

# Advances in Wireless Vital Signs Monitoring

## Bringing the Hospital ER into the Field

Continuous Non-Invasive Blood Pressure and Remote  
Wireless Vital Signs Helps EMS Upgrade Trauma Treatment

## Signs of Life and Changes

Continuous Information Supports In-Time Actions

Realities That Challenge Healthcare

Wireless and an Evolving Healthcare Environment



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# Foreword

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**M**ost people's image of a hospital will include an array of monitoring equipment and/or the charts that accompany each patient to tell clinicians involved with their care what is the status of their vital signs. They are 'vital' signs because each of them records a function or condition on which the maintenance of life depends. But, like everything, monitoring those signs takes time. Traditionally, vital signs have been monitored intermittently with intervals varying according to the severity and stability (or lack thereof) of a patient's condition. However, when changes occur between monitoring events, there's the risk that, by the time they are picked up by the next vital signs check, either the remedy will need to be more drastic or, worst case, the change has gone too far. For this reason, continuous and wireless vital signs monitoring can make better use of clinician resources and can help to avoid changes being missed between checks.

In this Report, we start with an article from Caretaker Medical LLC, a leader in wearable monitoring devices,

about vital signs: what they are, and how they can be monitored and assessed. We also consider their contribution to patient care and their value in dealing with all patients but, in particular, patients whose condition is dynamic, i.e. subject to frequent and significant changes. Building on that, Camilla Slade's article looks at the mechanics of monitoring vital signs and the pitfalls and limitations of using traditional methods and processes. She also compares continuous and intermitted monitoring methods. Next, and drilling down more to the patient, Peter Dunwell identifies those for whom monitoring vital signs is most important, before continuing to look at how improved monitoring can contribute to better outcomes for patients and lower costs for hospitals. Finally, we look at how continuous wireless monitoring is being received in the world of healthcare and at some recent developments.

**Tom Cropper**  
Editor

*John Hancock, an Editor of Hospital Reports, has worked in healthcare reporting and review for many years. A journalist for more than 30 years, John has written and edited articles, papers and books on a range of medical and management topics. Subjects have included management of long-term conditions, elective and non-elective surgery, wound management, complex health issues, Schizophrenia, health risks of travel, local health management and NHS management.*

# Bringing the Hospital ER into the Field

## Continuous Non-Invasive Blood Pressure and Remote Wireless Vital Signs Helps EMS Upgrade Trauma Treatment

Tim McGough NRP

**A** COMBAT medic enters the battlefield to assess a fallen fellow warfighter, risking his own life and abandoning the position of cover from enemy fire to personally detect signs of life in the casualty. All too often this brave action resulted in additional injury. This difficult scenario became the genesis of robust medical technology development that now allows for continuous monitoring of non-invasive blood pressure and full wireless vital signs in nearly any patient.

### Technology Can Improve Vital Signs Data

By bringing the sophistication of arterial line monitoring and continuous vital sign data streaming from the complex Operating Room and Emergency Department directly into the pre-hospital and out-of-hospital environs, it may be possible to dramatically improve the picture painted for the waiting care team. Emergency Medical Services personnel strive to accurately and continuously assess patient status, but no human can duplicate the resolution of continuous vital sign data, including heartbeat-to-heartbeat blood pressure detection, especially in a high-stress, task-saturated care setting. A paramedic may provide advanced or surgical airway procedures, cardiac intervention, pharmacological therapy, and respiratory or ventilatory support. During such high stress procedures including rapid sequence induction using paralytic sedatives and analgesics, the attending paramedic must be completely focused on these critical actions despite imminent risk of hemodynamic changes due to the drugs administered. Typical ongoing assessment involves attaching an advanced life support cardiac monitor with basic vitals and ECG recording capability. Lacking the

ability to continuously monitor blood pressure (NIBP), the pre-hospital providers must rely on occasional spot checks from the traditional device. While in the OR, ICU, or ER, clinicians have upgraded resolution from arterial line placement and continuous BP data not otherwise obtainable in the field. Since an arterial line transducer is generally impractical to place in the out-of-hospital setting, technology is needed to fill the void, and provide a more complete hemodynamic trend assessment of the critically injured or ill.

### The Value of Using a Simple Finger Cuff to Obtain a Clinical Picture

A simple finger cuff pressure sensor (Caretaker Medical), developed to accurately detect component pulsations in peripheral arteries and changes in central aortic pressure, can reliably provide both paramedic and receiving hospital trauma teams an excellent clinical picture of the injured patient's hemodynamic status. Beyond the simple trauma recording sheet, usually hard copy and handwritten by the trauma nurse on arrival, the sophisticated digital wireless reporting system shows trends in blood pressure, measured per heartbeat, and reports continuous vitals for the duration of the case. Transmitted from the field in advance by the transporting EMS units, the trauma team can properly prepare for arrival, guide staffing and equipment placement, and altogether form a more immediate treatment plan with a significant portion of the patient assessment complete yet ongoing.

