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National Early Warning Score systems that alert to deteriorating adult patients in hospital

Medtech innovation briefing

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This advice replaces MIB79.

Summary

- The 5 **technologies** described in this briefing are integrated software systems that output the national early warning score for adult patients in hospital.

- The **innovative aspects** are the potential for more accurate alerts and the greater availability of this information to identify a deteriorating adult patient, thereby reducing avoidable harm and making services more efficient.

- The intended **place in therapy** would be replacing paper-based charts that record observations and manually calculate the national early warning score.

- The **main points from the evidence** summarised in this briefing are from 2 prospective studies and 1 multicentre retrospective observational study in the NHS. This limited evidence base suggests that electronic systems that send out national early warning score-based alerts can release staff resources, reduce unplanned admissions to intensive care and reduce the frequency of cardiac arrests, compared with standard care.

- **Key uncertainties** are the lack of evidence for national early warning score-based alerts from these technologies in the NHS. Further research could improve understanding of how best to use them, and help determine the cost and resource impact.

- The **cost** of early warning systems typically ranges from £30,000 to £90,000 for initial system installation, configuration and set up, with ongoing annual licence costs from £0.35 to £0.70 per acute bed, per day (exclusive of VAT). The **resource impact** would be in addition to standard care because it requires changes to IT infrastructure and initial staff training. But once adopted it could release nursing resources for other tasks. There is limited evidence to support this release of resources.

The technology

The National Early Warning Score (NEWS2) is a system for scoring the physiological measurements that are routinely recorded at the patient's bedside. Its purpose is to identify acutely ill patients, including those with sepsis, in hospitals in England. The NEWS2 scoring system measures 6 physiological parameters:

- respiration rate

- oxygen saturation

- systolic blood pressure

- pulse rate

- level of consciousness or new-onset confusion

- temperature.

A score of 0, 1, 2 or 3 is allocated to each parameter. A higher score means the parameter is further from the normal range. Appropriate clinical responses are given for threshold

(trigger) levels, with a recommendation to review and agree these locally:

- Low risk (aggregate score 1 to 4) – prompt assessment by ward nurse to decide on change to frequency of monitoring or escalation of clinical care.

- Low to medium risk (score of 3 in any single parameter) – urgent review by ward-based doctor to determine cause and to decide on change to frequency of monitoring or escalation of clinical care.

- Medium risk (aggregate score 5 to 6) – urgent review by ward-based doctor or acute team nurse to decide on escalation to critical care team.

- High risk (aggregate score of 7 or over) – emergency assessment by critical care team, usually leading to patient transfer to higher-dependency care area.

The recommendation for a NEWS2 aggregate score of 0 (that is, no change to any parameter) is a minimum 12-hourly review and to continue routine monitoring.

This briefing focuses on 5 early warning score (EWS) 'track and trigger' systems that can be configured to the NEWS2 specifications. They integrate with electronic health record (EHR) systems to remotely monitor manually entered or automatically captured physiological parameter data directly from bedside patient monitors. They are designed to calculate aggregated scores and automatically generate NEWS2 alerts. This is so that patients in acute and general inpatient wards whose condition is deteriorating are identified and get the appropriate clinical response.

Other, similar technologies may be available but are not included in this briefing (for example, if they were not identified or the company chose not to participate).

The EWS technologies typically consist of a single or modular licensed software application, which integrates with a hospital's existing IT infrastructure. The EWS technologies interface with the hospital's EHR system via electronic health information standards (for example, Health Level 7 [HL7]) to store, access and monitor patient physiological parameter data. They also include hardware, including servers (for example, for the EWS application and database) and desktop or mobile computers, tablets, smartphones, pagers or digital enhanced cordless technology (DECT) phones. These are normally supplied at additional cost by the local hospital's IT services, which use Local Area Networks (LAN) or Wi-Fi to alert clinical staff to deteriorating patients, based on the calculated NEWS2 scores.

Standalone patient bedside monitoring systems with EWS functionality and standalone online or mobile app EWS calculators are out of the scope of this briefing.

The EWS technologies identified and their key features are summarised in table 1.

