Establishing a learning health system in low and middle income countries

Beane, A.E.C.

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Establishing a learning health system in low and middle income countries

Abi Beane

“Without data we cannot engage in research and without research we have no voice.”

M. Hashmi
Establishing a learning health system in low and middle income countries

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor

aan de Universiteit van Amsterdam

op gezag van de Rector Magnificus

prof. dr. ir. K.I.J. Maex

ten overstaan van een door het College voor Promoties ingestelde commissie,

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Faculteit der Geneeskunde
# Establishing a learning health system in LMICs

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Introduction
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**The impact of quality on acute care outcomes**

Poor quality healthcare has resulted in an estimated additional five million deaths, and US$ 6 trillion in economic losses worldwide.\(^1\) In South Asia, a region which accounts for over 25% of the world’s population, poor quality health care is the biggest driver of excess morbidity and mortality.\(^1,^2\) Whilst the relative contribution of curative care for critically ill patients to overall health and life expectancy has increased considerably, delivery of critical care services is both expensive, and complex.\(^3,^4,^5\)

There are many barriers to the delivery of care for critically ill patients in resource-restricted settings.\(^3\) Basic equipment for multi-para monitoring, treatment and diagnosis are often unavailable and its maintenance is suboptimal. Supplies of laboratory consumables or essential medication can be unpredictable, and the provision of basic commodities, such as oxygen, electricity and running water, is inconsistent.\(^6,^7\) Despite these challenges, demand for these services continues, and with it the need to establish a robust system to provide high-quality critical care.

Recent recommendations from the Lancet Global Health’s commission on High Quality Health Systems (HQHS)\(^8\) have called for four key actions to raise the quality of healthcare: building a shared vision of care quality; a clear strategy for quality evaluation; stronger regulation ensuring civic and professional accountability’; and capacity for continuous learning. The commission recommends a greater use of data to inform and drive evaluation and improvement, and to hold providers accountable for the care. The commission proposed that a shared vision with research to provide greater understanding of the core values of healthcare workers, patients and families is needed. These recommendations are especially relevant in critical care where a myriad of complex processes and often high-risk interactions occur daily between healthcare workers and patients, and evaluating and improving critical care requires an understanding of these multiple processes. Poor outcomes for critical care patients include untimely death or impaired functional recovery and poor quality of life.\(^7\) Regardless of outcome, having a family member develop critical illness is associated with significant economic losses and financial hardships for families.\(^10\) Interpreting what is quality and how to improve the quality of care for these patients is as complex as the processes involved.\(^1,^8\)
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Defining quality of care

Several analytical frameworks can be used to assess quality of healthcare. One of the most influential and holistic is the Institute of Medicine’s framework. This includes six domains of quality:\(^\text{18}\)

**Safety**: Avoiding harm in the delivery of care intended to help.

**Effective**: Providing services based on scientific evidence to all whom could benefit and refraining from providing the same services to those patients who are unlikely to benefit.

**Timely**: Avoiding and minimizing delays in care that may or may not be potentially harmful for both caregiver and the care receiver.

**Efficient**: Avoidance of waste, in terms of resources and activities

**Equitable**: Providing care of the same quality to all, regardless of personal character, socio-economic status, ethnicity, and gender.

**Patient centered**: Providing care that is responsive to individual needs and respectful to individuals’ values and preferences.

These six domains form the foundations of the HQHS’s call for health care that is equitable, resilient and efficient, providing competent care for a positive user experience.\(^\text{18}\) Efforts to evaluate and improve the quality of care in high-income countries (HICs) have increasingly focused on the measurement of indicators of quality. Indicators of quality are designed to measure structures, processes and outcomes of care across the patient pathway. Structure indicators refer to the organisation, resources and equipment; process indicators relate to process of care between caregiver and patient, and include access to care, decision making regarding acts and omissions of treatment. Outcome indicators reflect the results that are achieved at the patient level, and increasingly include patient’s perceptions of their treatment and recovery, family experience, and the economic and social impact of care alongside mortality. To affect improvement, these domains must be linked to clinical care and reflect the values of the patients and healthcare team. \(^\text{1,8,18}\)
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Barriers to improving the quality of care in LMICs

Lack of information
Increasingly, the lack of information to evaluate routine care is acknowledged as an important missing link in global health. This information is essential to empower stakeholders to identify setting-specific priorities for improvement and to measure the impact of targeted efforts to improve care. In HICs, continuous routine data capture drives national evaluation of outcomes, benchmarking of quality indicators and informs the way resources are allocated and services are organised. In low-income and middle-income countries (LMICs), the lack of infrastructure to capture reliable facility-level and national information on quality indicators has hampered attempts to evaluate quality of care. Long-term outcomes and patient perceptions of healthcare, which are important drivers for compliance and recovery, are unknown. A lack of replicable information has hindered implementation of quality improvement (QI) initiatives, disempowered clinicians from identifying local research priorities, and hindered attempts to hold those responsible for services accountable.

Limited success of quality improvement projects
Although many of the basic principles of ‘good quality’ critical care that have proved successful in HICs may be directly applicable to resource-limited settings, these practices often remain poorly implemented. To date, QI initiatives in LMICs seeking to implement even the most basic of these principals have had limited success in achieving sustained change, or have proven difficult to scale. For example, triage tools, and early warning scores, which have been designed to help identify patients at greatest risk of deterioration and successfully implemented in HICs, have encountered problems in LMICs. The challenges have been linked to concern over the validity of the scores in different disease categories and over the potential impact implementing such tools in already overburdened care contexts. However, little work has sought to explore how such tools may be best adapted for implementation within different health systems in a way that prevents unintended adverse consequences for care.

Quality improvement methods are generally not an established part of medical and allied health education. Nor are they a priority investment for healthcare institutions in resource-limited settings. It is unsurprising therefore that healthcare workers who are faced with high-burden of frontline care, limited resources and unrelentant systems often feel disempowered to drive change even when gaps in care are identifiable and potential solutions known. Consequently, interventions are often designed and implemented by external practitioners with limited insight into the context and behaviours that
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may drive existing care or undermine the adoption of evidence into practice. Furthermore, even if local priorities are identified, implementation with little data to assess progress means that implementers, healthcare providers and the recipients of change are left uncertain of the effect.\textsuperscript{11,12} This uncertainty, compounded by the unreliability of infrastructure and resources, may result in potentially effective improvements being abandoned or overlooked.

**Limited opportunities for training**

Improving the quality of healthcare is complex, and requires an interdisciplinary team equipped with the skills to design, implement and analyse setting-relevant improvement interventions.\textsuperscript{16} Such capacity is limited in many LMICs. However, training for healthcare workers in QI methods without buy-in from multidisciplinary stakeholders and without identifying setting-specific priorities is unlikely to be successful.\textsuperscript{11} Similarly, in HICs’ health systems, healthcare workers are exposed to training in patient safety and the skills, which help build effective team working from undergraduate education through continuous professional development. Conversely, in many LMIC-based healthcare training programmes, such a curriculum is absent, or if offered, originates from HICs without understanding differences in organisational culture, resources and equipment available or epidemiology of patients.\textsuperscript{12}

**Limited understanding of how organisational cultures impact on quality of care**

In LMICs, research has not explored how organisational structures, processes of care, and shared beliefs and practices influence quality of acute care.\textsuperscript{17} For example, recognition of deteriorating patients, which contributes to avoidable adverse events including death, is influenced by human factors; cognitive bias, team working, communication and inter-discipline relationships.\textsuperscript{14} Increasingly in HICs, recognition and referral to critical care is accompanied by strategies to promote communication, sign post escalation, expediting referral to critical care. Little however is known about how these same factors in LMIC health systems. In addition, in HICs, recognition of deterioration and care surrounding resuscitation and the chain of survival includes conversation regarding appropriateness of admission to critical care, and end-of-life care. The absence or unawareness of such decision making may contribute to inappropriate admission to intensive care and unnecessary costs.\textsuperscript{13}
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The components of a learning health system

In addition to strong foundations, the HQHS commission recommended that health systems develop the capacity to measure and use health data to learn about patient and clinicians’ care and drive improvement. Learning health systems (LHS) are capable of identifying those interventions and implementation strategies that work in routine contexts, and of improving quality consistently across the health system.\(^\text{16}\)

The Institute of Medicine describes a learning health care system as:

“[O]ne that is designed to generate and apply the best evidence for the collaborative healthcare choices of each patient and provider; to drive the process of discovery as a natural outgrowth of patient care; and to ensure innovation, quality, safety, and value in health care”\(^\text{18}\)

A LHS seeks to engage healthcare stakeholders in a cycle of continuous learning and improvement, informed and strengthened by routinely collected data. Data on existing care is used to identify priorities for improvement and drive pragmatic, contextually appropriate research, promote rapid adoption of evidence to improve quality and outcomes.\(^\text{19}\) Empowering healthcare workers to improve the quality of healthcare delivery requires them to have the skills to evaluate existing care, identify and drivers to change and to design, and implement interventions for improvement.

This thesis sets out answer the question as to whether a learning health system can be established in an LMIC. In doing so, it seeks to understand whether, a community of practice can generate new knowledge about existing care from routine observational data and facilitate them to develop capacity to improve quality of care and inform training.

This thesis consists of three parts. Part one sets out to better understand how lack of information and organisational culture drive or impede delivery of care for critically unwell patients. Part two evaluates the design and implementation of the components of a LHS – a platform for electronic data capture and feedback and the establishment of a community of practice with the skills to evaluate and improve care. Part three reports the findings of a holistic evaluation of acute care from primary admission to long-term outcome using the six domains of quality and its recommendations for improvement. In addition, it evaluates the implementation of a peer to peer training programme designed to support junior doctors to provide safe care for critically ill ward patients.
Chapter 1

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CHAPTER 2

Evaluation of the feasibility and performance of early warning scores to identify patients at risk of adverse outcomes in a low-middle income country setting

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Abi Beane, Ambepitiyawaduge Pubudu De Silva, Nirodha De Silva, Jayasingha A Sujeewa, R M Dhanapala Rathnayake, P Chathurani Sigera, Priyanthaka Lakmini Athapattu, Palitha G Mahipala, Aasiyah Rashan, Sithum Bandara Munasinghe, Kosala Saroj Amarasiri Jayasinghe
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Abstract

Objective
This study describes the availability of core parameters for Early Warning Scores (EWS), evaluates the ability of selected EWS to identify patients at risk of death or other adverse outcome and describes the burden of triggering that front-line staff would experience if implemented.

Design
Longitudinal observational cohort study.

Setting
District General Hospital Monaragala.

Participants
All adult (age >17 years) admitted patients.

Main outcome measures
Existing physiological parameters, adverse outcomes and survival status at hospital discharge were extracted daily from existing paper records for all patients over an 8-month period.

Statistical analysis
Discrimination for selected aggregate weighted track and trigger systems (AWTTS) was assessed by the area under the receiver operating characteristic (AUROC) curve. Performance of EWS are further evaluated at time points during admission and across diagnostic groups. The burden of trigger to correctly identify patients who died was evaluated using positive predictive value (PPV).

Results
Of the 16 386 patients included, 502 (3.06%) had one or more adverse outcomes (cardiac arrests, unplanned intensive care unit admissions and transfers). Availability of physiological parameters on admission ranged from 90.97% (95% CI 90.52% to 91.40%) for heart rate to 23.94% (95% CI 23.29% to 24.60%) for oxygen saturation. Ability to discriminate death on admission was less than 0.81 (AUROC) for all selected EWS. Performance of the best performing of the EWS varied depending on admission diagnosis and was diminished at 24 hours prior to event. PPV was low (10.44%).

Conclusion
There is limited observation reporting in this setting. Indiscriminate application of EWS to all patients admitted to wards in this setting may result in an unnecessary burden of monitoring and may detract from clinician care of sicker patients. Physiological parameters in combination with diagnosis may have a place when applied on admission to help identify patients for whom increased vital sign monitoring may not be beneficial. Further research is required to understand the priorities and cues that influence monitoring of ward patients.
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Introduction

Patients who suffer adverse events in hospital wards, such as cardiac arrest and death, often show changes in basic physiological parameters during the hours before the event. Based on this, Early Warning Scores (EWS) have been developed and widely implemented in high-income countries (HICs) with the aim of early identification of clinical deterioration.\(^1\)

Both aggregate weighted track and trigger systems (AWTTS) and single-parameter track and trigger systems (SPTTS) use physiological measures and other clinically significant variables (e.g., age) categorised and scored based on their degree of abnormality.\(^2\) AWTTS use a range of parameters which are weighted and calculated to form a composite and often complex score. SPTTS, while often including more than one parameter, allow for a single parameter to act as an independent trigger. Although less well evaluated, SPTTS tend to have acceptable specificities and negative predictive values (NPVs), but low sensitivities and positive predictive values (PPVs) for death or adverse events.\(^2\) Collectively, these EWS allow for stratification of patients at high risk of deterioration and for the objective evaluation of clinical status over time.\(^3,4\) In HICs, EWS are often implemented as part of a system connecting ward-based and critical care teams. Such systems often include a minimum of 12 hourly observation reporting, with the frequency of monitoring titrated according to score and/or clinician suspicion, and dedicated nurse-led rapid response teams, trained in critical care and resuscitation skills to respond in the event of clinical deterioration.\(^3,6,7\)

Despite a multitude of EWS being developed and validated,—each with varying ability to predict patient deterioration,—eight basic parameters feature consistently within the scores: age, respiratory rate, urine output, saturation of oxygen, temperature, systolic blood pressure, heart rate and a measure of mentation such as alert, response to voice, pain or unresponsive (AVPU) or Glasgow coma scale (GCS).\(^3,4,8,9\)
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In low-income and middle-income countries (LMICs), availability of critical care remains limited and variable.\textsuperscript{10–13} Healthcare services, and in particular inpatient wards, are usually overcrowded, poorly equipped and understaffed, hindering the systematic and accurate monitoring of physiological parameters required for multiparameter EWS implementation and validation.\textsuperscript{14, 15} Disease patterns and time to presentation differ from HICs. While data is limited, studies evaluating EWS in these settings show wide variation in performance.\textsuperscript{16, 17} Thus, evaluation of EWS feasibility, including availability of physiological parameters, the burden of monitoring when triggered and an estimation of EWS performance, prior to advocating for their implementation in an LMIC setting is crucial.

This study describes the availability of core parameters for EWS, evaluates the ability of selected AWTSS and SPTTS (EWS) to identify patients at risk of death or other adverse outcome and describes the potential burden of monitoring that front-line staff would experience if implemented. It further explores the impact that diagnosis, and the relationships which hospital presentation and adverse outcome have on EWS performance. This study further seeks to evaluate EWS performance at selected time points during the patient’s journey and across the most common admission diagnoses.

This study was conducted at an LMIC district-level general hospital. At the time of data collection, there were no EWS in use at the hospital, and there was no escalation policy in response to adverse observation. Vital sign measurement was reported to be on admission and then 12 hourly. Decision to admit a patient to this hospital was made by attending physicians. The 370-bed hospital is situated in a rural province in Sri Lanka, and serves a community of approximately 500,000 people. Hospital facilities include renal dialysis, an intensive care unit (ICU) and maternity services.
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Methods

All consecutive adult (age >17 years) patients admitted from May to December 2015 to District General Hospital Monaragala (DGHM) were prospectively included. Measures of pulse rate, respiratory rate, blood pressure, measure of consciousness (AVPU) and temperature, were all collected on admission and then two times per day (which is the usual frequency for recording these measures as described by the clinical team in this setting). The data was extracted daily from paper-based patient records by trained data collectors and entered into an electronic data capture system. All patients were followed up daily until hospital discharge. Diagnoses were coded as per the International Statistical Classification of Diseases and Related Health Problems, Tenth revision (ICD-10). The following were considered to be adverse outcomes; inhospital death, ICU admissions, clinical transfers to tertiary hospitals or to other ICUs in other hospitals, and cardiac arrest or cardiopulmonary resuscitation (CPR). Transfer to higher-level facilities and CPR both carry high mortality in this setting, hence their inclusion as adverse outcomes.

The selection of AWTTS for evaluation in this study was based on studies reporting on the use of these systems in LMIC settings. Age, heart rate, respiratory rate, AVPU as a measure of mentation, systolic blood pressure and oxygen saturations were included in the evaluation. The GCS and urine output are not part of routine observation in this setting outside of the ICU, and therefore AWTTS including these parameters were not considered. VitalPAC Early Warning Score (ViEWS), Standardised Early Warning Score (SEWS), Modified Early Warning Score (MEWS) and Cardiac Arrest Risk Triage Score (CART) (online supplementary table 1) were included based on their superior performance for detecting cardiac arrest, mortality, ICU transfer and composite adverse outcomes in HIC studies. National Early Warning Score (NEWS) was included as it is the national tool recommended in the UK by The National Institute for Health and Care Excellence and is now widely adopted within the National Health Service, UK.

Selection of SPTTS parameters was based on the finding of a systematic review, which measured their sensitivity and specificity for predicting inhospital mortality. The reviewers reported a wide variation in performance, and concluded that SPTTS should be validated prior to implementation in a clinical setting. The selected parameters were high and low pulse rate, high and low respiratory rate, high and low systolic blood pressure and high and low temperature (online supplementary table 2). Oxygen saturations and a measure of mentation were not considered in single-parameter scores due to their limited availability in the study setting.
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The performance of both AWTTS and SPTTS was evaluated with the missing values imputed as normal. Discrimination for the AWTTS was assessed by the area under the receiver operating characteristic (AUROC) curve for adverse outcomes and for death. Time from admission to adverse event was calculated. For patients with multiple events, only the first event was used. Availability of physiological parameters and the performance of EWS were evaluated at admission and at 24 hours prior to adverse event. The highest score in the 24 hours prior to discharge was calculated for patients who did not experience an adverse outcome.5,8 Clinically recommended cut-off values and corresponding sensitivity and specificity for MEWS, SEWS and ViEWS to predict death were applied.22 A NEWS score of 5 or more is used as trigger for escalation to senior review and the commencement of ward-level continuous bedside monitoring and was taken as the clinical cut-off.23,24 No clinical cut-off for CART was proposed in the original publication, with the premise that users should decide based on clinical application and resource availability. However, existing literature validating and comparing CART with MEWS used a cut-off of 20. This was, therefore, used in this analysis.2 All tests of significance for availability of observations considered a two-sided P value of less than 0.05 to be significant. AUROC values were considered poor when less than or equal to 0.70, adequate between 0.71 and 0.80, good between 0.81 and 0.90 and excellent at 0.91 or higher.25 Discriminatory power of the AWTTS was then reassessed using complete case analysis only.

The ability to predict mortality and adverse outcomes was assessed for each AWTTS and SPTTS class using sensitivity, specificity, PPV (the proportion of patients predicted to die who die) and NPV (the proportion of patients predicted to survive who survive). In addition, to further understand the feasibility of implementation of EWS in this setting, the burden of patients triggered for every correctly identified death and number needed to escalate (NNE) for the best performing of the AWTTS and SPTTS were also described.

Given a priori knowledge of observation reporting behaviours in the study setting, performance of the best performing of the SPTTS to predict death when applied at admission was then evaluated when using either single, two or three parameters. All possible combinations of single, two and three of the four parameters were described. Discrimination, sensitivity and specificity of the best performing of the AWTTS and SPTTS, respectively, were then described for the most common diagnostic groups (ICD-10 chapters).

All analyses were performed using Stata software V.13.1.26
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Results

There were 16,386 adult in patient episodes to DGHM over the 8-month period. The characteristics, adverse events and outcomes for the study population are described in Table 1. Of the 16,386 patients included, 502 (3.06%) had one or more adverse outcomes. A total of 102 (0.62%) cardiac arrests and 83 (0.51%) unplanned ICU admissions were reported, and 253 (1.54%) patients were transferred to tertiary facilities. Total inhospital mortality was 149 (0.91%). The availability of observations over the 8-month period is described in Figure 1.

Availability of physiological parameters on admission varied widely; heart rate 90.97% (95% CI 90.52% to 91.40%), systolic blood pressure 86.80% (95% CI 86.27% to 87.31%), respiratory rate 65.24% (95% CI 64.51% to 65.97%), saturation 23.94% (95% CI 23.29% to 24.60%) and assessment of mentation 32.89% (95% CI 32.17% to 33.61%). With the exception of temperature, availability of physiological parameters is significantly diminished after admission (P<0.05) (Table 2). Availability of physiological parameters on admission was significantly greater in patients who had an adverse event when compared with those who did not (P<0.05).

Of the AWTTS assessed for their ability to discriminate death on admission and at 24 hours prior to death, only CART 0.781 (95% CI 0.744 to 0.818) and SEWS 0.702 (95% CI 0.656 to 0.748) had an AUROC of >0.70 (Table 3). CART performed better (P<0.05) at predicting death both at admission and at 24 hours prior to death/discharge with missing values imputed as normal, when compared with the other four selected AWTTS. Two hundred and forty-nine patients (2%) would trigger (PPV of 10.44%) if CART was applied at the recommended clinical cut-off (Figure 2). Discriminatory power of all AWTTS diminished when evaluated for their ability to predict death at 24 hours compared with admission (Table 3). Fifty-two per cent of adverse events occurred within the first 48 hours of the patient’s admission (online supplementary figure).

SEWS and MEWS have an increased discriminatory ability (but AUROC <0.8.1) to predict death when applied on admission but not when applied at 24 hours prior to death when calculated without missing values imputed (complete case analysis). The discriminatory power of AWTTS when calculated with and without missing values, for all adverse outcomes, both on admission and at 24 hours prior to event was <0.70 (Table 3). Specificity to predict death when applied on admission was ≥97% for all AWTTS when evaluated at the recommended clinical cut-offs (Figure 2).

The performance of the SPTTS which used the four selected observations is shown in online supplementary table 3. The highest sensitivity for deaths and adverse outcomes for SPTTS applied on admission was for the system proposed by Kenward et al (online supplementary table 2, row vii), which is 59.1% and 48.4%, respectively (PPV 1.72%).27 Five thousand and sixty-two (32.46%) patients would be triggered if this system, which includes heart rate, respiratory rate, systolic blood pressure
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and temperature was applied on admission. All other selected SPTTS had sensitivity less than 47% to predict death when applied on admission and PPVs are low (<8.24%). Sensitivities and specificities of the best performing of the SPTTS to predict death when applied on admission when computing only one, two or three of the four parameters are reported in the online supplementary table 4. If the best performing of the AWTTS (CART) and of the SPTTS (Kenward et al) were implemented, the number of patients triggered to correctly detect one death is 9.58 and 58.07, respectively. The best performing of the AWTTS and of the SPTTS ability to predict death when applied on admission for the most common diagnosis groups (ICD 10 chapters) is described in table 4. Performance was not assessed in diagnosis groups i and ii (table 4), as no deaths were reported in patients assigned to these groups.

Discussion

This study reports the availability of physiological parameters, existing practices in vital sign monitoring and the performance of existing AWTTS and SPTTS in a large and diverse LMIC population. Insights gained from this dataset may have relevance beyond this setting and reinforce concerns regarding the place of EWS described in smaller LMIC cohorts.

Availability of observations is poor in this setting. Heart rate, respiratory rate and systolic blood pressure have the highest availability at admission; however, availability of these measurements also decreases throughout the hospital stay. Low nurse-to-patient ratios, limited equipment for monitoring and limited understanding of the importance of observations in detecting unwell patients and preventing avoidable death may contribute to their poor availability in this and other resource-limited settings. While still incomplete, availability of all physiological parameters (tables 2 and 3) was significantly greater on admission, and for inpatients who went onto have events (P<0.05). Reasons for this may include established roles such as ‘admission nurses’, and expectations from consultants or nurses in charge that this information needs to be available on admission. Clinicians may use this information as a tool to guide diagnosis, and/or request further investigations. In this study, the behaviour of recording of physiological parameters was sustained over the study period (figure 1). Parameters which require no equipment for measurement, such as AVPU, were also often incomplete (figure 1). The paucity of some vital signs (saturation, measure of mentation) throughout the patient stay may be a reflection of the limited value placed on these signs by doctors and nurses during acute care decision-making in this setting.

Performance of the AWTTS was variable (table 3. Sensitivity was low, echoing similar studies from LMICs. CART had the greatest ability to discriminate death and adverse event on admission (table 3). Performance at 24hours prior to event improved with complete case analysis when compared with
normal imputation (table 3). Efforts to improve availability of vital sign reporting in this and other LMIC acute care settings remain an important priority. EWS using parameters with the least proportion of missingness need to be prioritised for evaluation. Clinicians and researchers assessing the performance of EWS with higher percentages of missingness should consider alternative methods such as multiple imputation when handling missing data. CART had the lowest burden of patients triggered when applied at the clinical cut-off of 20, when compared with the other AWTTS evaluated (figure 1).

Of the SPTTS tested, Kenward et al’s (2004) had the highest sensitivity to predict death or any adverse outcomes when applied on admission; however, this sensitivity would not be high enough for implementation in clinical practice. The burden of patients triggered would be 5062, meaning nearly one in three patients would trigger.

CART’s NNE was 9.58, compared with 58.07 for the best performing of the SPTTS; important when considering the feasibility of implementation of EWS in this and other resource-limited settings with low nurse-to-patient ratios. Effects of alarm or trigger fatigue may occur very rapidly, hampering efforts to improve understanding the value of vital sign monitoring in critical illness and in implementing rapid response systems.

The relative proximity of time of event to admission (online supplementary figure) and the greater availability of observations may offer some explanation for the superior performance of AWTTS on admission compared with 24 hours prior to event: 59% (n=296) of events, of which 40 were deaths, occurred within 48 hours of admission. In this setting, on-admission physiology may have even greater importance in identifying at-risk patients and as a tool to guide subsequent decision-making, including the frequency of vital sign monitoring. Similar approaches such as WHO Quick Check tool for aiding triage based on on-admission physiological parameters have been shown to be effective in low-income countries.

Performance of the best performing of the AWTTS and SPTTS when applied to the most common admission diagnoses was also varied (table 4). Limited access to non-fee-paying general practice or community facilities may contribute to patients being admitted to acute care facilities for relatively simple investigations. No deaths were reported in the ‘obstetric’ and ‘routine investigation’ groups. Frequent multiparameter vital sign reporting for these patients (30.89% of the total population admitted) may be at best viewed as impractical by front-line clinical staff or at worst be detrimental to patient outcomes by diverting precious nursing time away from those at higher risk of adverse outcomes.

The first step towards a pragmatic solution for improving identification of patients at risk of deterioration in this setting may be the implementation of AWTTS at admission that, in combination
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with other relevant parameters (eg, reason for admission), could help identify patients at low risk of adverse outcomes. For patients who do not have acutely deranged physiology on admission, or for whom admission is not based on clinical presentation of acute illness (eg, those admitted for routine laboratory investigation), SPTTS or a two-parameter track and trigger system (eg, based on heart rate and respiratory rate) may offer simpler tools for monitoring (online supplementary table 4). If triggered, then more complete multiparameter monitoring could be initiated along with simple remedial interventions such as oxygen therapy.20

Greater understanding of the admission criteria, frequency of measuring physiological parameters, time of presentation to hospital and patterns of disease is warranted. Identification of additional cues that clinicians may be using to prioritise patients they perceive as acutely unwell or at risk of deterioration is required; in keeping with similar approaches suggested for other resource-limited settings, these can be then further evaluated for safety and effectiveness.15

A simple electronic tool to record and visualise observations, which is increasingly feasible in LMIC settings, may assist clinicians in identifying at-risk patients, improve visibility of observations and trends, assist to overcome the limitations of disparate paper systems and facilitate education in recognition and response to deterioration.33-36 Such tools have been successfully implemented to assist in surveillance, clinician decision support and quality improvement efforts within and outside of critical care in this setting by the study group.21, 34, 35

Limitations

The accuracy of the recording of these measures was not evaluated during this study. This is a widely acknowledged limitation of similar pragmatic studies both in HIC and LMIC settings.31, 36 Although a single centre study, the large sample size, diverse case mix and focus on the practical challenges of implementation of scores in resource-limited settings mean the findings and discussion arising from this study are relevant to other LMIC research.

Conclusion

There is limited availability of observation reporting in this setting. Indiscriminate application of EWS to all patients admitted to wards in this setting may result in an unnecessary burden of monitoring and may detract clinicians from caring for sicker patients. AWTTS in combination with diagnosis may have a place when applied on admission to help identify patients for whom increased vital sign monitoring may not be beneficial. Further research is required to understand the priorities and cues that influence nurses’ and doctors’ perceptions of critical illness and decision-making.
Chapter 2

Acknowledgements

The authors wish to acknowledge the support received from consultants in charge of wards at DGH Monaragala: Dr A C Weerarathne, Dr K Jayasuriya, Dr K C C Gamage, Dr H K S I Premaratne, Dr S S M Kariyawasam and the team that facilitated the data collection: N Dullewe, L Pieris, C S Suraweera, ET Jagoda and Dr M F Miskin.

Table 1: Summary of study population

<table>
<thead>
<tr>
<th>Patient characteristics (n=16386)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6640</td>
</tr>
<tr>
<td>Female</td>
<td>9710</td>
</tr>
<tr>
<td>Total</td>
<td>16386</td>
</tr>
<tr>
<td>Mean age in years (SD)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>48.40</td>
</tr>
<tr>
<td>Female</td>
<td>38.88</td>
</tr>
<tr>
<td>Mean age</td>
<td>42.70</td>
</tr>
<tr>
<td>Number of events</td>
<td></td>
</tr>
<tr>
<td>Patients with 1 or more event (%)</td>
<td>502</td>
</tr>
<tr>
<td>Death</td>
<td>149</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>102</td>
</tr>
<tr>
<td>ICU Admission</td>
<td>83</td>
</tr>
<tr>
<td>Transfers</td>
<td>253</td>
</tr>
</tbody>
</table>
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Table 2: Availability of observation reporting at admission and 24 hours before event

<table>
<thead>
<tr>
<th>Observation</th>
<th>Availability % (CI) on admission</th>
<th>Mean (SD) on admission</th>
<th>Availability % (CI) 24 hours prior to event</th>
<th>Mean (SD) 24 hours prior to event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic BP</td>
<td>86.80 (86.27,87.31)</td>
<td>122.07 (23.35)</td>
<td>45.17 (44.36,45.98)*</td>
<td>121.91 (22.73)</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>90.97 (90.52,91.40)</td>
<td>80.69 (11.38)</td>
<td>66.98 (66.21,67.74)*</td>
<td>78.92 (9.58)</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>65.24 (64.51,65.97)</td>
<td>19.85 (2.56)</td>
<td>61.63 (60.84,62.42)*</td>
<td>19.49 (2.33)</td>
</tr>
<tr>
<td>Temperature</td>
<td>63.60 (62.85,64.33)</td>
<td>98.58 (0.71)</td>
<td>67.61 (66.85,68.37)*</td>
<td>98.45 (0.30)</td>
</tr>
<tr>
<td>Saturation</td>
<td>23.94 (23.29,24.60)</td>
<td>97.49 (3.83)</td>
<td>16.67 (16.07,17.28)*</td>
<td>97.70 (3.75)</td>
</tr>
<tr>
<td>AVPU</td>
<td>32.89 (32.17,33.61)</td>
<td>5371 (99.67) score of A (%)</td>
<td>28.67 (27.93,29.41)*</td>
<td>4184 (99.88) score of A (%)</td>
</tr>
<tr>
<td>Age</td>
<td>99.38 (99.24,99.49)</td>
<td>42.70 (17.50)</td>
<td>99.38 (99.24,99.49)</td>
<td>42.70 (17.50)</td>
</tr>
</tbody>
</table>

* indicates a significant difference (p< 0.05) between availability at admission and 24 hours before the event. For patients who did not have an event, the highest CART score based on physiological parameters measured in the 24hrs prior to discharge were used.

