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Electronic surveillance of wall-mounted soap and alcohol gel dispensers in an intensive care unit

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Summary We describe a battery-powered recording device incorporating a force-sensitive resistor and a microcontroller that records depressions of wall-mounted soap and alcohol gel dispensers. The device has a two-second (2 s) lockout built into it, so that a single record is associated with a single hand-hygiene episode. Recorders were implanted within the wall-mounted dispensers found in two bed areas and the entrance of a 16-bedded intensive care unit. The use of the bed area dispensers was correlated (r) with the dependency of the patient in the open bed area ($r = 0.5$, $P < 0.01$), as assessed using the UK Department of Health critical care minimum data set. Both bed areas and the entrance dispensers showed wide but different fluctuations in use throughout the 24 h day. The recording device may help in feedback about soap and gel use for hand-hygiene quality improvement and educational initiatives.

Introduction

Hand hygiene is a fundamental intervention in the control of healthcare-associated infection (HAI) transmitted by staff contact.[1] It is therefore disappointing that poor compliance with hand hygiene is common in critical care areas where patients are particularly vulnerable to HAI.[2] Many attempts to improve hand hygiene have been described in critical care; these improvement efforts require some measure of performance to show whether the interventions have resulted in a sustained improvement.[3–5] Feedback to staff about their performance is also very important in most areas of staff development and is used in many educational interventions to improve hand hygiene.[6–8]

In this study we describe an electronic device for recording the use of wall-mounted soap and

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alcohol gel dispensers in an intensive care unit (ICU) and we present some initial results obtained using the device. The device gives a new opportunity to provide feedback about compliance with hand hygiene.

Methods

The local research ethics committee approved the study.

The recorder was designed to record depressions of the levers of the fixed wall-mounted alcohol gel and soap dispensers when used to dispense soap or gel for hand decontamination. It recorded no more than one episode every 2 s so that dispensing several aliquots of solution for one handwashing episode would only be recorded as a single episode.

The recorder was powered by a 9 V PP3 battery and consisted of the following main components: a force-sensitive resistor (FSR) (Model 402, Steadlands International Marketing Ltd, PO Box 41, Blyth, Northumberland, UK) and a BASIC stamp (BS2-LC, Milford Instruments, Leeds, UK). The FSR is a polymer thick-film device whose internal electrical resistance decreases (non-linearly) in response to an increasing pressure applied to its surface; whilst the BASIC stamp is a general-purpose microcontroller (tiny computer) that may be used as a controlling and/or recording device. Each BASIC stamp comes with a BASIC programming language interpreter chip, internal random access memory (RAM) and electronically erasable programmable read-only memory (EEPROM). Also provided is a 5 V regulator, a number of general-purpose input/output pins and a set of built-in commands for maths and input/output operations. These stamps are capable of running a few thousand instructions per second and are programmed with a simplified, but customized, form of the BASIC programming language called PBASIC.

The FSR formed one of the 'arms' of a potential divider circuit, and was strategically mounted behind the push button within standard GoJo Purell alcohol gel dispensers (GoJo industries, Akron, OH, USA) and Johnson—Diversey Lever-line soap dispensers (Johnson—Diversey UK, Northants, UK). At each button press of the dispenser, a pressure was applied to the resistor, which was then 'communicated', via the integrated electronic circuit, to the BASIC stamp as an event having occurred. There was an inherent latency programmed into the stamp that delayed the recording of the next event until 2 s had passed. This latency was required so that a distinction could be made between multiple presses by the same individual and a new demand for gel by another person, since the purpose of the study was to record numbers of handwashes per day. The 2 s lockout was chosen after a period of observation of practice on the ICU.

Each time an event was recorded, an internally programmed variable was incremented by one. The BASIC stamp was pre-programmed to sum the number of 'events' occurring within a 10 min interval, and then store this total number into one of its memory bins within the onboard non-volatile RAM for retrieval at a later time. The BASIC stamp was capable of storing up to 1450 numbers, which was equivalent to 10 days (14 500 min) worth of data. The electronics consumed $\sim$1 mA of current and was capable of running for 30 days using a 9 V 'Ultralife lithium power cell' or for seven days using a long life 9 V PP3 battery.

Once collected, the data were downloaded from each BASIC stamp under program control via the serial communications port of a PC-compatible computer, and stored as a comma delimited text file. This file was subsequently loaded into a Microsoft Excel spreadsheet for further data analysis.

The device was assessed by placing it in a number of soap and alcohol dispensers in the hospital's ICU. The unit is a 16-bedded mixed general and neurosurgical unit admitting 650 patients a year with a mean APACHE (Acute Physiological Assessment and Chronic Health Evaluation) score of 16 (SD: 7).[9] It has two side rooms which are generally used for patients who are immunocompromised or have transmissible infections or for other patients to allow a unit bed occupancy of over 95% for all 16 beds. The unit has two entrances; both visitors and staff use the main entrance. Figure 1 shows the layout of the main entrance and the side room and open bed area used in the study with the position of the sinks; the monitored wall-mounted soap and alcohol gel dispensers were located above these sinks. Visitors are asked, if possible, to visit between 13:00 and 20:00. The unit is required to collect data to inform the UK Department of Health critical care minimum dataset (CCMDS) which measures the number of organs supported for each critical care day.[10] The respiratory and cardiovascular systems can receive either basic support (for example more than 50% oxygen by face mask or vascular monitoring) or advanced support (for example mechanical ventilation or measurement of cardiac output). We use this data collection to allocate a dependency score based on the information shown in Table I.

In addition to the fixed alcohol gel and soap dispensers above the sinks at each bed area and the entrances to the unit, alcohol gel dispensers