Summaries and Abstracts from Sensium publications

	Title	Year	Journal
1	Monitoring of High- and Intermediate-Risk Surgical Patients	2019	Anesthesia & Analgesia
2	Continuous versus intermittent vital signs monitoring in patients admitted to surgical wards: a cluster-randomised, controlled trial	2018	Journal of Medical Internet Research
3	Early diagnosis of atrial fibrillation using a E-health application	2018	The American Journal of Emergency Medicine
4	Patient attitudes towards remote continuous vital signs monitoring on general surgery wards	2018	International Journal of Medical Informatics
5	Preliminary assessment of the SensiumVitals® System: a low-cost wireless solution for patient surveillance in the general wards	2015	35th Conference of the IEEE EMBS
6	Assessment of the feasibility of an ultra-low power, wireless digital patch for the continuous ambulatory monitoring of vital signs	2015	BMJ Open
7	Advances in Ultra-Low-Power Miniaturized Applications for Health Care and Sports	2013	Novel Advances in Microsystems Technologies and their Applications
8	Ultra-low-power semiconductors for wireless vital signs early warning systems	2011	Electronics Letters
9	Health-care electronics: The market, the challenges, the progress	2009	EDAA
10	Sensium: An Ultra-Low-Power Wireless Body Sensor Network Platform: Design & Application Challenges	2009	31st Annual International Conference of the IEEE EMBS
11	Energy Efficient Medium Access Protocol for Wireless Medical Body Area Sensor Networks	2008	IEEE Transactions on Biomedical Circuits and Systems, vol. 2, no. 4, December 2008
12	A 1 V Wireless Transceiver for an Ultra-Low-Power SoC for Biotelemetry Applications	2008	IEEE Journal of Solid-state Circuits
13	1V 14uW Switched-Opamp ADC for Bioelectric Data Acquisition	2007	Proceedings of the 4th IEEE-EMBS
14	Optimal Transmission Frequency for Ultralow-Power Short-Range Radio Links	2004	IEEE Transactions on Circuits and Systems —I: regular papers

1. Monitoring of High- and Intermediate-Risk Surgical Patients

Linda Maria Posthuma, MD, Maarten Joost Visscher, MD, Markus Werner Hollmann, MD, PhD, and Benedikt Preckel, MD, PhD
Anesthesia & Analgesia August 2019

Abstract summary

The publication from the Department of Anesthesiology at Amsterdam University Medical Center, reviews elements of rapid response systems for recognising deteriorating patients on the ward and suggests possible further improvements for clinical settings. The publication states that 'Some systems measure vital signs accurately, like the SensiumVitals system (Sensium Healthcare, London, UK). This is a wireless patch measuring respiratory rate, heart rate, and temperature every 2 minutes.'

The review highlights that 'monitoring vital signs might improve early recognition of a deteriorating patient because adverse events (AEs) preceded by changes in vital signs in most patients'. Research reported a '5.7% incidence of AEs in hospitalized patients in the Netherlands. Forty percent of the AEs were preventable. More than half of these AEs were related to surgical procedures.'

It is recommended, although not often practiced, that 'vital signs/MEWS measurement takes place at least once every 6–12 hours on the ward'. Early Warning Scores have been introduced to highlight patients at risk for critical events when their vital signs are deranging from predetermined baseline/cut off scores. However 'timely and accurate monitoring of vital signs is a crucial first step in providing adequate input for EWS systems'. The review emphasises that changes in respiratory rate seem to be the most important predictor of clinical deterioration.

The publication defines remote wireless monitoring as 'technology whereby patients wear a non-invasive sensor that measures physiological variables' with the advantage being that vital signs are constantly measured. 'Wireless monitoring technology sometimes rejects data when, for instance, vital signs measurement is distorted due to severe motion artefacts. Hence, only accurate data is transferred to the caregivers. Accurate vital signs are available 50%–96% of the time, thus far more frequently than when vital signs are measured manually'.

Introducing remote monitoring technology requires significant implementation and the report highlights that 'caregivers need to realize that the system provides for a reduction in workload because vital signs monitoring is time consuming and stressful, particularly at night, when the nurse: patient ratio declines.'

The publication concludes that elements of rapid response systems need further improvement, and education and training are essential. 'Remote monitoring systems can support caregivers in the afferent arm of the system by measuring vital signs continuously and most importantly in an accurate manner.'

