

Saint John's Health Center Health Economic Analysis

Wearable, wireless monitoring of vital signs with Sensium: a health economic analysis of the Saint John's Health Center pilot study

Abstract

Sensium was used to monitor heart rate, respiration rate and temperature in 168 patients in the general ward setting of Saint John's Health Center, California. Sensium notified nurses of deterioration in 12% of the patients. A retrospective study was conducted to compare

length of stay and direct medical costs. The results of this economic analysis showed an average reduction in length of hospital stay of 3.9 days and a cost saving of \$5500 for patients identified by Sensium as having deteriorated.

Introduction

Vital signs are typically measured at four- to six-hour intervals in hospitalized patients who are not receiving intensive care.¹ Patients can experience unexpected clinical deterioration, which can remain unnoticed if it occurs between routine measurements.^{1,2,3}

In response to clinical evidence and adverse media reports^{4,5,6}, recommendations have been made by the Royal College of Physicians and Royal College of Nursing for the adoption of a 'track and trigger' approach based on a set of "Early Warning Scores" (EWS or NEWS^{13,14}). A score is often calculated from the combination of seven parameters to highlight patients in need of immediate treatment and/or closer monitoring.

Despite these new measures, reports into patient outcomes have found that deaths and admissions to the intensive care unit might have been avoided if the patient's clinical deterioration had been noticed earlier.^{15,16,17,18}

Significant changes in one or more vital signs often occurs several hours before patient

deterioration is noted^{3,7,8}. Early identification of such adverse physiological changes provides a valuable time for efficient intervention of patients at risk, in order to stabilise their condition and prevent more serious complications. Recent studies^{1,2} have shown that continuous monitoring of vital signs can:

- reduce the overall length of time that patients spend in hospital
- reduce the number of days in the intensive care unit after a deteriorating patient has been transferred

For example, some studies have revealed that early identification and timely intervention in sepsis can improve patient outcomes and reduce mortality.^{9,10}

Increasing the frequency of monitoring of patients using traditional methods can be challenging for ward personnel – i.e. extremely labour intensive for nurses and can cause distress to patients, particularly at night when they wish to sleep.¹

Wireless technologies have now progressed to the point where they can provide the ability to monitor patients' status continuously without the inconvenience for the patient of being tethered to a cumbersome bedside monitor, allowing them to ambulate freely within the hospital.

However, in the increasingly cost-constrained health services environment, it is crucial for any new technology to demonstrate not only improved patient outcomes, but also that it delivers significant health economic benefits.

Sensium Wireless Patient Monitoring Solution

Sensium uses a disposable, lightweight (15g), ultra-low power, wireless digital patch, with a battery life of five days. It is designed to monitor patients' vital signs at two-minute intervals to enable early detection of clinical deterioration.

The Sensium patch is attached to the patient's chest using standard ECG pre-gelled electrodes. It contains a custom chip, which runs a number of embedded algorithms that allow patients to be monitored unobtrusively whilst moving about freely on the general ward or in the emergency department. The information obtained is transmitted directly to the nurses' station and clinicians and nurses can also set up notifications on their handheld devices or mobile phones (Figure 1). The patch is discarded when the patient is discharged, meaning that cleaning and sterilization for cross-contamination are not required.