Table 3: Discrimination of selected AWTTS for deaths and events. Sample size of non imputed scores are in brackets []

<table>
<thead>
<tr>
<th>AWTTS</th>
<th>Death</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AUROC (CI) admission</td>
<td>AUROC (CI) 24 hours</td>
</tr>
<tr>
<td>MEWS score</td>
<td>0.706</td>
<td>0.623</td>
</tr>
<tr>
<td>Score Type</td>
<td>Discrimination at Admission</td>
<td>Discrimination at 24 Hours Before for Imputed Scores</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>MEWS score with missing values imputed</td>
<td>0.667 (0.62, 0.72)</td>
<td>0.490* (0.42, 0.56)</td>
</tr>
<tr>
<td>NEWS score</td>
<td>0.792 (0.68,0.90)</td>
<td>0.657 (0.49,0.83)</td>
</tr>
<tr>
<td>NEWS score with missing values imputed</td>
<td>0.677 (0.62,0.73)</td>
<td>0.583 (0.53, 0.64)</td>
</tr>
<tr>
<td>SEWS score</td>
<td>0.793 (0.70,0.88)</td>
<td>0.676 (0.50,0.85)</td>
</tr>
<tr>
<td>SEWS score missing values imputed</td>
<td>0.702 (0.66,0.75)</td>
<td>0.599* (0.55,0.65)</td>
</tr>
<tr>
<td>CART score</td>
<td>0.764 (0.72,0.81)</td>
<td>0.787 (0.71,0.87)</td>
</tr>
<tr>
<td>CART score missing values imputed</td>
<td>0.781 (0.74,0.818)</td>
<td>0.744 (0.70,0.74)</td>
</tr>
<tr>
<td>ViEWS score</td>
<td>0.778 (0.67,0.89)</td>
<td>0.679 (0.52,0.84)</td>
</tr>
<tr>
<td>ViEWS score missing values imputed</td>
<td>0.677 (0.62,0.73)</td>
<td>0.585 (0.53,0.64)</td>
</tr>
</tbody>
</table>

Sample size of non imputed scores are in brackets [].

* indicate a significant difference between discrimination at admission and discrimination at 24 hours before for imputed scores.
Table 4: Performance of the best performing of the AWTTS (CART) and of the SPTTS (Kenward et al)\textsuperscript{27} to discriminate survivors from non-survivors when applied on admission for each diagnosis

<table>
<thead>
<tr>
<th>ICD-10 chapter (patients with no diagnosis reported=615)</th>
<th>N</th>
<th>CART score NI</th>
<th>CART score CCA</th>
<th>Deaths (N)</th>
<th>Kenward et al \textsuperscript{27}</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Pregnancy, childbirth and the puerperium</td>
<td>3316 (802)</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>(ii) Factors influencing health status and contact with health services*</td>
<td>1745 (874)</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>(iii) Other</td>
<td>1641 (1123)</td>
<td>0.798 [0.719 to 0.879]</td>
<td>0.767 [0.657 to 0.877]</td>
<td>13</td>
<td>61.538</td>
</tr>
<tr>
<td>(iv) Diseases of the genitourinary system</td>
<td>1608 (1077)</td>
<td>0.666 [0.543 to 0.790]</td>
<td>0.630 [0.486 to 0.774]</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>(v) Injury, poisoning and certain other consequences of external causes</td>
<td>1598 (950)</td>
<td>0.959 [0 to 1]</td>
<td>0.939 [to 1]</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Conditions</th>
<th>Cases</th>
<th>Probability</th>
<th>95% CI</th>
<th>N</th>
<th>%</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>(vi) Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified</td>
<td>1592 (1108)</td>
<td>0.655 [0.485 to 0.826]</td>
<td>0.792 [0.504 to 1]</td>
<td>14</td>
<td>35.714</td>
<td>67.680</td>
</tr>
<tr>
<td>(vii) Diseases of the circulatory system</td>
<td>1245 (1076)</td>
<td>0.766 [0.698 to 0.836]</td>
<td>0.807 [0.733 to 0.881]</td>
<td>41</td>
<td>73.170</td>
<td>59.136</td>
</tr>
<tr>
<td>(viii) Diseases of the respiratory system</td>
<td>977 (846)</td>
<td>0.715 [0.625 to 0.805]</td>
<td>0.786 [0.696 to 0.876]</td>
<td>24</td>
<td>62.5</td>
<td>45.435</td>
</tr>
<tr>
<td>(ix) Certain infectious and parasitic diseases</td>
<td>898 (822)</td>
<td>0.708 [0.572 to 0.845]</td>
<td>0.757 [0.574 to 0.940]</td>
<td>15</td>
<td>53.33</td>
<td>49.037</td>
</tr>
<tr>
<td>(x) Diseases of the digestive system</td>
<td>667 (440)</td>
<td>0.528 [0.381 to 0.676]</td>
<td>0.499 [0.324 to 0.674]</td>
<td>12</td>
<td>41.667</td>
<td>68.54</td>
</tr>
</tbody>
</table>
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Figure 1: Availability of observations during the 8-month study period. AVPU, alert, response to voice, pain or unresponsive; SBP, systolic blood pressure

![Observation completeness and number of admissions across weeks](image)

**Figure 1.** Availability of observations during the 8 month study period. Unit of measure= weeks.

Figure 2: Performance of EWS at clinical cut-offs. CART, Cardiac Arrest Risk Triage Score; MEWS, Modified Early Warning Score; NEWS, National Early Warning Score; SEWS, Standardised Early Warning Score; ViEWS, VitalPAC Early Warning Score

![Performance of CART score to predict deaths when applied on admission](image)

Performance of CART score to predict deaths when applied on admission

- % of patients triggered
- Sensitivity (%)
- Specificity (%)

Unit of measure = weeks.
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Performance of VIENS score to predict deaths when applied on admission

Performance of SEWS score to predict deaths when applied on admission

Performance of NEWS score to predict deaths when applied on admission

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Supplementary Table 1: Parameters and clinical thresholds for AWTTS included in the study

<table>
<thead>
<tr>
<th>AWTTS</th>
<th>Parameters included in AWTTS</th>
<th>Clinical threshold for escalation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CART</td>
<td>Heart Rate, Respiratory Rate, Diastolic Blood Pressure, Age</td>
<td>20</td>
</tr>
<tr>
<td>MEWS</td>
<td>Heart Rate, Respiratory Rate, Systolic Blood Pressure, Temperature, AVPU score</td>
<td>5</td>
</tr>
<tr>
<td>SEWS</td>
<td>Heart Rate, Respiratory Rate, Systolic Blood Pressure, Temperature, Oxygen Saturation, AVPU score</td>
<td>5</td>
</tr>
<tr>
<td>NEWS</td>
<td>Heart Rate, Respiratory Rate, Systolic Blood Pressure, Temperature, Oxygen Saturation, AVPU score, Supplemental Oxygen (Yes/No)</td>
<td>5</td>
</tr>
<tr>
<td>ViEWS</td>
<td>Heart Rate, Respiratory Rate, Systolic Blood Pressure, Temperature, Oxygen Saturation, AVPU score, Supplemental Oxygen (Yes/No)</td>
<td>5</td>
</tr>
</tbody>
</table>
## Supplementary Table 2: Reference values for SPTTS parameters

<table>
<thead>
<tr>
<th>SPTTS</th>
<th>Pulse rate (beats m(^{-1}))</th>
<th>Respiratory rate (breaths m(^{-1}))</th>
<th>Systolic BP (mmHg)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>i</td>
<td>&lt;50</td>
<td>&gt;125</td>
<td>&lt;8</td>
<td>&gt;25</td>
</tr>
<tr>
<td>ii</td>
<td>-</td>
<td>≥100</td>
<td>-</td>
<td>≥25</td>
</tr>
<tr>
<td>iii</td>
<td>&lt;50</td>
<td>&gt;130</td>
<td>-</td>
<td>&gt;30</td>
</tr>
<tr>
<td>iv</td>
<td>&lt;40</td>
<td>&gt;120</td>
<td>&lt;10</td>
<td>&gt;30</td>
</tr>
<tr>
<td>v</td>
<td>&lt;60</td>
<td>&gt;120</td>
<td>&lt;10</td>
<td>&gt;25</td>
</tr>
<tr>
<td>vi</td>
<td>-</td>
<td>&gt;120</td>
<td>-</td>
<td>&gt;30</td>
</tr>
<tr>
<td>vii</td>
<td>&lt;60</td>
<td>&gt;90</td>
<td>&lt;12</td>
<td>&gt;20</td>
</tr>
</tbody>
</table>


Supplementary Table 3: Performance of all SPTTS with 4 parameters to predict both death and events at admission and at 24 hours before the event

<table>
<thead>
<tr>
<th>SPTTS</th>
<th>Outcome</th>
<th>Admission</th>
<th></th>
<th>24 hours before</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sensitivity (%)</td>
<td>Specificity (%)</td>
<td>PPV (%)</td>
<td>NPV (%)</td>
</tr>
<tr>
<td>i</td>
<td>Death</td>
<td>27.52</td>
<td>94.33</td>
<td>4.27</td>
<td>99.30</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>16.14</td>
<td>94.46</td>
<td>8.43</td>
<td>97.27</td>
</tr>
<tr>
<td>ii</td>
<td>Death</td>
<td>46.31</td>
<td>86.34</td>
<td>3.02</td>
<td>99.43</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>28.89</td>
<td>86.92</td>
<td>6.37</td>
<td>96.47</td>
</tr>
<tr>
<td>iii</td>
<td>Death</td>
<td>28.19</td>
<td>92.87</td>
<td>3.5</td>
<td>99.30</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>15.74</td>
<td>92.94</td>
<td>6.58</td>
<td>97.21</td>
</tr>
<tr>
<td>iv</td>
<td>Death</td>
<td>14.77</td>
<td>97.87</td>
<td>5.98</td>
<td>99.21</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>7.37</td>
<td>97.92</td>
<td>10.05</td>
<td>97.10</td>
</tr>
<tr>
<td>v</td>
<td>Death</td>
<td>32.89</td>
<td>89.61</td>
<td>2.82</td>
<td>99.32</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>20.72</td>
<td>89.73</td>
<td>5.99</td>
<td>97.28</td>
</tr>
<tr>
<td>vi</td>
<td>Death</td>
<td>22.15</td>
<td>97.93</td>
<td>8.94</td>
<td>99.28</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>11.35</td>
<td>98.04</td>
<td>15.45</td>
<td>97.22</td>
</tr>
<tr>
<td>vii</td>
<td>Death</td>
<td>59.06</td>
<td>69.07</td>
<td>1.72</td>
<td>99.46</td>
</tr>
<tr>
<td></td>
<td>Event</td>
<td>48.41</td>
<td>69.36</td>
<td>4.76</td>
<td>97.70</td>
</tr>
</tbody>
</table>

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Chapter 2

References for SPTTS


Supplementary Table 4: Performance of the best performing of the SPTTS (Kenward et al 2004) to predict death when applied at admission, using single, 2 and 3 parameters

<table>
<thead>
<tr>
<th>Parameter combinations</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate Resp. rate</td>
<td>59.1</td>
<td>69.7</td>
<td>1.75</td>
<td>99.5</td>
</tr>
<tr>
<td>Heart rate Resp. rate</td>
<td>54.4</td>
<td>72.6</td>
<td>1.79</td>
<td>99.4</td>
</tr>
<tr>
<td>Heart rate Temperature</td>
<td>47.7</td>
<td>81.9</td>
<td>2.36</td>
<td>99.4</td>
</tr>
<tr>
<td>Resp. rate Systolic BP</td>
<td>45.6</td>
<td>77.0</td>
<td>1.79</td>
<td>99.4</td>
</tr>
<tr>
<td>Heart rate Resp. rate</td>
<td>57.6</td>
<td>72.15</td>
<td>1.64</td>
<td>99.52</td>
</tr>
<tr>
<td>Heart rate Systolic BP</td>
<td>49.6</td>
<td>81.98</td>
<td>2.17</td>
<td>99.50</td>
</tr>
<tr>
<td>Heart rate Temperature</td>
<td>43.2</td>
<td>85.54</td>
<td>2.36</td>
<td>99.46</td>
</tr>
<tr>
<td>Resp. rate Systolic BP</td>
<td>48</td>
<td>76.99</td>
<td>1.66</td>
<td>99.45</td>
</tr>
<tr>
<td>Systolic BP Temperature</td>
<td>19.2</td>
<td>92.81</td>
<td>2.11</td>
<td>99.30</td>
</tr>
<tr>
<td>Resp. rate Temperature</td>
<td>40</td>
<td>80.69</td>
<td>1.65</td>
<td>99.40</td>
</tr>
<tr>
<td>Heat rate -</td>
<td>41.6</td>
<td>86.41</td>
<td>2.41</td>
<td>99.46</td>
</tr>
<tr>
<td>Resp. rate -</td>
<td>39.2</td>
<td>81.77</td>
<td>1.71</td>
<td>99.40</td>
</tr>
<tr>
<td>Systolic BP -</td>
<td>16</td>
<td>94.16</td>
<td>2.16</td>
<td>99.28</td>
</tr>
<tr>
<td>Temperature -</td>
<td>3.2</td>
<td>98.42</td>
<td>1.61</td>
<td>99.21</td>
</tr>
</tbody>
</table>

All possible combinations of single, 2, and 3 of the 4 parameters are described.
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Supplementary Table 5: Availability of variables for patients who did and did not go onto to have an event

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage availability (no event)</th>
<th>Percentage availability (event)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic BP*</td>
<td>86.67(86.13,87.19)</td>
<td>91.04(88.19,93.39)</td>
</tr>
<tr>
<td>Heart Rate*</td>
<td>90.92(90.46, 91.36)</td>
<td>92.43(89.76, 94.59)</td>
</tr>
<tr>
<td>Respiratory Rate*</td>
<td>64.91(64.17, 65.66)</td>
<td>75.70(71.70, 79.39)</td>
</tr>
<tr>
<td>Temperature*</td>
<td>63.30(62.55, 64.05)</td>
<td>72.91(68.79, 76.75)</td>
</tr>
<tr>
<td>Saturation*</td>
<td>23.56(22.91, 24.23)</td>
<td>35.86(31.66, 40.23)</td>
</tr>
<tr>
<td>Diastolic BP*</td>
<td>86.62(86.08, 87.15)</td>
<td>91.04(88.19, 93.38)</td>
</tr>
<tr>
<td>AVPU score*</td>
<td>32.57(31.84, 33.30)</td>
<td>43.03(38.65, 47.49)</td>
</tr>
</tbody>
</table>

*p < 0.05

Supplementary figure 1: Histogram of the time point of adverse event following admission
Chapter 2

Supplementary information ICD 10 Chapter ‘Factors influencing health status and contact with health services.’

This chapter includes symptoms, signs, abnormal results of clinical or other investigative procedures, and ill-defined conditions regarding which no diagnosis classifiable elsewhere is recorded. In general, categories in this chapter include the less well-defined conditions and symptoms that, without the necessary study of the case to establish a final diagnosis, point perhaps equally to two or more diseases or to two or more systems of the body.

Such cases where this code may be used include,

- cases for which no more specific diagnosis can be made even after all the facts bearing on the case have been investigated;
- signs or symptoms existing at the time of initial encounter that proved to be transient and whose causes could not be determined.
- provisional diagnosis in a patient who failed to return for further investigation or care.

In this setting patient self discharging once their symptoms have dissipated or failing to return for follow up are common occurrences. This differs from ‘other’ whereby no appropriate code could be found.
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CHAPTER 3

Determinants of recognition of the deteriorating patient in acute care wards. A qualitative study from a lower-middle-income setting

Under review with BMJ Quality and Safety
Chapter 3

Abstract

Background

Lack of infrastructure, equipment, staffing are often cited as barriers to recognition and rescue of deteriorating patients in resource-limited settings. Poorly understood however, is the impact variances in health-system organisation, decision-making and organisational culture have on recognition of deterioration. We investigated determinants of recognition of deterioration in acute-care in South Asia.

Methods

A qualitative study of acute medical and surgical teams in ten wards at a district general hospital was conducted. An inductive approach was used to analyse the emerging themes from 22.4 hours of face to face interviews with a purposive sample of 23 informants.

Results

A legacy of initial admission assessment and inimical organisational culture undermined recognition of deteriorating patients in this setting. Informal triaging at the time of ward admission resulted in patients presenting with red-flag diagnoses and vital sign derangement requiring resuscitation being categorized as “bad”. The legacy of this categorization was a series of decision-making biases anchored in the initial assessment which remained with the patient throughout their stay. Management for those patients categorised as “bad” was prioritized, however healthcare workers (HCWs) expressed a sense of fatalism regarding adverse outcomes. HCWs were reluctant to deviate from the original plan of care despite changes in patient condition (continuation bias). Organisational cultures; vertical hierarchy, siloed working and a reluctance to accept responsibility- resulted in omissions in care which undermined recognition of deterioration. Fear of blame was a barrier to learning from adverse events.

Conclusion

The legacy of informal triage and organisational culture undermined recognition of deteriorating patients. Opportunities for improving recognition of deterioration in this setting may include establishing formal triage and medical emergency teams to facilitate timely recognition and escalation.

Key words: Recognition of deterioration, Critical care
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Background

Recognizing patient deterioration and timely response is a universal priority for patient safety and a key component of achieving high quality healthcare.\textsuperscript{1,2} In low- and middle-income countries (LMIC), where access to and availability of critical care services and complex interventions are limited, delays in recognition or escalation of deteriorating patients can be catastrophic for patients and families.\textsuperscript{3,4,5}

In high-income countries (HICs), strategies to improve the recognition of deterioration have resulted in health system-wide changes to patient care.\textsuperscript{1} These strategies have included assembling medical emergency teams, mandatory training for all frontline staff in recognising patient deterioration, and greater transparency over reporting of adverse events and near misses to maximise learning from cases of failure to rescue.\textsuperscript{6} Nation-wide protocols for vital signs monitoring and early warning scores have been implemented.\textsuperscript{7} Implementation of these strategies has required a shift in the organisation and prioritisation of care processes for individual patients and a change in the structure and behaviours of health care teams.\textsuperscript{8,9,10}

In LMIC settings, attempts to translate vital signs monitoring and early warning score strategies have been hampered by an absence of vital signs monitoring, driven by low levels of equipment and staffing. However exploration or vital sign recording suggests that low availability of vital signs is not random.\textsuperscript{11,16} Research has not explored how variances or similarities in organisational structures, prioritization of care processes, and shared beliefs and practices influence recognition of patient deterioration.\textsuperscript{11} Poor understanding of these contextual factors hinders efforts to implement strategies to improve patient safety and may drive poor quality care.\textsuperscript{2,12}

Methods

Aim

This study examines the factors that determine healthcare workers’ recognition of deteriorating ward patients.

Design

Given the complexity of the potential determinants of recognising deterioration, individual face-to-face interviews with healthcare workers were conducted.\textsuperscript{13,14}
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Setting

This study was conducted in a 370-bed district general hospital in Sri Lanka catering for an estimated population of 501,349. Clinical facilities include 10 wards and an eight-bed intensive care unit. Supportive services include a medical laboratory, blood bank, haemodialysis services and radiology department. Staff at this hospital and all hospitals in the country are allocated to work in a given institution by the Ministry of Health following a centralised system of training. Nurse to bed ratios on the wards range from 1:8 during the day to 1:14 at night.

Data Collection

Respondents were drawn from a purposive (diversity) sample of healthcare workers, nurses, doctors and ward assistants/ attendants from all 10 wards. All levels of staff seniority were invited to participate in an interview to enable maximum variation of perspectives. Permissions to conduct the interviews were obtained from the medical director and the matron of the hospital as part of an ongoing collaboration of quality improvement and research and from the Research and Ethics Committee. Interviews were conducted by two bilingual - Sinhala and English- research assistants with healthcare and qualitative research experience in similar settings. The interview approach, instructions for respondents, scene setting, participant- briefing and acquisition of consent were co-developed by the research assistants (WW and ND) and an experienced nurse researcher (AB) and written into the interview guide (Supplementary file 1). The interview began with a question to the interviewee to recall the last time they cared for a patient who went on to deteriorate in the ward. Further open-ended questions were posed to elaborate on their statements. The interviews were focused on healthcare worker perspectives to elicit individual beliefs and contextual nuances that underpin team behaviours. A series of training interviews were role-played to train the research assistants using practical examples of questions, answers and respondent behaviours.

A written information leaflet was given to each prospective interviewee informing the aims of the research and its relevance to quality improvement. Interviewees were reassured that they could pause, stop or withdraw from the interview at any time during or after the interview. Verbal consent was sought at the beginning of the interview and anonymity was assured. Each healthcare worker selected a convenient time and place to be interviewed. All interviews were conducted in the hospital but away from clinical areas ensuring privacy and minimising interruption. Only the research assistants and the interviewee were present during the interview. Research assistants were not known to the respondents prior to the interviews. Interviews were conducted in Sinhala or English, depending
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on the healthcare workers preference, digitally recorded and transcribed verbatim (WW and ND) into a text enabled e-data collection instrument in English within five days of the interview.

Data Analysis

An inductive approach was used for analysis. The transcripts were analysed by AB, assisted by WW and overseen by CP. Document names and content was standardised to facilitate coding. A random sample (n=8) of the audio interviews was validated for accuracy of translation, transcription and coding by an independent member of the research team fluent in both languages (RH). A selection of the first half of the transcribed interviews were read independently and initial themes and statements highlighted within the text. Highlighted transcripts were then re-read by the authors whilst drawing reference from the field notes. Emerging sub-themes were noted, compared, grouped and then harmonised to identify core themes. These core themes were used to develop a framework which was used to thematically code the remaining transcripts with a focus on how these categories determined recognition of deterioration. A recursive process of interview, transcription and analysis continued until saturation, with no new themes being identified. The categories were then reviewed by the authors for consistency. Themes arising from the interviews and the potential implications for future interventions to improve patient safety were fed back to the healthcare team as part of the ongoing collaboration.

Results

Twenty-four healthcare workers were invited to participate in interviews. Respondents represented the different cadres of frontline healthcare workers that have direct contact with patients during their journey through acute care. One healthcare worker declined participation because of concern over how senior staff may perceive the study findings. Twenty-three respondents provided 22.4 hours of interview data. On average the interviews lasted 44 minutes (SD 22.4 minutes).

The guide was adapted following the first five interviews and initial analysis to elicit more detailed responses regarding the recognition of deterioration. Respondents were therefore asked to recall recent clinical situations where they recognised patient deterioration and others where they did not. The themes arising from the analysis are summarised in Figure 1. Quotations from the interviews illustrating the themes described below are provided in supplementary file 2.
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Legacy of admission assessment

On admission to the ward, junior doctors undertook an informal triage of patients. This triage was pivotal to the ward team’s recognition of subsequent deterioration [Q1,Q2,Q4]. Although no explicit triage tools were in use, based on patients’ clinical presentation and working diagnosis, junior doctors characterised a minority of these patients as “bad”. These “high risk” diagnoses included: snake bite, road traffic injuries, stroke, leptospirosis and fever [Q4,Q5,Q7]. Similarly, patients recognised as acutely unwell at ward presentation and requiring interventions such as oxygen, fluids, intravenous antibiotics or imaging were also labelled as “bad”. Conversely, an absence of diagnoses recognised by junior doctors as “high risk” or physiological instability requiring resuscitation at admission meant patients were not triaged as “bad” [Q2]. Patients who were not characterised by healthcare workers as “bad” included those presenting with chronic conditions such as, ischemic heart disease, chronic renal disease and those presenting for routine investigation and planned surgery [Q14,Q17]. Similarly, individuals presenting with symptoms such as chest pain—not obviously attributable to cardiac causes, abdominal pain not requiring immediate interventions, nausea, vomiting or diarrhoea were unlikely to be identified as “bad”[Q14,Q15]. Whilst being aware that these symptoms may be part of serious underlying conditions, the doctors appeared to be reluctant to label such patients as “bad”. Patients previously admitted to the same ward or who were known to the team were less likely to be assigned the label of “bad”.

Healthcare workers (HCW) perceived patients labelled “bad” at admission as having a higher risk of subsequent deterioration [Q9]. This notion resulted in a higher frequency of vital sign monitoring, allocation of a bed closer to the nursing station, family members or attendant being encouraged to stay and a greater priority being placed on obtaining and reviewing laboratory information and imaging in support of the working diagnosis. In contrast, not being identified as “bad” on admission resulted in HCW having a lower perception of the risk for deterioration not only during the immediate period following admission but throughout the patients’ hospital stay [Q10]. Actions that might assist HCWs to detect deterioration, such as locating patients within geographic proximity to the nursing station, increasing the frequency of recording of vital signs, reassessment or re-categorisation, were given a lower priority [Q11]. Whilst an absence of vital signs was acknowledged as a barrier to recognition of deterioration for all patients, the failure to measure and record vital signs for patients who were without the characterization of “bad”, was seen as unavoidable [Q10, Q11].

Healthcare workers expressed a sense of inevitability (‘fatalism’) in the event of adverse events such as ICU admission, cardiac arrest or death for those patients categorized as “bad” [Q7]. Whilst healthcare workers perceived patients with this characterization as having a greater risk of
deterioration, treatment goals, trajectory of illness and prognosis were not discussed formally within the multidisciplinary team, or with patients or family members as part of care planning [Q16]. Whilst perceptions of inevitability were present for those triaged as bad, individuals expressed surprise when patients not triaged as “bad” at admission went on to have adverse events [Q3, Q17]. Deterioration in these patients was perceived to be both unpredictable and unpreventable— even with antecedents such as derangement in vital signs or commencement of antibiotics [Q27]. For example, deranged vital signs did not prompt a re-categorisation of patients to “bad” or a prioritisation of subsequent vital signs monitoring. Nurses in particular felt they could not predict deleterious outcomes for patients regardless of their status at admission [Q11, Q16, Q17]. HCW and particularly nurses prioritised their role in providing emergency care and resuscitation for patients with characteristics of acute illness at admission over the re-assessment of established ward patients [Q10].

Organisational Cultures

Organisational culture describes the discrete and tacit shared behaviours, practices and beliefs within the hospital. 9

Team dynamics

A strong vertical hierarchy was evident within the ward team, with all healthcare workers identifying the consultant (attending physician or surgeon) at the apex [Q13, Q18, Q19]. Ward rounds were described as almost exclusively consultant-led with consultants determining the sequence of the ward round, the time of round, prioritisation of patients for review, and major decisions regarding the direction of care and interventions. All HCWs expressed a deference towards their superiors when describing care practices and decision making. An absence of a senior doctor both on ward round and during individual patient reassessment was perceived to be a barrier to recognising deteriorating patients by all team members [Q12, Q13, Q15].

Doctors and nurses described separate roles in detecting deterioration. Junior doctor’s role included formal ward based assessment and reassessment [Q13, Q18]. Consultants and senior clinicians, who had responsibilities outside the ward in clinic and theatres, would review patients at ward round or in response to an alert from a ward-based doctor. In contrast, nursing roles were task focused [Q8, Q9]. These separate roles, along with individual’s positioning within the team’s hierarchy, influenced HCW’s sense of empowerment to recognise deterioration in patients, and in their perception of responsibility for missed recognition. Doctors perceived hierarchy to be a positive influence, empowering them to participate in collective decision-making. For nurses, responsibility was
perceived negatively and was strongly linked with concerns over blame and personal criticism [Q20, Q21].

The differing roles and perceptions of responsibility within the team resulted in varied approaches to decision-making. Junior doctors’ decisions to categorise a patient as “bad” at admission was primed by experience and recognition of patterns of illness associated with “high risk” diagnosis [Q4]. Their subsequent decisions regarding patient care were approached collaboratively, but within their peer group. They cited opportunities to discuss clinical findings with senior doctors as a key component of their ability to recognise deterioration [Q13]. Characteristics of collective decision-making included face to face discussion at ward round and remotely via messaging applications or telephone calls [Q13]. Senior doctors and consultants on the other hand described more individualistic styles of decision-making. Not restrained by hierarchy, their decision-making style signified a strong sense of self-belief, whereby experience and an ability to make rapid decisions under pressure were valued highly [Q19]. Furthermore, they saw themselves as having overall responsibility for patient care. In contrast to doctors, nurses recounted only limited involvement in decision-making and were absent from collective decisions. Whilst present during ward rounds, nurses were reluctant to contribute to the collective discussion regarding patients’ progress or treatment goals. Uncertainty over treatment goals and prognosis resulted in inertia in nursing practice- particularly in recategorisation of patients identified as “bad” at admission when faced with signs of improvement. Similarly, they expressed reluctance to escalate the frequency of vital signs in patients not identified as “bad” at admission even in the event of deterioration.

**Fear of blame**

Fear of blame inhibited nurses’ and junior doctors’ ability to re-prioritize tasks that could enable timely recognition of deterioration. Whilst healthcare workers of all cadres were concerned about blame for not completing vital signs and for failure to recognise deterioration, this culture was most evident amongst nurses [Q20,Q22].

In comparison to doctors, who recounted how events including failure to rescue provided them with opportunities to learn, nurses associated such events with blame, recalling how they would be personally criticised if information which could be perceived to enable recognition of deterioration in “bad” patients was missed [Q23]. Fear of blame was the catalyst for monitoring “bad” patients and the prioritisation of tasks described above. Information that was contradictory to the initial categorization of patients was viewed with suspicion by both doctors and nurses recalling how they would often repeat vital signs and assessment in the event of deterioration [Q24, Q26]. This misgiving
was heightened if the source of information was a team member perceived to be junior [Q26]. Junior doctors and nurses recounted how they would sometimes defer decision-making until seniors were present at review to further avoid criticism [Q15]. The culture of fear of blame extended to the three-way relationship between HCW, patient and any bystanders. Junior nurses, in particular, were concerned that family members would be critical in the event that their relatives deteriorated [Q25].

