

## Impact case study (REF3)

<b>Institution:</b> University of the West of Scotland		
<b>Unit of Assessment:</b> 3: Allied Health, Dentistry, Nursing and Pharmacy		
<b>Title of case study:</b> Saving lives by improving structured responses to sepsis patient deterioration		
<b>Period when the underpinning research was undertaken:</b> 2012 - 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Prof Kevin D. Rooney	Professor	2011 - 2020
Ms Elaine Stewart	Research Fellow / Lecturer	2013 - 2020
Dr William G. Mackay	Senior Lecturer / Reader	2012 - 2020
Prof Harry Staines	Professor	2017 - 2018
Prof Debbie Tolson	Professor	2013 - 2020
Dr Barbara O'Donnell	Lecturer / Head of Division	2006 - 2020
<b>Period when the claimed impact occurred:</b> 2014 - 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		
<b>1. Summary of the impact</b>		
<p>Mismanaged patient deterioration is a leading cause of safety-related death. Sepsis, a leading cause of deterioration, kills 11 million per annum, globally. Prior to our research, early warning scores, used to improve detection and responses, were only used in hospitals. We validated these scores for both adult and children in the prehospital setting, in order to facilitate early recognition of patient deterioration. These scores are now used across the UK and internationally. Our research also informed on how to deliver a sepsis treatment bundle, including which monitors to use. State-of-the-art approaches established through our research have been pivotal to practice changes driven by the Scottish Patient Safety Programme. In Scotland alone, our research has contributed to a 21% reduction in Sepsis mortality and a 31% reduction in cardiac arrests.</p>		
<b>2. Underpinning Research</b>		
<b>Description of the Primary Research</b>		
<p>A leading cause of patient deterioration is sepsis: there are an estimated 123,000 cases of sepsis in England every year, resulting in approximately 36,900 deaths. In Scotland, every four hours, someone dies of sepsis. Over 70% of these cases arise in the prehospital setting. Consequently, a structured response to prehospital patient deterioration is key to improving patient outcomes. Over the last 6 years, <b>our ground-breaking research has informed the Scottish Patient Safety Programme</b>, generating research evidence necessary to create a state-of-the-art, reliable structured response for 'Recognition, Rescue, Review and Referral' of deteriorating patients in prehospital settings.</p> <p>Uncertainty existed over the National Early Warning Score (NEWS) in the prehospital setting, despite it being a good predictor of inpatient mortality. NEWS involves analysis of clinical observations in hospital inpatients, in whom a course of treatment has already been started. With prehospital patients, these scores would be derived before treatment started. We performed a retrospective cohort study of 1,684 adults to evaluate NEWS in identifying those at risk of death or ICU admission in the prehospital setting. This study demonstrated that an elevated NEWS (7 or greater) among prehospital patients gives an 11% chance of death or ICU admission within 48 hours. <b>[3.1]</b> An award, <b>[3.A]</b> allowed later confirmation that prehospital NEWS in the older person was an independent predictor of death or ICU admission, through the retrospective analysis of 285,587 older persons.</p> <p>The early warning score, quick Sepsis Related Organ Failure Assessment (qSOFA), had been recommended to identify sepsis patients who were at increased risk of adverse outcome. However, concern existed over using different scores for different diseases. Prospective validation had been called for and, in our research, we uniquely compared NEWS versus qSOFA at predicting adverse outcomes across 1,713 prehospital patients <b>[3.2]</b>. We demonstrated that while qSOFA identifies patients at risk of adverse outcomes before admission, in the prehospital setting,</p>		

NEWS is superior to qSOFA at predicting ICU admission or 30-day mortality. Specifically, across a range of patient presentations, **we robustly demonstrated that patients with a NEWS of 7 or greater had 11% chance of death or ICU admission within 48 hours.** Comparison of qSOFA and NEWS performance was assessed using receiver operating characteristic curves. The area under the receiver operating characteristic curve for the primary outcome for qSOFA was 0.679 (95% CI: 0.624-0.733), for NEWS category was 0.707 (95% CI: 0.654-0.761) and for NEWS total score was 0.740 (95% CI: 0.685-0.795) **[3.2].**