Table 1 Summary of included EWS technologies

EWS system and the company that makes it	EHR integration	Data capture	Mobile alert device types	CE marking
KEWS300 (Syncrophi Systems Ltd)	Yes, via HL7 and web services API	Automatic or manual	Windows and web-based devices	Class IIb
Med eTrax (Med eTrax)	Yes, via HL7 and web services API	Automatic (via Bluetooth or Wi-Fi) or manual	Apple iOS or Windows-based mobile devices	Self-certification to Class I in progress
Patientrack (Patientrack [UK] Ltd)	Yes, via HL7 and web services API	Automatic or manual	Android, Apple iOS or Windows-based mobile devices; pagers and DECT phones	Class I
SEND (Sensyne Health)	Yes, via HL7	Manual via bedside tablet on roll stand	Tablet, PC or laptop devices	Class I
CareFlow Vitals (formerly Vitalpac & The Learning Clinic, now produced by System C Healthcare)	Yes, via HL7 and web services API	Automatic or manual	Apple iOS-based mobile devices	Class I

Abbreviations: API, application programming interface; DECT, digital enhanced cordless

technology; EHR, electronic health record; EWS, Early Warning Score; HL7, health level 7 standard; SEND, System for Electronic Notification and Documentation.

Innovations

Automatic capture of physiological measurements could lead to fewer data input errors to the NEWS2 algorithm than manual recording and fewer calculation errors, giving a more accurate NEWS2 alert. The technology can address issues such as illegible written observations on paper charts.

The potential for greater availability of the NEWS2 alert through the hospital's EHR system and automated alerting could also trigger an earlier clinical response, such as escalation to intensive care and improved recognition of sepsis in hospital-acquired infections.

Such interventions have the potential to benefit patients by reducing avoidable harm, and also benefit the healthcare system, for example by reducing length of hospital stay.

Current care pathway

The NICE guideline on acutely ill adults in hospital: recognising and responding to deterioration recommends that adult patients in acute hospitals should have physiological observations recorded at initial assessment or admission. Physiological observations should then be monitored at least every 12 hours, unless a decision has been made at a senior level to increase or decrease the frequency of monitoring for an individual patient. NICE recommends that 'physiological track and trigger systems' should be used to monitor all adult patients in acute hospitals, with multiple-parameter or aggregated weighted scoring systems used to set trigger thresholds locally. NEWS2 is recommended in the NICE guideline's section on choice of physiological track and trigger system as the system endorsed by NHS England.

NHS England and NHS Improvement mandated NEWS2 for use for adults in acute and ambulance trusts by publishing a Patient Safety Alert for NEWS2 in April 2018 (last updated 9 December 2019), which highlighted resources to support its safe adoption. NEWS2 should not be used in children under 16 or pregnant women. This is because the physiological changes of pregnancy can render the existing NEWS2 inappropriate because the physiological response to acute illness can be modified in children and by pregnancy. Baseline physiological parameters are different in these 2 populations to the non-

pregnant, adult population. NHS England, NHS Improvement and the Royal College of
Paediatrics and Child Health (RCPCH) are developing a Paediatric Early Warning score
(PEWScore) and Paediatric Early Warning System (PEWSystem) as a standardised tool for
England. The National PEWS Programme update indicates a pilot roll-out starting in April
2020 and national roll-out starting in November 2020.

The integrated electronic EWS systems in the scope of this briefing may be used in place
of the manual recording of NEWS2 parameters on paper charts, and manual calculation, to
trigger alerts for appropriate clinical response.

NICE has produced medtech innovation briefings on 3 EWS systems:

- Visensia for early detection of deteriorating vital signs in adults in hospital

- EarlySense for heart and respiratory monitoring and predicting patient deterioration

- Vitalpac for assessing vital signs of patients in hospital.

Visensia and EarlySense are not NEWS2 compatible and therefore not in the scope of this
briefing. NICE's advice on Vitalpac has been updated and replaced by this briefing.

Population, setting and intended user

The EWS systems in the scope of this briefing are for adults in acute and general inpatient
wards in secondary care. NEWS2 is used across the NHS in England. It's used by all
ambulance trusts and 76% of acute trusts. Other early warning scores are used in other
areas (NHS England National Early Warning Score, accessed 4 December 2019). The
national clinical lead for deterioration and national clinical adviser for sepsis at NHS
England and NHS Improvement said that, at the last count, 139 out of 140 acute trusts in
England had either moved to NEWS2 or were in the process of doing so.

