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Game-based training to promote handwashing, handrub and gloving for hospital pharmacy operators

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ABSTRACT

Objectives Adherence to handwashing, handrub and gloving procedures is mandatory for safe, aseptic drug compounding in hospital pharmacies. This study measured participants' satisfaction and effectiveness of a game-based training tool (Handtastic Box) developed to improve adherence.

Methods Handtastic Boxes were played by pairs of pharmacy operators (introductory video, 1 min study of guidelines, game). In module 1, players watched videos of somebody handwashing and had to find the missing step. They examined wooden models of hands under ultraviolet (UV) light, with some areas stained with fluorescein, to find the hand showing contamination. In module 2, players used a fluorescein hydroalcoholic solution and placed their hands under UV light to highlight missing areas. In module 3, players identified major errors that could compromise glove sterility and linked them to a problem explanation. Then, they applied paint to their fingertips and donned gloves—the paint had to stay inside them. Satisfaction about the training was assessed with a 10-question survey; knowledge about procedures was assessed using a before-and-after questionnaire of nine questions, a 100-point confidence score (modules 1 and 2), and the number of before-and-after errors made during donning gloves (module 3).

Results Operators were very satisfied and felt more competent after training. Average knowledge score increased from 56.3% (SD 18.2%) to 93.7% (SD 9.5%), and confidence in answers increased from 66.4% (SD 18.7%) to 95.7% (SD 5.52%) (n=14, both modules 1 and 2). The mean error score for gloving procedure decreased from 1.7 (SD 0.8%) to 0.3 (SD 0.5%) (n=10, module 3).

Conclusion Handtastic Boxes proved to be a highly effective training method for improving knowledge of handwashing, handrub and gloving.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Handwashing, hand disinfection and hand gloving are three fundamental skills an operator has to manage perfectly to work in a hospital pharmacy cleanroom, but these topics are rarely addressed in Good Manufacturing Practices (GMP) training.

WHAT THIS STUDY ADDS

⇒ This study presents and assesses the impact of an innovative training method using game-based training to improve these skills. With a high rate of satisfaction and a significant increase in operators' knowledge, it proved to be a highly effective training method.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ With greater competencies in handwashing, hand disinfection and hand gloving, operators comply to GMP and contribute to improving safety in healthcare.

INTRODUCTION

Requirements for operators

Pharmaceutical technologies include the methods, techniques and instrumentation used when compounding the drugs and other preparations used in patient diagnostics and treatment. This work occurs in a cleanroom, where pharmacy technicians dress and behave according to Good Manufacturing Practices (GMP). GMP are a compilation of guidelines elaborated by international organisations to ensure the highest standards of efficacy, quality and safety in any process that involves the manufacture of health products, whether in big pharmaceutical companies or hospital pharmacies with a manufacturing authorisation.[1] Switzerland's health authority, Swissmedic, follows the European Union Pharmaceutical Inspection Convention and Pharmaceutical Inspection Co-operation Scheme (PIC/S) principles of GMP, which are detailed extensively in the PIC/S guidelines and summarised in EU Regulation No. 1252/2014. Article four requires that personnel should have "the necessary qualifications acquired through education, training or experience to carry out and supervise the manufacturing of active substances", and they should "practice good sanitation and hygiene in the manufacturing area".[2] Consequently, hospital pharmacies must ensure that handwashing, handrub and gloving procedures are strictly observed with the aid of relevant and appropriate training.

GMP education

After their initial education, pharmacy technicians undergo continuous education throughout their careers and are periodically requalified to ensure that their skills are up to date. Dale's Cone of Experience is an intuitive model of what trainees remember depending on how they are taught.[3] Its simple principle states that the more students experiment, the more they 'live' the training and the more they remember. Not only do emotions substantially influence memory performance, but positive emotional content is remembered better than negative emotional content.[4 5] This is the credo of game-based training, which makes learning interactive,

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increases knowledge retention and encourages the subsequent application of learning. Games for learning GMP already exist, such as the PHARM Game (which goes through every aspect of drug discovery and development), the GXP Game (a board game with questions and answers about different themes on cards) or the Esclean Room game (an escape game for learning GMP).[6–8] However, these games are related to knowledge of general GMP, not to operators' daily specific skills.