### Continuous Development

Blood volume and hemorrhage detection is a future planned feature and has been clinically validated with military lower-body negative

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*Since an arterial line transducer is generally impractical to place in the out-of-hospital setting, technology is needed to fill the void, and provide a more complete hemodynamic trend assessment of the critically injured or ill*

pressure studies, blood donation center patients, and dialysis patients. Once the patient has been attached to the Caretaker Medical cNIBP finger sensor, the display will indicate changes in blood volume from the tare point in time at the start of the session. Future integration into trauma treatment algorithms including choice of tranexamic acid (TXA), whole Blood products, and guided fluid resuscitation, is expected to rely on continuous blood pressure data.

According to *Nursing Management*, September 2016, Volume :47 Number 9, page 11 – 12, “A proactive approach is crucial to ensure a patient’s condition doesn’t deteriorate; most conditions can be addressed by reassessing vital signs. Unfortunately, research has shown that vital signs aren’t consistently assessed, recorded,

which interferes with appropriate and timely interventions for deteriorating patients.”

And “in one exploratory study reviewing over 43,232 patient visits to 94 different EDs, the median time between documentation of BP in the ED was every 2.3 hours for all patients. In a retrospective chart review of 202 randomly selected adult ED patients, it was concluded that a greater time between vital signs assessment can lead to errors by not detecting changes in patient condition” (Miltner RS, Johnson KD, Deierhoi R. Exploring the frequency of blood pressure documentation in emergency departments. *J Nurs Scholarsh.* 2014;46(2): 98-105)

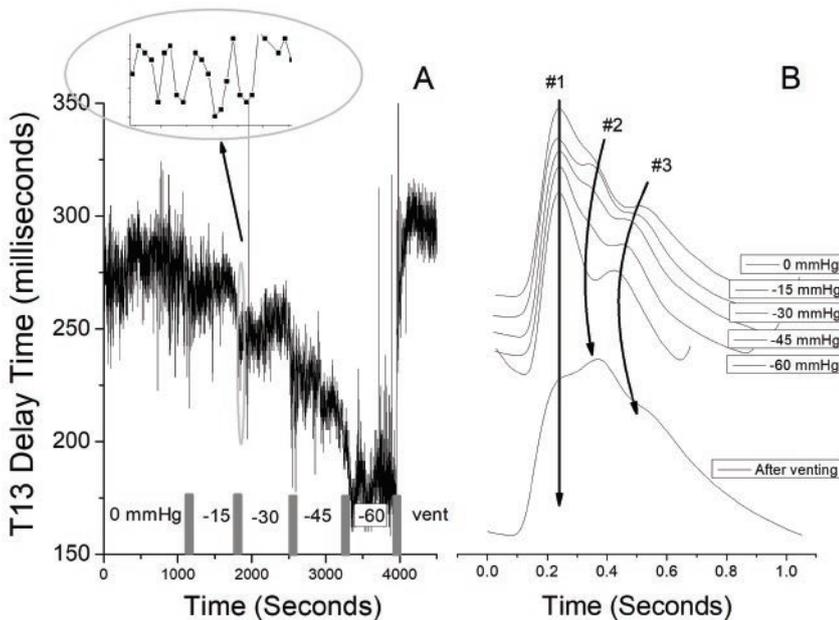
In the case of EMS applying a multi-parameter cNIBP and wireless Bluetooth vital signs monitor, such as the Caretaker device, in the field, within moments of patient contact, the problem of insufficient vital signs is eliminated, continuity of care virtually guaranteed, and providers retain a consistent record of patient status in the electronic record of the case.