The intended users are primarily nursing staff on the wards. The systems could also
potentially be used by multidisciplinary clinical teams, which would need to be trained in
how to use them. Most companies offer training and ongoing support.

Costs

Technology costs

The costs of EWS systems are based on an assessment of the size of the trust (for
example, the planned number of beds to be monitored) and the EWS system functionality
required; there is no standard 'list price'. Pricing will also include initial installation, set up
and configuration, a software licence, and ongoing support and maintenance. Typical
prices range from £30,000 to £90,000 for initial system installation, configuration and set
up over 6 to 9 months, with ongoing annual licence costs from £0.35 to £0.70 per acute
bed, per day.

Costs of standard care

Standard care is manually recording physiological parameters on NEWS2 paper-based
charts, and manual calculation to trigger alerts for the appropriate clinical response. A
series of standardised NEWS2 charts can be downloaded for free from the Royal College
of Physicians website, which includes:

- Chart 1 – the scoring system for each physiological parameter

- Chart 2 – thresholds and triggers

- Chart 3 – the NEWS2 observation chart

- Chart 4 – the standardised clinical response to NEWS2 trigger thresholds. This
  includes escalating and de-escalating frequency of monitoring.

Wong et al. (2017) found the mean time taken for nursing staff to capture and record the 6
physiological parameters on paper-based charts and manually calculate the EWS was
3 minutes, 35 seconds (95% confidence interval: 2 minutes 57 seconds to 4 minutes
22 seconds) for 577 nurse events across 3 wards in 1 NHS trust (in 2 university teaching
hospitals).

The cost of a nurse on band 4 of the NHS payscale per working hour is £28 (Personal
Social Services Research Unit, 2018). Assuming a time of 3 minutes, 35 seconds for a
band 4 nurse to manually capture and record the 6 physiological parameters on the chart
and calculate the NEWS2, this costs an estimated £1.67 per patient, per observation set
(assuming the cost of printing a NEWS2 chart is negligible).

Resource consequences

Wong et al. (2017) found that the mean time taken for nursing staff to capture and record the 6 physiological parameters and calculate a NEWS2-based EWS using the technology reduced to 150 seconds (from 215 seconds with standard care).

Implementing the technology in an NHS trust could require changes to the IT infrastructure and significant upgrade costs during the lifetime of the system. There may be ongoing revenue costs from lost or damaged devices. Staff will need training alongside a phased roll-out of the technology, including an initial session to identify and validate staff as authorised system users. Local policies and procedures will also need to be revised. Also, specific staff training and feedback in managing deterioration is essential to the success of all early warning systems. However, an electronic system would allow feedback to be gathered in real time.

Assuming an average of 3 to 6 sets of observations per day for acute patients in a large trust (1,800 acute beds) then, after installation, the ongoing licence costs of an automated EWS system at £0.35 to £0.70 per acute bed, per day, equates to £229,950 to £459,900 per year. The costs of a band 4 nurse manually recording the same observations and calculating the NEWS2 score would be £3,291,570 to £6,583,140.

Installing automated EWS systems does not save money because the number of staff may not be reduced in practice. But it could release nursing resources. Reductions in reviewing clinician time (doctor availability) should also be considered in the out-of-hours time period.

Regulatory information

The following manufacturer field safety notices or medical device alerts have been identified.

The Medicines and Healthcare products Regulatory Agency (MHRA) issued a field safety notice in April 2015 for the Vitalpac system, one of the 5 technologies assessed in this briefing. It reported that Vitalpac under-scored the EWS in Vitalpac V2.3 and V3.0, resulting in potential misclassification of deterioration risk. A product fix was delivered, and affected customers were also asked to review the case notes of patients at potential risk of harm. A notice in February 2016 reported that clients' servers sometimes rejected

patient observation data submitted from Vitalpac Nurse V3.x, with the observations not appearing in patient charts and records. A product fix was delivered, and affected customers were also asked to review case notes of patients who were potentially affected.

Equality considerations

NICE is committed to promoting equality, eliminating unlawful discrimination and fostering good relations between people with particular protected characteristics and others.

Older patients who are unwell are more likely to be treated in acute and general inpatient settings than younger patients, and therefore are more likely to be monitored by the technologies covered in this briefing. The National Early Warning Score does not apply to children under 16 or pregnant women. Comparable EWS algorithms are being developed by NHS England, NHS Improvement and the Royal College of Paediatrics and Child Health (RCPCH) for paediatrics. Age and pregnancy are protected characteristics under the Equality Act 2010.