A key recommendation for sepsis patients is to measure lactate within the hour following admission. However, it was well-recognised that despite having near patient analysers to measure lactate, these devices were not portable, and their availability was usually restricted to areas such as ICU. Consequently, between 2012 and 2014, we led a method comparison and prospective observational study, to compare lactate measurement of a point-of-care handheld device to near patient analysers **[3.B].** The handheld device produced accurate, efficient and quicker measurements with potential to influence decision-making sooner **[3.3].** Two awards [2013 to 2017] prospectively confirmed the earlier validation of prehospital NEWS; however, **the handheld device was not accurate or reliable in this setting [3.C, 3.D].**

Implementation of the 'Sepsis Six' – 1. Deliver high flow Oxygen 2. Take blood cultures 3. Administer empiric intravenous antibiotics 4. Measure serum lactate and send full blood count 5. Start intravenous fluid resuscitation 6. Commence accurate urine output measurement – is recommended to reduce mortality. However, achieving this has proved challenging, with little understanding of barriers to implementation. Between 2012 and 2016, we examined clinical practice in implementing the Sepsis Six, using ethnography as well as evaluating a national quality improvement collaborative **[3.E].** We discovered that in addition to focussing on behaviour change, **efforts should focus on task simplification and workflow co-ordination [3.4].**

Identification of unwell children is challenging, creating uncertainty over whether the Paediatric Early Warning Score (PEWS (Scotland)) is beneficial in the prehospital setting. Between 2015 and 2017, we researched the utility of prehospital PEWS by performing a retrospective cohort analysis of 21,202 children **[3.F]** (USD49,063). On multivariate logistic regression, PEWS (Scotland) was an independent predictor of ICU admission within 48 hours or death within 30 days, with an odds ratio of 1.403 (95%CI 1.349–1.460,  $p < 0.001$ ). Area Under Receiving Operator Curve (AUROC) for aggregated PEWS was 0.797 (95% CI 0.759 to 0.836,  $p < 0.001$ ) **[3.5].** As PEWS (Scotland) could only be analysed for 1/5<sup>th</sup> of the children, in 2019 we analysed 102,993 children, revealing that a four-component score, quick PEWS (qPEWS), was as good at predicting adverse outcomes **[3.6]** as PEWS (Scotland), which has eight components. This clinically important study was the first to demonstrate that a complete eight-point PEWS recorded in paediatric ambulance patients can predict outcome on a population basis; specifically ICU admission within 48 hours or death within 30 days for an unselected group of paediatric ambulance patients aged under 16 years. These serious outcomes are thankfully rare in children and young people but, nonetheless, our ground-breaking research has enabled **critical and life-saving changes to treatment protocols and guidance.**

### 3. References to the research

**3.1** Silcock, D J., Corfield, A R., Gowens, P A., **Rooney, K D.**, (2015) Validation of the National Early Warning Score in the prehospital setting. *Resuscitation*, 89: 31-35.

<https://doi.org/10.1016/j.resuscitation.2014.12.029>.

**3.2** Silcock, D J., Corfield A R., **Staines, H., Rooney, K D.**, (2019) Superior performance of National Early Warning Score compared with quick Sepsis-related Organ Failure Assessment Score in predicting adverse outcomes: a retrospective observational study of patients in the prehospital setting. *European Journal of Emergency Medicine*, 26(6): 433-439. DOI: 10.1097/MEJ.0000000000000589.

**3.3** Ismail, F., **Mackay, W G.**, Kerry, A., **Staines, H.**, **Rooney, K D.**, (2015) The accuracy and timeliness of a Point Of Care lactate measurement in patients with Sepsis. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 23: 68 <https://doi.org/10.1186/s13049-015-0151-x>.

**3.4** Tarrant, C., O'Donnell, B., Martin, G., Bion, J., Hunter, A., **Rooney, K D.**, (2016) A complex endeavour: an ethnographic study of the implementation of the Sepsis Six clinical care bundle. *Implement Sci*. 11: 149. <https://doi.org/10.1186/s13012-016-0518-z>.

**3.5** Corfield, A R., Silcock, D., Clerihew, L., Kelly, P., **Stewart, E.**, **Staines, H.**, **Rooney, K D.**, (2018) Paediatric Early Warning Scores are predictors of adverse outcome in the pre-hospital setting: a national cohort study. *Resuscitation*. 133: 153-159. <https://doi.org/10.1016/j.resuscitation.2018.10.010>.

**3.6** Corfield, A R., Clerihew, L., **Stewart, E.**, **Staines, H.**, Tough, D., **Rooney, K D.**, (2019) The discrimination of quick Paediatric Early Warning Scores in the pre-hospital setting. *Anaesthesia*, 75(3): 353-358 <https://doi.org/10.1111/anae.14948>.