Discussion

The legacy of the assessment at the time of ward admission is an alteration of the HCW heuristic when encountering the deteriorating patient. The informal triaging of patients presenting with red-flag diagnosis or vital sign derangement requiring immediate intervention as “bad”, leads to HCWs being inhibited from recognising deterioration early in other patients and a resistance to seek out and act on information that might challenge the initial categorisation. Limited opportunities for collective goal-setting and interdisciplinary discussions regarding prognosis, contributes to a sense of HCW fatalism regarding deterioration in patients identified as “bad” on admission. Strong vertical hierarchy, fear of blame, fragmented roles and negative perceptions of responsibility contribute to delays in recognising deteriorating patients and hinder future improvement initiatives. 8,19

The informal triage system leads to inconsistencies and mis-categorisation due to inter and intra-observer variability and unintended consequences.20,21 Excessive dependence on diagnostic red flags by HCWs may result in mis-categorisation due to misdiagnosis and atypical presentation at admission.16,19,22 For example, during the annual dengue “season”, triaging based purely on empirical clinical diagnosis can lead to the number of “bad” patients (and workload) increasing manifold, overwhelming healthcare workers and impeding quality of reassessment. This overreliance on the initial assessment (anchoring), resulted in a series of cognitive biases in HCWs subsequent decision-making.18

The legacy of this informal triage system is a misperception by HCWs that patients not triaged as “bad” at admission are at virtually no risk of subsequent deterioration. This bias was evident in HCWs reluctance to deviate from this initial risk assessment even when there was evidence of subsequent deterioration in the clinical status in patients.18,23,24 The consequences of decisions being anchored in the initial assessment include limited vital sign recording in patients not identified as “bad” (confirmation bias) and a reluctance to re-categorise patient risk, even in the presence of antecedents to adverse events (known as plan continuation bias).23 The absence of reliable, regular and complete vital signs inhibits both the identification of patients whose deterioration may be preventable and any
opportunity to learn from cases of failure to rescue through mortality reviews and activities designed to enable reflection and learning; such as an After Action Review.19

The fear of blame is a strong impediment for healthcare systems to learn from failure to rescue deteriorating patients25,26. Fear of blame and inimical organisational behaviours are a barrier to individual HCW and teams from self-reflection about processes of care and the consequences of decision-making.8,27,28 In this study, concern over blame from peers and the wider public deterred nurses and junior doctors from revising the initial categorisation, and is a driver for the consistent prioritisation of vital signs in patients labelled as “bad”. The fear of blame, rather than fear of failure to rescue, motivated vital sign recording. A reluctance to take responsibility for decisions (omission bias), results in a failure of HCW to respond to changes in patients condition - a phenomenon described in HIC settings and in other industries seeking to improve safety in Sri Lanka.18,29 Similarly, institutionalised vertical hierarchies, as observed in this study, have been identified as impediments to delivery of high-quality care and a barrier to improvement.9,19,28,30 Opportunities for improving recognition of deterioration in this setting, require a shift in organisational culture – similar to efforts in High Income Countries – away from blame or criticism of individuals and towards a shared institutional responsibility.9,7

Implementation of an explicit triage system for patients on ward admission could improve the recognition of unwell patients requiring immediate intervention and stratification of those at increased risk of subsequent deterioration.22,21 The risk stratification can help explicitly guide both the frequency of nurse recorded vital signs and junior doctors’ reassessment. Incorporating reassessment into the ongoing care pathway may help provide information to challenge the initial assessment and the cognitive biases which currently influence subsequent decision making.

By diverting immediate resuscitation away from the busy, under-resourced and unprepared ward to emergency units, theatres and intensive care where senior staff with specialist training and higher nurse to patient ratios are available, minimizes the conflicting priorities for ward teams between immediate resuscitation and care of established patients. Encouragingly, ongoing restructuring of health facilities to incorporate formal emergency department in the region provide an opportunity to improve organisation of care.31

In many HICs, multidisciplinary medical emergency teams provide support for junior ward staff in assessing, managing and transferring acutely unwell patients. In this and other LMIC health systems, where inexperienced ward teams are often at the frontline of assessing and identifying patients who may be at risk of deteriorating, such rescue teams could be hugely beneficial.32 In addition, they could
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provide a conduit of communication between junior and senior ward staff and critical care teams, facilitating ICU admission, and when appropriate discussions regarding prognosis and end of life care.

Limitations

This report from a single LMIC hospital explores how different organisational cultures and processes of care may influence recognition of deterioration in acute care in a South Asian setting. Generalisability to other hospitals in this setting and beyond is the subject of work being currently undertaken by this group.

Conclusion

The legacy from the informal triage at ward admission by junior doctors and an inimical organisational culture- characterised by vertical hierarchy, task-based role separation between doctors and nurses and an overarching fear of blame, undermined recognition of deterioration. Opportunities for improving recognition of deterioration in this setting may include establishing formal triage systems, implementing medical emergency teams to support ward based HCW and facilitating a shift in organisational culture including through opportunities to learn from failure to rescue.

Declarations

Ethics approval and consent to participate

Permissions to conduct the interviews were obtained from the medical director and the matron of the hospital as part of an ongoing collaboration of quality improvement and research and from the Research and Ethics Committee.

Consent for publication

All participants were informed that the findings of this research would be published for dissemination amongst the wider academic community.

Availability of data and materials

The datasets generated and/or analysed during the current study are available in a text enabled e-data collection instrument.
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Competing interests

The authors declare that they have no competing interests.

Funding

This study has been funded by a charitable organisation supporting researchers and healthcare workers to improve acute care in resource limited settings. The funding body had no role in the study design, or in collection, analysis or interpretation of and writing up of the findings.

Authors’ contributions

AB, RH and AMD were responsible for the concept and design of the study. AB led the study development, data collection, transcription and analysis of the findings. This was assisted by WW, ND and overseen by CP and RH. The manuscript was prepared by AB and RH, with contributions from CP and AMD. All authors read and approved the final manuscript.

Acknowledgements

The study authors would like to acknowledge the contribution of all healthcare workers who contributed to this study. Their willingness to share their perspectives and insights into this subject has been essential to the ongoing collaboration which aims to improve the quality of acute care in the region.
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Supplementary file 1: Interview Guide -Recognition of deteriorating patients

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<th>1. Knowledge and beliefs about deteriorating patients</th>
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<tr>
<td>Thinking back, can you describe the last patient that came to the ward that you were caring for who got “bad”?</td>
</tr>
<tr>
<td>Prompts: Signs and symptoms, causes, diagnosis, treatment, prognosis, sources of knowledge</td>
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<tr>
<td>Compared to a patient who did not get “bad” what was different about this patient?</td>
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<td>Prompts: Signs and symptoms, causes, risk, treatment, prognosis</td>
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<td>- Why do you think these differences exist?</td>
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<td>Prompts: Experiences, sources of knowledge</td>
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<tr>
<td>Thinking back, can you describe the last patient that came to the ward that you were caring for who had an adverse event?</td>
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<td>Prompts: Signs and symptoms, causes, diagnosis, treatment, prognosis, sources of knowledge</td>
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<td>Compared to a patient who did not have an adverse event what was different about this patient?</td>
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<td>Prompts: Signs and symptoms, causes, risk, treatment, prognosis</td>
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<td>Do you think you could have prevented the patient from getting “bad”?</td>
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<td>Prompts: Susceptibility, vulnerabilities, risk factors</td>
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<td>Do you think you could have prevented the patient from having an adverse event?</td>
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<td>Prompts: tasks, recognition, assessment, Susceptibility, vulnerabilities, risk factors</td>
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<td>Do you think you could have predicted that the patient would get “bad”?</td>
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<td>Prompts: Susceptibility, vulnerabilities, risk factors</td>
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<td>Do you think you could have predicted that the patient would have an adverse event?</td>
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<td>Prompts: tasks, recognition, assessment, Susceptibility, vulnerabilities, risk factors</td>
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<th>2. Route to recognition</th>
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<tr>
<td>How would you recognise a patient who was getting “bad” in the ward?</td>
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<tr>
<th>Prompts: Signs and symptoms, causes, treatment, prognosis, similarities and differences to other illnesses</th>
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<tr>
<td>What actions might you take to recognise this “badness”?</td>
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<td>Prompts: What should they do? What kind(s) of treatment should they have?</td>
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<tr>
<td>- Would anything change your actions to recognise?</td>
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<tr>
<td>Prompts: Ethnicity, gender, age, marital status, employment status, diagnosis, previous admissions etc</td>
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<tr>
<td>What are the tasks you associate with assessing and recognising whether a patient is deteriorating “getting bad”?</td>
</tr>
<tr>
<td>Prompts: clinical assessment, investigations, imaging, conversation with patient/ family members/colleagues?</td>
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<tr>
<td>Can you describe any difficulties or delays you faced in completing these tasks?</td>
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<tr>
<td>Prompts: What? How did you overcome them? What would help / hinder?</td>
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<tr>
<td>When performing those tasks what makes you think they are getting “bad”?</td>
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<tr>
<td>Prompts: No improvement / deterioration of condition? changes in vital signs? change in behaviour?</td>
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<tr>
<td>Advice from trusted other? eg consultant / doctor/ senior nurse/ family member.</td>
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<tr>
<td>Can you describe any difficulties or delays you faced in recognising the patient was getting “bad”?</td>
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<td>Prompts: What? How did you overcome them? What would help / hinder?</td>
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<tr>
<td>Do you think these same difficulties or delays are predictable or avoidable?</td>
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<tr>
<td>Prompts: Why / why not? What are the biggest difficulties / delays?</td>
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3. Work planning and decision making

| How do you prioritise patients on the ward? |
| Prompts: Signs and symptoms, causes, treatment, prognosis, similarities and differences to other illnesses |
| What influences how you prioritise your work? |
| Prompts: ward round/ diagnosis/ Impacts of staffing, patient numbers, casualty days/ non casualty days/ seasonal variation |
| Do you discuss your prioritisation with anyone else in the team? |
| Prompts: seniors/ colleagues/ family/ patients/ ward round/ staffing meeting |

4. Roles and responsibilities

| Can you describe your role in recognising deterioration “getting bad” and how this relates to that of your colleague? |
| Prompts: ward round, communication, roles and responsibilities, team working /task sharing |
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<th>5. Disclosure</th>
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<tr>
<td>How do you feel when a patient gets “bad” and has an adverse event?</td>
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<tr>
<td>Prompts: personal/ professional? Impacts of disclosure / discovery</td>
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<td>Who, if anyone, do you talk to about this?</td>
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<tr>
<td>Prompts: Why / Why not? Impacts of disclosure / discovery</td>
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<tr>
<td>What are the consequences of not recognising a patient who is “bad”?</td>
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<td>Prompts: from whom? Why do you think this? – experience? / formal information? What do you think accounts for this? What are the impacts?</td>
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<tr>
<td>What are the consequences of a patient having an adverse event?</td>
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<td>Prompts: from whom? Why do you think this? – experience? / formal information? What do you think accounts for this? What are the impacts?</td>
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<th>6. Social/ family impacts of deterioration and adverse events</th>
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<tr>
<td>Can you tell me about any impacts family members have on your ability to recognise deteriorating patients?</td>
</tr>
<tr>
<td>Prompts: proxy social sanctions, presence, social status, education levels</td>
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<tr>
<td>Can you tell me about your experiences in communicating with family members and patients when a patient deteriorates and has an adverse event.</td>
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<tr>
<td>Prompts: family members’ response to illness, impacts of any shifts in roles and relations</td>
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<th>7. Professional impacts of deterioration and adverse events</th>
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<td>Can you tell me about any impacts on you professionally when a patient deteriorates and /or has an adverse event?</td>
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<tr>
<td>Prompts: changing roles and relations, social sanctions, accountability, responsibility</td>
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<th>8. Expectations</th>
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<tr>
<td>Do you think you can improve recognition of deteriorating patients?</td>
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<tr>
<td>Prompts: Why / Why not? What would help / hinder?</td>
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Supplementary file 2. Determinants of recognition. Quotations identified through the thematic content analysis

Q1. “When the patient is entered to the ward, we can see how they look. When the patient comes in a critical phase, then we act accordingly. If it is a trauma patient - then we know we are going to be busy. It takes lots of time to get them stable and there’s lots we have to do. We work together but it’s hard. I still have my other tasks to do.”

Nurse, Surgical ward

Q2 “Depends on the different diagnosis. So then we know from the admission, first when we receive a patient we take the admission sheet and if it is a stat (emergency) case, we inform the doctor then we take the patient to a bed. After taking the patient to a bed we check the patient, and inform the doctor to assess. We observe pulse, respiration and body weight.” “[when we have a diagnosis] we can prioritize the patients better when we know what’s wrong”

Nurses, Medical ward

Q3. “I did not expect him to die, he was not bad when he came to the ward. I remember- he has come before and he looked the same. He was well when he arrived.. He always comes [for his dialysis]. At the beginning he was in the chair, then later bedridden. He wasn’t like he was before.”

Nurse, Medical ward

Q4. “I have worked a long time here. I am confident in recognising the patients that come in [that might deteriorate]- fever, dengue, snake bites. So I think I can manage.”

Doctor, medical ward

Q5. “bad patients -I have experience. After working with patients we know after some point the patient will get bad. I get that idea from seeing and observing a lot of patients arrive with the same things- fever, headache, they get drowsy.”

Senior nurse, Medical ward

Q7. “I knew he would get bad- he came with Dengue” they called me over saying they could not wake him up- I suspected it would happen as they [the family] had stayed all night, that’s always when something happens”

Nursing Assistant, Medical ward
### Chapter 3

| Q8. “Doctor tells what to be done. The doctor is saying the frequency [of vital signs measurement] and then we follow. Sometimes it’s a lot... doctors assess and identify the patients as bad, then we [the nurses] can monitor them......minor staff and family, they help. We [the nurses] can’t make decision alone, but we can suggest- especially with the junior doctors. They know we have some experience”
| Nurse, Medical ward |
| Q9. “Once we know the patients is bad we monitor them check [their vitals, and their bloods] and observe regularly, I could see he was unwell so I checked the vital signs”  “ once we know the patient is bad then we must do the vital signs. We get criticized if not.”
| Nurses, Medical ward |
| Q10. “Sometimes the patient can appear normal a little before but then they get bad- In those situations they can be missed [vital signs]. I might not get them done as well as other tasks -especially as the patient looks OK”
| Nurse, Medical ward |
| Q11. “There were lots of new sick patients- I couldn’t get to complete the vital signs on the other patients”.  “It’s a lot when it’s a casualty day- lots of admissions- some needed treatment straight away.”  “I didn’t know he was not well. He wasn’t bad when he came, so I didn’t think”
| Nurse, Medical ward |
| Q12. “when patient is getting deteriorating the patient is identified then we inform the doctor. After that nurses help the doctor according to doctors' decision on the plan. Sometimes we wait for the consultant- but they usually come quick- then we can manage”
| Nurse, Medical ward |
| Q13. “ It’s really important to get the seniors opinions. My current consultant- he is supportive if we make decisions, and he helps us plan ahead- then we know what we can do and what not. My colleagues and I’ve text each other- that helps, especially at night. It feels better to check with someone that way- otherwise it can be a long time to wait till the morning.”
| Doctor, Medical ward |
| Q14. “ hard in telling MI patients to gastritis patients since they both complain of chest pains- it’s difficult to tell. Chest pain, sweating, vomiting as general presentation. These are the difficult ones. there may be more types of chest pains. chest pain due to digestive problem . Only when the pain is radiating through the arm- then we know it is more critical.... Sometimes they come in complaining but then they settle quickly. I usually
Chapter 3

<table>
<thead>
<tr>
<th>Question</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q15.</td>
<td>&quot;We didn’t know he was bad… nobody knew what was wrong with him when he came in. We were waiting for the consultant. I could not recognise what was wrong&quot;</td>
</tr>
<tr>
<td>Nurse, Surgical ward</td>
<td></td>
</tr>
<tr>
<td>Q16</td>
<td>“patient was getting bad during last 2 days but the arrest happened suddenly… it [death] wasn’t expected. I was really surprised. But it was OK. The doctor said it was expected and he spoke to the family. It was OK. Guess it was at it was going to be like that “</td>
</tr>
<tr>
<td>Nurse, Medical ward</td>
<td></td>
</tr>
<tr>
<td>Q17</td>
<td>“I was really surprised he got bad since patient was ok for first three days of time after surgery. Only then he got bad. since the patient was good for the first two days after surgery we thought that he would be OK. He had a fast pulse- but I thought like it was the fever. I thought it would settle “</td>
</tr>
<tr>
<td>Nurse, Surgical ward</td>
<td></td>
</tr>
<tr>
<td>Q18</td>
<td>“when we come to the wards we check the patient for ward round, handover and then the doctor can assess. It’s important that we have the charts ready for ward round. Sometimes it’s a rush to finish for the round, but they are important then. Through the ward round they can assess the information and they [the doctors] decide”</td>
</tr>
<tr>
<td>Q19</td>
<td>“I lead my team, consider the information and make the decisions regarding care. I then explain to the juniors…they can ask me anything…ward round is for teaching them. I have set that example on my wards.”</td>
</tr>
<tr>
<td>Senior doctor, Medical ward</td>
<td></td>
</tr>
<tr>
<td>Q20</td>
<td>“If I miss a dengue patient getting bad there will be criticism given by the other team members. We know these patients are risky- especially in the first few days. I feel sad if I miss them getting bad”</td>
</tr>
<tr>
<td>Nurse, Surgical ward</td>
<td></td>
</tr>
<tr>
<td>Q21</td>
<td>“I support my nurses. I come to ward round and I speak with them each day. The doctors tell the plan. They must carry out the task and chart down if there is a problem. Still, they [junior nurses] fear to get the full responsibility of the patient”</td>
</tr>
</tbody>
</table>
Chapter 3

Sister, Medical Ward

Q22. “sometimes- the relatives tell us we have not paid attention to their patient, the relatives are criticizing, they are saying like patient was good in the morning, but now at the lunch time the patient is bad. The patient’s relatives will criticize that the nurse didn’t pay attention to the patient. It makes me feel bad. It’s different if we can get the doctors to speak with them. Once the doctor explained then it was ok”

Nurse, Medical ward

Q23. “it’s not all about criticism it’s a kind of lesson not to do that missing again. seniors are showing what are the steps missed and not done properly- reduction of satisfaction for me. My team is working together and consultant is responding quickly to the phone calls and they answer quickly to their queries.” “ If we miss a patient- there’s learning. it’s a kind of lesson not to do that missing again. Seniors are showing what are the steps missed and not done properly. it is a lesson to do better next time.”

Doctor, Medical ward

Q24. “I [ the doctor] will want to check [vital signs] for myself once a nurse or junior tells me a patient is bad. I need to be certain. I will be the one speaking to the consultant and I need to be sure of my facts before I call him.”

Doctor, Surgical ward

Q 25. “Patient comes to the ward with the belief in the staff of the hospital. Patient needs more focus towards himself rather than to others. Even if we miss a little thing about the patient they will complain it to us. They do not feel we have cared until we do something. so that is why we need to focus and build trust among the patients, not only the bad patients, the normal patients also. Otherwise its tough on us…. I feel proud when we recognise the patient is bad early. Then we can send them home- they get better. The family are always so grateful. It’s a blessing. I am proud I can help.”

Nurse, Medical Ward

Q26.”I am always feeling more anxious when I am working with junior nurses. She might not know what to look for- or might not record correctly- then I will have to check myself......if I don’t check myself then it will be me who is blamed”

Nurse, Medical ward
Q27. “Since the patients’ level was not good, it was suspected that the patient will get bad but the nurse didn’t expect that the patient will get bad at that time. Patient was under observation and his BP was low. Surgery was successful. That patient was not a patient to be dead. The problem was not identifying.”

Doctor, Surgical ward
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CHAPTER 4

Abi Beane, Pubudu De Silva Ambepitiyawaduge, Kaushila Thilakasiri, Tim Stephens, Anuruddha Padeniya, Priyantha Athapattu, Palitha G. Mahipala, Ponsuge Chathurani Sigera, Arjen M. Dondorp, Rashan Haniffa
Chapter 4

Abstract

Objective
The objective of this study is to describe the characteristics of in-hospital cardiopulmonary resuscitation (CPR) attempts, the perspectives of junior doctors involved in those attempts and the use of do not attempt resuscitation (DNAR) orders.

Methods
A cross-sectional telephone survey aimed at intern doctors working in all medical/surgical wards in government hospitals. Interns were interviewed based on the above objective.

Results
A total of 42 CPR attempts from 82 hospitals (338 wards) were reported, 3 of which were excluded as the participating doctor was unavailable for interview. 16 (4.7%) wards had at least 1 patient with an informal DNAR order. 42 deaths were reported. 8 deaths occurred without a known resuscitation attempt, of which 6 occurred on wards with an informal DNAR order in place. 39 resuscitations were attempted. Survival at 24 h was 2 (5.1%). In 5 (13%) attempts, CPR was the only intervention reported. On 25 (64%) occasions, doctors were "not at all" or "only a little bit surprised" by the arrest.

Conclusions
CPR attempts before death in hospitals across Sri Lanka is prevalent. DNAR use remains uncommon.

Introduction
Resuscitation following cardiac arrests occurring either as an end of life event, or after maximal treatment are unlikely to be successful, and may result in loss of patient dignity and futility. In such situations, pro-active Do Not Attempt Cardio Pulmonary Resuscitation (DNACPR) orders are increasingly being used in High Income Countries (HICs). National data from Sri Lanka, a low-middle income country, indicates that the majority (87%) hospital deaths are preceded by resuscitation. This suggests that some patients, for whom the likelihood of survival is minimal, are receiving futile and unnecessary resuscitation attempts. Recent data from Intensive Care Units in low and middle income countries (LMICs) suggests formal DNACPR orders remain uncommon. This paper reports on the results of a survey, in adults in acute hospital ward settings across Sri Lanka, to establish the characteristics of resuscitation attempts, immediate outcomes after cardiac arrest and DNACPR usage.
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Materials and methods

A cross-sectional survey was conducted in all adult general wards in Sri Lanka hospitals where medical or surgical patients are treated under the care of specialist (consultant) doctors (n=90). Specialty specific wards such as Obstetrics and Gynaecology were not included.

Wards were contacted by telephone. In each ward, a house officer (HO, a junior doctor undergoing internship training) was invited to participate in an anonymous, short, structured interview describing resuscitation attempts for which they were present, during their previous shift of 36 hrs. These doctors typically cover shifts consisting of a day, followed by a night on call, followed immediately by a day shift. House officers in Sri Lanka are allocated to one ward for several months and invariably participate or lead in-ward resuscitation following cardiac arrest.

Calls were made by the investigators and were repeated if the HO’s were unavailable on initial contact. Responses were electronically collated.

The survey tool consisted of questions to determine the number of deaths in the ward, attempted resuscitations and their outcomes, post resuscitation status and prevalence of DNACPR orders. For each resuscitation attempt where the HO participated, the survey explored the objective practices of; defibrillation, intubation, use of adrenaline, post resuscitation care and whether a senior doctor was contacted during the resuscitation attempt. Further questions ascertained the extent of surprise felt by the doctor regarding the event and the perceived probability of success following attempted resuscitation.

Descriptive analysis was undertaken based upon the characteristics of resuscitation attempts associated with the chain of survival. The study was conducted in collaboration with the Government Medical Officers Association, Ministry of Health and Network for Improving Critical care Systems and Training (NICST). The study was funded by the NICST. 8, 9
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Results

During the survey, 82 of the 90 target hospitals were successfully contacted. A total of 336 adult general wards in these 82 hospitals were contacted. HO’s in two wards declined to participate. Study findings are summarised in figure 1 and table 1.

A total of 39 resuscitation attempts were surveyed. A further three attempts had no further information available as the HO interviewed was aware of, but did not participate in the resuscitation attempt. Of these 39 attempts, 34 (87.2%) were immediately unsuccessful. Five (12.8%) attempts resulted in Return of Spontaneous Circulation (ROSC) with 3 patients being transferred to Intensive Care Unit (ICU) for post-resuscitation care, whilst the other 2 patients remained on the ward. HO were able to report that 24 hours from the time of resuscitation, only the two patients transferred to an ICU were still alive (5.1%), with outcome for the third patient in the ICU was unknown. Eight deaths occurred without a known resuscitation attempt. Of these 6 deaths occurred on wards where there were informal DNACPR instructions in place, though it is not known whether these particular patients had treatment limitations. In total, 15 wards (4.4%) in 12 different hospitals, had at least one patient with informal DNACPR instructions. Thirteen of these (86.6%) were medical wards.

Of the 5 resuscitation attempts that resulted in ROSC, doctors reported that they were ‘somewhat surprised’ or ‘very surprised’ on all 5 (100%) of occasions. Conversely, 82% of respondents indicated little or no surprise in those patients who had unsuccessful resuscitation attempts. They further reported that they felt the likelihood of a successful outcome was an ‘even chance’ to ‘very likely’ in all these ROSC instances.

Discussion

This national survey of resuscitation in Sri Lanka confirms that the majority (80.9%) of in-patient deaths in general wards are preceded by some attempts at CPR. In contrast, in Singapore this number may be as low as 33.8%, for patients outside the ICU.10 The majority (87.2%) of patients were not defibrillated, suggesting non-shockable rhythms as the cause of arrest, though a question regarding cardiac rhythm or equipment availability was not included in the survey. These characteristic in combination with poor outcomes and limited use of DNACPR may suggest that attempted resuscitation remains a feature of end of life care in Sri Lanka. Sixty four percent of patients who did not have ROSC received more than one vial of adrenaline during the resuscitation attempt, suggesting that these attempts were of a concerted nature lasting at least 2 minutes.

Of the 8 patients who had no CPR attempted before death, 6 patients were in wards where informal DNACPR instructions were in use. The use of informal DNACPR instructions, although often unwritten and infrequent, may be clinically effective in this setting. The cross-sectional nature of the survey precluded ascertaining the actual proportion of wards which utilise such instructions (as all doctors in
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a ward were not interviewed) and whether the patients who died without attempted resuscitation were the subject of these particular DNACPR instructions.

Junior doctors were “surprised” by the cardiac arrest in all the patients who went on to have ROSC but expressed “little” or “no surprise” at cardiac arrest in the vast majority of those who had unsuccessful resuscitation attempts. Even allowing for bias due to the retrospective questioning and outcomes being known, opportunities for discussions regarding appropriateness of resuscitation or limitation of care may thus have been missed. Confounding influences on such decision-making in LMICs may include cultural norms, religious beliefs, public expectation, and lack of locally generated guidance.\textsuperscript{3,11} The impact, if any, of the family being present in nearly 75% of these attempts is not known and merits further exploration.

ROSC following resuscitation was low (12.8%). This poor survival rate mirrors limited data from other LMICs such as Uganda 7.4\%\textsuperscript{12} and is lower than those reported from HIC’s \textsuperscript{1,4,11} Though outcomes after resuscitation attempts for patients who have in-hospital cardiac arrests with non-shockable rhythms are poorer than when shockable, these findings highlight the need for urgent investment to improve resuscitation management in LMICs.\textsuperscript{13,14} Such efforts should be focused around early recognition and escalation of deteriorating patients where appropriate, combined with culturally appropriate efforts to research and implement the practice of appropriate DNACPR orders for patients where resuscitation is likely to be futile. In Europe, inter-disciplinary resuscitation programs now include sessions considering appropriate of resuscitation in an effort to reduce futile and undignified resuscitation attempts.\textsuperscript{15,16} Work is ongoing to provide similar training opportunities for nurses and doctors in Sri Lanka.\textsuperscript{17} Further research and investment in this area is justified.

This brief retrospective cross-sectional survey does not explore the underlying reasons for the cardiac arrests and subsequent resuscitations attempted. While suggesting a difference in perspectives of doctors between successful and unsuccessful attempts, it does not interrogate the appropriateness of resuscitation for each patient. Findings are difficult to generalise to all clinical staff on the ward.

As a conclusion, CPR precedes the vast majority of in-patient ward deaths. Successful outcomes following resuscitation in Sri Lanka are lower than in HIC settings and similar to other LMICs. DNACPR orders (even informal) are not common in general wards. Most cardiac arrests were anticipated, nearly one third of unsuccessful attempts do not appear to be concerted in nature and the likelihood of ROSC overall is low. LMICs such as Sri Lanka would benefit from better training and systems to care for the acutely deteriorating patient, further development of DNACPR orders, and from research and training in end of life decision-making.

Acknowledgments
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The authors would like to thank Dr Dineshan Ranasinghe and Network for Improving Critical care Systems and Training (NICST) faculty; Dr Gayan Gajaweera, Dr Gevindu Kaluarachchi, Dr Sri Raman, Dr Buddhini Bagya, Dr Malmee Dharmawardhane, and Dr Thilina Ranathunga, for their role in data collection.

**Table 1: Characteristics of Resuscitation attempts**

<table>
<thead>
<tr>
<th>Characteristics of Resuscitation attempts.</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alerted by</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff member</td>
<td>26</td>
<td>66.7</td>
</tr>
<tr>
<td>Visitor / family member</td>
<td>11</td>
<td>28.2</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>Family member(s) present during CPR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>29</td>
<td>74.3</td>
</tr>
<tr>
<td>Not present</td>
<td>10</td>
<td>25.6</td>
</tr>
<tr>
<td><strong>Defibrillation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attempted</td>
<td>5</td>
<td>12.8</td>
</tr>
<tr>
<td>Not attempted</td>
<td>34</td>
<td>87.2</td>
</tr>
<tr>
<td><strong>Intubation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attempted</td>
<td>3</td>
<td>7.7</td>
</tr>
<tr>
<td>Not attempted</td>
<td>36</td>
<td>92.3</td>
</tr>
<tr>
<td><strong>Adrenaline</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>5</td>
<td>12.8</td>
</tr>
<tr>
<td>1 vial</td>
<td>9</td>
<td>23.1</td>
</tr>
<tr>
<td>More than 1 vial</td>
<td>25</td>
<td>64.1</td>
</tr>
<tr>
<td><strong>Other drugs given during CPR</strong></td>
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<td></td>
</tr>
<tr>
<td>Atropine</td>
<td>11</td>
<td>28.2</td>
</tr>
<tr>
<td>Inotrope</td>
<td>4</td>
<td>10.2</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>More senior doctor informed</strong></td>
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<td></td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>23.0</td>
</tr>
<tr>
<td>Yes</td>
<td>30</td>
<td>77.0</td>
</tr>
<tr>
<td>SHO/Registrar</td>
<td>20</td>
<td>51.3</td>
</tr>
<tr>
<td>Consultant</td>
<td>10</td>
<td>25.7</td>
</tr>
</tbody>
</table>
Figure 1: Outcomes of resuscitation attempts surveyed

- Ward surveyed 334
- Resuscitation attempts excluded 3
- Resuscitation attempts surveyed 39
- ROSC 5:
  - Dead at 24 hrs 2
  - Alive at 24 hrs 2
  - Outcome unknown 1
- No ROSC 34
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Figure 2: HO perspectives regarding cardiac arrest occurrence and outcome

How surprised were you about this patient having a cardiac arrest?

What was the likelihood of a successful resuscitation?
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CHAPTER 5
Addressing the information deficit in global health: lessons from a digital acute care platform in Sri Lanka

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Abi Beane, Ambepitiyawaduge Pubudu De Silva, Priyantha Lakmini Athapattu, Saroj Jayasinghe, Anuja Unnathie Abayadeera, Mandika Wijerathne, Ishara Udayanga, Shriyananda Rathnayake, Arjen M Dondorp, Rashan Haniffa
Chapter 5

Abstract
Lack of investment in low-income and middle-income countries (LMICs) in systems capturing continuous information regarding care of the acutely unwell patient is hindering global efforts to address inequalities, both at facility and national level. Furthermore, this of lack of data is disempowering frontline staff and those seeking to support them, from progressing setting-relevant research and quality improvement. In contrast to high-income country (HIC) settings, where electronic surveillance has boosted the capability of governments, clinicians and researchers to engage in service-wide healthcare evaluation, healthcare information in resource-limited settings remains almost exclusively paper based. In this practice paper, we describe the efforts of a collaboration of clinicians, administrators, researchers and healthcare informaticians working in South Asia, in addressing the inequality in access to patient information in acute care. Harnessing a clinician-led collaborative approach to design and evaluation, we have implemented a national acute care information platform in Sri Lanka that is tailored to priorities of frontline staff. Iterative adaptation has ensured the platform has the flexibility to integrate with legacy paper systems, support junior team members in advocating for acutely unwell patients and has made information captured accessible to diverse stakeholders to improve service delivery. The same platform is now empowering clinicians to participate in international research and drive forwards improvements in care. During this journey, we have also gained insights on how to overcome well-described barriers to implementation of digital information tools in LMIC. We anticipate that this north–south collaborative approach to addressing the challenges of health system implementation in acute care may provide learning and inspiration to other partnerships seeking to engage in similar work.