Clinical and technical evidence

A literature search was carried out for this briefing in accordance with the interim process and methods statement. This briefing includes the most relevant or best available published evidence relating to the clinical effectiveness of the technologies. Further information about how the evidence for this briefing was selected is available on request by contacting mibs@nice.org.uk.

Published evidence

This briefing summarises 2 prospective studies and 1 multicentre retrospective observational study, which include:

- 577 nurse events comparing the System for Electronic Notification and Documentation (SEND) with paper-based observation charts

- 18 wards comparing the Vitalpac technology with standard care

- 251,266 admissions comparing scores from the latest version of the National Early Warning Score (NEWS2) to the earlier version (NEWS) using either the SEND or Vitalpac systems.

These studies were carried out across 3 different NHS trusts.

Overall assessment of the evidence

There is limited published evidence on applying the technologies in this briefing to NEWS2 early warning alerts and the associated outcomes for deteriorating adult patients in hospital.

Both of the identified prospective studies reported outcomes relevant to the NHS care pathway. One study concluded that using the technology can save healthcare professionals' time when capturing and recording physiological observations and calculating a NEWS2-based score. The second prospective study found that using the technology can increase physiological observations, and reduce unplanned intensive care admissions and cardiac arrests.

The multicentre retrospective study reported clinical outcomes stratified by patients at risk of, or with confirmed, type II respiratory failure. It found that the NEWS2 oxygen saturation (SpO_2) scoring modifications to NEWS do not improve discrimination of adverse outcomes in patients with documented type II respiratory failure or reduce discrimination of adverse outcomes in patients at risk of type II respiratory failure.

Future large, multicentre prospective studies in the NHS would help develop the evidence base. These should focus on relevant outcomes, such as the accuracy of NEWS2 alerts, and report clinical outcomes, such as a need for a higher level of care, cardiac arrest incidence, length of stay in hospital, and mortality, when compared with standard care. Further research could identify which groups of patients would benefit from this technology the most. A full economic evaluation of introducing such a system to the NHS is also needed, including the resources required to respond to increased alerts.

The following summarises the clinical evidence and its strengths and limitations.

Wong et al. (2017)

Study size, design and location

A before-and-after, prospective, observational study, in which 577 nurse events were observed across 3 wards in 2 university teaching hospitals in 1 NHS trust (Oxford, UK).

Intervention and comparator(s)

Intervention: SEND system (n=296). Comprising manual data entry at the patient's bedside, on a roll stand mounted tablet, alongside the vital signs monitor.

Comparator: paper-based observation chart (n=281).

Key outcomes

The observation recording process was divided into 'view chart' and 'take vital signs' tasks. The former was defined as the task of locating and opening the chart, the latter was defined as measuring and documenting vital signs. Any interruptions were timed, classified and excluded from the overall comparison.

Overall, the mean time to complete a set of physiological observations and output a NEWS2-based early warning score was lower using SEND (150 seconds; 95% confidence interval [CI]: 130 seconds to 172 seconds) than paper-based observation charts (215 seconds; 95% CI: 177 seconds to 262 seconds). The treatment effect ratio was 0.70 (95% CI: 0.57 to 0.85, $p<0.001$), equivalent to a 30% reduction in time.

Of the 2 tasks, 'view chart' and 'take vital signs', the greatest time savings were observed in the latter. The mean time to locate and open the chart was 13 seconds (95% CI: 10 seconds to 17 seconds) using SEND and 18 seconds (95% CI: 13 seconds to 27 seconds) using paper (treatment effect ratio 0.36, $p=0.052$). The mean time to measure and document a set of physiological observations was 140 seconds (95% CI: 120 seconds to 164 seconds) using SEND and 194 seconds (95% CI: 156 seconds to 241 seconds) using a paper chart (treatment effect ratio 0.72, $p=0.005$).

Strengths and limitations

There were a relatively large number of nurse events observed, but the study was only in 1

NHS trust, and may not be generalisable across the wider NHS.

Measurements were taken between 9am and 5pm on weekdays only, and may not reflect practice outside those times.

Nurses were aware that they were being measured, which may have altered their normal behaviour (the Hawthorne Effect).