### The Need for More Frequent Assessments of Vital Signs

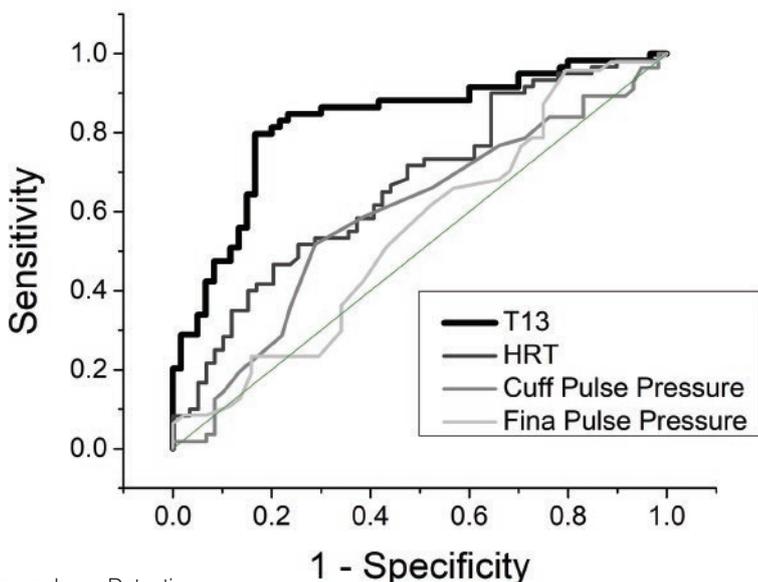
This represents a significant change in patient care standards for typical EMS providers who are taught, as part of primary and secondary (ongoing) trauma assessments in standardized curricula such as Pre-Hospital Trauma Life Support (PHTLS), International Trauma Life Support (ITLS), and Trauma Nursing Core Course (TNCC), to reassess vital signs approximately every 5 minutes for trauma patients. In several assessment algorithms in these curricula, the practice involves treatment (FIX-IT – ITLS), secondary assessment (OPQRST, DECAP-BTLS, in PHTLS) packaging, and transport in addition to the vital signs monitoring necessary to effectively capture and recognize a developing clinical data trend. Five minute vitals are just not sufficient for this goal. But nonetheless, due to technology limitations thus far, checking a blood pressure every five minutes is accepted and standard. It is known that significant events and deterioration can occur in the even short periods between BP assessment.

### More Effective at Lower Cost

In the most critical care settings in operating rooms, post-anesthesia case units and intensive care units, it is generally expected that an arterial line would be introduced for the most hemodynamically unstable patients. But in many cases, an attending physician may balance the risks and benefits of an invasive line and elect not to place the arterial catheter. In these

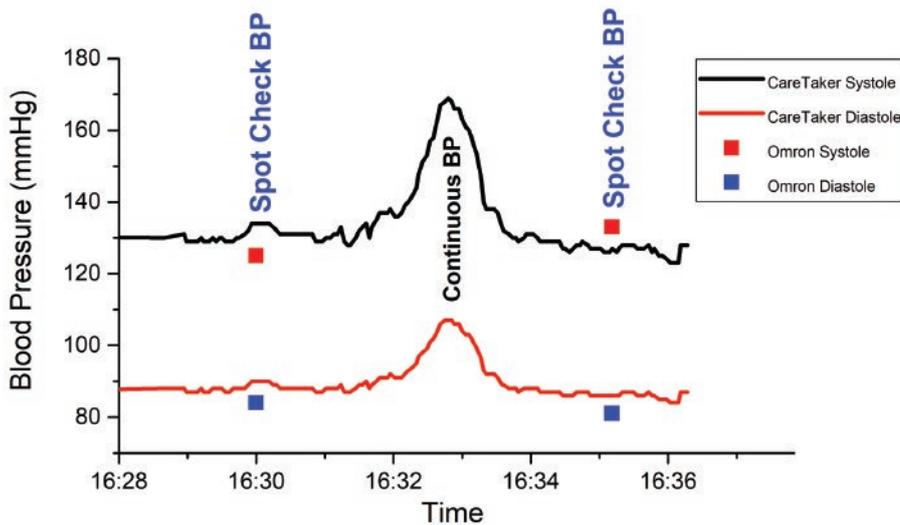


• Pulse shape change during increasing lower-body-negative-pressure (LBNP) or interpreted,



Hemorrhage Detection

- Distinct arterial pulse shape changes (T13)
- Blood donation 65 subjects, Central hypovolemia



examples, a non-invasive alternative like a peripheral finger cuff with the ability to detect changes in central aortic pressure is highly desired. The Caretaker finger sensor is well tolerated for long periods of conscious or sedated patient monitoring, with a significantly lower cost than the arterial line procedure, making it an effective alternative with a lower risk assessment.

Such longer periods of monitoring can produce excellent clinical data from pre-hospital, to in-hospital, and onwards beyond discharge back into the patient's home environment, allowing ongoing monitoring for the recently hospitalized patient. Incorporated into a mobile integrated health (MIH) or community paramedic program, again the hospital technology is deployed into the field for follow up assessments.

With the availability of continuous BP, or cNIBP, the standard may change to an expectation of all blood pressure being measured over time, and continuously, like most other vital signs – heart rate, ETCO<sub>2</sub>, SpO<sub>2</sub>, and respiratory rates – all long expected to be continuous measurements. A small bit of acute care hospital practice, effectively deployed into the field care setting, may really improve patient outcomes in the foreseeable future.