Objective

The study aimed to measure the effectiveness of a purposefully designed, game-based training tool called Handtastic Box created to improve knowledge of the correct execution of handwashing, handrub and gloving processes as well as participant satisfaction.

METHODS

Design of the training

The training was designed through a collaboration between our hospital (a pharmacist specialised in pharmaceutical technology) and the company InTheBox Consulting (specialised in the building of adaptive escape rooms for businesses, scalable learning solutions for institutionalised processes and teamwork; https://in-the-box-consulting.ch/) during a period of approximately 6 months. The training was specifically designed for the pharmacy operators working in our hospital cleanroom. The training was conducted in the meeting room of the pharmacy with the above-mentioned pharmacist being the main trainer and facilitator.

Three game-based training tools, called Handtastic Boxes (a contraction of *hand* and *fantastic*), were created to support the three modules conducted by pairs of players. Each module—which can be executed independently—lasts 30 min, so the total training duration is 1.5 hours.

The training flow for modules 1 and 2 was:

- Self-study introductory video including learning targets (handwashing or using handrub) (4 min)
- Study time to memorise the WHO handwashing or handrub guidelines (1 min)
- Game with Handtastic Box module 1 or 2 (15 minutes)
- Debriefing (10 min)

The training flow for module 3 was:

- Self-study introductory video including learning targets (sterile gloving) (4 min)
- Study time to memorise the WHO guidelines for donning and removing sterile gloves (1 min)
- Game with Handtastic Box module 3 (10 minutes)
- Practical exercise (5 min)
- Debriefing (10 min)

The Handtastic Boxes

Handtastic Box module 1 is a collaborative, two-player game to train handwashing (figure 1). On one side, a video screen can only be seen by Player 1. On the other side, an ultraviolet (UV) lightbox and nine wooden model hands can only be accessed by Player 2. Fluorescein is applied to specific areas of each wooden hand, but these are only visible under UV light. Player 1 activates the box by pressing the START button and watches a video of a person washing their hands. The box contains six videos, one showing the fully correct process and five each containing a different missing step. While watching each video, Player 1 should repeat the handwashing movements shown on the screen. Player 2 carefully observes Player 1's movements, and together they assess whether the handwashing was executed correctly or not. If they feel it was executed incorrectly, they must identify the missing step by thinking back to the WHO handwashing guidelines they studied before the game. Then, Player 2 examines the wooden hands provided under the UV light. The goal is to match the missing step to the fluorescent area, representing the area which has not been washed. When Player 2 thinks he has found the correct wooden hand, he places it on the red circle on the top of the box, where a chip detects it. If the wooden hand selected is the correct one, the players hear "Well done!" over the speaker and move on to the next video. If they are wrong, they will hear a loud beep, receive a time penalty, and Player 2 must try again. Players exchange roles after three videos.

Handtastic Box module 2 is a collaborative, two-player game to train correct handrub application (figure 2); the game uses a commercially available UV lightbox and fluorescent handrub. Player 1 applies a handrub of fluorescent hydroalcoholic solution. Player 2 observes, corrects or comments on the execution of the process if needed. Player 1 puts their hands under UV light and checks for missed areas. Players highlight any missing areas on a hand diagram. Their drawing links the different movement types to the area of the hand where the handrub solution is applied. This visualisation tool is used during the debriefing. Both players apply handrub.

Handtastic Box module three is a collaborative two-player game to train the donning of sterile gloves (figure 3). Many different mistakes can compromise glove sterility. These mistakes are committed on purpose in seven videos of a person donning sterile gloves. An eighth video is entirely correct. Possible mistakes are written on red cards, and several possible explanations of these mistakes are written on blue cards. Players must identify the mistake in the video and connect it to the appropriate explanation. After module 3, players play a practical exercise. They apply some paint to their fingertips and don sterile gloves. If done correctly, there should be paint nowhere but inside the gloves.