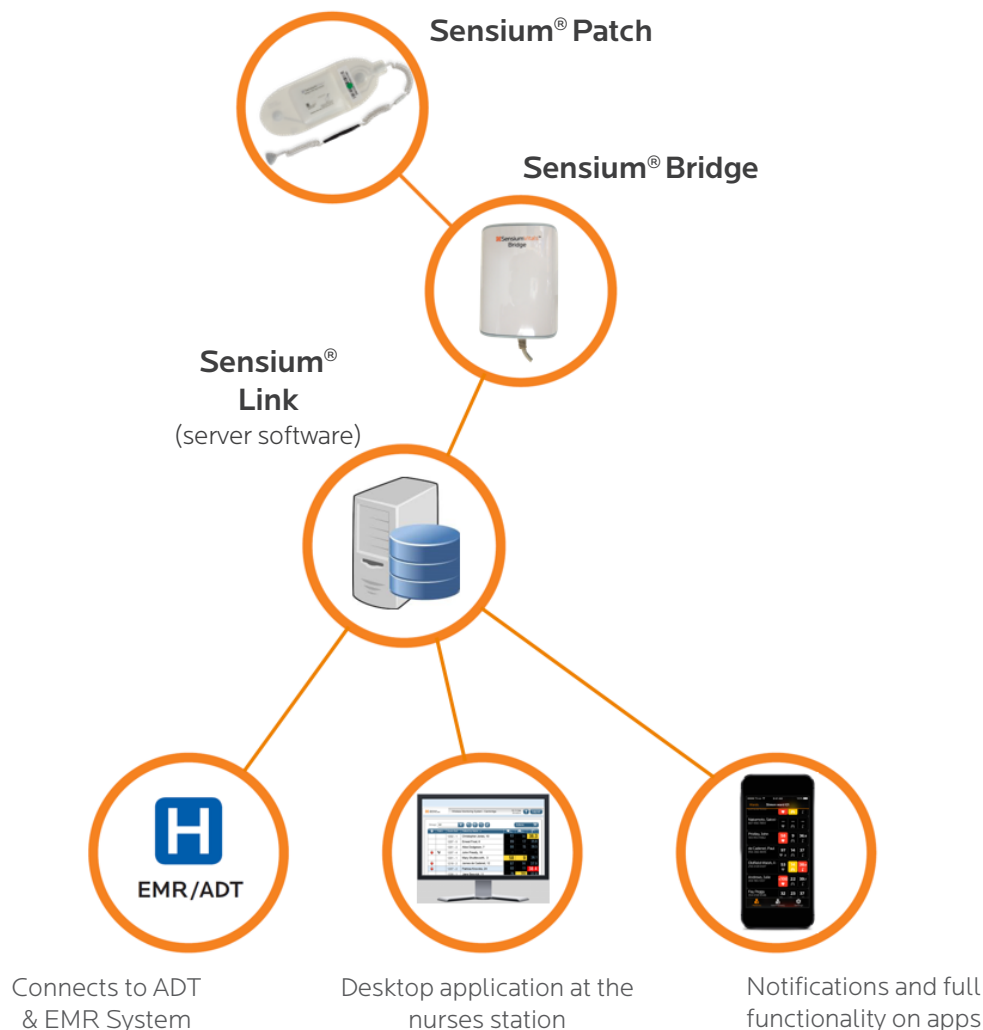


Figure 1. The end-to-end system for continuous wireless monitoring with the Sensium patch.

The Saint John's pilot study¹¹

One of the first studies to assess the effectiveness of Sensium and its acceptability to hospital staff and patients was carried out at Saint John's Health Center in California. Sensium was used to monitor heart rate, respiration rate, and axillary temperature in 168 patients (mean age 69.3 years) hospitalised in the general ward, and who presented with a variety of conditions. All nurses who took part were fully trained in the use of Sensium.

Patients who were 18 years or over who were not currently on telemetry or using a pacemaker or implanted defibrillator were eligible to take part in the study. Patients who had an open wound at the patch attachment site or who were allergic to ECG electrodes or medical-grade tape were not

eligible for inclusion. All patients gave informed consent.

In addition to various measures (such as acceptability of the system among nurses and patients, and the perceived usefulness of the system), the key outcome was the detection of patient deterioration. Sensium notified nurses of deterioration in 12% of the patients monitored in the trial. Furthermore, there were no reported incidents of patient deterioration that the system had failed to detect. Therefore, it was concluded that Sensium is effective for detection of adverse physiological events before the onset of clinical deterioration; thus enabling earlier treatment of patients at risk and improving patient safety.

Cost-effectiveness of Sensium

Following the assessment of Sensium at Saint John's, a health economics study was carried out by Analysis Group Inc (Boston, Massachusetts, USA) to discover whether these findings also resulted in cost savings for the hospital.

Design and methods

The study matched patients from the Saint John's pilot study with a retrospective group of control patients from US claims databases to establish and compare the length of hospital stay and the direct medical costs between groups.

As the patient group from the pilot study contained adult patients above and below 65 years of age, two different databases were used to identify suitable control patients:

1. The OptumHealth database contains approximately 13.7 million health insurance claims from privately insured patients and their dependants for inpatient medical services including diagnoses, procedures, charges billed, and amount reimbursed. Claims used were from patients aged 40-64 years between Q1 2009 and Q1 2012
2. For patients aged 65 years or more, the Medicare database was used. This contains claims from 3.5 million people for the same services as the OptumHealth database.