*A small bit of acute care hospital practice, effectively deployed into the field care setting, may really improve patient outcomes in the foreseeable future*

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# Signs of Life and Changes

John Hancock, Editor

Vital signs are a means for a clinician not only to discover a patient's condition but also how it develops

*The measurement and recording of the vital signs is the first step in the process of physically examining a patient. This step involves collecting objective data*

**V**ITAL SIGNS might be described as a catch-all term for a range of indicators as to whether the body is performing normally or not and/or is in danger or not, and how a condition or treatment is progressing.

## What Are Vital Signs?

Those who are familiar with hospitals will also be familiar with the charts, often at the end of the bed, recording a patient's vital signs: but vital signs have a much broader application than only on end-of-bed charts. Any clinician will, if possible, ask the patient how they feel but, as well as the possibility that they might not be able to respond through injury or concussion, there is also the consideration that what different patients feel with identical injuries or conditions will vary according to their pain threshold or nature or other outside factors. Clinicians need something constant against which to measure a patient's condition: UK Essays<sup>1</sup> explains that, "The measurement and recording of the vital signs is the first step in the process of physically examining a patient. This step involves collecting objective data." That word 'objective' is critical and is supported by the fact that there are established parameters for vital sign measurements in healthy adults. The main vital signs used and their healthy levels or measurements are listed in the UK Essays article as...

VITAL SIGN	HEALTHY RANGE
Blood pressure (BP)	120/80 mmHg
Pulse or heart rate (HR)	60-100 beats per minute
Temperature (T°)	36.5°C to 37.5° Celsius
Respiratory rate (RR)	10 to 16 breaths per minute
Blood oxygen saturation (SpO2)	98%-100%

## Monitoring Vital Signs

As we've already noted, there other factors to take into account. The Milton S. Hershey Medical Center<sup>2</sup> explains that, "Some medical problems can cause changes in one or more vital signs." and that medication and age can also have their effects. But, generally, readings that fall outside of

these parameters might indicate that something is wrong and changes between periodic readings might indicate a rate of change in the patient's condition. The Lippincott Nursing Center<sup>3</sup> recommends that, when dealing with patients in an Accident and Emergency department, vital signs should be monitored, "Every 5 to 15 minutes as needed based on clinical presentation and no less frequently than every hour for the first 4 hours, then every 2 hours if clinically stable." The article continues to outline changing frequencies as the patient progresses.

Vital signs are an important component in patient care. They determine which treatment protocols to follow, provide critical information needed to make life-saving decisions, and confirm feedback on treatments performed. Accurate, documented vital signs are a very important part of a managed treatment program. But they also can save lives. The *Telegraph*<sup>4</sup> reported in May 2019 that, "Six thousand patients are dying every year because hospital staff are not properly monitoring vital signs." The article continues to highlight The Royal College of Physicians proposal of a National Early Warning Score to standardize the monitoring of and reading of vital signs (temperature, pulse, blood pressure, breathing rate, level of consciousness, and oxygen saturation) across all UK healthcare facilities. That last sign, oxygen saturation, is a measure of how much oxygen is in the blood and has only recently been adopted by hospitals. A low score can indicate heart and lung problems.

While vital signs are often used in cases where rapid and unpredictable change is a feature of the patient's condition – trauma, rapid onset of infection, during transport to hospital – they are also very useful in more controlled clinical and surgical situations such as on the general ward, in the critical or intensive care ward and during anesthesia. Monitoring vital signs is a key factor in determining the development and outcome of most clinical conditions and procedures. Perhaps a last word on this can come from the Patient Safety Network (PSN)<sup>5</sup>, "... vital sign monitoring leads to early identification of patient deterioration and rapid response activation."



### The Value of Vital Signs

A PLoS One article carried by NCB<sup>6</sup>, tells us that, "... surprisingly few attempts have been made to quantify [vitals signs'] clinical performance [although] numerous studies have reported that changes in vital signs occur several hours prior to a serious adverse event." The article adds, "Even though it is accurately predicted by vital sign changes, clinical deterioration often goes unnoticed, or is not detected until it is too late to treat. This is mainly caused by inadequate recording of vital signs or as a result of an inappropriate response to abnormal values. Among nurses and doctors there is insufficient knowledge and appreciation of vital sign changes and their implications for patient care."