Introduction
Disparity in quality of care is increasingly recognised as important causes of excess mortality and morbidity in acute healthcare internationally. In South Asia, services essential to the management of acute conditions— surgical, medical and critical care—are becoming increasingly available in the region, given the rising burden of non-communicable disease. Data from LMICs— although limited— suggests that outcomes for acutely unwell patients are poorer when compared with high-income countries (HICs). In increasingly, the inability measures continuous information to evaluate routine care and empower stakeholders to identify priorities for improvement is acknowledged as an important missing link in health system infrastructure. In HICs, national evaluation of outcomes, benchmarking of quality indicators and patient experience are driving care improvement and the way resources and services are delivered in acute care. In low-income and middle-income countries
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(LMICs), the lack of reliable facility level and national information has hampered attempts to continually evaluate the quality of care, hindered implementation of quality improvement initiatives and disempowered clinicians from identifying local research priorities. There has been little investment in health systems infrastructure or training for clinicians and administrators seeking to evaluate care in LMICs (figure 1). In addition, systematic information pertaining to patient experience and recovery following acute or critical illness is virtually non-existent in LMIC settings. While there is much in the literature to recommend what data should be collected, there is limited practical advice or examples on how day-to-day clinical information can be successfully captured, especially in overstretched and under-resourced LMIC settings. It is noticeable in HIC settings that healthcare providers and researchers have increasingly turned towards technology and digital surveillance in order to achieve the breadth and saturation of continuous information needed to improve care.

The worldwide digital boom in accessible mobile technology and internet connectivity over the last 5 years has been most pronounced in South Asia and regions of sub-Saharan Africa. Digital (mHealth) tools to connect remote communities, most notably in health promotion and primary disease prevention, have been shown to have an impact on patients' self-education and adherence to treatment. In contrast to these community settings, application of similar systems in acute and tertiary care in LMIC have been less well explored. Instead, disparate, paper-based systems persist, with patient records remaining ununified as patients move through the healthcare system, not only delaying the delivery of clinical care but also hindering efforts by clinicians seeking to prognosticate, benchmark and improve care. Complex routes to admission, heterogeneous populations, diverse patient journeys and the need to synthesise often high volumes of clinical and laboratory information from multiple sources further hinder efforts to apply technology in the acute setting, especially in LMICs. To be effectively adopted within health systems, such innovations must harmonise with existing workflows, empower users, minimise user risk, optimise use of existing resources and augment evidence-based clinical management. The ability to integrate with existing or scaled national health information programmes is also essential if technologies are to be transferable with future traction beyond the existing infrastructure. These onerous requirements -often underestimated even in HIC- can seem insurmountable in resource-limited settings, where existing barriers to the adoption of such systems include cost, variable technology infrastructure and a perceived lack of value among busy clinicians. In addition, overburdened frontline staff are often unable to engage with such systems, perhaps due in part to the perceived enormity of behavioural change, task shift and burden of data capture that is potentially required. Furthermore, frontline clinicians also highlight the limited opportunities available to develop the necessary skills to
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heuristically evaluate care improvements in their healthcare facility. In this article, we draw from our experiences on designing, implementing and evaluating a clinician-led national digital mHealth information platform in acute care settings in Sri Lanka. We aim to share lessons on how successful engagement of clinicians in development and evaluation of the platform can help overcome the potential barriers to adoption described above. We also consider how this experience in Sri Lanka is now informing implementation and scaling of the platform in Pakistan, and how the methodology has potentially wider relevance for others seeking to address the information deficit for improving acute care in other LMICs.

Setting

Nestled in South Asia, Sri Lanka has seen rapid economic, industrial growth and urbanisation in the last decade. Sri Lanka has outperformed neighbouring countries in public health and social welfare with high rates of literacy (91%), the lowest maternal mortality and the presence of a robust public health network, coordinated through the Ministry of Health. The country is experiencing growth of commercial and services industry from a predominantly agricultural past. As in other LMICs, non-communicable disease burden is on the rise resulting in increasing demand on tertiary services, including but not limited to cardiovascular, surgical, obstetric, emergency and critical care.

Approach

To address the deficits in granular information for both clinical care and for facility-level healthcare evaluation, an international not-for-profit collaborative consisting of clinical researchers, administrators and healthcare information technologists constructed a clinician-led, acute care digital mHealth platform (Platform for Reporting Outcomes, Epidemiology, Clinical Trends, and Surveillance). Motivated by an ambition to address the need for data-driven healthcare improvement that empowers users, the platform was developed using a cycle of implementation, co-evaluation and feedback. To support evaluation of adoption, qualitative enquiry founded in technology adoption frameworks were utilised to guide understanding of potential social and behavioural influences of the team.
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Design

Working directly in partnership with the Ministry of Health, clinicians and administrative end users, a minimal data set was derived based on previous work undertaken by the collaboration.\(^7, 19\) This minimum data was purposefully narrow to enable coalesced deployment of the platform across acute care facilities including critical care, surgical and perioperative care and acute medicine.\(^20\) Diagnoses, procedures and comorbidities were described using commonly used, context-specific terminology, offering users words and phrases synonymous with existing practice. Inbuilt mapping to universally compatible coding (International Statistical Classification). Quality dashboards in the ward setting help nurses improve completeness of vital sign reporting during adoption. Diseases and Related Health Problems 10th Revision and Systematized Nomenclature of Medicine), facilitates research and increases the shareability of the information for future collaborative studies.\(^21, 22\) Vital signs (e.g., measure of mentation, respiratory rate, pulse, temperature, blood pressure), basic biochemical, haematological and microbiological measures were captured, with trends highlighting abnormal measures within the patient profile. Patient-reported measures of quality of life following discharge (EQ5D) were captured through the platform by a trained support officer using telephone follow-up.\(^23\)

The user interface is designed to be navigated as patients progress through their journey of care. For example, information pertaining to presentation and reasons for admission are visible on the clinician’s home screen following login, and information can be edited throughout the patients treatment progression. Edits are stored sequentially ensuring an audit trail of information. Laboratory test and physiological observations can be added sequentially and are viewed in a single window, aiding treatment decision-making. Offline functionality and visual alerts for connectivity and data synchronisation status within the platform helped minimise the challenges of intermittent internet connectivity and provides confirmation to users that information entry and upload was successful. This visual reassurance was an important step in building trust between users and the technology. Co-designed desktop and tablet dashboards, using non-proprietary analytics software and a business analytics tool visualise trends for individual patients and aggregate groups tailored to reflect the user’s priorities. For example, automated visual alerts were applied to abnormal physiological measures, helping nurses and doctors identify potentially unwell patients. Simultaneously and in real time, admission, occupancy and information regarding length of stay were made available to hospital management and administrators seeking to optimise organisational aspects of care, staffing, elective surgeries and critical care bed capacity. This information is visible through desktop and mobile devices.
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Implementation

The platform was implemented at the invitation of and in partnership with clinical teams, hospital administration teams, professional bodies (e.g., professional colleges) and ministry departments. The collaborative drew on methods from the disciplines of improvement and behavioural science (human factors) and engineering to help identify drivers and barriers to adoption. Facilitator-led focus groups were used to support early phase adoption alongside a traditional cycle of implementation and evaluation (plan, do, study, act) (figure 2). Clinical setting champions (often senior nurses well placed to facilitate the behavioural change needed for adoption, given their central role in the daily organisation of patient care) were trained to lead implementation in their clinical area. They supported peer training and troubleshooted technical or task allocation challenges and challenges in the daily utilisation of the platform. A site coordinator made daily visits to the clinical settings during the initial implementation phase (2 weeks), liaising with the local champion and supporting the team with using the platforms features. Following initial implementation, day-to-day support was provided remotely via telephone to review progress, identify new barriers to sustainable use and identify processes of care where the platform may add value.

Evaluation

Adoption

The platform has been successfully adopted in 56 acute healthcare facilities (including 102 intensive care units) in Sri Lanka and supports the only national intensive care registry in South Asia (figure 3), which commenced in 2012 took 2 years to scale nationally.

Scaling of the platform across acute care was driven by frontline stakeholder engagement and on an invitation basis. Seven sites dropped out during implementation, citing concerns regarding sharing of information. Recruitment remains active. Completeness of reporting of information is validated weekly by cross-referencing aggregate admission numbers and this is then reported through the visual dashboard and as part of a monthly individualised summary for each centre. Clinician-led adoption, using locally driven cycles of implementation and qualitative interviews, enabled identification of drivers and acceptable solutions to key barriers; burden of data collection, integration into workflow and the potential for legal implications of transition from paper to digital documentation. Focus group discussion with frontline users (nurses and doctors) led to iterative adaptation of the platform. Adaptation included development of aggregate reports on completeness of vital sign reporting which provided positive reinforcement and direct feedback during the adoption phase (figure 4). Focus groups including nurses, doctors and allied healthcare professionals elicited potential barriers such as
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time taken to enter and find information at critical steps (admission, ward round and discharge) in patient care. Feedback from users led to the addition of an editable and auditable ‘reason for admission’ field and the ‘diagnosis field’ mapped to international classification being placed in the discharge section of the user interface. Trends in physiological variables, common presentations and patient groups at high risk of adverse events were highlighted, facilitating treatment evaluation and providing objective data for ward rounds, empowering the nurses role in monitoring of unwell patients and supporting communication between team members.

Mobile accessibility of information has been an essential feature of the platforms usefulness in the acute-care setting enabling acute care teams a reliable mechanism to record, view and communicate information as the patient and the clinician move from emergency department, ward, critical care, surgery and clinic during daily care (figure 5). Features for saving information as PDF for printing were added in response to user feedback, to enable information sharing with patients and community services on discharge. Printing options also helped reduce anxiety over the perceived legal superiority of paper over electronic records and integrating digital and hand written information in paper-based medical records.

The platform was further used to facilitate training and governance meetings, providing clinicians with accessible information to review care processes, such as recognition of sepsis postoperatively, and time from referral to intervention in acute cardiac care, and to direct learning regarding clinical presentation and diagnosis. Furthermore, nurses reported an improved nurse and patient relationship, giving patients a greater feeling of safety by having information regarding their care visible. These adaptations based on user feedback reflect the dynamic nature of acute care workflow which necessitates information to be accessible to healthcare workers and patients throughout their continuum of care. As barriers to adoption have been addressed in an iterative manner, implementation in new sites in both Sri Lanka has become increasingly efficient with little or no new barriers to adoption in the clinical settings arising. This may suggest that the barriers and facilitators to adoption of technology in these settings are somewhat universal and the solutions potentially transferable.

Utilisation

Service evaluation

The platform has assisted clinicians in the care of over 100 000 patient episodes, from critical care admission, through to outcomes at 30 days following discharge.24 The digital intensive care unit (ICU)
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platform has increased availability of variables for benchmarking acuity of admissions and supported the validation of prognostic models.\textsuperscript{11, 19, 20, 25} The platform has also facilitated participation in international multisite observational studies on ventilation management.\textsuperscript{26} Prior studies attempting to answer similar questions in this setting have highlighted challenges of lack of information, missing outcomes and small data sets. The platforms ability to increase availability of routine clinical information, address known potential barriers to technology adoption and subsequent evaluation of clinical care is an important step forward in establishing health systems in LMICs equipped to evaluate and improve care.

Service delivery

Real-time aggregate information generated by the platform supports a 24-hour national bed availability system which has assisted clinicians locate ICU beds for over 3700 patients.\textsuperscript{11, 24, 27} The system has highlighted barriers to successful patient transfer including geographic distance of the available bed from the referral centre and clinical instability of the patient. Nurses, who are often early adopters of the platform report value in access to information on ward activity, acuity and staff to patient ratios, which, displayed on desktop dashboards have helped them overcome existing burden of collecting and reporting this information manually as part of existing monthly organisational reports.

Decision support in acute clinical care

In the acute care setting, the adapted mobile version of the digital platform has empowered nurses and doctors to adopt digital vital sign reporting (500 000 observations) in busy ward settings.\textsuperscript{28} Adaptation of an early warning score has helped identify over 4800 deteriorating ward patients by flagging patients who have deranged physiology on admission, for whom on increased frequency of vital signs monitoring may be beneficial.\textsuperscript{26–28} Health system research The platform has enabled national and international research in prognostic modelling in acute care (including for sepsis), the external validation of severity of illness models and related risk stratification tools.\textsuperscript{19, 20, 25, 29}

Risk stratification of surgical patients

Incidence of postoperative complications, description of quality of life for patients following critical illness and surgery and patient experiences and satisfaction following critical care admission have also been evaluated.\textsuperscript{30} Focus group discussion with frontline users during implementation has engaged stakeholders in further care evaluation. Using the platform implementation as a lens, clinical teams are gaining insights into the existing processes in patients care. For example, in acute care wards, the
dashboards visual display of the location of patients with abnormal vital signs is prompting nurses to consider reorganisation of the location of unwell patients within the ward to an area designated for closer observation or with the availability of continuous monitoring.

Remaining Challenges
Perhaps, the greatest challenges remain in understanding the more hidden barriers that prevent clinicians from actively using information captured through such platforms to drive change. Recent literature suggests that such impediments may extend beyond knowledge, opportunity and resource. Further exploration of healthcare worker perceptions in resource-limited settings is needed. Similarly, the disparity that exists between countries in support for clinicians seeking to undertake research and training in these domains needs to be addressed. In addition, further work is needed to engage researchers, clinicians, administrators, developers and the public regarding security, safety and risks of digital information. While all acknowledge the flaws of existing paper systems and the negligible security of the information that dwells dormant in healthcare facilities internationally, there remains anxiety over the potential for misuse of digital information, especially in LMIC. Perhaps, empowering patients to be the gatekeepers and equal stakeholders in their information and in the care it informs, as pioneered with patient-reported outcomes in surgical care, offers a way forward.

Transferability
The platform is being implemented across 18 intensive care units in four provinces in Pakistan; the collaboration has shared technology, approach to implementation and solutions to the barriers to adoption in a South-to-South partnership. While Sri Lanka has a predominantly centralised government-led health system, governance in Pakistan is devolved to regional organisations with a higher proportion of privately funded facilities. The approach to stakeholder engagement, frontline stakeholder driven collaboration with professional bodies, ministry organisation already identified as key stakeholders in Sri Lanka, is proving effective in implementation in Pakistan. Implementation challenges in Pakistan have so far been minimal compared with the original registry rollout in Sri Lanka. Implementation in Sri Lanka starting back in 2012 required installing internet and landlines in each ICU, whereas IT infrastructure in Pakistan was comparatively well developed already, reflecting the significant growth in internet and digital connectivity in the region. The user-friendly mobile application-based platform has been easily introduced without the need for extensive end-user training or installation of software. The registry offline functionality has been successful in overcoming interrupted internet connectivity, which remains a challenge in the region. Sri Lanka is in the process
of developing and implementing a national digital health information system. This system is currently under pilot implementation in selected facilities. The PROTECTS platforms ability to harmonise with existing systems has enabled successful co-implementation to date and we look forward to collaborating on future integration (online supplementary file).

Next steps
A mixed-methods evaluation of critical care outcomes including measures of quality of life and patient-reported outcomes is underway in Sri Lanka. ‘Work is currently underway within the collaboration to identify priorities for decision support tools incorporating prognostic models validated and developed from the information captured through the platform’. Mobile interfaces are being developed for patient-reported information giving patient greater opportunity to participate in the decision regarding their care and guiding patient-led health service improvement. The dashboards are providing a real-time feedback to facilitate setting-specific research focused on evaluating and improving the quality of care, antibiotic use and time to referral for patients with myocardial infarction.\textsuperscript{19, 20, 26, 30} Funding is being sought to scale the platform in Pakistan and to partner with other LMIC in sub-Saharan Africa, who are keen to collaborate by employing both the technology and methodology described here.

Conclusion
Adoption of digital mHealth platforms to support acute care in South Asia is feasible. Such platforms can help close the gap in availability of continuous facility level and national information needed for service evaluation and research. A collaborative approach engaging clinicians, researchers and healthcare informaticians offers a pragmatic solution to overcoming barriers to adoption, disruption to workflow and user engagement. Digital platforms can support evaluation of existing care at local and national levels and empower clinicians working in LMIC to participate in international research. Greater investment in successful methodologies for health system improvement will improve their penetration in LMIC health systems. Accessible opportunities for clinicians and patients in resource-limited settings to set the agenda for research better and directly use output from digital platforms are required.
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Contributors
This practice paper describes the experiences and insights of a multidisciplinary collaborative. Each author is a key stakeholder in the collaborative and represents a wider network. All made significant contribution to the learning described. AB and RH were responsible for manuscript preparation.

Figure 1: Existing pathways and bottlenecks for information flow and proposed enhanced systems following mHealth platform implementation for acute and critical care

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Existing care pathway
Existing bottlenecks
mHealth platform
Future care pathways
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Figure 2: Cycle of implementation and co-evaluation

Figure 3: Network for Improving Critical care Skills Training user interface
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Figure 4: Quality dashboards in the ward setting help nurses improve completeness of vital sign reporting during adoption

Figure 5: Acute care mHealth platform adopted in an inpatient setting in Sri Lanka
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CHAPTER 6
Pakistan Registry of Intensive CarE (PRICE): Expanding a lower middle-income, clinician-designed critical care registry in South Asia
Chapter 6

Abstract

Introduction
In resource-limited settings - with inequalities in access to and outcomes for trauma, surgical and critical care - intensive care registries are uncommon.

Aim
The Pakistan Society of Critical Care Medicine, Intensive Care Society (UK) and the Network for Improving Critical Care Systems and Training (NICST) aim to implement a clinician-led real-time national intensive care registry in Pakistan; the Pakistan Registry of Intensive Care (PRICE).

Method
This was adapted from a successful clinician co-designed national registry in Sri Lanka; ICU information has been linked to real-time dashboards, providing clinicians and administrators individual patient and service delivery activity respectively.

Output
Commenced in August 2017, five ICU’s (three administrative regions-104 beds) were recruited and have reported over 1100 critical care admissions to PRICE.

Impact and future
PRICE is being rolled out nationally in Pakistan and will provide continuous granular health care information necessary to empower clinicians to drive setting-specific priorities for service improvement and research.

Key words

Intensive care, health system strengthening, intensive care registries, lower-middle income countries.
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**Intensive care registries**

Intensive care registries in High-Income Countries (HICs) play an increasingly pivotal role in evaluating treatment outcomes, benchmarking services and providing opportunities for service forecasting. These high-quality continuous surveillance systems are ideally suited to capture the level of granular data needed to evaluate care processes and outcomes, and to inform strategies to improve care. However intensive care registries remain notably absent in the vast majority of the world’s health care systems. In South Asia, a region encompassing eight countries and a population 1.87 billion; 24.6% of the world’s population, only Sri Lanka has a national intensive care registry.

Investment in registries remains limited with ambiguity and concern over cost, sustainability and feasibility. Experiences from HICs have demonstrated that registries can be difficult to implement; requiring specialist and expensive information technology. In addition, implementation in Low and Lower-Middle Income Countries (LMICs) also needs to overcome low information availability and poor infrastructure. Scarce resources and high patient numbers often disconnect frontline staff from the potentially long-term benefits of such systems.

In South Asia, improving sanitation, industrial urbanisation and increasing life expectancy have generated a shift in the region’s health care priorities: trauma care and curative services including surgical and cancer care are in growing demand. Whilst mortality is estimated to be higher in the region compared to HICs, the true burden of morbidity on recovery and on economic growth remains unquantified. As intensive care services become more accessible in the region, the lack of reliable, granular, setting-specific data hampers efforts to address inequalities in care and evaluate therapies such as respiratory support, fluid management and antibiotic use.

**A trend for change**

Encouragingly, there are indications that intensive care registries are being implemented in non-HIC settings. Epimed, a privately funded registry in Brazil (an upper-middle income country) incorporates 598 ICU’s from 318 hospitals predominantly in the southeast region of the country. In Malaysia, another upper-middle income country, The National Audit on Adult Intensive Care Units (NAICU, formerly MRIC) similarly combines annual data on occupancy, with measures of ICU performance and national service provision. In Sri Lanka, National Intensive Care Surveillance supported by the Network for Intensive Care Systems and Training (NICST) in partnership with the Sri Lankan Ministry of Health includes virtually all 102 state adult (and most paediatric and neonatal) ICUs. This lower-middle income country national registry (as with Epimed in Brazil) provides real-time aggregate
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information on ICU occupancy and acuity. Focused on supporting quality improvement, these registries provide classical demographic and occupancy information, alongside detailed data regarding infectious episodes, adverse events and checklists aimed at improving adherence to best practice guidelines. In addition, the Sri Lankan registry informs a national 24hr bed availability system and has to date assisted in locating ICU beds for over 4800 patients. The registry output has also resulted in collaborative service evaluations, multicentre validations of prognostic models and international research projects.

These grass roots initiatives, driven by frontline clinicians, demonstrate that electronic ICU registries providing real-time, continuous data are feasible in non-HICs. This paper describes the collaborative efforts to develop such a national critical care registry for Pakistan.

Aim

A clinician-led partnership of the Pakistan Society of Critical Care Medicine (PSCCM), Intensive Care Society (ICS, UK) and Network for Improving Critical care Systems and Training (NICST) aims to implement a national intensive care registry – Pakistan Registry of Intensive CarE (PRICE) - which has been adapted from the electronic registry methodology used in Sri Lanka. The collaboration aims to develop a critical care network linking South Asia and the UK, with a focus on system strengthening and increased availability of granular data needed for setting-specific, globally relevant research.

Methodology

In partnership with clinician, academic and administrative stakeholders in Pakistan, ICUs from both government, and semi-government healthcare facilities have been recruited. Initial recruitment has focused on hospitals recognised for postgraduate training by the College of Physicians and Surgeons Pakistan (CPSP) enabling PRICE to build on a core group of accredited ICUs from each region.

Registry design

Admission characteristics, diagnosis and basic physiology were captured daily for each patient admitted to the ICU, adapted from the NICST registry. Diagnoses were mapped to APACHE IV enabling risk adjustment, benchmarking and the potential for international comparison. Real-time information was displayed in dashboards, supporting clinicians with routine clinical care. De-identified information was displayed in dashboards, enabling administrators and researchers to evaluate trends in unit activity, severity of illness, bed occupancy and outcomes within their respective
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Anonymised aggregate data was developed to provide centres (and the public) the opportunity to see their output in relation to their peers.

Implementation and stakeholder engagement

In partnership with frontline ICU healthcare teams, clinical stakeholders (doctors, nurses, technicians) were locally appointed as centre coordinators during site recruitment. Following face-to-face training, centre coordinators then led local implementation, supporting data collection and assisting colleagues with dashboard navigation. A cycle of adaptation, implementation and evaluation, (including user feedback and data completeness) was used to refine the data set and highlight the priorities in information requirement of frontline users.

Data entry and management

Centres contributed information voluntarily through a secure cloud-based mobile or desktop portal, co-designed by clinicians and researchers in Sri Lanka (NICST). To reduce the burden of data entry and enable real-time data visualisation, free-text fields were avoided and instead drop-down and checkbox options were utilised. Weekly telephone follow-up, conducted through the nominated local coordinators was used to extract admission numbers from existing (paper-based) records within each ICU. Telephone follow-up combined validation of reporting with an opportunity for technical support and regular contact with local coordinators and clinicians. Information on completeness of reporting was displayed monthly through each participating centre’s own dashboard, guiding the participating ICUs towards greater data completeness. 20

Pilot data

PRICE, founded in August 2017, has recruited five member ICU’s, with a combined capacity of 104 ventilated beds (figure 1).

Recruited ICUs were from three cities; Karachi, Lahore and Islamabad connecting three of the countries seven administrative regions. The network has reported 1,100 admissions, of whom 494 (44.83%) were unplanned and 640 (58.1%) were male patients (figure 2).

The most common specialties were general surgery 174 (15.8%), cardiac surgery 278 (25.3%) and neuro-trauma 144(13.1%). Mechanical ventilation on ICU admission was required in 666 (60.48%) cases.
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Dashboards enabled users to highlight specific trends and sort the aggregate information by week, month or by admission characteristics (e.g. planned versus unplanned, or operative versus non-operative) depending on their requirements (figure 3).

Challenges

Data security and appropriate data management are universal considerations in electronic health systems and registries. Following the international standards set by existing registries, data is stored in secure servers, and access is curated. Contributing sites have full access to all data submitted from their ICU but do not have access to raw data submitted by other contributing units.

Technical support for the registry, data management and storage is currently provided by the NICST team based in Sri Lanka. The collaboration is working with local experts and existing health-related registries in Pakistan to build capacity (funding and human resources) for local management.

Impact and future

Output from the registry is already supporting ongoing international research collaborations in ventilation practices in LMIC’s. The registry will also enable identification of specific risk factors for mortality in critically ill patients within the region. PRICE will provide an opportunity for routine, continuous capture of granular health care information necessary to empower clinicians driving setting-specific priorities for service improvement and research in intensive care. Improving access to and delivery of surgical care and evaluation of measures in quality of life for patients following intensive care admission have been identified as priorities.

Implementation will next focus on recruitment of all centres recognised by CPSP for postgraduate training and expansion to the administrative regions of Khyber Pakhtunkhwa, Balochistan, Gilgit Baltistan and Azad Kashmir.

Contemporaneous to the expansion of PRICE, a national cross-sectional survey, adapted from NICST, is being undertaken in collaboration with the Pakistan Society of Critical Care Medicine (PSCCM). This survey will provide the first detailed profile of state and private intensive care facilities in Pakistan including infrastructure, human resources and staff training.

The collaboration will strengthen critical care networks internationally by linking South Asia and the UK, and by providing real-time epidemiology (e.g. sepsis, respiratory infections and febrile illness) the
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registry network will provide a springboard for future globally relevant research. PRICE will further contribute to the ongoing work by South Asian collaborations including the South East Asia Research in Critical care Health (founded in 2015) which under the umbrella of South Asian Association for Regional Cooperation (SAARC) aims to improve collaborative research and development of healthcare in the region.

Figure 1: ICU centres recruited to PRICE August 2017- January 2018

1: Pakistan Institute of Medical Sciences, Islamabad
2: National Hospital and Medical Centre, Lahore
3: Jinnah Hospital, Lahore
4: National Institute of Cardiovascular Diseases, Karachi
5: Civil Hospital Karachi
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Figure 2: Cumulative admission episodes to PRICE, August 2017- January 2018

Figure 3: PRICE - Clinician co-designed real-time dashboards
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CHAPTER 7
A learning health systems approach to improving the quality of care for patients in South Asia

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Abi Beane, Duncan Wagstaff, Anuja Abayadeera, Mandika Wijeyaratne, Gotabhaya Ranasinghe, Samuel Mirando, David Walker, Rashan Haniffa
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Abstract

Poor quality of care is a leading cause of excess morbidity and mortality in low and middle income countries (LMICs). Improving the quality of healthcare is complex, and requires an interdisciplinary team equipped with the skills to design, implement and analyse setting-relevant improvement interventions. Such capacity is limited in many LMICs. However, training for healthcare workers in quality improvement (QI) methodology without buy-in from multidisciplinary stakeholders and without identifying setting-specific priorities is unlikely to be successful. The Care Quality Improvement Network (CQIN) was established between Network for Improving Critical care Systems and Training (NICST), and University College London Centre for Perioperative Medicine (UCL-CPOM), with the aim of building capacity for research and QI. A two-day international workshop, in collaboration with the College of Surgeons of Sri Lanka was conducted to address the above deficits. Innovatively, the CQIN adopts a learning health systems (LHS) approach to improving care by leveraging information captured through the NICST electronic multi-centre acute and critical care surveillance platform. Fifty two delegates from across the CQIN representing clinical, civic, and academic healthcare stakeholders from six countries attended the workshop. Mapping of care processes enabled identification of barriers and drivers to the delivery of care and facilitated the selection of feasible QI methods and matrices. Six projects, reflecting key priorities for improving the delivery of acute care in Asia, were collaboratively developed: improving assessment of postoperative pain; optimising sedation in critical care; refining referral of deteriorating patients; reducing surgical site infection after caesarean section; reducing surgical site infection after elective general surgery; improving provision of timely electrocardiogram (ECG) recording for patients presenting with signs of acute myocardial infarction. Future project implementation and evaluation will be supported with resources and expertise from the CQIN partners. This LHS approach to building capacity for QI may be of interest to others seeing to improve care in LMICs.
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Key words

Quality improvement, acute-care, capacity building, surveillance, learning health systems

Background

Addressing deficiencies and inequities in acute and critical care in resource-poor settings remain global health priorities. Poor quality of care has been identified as a leading cause of excess mortality and morbidity in Low and Middle Income Countries (LMICs); most notably in South Asia, where poor quality exceeds limited access to or unavailability of care as a cause of mortality. In response, the Lancet Global Health Commission on Care Quality has set out four key actions to raise the quality of healthcare delivered; building a shared vision of care quality, a clear strategy for quality evaluation, stronger regulation ensuring civic and professional accountability, and continuous learning.

Capacity for capturing information to evaluate the quality of care and measure the impact of interventions in LMICs is limited. Internationally, the information needed to evaluate and benchmark healthcare is increasingly derived from electronic surveillance systems, implemented at facility level and scaled nationally. Such systems are only now starting to emerge in LMICs where local collaborators emphasise that continuous reporting of processes of care, essential for evaluating quality, is often too burdensome. In addition, health system evaluation and quality improvement methods are neither an established part of medical education nor prioritised by clinicians faced with daily assault of delivering frontline care with limited resources. Subsequently, QI initiatives in LMICs are often led by external experts, who may have limited insight into determinants of care, or of discreet organisational or cultural barriers to implementation of QI initiatives. Whilst the importance of North-South partnerships to facilitate transfer of such skills is being increasingly recognised, practical initiatives to engage inter-professional teams remain uncommon.

Care Quality Improvement Network

The Care Quality Improvement Network (CQIN) is a collaboration between University College London Centre for Perioperative Medicine (UCL-CPOM) and Network for Improving Critical care Systems and Training (NICST). NICST is a non-profit organisation which has developed a clinician-led, setting-adapted continuous surveillance platform, supporting the delivery of acute medical, surgical and critical care for over 250,000 patients in South Asia. The platform, part of a Learning Health System (LHS) methodology to improve acute care in LMICs, has enabled evaluation of patient
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outcomes, development of prognostic models, observational research and quality improvement through real-time information feedback and clinical training. The CQIN aims to develop an international network of health care workers, researchers, educators and administrators with capacity to improve acute care in LMIC settings.

Aim

This short communication describes an innovative learning health systems approach to identifying setting relevant priorities for improving the quality of care using routine clinical data captured through digital health information platforms.

Approach

Using a health systems approach, structured discussions with frontline clinicians and stakeholders examined existing information from three NICST registries (cardiology, critical care, surgery) to select candidate QI themes. The themes selected were: internationally recognised indicators of quality of the processes and outcomes of care; routinely used tools for assessment of risk, complication and recovery; and efficiency of treatment pathways. Examples include, the time between referral and an intervention, patient satisfaction and complications following intervention. These replicable, objective processes, common to the cardiology, critical care and surgical care patient pathways, were chosen to provide a focus through which groups at the workshop could identify clear gaps in existing care that may be amenable to quality improvement.

