Institution: University of Portsmouth

Unit of Assessment: 11 Computer Science and Informatics

Title of case study: Clinical outcome modelling saves lives

1. Summary of the impact

1. **Practitioner/professional service impact.** Our work on clinical outcome modelling has influenced the Royal College of Physicians' (RCP) new standard for the assessment of the severity of acute illness (known as the "National Early Warning Score" or NEWS). The specific recommendation is for adoption by NHS bodies, but is already being adopted internationally.
2. **Health impact**. The chairman of the RCP working party estimated that our work could result in the saving of thousands of lives per year.
3. **Economic impact**. Our work is incorporated in the *VitalPAC* system developed by The Learning Clinic Ltd (TLC), and currently deployed to more than 20 hospitals.

2. Underpinning research

Outline of research

The impact arises from the health informatics research carried out in Portsmouth by Professor David Prytherch and Dr Jim Briggs, supported by Bernie Higgins, Jeff Sirl and others. Our collaborators included Portsmouth Hospitals NHS Trust (PHT), Bournemouth University and The Learning Clinic. 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.

We collect and use clinical data to model adverse patient outcome. The models enable clinicians to predict which patients are at risk of deterioration, and medically intervene. Our research has built on work done in the late 1990s and up to 2003 to develop models (P-POSSUM) of outcomes in surgery (1). P-POSSUM was a success and has been widely adopted, but is only applicable to surgical cases. This led us to investigate ways to model outcomes in general medicine cases, using pathology data. We have shown that biochemistry and haematology outcome models (BHOM) can be used to identify patients at risk of mortality with very high discrimination (2, 3). Other monitoring and surveillance systems (e.g., Dr Foster, CHKS and HES) require coded administrative data only available after discharge. Our techniques add clinical context to these, and have obvious uses in clinical governance and clinical performance management as well as direct patient care. Our approach only uses data routinely collected and available immediately after a patient's admission to hospital.

We know that serious physiological abnormalities frequently precede primary events (defined as in-hospital deaths, cardiac arrests, and unanticipated intensive care unit admissions) (4). The P-POSSUM / BHOM work led to our collaboration with The Learning Clinic Ltd (TLC). In return, TLC provided a means to collect vital signs data quickly and accurately in an electronic format. As a result we have access to probably the biggest database of vital signs data anywhere in the world. Using that data we have shown 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 (5)
- an EWS devised from vital signs data (ViEWS) performs better than any of the 33 other EWS systems in the literature (6)
- decision tree data mining techniques can be used to develop new early warning score systems (DT-EWS) quickly (Badriyah, Briggs, Prytherch, Smith, Schmidt, to appear)

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).

BHOM and the VIEWS/DT-EWS/NEWS family of models are applicable to virtually all hospital in-patients.

University of Portsmouth Researchers

- Prof David Prytherch (Visiting Senior Research Fellow seconded to UoP 2001-2011; Visiting Professor 2011-present).
- Drs Paul Schmidt and Peter Featherstone (Honorary Medical Senior Lecturers, appointed 2000)
- Dr Jim Briggs (currently Principal Lecturer and Director of the Centre for Healthcare Modelling and Informatics (CHMI), appointed 1995).
- Jeffrey Sirl (Research Associate 2002-2004).
- Bernard Higgins (Senior Lecturer in Mathematics; submitted in the Allied Health Professions, Dentistry, Nursing and Pharmacy UOA, appointed 1979).

3. References to the research

1. Prytherch DR, Whiteley MS, Higgins B, Weaver PC, Prout WG, Powell SJ. (1998). POSSUM and Portsmouth POSSUM for predicting mortality. Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity. Br J Surg. 85(9):1217-20. http://www.ncbi.nlm.nih.gov/pubmed/9752863

2. * Prytherch DR, Sirl JS, Schmidt P, Featherstone PI, Weaver PC, Smith GB. (2005). The use of routine laboratory data to predict in-hospital death in medical admissions. Resuscitation. 66(2):203-7. http://www.ncbi.nlm.nih.gov/pubmed/15955609

3. Prytherch DR, Briggs JS, Weaver PC, Schmidt P, Smith GB. (2005). Measuring clinical performance using routinely collected clinical data. Med Inform Internet Med; 30(2):151-6. http://www.ncbi.nlm.nih.gov/pubmed/16338803

4. Kause J, Smith G, Prytherch D, Parr M, Flabouris A, Hillman K, et al. (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. http://www.ncbi.nlm.nih.gov/pubmed/15325446

5. * Smith GB, Prytherch DR, Schmidt P, Featherstone PI, Knight D, Clements G, et al. (2006). Hospital-wide physiological surveillance-a new approach to the early identification and management of the sick patient. Resuscitation;71(1):19-28. https://www.ncbi.nlm.nih.gov/m/pubmed/16945465/?i=4&from=/20149516/related

6. * Prytherch DR, Smith GB, Schmidt PE, Featherstone PI. (2010). ViEWS--Towards a national early warning score for detecting adult inpatient deterioration. Resuscitation;81(8):932-7. DOI: 10.1016/j.resuscitation.2010.04.014

* Papers that best indicate quality of underpinning research

Funding

Briggs, Knowledge Transfer Partnership with TigerTeam Software Ltd (former name of TLC), Technology Strategy Board, 2006-2008, £114,000.

Briggs, *The Hospital of the Future*, Oxford University (Prof Tarassenko's group) – a sub-contract on their EPSRC-funded project, 2012-2013, £10,036.