In the UK, the Royal College of Emergency Medicine<sup>7</sup> has recognized this challenge and, in 2010, published 'The Vital Signs Standards'. In a 2018/19 update, the RCEM issued an information pack to help clinicians understand what could be learned from vital signs. As a first step, the pack confirmed that, in 2010/11, "[while] Pulse (97%), BP (97%), O2 saturation (96%) and respiratory rate (92%) were well recorded. Temperature

(88%) and GCS or AVPU (77%) were less well recorded... [and] The percentage of audited notes where abnormal vital signs were observed varied greatly between EDs [Emergency Departments] (from 8% to 98%) which suggests considerable variation in patient acuity."

An excellent source of information as to what clinicians can do with vital signs information is provided by Nursing Times, 'How to measure and record vital signs to ensure detection of deteriorating patients'<sup>8</sup> which focuses on patient deterioration and offers explanatory notes on each of the main vital signs, including what information can be gleaned from them and why regular monitoring can help a clinician detect even minor changes that, cumulatively, might point to a potentially more serious outcome. Further notes on 'Assessing and Responding to Changes/Abnormalities in Vital Signs' are available from Registered Nursing<sup>9</sup>.

What is clear from any source is that regular and systematic vital signs monitoring plus application of the results is a critical component in the receiving, assessing and continual monitoring of a patient's condition and progress.

*Even though it is accurately predicted by vital sign changes, clinical deterioration often goes unnoticed, or is not detected until it is too late to treat. This is mainly caused by inadequate recording of vital signs or as a result of an inappropriate response to abnormal values*

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# Continuous Information Supports In-Time Actions

Camilla Slade, Staff Writer

**Patients' conditions don't stand still just because monitoring isn't being conducted at a specific time**

*There are periods between monitoring events, and changes that might take place during these periods could be missed. This is especially the case with blood pressure readings where changes might well offer early warnings about heart conditions which, if acted upon, could avert a more serious situation*

**T**HERE ARE many reasons, including age-related and medication related factors<sup>10</sup>, why vital signs might vary from one person to another or, indeed, for one person at different times. However, as long as that person's condition and circumstances are understood, then the principle that vital signs offer an objective assessment of a patient's condition will still hold good. The continuing focus of concern is more to do with the uniformity, or lack thereof, in the way monitoring is carried out and how to avoid missing changes, even temporary changes, that occur between monitoring events.

## How Vital Signs Are Monitored

"The way vital signs such as blood pressure and temperature are monitored in hospitals needs to be standardized across the NHS, experts say." Was the opening line for a BBC<sup>11</sup> report which continued, "Currently [2012] over 100 different models are used, causing confusion and sometimes delays in patients getting help." Following the evidence to which the report referred, the 2018/19, Royal College of Emergency Medicine's audit, 'Vital Signs in Adults 2018/19'<sup>12</sup> has been established to assess progress in standardization and meeting standards.

Although each vital sign has, in the past, been measured individually – temperature with a thermometer, blood pressure with a cuff, heart and pulse rate with a stethoscope and timer, lung function with stethoscope and spirometer... and so on – more often today, vital signs measurements are monitored with electronic devices and/or multimodal devices that will maintain continual measurement of these critical conditions.

## Pitfalls and Limitations of Complexity

The problem with many traditional methods for vital signs monitoring is that they are complex,

costly and invasive, such as with the arterial catheter used to continuously measure blood pressure, and with any invasive process comes the risk of infection. "Catheters are medical devices that can be inserted in the body... By modifying the material or adjusting the way catheters are manufactured, it is possible to tailor catheters for cardiovascular, urological, gastrointestinal, neurovascular, and ophthalmic applications." is how an article in *Wikipedia*<sup>13</sup> describes catheters. Also, traditional methods are often intermittent, i.e. there are periods between monitoring events, and changes that might take place during these periods could be missed. This is especially the case with blood pressure readings where changes might well offer early warnings about heart conditions which, if acted upon, could avert a more serious situation such as a stroke or a heart attack.

There might be a notion that non-invasive methods for monitoring vital signs are less 'in touch' with the patient than traditional methods but comparisons such as the *British Journal of Anaesthesia*, 'Comparison of continuous non-invasive finger arterial pressure monitoring with conventional intermittent automated arm arterial pressure measurement in patients under general anaesthesia'<sup>14</sup> found the simpler to use method just as effective as traditional methods.

The traditional image of a patient in a hospital bed surrounded by pieces of equipment, each of which is attached to or inserted in the patient, is not entirely wrong. It is also expensive in the time required to 'plumb in' and dismantle the equipment array, the time it takes to monitor each device and even the space the equipment fills. But, in a critical or intensive care facility, that might all be feasible because monitoring is necessary.