Greengross et al. (2014) (poster)

Study size, design and location

18 wards were observed in a prospective study in 1 NHS trust (Croydon, UK).

Intervention and comparator(s)

Intervention: Vitalpac system.

Comparator: unclear.

Key outcomes

The mean number of observations per patient increased from less than 3 to more than 4 per day. The completeness of observations was sustained at more than 99%. Observations taken on time increased from 55% to 85%. Night-time observations increased from 40% of those expected to 100%. Unplanned admissions to the intensive care unit (ICU) reduced by 54%. Cardiac arrests reduced by 70%, equivalent to 120 fewer per year.

Strengths and limitations

A relatively large number of wards were observed, but the study was only in 1 NHS trust, and may not be generalisable across the wider NHS.

This study was conducted using the earlier version of NEWS scoring, but the alert system and care pathway would still be generalisable to NHS practice.

There is limited further information to make a judgement on the study's strengths and

limitations. However, resource requirements such as increased availability of advanced nurse practitioners and medical response teams were not reported in this study.

Pimentel et al. (2019)

Study size, design and location

A multicentre, retrospective observational study of 251,266 admissions at 5 acute hospitals in 2 NHS trusts (Oxford and Portsmouth, UK).

Intervention and comparator(s)

Intervention: NEWS2 scores using the SEND system in Oxford and Vitalpac system in Portsmouth.

Comparator: NEWS scores using the SEND system in Oxford and Vitalpac system in Portsmouth.

Key outcomes

Primary outcome: in-hospital death within 24 hours of an observation set.

Secondary outcomes: cardiac arrest, unanticipated ICU admission, and either cardiac arrest, unanticipated ICU admission or death within 24 hours of an observation set.

The NEWS2 adjustment for patients with or at risk of type 2 respiratory failure (T2RF) differs from NEWS in the assignment of weights to measured SpO_2 (NEWS weights SpO_2 values below 96%; NEWS2 below 88%). Additionally, for patients with or at risk of T2RF when receiving oxygen, NEWS2 assigns weights for SpO_2 values above 92%.

Among 251,266 adult admissions, 48,898 were identified to be at risk of T2RF by diagnostic coding. In this group, NEWS2 showed statistically significant lower discrimination (c-statistic; 95% CI) for identifying in-hospital mortality within 24 hours (0.860; 0.857 to 0.864) than NEWS (0.881; 0.878 to 0.884). For 1,394 admissions with documented T2RF, discrimination was similar for both systems: NEWS2 (0.841; 0.827 to 0.855), NEWS (0.862; 0.848 to 0.875). For all secondary endpoints, NEWS2 showed no improvements in discrimination.

Strengths and limitations

This study was clearly reported and focused on patient subgroups relevant to the new SpO_2 scoring method in NEWS2.

Large and clinically relevant cohorts of patients admitted with, or at risk of, T2RF were generated for analysis through the retrospective datasets. Vital signs measured throughout the patient's hospital journey were incorporated in complete observation sets. Multiple imputation methods were used to account for missing values.

Limitations identified by the authors include potential misclassification of the diagnostic codes and records of oxygen prescription that the study relied on to categorise patients with, or at risk of, T2RF. The local database did not include documentation of the 'new confusion' part of the assessment of consciousness in NEWS2, so this was omitted from the analyses. Evaluation of the cardiac arrest and unanticipated ICU admission secondary outcomes in the documented T2RF group should be interpreted with caution, given the small numbers of these events (fewer than 100).

In the documented T2RF group, NEWS and NEWS2 were comparable in terms of composite outcomes, but NEWS2 reduced the alerts by up to 39%, without increasing mortality. This may illustrate the impact of limitations of using diagnostic codes (including chronic obstructive pulmonary disease and obesity) to identify the 'at risk of T2RF' group.

Recent and ongoing studies

Bonnici et al. 2016 published the study protocol for a non-randomised stepped-wedge design evaluation of the SEND system in approximately 60,000 admissions, across 4 hospitals in one NHS trust. The company said that the results are due for submission shortly.

Other companies have also said that ongoing studies are in progress to quantify the benefits of these systems in the NHS.

Expert comments

Comments on this technology were invited from clinical specialists working in the field. The comments received are individual opinions and do not represent NICE's view.

All 8 specialists were familiar with or had used the technology before.

