# Radio Frequency Identification for the Development of a Smartphone Integrated Monitoring System for Hand Hygiene Compliance

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***Abstract*—In many different medical environments, there is a large risk of healthcare-associated infections (HAI). Thus the project is concerned with the development of a system to monitor the hand-washing performance of healthcare professionals. A monitoring system using radio-frequency identification (RFID), water sensors, an Arduino microprocessor, and communication capacities of a smartphone was developed in this pursuit. An Arduino microprocessor was programmed to access RFID cards within the vicinity of the device scanner. The system used the RFID code to monitor the hand-washing activity that should occur at the designated hygiene location. Inconsistent events would then be sent to management via a smartphone application. A prototype was developed that accomplished the aforementioned goals. The proposed smartphone-based system provides a convenient and cost-effective solution to monitoring hand hygiene compliance.**

***Keywords—radio-frequency identification (RFID), healthcare-associated infections, hand hygiene compliance***

## I. Introduction

Throughout developed nations, there is approximately between 5% and 10% of patients that acquire health care-associated infections, and it is estimated that 15%-40% of those admitted to intensive care suffer from HAI [1]. The World Health Organization also reports that there are approximately 90,000 deaths in the United States, with an estimated cost of $4.5 - 5.7 billion.

A collection of studies have found that when measures are taken to increase compliance with HHC regulations, that the number of those that comply with regulation increase with statistical significance [2]. Out of the studies covered by the previous reference, 58% of the included studies found a significant reduction in HAI when compared with a control group. Another study had observed that before monitoring HHC compliance, that the rates of compliance were 26% for intensive care units and 36% for non-intensive care units [3]. After a year of monitoring and observing, the study found the intensive care units rates of compliance increased to 37%, and non-intensive care units increased to 51%.

There have been several patents that discuss different approaches to implement monitoring methods for the goal of increasing hand-hygiene compliance (HHC). One patent in particular discussed the usage of radio frequency identification (RFID) technology to ensure that individuals with RFID cards enter a room must wash their hands while complying to hand-washing regulations [4]. Utilizing the basis of a RFID tracking system, the aim is to implement a system that tracks the HHC compliance with extra conditions. There were a few systems that appeared to be based on a complex system located with the professionals, not with the rooms. One system, named the nGage™ (Preventix, Hoorn, the Netherlands) utilized RFID tracking and dispenser sensors to monitor compliance [5]. The project is intended to take advantage of the ubiquitous smartphones and their communication capacities, which will allow for a simpler and cost-effective solution for immediate notification of HHC.

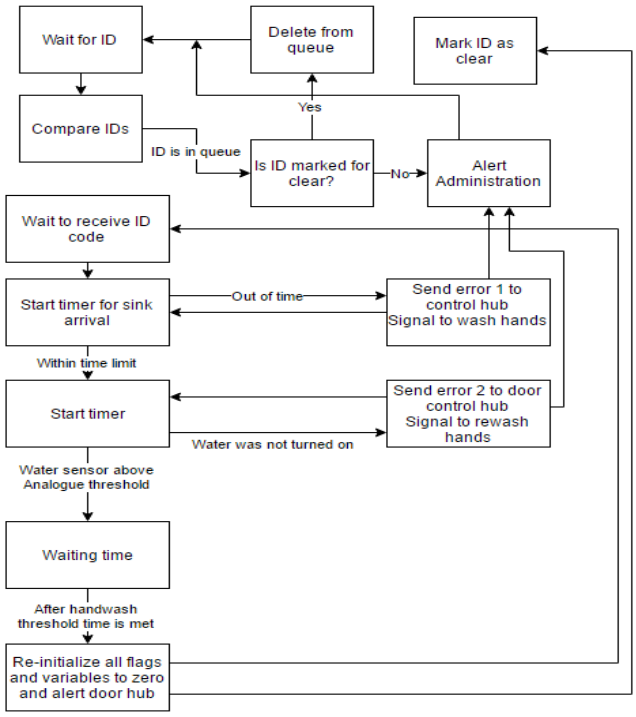


Figure 1. Flowchart of the proposed HHC monitoring system.

