Evaluation of Microcontroller Wireless Technology to Enable a Smart Connected Intensive Care Unit (ICU)

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Microcontrollers and Single Board Computers (SBCs) are small but powerful computers that have the potential to transform modern medical working environments. These devices are portable, cost effective, and have a wide variety of peripheral input and output devices. The rapid emergence of new technologies such as smart pumps, vital displays, and other smart bedside tools in healthcare provides an opportunity to improve the overall system's performance, but may also contribute to overall system's complexity. Ergonomists have taken interest in studying the complex medical environments with the overarching goal of diminishing the cognitive demand on the user to reduce medical errors. The Intensive Care Unit (ICU) is a complex environment where patients require complex care. The complexity of care, procedures, and medications involved can lead staff to commit medical errors (Slonim, LaFleur, Ahmed, & Joseph, 2003; Valentin et al., 2009). For example, while the development of automated drug infusion devices permits a constant medicine supply, setting up the device can be challenging and may result in an error (Nolan, 2000). In addition, having to manage numerous pumps simultaneously creates an error-prone complex environment. Errors can occur due to interruptions that cause a loss of focus on the task (Leape, 1997). External events such as interruptions can also disrupt the system users and take their cognitive focus away from the task-at-hand (Sasangohar, Donmez, Easty, Storey, & Trbovich, 2014). Mitigation of unnecessary interruptions is important to ensure the quality of patient treatment is intact and the working environment is safe. Microcontroller and SBC technology has made a positive impact in the medical working environment. In our previous studies, we developed and evaluated a Task Severity Awareness Tool (TAT) to enable nurses to inform others when a high-severity task such as medication administration is being performed. We implemented this tool in a cardiovascular intensive care unit (CVICU) of a Canadian teaching hospital. This tool consists of three actuators (two buttons and one foot pedal) located at the bedside, and a scrolling LED display on the outside of the CVICU room connected to a microcontroller. When any of the actuators is pressed, the microcontroller detects the input, and as an output the scrolling LED display lights up with a "do not disturb" message. This tool led to the mitigation of unnecessary interruptions that could distract nurses when performing high-severity tasks (Sasangohar, Donmez, Easty, & Trbovich, 2015). The ICUs of the future are in dire need of creative solutions to improve the quality of care while not putting additional perceived complexity load on the personnel. Work is in progress to improve the Task-Severity Awareness Display system, by utilizing several wearable actuators that establish a wireless communication. Bluetooth technology and internet connectivity are readily available, and inexpensive. This enables a connected smart system that can include several devices including pumps, vital sign displays, medication records, all connected through simple but powerful Microcontrollers and SBCs. Microcontrollers and SBCs are inexpensive devices that offer a wide range of inputs and outputs that can aid solve interoperability between tools in the ICU, and aid system users by reducing the cognitive workload, as the data of multiple devices can be centralized. Work is in progress to utilize these tools to design several systems to improve nursing task performance in ICU.

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