## Continuous Versus Intermittent Monitoring

Although continuous monitoring of vital signs is routine within most critical and intensive care units, it is less likely outside of that environment



and yet, *PubMed's*, 'The impact of continuous versus intermittent vital signs monitoring in hospitals...'15 found that, "The majority of studies showed benefits in terms of critical care use and length of hospital stay. Larger studies were more likely to demonstrate clinical benefit... Three studies showed cost-effectiveness." However, "Barriers to implementation included nursing and patient satisfaction and the burden of false alerts." The study concluded that, "Continuous vital signs monitoring outside the critical care setting is feasible and may provide a benefit in terms of improved patient outcomes and cost efficiency."

A *Journal of Medical Internet Research*16 publication went further with, "Vital signs monitoring is a universal tool for the detection of postoperative complications; however, unwell patients can be missed between traditional observation rounds. New remote monitoring technologies promise to convey the benefits of continuous monitoring to patients in general wards." *Science Direct*17 added, "Continuous vital signs monitoring on general hospital wards may allow earlier detection of patient deterioration and improve patient outcomes."

Up until now, we've considered vital signs monitoring in the context of a healthcare facility but for some vital signs, such as blood pressure, continuous monitoring over a period of, say 24 hours, can provide a clinician with more and more useful information about a patient's condition in their routine environment. The NHS18 explains this as, "[Continual and home blood pressure

monitoring] can give a better reflection of your blood pressure, as being tested in somewhere like a GP surgery can make you feel anxious and can affect the result." Another NHS paper19 cites a very real benefit for continuous blood pressure monitoring as, "Twenty-four-hour monitoring is thought to be more useful, as it produces an average score of blood pressure throughout the day and night. But it's more expensive, so it's used less often... [yet] The researchers found that 24-hour monitoring was much better than one-off clinic readings for predicting risk of cardiovascular death."

### Pulse decomposition analysis

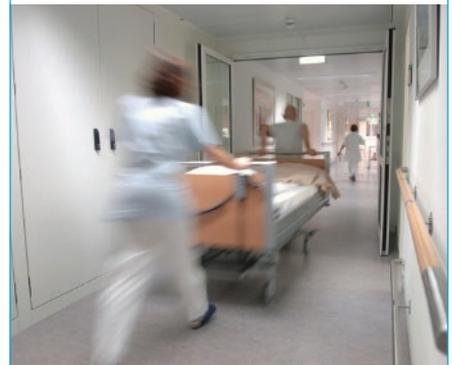
One specific application where continuous monitoring is useful is in pulse decomposition analysis, an algorithm that analyses components in the pulse, the components of the arterial pressure pulse envelope, which are the left ventricular ejection pulse component and the trailing pulse components. The value of this approach is explained by Research Gate20, "... pulse pressure appears to be a sensitive as well as specific marker for the detection of hemorrhage, [which] remains one of the leading causes of death on the battlefield as well as in civilian trauma cases while also being highly preventable if intervention can be implemented."

Perhaps we can best sum up the value of continuous monitoring of vital signs as the ability to see and, if need be, react to changes in the patient's condition in real-time, as they arise.

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# Realities That Challenge Healthcare

Peter Dunwell, Medical Correspondent

From the patient to the whole system, healthcare is always under pressure

*More intensive monitoring, which is commonly used in peri-operative and intensive care settings, is more likely to lead to the early identification of patients who are developing complications than is intermittent monitoring. Early identification can trigger appropriate management, thereby reducing the need for higher acuity care, reducing hospital lengths of stay*

SO FAR, we've considered vital signs, how they're monitored and some pros and cons for various different methodologies. Here, I want to look at a couple of specific cases and to consider vital signs monitoring in the context of the priorities that govern a modern healthcare system.

## Patients with Urgent and Fast Changing Needs

Sometimes things happen very quickly with a patient and a clinician needs the means to act as quickly.

### Trauma patients

One group for whom a real-time and continuous understanding of their condition is very important is trauma patients. Internal injuries can cause undetected stresses that can cumulatively lead to severe changes and outcomes. The *British Journal of Anaesthesia*<sup>21</sup> 'Early management of the severely injured major trauma patient' summarizes the imperative, "... multiple injured patients often present with complex conditions in a dynamic situation." In short, there is often a high pace of condition change with trauma patients in the early stages and a consequent high level of pressure on clinicians. Three things in particular need to be monitored for to manage the so-called "lethal triad of hypothermia, acidosis and coagulopathy [which] has been recognized as a significant cause of death in patients with traumatic injuries." That is explained in the *Journal of Emergency Medical Services*<sup>22</sup> article on the subject. But trauma patients also have a higher than average risk of death after discharge although, as the Baylor University Medical Center Proceedings research 'Timing and causes of death after injuries'<sup>23</sup> noted, "Deaths among trauma patients after discharge have largely remained overlooked in the trauma literature. This is due in large part to the difficulty of follow-up in the trauma patient population." The research continues to suggest that what amounts to an inability to monitor a patient's condition is a consequent factor arising from this.