Figure 1 Training procedure for module 1 (handwashing).

Figure 2 Training procedure for module 2 (handrub).

Debriefing process

For each team and module, the debriefing followed the three steps of standard recommendations: reaction, analysis and synthesis. During the reaction step, participants were encouraged to briefly expose their feelings after the game. During the analysis, the facilitator could make a connection between the results of the modules and the WHO guidelines. In module 1, videos taking more time to solve or leading to more mistakes were particularly discussed. In module 2, the hand diagram was used to discuss about the areas not correctly disinfected. In module 3, like in module 1, videos taking more time to solve or leading to more mistakes were particularly discussed, as well as the possible reasons why the players had paint outside their gloves. During the synthesis step, the facilitator asked the participants to list the take-home messages they got from the training. Globally, there was a time of exchange between the participants and the facilitator leading to a collective reflection on the skills learnt through the games. At the end of the study, a presentation of the results and a general debriefing were made in the presence of the whole team.

Participants learning objectives

Each module had a different learning objective :

- At the end of module 1, participants can correctly execute every step of the WHO handwashing guidelines[9]
- At the end of module 2, they can correctly execute every step of the WHO handrub guidelines, including the procedure's correct duration[9]
- At the end of module 3, they can correctly execute every step of the WHO guidelines for donning sterile gloves[9]

Effectiveness measures

The training's success was assessed using Kirkpatrick's Four-Level scale of Learning Evaluation.[10] The four levels are Reaction (measures if the participants have found the training to be relevant to their role, engaging and useful), Learning (measures whether or not participants have acquired the knowledge that the training programme is focused on), Behaviour (measures behavioural changes after learning to see if the participants are applying what they learnt in their job) and Results (measures the impact of the training at a business level). We chose to assess only the first two levels (Reaction and Learning) to obtain proof of concept of the training.

After the training, participants' satisfaction was assessed using 10 questions on a six-point Likert scale (online supplemental appendix 1). Participants were also encouraged to give specific written feedback on the training's strengths and points needing improvement.

Learning was assessed differently depending on the module. For modules 1 and 2, participants answered a nine-question multiple choice questionnaire with only one correct answer out of four possible options (online supplemental appendix 2), before and after the training. The participant's degree of certainty for each answer was recorded on a scale from 0 to 100.[11] Learning was assessed by evaluating the total score of the questionnaire. In addition, participants' confidence scores in their respective answers were compared.

The outcome from module 3 was assessed separately. Eleven possible mistakes that risk compromising glove sterility were listed (online supplemental appendix 3). Participants were video recorded donning sterile gloves before and after the training (pre-tests and post-tests), and the number of mistakes was assessed using the same list.

Data were collected on Excel and statistical tests were performed using Welch's paired unequal variances t-test.

RESULTS

On 27 April 2021, 14 pharmacy operators were trained using first module 1 and then module 2. On 24 August 2021, 10 pharmacy operators (among the 14 who completed modules 1 and

Figure 3 Training procedure for module 3 (sterile gloving).