## II. Methods

### A. Tracking

As shown in Fig. 1, the tracking component of the system is the RFID cards that would be carried by healthcare professionals. When an individual enters the room, a hub at the door with a RFID sensor receives the identification code (IDC), then enters the IDC into a queue. Upon scanning the

IDC, the sink module initializes timers. Once an inconsistent event is detected, the system sends the IDC and an error code back to the central hub and then reports the event to management. If the individuals wash their hands following the HHC compliance, the IDC will not be transmitted back to the hub.

### *B. Evidence*

The most basic option is a timer. This timer holds the individuals to HHC standards in the healthcare field, and requires enough time be spent on the hands. The next form of evidence is a sensor that detects the presence of water. The sensor prevents individuals from arriving at the sink and waiting there for the timer to expire while not washing their hands. The sensor is coded to detect whether or not the water faucet has been turned on and track the flow of water. The flowchart in Fig. 1 specifies the event sequence of the system.

## III. Results

A system and system structure was developed in order to monitor compliance in a medical setting. The Arduino processors were connected to devices that detect the presence of water, communicate via Bluetooth wireless channels, give indications via color-coded LED's, detect inconsistent events, and transmit the error codes out to a smartphone device. The network tracks hand-washing with timers and water sensors to ensure that hand washing occurs. If an error occurs, the sink system sends the door hub the IDC and the error code. A queue system was created to allow for tracking of multiple individuals. A basic smartphone application was developed for communication and alerts. The layout of the prototype systems are given in Figure 2.

## IV. Discussion

A prototype system for monitoring the hand-hygiene compliance by using the RFID technology and smartphones has been developed. While the system provides the basic functions to achieve the goal, a few conditions were not observed or accounted for in the programming. The queue system allows for members to enter the room while the system is able to monitor whichever individual person washes their hands. When someone enters the room, there is always the chance that they leave the room, realizing that they forgot something or that they potentially entered the wrong room, and thus do not need to wash their hands. The code to correct this situation has not yet been implemented in the software and can be improved as follows: When a duplicated IDC was sent by the door hub and the individual has not appeared at the sink's RFID sensor, a cancellation condition is met and the IDC is removed from the queue. When the individual finally exits the room, the system compares the IDC with the existing queue, then checks to see if the individual has washed their hands. If they have, their IDC's are deleted from the queue. Otherwise, their IDC's are reported to management.

A key development of the system structure is to advance what is already on the market. The main development by this system is the capacity to report HHC violations directly to management on a timely basis. Since the system can report the inconsistent events via a smartphone application, management of the HHC is not restricted by locality and accessibility of the hospital database or network. The instantaneousness and mobility of the system developed in the project allows for responses where the previously developed systems may not be able to achieve.

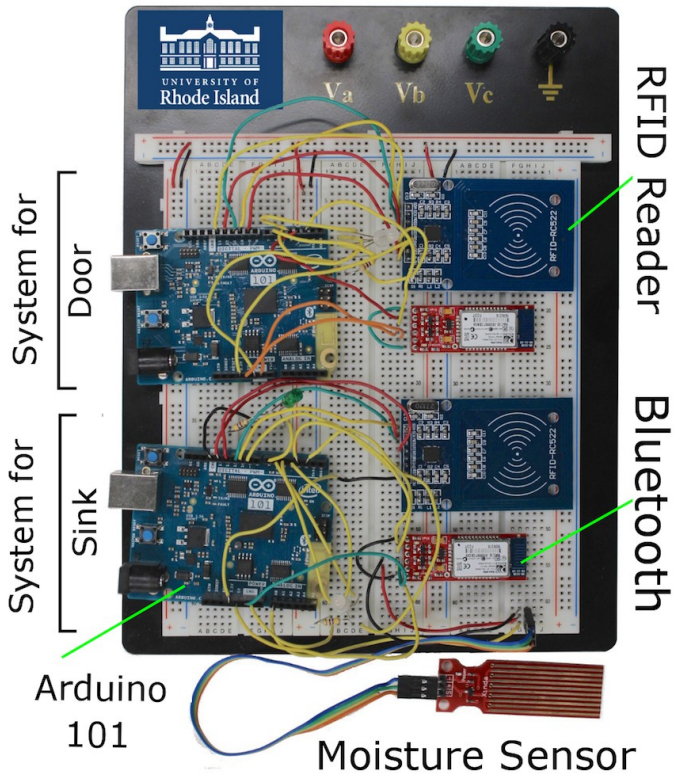


Figure 2. Prototype systems for HHC monitoring.

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