Impact case study (REF3)

Institution: University of Portsmouth		
Unit of Assessment: UoA 11: Computer Science and Informatics		
Title of case study: Clinical outcome modelling saves thousands of lives (NEWS)		
Period when the underpinning research was undertaken: 2004 to present		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Prof. Jim Briggs	Professor of Informatics	01/09/1995 - date
Prof. David Prytherch	Professor of Health Informatics	23/11/2016 - date Also had visiting roles since 2001. Submitted (Cat C) to RAE 2008 and REF 2014.
Period when the claimed impact occurred: 2008 to 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

The National Early Warning Score (NEWS) is, with only a couple of very small changes made by the Royal College of Physicians, based on our ongoing data science research. It has had enormous health impact:

- NEWS is estimated to save over 1,800 lives per year in England alone
- NEWS has been recommended by the World Health Organization for the clinical management of patients with suspected or confirmed COVID-19
- NEWS is mandated for use by all NHS acute hospitals and ambulance services in England, Wales and Scotland for the assessment of patients; NEWS is also used widely by UK general practitioners and in many hospitals overseas

2. Underpinning research

The impact arises from the health informatics research carried out in Portsmouth by Professor Jim Briggs and Professor David Prytherch (Note: prior to 2016, Prytherch was employed by Portsmouth Hospitals University NHS Trust (PHUT) and was a Visiting Professor at the University). Our collaborators included clinical colleagues at PHUT plus Oxford, Southampton and Bournemouth universities. Our approach is extremely inter-disciplinary, but embedded in all we do are the fundamental principles that information must be acquired by reliable means and reasoned about rigorously; all applied in a clinical context.

At the University of Portsmouth (UoP), we use clinical data to model adverse patient outcome. The models enable clinicians to predict which patients are at risk of deterioration, and medically intervene. Portsmouth has an international reputation for our work on the "general" patient on the ward, rather than being focused on patients with any particular medical condition. Our research was founded on work done between the late 1990s and 2003 to develop models (P-POSSUM) of outcomes in surgery. P-POSSUM was a success and has been adopted internationally, but is only applicable to surgical cases. This led us to investigate ways to model outcomes in general medicine cases, including using blood test data to develop biochemistry and haematology outcome models (BHOM) that can be used to identify patients at risk of mortality with very high discrimination. Our approach only uses data routinely collected and available immediately after a patient's admission to hospital and can thus be used for direct patient care.

We showed that serious events (defined as in-hospital deaths, cardiac arrests and unanticipated intensive care unit admissions) are frequently preceded by vital sign abnormalities (e.g. in pulse, blood pressure, temperature) (R1). A collaboration with The Learning Clinic Ltd (TLC) (G1), who were aware of our P-POSSUM / BHOM work, enabled us to explore this further. In return, TLC (in conjunction with PHUT) provided a means to collect vital signs data quickly and accurately at the patient's bedside and in an electronic format.

Using that data, we had shown (prior to 2014) that:

- innovative techniques can be used to join different databases in such a way that clinical significance is not lost or corrupted (unpublished work due to commercial confidentiality)
- vital signs data can be used to devise an early warning score (EWS) system that can both identify patients whose condition is deteriorating and minimise unnecessary false alarms (R2)

- an EWS devised from vital signs data (ViEWS, which subsequently was renamed as NEWS) performs better than any of the 33 other EWS systems in the literature (R3)
- decision tree data mining techniques can be used to develop new early warning score systems quickly (R4)

Since 2014, we have also shown that:

- aggregate scores are more important than single high scores for discriminating high-risk patients (R5)
- NEWS (which was developed on a population of general medicine patients) is equally applicable to surgery patients (R6)
- NEWS is better than the medical emergency team criteria systems typically used in US hospitals (R7)
- NEWS is better than the established mechanism (qSOFA) for assessing patients for risk of sepsis (R8)

Our EWS models can be applied to any patient under clinical care, but are increasingly used to allow nurses to determine which of their patients are deteriorating and when to summon assistance (e.g. a doctor), without causing too many false alarms (which would overburden hospital resources).

This work has led to several further funded projects at UoP, all applying data science, including:

- *Missed Care* (G2) assessing the impact that low nurse staffing has on patient mortality;
- *HAVEN* (G3 and G4) developing a means of identifying those patients on a general ward most appropriate for transfer to an intensive care unit;
- *Xim KTP* (G5) developing a non-contact video based vital sign monitoring system;
- *FOBS* (G6) determining the optimum frequency for nurses to take vital sign observations of their patients.