Link:

https://journals.lww.com/anesthesia-analgesia/Citation/publishahead/Monitoring_of_High__and_Intermediate_Risk_Surgical.96036.aspx

Status:

Summaries and Abstracts from Sensium publications

SensiumScience
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2. Continuous versus intermittent vital signs monitoring in patient admitted to surgical wards: a cluster-randomised, controlled trial

C. Downey, R. Randell, J. Brown, D. Jayne
Journal of Medical Internet Research December 2018 20(12):e10802

Abstract summary

Aims:

Vital signs monitoring is a universal tool for the detection of postoperative complications, but unwell patients can be missed in between traditional observation rounds. New remote monitoring technologies promise to convey the benefits of continuous monitoring to patients on general wards. The aim of this study was to evaluate whether continuous remote vital signs monitoring is a practical, acceptable and effective way of monitoring surgical patients.

Methods:

A cluster-randomised, controlled study was performed. Patients admitted to two surgical wards at a large tertiary hospital received either continuous and intermittent vital signs monitoring, or intermittent monitoring alone. The primary outcome measure was time to administration of antibiotics in sepsis. Secondary outcome measures included length of hospital stay, 30-day readmission rate, mortality and patient acceptability.

Results:

350 patients were recruited between January and June 2017. 140 patients received continuous remote monitoring and 210 received intermittent monitoring alone.

On average, patients receiving continuous monitoring:

- Administered antibiotics on averages six hours faster after evidence of sepsis
- Had a 10% shorter average length of hospital stay
- Were on average 45% less likely to require readmission within 30 days of discharge

Patients found the monitoring device to be acceptable in terms of comfort and perceived an enhanced sense of safety.

Conclusions:

Remote continuous vital signs monitoring on surgical wards is practical and acceptable to patients. Large, well-controlled studies in high-risk populations are required to determine if the observed trends translate into a significant benefit for continuous over intermittent monitoring.

Link:

https://www.jmir.org/2018/12/e10802

Status:

Open access to published article

3. Early diagnosis of atrial fibrillation using a E-health application

Aiham Daniel Ghazaliab, Christophe Choqueta, Enrique Casalinoac
The American Journal of Emergency Medicine
June 2018

Summary:

A case report from the Emergency Department, University Hospital of Bichat, Paris, details the rapid diagnosis of a cardiogenic pulmonary edema in an elderly patient who was suffering from pneumonia and atrial fibrillation (AF).

The routine use of the Sensium System in this clinical setting allowed a timely clinical intervention and ensured that this patient avoided a potentially serious deterioration that could have led to a cardiac arrest.

Cardiac events occur relatively commonly in patients with acute community-acquired pneumonia. In the elderly, pneumonia can cause heart failure and is proven to be a trigger for AF.

In this particular Emergency Department, patients requiring oxygen for pneumonia are clinically monitored by nurses performing manual observations with a maximum frequency of three or four times per day. These patients are also continuously monitored using the Sensium System. With this wireless monitoring in place, the physicians are proactively notified of abnormal changes in patients' vital signs suggestive of patient deterioration.

The 82-year-old female patient presented with high temperature and tachypnea and was diagnosed with bacterial right lower lobe pneumonia. The patient was treated with oxygen therapy (2 l/min) and a respiratory rate of 18bpm was noted. The patient was monitored with manual observations at 8-hour intervals and also continuously monitored with the Sensium technology.

During the night shift Sensium notified of a sudden increase in heart rate and the following clinical examination found an abnormal left ventricular systolic function and arrhythmia, an electrocardiogram then confirmed a diagnosis of AF.

This case demonstrated that the Sensium System was effective as an aid to early diagnosis. The Sensium notifications and trends allowed the clinician to hypothesise the presence of AF in a context of pneumonia, and to use this information to rapidly diagnose a cardiogenic pulmonary edema.

The prompt treatment allowed the patient to avoid a potentially life-threatening deterioration that could have led to a cardiac arrest.