Inter-professional stakeholders from the existing NICST registry partnerships and participants in UCL-CPOM’s academic programmes were invited to attend a two-day workshop in Sri Lanka. Healthcare researchers with expertise in health systems and quality improvement, alongside experienced clinicians who have undertaken change and improvement in their clinical settings, were recruited as faculty. The workshop was affiliated with the academic sessions of the College of Surgeons of Sri Lanka, themed as ‘Striding towards equity and excellence in surgical care’. During the workshop, measures of processes and outcomes of care, accessible through online live dashboards, were used to facilitate data-driven conversations regarding existing quality of care. CQIN faculty with expertise in QI, health informatics and health systems research, all with experience in South Asia, supported the delegates with the evaluation. Workshop sessions focused on the definition, measurement and evaluation of quality. Care as expected for the surgical, acute MI and critical care patients was analysed using process mapping tools available through the IHI. Actual care was then described by the delegates, informed by the digital registries.
Digital analytics dashboards (accessible as part of the NICST collaborative platform) displaying process and outcome measures were used to facilitate data-driven conversations regarding existing delivery of care from three acute care specialities (cardiology, critical care, surgery).\textsuperscript{21} CQIN statisticians, clinicians, health informatics researchers and behavioural scientists, all with experience in South Asia, supported the delegates with interpretation of the information. Workshop sessions focused on the definition, measurement and feedback of quality. Driver diagrams and facilitated discussion with the delegate groups were used to elicit enablers and potential barriers to care improvement.

The CQIN was registered with the Institute for Health Improvement (IHI) enabling access to the IHI’s online resources during the workshop.\textsuperscript{23} The workshop culminated in presentation of the project proposals and led to discussions on practical steps aiding implementation. Project proposals for the QI initiatives and ethics applications (if needed) were developed and delegate feedback captured.

**Priorities for improvement**

Fifty-two delegates from Europe, Hong Kong, India, Pakistan and Sri Lanka attended. Delegates included doctors, nurses, physiotherapists, medical students, hospital administrators and health ministry workers, representing surgery, obstetrics & gynaecology, anaesthesia, critical care, cardiology and public health (figure 1).

Facilitator-led discussion with delegates regarding the existing delivery of care resulted in the following deficits in care being identified:

- Under reporting of postoperative pain with no standard tool for pain assessment.
- No single route to critical care or cardiology for patients presenting to acute care services.
- Higher than expected patient reported symptoms of anxiety and sleep disturbance post critical care, with no standardised approach to daily sedation assessment.
- Higher than expected confirmed or suspected wound infection following surgery, with no standardised assessment for surgical site infection.

Six project proposals were developed, informed by these evaluations of care, using routine clinical information captured through the NICST platforms while acknowledging limitations in the collection and use of this information.\textsuperscript{11,16,21,24} The projects were: optimising sedation in ICU, refining referral of deteriorating patients, reducing surgical site infection after caesarean section, reducing surgical site infection after elective general surgery, improving perioperative pain assessment and improving efficiency in ECG recording and escalation for patients presenting to hospital with symptoms of acute myocardial infarction (AMI). These six project proposals for the QI initiatives, alongside ethics applications (if needed) were developed. Where necessary, additional process measures were
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identified to enable evaluation of the impact of the QI intervention and the relevant registries are being adapted to include specific metrics.

The following provides an example of how the health systems approach was used by the collaboration to identify their priority for improvement and develop their project.

‘Indicators of care quality measured through the Sri Lankan STEMI forum’s and NICST’s AMI registry, revealed that patients presenting with symptoms of acute coronary syndrome were experiencing delays in recognition of AMI on arrival and escalation to cardiology services.25 Process mapping undertaken by delegates identified specific bottlenecks to recognition and escalation of AMI (figure2). These included inefficiencies in requesting, acquisition and interpretation of ECGs, and absence of a single communication route to escalate patients requiring cardiology review. Working with the faculty, the delegates then developed a proposal to a have a single escalation pathway for ordering an ECG and identified teams and individuals that could facilitate relocation of the ECG equipment to the admission department. The proposed QI initiative included leveraging the mHealth tool currently implemented as part of the existing AMI registry to help the clinical team communicate requests for care escalation. Delays in inter-hospital referral for patients requiring specialist intervention, also highlighted by the registry data, were considered unsuitable for a first QI project. Task shifting, role responsibilities, duplication of data entry in paper and electronic tools, and challenges in changing team behaviours were elucidated as potential barriers to implementation of the QI project.’
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Next steps

Delegates returning to their clinical settings will be supported to implement and evaluate their projects with resources from NICST, including support from experienced locally trained project coordinators and data collectors trained in routine surveillance (figure 3). CQIN QI experts will provide ongoing support remotely through an online portal (www.nicst.com) and using an online healthcare learning platform.22 Reciprocal fellowships between the UK and South Asia will be utilised to support implementation of QI projects developed during the workshop and provide opportunities for shared learning. It is anticipated that evaluation of the QI projects will highlight successful and unsuccessful aspects of the solutions proposed. This learning will be invaluable to help further refinement and development of subsequent projects and will be disseminated to the wider CQIN collaboration.

Feedback

Delegate feedback was captured with pre- and post-workshop questionnaires to assess the needs of participants and their views on how well these needs had been met. Pre-course needs analysis reported that only 25% of delegates had received formal QI training prior to the workshop. Following the workshop, 81% of delegates strongly agreed that the course had contributed to their understanding of QI and all delegates agreed that they could apply what they had learned in their own clinical settings. Two days was an acceptable time frame for 84% delegates to take leave from clinical responsibilities and 78% wished to attend subsequent activities to support implementation.

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NICST team

- AWBWS Wijesiriwardena
- F Branco
- GDD Priyadarshani
- N Nazaar
- PC Sigera
- PGP Ishani
- S Samath
- I Udayanga

Author contributions

DW and AB were responsible for manuscript development, all authors contributed intellectually in the conception and delivery of the project.

Disclosure statement

DW and collaborator (PO), received travel grants from the Association of Anaesthetists of Great Britain & Ireland in order to attend the workshop. SM received a Volunteer Grant from the World Anaesthesia Society.

Ethics and consent

This activity was exempt from ethical review.

Funding information

The total cost of holding the workshop was approximately USD 1600. A delegate contribution of USD 7 covered the cost of refreshments. Industry partners in Sri Lanka covered the cost of the venue.
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All international faculty and administrative staff gave their time and expertise voluntarily, with travel and accommodation for international faculty supported by travel grants from UCL and the Association of Anaesthetists of Great Britain and Ireland.

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Paper context
This short communication reports an innovative, practical approach to building capacity for interventions to improve the quality of health care in LMICs. Two fundamental aspects of successful QI are explored: how to bridge the information gap by leveraging innovative real time electronic registries, and how to engage frontline healthcare workers in data driven quality improvement using co-design and academic collaboration. Methods described here may be transferable tools for other collaborative seeking to undertake similar initiatives.
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Figure 1: Participants mapping care as expected for acute care using process mapping tools, facilitated by international faculty
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Figure 2: Existing care pathways, bottlenecks and barriers for AMI referrals to cardiology in Colombo, Sri Lanka
Figure 3: Participants sharing their project proposals with the CQIN workshop
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CHAPTER 8
Closing the theory to practice gap for newly qualified doctors: evaluation of a peer delivered, practical skills training course for newly qualified doctors in preparation for clinical practice

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Key words
patient safety, education and training, acute care, clinical skills, peer learning

Abstract

Purpose
The Good Intern Programme (GIP) in Sri Lanka has been implemented to bridge the "theory to practice gap", of doctors preparing for their internship. This paper evaluates the impact of a 2-day peer delivered Acute Care Skills Training (ACST) course, as part of the GIP.

Study design
The ACST course was developed by an interprofessional faculty, including newly graduated doctors awaiting internship (pre-intern), focusing on the recognition and management of common medical and surgical emergencies. Course delivery was entirely by pre-intern doctors to their peers. Knowledge was evaluated by a pre and post-course multiple choice test. Participants' confidence (post-course) and 12 acute care skills (pre and post-course) were assessed using Likert scale based questions. A subset of participants provided feedback on the peer learning experience.

Results
Seventeen courses were delivered by a faculty consisting of 8 peer trainers over 4 months, training 320 participants. The mean MCQ score was 71.03 (SD 13.19) pre course compared to 77.98 (SD 7.7) post-course (p<0.05). Increased overall confidence in managing ward emergencies was reported by 97.2% (n=283) of respondents. Participants rated their post-course skills to be significantly higher (p<0.05) than pre-course, in all 12 assessed skills. Extended feedback on the peer learning experience was overwhelmingly positive and 96.5% would recommend the course to a colleague.

Conclusions
A peer delivered ACST course was extremely well received and can improve newly qualified medical graduates’ knowledge, skills and confidence in managing medical and surgical emergencies. This peer based model may have utility beyond pre-interns and beyond Sri Lanka.

Main Learning points

● Peer training provides a sustainable method for delivering practical skills programme to bridge the theory-practice gap for newly qualified doctors.

● A clinically focused, practical skills programme builds perceived confidence for newly qualified doctors as they prepare for internship.
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Peer to peer training enables continued professional development for doctors working in low and middle income countries where there might otherwise be limited opportunity for such learning.

Objective

To evaluate the effect of peer delivered practical 2 day acute skills training (ACST) course designed and delivered by a peer faculty, to improve participants knowledge, confidence and self-assessed skills to manage common acute medical and surgical emergencies.

Introduction

Newly qualified doctors undertaking internships often carry a large responsibility in patient care, yet with little practical experience, which is associated with adverse consequences.\(^1,2\) The introduction of newly qualified medics into the clinical team is associated with omissions in the recognition of deteriorating patients and failed communications to senior team members, which can result in a failure to escalate treatments.\(^3\) The ability to respond effectively to such emergency scenarios require clinicians to be confident in applying their knowledge and clinical skills in practice.\(^3,5\) It is often the junior members of the clinical team led by junior doctors who are the point of first contact for acutely unwell patients. Whereas undergraduate medical training lays the foundation for the knowledge and analytical skills that are required by junior doctors, there remains a gap in the translation of this knowledge into the skills needed to act quickly and confidently in emergency situations.\(^4,6\)

In High Income Countries (HIC) including the UK, clinical and decision-making skills training has been increasingly incorporated into final year medical undergraduate training programmes to assist students in their transition to practice, and peer learning has been explored as a method of delivering skills training for junior doctors and nurses.\(^7,9\) There is evidence that such a model may offer effective knowledge transfer, improve junior clinicians ability to problem solve and make decisions based on systematic assessment in emergency scenarios.\(^10,11\) In Low and Middle Income Countries (LMIC), practical acute care skills training for frontline staff is limited, despite ongoing remedial efforts.\(^8,11\) Unaffordability of training courses, unavailability of suitable trainers, traditional or didactic models of learning and lack of course material and equipment are contributory factors. In Sri Lanka, a LMIC, 1000 medical graduates begin internship annually, at least 150 of whom are overseas qualified graduates with limited exposure to the local healthcare system.\(^12\)
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Historically, there has been minimal opportunity for these students to prepare for the practical components of internship and no opportunity for structured handover between the outgoing junior doctors and the incoming newly qualified doctors. As such there is little capacity for colleagues to share experiences or knowledge of the structures and processes necessary to survive life on the front line. Upon publication of their final results, graduates have an approximately 9 month gap (an administrative period) before commencing their first clinical post. During this time, many are involved in administrative or support roles within the university, with little opportunity to develop or consolidate clinical skills.

Since 2014 the “Good Intern Programme” (GIP) has been piloted in Sri Lanka to help prepare graduates for transition to practice. This multi-component programme for newly qualified doctors includes essential information on health-care system infrastructure, cognitive skills for prescribing and medical documentation alongside lessons in regional dialects. In this paper, we report the evaluation of the peer (fellow graduates from the same intake) delivered practical 2 day acute care skills training (ACST) course designed and delivered by a peer faculty, to improve participants knowledge, confidence and self-assessed skills to manage common acute medical and surgical emergencies.

Design

Needs analysis

All newly qualified doctors awaiting internship were contacted via their respective universities and their trainee representatives and invited to participate in an online anonymous needs analysis to rate their competence and confidence to perform essential clinical skills. The survey included self-evaluation of graduates’ ability to undertake structured assessment, manage acutely unwell patients, and perform practical skills synonymous with advanced life support, including defibrillation, a structured systematic (A-E) assessment and airway manoeuvres. The findings of the needs analysis were used to devise the (ACST) course.

Course design and delivery

Course content was developed iteratively by an inter-professional collaboration including senior intensive care medicine trainee and nurses from the UK, senior physician and education fellow practising in Sri Lanka, international clinical educators with expertise in critical care, resuscitation and simulation, and junior doctors who had recently completed internship in Sri Lanka. The course was
designed to be practical, utilizing skills stations, clinical scenarios and small group sessions, to maximize participant participation and build confidence. Clinical scenarios were selected using a Delphi process reflecting situations commonly encountered by junior doctors working in acute medical hospitals in Sri Lanka and for their opportunity to integrate essential management guidelines. Scenarios included; respiratory failure, sepsis, acute coronary syndrome, anaphylaxis after antivenom, dengue fever and organophosphate poisoning.

The peer faculty was selected from newly qualified doctors participating in a series of Train the Trainer (TTT) session based on established methodology. Participants showing aptitude for teaching clinical skills-set and interest in building capacity within their profession were given preference to join the faculty. The faculty received training in skills instruction, facilitation, assessment (OSCE) structure and good practice, session setup, giving feedback and marking prior to the course and undertook observed practice.

The 2-day course was conducted for small groups of up to 20 doctors over 4 months. Enrolment for the program was voluntary, with publicity aimed at all newly qualified doctors awaiting internship and had responded to the needs analysis. Synonymous with undergraduate training, English was the medium of instruction with discussion sometimes continuing in the local languages. Participants were invited to access course materials online (lecture materials, guidelines, audio lectures) using a learning management system.

**Course assessment and feedback**

Graduates’ knowledge was assessed by a randomized pre and post-course multiple choice test of 20 questions selected from a question bank designed to minimize sharing across participant groups. Participants were invited to assess their confidence after each of 5 skills stations (figure 2) and at the end of course using a 5 point Likert scale ranging from “strongly disagree” to “strongly agree”. Skills ability (skills listed in figure 1) was rated by participants pre and post course using a 10 point Likert scale self-assessment questionnaire, comparable to those completed by doctors during foundation training in the UK.

In addition, 5 Objective Structured Clinical Examination (OSCE) stations were used to provide participants with objective feedback following course completion. The 5 stations covered were safe defibrillation, recognition and management of tachyarrhythmia, Basic Life Support, A-E structured assessment and emergency management of the airway. A structured marking criteria based on participants’ ability to perform each aspect of the skill safely and competently was utilised. The pass mark was set at 50%. In addition to the TTT sessions outlined above, the faculty undertook paired
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assessment for each OSCE station, to ensure validity and consistency in marking across the faculty group.9

Participants were invited to provide feedback rating their learning experience, the opportunity to actively participate in the skills stations and scenarios, course delivery and whether they felt learning objectives were achieved using the 5 point Likert scale described above. This feedback was collated electronically following each session and upon completion of the course. Suggestions for course improvement were requested in free-text format. A further 5 questions (figure 5) were used during feedback for the last three courses to evaluate the peer teaching process. All participants were not approached for these questions in order to limit the amount of feedback being sought from candidates. Course participation was voluntary with assessments and feedback also voluntary and anonymised. All candidates had the option to opt out of their information being used for analysis and research. No further ethical review was sought.9

Data analysis

Data was analysed using Stata Corp 13.21 Summary of the results for the MCQ and OSCE were presented as mean, with SD for continuous variables, whereas counts and percentages were used to describe the discrete variables. Wilcoxon signed-rank test was used to analysis paired nonparametric continuous variables and paired Likert scale variables. All tests were two sided and level of significance was taken as 0.05. The free-text suggestions for improvement provided by the participants in the feedback were listed by two investigators and coded for analysis.
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Results

Needs analysis

Seven hundred and thirty-two of 902 (81.1%) newly qualified doctors who responded to the survey wished to participate in a 2-day practically focused ACST course. Eight hundred and seventy-five (97%) responders stated they would benefit from such an opportunity as part of preparation for internship. Five hundred and eighty-six of these 902 (64.9%) doctors reported that they had never practiced advanced airway manoeuvres or defibrillation either in vivo or in a training environment. Six hundred and six of the 902 participants (67.1%) of those surveyed indicated that they were not confident in performing these skills without supervision. Furthermore, 433 of the 902 (48.1%) reported lack of confidence in interpreting key investigations for management of emergency situations, including ECG and ABG results.

Course delivery

Between July and October 2015, 17 courses were delivered by a faculty consisting of 8 peer trainers, training 320 newly qualified doctors at venues across Colombo. The estimated cost of delivering this 2-day course including refreshments in Sri Lanka was approximately 30 British Pounds (GBP).

Course assessment and feedback

The mean score of the MCQ pre-course was 71.03 (SD 13.19) compared to 77.98 (SD 7.70) post-course (p<0.05, n=320). Of the 283 participants who provided feedback, 97.2% (275) participants reported that the course had increased their overall confidence in managing ward emergencies (figure 4). Participant feedback describes an increase in confidence in performing defibrillation (98.9%, 280), BLS (98.3% 278), A-E assessment (96.8% 274) and ABG interpretation (99.2%, 281). (figure 2). Participants reported significantly higher (p<0.05) self-assessment ratings in all 12 assessed skills post-course, compared to pre-course (figure 1).

All course participants chose to participate in the 5 station OSCE. The mean score for tachyarrhythmia management OSCE was 56.77 (SD 29.60), and for airway and breathing OSCE was 54.98 (SD 34.03). The lowest mean marks were observed for A to E assessment (49.94, SD 29.15) whilst the highest were for observed for BLS (67.02, SD 36.86) and safe defibrillation 57.65 (SD 33.95), with 232 (72.50%) and 206 (61.39%) of participants scoring over 50.0 % respectively.
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Of the 320 newly qualified doctors who participated, 283 provided feedback on the overall course. All respondents (283, 100%) reported that the course improved their knowledge and 282 participants (99.3%) reported an improvement in their ability to perform skills (figure 4). In feedback following the clinical scenarios, participants report that the peer faculty had provided an effective learning environment and given constructive feedback for these scenarios (figure 3). A subsample of 66 participants, from the last three courses, reported that peer learning was an effective method of knowledge sharing, learning and confidence building (figure 5).

One hundred and three of the 320 participants (32.25%) gave recommendations for improvement. Of these, 42 (41.2%) recommended that more medical and surgical scenarios would be beneficial for their clinical practice and 50 (48.3%) participants suggested that the addition of obstetric and paediatric emergency scenarios would be of benefit.

Discussion

The needs analysis highlighted the limited opportunities available during undergraduate training to practice essential clinical skills required for managing emergency clinical situations. The ACST course conducted for 320 graduate participants preparing for internship in Sri Lanka, demonstrates that this co-designed peer delivered course significantly increased knowledge, confidence and skills necessary to manage acute medical and surgical emergency scenarios, of graduate doctors preparing for their clinical practice. The OSCE’s indicated that the majority of participants could demonstrate effective application of clinical knowledge within realistic clinical scenarios.

The post course MCQ scores were significantly higher when compared to pre-course MCQs. Greatest increase in both skill and confidence was reported in practical resuscitation skills such as defibrillation, BLS and ABG interpretation and when all candidates were enabled to participate and ask questions. This is perhaps not unsurprising given the low- pre course confidence levels reported by the both the needs assessment and pre course self-assessment. More advanced skills such as tachyarrhythmia management and intubation also resulted in increased ability, but with less marked increase in confidence- perhaps reflective of the complex nature of these procedures.

A priori knowledge from the expert faculty informs that junior doctors are called upon to deliver complex skills such as intubation during internship in Sri Lanka. Achieving measurable increase in competency of such complex skills in this learning forum is unrealistic, however it may be argued that inclusion of such skills provides opportunity for candidates to gain a level of situational awareness and preparedness- essential for safe delivery of such interventions that they would not otherwise experience. Internationally, similar programs have highlighted that whilst mastery of such complex
skills requires repeated immersion in the situation, scenario based practical skills training may offer insights and useful preparatory learning for candidates.\textsuperscript{23, 24} The results of the needs analysis, participant self-assessment, and feedback further add to the growing body of evidence in support of interactive, practical training methods, such as those utilised during this course, to improve recognition and management of acutely unwell patients.\textsuperscript{24, 25} These practical training methods provide unique opportunity for learners to gain experience and confidence in complex clinical decision-making needed to respond to emergency scenarios, and to reduce incidence of failure to rescue, without jeopardizing the safety of patients or colleagues.\textsuperscript{4, 7-9, 11}

This ACST course, perhaps uniquely, was designed and delivered by a group of newly qualified doctors. Course feedback demonstrates that participants found their peer faculty to be professional, knowledgeable and competent to deliver the course (figure 2-5). Although requiring investment of time and expert faculty up-front, the TTT model equipped newly qualified doctors with the skills and capacity to deliver an effective peer learning course and offers sustainable solution for delivering similar courses with each batch of new graduates.\textsuperscript{7-9}

Similarly, the cost per participant was relatively modest compared with many expert faculty or simulation delivered courses.\textsuperscript{24} Whilst expertise and training techniques including high fidelity simulation remains an essential part of developing specialist skills for trainees dealing with uncommon and complex emergencies, these results would suggest that peer delivered practical courses may be cost-effective training method for large cohorts of medical graduates in preparation for managing common medical and surgical emergencies in clinical practice.\textsuperscript{24, 26, 27} This co-design, peer-delivery method may also be beneficial for more senior doctors and interdisciplinary teams working in specialist areas, including critical care, to help refresh knowledge and provide opportunity for sharing of both knowledge and skills.\textsuperscript{4, 24, 27}

**Limitations**

Only 320 of the 902 needs assessment respondents attended the ACST course. This may in part have been due to the course venues only being available in Colombo. Participant numbers were limited by limited time available before commencement of internship in this inaugural year of the ACST course and high faculty to participant ratio. This led to some potential registrants not being invited to attend. Earlier start to the course in coming years and a larger group of peer trainers may help overcome this limitation. Newly qualified doctor’s delivering the course necessitates repeated TTT and upskilling each year. It is anticipated that over time experience faculty will return to facilitate junior faculty upskilling. Long term knowledge retention and effect on patient outcomes are unknown and warrants further exploration. Paired (pre and post course) self-assessment was used as the primary tool to
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evaluate skills gain. This method, although common in both undergraduate and postgraduate medical training, is questioned for validity. In postgraduate training doctors are often thought to overestimate their ability when completing self-assessment.\textsuperscript{17,18,28} Perspectives of including more complex skills in such a course are discussed above. Course delivery and OSCEs were facilitated by the same faculty resulting in the potential for scoring bias. This methodology, whilst clearly having limitation, reflects the limited availability of skilled resources in this setting and mirrors practices of similar programmes internationally.\textsuperscript{9,29,30}

Conclusion

This paper demonstrates the feasibility of a peer delivered training course in improving the knowledge, confidence and skills of newly graduated doctors in common medical and surgical emergencies as they prepare for clinical practice. Similar peer based courses may have utility beyond newly qualified doctors and beyond Sri Lanka, for honing essential practical skills in front-line staff in other LMIC settings.

Future research questions

- Is a peer-delivered practical skills programme to improve confidence of newly qualified doctors in the management of common medical and surgical emergencies transferable to other LMIC's?
- Does a peer delivered practical skills programme improve clinicians’ performance in response to common acute medical and surgical emergencies?
- Impact of a peer delivered practical emergency care skills programme for junior doctors on confidence in clinical practice - A one year follow up evaluation.

Conflict of interest and funding

The authors have no conflict of interest to declare. The courses were part funded by Education, Training and Research unit, Ministry of Health, Sri Lanka.

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The ACST course was a collaboration between the Government Medical Officers Association (GMOA, the doctors trade union), the Ministry of Health (Education, Training and Research directorate) and the Network for Improving Critical care skills and Training (NICST). NICST has been delivering short courses for doctors and nurses, focused on improving the care of the acute and critically unwell since
2014.7-9,22 The program was delivered free as the GIP in 2015 was funded by the Ministry of Health. Collaboration has, enabled this course to be integrated into a wider programme of preparing medical graduate for clinical practice from 2016 onwards. The MOH, GMOA and NICST are currently coordinating the 2016/17 ACST as part of GIP. Such a collaboration has an important role in achieving sustainability of such a course.
Figures and Tables

Figure 1: Participant feedback regarding peer-peer learning method


Figure 2: Session by session feedback from skills stations
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A: Skills were adequately demonstrated to me, B: I had the opportunity to then practice the skill, C: My level of confidence increased after completing this skill station.

Skills stations:

Figure 3: Session by session feedback from scenarios

A: I received constructive feedback, B: This was a good learning environment.

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Figure 4: Overall feedback from course participants

A: The course improved my knowledge, B: The course improved my skills, C: The course improved my confidence, D: The course improved my confidence to perform in a real life emergency situation, E: The course provided what I expected from a practical skills training programme, F: I would recommend this course to a colleague, G: I would like to contribute as a facilitator for this course
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Figure 5: Participant feedback regarding peer-peer learning method

A: I was encouraged to share my knowledge, B: I learnt from other candidates, C: I felt more confident to ask for clarifications, D: I enjoyed participating in the course, E: I felt valued as a candidate
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CHAPTER 9

Quality evaluation and future priorities for delivering acute myocardial infarction care in Sri Lanka

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Ranasinghe G *, Abi Beane *, Vithanage TDP, Priyadarshani GDD, Colombage Don DE, Ponnamperuma CJ, Karunarathne S, Constance Schultsz, Arjen Dondrop, Rashan Haniffa * joint first authors
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Abstract

Aim
This study evaluates the quality of care for patients admitted with AMI in a tertiary hospital in Colombo using the European Society of Cardiology (ESC) Quality of Care Working Group’s guidelines (2017).

Methods
A recently implemented electronic AMI registry m-Health tool was used for prospective data collection. Each patient was assessed for eligibility for each of the six domains of quality. GRACE Risk Model for predicted probability of mortality, and scores for risk of bleeding complications (CRUSADE) and severity of heart failure (Killip classification) were calculated as per published guidelines. A composite measure of quality was derived from compliance with the six domains. Patients were followed up via telephone at thirty days following discharge to evaluate outcome and satisfaction. Organisational information was assessed by administrative review and interview.

Results
Between March 2017 and April 2018, 934 AMI patients presented to the cardiology department. The majority of patients (90.4%) presented with features of STEMI. Mean (SD) overall compliance with the composite quality indicator (CQI) was 44% (0.07). Compliance of ≥ 50% to the CQI was achieved in 9.8% of STEMI patients. The highest compliance was observed for anti-thrombotics during hospitalisation (79.1%), and continuous measure of patient satisfaction (76.1%). The lowest compliance was for organisational structure and care processes (22.4%).

Conclusion
This study reports a registry-based continuous evaluation of the quality of AMI care from a LMIC. Priorities for improvement include improved referral, and networking of primary and secondary health facilities with the PCI centre.

Keywords
Acute myocardial infarction, quality of care, clinical registry, LMIC.
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What is already known about this subject?

Recent high profile publications, in this and other international journals have highlighted the impact that poor quality of care is having on outcomes globally, and specifically, the excess mortality and morbidity associated to poor quality of care for cardiovascular disease in South Asia. However as highlighted by an editorial in this journal and more recently in a review again earlier this year the existing quality of care, the impact of these investments on patient recovery remain absent. Efforts to evaluate care in the region have been hampered by sampling and limited to in hospital care.

What does this study add?

This evaluation in the South Asian region, uses international quality indicators including processes of pre-hospital care, measures of patient recovery, and outcomes at thirty days following hospital discharge. For the wider cardiology community internationally, it provides a practical method for establishing quality evaluation as part of routine care which is feasible even in resource limited health systems.

How might this impact on clinical practice?

This work provides an objective assessment from which specific recommendations for future improvement in AMI services can be compared against. Recommendations from this evaluation - specifically the clinician led restructuring of departmental patient flow and the establishment of a hub and spoke network for AMI care to help rationalise the use of pharmaco-invasive interventions for patients facing delays in accessing primary PCI are currently under development.
Introduction

Poor quality of healthcare is an important cause of excess mortality in Low and Middle-Income Countries (LMICs) even exceeding in importance unavailability and accessibility of care.\textsuperscript{1} Cardiovascular disease is globally a major cause of death, overtaking infectious diseases as the primary cause of death in South Asia. Delivery of high quality cardiovascular disease care, as with other non-communicable diseases (NCDs), places a significant burden on primary, tertiary and supportive health services.\textsuperscript{1-3} Addressing quality of care in patients with acute myocardial infarction in LMICs could thus have major impact on patient outcomes.

In Sri Lanka, government-led health services have invested heavily in tertiary services for management of AMI including catheterisation laboratories, imaging facilities, pharmacology and laboratory services. These facilities are essential for both immediate and intermediate management of patients presenting with AMI.\textsuperscript{4,5} However, there remains little known of the quality of in-hospital care processes and outcomes extending beyond the hospital setting. Furthermore, patient centred outcomes—satisfaction, quality of recovery and information on post intervention burden of symptoms remains largely absent.\textsuperscript{1}

Identifying gaps in existing care and the priorities for improvement requires detailed information regarding the organisational structures, and process of care that the patient experiences throughout their treatment and into recovery. Continuous surveillance systems, such as those implemented in High Income Countries (HICs) are ideally suited to capture the level of granular data needed to evaluate the quality of care for AMI and to help stakeholders identify priorities for improvement.\textsuperscript{6,7} Digital surveillance systems capable of replicable and continuous evaluation of care which can be embedded with healthcare delivery remain notably absent in many LMICs. However, recent efforts have shown that such systems are both feasible and can help guide priorities for care improvement.\textsuperscript{8-10}

Aim

This paper evaluates the quality of care for patients admitted with AMI in a large tertiary hospital in Colombo, Sri Lanka.
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Methods

Selection of quality indicators

The European Society of Cardiology (ESC 2017) Quality of Care Working Group’s consensus on quality was selected as the framework for evaluation. These guidelines were designed to provide a broader understanding of the quality of AMI care and include seven Domains; 1. centre organisation, 2. reperfusion invasive strategy; 3. in-hospital risk assessment; 4. anti-thrombotics during hospitalisation; 5. secondary prevention discharge treatment; 6. patient satisfaction and 7. a composite measure of care quality (table 2). This Table also provides the twelve quality indicators (QI) related to these domains. The guidelines are underpinned by the constructs of quality, structure, process and outcome. They include the holistic patient journey of AMI care, from prehospital recognition, through in-hospital management to patient recovery after discharge. The guidelines accommodate the evaluation of care using data from continuous surveillance. For domain 6, patient satisfaction, the Seattle Angina Questionnaire (SAQ) was used, which also measures the burden of symptoms and functional recovery.

Data collection

This study uses a recently implemented electronic AMI registry, co-designed by clinicians of the Sri Lanka STEMI Forum, with the purpose of enabling prospective systematic evaluation of care for AMI patients. Using the NICST methodology, the registry utilises a mobile platform with capacity for real-time visualisation of routine information (including referral, diagnosis and management). The same platform facilitates evaluation of patient reported outcomes; satisfaction, functional recovery and burden of symptoms following discharge.