### Grants

**3.A** **Rooney, K D.**, **Stewart, E.**, **Staines, H.**, **Tolson, D.**, *Validation of an older person's prehospital early warning score*. Dunhill Medical Trust, 2017 to 2018, GBP84,473

**3.B** **Rooney, K D.**, **Mackay, W G.**, "Can the i-STAT Point of Care (PoC) analyser aid the timely treatment of patients with Sepsis in Scottish Hospitals?" Abbott Point of Care, 2012 to 2014, GBP52,200

**3.C** **Rooney, K D.**, **Mackay, W G.**, **Stewart, E.**, **Staines, H.**, Validation of Early Warning Score and Lactate in Pre-hospital Setting (VELPS) Abbott Point of Car, 2013 to 2016, GBP40,520

**3.D** **Rooney, K D.**, **Mackay, W G.**, **Stewart, E.**, **Staines, H.**, VELPS II Abbott Point of Care, 2016 to 2017, GBP37,685.

**3.E** **Rooney, K D.**, Evaluation of a National Improvement Collaborative. Healthcare Improvement Scotland. 2012 to 2014, GBP59,000.

**3.F** **Rooney, K D.**, **Stewart, E.**, **Staines, H.**, Validation of Early Warning Score in Paediatric Ambulance Patients. Laerdal Foundation, 2015 to 2017, USD49,063.

### 4. Details of the impact

Mismanaged patient deterioration is a leading cause of safety-related death and harm within healthcare. Our research has led to the Scottish Patient Safety Programme improvements that contributed to significant reductions in mortality.

#### Impact on health

A **21% reduction in mortality from sepsis** and a **31% reduction in cardiac arrest** rate has been achieved across Scotland since 2012, as a result of the contribution our pioneering research has made to the Scottish Patient Safety Programme. Our research has directly informed the development of this programme. Through their grounding in clinical practice, improvement science and academia, our team tailored their research to uniquely answer the thorny questions which were preventing healthcare professionals from providing safe, effective and person-centred care to the people of Scotland. This research supported the **design and delivery of the national sepsis collaborative and Acute Adult Programme of the Scottish Patient Safety Programme**, including NEWS implementation, sepsis screening and treatment, escalation processes and person-centred planning. From 2012 to 2017, Rooney was the National Clinical Lead for Sepsis and the Acute Adult Programme for Healthcare Improvement Scotland. During this time, engagement with leaders of NHS boards and Scottish Government led to design of the

programme content of the national sepsis collaborative, to support boards to recognise patients with sepsis, and deliver the Sepsis Six within an hour. This National Sepsis Collaborative developed into the Acute Adult Programme of the Scottish Patient Safety Programme.

Scottish Government's National Clinical Director stated: "*Professor Rooney's ground-breaking research on the effectiveness of Early Warning Scores as a tool to identify those patients at an increased risk of an adverse outcome with or without Sepsis has created a strong foundation for the Management of the Deteriorating Patient across Scotland and the world*" [5.3]. Furthermore, he highlighted the specific contribution of our research to improving patient care in the prehospital setting, adding: "*Professor Rooney's research has also prompted recommendations that NEWS is used in the prehospital assessment of acutely ill patients by 'first responders', to identify and improve the assessment of acute illness, triage and the communication of acute-illness severity to receiving hospitals.*"

The Republic of Ireland has also seen a 20% reduction in sepsis-related mortality, due to the development of the Irish National Sepsis Programme. Through the contribution of Rooney as an external advisor on the development of the programme, our research has informed the aims and development of this programme focusing on the prehospital setting, and ward-based sepsis detection, rather than traditional approaches in critical care settings. The National Clinical Advisor and Group Lead for Acute Operations credits the research on "*the NEWS programme [in Scotland] and the recognition and management of the deteriorating patient*" as having **contributed to the success in reducing Ireland's sepsis mortality rate by 20%**.

#### **Impact on practice**

Our research on NEWS and its superiority to qSOFA has led SIGN and the Royal College of Physicians of London to recommend that NEWS is used to prompt clinicians to further investigate for organ dysfunction and escalate care [5.6-5.7]. Indeed, the strategy tested and developed by the research team has been, under guidance by Rooney, adopted in Ireland with similar impressive results [5.8].

For the aforementioned controversy over NEWS, we proved that an elevated NEWS among unselected prehospital patients is associated with increased levels of adverse outcomes. This research helped influence the **adoption of NEWS by not just the Scottish Ambulance Service but, indeed, ambulance services across the UK** [5.4-5.5].