Link:

https://www.sciencedirect.com/science/article/pii/S0735675718305436

Status:

4. Patient attitudes towards remote continuous vital signs monitoring on general surgery wards: An interview study.

C.L. Downey, J.M. Brown, D.G. Jayne, R. Randell
International Journal of Medical Informatics
Volume 114, June 2018, Pages 52-56

Background:

Vital signs monitoring is used to identify deteriorating patients in hospital. The most common tool for vital signs monitoring is an early warning score, although emerging technologies allow for remote, continuous patient monitoring. A number of reviews have examined the impact of continuous monitoring on patient outcomes, but little is known about the patient experience. This study aims to discover what patients think of monitoring in hospital, with a particular emphasis on intermittent early warning scores versus remote continuous monitoring, in order to inform future implementations of continuous monitoring technology.

Methods:

Semi-structured interviews were undertaken with 12 surgical inpatients as part of a study testing a remote continuous monitoring device. All patients were monitored with both an early warning score and the new device. Interviews were audio recorded, transcribed verbatim and analyzed using thematic analysis.

Findings:

Patients can see the value in remote, continuous monitoring, particularly overnight. However, patients appreciate the face-to-face aspect of early warning score monitoring as it allows for reassurance, social interaction, and gives them further opportunity to ask questions about their medical care.

Conclusions:

Early warning score systems are widely used to facilitate detection of the deteriorating patient. Continuous monitoring technologies may provide added reassurance. However, patients value personal contact with their healthcare professionals and remote monitoring should not replace this. We suggest that remote monitoring is best introduced in a phased manner, and initially as an adjunct to usual care, with careful consideration of the patient experience throughout.

Link:

https://www.sciencedirect.com/science/article/pii/S1386505618302508

Status:

5. Preliminary assessment of SensiumVitals: A low-cost wireless solution for patient surveillance in general wards

M. Hernandez-Silveira; K. Wieczorkowski-Rettinger; S. Ang; A. Burdett
2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); 2015; pp.4931 - 4937

Abstract:

This paper presents SensiumVitals - an FDA cleared and CE marked wireless wearable vital signs monitoring system, developed for frequent surveillance of in-hospital patients. A number of in-house evaluations with artificial data and healthy volunteers were carried out in different stages to assess the reliability of two crucial vital signs measured by the system - respiration and heart rate. In order to illustrate the potential of the system in hospital, a subset of data collected from acutely-ill patients during a separate clinical trial was also analyzed. In all cases the results revealed satisfactory agreement between the values reported by SensiumVitals and those recorded simultaneously by a clinically-approved bedside monitor. However, further work will be required to improve the reliability of the system under certain clinical conditions; which, although not crucial for our intended population (i.e. patients in general ward), pose interesting challenges for upgrading our technology for future use in these types of patients.

Link:

http://ieeexplore.ieee.org/document/7319498/

Status:

6. Assessment of the feasibility of an ultra-low power, wireless digital patch for the continuous ambulatory monitoring of vital signs

Hernandez-Silveira M, Ahmed K, Ang S, et al
BMJ Open 2015;5 :e006606. doi: 10.1136 bmjopen-2014-006606

Abstract:

Vital signs are usually recorded at 4–8 h intervals in hospital patients, and deterioration between measurements can have serious consequences. The primary study objective was to assess agreement between a new ultra-low power, wireless and wearable surveillance system for continuous ambulatory monitoring of vital signs and a widely used clinical vital signs monitor. The secondary objective was to examine the system's ability to automatically identify and reject invalid physiological data. Overall agreement between digital patch and clinical monitor was satisfactory, as was the efficacy of the system for automatic rejection of invalid data. Wireless monitoring technologies, such as the one tested, may offer clinical value when implemented as part of wider hospital systems that integrate and support existing clinical protocols and workflows.

Link:

https://bmjopen.bmj.com/content/5/5/e006606

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7. Advances in Ultra-Low-Power Miniaturized Applications for Health Care and Sports

M. Hernandez-Silveira; S. Ang; A. Burdett
Chapter 20 in Novel Advances in Microsystems Technologies and Their Applications; Part V Ultra Low Power Biomedical Systems; Editors L.A. Francis, K. Iniewski; CRC Press; July 2017; pp.463 -496

Abstract:

This chapter provides an overview of the Sensium technology health-care platform, with an emphasis on the development, evaluation, optimization and implementation of embedded biomedical algorithms suitable for body-worn devices. The engineering process leading to the ultimate incorporation of these algorithms into microchips is described, and trade-offs faced when implementing the software within limited hardware resources, without compromising the performance in terms of accuracy and reliability of the information, are discussed. In summary, this chapter provides an explanation of our methodology towards implementation of ultralow-power health-care platforms, focusing on the low power microchips and embedded software components.