Claims used were from patients aged 65-108 between Q1 2010 and Q1 2012

The criteria used to match the two groups of patients at baseline are listed in Table I.

- Hospitalization during the data collection period
- Exact match to the Saint John's patient in terms of primary diagnosis (ICD-9-CM codes)
- Same gender
- Matching birth date within ± 10 years of the Saint John's patient
- No use of a pacemaker, neurostimulator, ventricular assist device, or implanted defibrillator before hospitalization (ICD-9-CM codes), i.e. patients who would be appropriate candidates for SensiumVitals[®].

Table I. Selection criteria for control group patients.

Age (years)	Gender	Primary diagnosis	Matched patients without additional diagnoses	Matched patients with additional diagnoses	Total number of matched patients
86	F	Chronic obstructive asthma with acute exacerbation	285	288	573
69	M	Intestinal or peritoneal adhesions with obstruction (postoperative) (post infection)	156	78	234
75	F	Hypo-osmolality and/or hyponatraemia	612	381	993
89	F	Aspiration pneumonia due to inhalation of food or vomitus	672	693	1365
67	M	Neutropenia, unspecified	61	82	143
73	F	Abdominal pain, right lower quadrant	25	21	46
75	M	Other and unspecified non-infectious gastroenteritis and colitis	204	141	345
90	M	Unspecified septicaemia	441	1447	1888
62	M	Venous (peripheral) insufficiency, unspecified	44	37	81
67	F	Unspecified septicaemia	622	1381	2003
53	M	Secondary diabetes mellitus with hyperosmolarity, not uncontrolled	17	36	53
56	M	Hepatorenal syndrome	2	15	17
45	M	Acute pancreatitis	593	917	1510
53	M	Diverticulitis of colon without mention of haemorrhage	1076	1357	2433
57	F	Unspecified drug abuse	2	8	10
87	M	Unspecified septicaemia	587	1750	2337
82	M	Dehydration	561	315	876
92	M	Aspiration pneumonia due to inhalation of food or vomitus	492	437	929
103	F	Unspecified septicaemia	50	196	246
97	F	Urinary tract infection, not otherwise specified	1199	998	2197

Table II. The cohort of deteriorating patients and their matching controls from the OptumHealth (40-64 years of age) and Medicare databases

A total of 18,279 control patients from the two claims databases met the selection criteria for inclusion in the analysis; the number of matching controls for each Sensium patient ranged from 10 to 2433, as shown in Table II.

The comparison between the cohort of 20 patients where deterioration was detected in the Saint Johns trial (12%) and the control patients from the two databases was carried out in a number of ways to obtain the maximum amount of information.

Average costs were obtained through:

An overall comparison of costs, using the entire control sample

- A comparison between trial cohort patients and database patients who had no additional diagnoses during their stay in hospital
- A comparison between trial cohort patients and database patients who had at least one additional diagnosis during their inpatient stay

The costs for each Sensium patient were compared to those of the matched patients in the control sample. The average costs of the trial cohort were compared to the costs, averaged by diagnosis, of the entire control sample.

Results

The results of this economic analysis showed an average reduction in length of hospital stay of 3.9 days for patients identified by Sensium as having deteriorated, when compared to the matched control group, averaged by primary diagnosis.

Summary Comparison	Reduction in length of hospital stay with Sensium	Overall cost saving
Control patients	-3.9 days per patient	-\$5506 per patient

Table III. Economic benefit of Sensium for patients for which the system captured deterioration compared to those without Sensium, on the basis of matched primary diagnosis, age and gender.

Conclusions

This health economic analysis supported the clinical benefits observed with Sensium in the pilot study carried out at Saint John's Health Center in California. When the trial cohort who experienced deterioration (20 Sensium patients) were matched to a total of 18,279 control patients from US claims databases:

- Classifying the patients by diagnosis, an overall cost saving of approximately - \$5500 was achieved versus control patients, whether or not they had additional diagnoses.
- These patients had approximately four days shorter length of hospital stay versus the control group, which translated to cost savings versus matched control patients.

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