Information pertaining to patient presentation, diagnosis, management and in-hospital outcomes for all AMI admissions were prospectively captured through the registry’s m-health portal by a trained departmental research assistant. Data completeness and quality was reviewed by the research team through the registry’s real-time dashboard. Patients’ perspectives regarding outcomes, functional recovery, ongoing symptoms and satisfaction after discharge were collected via telephone administered patient interviews by trained research assistants. Information regarding centre organisation of AMI care was assessed by a review of administrative documentation, supplemented by information provided by the head of the department. Ethical approval for the study was obtained from the Colombo Research and Ethics committee (EC-17-059).

Analysis

Patient demographics, clinical presentation, investigations, provision of ESC recommended therapies and in-hospital events were described using descriptive statistical measures. Compliance with Domain 1- information regarding centre organisation structures and the presence of departmental guidelines
pertaining to the processes outlined above were described. Patients were assessed for eligibility for each of the 12 indicators within the different domains according to their presenting diagnosis and prognostic group using covariates from the Global Registry of Acute Coronary Events (GRACE) Risk Model. Indicators of AMI care processes (e.g. time to recognition and intervention) alongside indicators of treatment choice and availability were calculated as per the ESC guidelines. Compliance was reported as a percentage of the eligible population. For Domain 5 (secondary prevention discharge treatment) compliance with prescription of high intensity statins at discharge was calculated. Use of ACE inhibitors and β-blockers routinely available in this setting, (optional indicators in this domain) were not reported. The main composite QI (CQI- domain 7) was derived from the mean compliance of Domains 1-6. The GRACE Risk Model for predicted probability of mortality, and scores for risk of bleeding complication (CRUSADE) and severity of heart failure (Killip classification) were calculated as described previously. Similarly, Likert scale responses to the SAQ and EQ 5DL were reported according to published methods. Stata v.11.0 (College Station, TX, USA) statistical programme was used for statistical analysis.

Setting
This evaluation comes from the National Hospital of Sri Lanka (NHSL), the largest PCI-capable tertiary referral centre nationally and the country’s only centre with 24 hours primary PCI service.

Results
Demographics, risk factors and clinical presentation
Between March 2017 and April 2018, 934 AMI patients presented to the cardiology department. The majority of patients 844/934 (90.4%) admitted through the registry, presented with features of STEMI. The mean age of patients was 54.1 years (±12.0) and 791 (84.7%) were male. On admission 174 (18.6%) patients had a Killip classification of heart failure of > 1. Clinical presentation and the prevalence of co-morbidities and other risk factors for AMI are described in Supplementary Table 1.

Evaluation of quality of care across the Domains
Mean (SD) overall compliance with the composite quality indicator (CQI- Domain 7) was 44% (0.07). Compliance of ≥ 50% to the CQI was achieved in 9.8% of STEMI patients. The highest compliance was observed for indicators Domains 4 and 6: anti-thrombotics during hospitalisation (79.1%), and continuous measure of patient satisfaction (76.1%). The lowest compliance was observed for Domains 1 and 2 describing organisational structure and process of care: (22.4%) (table2). Thirty-day mortality following discharge was 11.8%. Predicted mortality using the GRACE Score at 30 days following discharge was 10.3%. (QI7.3). Compliance with individual QI for each of the 6 Domains measured is described below.
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Domain 1: centre organisation and system level structures of AMI care

The four aspects of centre organisation for AMI care as described by the ESC guidelines revealed limitations in the availability of these system level structures and processes. The head of the department reported absence of a centralised referral system or single telephone number for patients presenting with AMI in Sri Lanka, and absence of an organisational guideline for direct referral or transfer to this tertiary centre for primary reperfusion therapy (i). In addition, access to pre-hospital ECG for diagnosis and treatment decision-making is not universally available (ii). Similarly, there was no provision for the prehospital activation of intervention services (iii) and finally, no publicly available alternative to road transportation for patients requiring PCI intervention from greater distance currently exists in the region (iv). Routes to admission for patients with symptoms of AMI varies, including via acute medical wards and an emergency treatment unit in addition to via directly to the cardiology department. Clinicians currently communicate referrals through personal phones to cardiology in the absence of designated facility level services. Access to road transportation for patients presenting both as a referral from another healthcare facility and directly to the PCI centre is described in Supplementary table 2. A minority of 16 (7.1%) patients presenting directly to the PCI facility arrived by ambulance, whereas (91.1%) patients arrived by private or hired vehicle.

Regarding the secondary QIs for Domain 1 (QI 1.2 and 1.3), 488 (58.1%) of all STEMI patients underwent a primary reperfusion intervention (either PCI or thrombolysis). Primary percutaneous coronary intervention was performed in 435(51.8%) of all STEMI patients (table1).

Domain 2: Reperfusion invasive strategy

In patients admitted with STEMI, 442 (53.0%) underwent PCI within the first 12 hours of admission to the tertiary PCI facility. Of the 53 STEMI patients who received a fibrinolytic agent as their primary reperfusion strategy 10 (25.6%) were treated within 30 mins of admission (Q2.1). Median (IQR) door-to-needle time was 60 min (111.1). A total of 45 (14.6%) patients underwent primary PCI within 60 minutes, and the median (IQR) “door to balloon time” was 118.1 min (116.8) (Q2.2). Of those patients who were diagnosed as having NSTEMI, and with no identified contra-indication, 27(30%) received coronary angiography within 72 hours of admission (Q2.3).
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Domain 3: In hospital risk assessment
In patients presenting with NSTEMI 71 (78.9%) had a calculation of the GRACE score on admission (QI 3.1) [Supplementary Table 3]. Mean (SD) GRACE score in this population was 120 (40), translating to a predictive mean probability of death at hospital discharge of 1-3%. The majority of patients (71.8%) had a low or intermediate predicted risk of death. A GRACE score was available for 78.9% of patients with a NSTEMI. In these patients, the actual in-hospital mortality was 7.0%. In the remaining 19 patients without complete variables available for the GRACE score, actual mortality was 0. Variables enabling calculation of the CRUSADE score were available in only 22.2% of patients (QI3.2). Mean (SD) probability of post- MI bleeding risk was 24.7(14), indicating a low risk of bleeding (table2).

Domain 4: Anti-thrombotic treatment during hospitalisation
A total of 930 (99.6%) inpatients were eligible for anti-thrombotic therapy. Of these 738 (79.5%) patients received at discharge a prescription of a P2Y12 inhibitor (prasugrel or ticagrelor or clopidogrel) (QI 4.1), whereas 736 (78.8%) were prescribed dual antiplatelet therapy (Aspirin plus a P2Y12 inhibitor (QI 4.3). Criteria for Fondaparinux administration were met by 90 patients (QI 4.2), however, this drug was not available during the evaluation period.

Domain 5: Secondary prevention-discharge treatment
A total of 829 patients were eligible for high-intensity statins on discharge. Of these 729 (87.9%) patients were reported as having this prescribed at discharge (QI5.1).

Domain 6: Systematic measurement of patient satisfaction and symptom burden
A total of 829 (92.1%) patients were discharged alive, of which 751 (90.6%) patients were followed up at 30 days following discharge (Figure 1). At thirty days following discharge, 724 (96.4%) patients were alive, of whom 551 (73.4%) were interviewed for satisfaction with care, functional recovery and burden of symptoms. Mean (SD) score for physical limitation was 84.3 (22) with 512 (92.9%) of patients reporting comfort were reported by 34.9% of the STEMI population. Of those patients minimal-to mild limitations. Ongoing symptoms of pain and dis who underwent PCI, 98.2% of patients reported that their symptoms of angina were ‘somewhat’ or ‘much better’ 30 days following discharge (Supplementary Table 4). In addition, 448 (81.3%) patients reported having access to cardiology services following discharge. Mean patient satisfaction score reported by patients with STEMI was 76.0(SD 13.9) [range 0-100], with 333(67.6%) STEMI and 26 (44.8%) of NSTEMI were ‘completely satisfied’ with their treatment (QI.6.1).
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Discussion

This study provides a continuous evaluation of the quality of AMI care including patient-centred outcomes from a LMIC. It provides detailed information on the organisational structures and processes which influence patients' outcomes providing both a benchmark of the quality of care, and detailed information through which those responsible for AMI and CVD care can evaluate previous investments and focus future improvements to reduce mortality and morbidity.

Structural improvements in diagnostic and interventional services are evident at this PCI-capable tertiary care centre in Sri Lanka. Over 50% of patients eligible for reperfusion therapy received treatment within 12 hours of admission, and nearly three quarters (72.0%) of patients diagnosed with a STEMI underwent PCI. These numbers are higher than previously reported in Sri Lanka and may positively reflect the impact of recent investments in hospital services by the Ministry of Health—such as making stents available free at PCI centres since 2018.4, 5, 20-22 Availability of anti-platelet therapies, and high-intensity statins essential to reducing mortality in the AMI population were administered in over 75% and nearly 90% of all eligible patients respectively (Domains 4 and 5). This is an improvement on previous, smaller evaluations at the same centre, and is comparable with benchmarks of quality from the UK and Europe and higher than cited in neighbouring South Asia countries.15, 20, 23, 24 Similarly the timely availability of physiological and biochemical information for risk stratification is encouraging. The utilisation of such tools in frontline clinical care is reflective of not only an evidence-based approach to medicine, but of a notable improvement in the availability of laboratory and point of care testing—absence of which so often underlies the failure to apply risk stratification tools for acutely unwell patients in resource-limited settings.10,21

Patient-reported measures of outcome and satisfaction are central to understanding the quality of care and directing future improvements to achieve universal healthcare. It must be acknowledged however, that patient perspectives of quality and priorities for recovery may well be different depending on the setting, population demographics and the social context of patients and their families. In this systematic evaluation of symptoms and recovery, one fifth of patients were still reporting symptoms of pain and discomfort, limitations in routine activities of daily life (e.g. personal care) and in physical recovery at thirty days following discharge from hospital. Whilst ongoing symptoms up to one year following invasive intervention for STEMI are frequently described in the literature, limitation in functional capacity is a significant finding in this relatively young—working age, predominantly male population.16 Delays in recovery and ongoing burden of symptoms may be compounded by the paucity of access to both cardiac rehabilitation and more generalised ambulatory rehabilitation services in the region.25
Despite an ongoing daily burden of symptoms reported by patients, overall reported satisfaction was good (mean 75.5 SD14.0). This seemingly high level of satisfaction requires further exploration; there is limited understanding of the cultural variation in patients’ ability to interpret and describe satisfaction within different societies. Work undertaken in settings where access to healthcare is scarce, suggests that patients’ satisfaction is multi dimensional and is influenced by the caregiver-patient relationship, the environment of healthcare provision and administrative factors including direct and indirect costs of healthcare.26 Patients in this setting, may for example may report higher than expected levels of satisfaction when healthcare is offered free, or when treatments (such as PCI) for which they would previously have paid, have become newly available. Similarly, in Sri Lanka, where doctors of western medicine are revered highly within the community, patients may feel compelled to give positive responses. Further work to understand both patients’ perspectives and behaviours that influence patient expectation and experience is required.

The greatest opportunities to improve quality of AMI care are within the delivery (processes) and organisation of care. ‘Time to delivery’ of definitive interventions such as fibrinolytics and primary PCI was considerably longer than the ESC guidelines.11 Inefficiencies and delays in the delivery of in-hospital intervention and in the pathways related to accessing AMI services mirror barriers identified in a recent review of AMI care in LMICs.4,23,27 The absence of pre hospital services and bottlenecks in pre-hospital activation of interventional services- which includes assembling skilled clinicians and preparation of equipments, may further account for the higher than predicted mortality in this STEMI population.11,28 Despite the recent provision of ambulance service in the region, very few patients utilised the service when presenting to the tertiary facility from the community. Impact of this on accessing treatment is not explored within this evaluation, further evaluation is required to understand the reasons why patients may not be accessing this service and other potential barriers not identified here.22

Overcoming the barriers and bottlenecks to efficient organisational delivery of AMI care (both structure and process) is fundamental to improving the quality of care. Work already published by the authors in parallel to this systematic evaluation to identify priorities for acute care improvement using a collaborative health systems approach, have highlighted additional bottlenecks-organisational structure, process and patient-centred- in care not described here.29 Focus groups held with frontline healthcare workers to map the pathways of AMI care revealed that diagnosis of AMI was delayed due to inconsistencies in patients timeliness of presentation, accessibility of ECG investigation for patients
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when presenting with the symptoms of syndromic ACS, and delays in reporting of ECG. These delays were creating a bottleneck to accessing expert cardiology services.22,26 In response to this, a project is underway by the authors to explore how the mHealth platform used here for the registry, might help provide a solution to the organisational aspects of delay. Adaptation of the application to enable a digital referral pathway between PCI and non PCI capable cardiology centres and to enable direct designated communication between medics in the emergency admission unit and the oncall cardiologists is underway. Similar interventions, which have sought to network primary and secondary services around a central PCI centre, and to prioritise pharmacoinvasive interventions in the absence of revascularization services have successfully reduced mortality in India, and other LMIC settings.22

The Sri Lanka STEMI Forum’s registry is now live in four tertiary hospitals which serve the highly populated western and northern Provinces. Quality of care is multifactorial and work is underway to evaluate how pre hospital systems and human factors not explored here, may impact on clinical endpoints, such as clinician decision making following risk assessment, patient adherence to medication and time from first medical contact to intervention.10,28

Conclusion

This evaluation provides new patient- centred insights into the existing quality of care. Barriers to the delivery of high quality AMI appear common to those in other LMICs. Clear priorities for investment include improved pre hospital care, networking of primary and secondary facilities with PCI capable centres and streamlined in-hospital referral and treatment. Patient-reported measures including outcome and satisfaction are central to understanding the quality of care and directing future improvements to achieve universal healthcare.

Acknowledgements

We would like to acknowledge the following collaborators for their clinical intellectual contributions and the families and patients that provided important insights into their experiences of AMI care.
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Funding

This study was funded by Network for Improving Critical Care System and Training and the Sri Lanka STEMI forum as part of ongoing projects to improve the quality of acute care.
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Conflict of interest
No conflicts of interest to declare.
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Table 1: Demographics and admission characteristics
Availability of variables to calculate indicators is reported in column 2. Values are represented as mean ± standard deviations or as proportion (%).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>AMI 934</th>
<th>STEMI 844(90.4)</th>
<th>Non STEMI 90(9.6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender, Male, N (%)</td>
<td>934</td>
<td>791(84.7)</td>
<td>732(86.7)</td>
<td>59(65.6)</td>
</tr>
<tr>
<td>Age, years</td>
<td>928</td>
<td>54.1±12.0</td>
<td>53.6±11.9</td>
<td>58.5±12.4</td>
</tr>
<tr>
<td>Killip class &gt;i</td>
<td>934</td>
<td>174(18.6)</td>
<td>148(17.5)</td>
<td>26(28.9)</td>
</tr>
<tr>
<td>Killip class &gt;iii</td>
<td>149(15.9)</td>
<td>126(14.9)</td>
<td>23(25.6)</td>
<td></td>
</tr>
<tr>
<td><strong>In-hospital mortality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dead</td>
<td>900</td>
<td>71(7.9)</td>
<td>66(7.8)</td>
<td>5(5.6)</td>
</tr>
<tr>
<td>Not Recorded</td>
<td>34</td>
<td>33</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>30 days Mortality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dead</td>
<td>827</td>
<td>98(11.9)</td>
<td>91(12.1)</td>
<td>7(9.1)</td>
</tr>
<tr>
<td>Not Recorded</td>
<td>107</td>
<td>94</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td><strong>Length of stay in days</strong></td>
<td></td>
<td></td>
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</tbody>
</table>
Table 2. Compliance for ESC Domains of quality for patients with AMI.
Compliance for domains 2-7 is described below. Domains 1 includes descriptive information, which is described within the main body of the results. Compliance for each indicator is reported as a proportion (%) with the standard error where appropriate. The composite proportion of compliance for each domain is in **bold**.

<table>
<thead>
<tr>
<th>Domains</th>
<th>Total Population</th>
<th>Eligible population</th>
<th>Availability (%)</th>
<th>Compliance (%)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Centre organisation and system level structures of AMI care</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. Reperfusion invasive strategy</td>
<td>844</td>
<td>53</td>
<td>39 (73.6%)</td>
<td>22.4%</td>
<td>10(25.6)</td>
</tr>
<tr>
<td>QI 2.1. For patients treated with fibrinolysis &lt; 30 minutes from diagnosis to the needle.</td>
<td>844</td>
<td>442</td>
<td>309 (69.9%)</td>
<td>45(14.6)</td>
<td>0.02</td>
</tr>
<tr>
<td>QI 2.2. For patients treated with primary PCI and admitted: &lt;60 mins from door to balloon time.</td>
<td>90</td>
<td>90</td>
<td>90 (100%)</td>
<td>27(30.0)</td>
<td>0.05</td>
</tr>
<tr>
<td>QI 2.3. The proportion of patients with NSTEMI, and no contraindication, who receive coronary angiography within 72 hours after admission.</td>
<td>934</td>
<td>934</td>
<td>208(22.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. In hospital risk assessment NSTEMI</td>
<td>90</td>
<td>90</td>
<td>90 (100%)</td>
<td>50.6%</td>
<td>71(78.9)</td>
</tr>
<tr>
<td>QI 3.1. The proportion of patients with NSTEMI who have ischaemic risk assessment using the GRACE risk score</td>
<td>934</td>
<td>934</td>
<td>208(22.3%)</td>
<td></td>
<td>120.4(SD=39.9)</td>
</tr>
<tr>
<td>Mean GRACE score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median GRACE score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean probability of death in- hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QI 3.2 Proportion of patients admitted with STEMI or NSTEMI bleeding risk assessment using CRUSADE</td>
<td>934</td>
<td>934</td>
<td>208(22.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean CRUSADE score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Anti-thrombotic during hospitalisation</td>
<td>934</td>
<td>934</td>
<td>930 (99.6%)</td>
<td>79.1%</td>
<td>738(79.4)</td>
</tr>
<tr>
<td>QI 4.1 Number of patients eligible for in-hospital antithrombotic therapies who received =&gt;1 therapies.</td>
<td>934</td>
<td>934</td>
<td>930 (99.6%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>QI 4.3 Dual antiplatelet therapy</th>
<th>934</th>
<th>934</th>
<th>934(100%)</th>
<th>736(78.8)0.01</th>
</tr>
</thead>
</table>
| **5. Secondary prevention-discharge treatment.**
QI 5.1 Proportion of patients with AMI discharged on statins, unless contra -indicated | 934 | 829 | 829(100%) | 87.9%
| | | | | 729(87.9)0.01 |
| **6. Patient experience collected in a systematic way**
(Seattle Angina and EQ5DL).
Mean patient satisfaction (range 1-100)
QI 6.1. Pain reported as a symptom (EQ5DL) | 934 | 724 | 551 | 551 (76.1%)
| | | | | 75.5(SD=14.00) |
| **7. Composite Quality Indicator (mean)**
QI 7.3 30-day mortality rate adjusted for GRACE 2.0 | 934 | 571 | | 44%
| | | | | 0.4(0.07) |

Figure 1: Cohort information

![Cohort Information Diagram](image-url)
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References


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CHAPTER 10

Outcomes and quality of recovery at one year following percutaneous coronary intervention for ST elevation myocardial infarction in Sri Lanka

Abi Beane

Under review with European Journal of Cardiology
Chapter 10

Research Question: What is the quality of recovery at one year following PCI for patients presenting with acute myocardial infarction in Sri Lanka?

One sentence summary
This evaluation of long term quality of recovery after PCI for AMI patients in Sri Lanka highlights a disconnect between patient reported quality of recovery and their perceptions of quality of care.

Abstract
Aim
Long term quality of recovery following percutaneous coronary intervention in Sri Lanka are unknown. We evaluated quality of recovery at one year, compliance with secondary prevention medications and access to and uptake of cardiac rehabilitation services.

Methods
The GRACE Risk Model was used to compare predicted and actual mortality at hospital discharge and at one-year. Quality of recovery was assessed by the Seattle Angina Questionnaire (SAQ). Compliance with secondary prevention therapy was assessed using international guidelines. Access to cardiac rehabilitation was assessed via telephone-administered interview.

Results
Between April 2017 and March 2018, 699 consecutive patients underwent PCI. Mortality at one year was 13.6% (93); predicted mortality was (4.5-11%). Functional activity was significantly worse at one year 64.4 (75.6-55.6) compared to pre-admission (100, 100-84.4) (P-value<0.01). Frequency of angina was greater at one year (80, IQR=100-60), compared with 1 month post-discharge (100[IQR=100-80], P-value<0.01). Stability of angina remained unchanged (median[IQR]=72[100-50]). Patients’ perceptions of treatment satisfaction were high (P-value<0.01), disease perceptions worsened (P-value<0.01). Self-perceived compliance with secondary prevention therapy ranged from 75%-82%. Of the 362 patients followed up 146 (44.5%) reported being offered the opportunity to attend cardiac rehabilitation; 128 (87.7%) attended.

Conclusion
Outcomes at one year were poorer than expected. Patient-reported levels of satisfaction were high, despite worsening burden of symptoms. Research is needed to better understand patients’ expectations of quality of AMI care.

Keywords:
AMI, PCI, quality of recovery, SAQ, follow up
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Introduction
Cardiovascular disease is a major cause of death globally, overtaking infectious diseases as the primary cause of death in South Asia. Delivery of high-quality cardiovascular disease care, as with other non-communicable diseases (NCDs), places a significant burden on primary, secondary, tertiary and supportive health services. High prevalence of ischaemic cardiac disease in Sri Lanka has resulted in significant investment from the government in tertiary services, including cardiac catheterisation facilities to improve immediate and intermediate management of patients presenting with acute myocardial infarction (AMI). Recent studies evaluating the quality of these services have highlighted that whilst this investment has resulted in greater access to lifesaving reperfusion intervention, gaps in the quality of care across the continuum may be resulting in higher than predicted mortality at hospital discharge. Identified priorities for improving hospital outcomes include reducing delays in access to definitive treatment and improved prescription of secondary preventative therapies at discharge.1,2,3

Long term recovery post AMI depends on the quality of the multidisciplinary care in hospital and after discharge. Long term outcomes are unknown in most LMIC settings, as is, quality of recovery, access to and uptake of follow up services and patients’ perceptions of their satisfaction with treatment. Understanding these patient-centred outcomes is of potentially greater importance in LMIC settings such as Sri Lanka, where patients undergoing PCI treatment are younger than those in Europe and their poor functional recovery and high rates of complications necessitating rehospitalisation could have devastating health and economic implications for patients and their families. We sought to evaluate long-term quality of recovery and health related experiences for AMI patients after PCI (percutaneous coronary intervention).

Setting
Data was collected at the National Hospital of Sri Lanka (NHSL), the largest PCI-capable tertiary referral centre nationally and the country’s only centre with 24-hour primary PCI service.

Methods
Tools to evaluate the quality of recovery
The GRACE Risk Model was used to calculate predicted mortality at hospital discharge and one year. Killip classification (severity of heart failure) was used as the risk prediction index.4 The Seattle Angina Questionnaire (SAQ) was used to assess patient recovery at one month and one year post-discharge following primary PCI for ST elevation myocardial infarction (STEMI).5,6 SAQ is a validated tool for the measure of five clinically important dimensions of health in patients with coronary artery disease using Likert scales; physical capacity, symptom frequency, symptom stability, satisfaction with treatment, and patients perceptions of their disease. The first four dimensions are
widely accepted as important measures of quality of care.\textsuperscript{2,7,8} Patients' perceptions of their disease is a description of how patients view their disease and the impact of the disease and treatment on their health and wellbeing. It is an important driver for long term treatment compliance and therefore affects the overall quality of patient recovery.\textsuperscript{9}

**Data collection**

Data was collected through a recently implemented AMI mHealth registry, co-designed by clinicians of the Sri Lanka STEMI Forum, which is providing a mechanism for systematic and continuous evaluation of quality of care for AMI patients and facilitating quality improvement interventions.\textsuperscript{10} Mortality at hospital discharge, one month and one year post-procedure, along with patient's responses to the SAQ five dimensions of health were collected via telephone administered patient interviews by trained research assistants. In addition, patients were asked at the time of their hospital admission to describe their functional status (domain 1 of SAQ) prior to MI. Events of readmission, and re-intervention were captured at hospital discharge, one month and one year. For patients who did not respond to the initial follow up call, two further calls were made. Patient responses to this evaluation were reported through the AMI registry platform. In addition, patients’ self-reported adherence to secondary prevention medication (anti-platelets, statins and anti-hypertensives) were also reported. Finally, patients were asked to describe invitation to and uptake of cardiac rehabilitation services. Ethical approval for the study was obtained from the University of Colombo Research and Ethics committee (EC-17-059).

**Analysis**

Killip and GRACE scores were calculated as per the published methods.\textsuperscript{4,11} Likert scale responses to the SAQ were interpreted as follows; functional limitation- the lower the score the greater the degree of functional limitation experienced; angina stability and frequency- lower scores indicate more frequent angina, and higher scores less frequent angina. Treatment satisfaction and patients’ self-reported perception of their disease were interpreted in the same way. An angina frequency score of 50 indicates no change in angina frequency at the patient’s most strenuous level of activity.\textsuperscript{6,8,12} Prescription of secondary prevention therapies at hospital discharge along with patients’ subsequent adherence to these therapies were described at one year as a proportion of the eligible population. Wilcoxon signed-rank test was used to compare the median values for the SAQ between one month and one year post event. The Friedman test compared domain 1 of the SAQ between three time points (primary admission, one month and one year post event). Given that independent statistical tests performed simultaneously required comparison, Bonferroni correction
was applied (significance level set at \( p < 0.017 \)). Stata v.11.0 (College Station, TX, USA) statistical programme was used for statistical analysis.13

**Results**

**Mortality**

Between April 2017 and March 2018, 699 consecutive patients underwent PCI for STEMI and were enrolled in the registry. At one year, 13.6% (93) patients were known to have died (predicted mortality 4.5-11%). The greatest proportion of these deaths (n=72, 77.4%) were reported in the first 30 days following first admission (Figure 2). Readmission for a primary cardiac event was reported by 12.4% of patients (n=78), with 12.2% (n=71) patients undergoing subsequent intervention for MACE. Event-free survival at one year was 44.5% (304) (Table 1).

**Quality of recovery at one year**

Recruitment and loss to follow up are described in Figure 1. The SAQ was completed at one year by 57.5% (n=362) of patients (Figure 1). Median physical functioning at one year was 64.4(IQR=75.6-55.6) with 72.9% (n=264) of patients reporting ongoing physical limitation at one year, including walking short distances, washing and dressing. Patient satisfaction with treatment was high (median 88.2, 94.1-76.5). Patients reported ongoing concern about their disease and its impact on their general health status (median 50, 58.3-41.7). The results of the SAQ at one month and at one year are presented in Table 3.

**Progression of symptoms**

Functional activity worsened over the one year period (\( p<0.01 \), Supplementary Table 1). Burden of angina was the same or worse when compared to time of primary admission to hospital for 48.5% (169) of patients (Table 2). Frequency of angina was significantly greater (\( p<0.01 \)) at one year, whilst stability of angina remained unchanged (\( p<0.01 \)). Patients’ perceptions of their satisfaction with treatment improved between the two time points, (\( p<0.01 \)), but patients’ perceptions of their disease and the relative constraint on their health and wellbeing worsened (\( p<0.01 \)).

**Compliance with secondary prevention medications and access to cardiac rehabilitation services**

Self-perceived compliance at one year for secondary prevention therapy was 298 (82.3%) for anti-hypertensives, 277 (76.5%) for statins and 297(82.0%) for anti-platelets. Of those patients followed up at one year, 146 (44.5%) reported being offered the opportunity to attend cardiac rehabilitation, 128 (87.7%) patients did so on at least one occasion.
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Discussion

Long-term quality of recovery

This study reports higher than predicted mortality at one year post AMI in this relatively young, low risk cohort of patients. The causes of death in this cohort are unknown and accessing health records and death certificates in this setting is, as with many countries where there are no harmonised health and social records is not feasible. However, given the survivors reported an increasing burden of symptoms, associated with ongoing ischemia, it may be reasonable to attribute cardiac causes to at least a proportion of deaths reported14. The findings here regarding non-concordance with secondary prevention therapy and limited opportunity to attend cardiac rehabilitation may further predispose this population to subsequent adverse cardiac outcomes. Whilst the greatest risk of mortality for this cohort was within the first 30 days following infarct, and may be attributable to the limitations in pre hospital and acute care described previously in this setting,10 this study identifies gaps in the post-acute phase quality of care which may be further contributing to the poor long term survival 15,16,17,18.

Noncompliance with secondary prevention medication and inequity in access to cardiac rehabilitation may be contributing to the progressive worsening physical function and burden of angina reported by patients. Whilst research on long term outcome after AMI is notably absent from the region, studies undertaken in high income settings has described how poor functional recovery post AMI predisposes patients to a worsening sequelae of comorbidities and their complications.9,16,17 In this setting, where continuity of care between primary and secondary healthcare services is limited, such complications of chronic disease may go undetected and may have devastating effects for patients, their families and the wider social economic strata.7,20

The worsening disease perception described by patients in this study may also be contributing to the poor quality of recovery. Negative disease perception, which may manifest as anxiety and depression for patients, is in itself detrimental to mental health and wellbeing and may inhibit patients from participating in physical rehabilitation, hinder concordance with secondary poly treatment and inhibit patients willingness to engage in physical exercise and healthy eating.12,15 Importantly however, these negative sequelae of patient health status post AMI are responsive to intervention.21 Interventions undertaken in Europe to improve access and attendance to post AMI cardiac rehabilitation and to improve concordance with secondary prevention medications through patient education and multi-disciplinary led follow-up clinics were shown to have high levels of patient engagement and reportedly lead to a reduction in long term mortality.18,22,23 Similar interventions may be successful in Sri Lanka.
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Loss to study follow up and impact on evaluating the quality of care

Loss to follow up of patient outcomes in this study was 20.1% at one year for mortality (47.2% for quality of recovery) and may be masking significantly higher mortality. In this study, expired mobile phone numbers provided by patients for follow up was the main reason for failure to contact patients after discharge and may point to survival bias.24 This hypothesis is supported by the minimal loss to follow up once initial telephone contact was made. It is however not uncommon for follow up studies of AMI patients in high income healthcare settings to describe loss to follow up as high as 50%.22 In LMIC settings the challenges are often greater; absence of a unique patient identifiers in health systems, no national registry of patients admission to healthcare facilities, low penetrance of landline telephones and relatively mobile urban populations, all of which hampers efforts to follow patients.1,12,22

Disconnect between patient satisfaction and quality of care

Patients reported consistently high levels of satisfaction despite worsening symptoms and perceptions of their disease. Our previous evaluation of the in-hospital care for AMI patients in this setting using ESC guidelines25 reported median overall compliance to six domains of quality of in-hospital care for this cohort of patients at just 42%.12 There is the potential mismatch between what patients consider good quality care and that of the ESC guidelines, and raises questions of how patients’ perceived quality of healthcare in this setting and their priorities when seeking treatment.20,26,27 Patient expectations of care can be lowered by lack of exposure to higher-quality services, lack of knowledge about what constitutes high quality care (health literacy) and a general lack of information providing feedback to communities about health service provision. Low patient and family expectations of health services is problematic as it may perpetuate poor quality care and may delay efforts by clinicians such as those here from prioritising improvements in services.20,29,30,31

Recommendations

Providing post discharge follow up and cardiac rehabilitation services may be feasible in this setting and is already being offered in some tertiary settings. Information on the quality and timing of these services, as well as the barriers and facilitators to patient engagement with such services is needed. Further understanding of the biases influencing patients’ perceptions of satisfaction, and what communities value in their health care is urgently needed, given the increasing focus on patient values as a measure of quality of care. Qualitative work to understand patient values for quality of care and satisfaction is planned by this collaboration.
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Conclusion

This study highlights poor long-term outcomes after PCI in a relatively young, low risk population. Investment in health system infrastructure to evaluate long term patient centred outcomes has provided stakeholders with measurable targets for improvement. Investment in PCI services in the region is commendable, however further investment in access to services across the continuum of care is now needed. Exploring the whole multicomponent processes of care including patients health literacy, and greater investment in services to support follow up and rehabilitation of patients post discharge may be important considerations in future health services planning. Investment in pragmatic research into the determinants of value based care is needed.

