FEASIBILITY OF A NOVEL SMART SENSOR PLATFORM FOR MONITORING PATIENTS AT RISK OF PRESSURE INJURY IN A POST-ACUTE CARE FACILITY

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Interface pressure (IP) and skin microclimate have been identified as critical risk factors in pressure injury (PI) development.[1] Inpatient prevention and management protocols rely on two methods (i) Risk Assessment Scales[2] and (ii) head-to-toe skin assessments often completed by nurses. Comprehensive care planning involves addressing all identified risks, tailored to the individual's needs.[3]

Relieving IP where high levels are suspected is fundamental to PI prevention protocols. The accurate measurement of pressure exerted in a particular area (positioning) and how long a patient remains in one position (mobility) can be challenging.[4] Evidence-based advice about optimal repositioning remains inconsistent.[5,6]

Skin microclimate is influenced by the combined effects of temperature and humidity/moisture. Individuals with incontinence-associated dermatitis are five times more likely to develop PI.[7] Yet, continuous monitoring of microclimate is currently not possible in most clinical settings. Reviews of monitoring technologies show that sensor devices are associated with a substantial reduction in the risk of PIs.[8]

Objective

To evaluate the ability of a smart surface platform to measure clinical data on patient mobility and skin microclimate simultaneously and to compare data generated to scheduled nursing observations in line with clinical protocols.

Methods

This prospective trial was conducted at a single tertiary care facility in a large urban centre in Canada. Ethics approval was granted. All staff on the study units received training in recruitment and study protocols.

The eligible population was recruited from complex continuing care and post-acute care rehabilitation settings. Inclusion criteria were adults, hospitalized for > 18 hours, at-risk of pressure injuries, as defined by the InterRAI Pressure Injury Risk Assessment Scale with or without a current pressure injury.

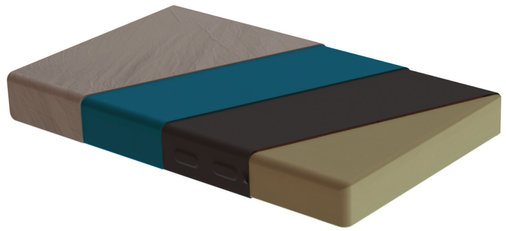

Figure 1: A cross-sectional view of the smart surface platform installed over a mattress. The smart surface platform comprises an array of sensors embedded in a thin, flexible surface placed underneath bed sheet. It is not in direct contact with the patient.

Participants received standard of care, including manual repositioning as appropriate, while placed on the smart surface for timed intervals. Nurses completed a baseline assessment at the start of the 8-hour period (time point T0). Following the same protocol at 3-hourly intervals (timed to coincide with manual turns where applicable), any changes from baseline (T0) or the previous assessment (T1-5) were noted.

Results

A total of 104-patients met the inclusion criteria and participated in the study. Mean age was 59 years (range 21-92, ± 19.15). Nurse observations totalled 511. The 1,407 sensor monitoring hours generated 1,101,780 frames of surface data.

	Nurse recorded events selected for analysis	Number of events identified using smart surface platform data	Inter-rater reliability	Naïve model inter-rater reliability
Interface pressure visualization	Total patient positions recorded n=630	Patient positions correctly identified by raters n=603	95.7 % (95% CI=(94%,97%))	61.1%
Humidity	Total events recorded n=132	Events identified using sensor humidity data n=125	94.6 % (95% CI=(89%,98%))	70.5%
Temperature	Total events recorded n=132	Events identified using sensor temperature data n=115	87.1% (95% CI=(80%,92%))	70.5%

Table: Overview of trial results. All tests of equal or given proportions between smart surface inter-rater reliability and naïve model inter-rater reliability produced p-values of less than .05.

Sensors gathered data from the subject's bedding surface in the form of interface pressure (mmHg), temperature (Celsius) and humidity (0-100% RH) at four second intervals. For the initial analysis, data related to mobility/activity status were extracted from the head to toe assessment forms. A comparative statistical analysis was conducted between the two datasets.

To establish inter-rater reliability (IRR) of IP data, classifications of sensor data by three independent raters were compared to patient position(s) recorded by nurses. For microclimate (temperature and humidity), IRR was established by comparing results of a model that classifies whether given data represented wetness event and comparing it to the classification inferred from nurse recorded moisture comments. A naïve model was employed that used the most common nurse observation as a prediction.[9] Testing the difference between the achieved IRR and the IRR of the naïve model was conducted using the two-sample test for equality of proportions with continuity correction (R function prop.test).

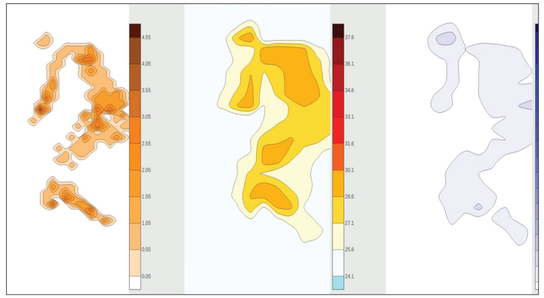

Figure 2: Interface pressure(PSI), relative humidity(% RH), and temperature(°C) visualizations of a patient in right fetal position. Generated from Smart Surface Platform sensor data.

Discussion

The study results demonstrate the smart sensor platform's ability to collect IP and microclimate data that correlate with nurse assessment data. The preliminary analysis shows the potential of continuous monitoring to simultaneously identify events including self-turns, urinary incontinence and patient temperature changes remotely. The large volume of data collected forms a basis for artificial intelligence applications (e.g., IP visualizations to train machine learning algorithms to detect self-turns). Existing PI prevention protocols that rely on intermittent physical assessment of mobility, temperature and humidity limit care providers' ability to identify risks, deliver personalized care and measure the effectiveness of interventions.[6] This technology has the potential to improve the allocation of limited nursing resources. It can decrease unnecessary interventions and inform targeted management strategies.

Conclusion

Manual repositioning and visual inspection of skin require resources, especially time, that may be limited due to high patient acuity and competing demands. The study shows statistically significant inter-rater reliability between nurses' intermittent physical assessments and sensor-generated data of both patient mobility (IP) and skin microclimate (humidity and temperature). The novel smart sensor platform can continuously measure PI risk factors accurately. This has the potential to enhance PI prevention approaches.

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