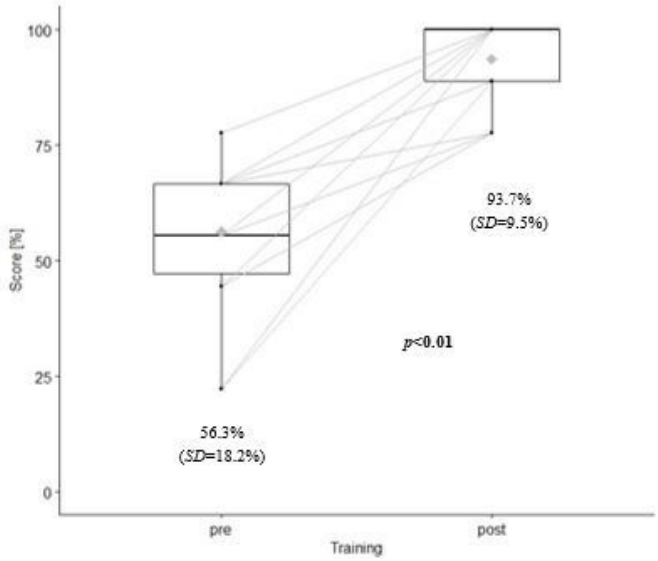

Figure 4 Evolution of the total score of the participants in handwashing and handrub (using Handtastic Box modules 1 and 2).

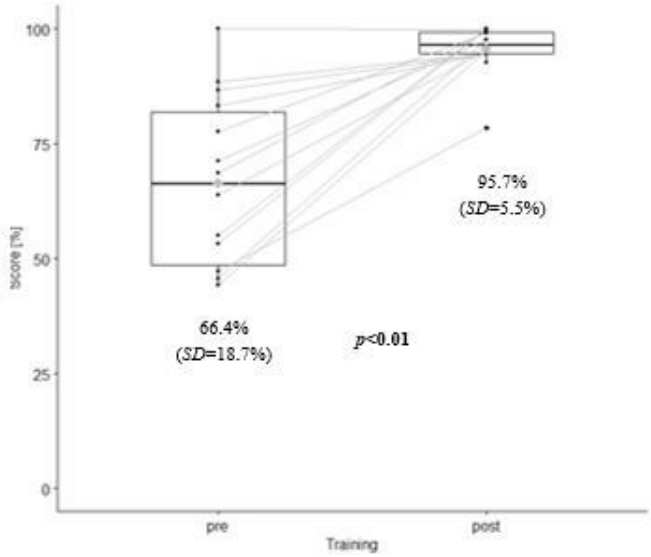

Figure 5 Evolution of the participant confidence in handwashing and handrub (using Handtastic Box modules 1 and 2).

2) were trained using module 3. All the operators work in the same setting and had between 3 and 30 years of experience in the hospital.

Reaction

Overall, participants were very satisfied with modules 1 and 2. Among them, 88.6% strongly agreed, 10% moderately agreed and 1.4% slightly agreed that they were satisfied with the modules, and no participants selected a 'disagree' option. All but one participant strongly agreed with the linear progression, the topic's usefulness and the training's playfulness. Participants strongly agreed that this type of training should be generalised to other topics, with 21% agreeing moderately.

Participants were very satisfied with module 3, as not a single 'disagree' option was selected. Eight out of ten participants provided feedback on module 3. Among them, 87.5% strongly agreed and 12.5% moderately agreed that they were satisfied with it. All the participants strongly agreed that the training was of good quality. Fifty per cent of the participants strongly agreed that the experience had had a positive effect on their competency, 25% felt that it had a moderate improvement and 25% slightly agreed that the training had improved their competency. All participants strongly agreed that this type of training should be generalised to other topics.

Learning

Concerning modules 1 and 2, figures 4 and 5 underline a significant improvement in questionnaire scores and confidence in answers. Every participant achieved a higher total score and felt increased confidence. The mean total score increased from 56.3% (SD 18.2%) to 93.7% (SD 9.5%) ($p<0.01$), and mean confidence in answers rose from 66.4% (SD 18.7%) to 95.7% (SD 5.5%) ($p<0.01$). The SD indicate that the training reduced interindividual variability.

Concerning module 3, figure 6 shows the positive changes in participants' performance. Nine participants reduced their number of mistakes, and one had the same result of a single mistake. There was a significant difference in the number of mistakes made during the donning of sterile gloves considering that the mean decreased from 1.7 (SD 0.8%) in pre-training to 0.3 (SD 0.5%) in post-training ($p<0.05$).