Status:

8.Ultra-low-power semiconductors for wireless vital signs early warning systems

P. Soon-Shiong; C. Toumazou; A. Burdett
Electronics Letters; 2011; Volume: 47(26); pp. S26 - S28

Abstract:

Most patients in hospital have measurements of their 'vital signs' taken and recorded only intermittently, thus deterioration can occur to a point of serious consequence before it is recognised. New technologies are being developed which allow increased surveillance of patients` status without the inconvenience of being physically attached to immobile monitoring systems, and thus allowing patients to move around their rooms and floor areas. The implementation of a small, low-cost, ultra-low-power and disposable vital signs monitor is described, made possible by the development of a semiconductor SoC - Sensium - which implements all the required electronic functionality in a few square millimetres of silicon.

Link:

https://ieeexplore.ieee.org/document/6111653/

Status:

9. Health-care electronics: The market, the challenges, the progress

Wolfgang Eberle; Ashwin S. Mecheri; Thi Kim Thoa Nguyen; Georges Gielen; Raymond Campagnolo; Alison Burdett; Chris Toumazou; Bart Volckaerts
2009 Design, Automation & Test in Europe Conference & Exhibition; 2009; pp.1030 - 1034

Abstract:

Exploding health care demands and costs of aging and stressed populations necessitate the use of more in-home monitoring and personalized health care. Electronics hold great promise to improve the quality and reduce the cost of health care. The speakers in this hot topic session will discuss the field of health care electronics from all aspects. First, the market of health care electronics is described, and realities, trends and hypes will be pointed out.

The second presentation describes the engineering challenges in ultra-low-power disposable electronics for wireless body sensor applications. Both the sensor aspects, the related signal processing, and business models will be discussed. The third presentation talks about embedded bio-stimulation applications in cochlea implants, thereby highlighting the design challenges in terms of power consumption and extreme reliability of these devices.

The final presentation discusses the application of brain stimulation and recording with respect to artifact reduction and field steering, and describes aspects of the modeling and design strategy. In this way, this hot-topic session offers the attendees a complete picture of the field of health-care electronics, ranging from the business to the technological and design aspects.

Link:

http://ieeexplore.ieee.org/document/5090815/

Status:

10. Sensium: an ultra-low-power wireless body sensor network platform: Design & application challenges

A. C. W. Wong; D. McDonagh; O. Omeni; C. Nunn; M. Hernandez-Silveira; A. J. Burdett
2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society; 2009; pp. 6576 - 6579

Abstract:

This paper describes the Sensium system-on-chip for wireless body sensor networks, which integrates a transceiver, hardware MAC protocol, microprocessor, IO peripherals, memories, ADC and custom sensor interfaces. As well as addressing design challenges, this paper also discusses applications of this technology to body worn monitoring for real-time measurement of ECG, heart rate, physical activity, respiration and/or skin temperature. Two application challenges are described; the real-time measurement of energy expenditure using the LifePebble, and the development challenges surrounding the 'Digital Patch'.

Link:

https://ieeexplore.ieee.org/document/5334001/

Status:

11. Energy Efficient Medium Access Protocol for Wireless Medical Body Area Sensor Networks

Okundu Omeni; Alan Chi Wai Wong; Alison J. Burdett; Christofer Toumazou
IEEE Transactions on Biomedical Circuits and Systems; 2008; Volume: 2(4); pp 251 - 259

Abstract:

This paper presents a novel energy-efficient MAC Protocol designed specifically for wireless body area sensor networks (WBASN) focused towards pervasive healthcare applications. Wireless body area networks consist of wireless sensor nodes attached to the human body to monitor vital signs such as body temperature, activity or heart-rate. The network adopts a master-slave architecture, where the body-worn slave node periodically sends sensor readings to a central master node. Unlike traditional peer-to-peer wireless sensor networks, the nodes in this biomedical WBASN are not deployed in an ad hoc fashion. Joining a network is centrally managed and all communications are single-hop. To reduce energy consumption, all the sensor nodes are in standby or sleep mode until the centrally assigned time slot. Once a node has joined a network, there is no possibility of collision within a cluster as all communication is initiated by the central node and is addressed uniquely to a slave node.
To avoid collisions with nearby transmitters, a clear channel assessment algorithm based on standard listen-before-transmit (LBT) is used. To handle time slot overlaps, the novel concept of a wakeup fallback time is introduced. Using single-hop communication and centrally controlled sleep/wakeup times leads to significant energy reductions for this application compared to more flexible network MAC protocols such as 802.11 or Zigbee. As duty cycle is reduced, the overall power consumption approaches the standby power.
The protocol is implemented in hardware as part of the Sensium system-on-chip WBASN ASIC, in a 0.13- mum CMOS process.

