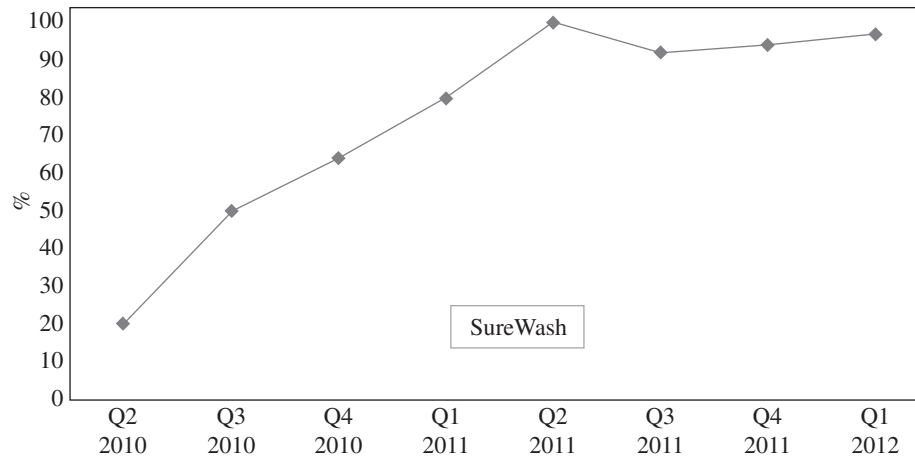
The study was conducted in the context of a working clinical environment, and multiple IPC activities may have confounded the results. The extra alcohol hand rub stations in the clinical area in 2011 most likely had a confounding effect on the increased use of alcohol hand rubs noted during audits. However, handwashing also increased and both had a statistically significant impact on compliance rates ( $P < 0.0001$ ). Ongoing audits by the same personnel will certainly have had a Hawthorn effect, with practice improving when HCWs knew they were being observed. However, this was true at all stages of the study. There was some attempt to control variables by ensuring that the same HCWs performed the audits in a consistent manner.

Table 1

Compliance with the Five Moments for Hand Hygiene: audit results

Five Moments for Hand Hygiene audits	Q4 2009	Q1 2010	Q2 2010	Q3 2010	Q4 2010	Q1 2011	Q2 2011	Q3 2011	Q4 2011	Q1 2012
Number of opportunities audited	102	118	124	120	129	157	251	181	146	512
Missed opportunities	81	50	75	70	92	22	36	30	29	101
Compliance (%)	20	58	39	40	29	86	86	82	80	80

Q, quarter.



**Figure 2.** Percentage of passes (score <25) from adenosine triphosphate swabs of randomly selected healthcare workers' hands after washing.

No attempt was made to measure improvements in technique for application of alcohol hand rub, as the ATP method chosen is not effective in the presence of alcohol.

As the study was undertaken in a single acute care setting, it is not known if the results can be replicated in other hospitals or generalized to the population. Further studies examining the impact of SureWash in other settings would be useful to determine the benefits of using this type of gaming technology for other forms of education. Use of a crossover quasi-experimental approach in multiple sites would be more rigorous.

## Conclusion

The use of gaming technology to provide education and assessment not only improved technique, but also increased compliance with the Five Moments for Hand Hygiene across the hospital. However, it is not a replacement for education, audit with feedback and reminders in the clinical area. It is a tool to capture the imagination of staff and engage HCWs in learning. It has a major role to play in a multi-faceted hand hygiene programme.

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### Conflict of interest statement

None declared.

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None.

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