

Using Gamification Combined with Indoor Location to Improve Nurses' Hand Hygiene Compliance in an ICU Ward

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Abstract. Healthcare acquired infections are among the biggest unsolved problems in healthcare, implying an increasing number of deaths, extra-days of hospital stay and hospital costs. Performing hand hygiene is a simple and inexpensive prevention measure, but healthcare workers compliance with it is still far from optimal. Recognized hurdles are lack of time, forgetfulness, wrong technique and lack of motivation. This study aims at exploring gamification to promote nurses' HH compliance self-awareness and action. Real-time data collected from an indoor location system will provide feedback information to a group of nurses working in an ICU ward. In this paper both the research's motivation and methods is presented, along with the first round of results and its discussion.

Keywords. Internet of Things, Healthcare acquired infections, indoor location, gamification, nursing, design science research

Introduction

Healthcare acquired infections (HAI) are infections that are neither present nor incubating when a patient is admitted to hospital [1][2]. HAI are a risk that hospitals must control to manage healthcare economically and safely for patients who can become disabled in the long-term or even die. Although preventable, by means of hand hygiene (HH) compliance, these infections are the most frequent adverse event a patient can experience during care delivery, and cause more deaths than AIDS, breast cancer and car accidents together [3]. Nonetheless, leading busy healthcare workers (HCW) to comply with HH remains puzzling. Recognized hurdles are lack of time, forgetfulness, wrong technique and lack of motivation. Besides, nurses' perception about their compliance is often disturbed by a busy schedule. Therefore, it becomes crucial to monitor nurses' compliance with existing guidelines and provide them with feedback regarding their performance. Direct observation, the observation of HCW's

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HH practice by professional observers, is the standard approach to fulfil this task, but it is costly and time-consuming. Hospitals need to come up with innovative ways of doing this. Automated monitoring systems have emerged during the last few years, and can electronically identify when an HCW uses a sink or a hand rub dispenser. It provides exact quantitative results, which can be used to examine trends regarding the value of HH compliance over time.

Gamification is a recent but popular approach which can be defined as “the use of game elements and game-design in non-game contexts” [4] to “engage and motivate people to achieve their goals” [5], providing a whole different user experience. It aims at stimulating people’s intrinsic motivation in doing an activity by making it rewarding for itself. Game elements are the “toolkit” for building a game [4], they must be chosen at the end of the game design process, after some variables are analyzed and defined (goals, behaviors we want to stimulate, target players, etc.). Wabash and Hunter provide a list of game elements divided into three categories with different levels of abstraction [4].

This study aims at exploring the use of gamification to promote nurses’ HH compliance self-awareness and action. An automated monitoring system is used to collect data in real time and provide feedback information to a group of nurses working in an ICU ward, in a fun and engaging way.

1. Methods

The solution, which consists on an automated monitoring system composed by an indoor location system and a gamified system is iteratively designed, tested and evaluated using a design science research approach [6]. The solution was presented to its target users (the nurses) and its usage was simulated in both artificial setting (by voluntary users, i.e. the researchers) and clinical environment (by nurses).

1.1. Design and implementation of the solution

The first component of the solution is an innovative indoor system based on smart beacon’s technology. This was developed together with a Portuguese startup, focused on the development of solutions related with “Internet of Things” that communicates using Bluetooth and a proprietary protocol (operating on the 2.4GHz frequency band). The system was built using a proximity based technique. More specifically, the smart beacons receive information from smart tags (carried by nurses) and they send a message to the server (communicating its position, the smart tag detection and the current time) whenever a smart tag is detected approaching the beacon or walking away from it. Analyzing the messages stored in the server, we are able to detect nurses’ positions over time.

The next step is for the system to detect and validate HH moments. To achieve this, we use the World Health Organization (WHO)’s “My five moments for hand hygiene” framework [7], which links specific moments to HH opportunities.

With this framework, we are able to create and implement business rules in our system (for example, if a nurse is approaching a bed, it must have approached an alcohol hand rub dispenser or a sink previously). After this processing, we have information about each nurse’s compliance, which is displayed, in an anonymous way, in a screen in real-time.

This, along with other elements, including the player's profile, composes the gamification solution which aims at solving the compliance problem by engaging and motivating people to achieve specific (and preferably pre-determined) goals [8], using several and distinct game elements (feedback, competition, points, levels, badges, etc.).

The technological architecture of this solution is presented in Figure 1.