Link:

https://ieeexplore.ieee.org/document/4668460/

Status:

12. A 1 V Wireless Transceiver for an Ultra-Low-Power SoC for Biotelemetry Applications

Alan Chi Wai Wong; Ganesh Kathiresan; Chung Kei Thomas Chan; Omar Eljamaly; Okundu Omeni; Declan McDonagh; Alison J. Burdett; Christofer Toumazou
IEEE Journal of Solid-State Circuits; 2008; Volume: 43(7), pp.1511 - 1521

Abstract:

This paper presents a 1 V RF transceiver for biotelemetry and wireless body sensor network (WBSN) applications, realized as part of an ultra low power system-on-chip (SoC), the Sensium. The transceiver utilizes FSK/GFSK modulation at a data rate of 50 kbit/s to provide wireless connectivity between target sensor nodes and a central base-station node in a single-hop star network topology operating in the 862-870 MHz European short-range-device (SRD) and the 902-928 MHz North American Industrial, Scientific & Medical (ISM) frequency bands. Controlled by a proprietary media access controller (MAC) which is hardware implemented on chip, the transceiver operates half-duplex, achieving -102 dBm receiver input sensitivity (for 1E-3 raw bit error rate) and up to -7 dBm transmitter output power through a single antenna port. It consumes 2.1 mA during receive and up to 2.6 mA during transmit from a 0.9 to 1.5 V supply. It is fabricated in a 0.13 mum CMOS technology and occupies 7 mm2 in a SoC die size of 4 times 4 mm^2.

Link:

https://ieeexplore.ieee.org/document/4550651/

Status:

13. 1V 14uW Switched-Opamp ΔΣ-ADC for Bioelectric Data Aquisition

D. McDonagh; O. Eljamaly; A. J. Burdett
2007 4th IEEE/EMBS International Summer School and Symposium on Medical Devices and Biosensors; 2007; pp.147 - 150

Abstract:

In this paper, a 1 V DeltaSigma-ADC for bioelectric data acquisition is presented. Low power consumption is the major requirement in this design. Both the biquad low pass filter and the delta-sigma modulator are designed using switched-capacitors & switched-opamps. The low pass filter is used to limit the signal bandwidth to 100 Hz. The modulator is a 3rd order 1-bit topology. The sampling frequency and OSR are 32 kHz and 64 respectively. The digital filter is multi-stage & multi-rate to reduce power consumption. These circuits are a sub-part of a system-on-chip (SoC) for wireless body area sensor networks called the Sensiumtrade. The total area of the circuits is ~0.38 mm2. The ADC achieves 58 dB dynamic range (ENOB~9.6 bits) and consumes 14 uW of power.

Link:

https://ieeexplore.ieee.org/document/4338314/

Status:

14. Optimal transmission frequency for ultralow-power short-range radio links

D. C. Yates; A. S. Holmes; A. J. Burdett
IEEE Transactions on Circuits and Systems I: Regular Papers; 2004; Volume: 51(7); pp. 1405 - 1413

Abstract:

Analysis determining the optimal transmission frequency for maximum power transfer across a short-range wireless link is introduced, including a comparison of near-field transmission with far-field transmission. A new near-field power transfer formula has been derived, which allows direct comparison with the well-known far-field Friis transmission formula. Operating charts are presented, which provide the designer with the preferred transmission frequency as a function of distance and antenna dimensions, together with surface plots which show the power transfer for this frequency. The analysis, performed for loop antennas, has been used to evaluate the oscillator transmitter as a low-power topology. It is shown that the requirement of a high-Q factor to realize a low-power oscillator need not be contradictory to achieving optimal far-field radiation characteristics. Based on this fact an approach to sizing loop antennas for low-power oscillator transmitters is suggested.

Link:

https://ieeexplore.ieee.org/document/1310511

Status:

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