Acknowledgements

We would like to acknowledge the collaborators for their clinical intellectual contributions and the families and patients that so generously provided important insights into their experiences of AMI care. The opportunity to follow up patients at one year following treatment is greatly important for improving the quality of care and directing future resource investment.

Funding

This study was funded by Network for Improving Critical Care System and Training and the Sri Lanka STEMI forum as part of ongoing projects to improve the quality of acute myocardial infarction care.

Conflict of interest

No conflicts of interest to declare.
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Table 1: Outcomes

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N (%)</th>
<th>AMI (n=699)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender, Male, N (%)</td>
<td>699</td>
<td>610(87.3)</td>
</tr>
<tr>
<td>Age, mean (SD), years</td>
<td>693</td>
<td>52.9(11.7)</td>
</tr>
<tr>
<td>Killip class &gt;i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Killip class &gt;iii</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grace score risk classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (49-125)</td>
<td>505</td>
<td>273(54.1)</td>
</tr>
<tr>
<td>Intermediate (126-154)</td>
<td>505</td>
<td>156(30.9)</td>
</tr>
<tr>
<td>High (155-319)</td>
<td></td>
<td>76(15.0)</td>
</tr>
<tr>
<td>Mean score (SD)</td>
<td></td>
<td>124.1(29.2)</td>
</tr>
<tr>
<td><strong>In-hospital mortality</strong></td>
<td>699</td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>53</td>
<td>7(6.6)</td>
</tr>
<tr>
<td>Not Recorded</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Predicted (%)</td>
<td></td>
<td>&lt;2</td>
</tr>
<tr>
<td><strong>30 days Mortality</strong></td>
<td>683</td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>72</td>
<td>10.6</td>
</tr>
<tr>
<td>Predicted</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td><strong>One Year mortality</strong></td>
<td>683</td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>93</td>
<td>13.6</td>
</tr>
<tr>
<td>Predicted (%)</td>
<td></td>
<td>4.5-11.0%</td>
</tr>
<tr>
<td><strong>MACE at one year</strong></td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>Readmission within one year</td>
<td>78</td>
<td>12.4</td>
</tr>
<tr>
<td>One or more intervention</td>
<td>77</td>
<td>12.2</td>
</tr>
<tr>
<td>Event free survival at one year</td>
<td>683</td>
<td>304(44.5)</td>
</tr>
<tr>
<td>Offered access to cardiac rehabilitation services</td>
<td>630</td>
<td>146(23.2)</td>
</tr>
<tr>
<td>Attended cardiac rehabilitation services</td>
<td>146</td>
<td>128(87.7)</td>
</tr>
</tbody>
</table>
Table 2: Seattle angina Questionnaire for patients on admission and at one month and one year

<table>
<thead>
<tr>
<th>Seattle Angina Score</th>
<th>On admission N=507</th>
<th>One month N=410</th>
<th>One year N=362</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical limitation, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal (75-100)</td>
<td>100(100-84.4)</td>
<td>91.1(100-82.2)</td>
<td>64.4(75.6-55.6)</td>
</tr>
<tr>
<td>Mild (50-74)</td>
<td>448(88.4)</td>
<td>354(86.3)</td>
<td>98(27.1)</td>
</tr>
<tr>
<td>Moderate (25-49)</td>
<td>48(9.5)</td>
<td>37(9.0)</td>
<td>202(55.8)</td>
</tr>
<tr>
<td>Severe (0-24)</td>
<td>9(1.8)</td>
<td>7(1.7)</td>
<td>54(14.9)</td>
</tr>
<tr>
<td><strong>Angina Stability, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal (75-100)</td>
<td>-</td>
<td>100(100-75)</td>
<td>75(100-50)</td>
</tr>
<tr>
<td>Mild (50-74)</td>
<td>-</td>
<td>374(91.2)</td>
<td>197(54.4)</td>
</tr>
<tr>
<td>Moderate (25-49)</td>
<td>-</td>
<td>29(7.1)</td>
<td>123(34.0)</td>
</tr>
<tr>
<td>Severe (0-24)</td>
<td>-</td>
<td>7(1.7)</td>
<td>30(8.3)</td>
</tr>
<tr>
<td><strong>Angina frequency, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Much better (76-100)</td>
<td>-</td>
<td>100(100-80)</td>
<td>80(100-60)</td>
</tr>
<tr>
<td>Slightly better (51-75)</td>
<td>-</td>
<td>370(90.2)</td>
<td>201(55.5)</td>
</tr>
<tr>
<td>Unchanged (50)</td>
<td>-</td>
<td>30(7.3)</td>
<td>83(22.9)</td>
</tr>
<tr>
<td>Slightly worse (25-49)</td>
<td>-</td>
<td>1(0.2)</td>
<td>48(13.3)</td>
</tr>
<tr>
<td>Much worse (0-24)</td>
<td>-</td>
<td>7(1.7)</td>
<td>23(6.4)</td>
</tr>
<tr>
<td><strong>Treatment satisfaction, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely satisfied (75-100)</td>
<td>-</td>
<td>76.5(88.2-70.6)</td>
<td>88.2(94.1-76.5)</td>
</tr>
<tr>
<td>Somewhat to mostly satisfied (50-74)</td>
<td>-</td>
<td>275(67.1)</td>
<td>287(79.3)</td>
</tr>
<tr>
<td>Somewhat dissatisfied to not satisfied at all (0-49)</td>
<td>-</td>
<td>112(27.3)</td>
<td>56(15.5)</td>
</tr>
<tr>
<td>Excellent (75-100)</td>
<td>-</td>
<td>23(5.6)</td>
<td>19(5.2)</td>
</tr>
<tr>
<td><strong>Disease perception, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good (50-74)</td>
<td>-</td>
<td>75(83.3-58.3)</td>
<td>50(58.3-33.3)</td>
</tr>
<tr>
<td>Fair (25-49)</td>
<td>-</td>
<td>259(63.2)</td>
<td>11(3.0)</td>
</tr>
<tr>
<td>Poor (0-24)</td>
<td>-</td>
<td>109(26.6)</td>
<td>187(51.7)</td>
</tr>
<tr>
<td>Excellent (75-100)</td>
<td>-</td>
<td>38(9.3)</td>
<td>132(36.5)</td>
</tr>
<tr>
<td>Good (50-74)</td>
<td>-</td>
<td>4(1.0)</td>
<td>32(8.8)</td>
</tr>
</tbody>
</table>
### Table 3: Comparisons of responses for patients who reported SAQ at relevant time points.

* All results were significant when compared to the previous time point. (Supplementary table 3 provides the tests of significance)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>AMI Median (IQR)</th>
<th>Primary PCI Median (IQR)</th>
<th>Secondary PCI Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical limitation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On admission</td>
<td>260</td>
<td>100(100-80.0)</td>
<td>100(100-80.0)</td>
<td>100(100-82.2)</td>
</tr>
<tr>
<td>One month</td>
<td></td>
<td>91.1(100-82.2)</td>
<td>91.1(100-82.2)</td>
<td>93.3(100-80.0)</td>
</tr>
<tr>
<td>One year</td>
<td></td>
<td>64.4(77.8-55.6)</td>
<td>64.4(76.7-55.6)</td>
<td>66.7(77.8-55.6)</td>
</tr>
<tr>
<td><strong>Angina stability</strong></td>
<td>275</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One month</td>
<td></td>
<td>75(100-75)</td>
<td>75(100-75)</td>
<td>75(100-75)</td>
</tr>
<tr>
<td>One year</td>
<td></td>
<td>75(100-50)</td>
<td>75(100-50)</td>
<td>75(100-50)</td>
</tr>
<tr>
<td><strong>Angina frequency</strong></td>
<td>275</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One month</td>
<td></td>
<td>90(100-80)</td>
<td>90(100-80)</td>
<td>100(100-90)</td>
</tr>
<tr>
<td>One year</td>
<td></td>
<td>70(100-50)</td>
<td>60(100-50)</td>
<td>80(100-50)</td>
</tr>
<tr>
<td><strong>Treatment satisfaction</strong></td>
<td>275</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One month</td>
<td></td>
<td>76.5(88.2-70.6)</td>
<td>76.5(88.2-70.6)</td>
<td>76.5(88.2-70.6)</td>
</tr>
<tr>
<td>One year</td>
<td></td>
<td>88.2(94.1-76.5)</td>
<td>88.2(94.1-76.5)</td>
<td>88.2(94.1-76.5)</td>
</tr>
<tr>
<td><strong>Disease perception</strong></td>
<td>275</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One month</td>
<td></td>
<td>75(83.3-58.3)</td>
<td>75(83.3-58.3)</td>
<td>75(91.7-58.3)</td>
</tr>
<tr>
<td>One year</td>
<td></td>
<td>50(58.3-41.7)</td>
<td>50(58.3-41.7)</td>
<td>50(66.7-41.7)</td>
</tr>
</tbody>
</table>
Supplementary Table 1: Tests of significance at different time points, using the Wilcoxon sign rank test

<table>
<thead>
<tr>
<th>SAQ</th>
<th>N</th>
<th>Baseline median (IQR)</th>
<th>One month median (IQR)</th>
<th>One year median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical limitation</td>
<td>260</td>
<td>100(100-80.0)</td>
<td>91.1(100-82.2)</td>
<td>64.4(77.8-55.6)*</td>
</tr>
<tr>
<td>Angina Stability</td>
<td>275</td>
<td>-</td>
<td>75(100-75)</td>
<td>75(100-50)*</td>
</tr>
<tr>
<td>Angina frequency</td>
<td>275</td>
<td>-</td>
<td>90(100-80)</td>
<td>70(100-50)*</td>
</tr>
<tr>
<td>Treatment satisfaction</td>
<td>275</td>
<td>-</td>
<td>76.5(88.2-70.6)</td>
<td>88.2(94.1-76.5)*</td>
</tr>
<tr>
<td>Disease perception</td>
<td>275</td>
<td>-</td>
<td>75(83.3-58.3)</td>
<td>50(58.3-41.7)*</td>
</tr>
</tbody>
</table>

Difference *= (p value<0.01)
Chapter 10

Figure 1: Follow up
Chapter 10

Figure 2: Plot of Kaplan-Meier survival analysis up to one year estimated after PCI

Supplementary Figure 1.

<table>
<thead>
<tr>
<th></th>
<th>50</th>
<th>100 (Better functioning)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (Worse functioning)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>50</th>
<th>100 (Less frequent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (More frequent Angina)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>50</th>
<th>100 (more satisfaction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (Less satisfaction)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 10

References


13. Stata v.11.0 (College Station, TX, USA)
Chapter 10


CHAPTER 11
Discussion
Chapter 11

The overall aims of this thesis were threefold: first, to better understand barriers and enablers to evaluating and improving the quality of care for acutely unwell patients; second, to evaluate whether the components of a learning health system could be implemented in LMICS; and, third, to assess whether a learning health system could overcome the barriers to evaluating the quality of acute care in LMICs. The components of the proposed learning health system were: a platform for electronic data capture and feedback; a community of practice with the skills to evaluate the quality of care; and interventions for improvement. This chapter summarises the main findings, discusses the results in the context of lessons from the three parts of the thesis and provides recommendations for future research.

Principal findings

Part one of this thesis presented an evaluation of the barriers and enablers of vital sign reporting and the feasibility of early warning scores (EWS).\(^2\)^\(^3\) Implementation of EWS and standards of practice for vital sign monitoring are central tenets of efforts to improve recognition of deterioration in HIC health systems.\(^4\) Failure to recognise deteriorating patients can result in avoidable morbidity and mortality, and as such ‘failure to rescue’ has become a measure of quality of care.\(^5\) Implementation of these tools has been limited in LMIC health systems, and cases of failure to rescue remain.\(^6\)

Chapter 2 reported how vital sign recording in a Sri Lankan setting was poor, even for parameters that were not reliant on specialist equipment for measurement.\(^2\) The study of 16,000 episodes of ward-based care found that availability of physiological parameters was greatest at admission and varied depending on diagnosis. Greater than half of all adverse events occurred within 48 hours of admission. Vital sign recording was greater at admission among patients who went on to record an adverse event compared to those who did not. Availability of physiological parameters on admission ranged from 90.97% (95% CI 90.52% to 91.40%) for heart rate to 23.94% (95% CI 23.29% to 24.60%) for oxygen saturation. Ability to discriminate death on admission was less than 0.81 (AUROC) for all selected aggregated weighted track and trigger systems (AWTTS). Performance of the best performing AWTTS (CART) varied, depending on admission diagnosis and was diminished at 24 hours prior to event. Positive Predictive Value was low (10.44%) and number needed to escalate was 9.58%, lower than the best performing SPTTS, which would result in one in three patients being triggered.\(^2\)

Two key themes emerged from the qualitative study in chapter 3: legacy of admission assessment and inimical organisational cultures.\(^7\) Primary assessment of patients was undertaken directly on the ward without prior risk assessment, resuscitation or stabilisation. No formal triage system was in place.
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Informal triaging at the time of ward admission meant that patients that presented with red-flag diagnoses and vital sign derangement requiring resuscitation were categorized as ‘bad’. This categorization led to a series of decision-making biases. Patients identified as ‘bad’ at admission were prioritised over other patients for monitoring and reassessment. Omissions in monitoring that might have helped detect deterioration in patients not categorised as ‘bad’ were seen as unavoidable. Healthcare workers expressed a sense of inevitability in the event of adverse events for patients identified as ‘bad’ at admission. Theme two- organisational cultures encompassed two sub themes: ‘team dynamics’ and ‘fear of blame’. A strong vertical hierarchy was observed in the care setting. Yet nurses and doctors perceived this hierarchy differently and this affected their approach to decision making. Doctors’ decision making was collective and reflective. In contrast, nurses expressed a more task-focused approach to care and were absent from treatment planning and goal setting. Fear of blame was a strong impediment to healthcare workers seeking opportunity to learn from failure to rescue deteriorating patient. Fear of blame rather than fear of failure to rescue, motivated vital sign recording and prioritisation of reassessment. This same organisational culture resulted in a reluctance among nurses and some junior doctors to take responsibility for their decisions regarding prioritisation of care.

Part 2 of this thesis reports the implementation of the components of a learning health system. Cycles of co-evaluation and feedback during implementation used technology adoption frameworks for behaviour change. Motivated by an ambition to address the need for data-driven healthcare improvement that empowers users, the platform was leveraged in a workshop to train stakeholders to identify gaps in existing care amenable to improvement. Finally, a peer delivered practical two-day acute care skills training (ACST) course designed and delivered by a peer faculty (part of the community of practice) was evaluated.

The surveillance platform was implemented in 56 acute care facilities in Sri Lanka, supporting stakeholders with clinical decision-making, and evaluation of quality for over 100,000 episodes of patient care. Barriers were identified and overcome in an iterative manner during implementation and co-evaluation. These included minimising the burden of data capture, developing a mobile-platform to ensure utility for busy clinicians, offline functionality to overcome variability in connectivity and agile data-sets responsive the stakeholder priorities. In addition, ontological structuring of data to mirror processes of clinical care were important to enable clinicians to use the information for clinical decision-making. Similarly transitioning the information from raw data to meaningful output viewed through real-time clinician-facing dashboards was important for user
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engagement. Co-implementation, stakeholder engagement, collaboration with professional bodies, proved successful for the transfer and scale up of the platform as a critical care registry in Pakistan (chapter 6).11

A workshop to equip delegates with the skills to evaluate the quality of care and identify setting-relevant priorities for improvement was delivered in Sri Lanka (chapter 7). Measurement of the structures, processes and outcomes of care, visible through the clinician facing dashboards, facilitated data-driven conversations regarding existing quality of care. Using a tool box of QI, health informatics and health systems research methods, gaps in care amenable to improvement were prioritised and achievable targets set by frontline healthcare teams. Of the 52 international delegates from LMICs who attended workshop, only one quarter reported that they had previously had the opportunity to participate in quality improvement, implementation science or health informatics training.9 More than three quarters wanted to attend subsequent workshops to support the implementation of data driven improvement initiatives. Investment networks or communities of practice to facilitate training in and transfer of skills to evaluate and improve care is both needed and achievable in LMICS.

The components of the learning health system reported in part 2 have been subsequently translated to Ethiopia. A short view point, published in Anaesthesia News Issue number 388 (Appendix 1), describes the reflections of Mr Fitsum Kifle, a non-medical anaesthetist, who joined Network for Improving Critical care Systems and Training (www.nicst.com) in Sri Lanka to undertake a three month fellowship in partnership with the Faculty of Medicine, University of Colombo. This report highlights the similarities of barriers experienced to evaluating care in an Ethiopian hospital setting, the limited opportunity for training in research and QI methods and the need for data to drive improvement.

Part 3 of this thesis reports the evaluation of the quality of AMI care, long-term outcomes and patient-centered measures of recovery.12 The evaluations were led by healthcare workers who attended the QI workshops following a newly formed national AMI registry using the surveillance platform.

In this setting, registry-led evaluation revealed gaps in quality of AMI care for this cohort of 934 AMI patients presented to the cardiology department (chapter 9). Mean (SD) overall compliance with the composite quality indicator (CQI- Domain 7) was 44.0% (0.07). Compliance of ≥ 50% to the CQI was achieved in 9.8% of STEMI patients. The highest compliance was observed for indicators Domains 4 and 6: anti-thrombotics during hospitalisation (79.1%), and continuous measure of patient satisfaction (76.1%). The lowest compliance was observed for Domains 1 and 2 describing organisational structure
Chapter 11

and process of care: (22.4%) (table2). Thirty-day mortality following discharge was 11.8%. Predicted mortality using the GRACE Score at 30 days following discharge was 10.3%. (QI7.3).12

Chapter 10 reports the long-term survival and quality of recovery for AMI patients. This is the first time such evaluation has taken place in this setting. At one year, 13.6% (93) of the 699 consecutive patients who underwent PCI for STEMI were known to have died, higher than the predicted mortality (4.5-11.0%). Event-free survival at one year was 44.5% (304) The Seattle Angina Questionnaire (SAQ) was completed at one year by 57.5% (362) of patients. Loss to follow up was 27.5% (192). Median physical functioning at one year was 64.4 (IQR=75.6-55.6) with 72.9% of patients (264) reporting ongoing physical limitation at one year; walking short distances, washing and dressing. Similarly, 48.5% (169) of patients reported ongoing burden of angina- the same as or worse than compared to at the time of primary admission to hospital 74.7(23.2). Patient satisfaction with treatment was high (median 88.2, 94.1-76.5). Patients reported ongoing concern about their disease and its impact on their general health status (median 50, 58.3-41.7). Functional activity worsened over the one year period (p<0.01). Frequency of angina was significantly greater (p<0.01) whereas stability of angina remained unchanged (p<0.01). Patients’ perceptions of their satisfaction with treatment improved (p<0.01), but patients’ perceptions of their disease and the relative constraint on their health and wellbeing worsened. (p<0.05). Self-perceived compliance at one year for secondary prevention therapy ranged between 75% and 82%. Of those patients followed up at one year, 146 (44.5%) reported being offered the opportunity to attend cardiac rehabilitation, 128 (87.7%) patients did so on at least one occasion.

Discussion and implications

Part 1
Poor availability of information is a barrier to evaluating quality of acute care in Sri Lanka. The research reported in part 1 demonstrates the impact that absence of information has on individual patients’ safety and how it disempowers frontline staff from learning from mistakes. The studies reported in chapter 2 and 3 described how low availability of vital sign recording was driven by and reinforced decision-making biases in the assessment and reassessment of patients. Absence of information further inhibited the evaluation of the performance of EWS.1,2 Performance of EWS was variable. Low sensitivities reported in chapter 2 mirror similar studies undertaken in LMICs.15 In healthcare settings where nurse to patient ratios are low and where reasons for admission to acute care may differ from HIC acute care wards, indiscriminate implementation of EWS may result in significant increase in burden of workload and may result in alarm fatigue.2
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Similar decision-making biases and inimical organisational cultures as described in chapter 3 have been identified as impediments to patient safety and quality improvement efforts in HIC healthcare institutions. Healthcare workers expressed feelings of futility in the advent of adverse events among patients identified as ‘bad’ at admission. The absence of do not attempt resuscitation orders and the practice of resuscitation preceding in hospital death in this setting (chapter 4) may contribute to the perceptions of inevitability and may be a barrier to improving outcomes following resuscitation for patients for whom cardiac arrest is not inevitable. Fear of blame rather than fear of failure to rescue, motivated vital sign recording and prioritisation of reassessment. This same organisational culture resulted in reluctance among nurses and some junior doctors to take responsibility for their decisions. Fostering accountability in healthcare professionals and systems has been identified as a key driver for improving the quality of care in LMICs. Efforts to establish such accountability should consider creating opportunities for professional development and training, with a focus on team working and shared learning.

Efforts to improve the quality of care without simultaneously addressing inimical health care cultures, may serve to disempower healthcare workers, increase burnout for staff and perpetuate poor care. Strategies and tools that enable staff to learn from mistakes without fear of blame are needed. Implementing standards of practice (SOPS) without first understanding the differences in patient population, organisation of patient care and processes of decision making is likely to be unsuccessful and may have unintended adverse impacts on patient outcomes.

Part 2.

Implementation of a cloud-based surveillance platform for acute care in South Asia is feasible (chapter 5 and 6). A collaborative approach engaging clinicians, researchers and healthcare informaticians offered a pragmatic solution to overcoming barriers to adoption, minimised disruption to workflow and facilitated user engagement. Granular data captured through the surveillance platform was a driver for changes in decision making practices identified in chapters 2 and 3. Similarly clinician facing dashboards were instrumental in empowering stakeholder identification of setting specific priorities for improvement (chapter 7). Similar audit and feedback techniques have been used in HIC healthcare settings. Combining dashboards with the methods used in the workshops (chapter 7) have been demonstrated to support efforts to improve the quality of acute care. Interventions which use the audit and feedback cycle, supported by the surveillance platform are now being implemented within
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AMI care and in acute care wards in Sri Lanka. Evaluation of the impact that these interventions will follow.

Priorities for improving quality of acute care were similar across the different acute care settings: streamlining prehospital and interdepartmental organisation of care; implementing standardised tools for assessment; recognising complications in the acute and critical care patient pathway; and measuring longer term recovery and outcome. The similarities in gaps in care amenable to intervention and the approach to pragmatic solutions highlights the value that opportunities for shared research and learning can have on improving quality of care in LMICS.

Part 3.

These two studies highlight poor long-term outcomes after PCI in a relatively young, low-risk cohort in this LMIC setting. Poor quality of care may contribute to these outcomes. Excess deaths from cardiovascular disease attributable to poor quality of care are high in South Asia as have been highlighted by the recent HSHQ report. Comparison between the domains (chapter 9) highlighted that the greatest gaps in quality of care were caused by fragmented communication between departments; delays with intra-hospital transfer; and missed opportunities for offering patients access to rehabilitation services and clinic follow up post discharge (chapter 10). Prior studies attempting to evaluate AMI in this setting have highlighted challenges of lack of information, missed outcomes, small data sets. Follow up for long-term outcomes was not considered feasible. The platform’s ability to increase the availability of routine clinical information and facilitate subsequent evaluation of clinical care including up to one year after intervention is an important step forward in improving the quality of care in this region.

The disparity between quality of care, and perceptions of treatment satisfaction raises questions as to patients expectations of quality of healthcare in this setting. Expectations of care can be lowered by lack of exposure to higher-quality services, lack of knowledge about what constitutes high quality care and a general lack of information providing feedback to communities about health service provision. Low patient and family expectations of health services is problematic and is a driver for poor care, and may perpetuate lack of accountability within health systems. Further understanding of the factors influencing patients’ perceptions of satisfaction, health literacy and patient centered health values is urgently needed, given the increasing focus on patient centered outcomes as an international measure of quality of care.
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Conclusion

This chapter presents an overall discussion of the work presented in this thesis. The components of a learning health system, namely m-Health surveillance platform, a community of practice facilitating training in health system evaluation and QI methods, can help overcome barriers to evaluating care and identifying context specific priorities for improvement. Awareness of the differences in health system organisational cultures that underpin decision-making in acute care is important for those seeking to implement interventions for improvement. Information made visible through clinician-facing dashboards is a powerful tool to engage healthcare workers and may facilitate behavioural change as part of future QI efforts. The iterative approach to clinician-led implementation of the platform and the solutions used to overcome barriers to adoption may be relevant to m-Health interventions internationally.
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Appendix 1. Improving perioperative care is a priority in Ethiopia

Improving perioperative care is a priority in Ethiopia

The federal government of Ethiopia with the support of NGO’s and organisations such as SAFE Surgery, have invested in services to improve the quality of perioperative care in the country. This has included increasing surgical operating and bed capacity, establishing a graduate programme for surgical and anaesthetics training, implementing standards of perioperative care and establishing post-anaesthetic care units (PACUs) such as the one in Debre Berhan Referral Hospital where I am based and where patients can recover from general, regional or local anaesthesia and receive additional monitoring under the care of nurses and anaesthetic staff.

These changes, whilst welcome, have been a challenge for those of us leading improvements at the frontline of care. There has been little guidance on how to implement and evaluate these changes, and our current training offers little in the way of translational and improvement research which might equip us with these skills. Like all frontline healthcare practitioners seeking to improve care, I am faced with the challenges of translating policy into practice and supporting colleagues through the change process whilst juggling clinical duties. This is why the Network for Improving Critical care Systems and Training (NICST), https://nicst.com/ fellowship in Sri Lanka appealed to me. I had the opportunity to join a team with skills in evaluating the quality of care and building capacity for better care. During the three-month fellowship I undertook a period of clinical observation in the Department of Surgery in the Faculty of Medicine at the University of Colombo, developed practical skills in translational research and evaluating quality of care in my home setting in Ethiopia, and participated in delivering simulation based training in partnership with local clinicians in Sri Lanka.

Gaining insights into clinical care and adding value back to the team

During the first two months of my fellowship, I joined colleagues in Sri Lanka and shared clinical experiences related to my specialty from a different healthcare setting. Besides observing and gaining new exposure to common surgical cases, I had the opportunity to see the anaesthetic management of rare and challenging surgical and obstetric cases. Seeing how diseases and conditions akin to those I might experience in Ethiopia were managed in a more developed healthcare system, but one that still has the challenges of limited resources and a high volume of patients, was inspiring. I was impressed by the expertise and skills of the multidisciplinary team and how they worked together in the OR and in the PACU. Providing practical training during the fellowship was an important experience as it was a way of contributing to strengthening the delivery of care in Sri Lanka. Working in collaboration with Karunagahawa Hospitals and registers in medicine and anaesthetics, we were invited to deliver simulation-based assessment and training building training to nurses and junior doctors working in the Emergency Treatment Unit.

During my clinical and training activities I visited several PACUs and surgical wards and joined the team who, with local surgeons, discussed their solutions to overcome barriers to implementing guidelines. Considering care in the PACU back home I appreciated the impact that a structured approach to implementation can have and how projects in Sri Lanka have focused on the role of nurses in monitoring patients, and the use of objective tools to support risk assessment and readiness for discharge. It was great to be able to speak with colleagues and hear from those facing similar challenges of health system improvement at different stages of their career.

It was the use of tools to support the decision to discharge that caught my attention. In Ethiopia, we have recently implemented the Adverse Rate (PAR) score in an effort to overcome challenges of delayed or untimely discharge and to improve the safe transfer of patients from the PACU as they step down to ward-based care.
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Analysis of the data quickly followed and with the support of the team in Sri Lanka I was able to capture a snapshot of care for surgical patients from anaesthetic all the way through to the postoperative ward. I identified gaps in the teams' knowledge of the Aldrete score, and the challenges for the team in how to escalate concerns when a patient is not ready for discharge.

Data collection continues and expansion to other hospitals is underway. I have gained new insights into the challenges of capturing information, how to design a data set and in the skills of translating guidelines into practical tools to help evaluate care. My biggest challenges and success have been in communicating and leading change with my colleagues.

Next steps on the road to improvement

Since returning to Ethiopia I have presented to the hospital management and to the wider surgical teams using the NICST dashboard, which provides an easy to understand visual overview of the information being reported and compliance with indicators of quality. I am currently working with colleagues to explore how we might use the tool of multi-disciplinary training, allocation of specific roles in PACU and new information from the registry to design a quality improvement project. The NICST team have continued to support us remotely via video conferencing and team members are visiting in the next few months to help deliver a 'train the trainer' workshop in collaboration with Debre Berhan University Anaesthesia Department to help colleagues in improving care.

I would like to extend my thanks and gratitude to the clinicians with whom I spent this fellowship who so generously shared this opportunity for professional development.

Fisatum Kifle
Perioperative Medicine Fellow
Debre Berhan University
Ethiopia

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Implementing has been a challenge, and I and my colleagues have a sense that we are not using the score as effectively as we might. I was keen to see how the fellowship might help.

Developing the skills to evaluate care and lead change

Chatting with colleagues at Debre Berhan Hospital and with the NICST team, my research project was set. My aim was to evaluate the adoption of the Aldrete score and to evaluate existing delivery of care. With a fresh perspective from my clinical exposure I explored how we might measure quality of care, and how I would understand challenges the anaesthetists and PACU nurses experiences in using the Aldrete score in the context of the busy clinical setting.

Using the recently developed Ethiopian Federal Ministry of Health Perioperative Guidelines, and with support from the NICST team, the Hospital Director and my senior colleagues from Debre Berhan University Anaesthesia Department, I developed a framework for assessment of care using the 11 indicators described in the guidelines. Using the already active and successful perioperative registry modal in Sri Lanka we adopted a secure cloud based platform to include measures of the 11 domains of quality. Using video conferencing and some audiovisual training tools I helped the staff at Debre Berhan Hospital install the mobile application and with a little encouragement the evaluation of care using routine information was underway (see Figure 1).
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Summary

Poor quality of care is an important cause of excess mortality globally. Quality of care includes: safety (Q1), timeliness (Q2), efficacy (Q3), equity (Q4), efficiency of care (Q5) and patient-centred outcomes (Q6). In low and lower-middle income countries (LMICs), lack of infrastructure, staffing and equipment have traditionally been seen as major barriers to addressing the quality gap. More recently, the absence of granular data and a lack of opportunity for frontline clinicians to gain the skills necessary to prioritise, implement and evaluate QI interventions, have stalled efforts to improve acute and critical care. Learning health systems (LHS) which embed knowledge generating processes to improve care in daily practice are emerging internationally. With the aim of leveraging advancements in science, technology and practice to improve health system performance, this approach may be applicable in LMICs.