### Deteriorating patients

While this group might well include trauma patients, it won't be exclusively so. The Oxford Academic 'Attitudes towards vital signs monitoring in the detection of clinical deterioration...'<sup>24</sup>, explains, "The majority of adverse events are preceded by a period of abnormal vital signs (minutes to hours), which could be identified through consistent and accurate monitoring. Close monitoring of vital signs is essential to detect and act upon deterioration with the potential to reduce adverse events, such as cardiopulmonary arrest." It might also reduce the level of care to be borne by a patient and the cost to the hospital and healthcare system. The *European Journal of Anaesthesiology*, considering 'Improving detection of patient deterioration in the general hospital ward environment'<sup>25</sup> suggests, "More intensive monitoring, which is commonly used in peri-operative and intensive care settings, is more likely to lead to the early identification of patients who are developing complications than is intermittent monitoring. Early identification can trigger appropriate management, thereby reducing the need for higher acuity care, reducing hospital lengths of stay and admission costs and even, at times, improving survival."

## Pressures on Healthcare Systems

It doesn't require me to tell readers that healthcare systems face ever greater pressures as they endeavor to meet infinitely expanding needs with painfully finite resources. In that sense, anything, especially something as obvious and basic as monitoring vital signs, that can help to address those pressures should be welcomed.

### Improving patient care and safety

Scandals, such as that at Stafford Hospital in the years up to 2008, highlighted just how important patient care and safety are and what damage can result from healthcare systems getting it wrong. However, on the other side of that coin according to The King's Fund<sup>26</sup>, "Between 2003/4 and



2015/16, the number of admissions to hospital increased by 3.6 per cent a year. At the same time, the health service is enduring a prolonged slowdown in funding... The mismatch between demand and funding means that NHS services are struggling to maintain standards of care." Add to that, people's rising expectations as to the quality of care they receive and a growing tendency to go to litigation when something goes wrong, and the pressure to improve patient care and safety becomes very clear. In response to this challenge, PWC Global 'Depleting resources adding pressure to healthcare'<sup>27</sup> reports that, "Health systems are optimizing human resources and adopting process-driven advances, standardized procedures and technological innovations to cut costs and improve quality."

NHS England responded to the challenge with its 2013/14-2015/16 business plan 'Putting Patients First'<sup>28</sup> which stated, "Recent events have demonstrated the stark realities when standards of care fall woefully short. We in the NHS must all remain vigilant to ensure that patients are never again subjected to such poor quality of care." Resources are a key component in the pressure to improve patient care and safety and that translates to an increased workload for clinicians in the system. So, anything that can help to reduce that workload without reducing

the quality of care but, preferably, improving it, will be welcome.

#### Shorter hospital stays reduce healthcare costs

The King's Fund<sup>29</sup> explains that, "Rising admissions would be easier to deal with if patients could be discharged quickly. Indeed, in most years the average length of stay in hospital has fallen, freeing up staff and beds to deal with new arrivals. The combination of reductions in average length of stay and a switch to day-case surgery has meant the NHS has often been able to manage demand." Those are the bald facts to which the Nuffield Trust<sup>30</sup> adds, "There is a significant opportunity to reduce length of hospital stay through improvements in internal processes and the development of alternative services." and, "Reducing hospital length of stay has the potential to be an effective way of containing the growing demand for beds and releasing capacity in the hospital system."

All of this is very important in the context of healthcare systems (the NHS in the UK) not being exempt from the general economic pressure felt in all societies. There is an overall pressure to reduce healthcare costs in order to limit the amount of funding increases to within economic growth outcomes, but without reducing the quality of service delivered.

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# Wireless and an Evolving Healthcare Environment

*John Hancock, Editor*

**A monitoring system that matches patient, clinician and healthcare priorities**

*With the older population growing rapidly, along with the numbers suffering chronic health problems, and a growing pay and drugs bill, demands on the health service will only continue to grow*

**W**E'VE LOOKED at the importance not just of monitoring but also of how it is carried out; and we've looked at some of the pressures challenging healthcare systems and, broadly, what sort of changes might help to tackle those challenges. Those challenges are summed up by The Health Foundation<sup>31</sup>, "With the older population growing rapidly, along with the numbers suffering chronic health problems, and a growing pay and drugs bill, demands on the health service will only continue to grow. Just to keep the NHS providing the level of service it does today will require us to increase spending by an average 3.3% a year for the next 15 years [which] would take health spending from 7.3% of national income today to 8.9% of national income by 2033/34." In this article, we'll look at one developments and how it might be useful in helping to address the challenges outlined above.

