TECHNOLOGICAL INTERVENTIONS FOR HAND HYGIENE ADHERENCE

Research and intervention for smart patient room

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ABSTRACT: Improved adherence to hand hygiene (hand washing or use of alcohol-based hand rubs) can significantly reduce the transmission of multi-drug resistant organisms and prevent many healthcare associated infections. This paper describes a technological intervention with sensing and reminding mechanisms for hand hygiene adherence in a smart patient room.

KEYWORDS: Smart room, RFID, hand hygiene adherence, patient room, technological intervention

RÉSUMÉ: Une meilleure observation des règles d’hygiène des mains (lavage des mains ou utilisation de pommade à base d’alcool) peut réduire de façon significative la transmission d’organismes résistants à divers types de médications et prévenir plusieurs infections associées aux séjours en milieu hospitalier. Cet article décrit une intervention technologique à l’aide de mécanismes de détection et de rappel pour l’observation des règles d’hygiène des mains dans une chambre de patient intelligente.

MOTS-CLÉS: Chambre intelligente, RFID, observation des règles d’hygiène des mains, chambre de patient, intervention technologique

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1. MOTIVATION – INFECTION CONTROL WITH HAND HYGIENE PRACTICE

Hospital-acquired infections pose a serious threat to public health (Albert and Condie 1981; Larson 1988; Graham 1990; Larson and Kretzer 1995; Boyce, Potter-Bynoe et al. 1997; Pittet 2000), causing an estimated 99,000 deaths in the US in 2002 (Weinstein 1998; Klevens, Edwards et al. 2007). It is estimated that 2 million patients a year contract dangerous infections in U.S. hospitals (CDC 2002). The hands of healthcare workers are the principal cause of contact transmission from patient to patient (Larson 1988; CDC 2002). The most effective infection control measure to reduce direct and indirect contact transmissions is hand hygiene (hand washing with soap and water or use of alcohol based hand-rubs) (Boyce and Pittet 2002). Automated monitoring and measuring of hand hygiene efforts of healthcare personnel would raise the awareness of care practices, help enforce critical prevention practices, and facilitate process improvement activities.

Improved adherence to hand hygiene can significantly reduce the transmission of multi-drug resistant organisms including methicillin-resistant Staphylococcus aureus and prevent many healthcare associated infections (Boyce and Pittet 2002). Despite widespread acceptance of the importance of hand hygiene and the existence of CDC/HICPAC guidelines recommending hand hygiene before and after patient contact, compliance with hand hygiene is poor in many healthcare settings (Graham 1990; Dorsey, Cydulka et al. 1996; Voss and Widmer 1997; Pittet, Mourouga et al. 1999; Kuzu, Ozer et al. 2005; Saba, Seyman et al. 2005; Sacar, Turgut et al. 2006; Trick, Vernon et al. 2007).

Successful programs to increase hand hygiene compliance are multifaceted and include a component of compliance monitoring (Dubbert, Dolce et al. 1990; Kuzu, Ozer et al. 2005; Trick, Vernon et al. 2007). Without such monitoring, it is not possible to measure the impact of interventions. However, hand hygiene monitoring is difficult to do, especially in patient care areas where direct observation of hand hygiene opportunities is either not possible or would be obtrusive. Measuring hand hygiene compliance by observation is also costly and can introduce bias if the presence of the observer is known. Electronic monitoring and reminding systems show considerable promise (Swoboda, Earsing et al. 2004) in providing significant and lasting improvements in hand hygiene but current systems do not allow identification of the identity or role of the clinicians being monitored. These problems result in uncertainty in hand hygiene rates and make it difficult to design and implement education and reward programs.
2. SMART ROOM DESIGN

Situated in the city of Atlanta where Georgia Institute of Technology and Emory University are located, we formed an interdisciplinary team with architects, doctors, nurses, system engineers, computer scientists and human-computer interaction practitioners to address hand hygiene issues in the hospital rooms. Our project takes advantage of advances in remote monitoring and RFID—radio frequency identification technologies (Want 2004)—to create a next generation reminder and monitoring system that will provide lighting cues and reminders for hand hygiene opportunities and offer more accurate automatic data measurement and recording. We created a Smart Room with environment and behaviour analysis and technological intervention integrated into the design of physical environments so that the hand hygiene adherence can become an easy and integral part of the care process.

