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Title: A real time system to warn carers that a patient, at risk of falling, is leaving the bed

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Introduction:

Primum non nocere. "First, do no harm". It is a principle deeply engraved into the minds of those in the medical profession, yet, unfortunately, some patients admitted to a hospital suffer a 'serious adverse event' and end up worse off. While some of these events aren't avoidable, some can be prevented- notably the incident of patient falls.

Patient fall injuries account for 52 per cent of serious adverse events in hospitals and present a significant problem for all district health boards. It mainly affects older people, causing psychological trauma, physical injury and occasionally death. As well as affecting the patient, it is also a burden on our healthcare system- with longer hospital stays and extra medical attention a result of most falls.

While there are various fall detection systems are available on the market, a system which can effectively prevents a fall event before it happen has yet to be developed. With 80 percent of falls occurring around the hospital bed, developing a solution targeting this hotspot is an appropriate place to start.

Aims:

We developed a real-time system to predict when a patient is leaving the bed, warning support staff of an imminent fall event. This project is part of a larger initiative which is broken down into three stages:

I. Background research and proof of concept.
- In this stage we review the range of fall management systems currently available and evaluate the risk factors involved in a fall. We will then propose and develop working prototypes as a proof of concept.

II. Design cycle.
- In stage II we assess our prototype iterations, testing the performance and refining its capabilities into a fully functional system.

III. Trial and testing.
- In the latter stage we will evaluate our prototype performance in a real world setting and measure its effectiveness in preventing patient fall events.

Methods:

For the initial phase we identified the risk factors involved in a fall and reviewed the prevention strategies currently available. Subsequently, we conducted interviews with staff at Christchurch Hospital, focusing on those working in departments identified as having a high risk of patient falls. We then proposed a range of systems able to track a patient's position on a bed and, with the engineering department at Canterbury University, an initial 'proof-of-concept' prototype was developed. Further prototype development into a robust

system able to monitor a patient's movement and orientation on a hospital bed is underway.

Results:
From our interviews we identified the major criteria required to guide the development of a novel fall prevention system. These include a system which:

- is simple to use
- can be easily integrated into the current hospital setup
- is able to alert specific support staff, as well as those around the patient
- has a low rate of false alarms

Taking into account the above criteria, we decided to implement a system using a wireless technology called Bluetooth (BLE). By measuring the strength of a wireless Bluetooth signal we are able to get a value, called the RSSI (received signal strength indicator) value. This value varies with the distance from the transmitting source, thus we can determine the distance between two sensors.
By placing a sensor on the patient's feet (like an ankle bracelet), and another on a fixed point of their bed, we can monitor the patient's movement and predict if they are trying to get out of the bed; alerting nurses to provide assistance and avoiding the risk of a fall.
Our early prototype was developed using open-sourced hardware (an Arduino Uno-compatible microcontroller with a Bluetooth module). For monitoring we created a mobile application on the Android operating system to process the Bluetooth signal.
Early performance test showed a detectable change in RSSI value up to a range of 2 meters from the transmitting device, with a percentage error ranging from 3-4%; its accuracy fluctuating when exposed to a physical obstruction between the sensors.

Conclusion:
Future plans include improving the algorithms used to obtain the RSSI value and the implementation of additional sensors, e.g. a gyroscope and accelerometer, to provide a dynamic detection system able to warn carers of an approaching fall event.
While there may be limitations to the technology, the measure of RSSI value has shown to be an effective indicator of distance, and the integration of Bluetooth sensors in a fall prevention system has shown promising potential.