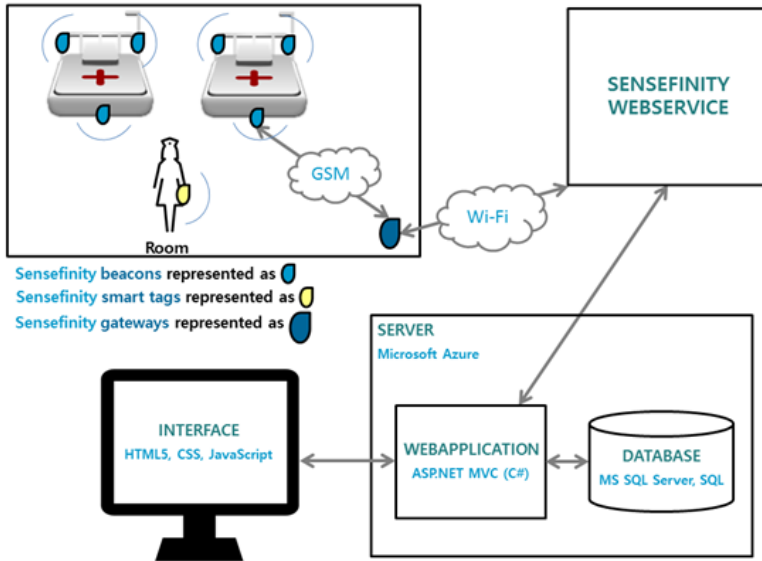


Figure 1. Technological architecture of the solution designed.

1.2 Meeting with the users

There have been some meetings with the nurses from the UCI. We presented the Information System (IS) aiming at gathering feedback regarding their feelings about it.

1.3 Simulation and tests

In order to validate if the solution was technically practical, it was tested in a simulated environment by voluntary users composed of the research members. A protocol was written and executed and the computed HH compliance rate was compared with the expected rate. To analyze the impact of the IS's usage by our target user, four nurses from the ICU ward were asked to carry a smart tag during a workday. This data was compared to a previously established baseline (in respect to an observational study) to measure the behavioral changes.

2. Results

2.1 Installation of the system

After being designed and implemented, the IS has been installed in the ward. A screen was positioned in the nurses' room and 26 beacons fixed at specific positions: in the rooms' doors, in each alcohol-based hand rub container, in each sink and in each bed.

By doing so, the system was able to trace a nurse's position along time based on the proximity to each beacon.

2.2 *Feedback from the nurses*

The group of nurses to whom the IS was presented to test the concept reported that they considered this system as a unique opportunity to receive feedback about their performance. Although they are sometimes subject to audits, they reported that the system would give them a totally different experience. Even though worried by the accuracy of the location system, they found the avatars experience amusing. About future improvements, they showed little interest in components like badges, virtual goods and content unlocking because it would require them to use the system outside their labor hours. They, however, liked the concept of leaderboards.

To conclude, we asked them if they would prefer to maintain their privacy or if they would like their name (or a chosen nickname) to appear on the screen. They said that this was indifferent for them, since they had no problem in having their identity exposed on the screen.

2.3 *Simulation*

The simulation in a non-clinical setting by the researchers presented good results. The system worked accordingly to our expectations, returning a HH compliance rate of 100%. Regarding the simulation performed by the nurse from the ICU ward during one 12-hour shift, the feedback received was that she got happier as she progressed in the game, and whenever she noticed that the rate had decreased (even if only a little), she felt the urge for being more aware of the HH moments.

3. Discussion

Since we were able to detect the nurse's movements using proximity and to quantify the compliance with a very good precision, the IS was conceptually validated. This wouldn't be possible without the indoor location solution that provided the nurse's position with accuracy in a real-time basis.

The participating nurses recognized the experience as an opportunity to improve their performance, which corresponds with their expectations collected during the initial meeting. Since nurses were a little skeptical in using some game elements that required them to access the system outside their work time, we decided to include a functionality in the system to send an e-mail to each nurse at the end of the day. This simple e-mail provides feedback regarding their HH compliance rate and has a link to their profile for further information. One of the nurses realized that she ended up consulting the webpage, even though she said she wouldn't in a first instance. The impact of gamification on HH compliance is still under evaluation. Even though we only performed low scale validation tests to check whether or not the concept would work, so far the results show that the IS is a promising solution in improving nurses' awareness.

A demonstration in the ICU ward is already planned. During a 5-days trial, 24 nurses will be using the gamification solution and will be provided with feedback regarding their HH compliance rate. Simultaneously, we will observe their behaviors and reactions, trying to understand if they are comfortable with the system and if they trust the presented results. We will also focus on spotting technical issues that might be

leading to undesired side effects of the system. In the end, we will analyze the gathered results and refine our tool, both in terms of improving our gamification solution and fixing some problems that may emerge during the demonstration. After this larger evaluation, our goal is to implement the solution in a unit of another hospital for a longer period.

To conclude, we believe that the IS is aligned with nurses' needs and that it has a positive impact on their daily routine. Although we noted some resistance to some ideas we discussed for future work with the nurses. The nurse who participated in our initial test agreed that she ended up using the system, so we trust that after using the IS on a daily basis nurses can be more interested in different options. It must be highlighted that the nurses participated from the beginning in the IS's design, which enabled a higher sense of ownership in the process, recognized as a factor to improve performance.

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