2.1. Integrating Environmental and Behavioral Design

The team first performed field observations in several local hospitals. The observation methods include the fly on the wall technique, as well as shadowing and interviewing the caregivers. Extensive field notes were taken to capture the activities, environments, interactions and objects engaged by the different stakeholders. A variety of information such as rough sketches, photos, records of behaviors, thoughts, questions and insights were collected in the note taking process. In the meantime, we also conducted literature survey related to Evidence-Based Design (Hamilton 2003; Ulrich, Zimring et al. 2004) to analyze the opportunities for interventions.

We came to the conclusion that we could either change the environment of the hospital to promote hand washing and proper infection control procedures or we could change the behaviors of the caregivers. Our solution was to integrate both techniques to design an infection control Smart Room that would change the environment and also modify behavior. Figure 1 shows an overview of the components of the Smart Room design.
2.1.1. RFID Smart Room

The Smart Room has an RFID reader by the door that reads clinician’s badge ID as they enter the room. The path that leads to the sink as well as the sink itself would then light up. This integrated environment provides subtle cues for both the clinicians and patients (and accompanying family members) that hand washing opportunities are present.

Radio frequency identification technology, or RFID, is relatively new to the mass market. RFID, consisting of a microchip and an antenna, is an electronic tagging technology that allows an object, place, or person to be automatically identified at a distance without a direct line-of-sight (Want 2004). The tracking is an electromagnetic response exchange. Typical RFID applications include inventory tracking, animal tagging, rapid product checkouts, tracking library books, transportation payments, timing marathon runners, passports, and access control for secure vehicles and facilities (Zhao and Gan 2006; Niederman, Mathieu et al. 2007; Pala and Inanc 2007).

In 2003, Wal-Mart, the world’s largest public corporation by revenue, started requiring its top suppliers to put RFID tags on shipping crates and pallets; Wal-Mart is expanding its RFID capability to additional facilities (Vijayan and Brewin 2003; Wal-Mart 2007). Each tag stores an electronic product code to
track products as they enter distribution centers and then in turn are shipped to individual stores. Tesco, the largest retailer in the United Kingdom started putting RFID tags on cases of nonfood items at its distribution centers and track them through to stores since 2004 (Want 2004). The U.S. Department of Defense requires all of its suppliers to use passive radio frequency identification tags (RFID) on all cases and pallets since January 2005, and remains committed to the implementation of Radio Frequency Identification (RFID) technology as outlined in July 30, 2004 policy memorandum (DoD 2004). The U.S. State Department issued its final rules in 2005 specifying its plans to issue electronic passports (e-passports) containing RFID tags (Vijayan and Brewin 2003). RFID is considered to be the next generation bar code. Analysts predict the cost for tags (and readers) will fall dramatically (Fabris 2005; Das and Harrop 2008).

Augmenting the RFID technology with sensors placed at different locations, the Smart Room can provide more opportunities for studies of the environment and behavior as well as cues and reminders for the caregivers. For example, when detecting the caregiver’s location in the patient room, different hand hygiene opportunities (i.e. sink and sanitizer locations) would provide lighting cue and send vibrations to the caregiver’s pager or cell phone. The system deactivates when the caregiver leaves the room.

2.1.2. Integrated Medical Records

Once the RFID reader by the door detects the caregiver’s identification, this information is sent through the network and then the computer automatically signs on for the caregiver and then requests input of PIN (personal identification number) to confirm access privilege (as shown in Figure 2).

**FIGURE 2. INTEGRATED MEDICAL RECORD DISPLAY SCREEN FOR PIN INPUT.**

Electronic medical records can be accessed on the touch screen monitor display located between the sink and the patient bed. This arrangement enables
the clinician to wash hands while looking at the medical record on the screen and facing the patient’s head at the same time. Studies have showed that placing sinks or hand-rubs in more accessible locations may improve handwashing compliance (Kaplan and McGuckin 1986; Graham 1990; Cohen, Kitai et al. 2002). The monitor display also has a count down bar that indicates the duration of the length of hand washing (at least 15 seconds) as shown in Figure 3.

**FIGURE 3. COUNT-DOWN BAR DISPLAY ON THE SCREEN WHILE EXAMINING PATIENT’S ELECTRONIC MEDICAL RECORD.**

![Count Down Bar Display](image)

2.1.3. Hand Washing Lighting Cues

The Smart Room also provides several lighting cues to help caregivers notice the hand hygiene opportunities. For example, the track lighting installed on the floor illuminates path to sink to draw people’s attention. Meanwhile, as shown in Figure 4, the lighting installed under the sink would light up. If the sink is not activated within 15 seconds, lighting begins to blink.