3. References to the research

Bibliography

R1	Kause, J., Smith, G., **Prytherch, D. R**., Parr, M., Flabouris, A., & Hillman, K. (2004). A comparison of Antecedents to Cardiac Arrests, Deaths and EMergency Intensive care Admissions in Australia and New Zealand, and the United Kingdom - The ACADEMIA study. *Resuscitation*, *62*(3), 275–82. https://doi.org/10.1016/j.resuscitation.2004.05.016
R2	Smith, G. B., **Prytherch, D. R**., Schmidt, P., Featherstone, P. I., Knight, D., Clements, G., & Mohammed, M. A. (2006). Hospital-wide physiological surveillance-A new approach to the early identification and management of the sick patient. *Resuscitation, 71*(1), 19-28. https://doi.org/10.1016/j.resuscitation.2006.03.008
R3	**Prytherch, D. R.**, Smith, G. B., Schmidt, P. E., & Featherstone, P. I. (2010). ViEWS-Towards a national early warning score for detecting adult inpatient deterioration. *Resuscitation, 81*(8), 932–937. https://doi.org/10.1016/j.resuscitation.2010.04.014
R4	Badriyah, T., **Briggs, J. S.**, Meredith, P., Jarvis, S. W., Schmidt, P. E., Featherstone, P. I., **Prytherch, D. R**., & Smith, G. B. (2014). Decision-tree early warning score (DTEWS) validates the design of the National Early Warning Score (NEWS). *Resuscitation, 85*(3), 418–423. https://doi.org/10.1016/j.resuscitation.2013.12.011
R5	Jarvis, S., Kovacs, C., **Briggs, J. S**., Meredith, P., Schmidt, P. E., Featherstone, P. I., **Prytherch, D. R.**, & Smith, G. B. (2015). Aggregate National Early Warning Score (NEWS) values are more important than high scores for a single vital signs parameter for discriminating the risk of adverse outcomes. Resuscitation, *87*, 75-80. https://doi.org/10.1016/j.resuscitation.2014.11.014
R6	Kovacs, C. M. S., Jarvis, S. W., **Prytherch, D. R.**, Meredith, P., Schmidt, P. E., **Briggs, J. S**., & Smith, G. (2016). Comparison of the National Early Warning Score in non-elective medical and surgical patients. *British Journal of Surgery, 103*(10), 1385–1393. https://doi.org/10.1002/bjs.10267

R7	Smith, G. B., **Prytherch, D. R.,** Jarvis, S. W., Kovacs, C. M. S., Meredith, P. G., Schmidt, P. E., & **Briggs, J. S.** (2016). A Comparison of the Ability of the Physiologic Components of Medical Emergency Team Criteria and the U.K. National Early Warning Score to Discriminate Patients at Risk of a Range of Adverse Clinical Outcomes. *Critical Care Medicine, 44*(12), 2171–2181. https://doi.org/10.1097/CCM.0000000000002000
R8	Redfern, O. C., Smith, G. B., **Prytherch, D. R**., Meredith, P., Inada-Kim, M., & Schmidt, P. E. (2018). A Comparison of the Quick Sequential (Sepsis-Related) Organ Failure Assessment Score and the National Early Warning Score in Non-ICU Patients With/Without Infection. *Critical Care Medicine, 46*(12), 1923-1933. https://doi.org/10.1097/CCM.0000000000003359

All the papers above appeared in leading medical journals, including Resuscitation, which is the leading European journal in acute disease management, and Critical Care Medicine, which is its US equivalent. All papers are highly cited, particularly R3 which has over 450 citations and R1 over 600. R5, R6 and R7 are in our current REF2 submission.