DISCUSSION

This study assessed the effectiveness of a game-based training tool to learn the WHO's handwashing, handrub and gloving procedures. Indeed, several factors influence adherence to its recommended hand-hygiene practices.[9] In our settings and according to the WHO, observed risk factors include being a technician, male sex, working weekdays (vs weekends), wearing gloves and automated sinks.[9] In our hospital's pharmaceutical technology areas, these factors are unchangeable. However, self-reported factors for poor adherence include lack of experience, education and knowledge about guidelines or protocols,[9] and these can be improved. The WHO compiled 42 studies involving posters, films, slogans, musical parodies, feedback, memos, lectures, brochures, better availability of alcohol handrub, more conveniently located sinks or verbal reminders.[9] The goal of these studies is to demonstrate effective interventions to improve hand-hygiene adherence among healthcare workers. However, none of them used a game-based training intervention.

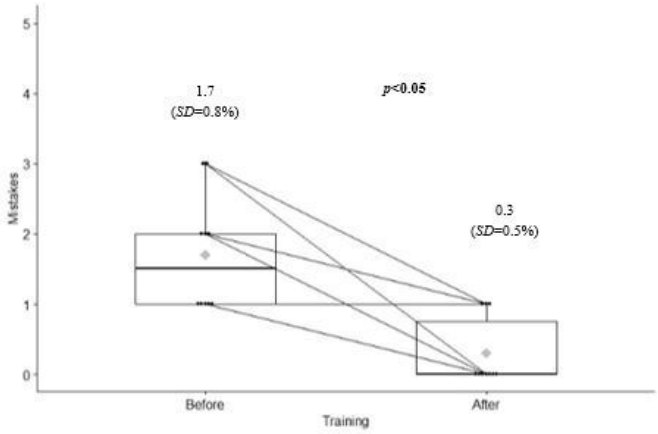

Figure 6 Change in mistakes made during donning of sterile gloves between pre- and post-training tests (using Handtastic Box module 3).

Several game-based training methods, including escape games, role-playing and board games have been used in the field of hospital pharmaceutical technologies, but none has focused on compliance with hand hygiene specifically for pharmacy operators.[12] The method's improvements in knowledge (39.9%) and confidence (30.6%) for modules 1 and 2 were comparable to other game-based training methods in hospital pharmaceutical technologies found in the literature, such as Berthod *et al*'s escape game to learn GMP, where knowledge improvement was 38.5% and degree of certainty increased by 23.5%.[8] The escape game is now very popular, but it requires a very specific space with decoration, objects, lockers or enigmas to comply with the environment fidelity needed by trainees. On the contrary, Handtastic Boxes, containing all the necessary information, can be set up on a table. In Serag-Bolos *et al*'s role-playing study, improvement in knowledge was only 17.2%, but the population was made up of pharmacy students, and only three of six questions concerned cleanroom procedures.[13] Role-playing is a great way to train teamwork skills with a minimal investment of resources, but it provides limited opportunities to practice technical skills. On the contrary, the Handtastic Boxes make it possible to practice very specific practical gestures.

Developing these tools took approximately 6 months, and training a trainer requires 1 hour. Our institution now has two Handtastic Boxes for each module, enabling us to train 12 operators every 1.5 hours or approximately 60 operators a day. Even if it was initially created for pharmacy operators, the training can also be adapted to any other health worker, student or professional who needs to train for handwashing, hand disinfection and donning of sterile gloves.

Limitations

Our study includes a small sample size (14 operators for modules 1 and 2 and 10 operators for module 3). Also, the Handtastic Boxes are relatively simple electronic tools, but we noticed that some participants needed time to get into the games and understand how they work.

CONCLUSION

The Handtastic Boxes developed and the training associated with them were playful, interactive, memorable, easy to transport, easily adaptable, quick to set up anywhere and facilitated teamwork. Participants greatly appreciated the training sessions which were efficient in improving their knowledge of and confidence in handwashing, handrub and gloving. Interesting perspectives include assessing participants learning a few months after the training, and assessing the third level of Kirkpatrick's pyramid (application of learning in practice) to confirm that operators really did wash their hands, use handrub and don their gloves safely in their daily work.

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