Level of innovation

Three experts observed that the novel aspects of the technology relate to the automatic capture of physiological measurements instead of manual data entry, and how this can be extended to all aspects of identifying a deteriorating patient. This includes recognising frailty and developing acute kidney injury or sepsis. The technology also enables an overview of the hospital's acuity of illness and intervention to counter deterioration in patients who would benefit from more aggressive support. It would also minimise harmful or futile intervention in patients who are dying. Three other experts broadly concurred that early warning score (EWS) systems are a minor variation to current standard care, removing the risks to patients caused by human error in chart-based calculations by recording observations electronically and integrating with electronic health record (EHR) systems to produce alerts. Another commented that extensive resource impact studies have been carried out in their NHS organisation. Because they own and build these systems, they can react to findings and implement service change as needed. However, they also said that EWS systems are not yet well-validated and there are patient groups for whom exceptions must be considered, such as patients in burns, neurosurgery and paediatric settings.

Potential patient impact

There was a general consensus from all experts that the technology has resulted in more reliable monitoring of the National Early Warning Score (NEWS2), including:

- less failure to record observations and escalate incidents

- fewer calculation errors

- the added opportunity for non-verbal communication through text alerts.

In one case, local data suggest a trend of reduced moderate harm and increased low and no-harm incidents after roll-out, and potential reductions in unplanned admissions to critical care.

Two experts also observed that a system that prompts staff about a required action improves patient safety and the timeliness of interventions. In addition, electronic systems

offer clarification over who should be contacted, according to the NEWS2 score. However, another expert identified a potential risk to patients through the automatic upload of electronic observations, because nursing contact time with the patient is vital to make an overall assessment of their condition. Local experience is that a nursing concern can precede physiological changes by a median of 3 to 4 hours. Therefore their trust has opted for bedside observations and manual data entry into the electronic system instead of automatic data upload. The trust plans to re-enable automated data upload in the future so it can check for manual transcription errors.

Another expert observed that all hospital patients are likely to benefit from these technologies, because patients who become unexpectedly unwell are often the most at risk of harm from delayed escalation of care, rather than critically ill patients, who are already under close observation in NHS hospitals. Earlier recognition of deterioration and timely intervention is likely to improve patient outcomes.

Potential system impact

According to one expert, the technology saves approximately 1 minute per patient, per set of observations, releasing up to 140 hours per day of staff time across their NHS trust (90 wards). There are also financial benefits from reduced critical care admissions. Reduced length of stay releases bed occupancy.

Another NHS trust said that it has significantly reduced its set-up costs and recurrent revenue by building an in-house EWS system, requiring 1 band 6 programmer and using the existing infrastructure of the IT department to maintain and support after-project delivery. This large acute trust is part of NHS England's Acute Global Digital Exemplars programme, which will share its experiences with the rest of the NHS. Experience to date has shown that hospital patient flow can be more intelligently managed. Ward rounds can be prioritised by seeing the sicker patients (higher NEWS2 scores) first. Admissions can be distributed to less dependent wards; that is, the total dependency of a ward by cumulative observation frequency can inform how much nursing resource is required to monitor patients on that ward. More widely, the technology may enable a regional network review of hospital dependency in managing any major or mass casualty incident, diverting patients who do not need major trauma care to units with lower dependency, away from the trauma centres at times of peak demand, where appropriate.

A expert at another NHS trust advised that they will be able to study the technology in a hospital that currently does not have an electronic health record system. Outcomes of

interest include the impact of rapid early response to the deteriorating patient on critical care admission. The installation costs of adopting the technology are recognised and staffing resource requirements may also increase as early intervention teams are needed. However, such costs may be offset by decreased costs of overall admissions to critical care, or reduced length of stay in critical care and hospital wards.

General comments

One expert said that there is not enough published evidence to give a reasonable opinion on the systems in the scope of this briefing and that further research in NHS hospitals is needed. Most wards in the NHS are reliant on old, slow computers and generally poor-quality operating systems, which sometimes prevent clinicians accessing vital data. They said that how easy it is to log on and input data is crucial and should be a key outcome measure in any future studies. If the NHS adopts the technology there will be the opportunity for large-scale research on patient deterioration. The commentator also said that the commercial system providers should be mandated to automatically keep up with proposed NHS changes without large costs to organisations, and to ensure interoperability with other computer systems across the NHS. The future aim should be for physiological observations captured in the community, from GP and ambulance systems, and other secondary care settings, to seamlessly follow the patient. Furthermore, historical records should be maintained, so that baseline physiological data can be easily compared.