Research grant funding

G1	**Briggs, J.S**. Knowledge Transfer Partnership with TigerTeam Software Ltd. Funded by Technology Strategy Board and the company, April 2006-April 2008, (GBP114,000).
G2	Griffiths, P., Meredith, P., Schmidt, P., de long, A., Sinden, N., Maruotti, A., Bohning, D., **Prytherch, D**., Smith, G., Ball, J., **Briggs, J.S** & Bloor, K. The association between missed observations and nurse staffing levels in hospital wards (Missed Care). Funded by the National Institute of Health Research. June 2015-September 2017, (GBP84,771).
G3	Watkinson, P., Young, J.D., **Prytherch, D.**, Tarassenko, L., Clifton, D., & **Briggs, J.S.** Hospital Alerting Via Electronic Noticeboard (HAVEN). Funded by the Wellcome Trust & Department of Health), August 2015-August 2018, (GBP297,675).
G4	Watkinson, P., Young, J.D., **Prytherch, D.,** Tarassenko, L., Clifton, D., & **Briggs, J.S**. Hospital Alerting Via Electronic Noticeboard (HAVEN) extension. Funded by the Wellcome Trust & Department of Health), August 2018-August 2019, (GBP41,796).
G5	**Briggs, J.S**. & Powell, W. Non-contact video based vital sign monitoring in home settings. Knowledge Transfer Partnership with Xim Ltd. Funded by Innovate UK and the company, January 2017-December 2018, (GBP146,675).
G6	**Briggs, J.S**., Jones, J., Redfern, O., Meredith, P., Schmidt, P., Lawrence, R., Maruotti, A., **Prytherch, D**., Smith, G., Griffiths, P., & Watkinson, P. FOBS: Safer and more efficient vital signs monitoring to identify the deteriorating patient: An observational study towards deriving evidence-based protocols for patient surveillance on the general hospital ward. Funded by the National Institute of Health Research, October 2018-March 2021, (GBP867,316).

4. Details of the impact

Since August 2013, our research has had impact on public policy, changed the way practitioners and professionals monitor patients, led to improved efficiency in hospitals and economic impact in a company, and improved patient outcomes, including saving thousands of lives.

Background (impact prior to 2013)

In 2012, the Royal College of Physicians (RCP) published a report recommending adoption across the NHS of a new National Early Warning Score (NEWS) for monitoring patients in hospital (S1). NEWS was (with only a couple of very small changes) based on ViEWS as published in our 2010 paper (R3).

The background to this was that the RCP had set up a NEWS Development and Implementation Group (NEWSDIG). One of the members of the group was Professor Gary Smith, our long-time collaborator and a former Consultant Physician at PHUT, now affiliated to Bournemouth University. Prytherch and Smith undertook (on behalf of NEWSDIG) the performance analysis that confirmed the weightings and triggers.

Adoption of NEWS was rapid and widespread. By 2013, two-thirds of UK hospitals had already adopted it or were intending to do so.

NEWS2

In December 2017, RCP published a second report (S2) that reviewed NEWS and introduced an update, NEWS2. The report both documented the reach of NEWS since its inception (describing its uptake as extraordinary) and provided a justification for the changes made to create NEWS2. The report's conclusion was, *"The NEWS has driven a step-change improvement in safety and clinical outcomes for acutely ill patients in our hospitals by standardising the assessment and scoring of simple physiological parameters and the adoption of this approach across the NHS."*

One of the changes in NEWS2 involved escalation criteria. Our 2015 paper (R5) was cited as evidence to change the recommendation regarding when a nurse should call a doctor.

The RCP report also evidenced that: *"The majority of NHS hospitals are now using the NEWS; over 120,000 NHS staff have voluntarily completed the online NEWS training and accreditation programme; and the NEWS is being used by many ambulance services and beginning to be used by some vanguard primary care centres to help better triage acutely ill patients."*

Further, the report said, *"First, the NEWS has now received the formal endorsement of NHS England (NHSE) and NHS Improvement (NHSI) for the NEWS to become the early warning system for the NHS in England. The NEWS has already been endorsed in Scotland and Wales. … Second, NHSE has incorporated the NEWS as the early warning system to improve the detection of clinical deterioration due to sepsis in adults. These are major steps towards the ultimate aim, to see NEWS embedded across the NHS to improve the detection of acute illness and improve patient outcomes"* (S2).

Effectiveness in improving patient outcomes

Evaluation of NEWS in clinical settings (S3) showed a reduction in patient mortality of around 18% in two pilot hospitals when comparing the years before and after the introduction of electronic early warning score systems to the wards. Extrapolating this to every hospital in the UK, this represents the saving of thousands of lives a year. The NHS England NEWS web page (S4) quantifies this by saying, *"Through standardisation of NEWS2, we can reduce the number of patients whose conditions deteriorate whilst in hospital, and potentially save over 1,800 lives a year".*

Sepsis guidelines

In 2016, the National Institute for Health and Care Excellence (NICE) updated its guideline (S5) on the recognition, diagnosis and management of Sepsis (severe infection that damages tissues and organs). This guideline recommends use of an early warning score to assess people with suspected sepsis in acute hospital settings to better direct treatment. The NEWS2 report (S2) notes that NHS England endorses NEWS2 for this purpose. That choice was in preference to an internationally developed alternative (qSOFA) as a result of work that led to our published analysis (R8).