4. Details of the impact

Our research has had three types of impact during the period 2008-2013:
1. economic impact by increasing the prosperity of TLC Ltd
2. practitioner/professional service impact on the RCP (and its members) in its development of the National Early Warning Score (NEWS)
3. health impact by the lives saved by the adoption of NEWS

Economic impact on TLC
TLC have incorporated our ViEWS (VitalPAC Early Warning Score) model (and more recently, NEWS, see below) into their VitalPAC family of products. This work was done as part of a KTP (April 2006 - April 2008) to give them that capability. The KTP associate was also involved in the development of the doctor interface to the system. TLC became aware of us because of our BHOM work and our links with the Vascular Society of GB & Ireland.

VitalPAC replaces the typical paper chart at the foot of a hospital patient's bed by recording (electronically on a mobile device) the vital signs measurements, typically taken by a nurse every few hours. ViEWS/NEWS translates the vital sign measurements into a single number known as an *early warning score* (EWS). Depending on the value, the nurse is instructed to take some action, which (in increasing order of severity) involves taking further observations more frequently, calling a doctor to see the patient, or calling a doctor urgently. Our research identified recommended thresholds for these actions.

The economic benefits to TLC included increased turnover (13-fold over 3 years), created 15 new jobs, and allowed them to attract over £1m from private investors (source 1). The VitalPAC product generates 80% of their revenue.

Policy impact on RCP work
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 (source 0, source 3). NEWS is (with only a couple of small changes) based on ViEWS as published in our 2010 paper (research reference 6).

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 PHT, now affiliated to Bournemouth University. David Prytherch and Gary Smith undertook (on behalf of NEWSDIG) the performance analysis that confirmed the weightings, triggers and escalation criteria.

Health impact and the ultimate beneficiaries
Ultimately the research impacts everyone who is admitted to a hospital that uses the system. Portsmouth Hospitals Trust led the way – it served as the development site for the VitalPAC software. PHT began piloting the software in 2006 and by 2010 its use had spread to the whole hospital. Currently, ViEWS/NEWS is used in 20 hospitals via the VitalPAC system, but it has also been carefully designed to be used in hospitals still using paper records. An ongoing survey of 116 UK hospitals by the National Outreach Forum (source 4) revealed that (as of September 2013) 28% had already implemented NEWS, a further 31% planned to introduce it within a year and a further 9% had longer-term plans. Only 8% were not considering it. NEWS has 100% adoption by NHS Wales (source 5) and it has been adopted by the Health Service Executive in the Republic of Ireland (source 6).

Since introducing VitalPAC, initial findings are that hospitals have seen fewer unanticipated intensive care unit admissions, shorter lengths of stay (source 7) and (in one hospital) a 22% decrease in seasonally-adjusted mortality (source 8). A paper evidencing this is in preparation. A 2012 study published in the journal BMJ Quality and Safety found there were nearly 12,000 avoidable deaths of adults in English acute hospitals annually. In the publicity surrounding the RCP's publication of NEWS, the chairman of the Working Party (Professor Bryan Williams from

UCL) estimated that up to half of those lives might be saved. Not only does NEWS aid in identifying deteriorating patients in need of additional clinical intervention, but its adoption nationally results in savings in the training of nurses. This attracted much press attention, for example by the BBC (source 9) and the Independent (source 10).

Finally, the collaboration between PHT and TLC for the development of the VitalPAC system has won three national awards (the NHS Connecting for Health Leadership in Health Information Accolades Scheme 2006, the "Technology and IT to improve Patient Safety" category in the 2010 Health Service Journal/Nursing Times Patient Safety Awards, and the Bupa Foundation Patient Safety Award 2010).

5. Sources to corroborate the impact

1. Letter of support from the Chief Executive of TLC, on the economic benefits to TLC, 16th September 2013

2. 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. Report by the RCP recommending the adoption of NEWS in all NHS hospitals.

3. New National Early Warning Score could save 6,000 lives, http://www.rcplondon.ac.uk/press-releases/new-national-early-warning-score-could-save-6000-lives. RCP press release relating to the publication of the report above.

4. http://www.norf.org.uk/news_implementation_forum. Evidence from the National Outreach Forum that NEWS is being adopted by 68% of NHS hospitals.

5. http://www.1000livesplus.wales.nhs.uk/sitesplus/documents/1011/Rapid%20response%202%20page%20leaflet.pdf. Leaflet describing Wales as the first country to adopt NEWS nationally.

6. http://www.hse.ie/eng/about/Who/clinical/natclinprog/acutemedicineprogramme/earlywarningscore/. Evidence of the adoption of NEWS in Ireland (as National Clinical Guideline No. 1, and as part of the national COMPASS education programme).

7. http://www.thelearningclinic.co.uk/documents/response_to_RCP.pdf. Open letter from the Medical Director of TLC relating to the RCP's report.

8. http://www.rcplondon.ac.uk/sites/default/files/6.1.5_-_lunchtime_tue_schmidt_greengross_tues_12.55_wolfson.pdf. Preliminary results of a study showing reduced mortality from the introduction of VitalPAC, presented at RCP.

9. http://www.bbc.co.uk/news/health-19001271. BBC coverage of the RCP report.

10. http://www.independent.co.uk/life-style/health-and-families/health-news/new-patient-chart-to-save-6000-lives-a-year-in-the-uk-7979658.html. An example of the extensive newspaper coverage of the RCP report.