Another expert observed that, for widespread adoption, the technology must be timely, applicable and have a good user interface, and ideally be clinician-designed and led. Wi-Fi and communication networks must be high-speed and readily accessible in NHS hospitals. Hardware must be up to date and widely available to allow individual data to be inputted from every bed space in the hospital. They said that all inpatients in their organisation are monitored with the technology (1,200 beds and more than 25,000 admissions per year). However, this is not yet the situation for large numbers of secondary and tertiary care providers in England. Another expert expressed concern about what happens if Wi-Fi is lost and devices cannot be used; then back-up paper charts are needed. Other concerns are potential faults and errors in calculation or alerting (however systems are required to mitigate for this) and the potential for over-reliance on systems, so staff do not react to a clinical concern if the system fails to alert even when there may be other signs of deterioration. One expert noted the potential for over-alerting and alert fatigue, which may divert or interrupt staff resources allocated to deal with deteriorating patients. One expert suggested that an additional core requirement is for 'worry' to be built into systems, which would generate an action and potential escalation based on the clinical judgement of

frontline staff, but would not add to the NEWS2 score.

One expert advised that their trust has approximately 7,000 devices and undertakes around 50,000 observations per week, on around 5,000 to 8,000 patients. They experience around 3,000 automated escalations per week. Another trust admits an average of 90 adult patients per month in an unplanned manner to critical care, with an average predicted mortality of 20% to 30%. Small improvements through earlier identification, leading to a reduction in severity of the patient's condition at the time of critical care admission will be associated with a mortality reduction (because physiology accounts for around 80% of the Intensive Care National Audit and Research Centre (ICNARC) mortality prediction model). Therefore the technology will save a significant number of lives. Ward staff at this trust like the system and prefer it to paper charts.

Another expert concluded that it is often difficult to prove the effectiveness of a single intervention (such as the introduction of an electronic EWS technology) when it comes as part of a complex healthcare intervention. For example, an electronic solution will not be successful unless accompanied by education, feedback, and re-evaluation as part of a trust executive-led change management culture that encourages quality improvement.

Expert commentators

The following clinicians contributed to this briefing:

- Dr Keith Girling, medical director, Nottingham University Hospitals NHS Trust, did not declare any interests.

- Dr Matt Inada-Kim, consultant acute physician and sepsis lead, Hampshire Hospitals NHS Foundation Trust, national clinical lead for deterioration and national clinical adviser for sepsis at NHS England and NHS Improvement, declared that he has authored 4 recent papers and 2 NHS England blogs that may be or may have been previously used by NICE.

- Dr Tanya Pankhurst, deputy director of digital healthcare, University Hospitals Birmingham NHS Foundation Trust, declared that her trust builds, uses and now markets this technology through a third party, but she does not have any personal shares or other commercial interest in the technology.

- Dr Emmanuel Nsutebu, consultant infectious diseases physician, Royal Liverpool and Broadgreen University Hospitals NHS Trust, did not declare any interests.

- Ingrid O'Neil, sister (retired), critical care outreach, The Newcastle upon Tyne Hospitals NHS Foundation Trust, did not declare any interests.

- Dr Phil Laws, consultant in intensive care medicine, clinical director of quality and safety, and NEWS champion, The Newcastle upon Tyne Hospitals NHS Foundation Trust, did not declare any interests.

- Dr Richard M Venn, consultant anaesthesia and intensive care, Western Sussex Hospitals NHS Foundation Trust, declared that he holds grants from the Small Business Research Initiative and managed by the National Institute for Health Research Devices for Dignity Healthcare Technology Co-operative (NIHR Devices for Dignity HTC) and the British Kidney Foundation.

- Melanie Palmer, senior sister, critical care outreach, The Newcastle upon Tyne Hospitals NHS Foundation Trust, did not declare any interests.

Development of this briefing

This briefing was developed for NICE by Newcastle External Assessment Centre. The interim process and methods statement sets out the process NICE uses to select topics, and how the briefings are developed, quality-assured and approved for publication.

Update information

Minor changes since publication

October 2020: In table 1, the company that makes the System for Electronic Notification and Documentation (SEND) was corrected to Sensyne health.

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