## Clinical and Best Practice Guidelines

The NICE (National Institute for Health and Care Excellence) Guidance, 'Improving the detection and response to patient deterioration'<sup>32</sup>, "requires that all adult patients in hospital have (i) a clear written monitoring plan specifying which vital signs should be recorded (and at what frequency), (ii) their severity of illness measured using a physiological early warning score (EWS) and (iii) a graded response strategy." As long ago as 2012, a group of senior clinicians in the NHS<sup>33</sup> called for the standardization of monitoring vital signs across the system which led to the establishment of the National Early Warning Score (NEWS). NHS England<sup>34</sup> recorded that implementation of NEWS had, "significantly improved patient safety and outcomes, improved staff experience, and streamlined and standardized handovers which has increased time spent caring for patients."

## Wireless Vital Signs Monitoring

One area where the NHS has shown interest in order to be able to match those clinical best

practice guidelines has been the use of wireless vital signs monitoring. In 2015, The Telegraph reported the, 'End of the thermometer as first NHS hospital trials wireless monitoring.'<sup>35</sup> The article opened with, "The era of a nurse diligently making the rounds with a thermometer may be coming to an end after a British hospital began trialing new technology which monitors vital signs remotely." and continued to set out the benefits of such a system. Those benefits include the frequency with which a wireless system can 'report' to a nurse, thus minimizing the risk of a patient's deterioration between vital signs monitoring events going unnoticed until too much time has passed. It can also free the nurse to spend more time on treatment with less time needed to conduct vital signs monitoring than would have been the case with traditional methods.

Remote and wireless vital signs monitoring can also allow some patients to be discharged earlier with monitoring able to continue in their home environment. That is a good outcome for the patient and for the budget at the healthcare facility. As such possibilities for wireless monitoring of vital signs become possible, the requirements for viable and cost-effective solutions are evolving to take advantage of improving capabilities.

For instance, along with wireless monitoring have come wearable sensors that can record vital signs information without the intrusive nature of traditional equipment and methods. Although not exclusively so, such technology is particularly applicable when dealing with older patients whose vital signs might well need to be monitored but whose health does not otherwise justify them being in a hospital bed. 'Sensors'<sup>36</sup> on NCBI explains, "Such systems equipped with non-invasive and unobtrusive wearable sensors can be viable diagnostic tools to the healthcare personnel for monitoring important physiological signs and activities of the patients in real-time..." And, of course, in all this, we mustn't forget the patient. ResearchGate's 'Review of Vital Signs Monitoring Systems – Patient's Acceptability Issues and Challenges'<sup>37</sup> concludes, "... that despite some limitations commented by patients



and clinicians, these systems should be more compact and simple to operate and they should be available to healthcare professionals with minimum interruption to normal daily life activities (ADLs)."

### Improving Patient Comfort, Safety and Outcomes

Hopefully, by now it is clear what the advantages are for using wireless devices to deliver remote and continuous vital signs monitoring. Changes in the patient's condition can be better responded to than if the monitoring is at intervals which, in turn, will improve patient care and safety. This is a critical advantage in those situations where speed of response will have literally life-or-death consequences: patients whose condition could be subject to rapid change such as with trauma and for those whose condition might deteriorate rapidly and (with some conditions) catastrophically. Clinicians don't have to invest time in monitoring and yet have the benefit of better monitoring results to support their professional efforts; hospitals will not only be better informed to improve care of any patients but might also be able to discharge patients earlier. All of this contributes to reduced costs for

financially stretched healthcare systems. And one thing that we have not covered but will be true is that, for patients and their families, a single, digital wireless device will be a lot less alarming than the traditional array of monitoring equipment.

Events and developments are progressing rapidly in this field with devices such as the CareTaker® finger-cuff wireless patient monitoring platform for continuous non-invasive blood pressure and vital signs. These types of devices can measure beat-by-beat blood pressure and heart rate in a non-invasive wearable form-factor. The best include features that enable clinicians to have a continuous and comprehensive view of patient's physiological condition.

It also enables a clinician to manage several patients but with better levels of real-time information for each patient than if they had to rely on periodic vital signs monitoring. Let's allow the last word on monitoring to Professor Sir Bruce Keogh, Medical Director of the NHS, "Catching deterioration in the early stages can mean huge improvements in patient safety and outcomes. This score offers an opportunity for the NHS to standardize how it monitors a patient's condition across different healthcare settings."

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- Vital Signs Platform



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