**FIGURE 4. LIGHTING UNDER THE SINK LIGHTS UP TO SUGGEST HAND WASHING.**

![Lighting Under Sink](image)

2.1.4. Infection Control Clean Pocket

As the RFID reader registers the entry of the caregivers, if the caregivers chose not to comply with hand washing practice within a time frame (for example, can be adjusted to be 30 seconds or 2 minutes), the system will automatically
dial up the caregivers’ cell phones or pages to remind them to wash their hands. When this happens, the clinicians can reach into the Clean Pockets in their lab coats to take out a portable disinfectant hand gel wherever their locations are (see Figure 5).

We designed the antiseptic gel bulb to be kept in a waterproof clean pocket of the lab coat. The advantage of this is that the disinfectant solution would always be with the caregivers no matter where they might be. The container gel cartridge can be easily refilled or replaced. Caregivers can also give them to the patients or family members to use. We also consider the hand cleaner carrying methods in the forms of a pendant, or a bracelet that can be worn or clipped on to the caregiver’s clothing.

**FIGURE 5. CAREGIVER REACHES INTO THE CLEAN POCKET TO TAKE OUT AND SQUEEZE THE ANTISEPTIC GEL BULB TO CLEAN HANDS.**

3. DISCUSSION AND FUTURE WORK

The project was demonstrated at an open house event with over a hundred clinicians visiting from healthcare environments. These healthcare professionals including medical doctors, nurses, hospital chief executive officers, chief medical officers and chief nursing officers found the project idea practical and useful. This Smart Room project has demonstrated the proof-of-concept feasibility of installing sensing abilities using RFID reader and tags in a patient room. As a result of this design, we are currently working with the chief medical officer Dr. Steinberg of Emory Crawford Long Hospital to build on the ideas of this work for two different hospitals and to investigate real time locating system potentials of using RFID and other sensing technologies in the hospitals to track hand hygiene adherence.

Currently, both Emory Crawford Long hospital, and Emory University Hospital use HID Proximity PVC cards with Magnetic stripes for access and identification control. For asset tracking, IntelliMotion from GE Healthcare (GE 2008; HID 2008) using RFID technology are installed in different hospital wings and floors to monitor equipment locations. The current asset tracking and management system focuses on large area and zones and does not have
the fine granularity for tracking single room entry. We would explore and experiment with both existing systems and new interventions to achieve real-time location tracking and status reports.

The design of the Smart Room included both behavioral and environmental considerations. Information and computing technologies were designed and integrated into the physical environment to facilitate behavioral change.

Research has showed that electronic monitoring and voice reminding improved hand hygiene and decrease infections in an intermediate care unit (Swoboda, Earsing et al. 2004). The monitor system used in this previous study, however, only included electronic beam breakers or motion detectors placed at the threshold of each room to monitor entry and exit of people (both staff and visitors were recorded). This type of system cannot identify who the person was or whether if they were providing patient care when they entered or exited the rooms. Neither the identity nor the role of the clinicians was monitored in this case. A study showed that behavior varies as a function of health care professional status and patient interaction, among the healthcare workers with MDs medical doctors being the least likely to wash hands (15% versus RN registered nurse 50%, NSP nursing support personnel 37%, p < 0.01) (Lipsett and Swoboda 2001). The Smart Room project uses RFID tracking; this represents an improvement over the existing study in that each RFID tag attached on each healthcare worker’s ID badge has a unique identifier. When the Smart Room is in a larger scale deployment, we would be able to record data and compare with previous findings about the correlation between professional status and hand hygiene adherence.

Previous behavior research in hand hygiene has suggested that successful implementation of change have been a multidisciplinary approach with open communication (Kretzer and Larson 1998; Pittet, Hugonnet et al. 2000). Communication with data collected from the Smart Room may help people realize the gap between perceived and actual hand hygiene adherence practice and facilitate behavioral modifications.

The design and implementation of the Smart Room is an interesting adventure. This project explores the topic of how interactive computing technology can change human behaviors and support care process and tasks. As architects and Computer-Aided Architectural Design researchers, we see the opportunities of applying evidence-based design, knowledge-based design, collaboration and communication technologies as well as design prototyping to not just interaction design, or virtual and augmented reality, but to intelligent, interactive and responsive environments in the reality of our daily lives to create innovation with impact.
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