While handheld device lactate measurement produced accurate, efficient and timely results compared to near patient testing, the time difference was not thought to be clinically significant, with no benefit on return of investment. As a result, health boards continue to invest in near patient blood gas analysers.

Our ethnographic study was conducted nationally [5.9], revealing that rather than being an apparently simple sequence of six steps, the 'Sepsis Six' actually involved a complex trajectory comprising multiple interdependent tasks that required prioritisation and scheduling, and which was prone to problems of coordination and operational failures. This pivotal discovery **allowed healthcare professionals to change their implementation**, allocating specific roles and responsibilities for completing the Sepsis Six in ways that reduced the need for coordination and task switching. An evaluation report of the impact of applying this critical new understanding in practice, across multiple Scottish NHS sites, demonstrated **high clinician/practitioner compliance with rapid (within one hour) delivery of the Sepsis Six, with improved patient outcomes** [5.9].

Validation of PEWS showed that a single set of vital signs undertaken prior to arrival at hospital can identify a group of children at higher risk of an adverse in-hospital outcome. With the introduction of major trauma centres in the UK, PEWS may allow changes to paediatric prehospital pathways to improve child mortality rates. **PEWS has now been adopted by the Scottish Ambulance Service.**



**Impact on practice education**

Along with NHS Education for Scotland, we designed an award-winning (Scottish Health Award for Innovation 2014) NEWS and Sepsis Screening App that has been downloaded in the UK and internationally 28,000 times and helps clinical staff with bedside care and education [5.10]. Reviews of the app indicate that it is a valuable sepsis screening tool for practitioners within clinical settings, and even more for those in prehospital settings,. One user review highlights the accessibility of the app in making diagnosis quicker: *“Excellent for prehospital diagnosis. I have found this a great tool in my day to day treatment on the accident and emergency ambulance service, thank you, you have just made my life a little easier”*.

An evaluation project on the usage of the app found that it had increased awareness of sepsis (57%), it was easy to use (82%) and that it would save time in the clinical setting (64%). 67% of clinicians (n=34) said that the app would enhance the way they make clinical decisions. The app has already shown evidence of **improving diagnosis and potentially saving lives** as highlighted in this quote from a GP from an NHS Board in the West of Scotland, who described how the app enabled him to more quickly recognise a patient’s need for urgent hospital care. He said: *“[The app] alerted me to the gentleman’s risk of deterioration and I requested an ambulance [sooner] than I would otherwise have done...the gentleman was assessed as ‘sepsis’ at A&E triage, and received ‘sepsis 6’ [care]... The gentleman recovered from his illness and is now home again.”*

This exemplifies one of the most important impacts in practice, delivered through innovative research-informed approaches to patient safety, namely **it saves lives**.

**5. Sources to corroborate the impact**

**5.1** Healthcare Improvement Scotland iHub, Generic response to deteriorating patients: 90 Day Learning Cycle, July 2019 <https://ihub.scot/media/6587/20190520-90-day-project-charter-generic-response-to-deteriorating-patients-v10.pdf>

**5.2** Testimonial available from Healthcare Improvement Scotland.

**5.3** Testimonial available from the Directorate for Healthcare, Quality and Improvement, Scottish Government.

**5.4** Testimonial available from Scottish Ambulance Service, Healthcare Quality and Strategy Directorate, Scottish Government.

**5.5** NHS England and NHS Improvement endorsement of NEWS for use in acute and ambulance settings. <https://www.england.nhs.uk/ourwork/clinical-policy/sepsis/nationalearlywarningscore/>

**5.6** Care of deteriorating patients - SIGN guideline139. <https://www.sign.ac.uk/assets/sign139.pdf>

**5.7** National Early Warning Score (NEWS 2) Standardising the assessment of acute-illness severity in the NHS. December 2017. <https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news-2>

**5.8** Testimonial available from Health Services Executive, Ireland.

**5.9** Evaluation of the Scottish Patient Safety Programme sepsis VTE collaborative: Short Report. <https://ihub.scot/media/2226/sepsis-vte-evaluation-short-report.pdf>

**5.10** Mobile clinical decision support for diagnosis and treatment of sepsis across Scotland – NHS Education Scotland. <https://www.ehealth.scot/case-studies/mobile-clinical-decision-support-for-diagnosis-and-treatment-of-sepsis-across-scotland/>