NHS England adoption

After the publication of NEWS2, NHS England took a number of steps to ensure that NEWS2 was used as widely as possible across the country. In April 2018, it sent a Patient Safety Alert (S6) to all acute hospital trusts and ambulance trusts mandating adoption of NEWS2 by March 2019. This was accompanied by the setting of a related Commissioning for Quality and Innovation (CQUIN) indicator (S7) requiring hospitals to use NEWS2 to screen patients arriving as emergency admissions. The CQUIN means that a proportion of a hospital's income is tied to them meeting a target of screening at least 90% of patients this way, so provided a financial incentive to hospitals to comply. The NHS England webpage (S4) (accessed in December 2020) evidences current compliance: 100% of ambulance trusts and 76% of acute hospital trusts now use NEWS2.

International impact

The RCP report (S2) reported that they had received reports of the adoption of NEWS internationally, with requests to use NEWS coming from health services across the world from Europe to India and the USA. More recently, a 2020 systematic review in the BMJ (S8) noted that 50 papers (out of 84 reviewed) had performed evaluative reviews of NEWS/ViEWS including studies from USA(x13), Denmark(x3), South Korea(x3), Canada(x2), Australia, Finland, Italy,

Netherlands, Portugal, Sri Lanka, Sweden, Turkey and Uganda, in addition to the UK(x20). We are aware of adoption in Brazil and Ireland too.

However, the icing on the cake for the reach and significance of our work came during the recent coronavirus crisis. NEWS2 was the only adult early warning score mentioned in the May 2020 guidance (S9) issued by the World Health Organisation (WHO) for the clinical management of patients with suspected or confirmed COVID-19. The WHO recommended it for *"the recognition and escalation of treatment of the deteriorating patient".*

Economic impact

The Knowledge Transfer Partnership (KTP) work we did with The Learning Clinic Ltd (TLC) (G1) between 2006 and 2008 supported the development of their Vitalpac system (bedside recording of vital signs). The KTP Associate was involved in the development of the doctor interface to the system. TLC firstly incorporated ViEWS, then NEWS and then NEWS2 into this.

TLC continues to have economic success with their Vitalpac product. The company was acquired in October 2015 by SystemC Ltd (a company delivering IT solutions to the health sector) but still exists as a distinct trading entity. Since acquisition, a loss of GBP888,000 in 2014 has been converted into a profit of GBP793,000 in 2019. At its peak, TLC employed 64 people, all related to this work.

5. Sources to corroborate the impact

S1	Royal College of Physicians. National Early Warning Score (NEWS): Standardising the assessment of acute-illness severity in the NHS. Report of a working party. London: RCP, 2012. http://www.rcplondon.ac.uk/resources/national-early-warning-score-news
S2	Royal College of Physicians, report "National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS" published in December 2017 (https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news-2)
S3	Schmidt PE et al, Impact of introducing an electronic physiological surveillance system on hospital mortality, BMJ Quality & Safety 2015;24:10-20. http://dx.doi.org/10.1136/bmjqs-2014-003073
S4	NHS England, "National Early Warning Score (NEWS)", 2020 https://www.england.nhs.uk/ourwork/clinical-policy/sepsis/nationalearlywarningscore/
S5	NICE, "Sepsis: recognition, diagnosis and early management", NICE guideline [NG51], Updated 13 September 2017 https://www.nice.org.uk/guidance/ng51
S6	NHS Improvement, "Patient Safety Alert: Resources to support the safe adoption of the revised National Early Warning Score (NEWS2)", 25 April 2018 https://improvement.nhs.uk/documents/2508/Patient_Safety_Alert_-_adoption_of_NEWS2.pdf
S7	NHS England, "2017/19 CQUIN", The NHS England CQUIN is specified in row 5 of the "National CQUIN details" tab of the spreadsheet downloadable from https://www.england.nhs.uk/publication/commissioning-for-quality-and-innovation-cquin-201719-indicators/
S8	Gerry S et al. Early warning scores for detecting deterioration in adult hospital patients: systematic review and critical appraisal of methodology, BMJ, 2020; 369 :m1501 https://www.bmj.com/content/369/bmj.m1501
S9	World Health Organisation, "Clinical management of COVID-19: interim guidance", Report WHO/2019-nCoV/clinical/2020.5, 27 May 2020 https://apps.who.int/iris/rest/bitstreams/1278777/retrieve