LHS include:

- A system by which data regarding routine care can be captured, evaluated and utilised by healthcare service stakeholders
- Training for healthcare workers in the clinical, academic, research and quality improvement skills necessary to implement interventions and make sustainable change
- A health system change at policy level that is cognisant of the need for high quality, value based health care.

We hypothesised that an acute and critical care LHS could be established in LMIC settings. In three parts, this thesis describes the establishment of a LHS for acute care in two South Asian countries. Part one reports the findings of a series of studies to understand the barriers to improving the quality of care in LMIC. Part two reports the design, implementation and scale up of an electronic surveillance platform, and how a community of practice has been established to empower healthcare workers to gain the translational research and implementation science skills necessary to drive context specific QI. Part three describes the subsequent evaluation of quality of acute care from pre hospital through to one year following discharge using data captured through the electronic surveillance platform and the evaluation of a peer delivered training programme for newly qualified doctors in preparation for clinical practice.

Part 1

A mixed methods evaluation of healthcare workers’ perceptions and practices of recognition of deterioration and resuscitation provided a lens through which the organisational and contextual barriers to the delivery of quality of care for acutely unwell patients have been identified. Key findings include; availability of vital signs on admission to hospital are poor (ranging from 91.0% (95% CI 90.52%
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to 91.40%) for heart rate to 23.9% (95% CI 23.29% to 24.60%) for oxygen saturation (Q1,2,5)).

Efficacy of Early Warning Score (EWS) to discriminate death on admission was variable, and positive predictive value to determine burden of triggering for frontline staff was low (10.44%) (Q4). Implementing such tools in resource limited settings without first understanding existing behaviors for triage and prioritisation, may result in high numbers of patients being indiscriminately triggered (Q1). Unintended consequences of this could include alarm fatigue, and inappropriate referral - potentially diverting limited resources away from the sickest patients (Q1,2,5).

Health care worker interviews to understand the determinants of recognition of deteriorating patients revealed a lack of formal triage, rigid team hierarchies and fear of blame as barriers to recognition (Q1,Q5). Informal triage systems and admission of all patients to acute care wards (even those admitted for routine investigation) resulted in a series of cognitive biases in subsequent decision-making and risk assessment (Q1, Q3). These cognitive biases led to omissions in information seeking about patients perceived as being at less risk of deterioration, and a reticence from healthcare workers to respond to information which challenged their initial assessment. Detrimental organisational cultures - vertical hierarchy, siloed working and a reluctance to take responsibility, further undermined health care workers’ ability to recognise deterioration in patients. In addition, fear of blame was a barrier to healthcare workers seeking opportunities to learn from adverse events or challenge decision-making from seniors(Q1, Q5).

To complement this qualitative study, a national evaluation of healthcare worker perspectives regarding resuscitation attempts was undertaken. This survey revealed that resuscitation antecedes in hospital death in Sri Lanka even for patients for whom deterioration and death was perceived by healthcare workers as the most likely outcome. Described in the context of limited use of do not attempt resuscitation (DNACPR) orders in the country, these findings highlight the need for greater exploration of the impact that such practices may be having on healthcare systems’ ability to provide high quality care; specifically how already limited resources are currently utilised, and how healthcare workers’ decision-making processes regarding escalation to critical care may be influenced by limited use of policies such as DNACPR. Chapters 2, 3 and 4 report the findings of this mixed methods research.

Part 2

To address the absence of information needed for evaluation and improvement of care, chapter 5 describes the implementation of a co-designed electronic surveillance platform which has enabled continuous and replicable evaluation of the quality of existing care. Implemented across a collaboration of acute and critical care facilities in LMICs, the platform captures routine data regarding
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organisation, processes and outcomes up to one-year following discharge.\textsuperscript{7} Networking 75 hospitals in South Asia and Sub-Saharan Africa, the platform has captured over 29,000 patient episodes since 2017. Key learning from this chapter includes how a co- designed user centric approach overcame barriers to adoption, and how display of information captured through interactive real-time dashboards has improved the availability and quality of information.\textsuperscript{3,6,7} Chapter 6 reports the successful adaptation, transfer and scale up of the platform in Pakistan, a neighboring LMIC in South Asia, with a different health-system organisational and governance structure for healthcare service delivery when compared to Sri Lanka. The platform is supporting a new national registry for critical care in Pakistan (PRICE).\textsuperscript{6}

Chapters 7 describes how through a community of practice is being equipped with the skills to evaluate the quality of care, identify priorities for improvement.\textsuperscript{7} A series of multidisciplinary workshops were conducted to provide facilitated training for over 100 members of the community to undertake practical training in data interpretation, and in the skills to understand drivers of poor care and to design and implement quality improvement interventions.\textsuperscript{7} Delegates from across the collaboration representing clinical, civic and academic healthcare stakeholders from six countries attended the workshop. Mapping of care processes enabled identification of barriers and drivers to the delivery of care and facilitated the selection of feasible QI methods and matrices. Six projects, which reflect key priorities for improving the delivery of acute care in Asia, were collaboratively developed: improving assessment of postoperative pain; optimising sedation in critical care; refining referral of deteriorating patients; reducing surgical site infection after caesarean section; reducing surgical site infection after elective general surgery; and improving provision of timely electrocardiogram recording for patients presenting with signs of acute myocardial infarction. Collaborating members are being supported with implementation of these projects through a fellowship programme offering reciprocal South to South training opportunities.

Part 3

Chapter 8 and 9 reports how, informed by data captured through the platform, all 6 domains of quality described by the HQSS commission were evaluated.\textsuperscript{1} A clinician-led national registry for improving quality of Acute myocardial Infarction (AMI) care in Sri Lanka implemented using the electronic surveillance platform evaluated care for over 1000 consecutive admissions to the country’s only 24 hr emergency percutaneous coronary intervention centre using guidelines for the European Society of Cardiology.\textsuperscript{8,9} The highest compliance was observed for anti-thrombotics during hospitalisation (79.1%) and a measure of patient satisfaction (76.1%) (Q6).\textsuperscript{9} The lowest compliance was for organisational structure and timeliness of the reperfusion intervention (22.4%, Q5). Mean (SD) overall
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compliance as per composite quality indicator was 44% (0.07) (Q4). Predicted mortality at 3 days using the GRACE Score was 10.3% compared to observed mortality of 11.%. Key recommendations from this evaluation include clinician-led restructuring of departmental patient flow to improve timeliness of interventions, and the establishment of a hub and spoke network for AMI care to help rationalise the use of pharmaco-invasive interventions for patients facing delays in accessing primary PCI.

The surveillance platform also supported the evaluation of outcomes and quality of recovery for post-PCI patients in this cohort at one year following discharge- the first long-term study evaluating the quality of patient recovery and event free survival for this group in South Asia. Outcomes at one year following PCI in Sri Lanka were higher than predicted mortality, predominantly in the first 30 days following intervention, and event free survival at one year of 78.7%. Patients reported moderate functional recovery, minimal symptoms of angina but with high reported use of symptom relief medications. Compliance with secondary prevention therapies was 74.1%. Opportunity to access follow up services was 43.9%. Overall patient satisfaction was good (81.3 mean) despite only 42% of patients receiving all European society domains of quality AMI care during their inpatient stay. Despite this evaluation being hampered by attrition to follow up of 45% (a rate which mirrors other follow up studies internationally), the findings suggest that further work needs to be done to educate patients and the public in general cardiovascular health. In addition, the disparity between quality of care objectively evaluated and patients’ self-reported perceptions of satisfaction suggest work to understand what care attributes patients and families value in their healthcare provision is warranted.

Chapter 10 reports how junior doctors were supported to deliver peer training to frontline healthcare workers in the skills necessary to provide timely safe and efficient care for acutely unwell patients. In partnership with the Faculty of Medicine of the University of Colombo, a practical, peer delivered training programme to train newly qualified doctors in the skills necessary to transition from medical student to newly qualified doctor working on acute care wards was developed, piloted and implemented in Sri Lanka. This peer training programme has provided a sustainable method for delivering practical skills programme to bridge the theory-practice gap for over 3000 newly qualified doctors and is now embedded in undergraduate medical education nationally. The clinically focused, practical skills programme has built perceived confidence for newly qualified doctors as they prepare for internship and enabled continued professional development for doctors working in health care systems where there might otherwise be limited opportunity for such learning.

Establishing a learning health system for acute care has successfully enabled a community of practice to evaluate and benchmark existing quality of acute care, understand contextual and organisational barriers to improving care and resulted in healthcare workers being equipped with the skills to care
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for acutely unwell patients. Future work will focus on supporting the community of practice to deliver and evaluate interventions to address the identified priorities for improvement. In addition, the collaboration will seek to explore and advocate for care quality that better represents the values of patients and their families.
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Nederlandse samenvatting

Slechte kwaliteit van zorg is wereldwijd een belangrijke oorzaak van te voorkomen sterfte. Belangrijke aspecten van kwaliteit van zorg zijn: veiligheid (Q1), tijdigheid (Q2), werkzaamheid (Q3), gelijkheid (Q4), efficiëntie (Q5) en patiëntgerichte resultaten (Q6). In lage- en middeninkomenslanden (lower middle income countries, LMICs) worden gebrek aan infrastructuur, personeel en apparatuur traditioneel gezien als de belangrijkste belemmeringen voor het verbeteren van de kwaliteit van zorg. Echter, ook niet-materiële tekortkomingen kunnen verbetering van de acute en intensieve zorg in de weg staan, zoals het gebrek aan gedetailleerde patiënten gegevens en aan vaardigheden van clini, essentieel om kwaliteitsverbetering te identificeren, te implementeren en te evalueren.

Zogenaamde ‘learning health systems’ (LHS), waarin kennisverwerving onderdeel uitmaakt van de dagelijkse praktijk, zijn internationaal in opkomst. Een dergelijke aanpak, waarbij nieuwe ontwikkelingen in de wetenschap, technologie en klinisch handelen worden ingezet om het gezondheidssysteem te verbeteren, zou ook in LMIC een succesvolle benadering kunnen zijn.

Een LHS omvat:

● Een systeem waarmee gegevens die gegenereerd worden tijdens dagelijkse patiëntenzorg kunnen worden vastgelegd, geëvalueerd en gebruikt door belanghebbenden.

● Training van zorgverleners in klinische- en onderzoekvaardigheden en in vaardigheden die nodig zijn om interventies ten behoeve van de verbetering van zorg duurzaam te implementeren en om duurzame verandering aan te brengen.

● Aanpassing op beleidsniveau ter stimulering van een groter bewustzijn van het belang aan hoogwaardige, op waarde gebaseerde gezondheidszorg.

Onze hypothese was dat het mogelijk moet zijn om een LHS voor acute en intensieve zorg op te zetten in LMIC en in dit proefschrift wordt het onderzoek beschreven waarin een LHS wordt opgezet in twee Zuid-Aziatische landen. Het eerste deel beschrijft de bevindingen van een reeks onderzoeken om de barrières voor het verbeteren van de kwaliteit van zorg in LMIC te begrijpen. Deel twee beschrijft het ontwerp, de implementatie en de toepassing van een elektronisch surveillance platform. In dit deel wordt ook beschreven hoe gezondheidswerkers de benodigde vaardigheden kunnen verwerven die nodig zijn om context specifieke kwaliteitsverbetering in gang te zetten. Deel drie beschrijft de daaropvolgende evaluatie van de kwaliteit van de acute zorg vanaf eerste lijnszorg en ziekenhuisopname tot de periode na ontslag. Dit deel bevat ook de evaluatie van een trainingsprogramma voor recent gekwalificeerde artsen ter voorbereiding op de klinische praktijk.
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Deel 1

Met een combinatie van kwalitatieve en kwantitatieve onderzoekmethoden werden contextuele belemmeringen voor het leveren van kwaliteit van zorg voor acute patiënten geïdentificeerd. De beschikbaarheid van metingen van vitale functies bij opname in het ziekenhuis bleek slecht, variërend van 91.0% (95% BI 90.52% tot 91.40%) voor hartslag tot 23.9% (95% BI 23.29% tot 24.60%) voor zuurstofsaturatie (Q1,2,5 4). De effectiviteit van de Early Warning Score (EWS) om de sterfte bij opname te voorspellen was variabel en de positieve voorspellende waarde laag, (10.44%), wat de waarde voor concreet handelen van dokters en verplegend personeel zeer beperkt maakt (Q4). Het implementeren van dergelijke basale patiëntenvariabelen in ziekenhuizen met overigens beperkte middelen is niet effectief als niet eerst de bestaande praktijk van triage en prioritering onderzocht wordt (Q1). Bijvoorbeeld, ongefundeerd triggeren van alarmen kan ‘alarmvermoeidheid’ en onjuiste consultatie veroorzaken en oneigenlijk gebruik van de beperkte middelen stimuleren die dan niet ingezet kunnen worden voor de ziekste patiënten (Q1,2,5).

Interviews met zorgverleners om de barrières voor herkenning van verslechterende patiënten beter te begrijpen, onthulden een gebrek aan formele triage, rigide teamhiërarchieën en angst voor terechtwijzing (Q1,Q5). Informele triage-systemen en toelating van alle patiënten tot acute zorgafdelingen (zelfs voor routinematig onderzoek) resulteerden in vooringenomenheid bij de daaropvolgende besluitvorming en risicobeoordeling (Q1, Q3). Bij patiënten bij wie het risico op achteruitgang minder groot werd beschouwd, werden minder gegevens verzameld en was er terughoudendheid bij zorgverleners om te reageren op informatie die hun initiële beoordeling in twijfel trok. Een niet ondersteunende organisatiecultuur - verticale hiërarchie, werken in silo’s en terughoudendheid om verantwoordelijkheid te nemen - ondermijnde ook het vermogen van zorgverleners om achteruitgang bij patiënten te herkennen. Bovendien vormde angst voor terechtwijzing een belemmering voor zorgverleners om te leren van fouten of om besluitvorming van meer senior zorgverleners in twijfel te trekken (Q1, Q5).

Als aanvulling op dit kwalitatieve onderzoek werd een nationale evaluatie van de praktijk en het nut van reanimatie vanuit het perspectief van gezondheidswerkers uitgevoerd. patiënten met een door de zorgverleners onderkende zeer slechte prognose Sri Lanka kent een zeer beperkt gebruik van niet-reanimeren afspraken (Do Not Attempt Resuscitation; DNACPR), Deze bevindingen tonen de noodzaak van verder onderzoek naar de impact van de huidige reanimatie praktijk op de kwaliteit van zorg, in het bijzonder hoe beperkte middelen gebruikt bij reanimaties het best kunnen worden ingezet en hoe besluitvormingsprocessen met betrekking tot escalatie naar intensieve zorg kunnen worden beïnvloed.
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door uitgebreider gebruik van niet-reanimeren codes (DNACPR). De hoofdstukken 2, 3 en 4 beschrijven de bevindingen van dit onderzoek.

Deel 2


Hoofdstuk 7 beschrijft het proces hoe zorgverleners kunnen leren om de kwaliteit van zorg te evalueren en om daaruit prioriteiten voor verbetering te identificeren. In een reeks multidisciplinaire workshops werd aan meer dan 100 zorgverleners praktische training gegeven in data-interpretatie en in de vaardigheden om oorzaken van slechte zorg te identificeren en om kwaliteitsverbeteringsinterventies te ontwerpen en te implementeren. Afgevaardigden werkzaam in klinische, maatschappelijke en academische gezondheidszorg uit zes landen woonden de workshop bij. Het in kaart brengen van zorgprocessen maakte identificatie van barrières en drijfveren voor de levering van goede zorg mogelijk en ondersteunde de selectie van haalbare methoden voor kwaliteitsverbetering. Zes projecten, die de prioriteiten weerspiegelen voor het verbeteren van de levering van acute zorg in Azië, werden sindsdien gezamenlijk ontwikkeld: verbetering van de beoordeling van postoperatieve pijn; het optimaliseren van sedatie in intensieve zorg; verbetering van de verwijzing van verslechterende patiënten; het verminderen van postoperatieve wondinfecties na een keizersnede; verminderen van postoperatieve wondinfecties na electieve algemene chirurgie; en het verbeteren van het tijdig uitvoeren van een elektrocardiogram bij patiënten met tekenen van acuut myocardinfarct. Samenwerkende deelnemers werden ondersteund bij de uitvoering van deze
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projecten via een fellowship-programma dat wederzijdse ondersteuning tussen de deelnemers van de participerende LMIC biedt.

Deel 3

Hoofdstuk 8 en 9 beschrijven hoe, op basis van gegevens verzameld via het surveillance platform, alle 6 domeinen van kwaliteit \(^1\) werden geëvalueerd. Een door een arts geleid register voor het verbeteren van de kwaliteit van zorg rondom patiënten met acuut myocardinfarct (AMI) in Sri Lanka evalueerde de kwaliteit van de zorg voor 1000 opeenvolgende opnames in het enige continu opererende interventiecentrum voor percutane coronaire interventie (PCI) in Sri Lanka, en volgt de richtlijnen voor de European Society of Cardiology (ESC).\(^{8,9}\) De beste naleving van de richtlijnen was voor het gebruik van antitrombotica tijdens ziekenhuisopname (79,1%) en het meten van patiënttevredenheid (76,1%) (Q6).\(^9\) Richtlijnen voor de organisatiestructuur en benodigde spoed van de reperfusie-interventie (22,4%, Q5) werden het minst gevolgd. De gemiddelde (SD) algemene adherentie per samengestelde kwaliteitsindicator was 44% (0.07) (Q4). Voorspelde sterfte 3 dagen na opname met behulp van de GRACE-score was 10.3%, terwijl de waargenomen sterfte 11% was. Belangrijke aanbevelingen voortkomend uit deze evaluatie waren een door de lokale arts geleide herstructurering van de patiëntstroom op de afdeling om de tijdlijn tot aan de interventies te verkorten, en de oprichting van een “hub and spoke” netwerk voor AMI-zorg om het gebruik van invasieve interventies te rationaliseren en de tijdlijn van binnenkomst tot aan de primaire PCI te versnellen.

Het surveillanceplatform ondersteunde ook de evaluatie van uitkomsten en kwaliteit van herstel één jaar na ontslag voor post-PCI-patiënten in dit cohort -. Deze studie is hiermee de eerste die de langere termijn overleving en kwaliteit van het herstel van deze patiëntengroep in Zuid-Azië evalueerde. De mortaliteit één jaar na PCI in Sri Lanka was hoger dan de voorspelde mortaliteit, voornamelijk in de eerste 30 dagen na de interventie, de gebeurtenisvrije overleving na een jaar was 78.7%. Patiënten rapporteerden matig functioneel herstel, minimale symptomen van angina maar een hoog gebruik van medicatie voor angineuze symptoomverlichting. Naleving van secundaire preventietherapie was 74.1%. De mogelijkheid om gebruik te maken van follow-up services was 43.9%. De algemene patiënttevredenheid was goed (gemiddeld 81.3 uit 100), ondanks het feit dat slechts 42% van de patiënten tijdens opname de zorg kregen conform alle kwaliteitsdomeinen van de AMI richtlijnen van de CSI. Hoewel 45% van de patiënten niet vervolgd konden worden (een percentage dat overeenkomt met andere internationale follow-up studies), suggereren de bevindingen dat er nog meer moet worden gedaan om patiënten en het publiek te informeren over cardiovasculaire aandoeningen. Bovendien suggereert het verschil tussen de kwaliteit van de objectief geëvalueerde zorg en de zelf
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gerapporteerde percepties van de patiënt, dat er aanvullend onderzoek nodig is om te begrijpen welke
zorg patiënten en families het beste waarderen.

Hoofdstuk 10 beschrijft een programma waarin junior artsen werden ondersteund om training te
geven aan nieuw gekwalificeerde artsen in vaardigheden ten behoeve van tijdige, veilige en efficiënte
zorg voor acute patiënten. Dit programma werd ontwikkeld in samenwerking met de Faculteit der
Geneeskunde van de Universiteit van Colombo, en getest en geïmplementeerd in Sri Lanka. Dit
duurzame peer training-programma biedt praktische vaardigheden om de kloof tussen theorie en
praktijk voor meer dan 3000 nieuw gekwalificeerde artsen te overbruggen en is nu ingebed in de
nationale medische vooropleiding. Het klinisch gerichte en praktische vaardighedenprogramma geeft
vertrouwen aan nieuw gekwalificeerde artsen die zich voorbereiden op hun stage en faciliteert
doorlopende professionele ontwikkeling aan artsen die werken in een gezondheidszorgstelsel met
beperkte mogelijkheden voor nascholing.

Het opzetten van een lerend gezondheidsysteem voor acute zorg heeft een “community of practice”
in staat gesteld de bestaande kwaliteit van acute zorg te evalueren en te benchmarken, contextuele
en organisatorische belemmeringen voor het verbeteren van de zorg te begrijpen en heeft ertoe
geleid dat zorgverleners zijn uitgerust met de vaardigheden om voor acuut zieke patiënten te zorgen.
Toekomstig werk omvat onder meer het ondersteunen van interventies gericht op de geïdentificeerde
verbeteringsprioriteiten. Bovendien zal onderzocht worden welke aspecten in de kwaliteit van de zorg
de waarden van patiënten en hun families het best representeren.

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Appendices

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Appendices

About the Author

Abi Beane was born in the UK in 1981. After qualifying as Nurse from Cambridge University in 2004 she spent 12 years working clinically as a critical care nurse, and educational lead within the National Health Service (NHS) during which she successfully completed an MSc in Advanced Clinical Practice from King’s College London and an MSc in Critical Care Medicine from Queen Mary’s University, London. Alongside her clinical practice in the NHS, she worked clinically with international non-government organisations between 2005 and 2012, where she helped provide emergency surgical and medical care during conflict and natural disaster. Serving in Liberia, Benin, Togo, Sierra Leone, Afghanistan and Oman, she was honoured for her services to humanity in the non-government sector in 2010. During this time, she successfully completed the Diploma in Tropical Medicine and Hygiene postgraduate course in London, and has subsequently lectured as guest faculty at the LSHTM and at University College London.

In 2014, she and Dr Rashan Haniffa together co-founded the organisation ‘Network for Improving Critical care Systems and Training.’ This non profit, UK registered Charity (1171106) seeks to strengthen acute care health systems internationally through information platforms combined with locally driven translational research and quality improvement tools. The organization based predominantly in Sri Lanka, currently employs over 35 staff internationally including clinical educators, software analysts, researchers, statisticians and bioinformaticians. It currently supports the MoH Sri Lanka with a national bed availability system for all government intensive care units, finding over 6000 beds for critically unwell patients. In addition, it supports the implementation and curation of national registry networks for critical care, cardiology and perioperative medicine in Sri Lanka, Pakistan, India, Sierra Leone and Ethiopia. More recently NICST has partnered with Doctors with Africa, an Italian NGO to support quality improvement for acute care in 6 countries in sub-saharan Africa. The organisation successfully provides opportunities for fellowships which offer exchange experiences for LMIC based healthcare workers, including eight MSc students from LMICs and HICs who have all successfully completed projects in global health, implementation science and quality improvement.

Abi commenced her PhD at the Academic Medical Centre, University of Amsterdam, (promotors; Professor Constance Schultsz, Professor Arjen M Dondorp, co-promotors; Dr Chris Pell, Dr Rashan
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Haniffa) in 2017. She has studied health systems research methods to evaluate and improve the quality of acute and critical care. She has developed and successfully implemented the components of a learning health system; electronic data surveillance platform which provides real time feedback of clinical and service information to healthcare stakeholders in acute medical and surgical care; a national training programme for newly qualified doctors transitioning from training to clinical practice and an undergraduate medical curriculum focused on integrating decision making and clinical reasoning to improve patient safety within mainstream medical education in Sri Lanka. Her work has contributed to an international network of 150 acute and critical care units in 5 countries including Sri Lanka, Pakistan, India, Sierra Leone and Ethiopia, for which the NICST team now provides technical and research support for service evaluation and quality improvement. This formative work has contributed to helping secure a Wellcome Flagship Innovations grant, led by Mahidol Oxford Tropical Network Research Unit, Thailand and Oxford University, which in partnership with collaborators within the network aims to expand, strengthen and develop research and quality improvement in nine countries in South and South east Asia. Abi spends her time between South Asia and the UK, where she lives on her beloved traditional narrow boat ‘Galloper’ in the heart of London’s Regent’s canal.

Grants

Wellcome Innovations Flagship Grant 2019. Project co-lead. Critical Care Network Asia. Wellcome Oxford. £4.9 million

Wellcome Oxford ITPA Grant 2018. Joint lead. Scalability of ICU registry platform South Asia. £45,000

National Science Foundation - Grant RPHS/2016/CKDu02- Dec 2016- Co-Investigator. The burden of CKD/CKDu on dialysis units in Sri Lanka £ 12,000

National Science Foundation- Grant RPHS/2016/C01- Dec 2016- Co-Investigator. Development of a web-based live updated cancer patient system. £12,000

Awards

Intensive Care Society UK Gold Medal Award for Research: Winner. 2019

Commonwealth Awards for health innovations, South Asia. 2017

Award for innovations and advancement in education. BACCN Winner 2017
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PORTFOLIO

Abi Beane
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Portfolio

<table>
<thead>
<tr>
<th>General courses completed</th>
<th>Workload/ Hours / ECTS</th>
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<tbody>
<tr>
<td>Queen Mary’s School of Medicine Research methodologies workshop</td>
<td>27 hrs 0.9</td>
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<tr>
<td>Institute of Health Improvement ‘improvement capability course with the online school’</td>
<td>12 hrs 0.4</td>
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<table>
<thead>
<tr>
<th>Seminars, workshops and master classes</th>
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<tbody>
<tr>
<td>ISN World Congress of Nephrology: Establishing registries</td>
<td>16 hrs 0.8</td>
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<tr>
<td>Data science workshop. Technologies Trust</td>
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<tr>
<td>Critical care Datathon, Health Informatics team, University College London</td>
<td>20 hrs 1</td>
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<tr>
<td>World Congress, Melbourne, Australia</td>
<td>24hrs 0.75</td>
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<tr>
<td>SAARC Critical care Society Conference, Lahore Pakistan.</td>
<td>24hrs 0.75</td>
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<tr>
<td>Singapore ANZICS. Singapore</td>
<td>24hrs 0.75</td>
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<tr>
<td>National Outreach Forum and</td>
<td>16 hrs 0.50</td>
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</tbody>
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Critical care Society Conference
Manchester

Criticon, Bangladesh Society of Critical Care Medicine, Dhaka. 2018
24hrs 0.75

APICON Critical care and
Anaesthesia Conference 2018 16 hrs 0.50
Pakistan.

AAGBI World Anaesthesia
Society Seminar. 2017 8hrs 0.25
National Trauma Conference, UK
Trauma and Research council,
Sheffield. 2017 8hrs 0.25

Presentations (invited speaker)
World Congress, Melbourne,
Australia: Quality in Critical care 2019 14 hrs 0.5
Chair: Technology in Critical care
Chair: Nurse academics in Critical care

SAARC Critical care Society
Conference, Lahore Pakistan. 2019 14 hrs 0.5

Singapore ANZICS. Singapore 2019 14 hrs 0.5

National Outreach Forum and
Critical care Society Conference
Manchester, UK 2018 14 hrs 0.5

Criticon, Bangladesh Society of
Critical Care Medicine, Dhaka, 2018 14 hrs 0.5
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Bangladesh

APICON Critical care and Anaesthesia Conference, 2017
Peshawar, Pakistan.  
14 hrs  
0.5

AAGBI World Anaesthesia Society Seminar, London, UK
2017  
14 hrs  
0.5

National Trauma Conference, UK
Trauma and Research council, 2017
Sheffield, UK
2017  
14 hrs  
0.5

Programmes founded and chaired

Critical care for Nurses, Dhaka, Bangladesh
2018  
56 hrs  
2

Care Quality Improvement Collaborative: 2 day international workshop attended by 52 acute care healthcare delegates to gain skills in quality improvement and data science
2018  
56 hrs  
2

Research Methods Workshop
A series of 1 day workshops conducted annually 2017-2019 to provide skills in basic research
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methods for allied healthcare professionals in Sri Lanka. 2017 28 hrs 1
2018 28 hrs 1
2019 28 hrs 1

Data science for Doctors, in collaboration with the Technologies trust and University College London Hospital.

2017 56 hrs 2

Lecturing

University College London, Department of Perioperative Medicine and interventional Services 2018-2019 28 hrs 1

MSc Critical Care. Queen Mary’s School of Medicine and Dentistry 2017-2018 28 hrs 1

MSc Global Health. Vrije Universiteit Amsterdam 2018-2019 28 hrs 1

AIGHD and Duke University, Undergraduate medical programme. Global Health Exchange 2018 28 hrs 1

Teaching

University of Kelenyia
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Undergraduate medical Student programme

*Clinical Skills teaching* 2017-2019 56 hrs 2

University of Colombo
Postgraduate Institute of Medicine

*Simulation in Education training as part of the medical education curriculum.* 2017-2019 56 hrs 2

Mentoring and Supervising

Vrije Universiteit Amsterdam
Global Health MSc

*Ms Laura Shackmann*

*Ms Sitara Khan* 2018 28 hrs (x2) 2

University College London
MSc Human Computer Interaction.

*Ms Nikashani Srishanan* 2018 28 hrs (x3) 3

*Ms Talia Craiu*

*Ms Lui Chan*

University College London MSc Perioperative Medicine.

*Dr Vihara Dassanayake*

*Dr Samuel Miranda* 2018-2019 28 hrs (x2) 2
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Other

Co-founder LOGIC International network for ICU improvement and benchmarking.

Peer reviewer for international journals

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<th>Journal</th>
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<td>BMJ Global health</td>
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<tr>
<td>BMJ Open</td>
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<td>Brasileira de terapia</td>
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<td>Journal of Intensive Care</td>
<td>2019</td>
<td>14 hrs</td>
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</table>

ECTS total 38.6
CONTRIBUTING AUTHORS
Appendices

Abayadeera, AU  
Department of Surgery, University of Colombo, Colombo, Sri Lanka

Athapattu, PL  
Ministry of Health, Colombo, Sri Lanka

Colombage, Don DE  
Institute of Cardiology, National Hospital Sri Lanka, Colombo, Sri Lanka

De Silva, AP  
National Intensive Care Surveillance, Ministry of Health, Colombo, Sri Lanka

De Silva, N  
Monaragala District General Hospital, Monaragala, Sri Lanka

Deshani, EM  
Institute of Cardiology, National Hospital Sri Lanka, Colombo, Sri Lanka

Dondorp, AM  
Department of Critical care and Malaria, Mahidol Oxford Tropical Medicine Research Unit, Bangkok, Thailand

Haniffa, R  
Mahidol Oxford Tropical Research Unit, Bangkok, Thailand. Network for Improving Critical Care Systems and Training, Colombo 08, Sri Lanka

Hashmi, M  
Founder, PRICE registry and South East Asia Research collaboration. Karachi, Pakistan

Jayasingha, AS  
Monaragala District General Hospital, Monaragala, Sri Lanka

Jayasinghe, K SA  
Department of Clinical Medicine, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka

Karunarathne, S  
Institute of Cardiology, National Hospital Sri Lanka, Colombo, Sri Lanka

Khan, Z  
Queen Elizabeth Hospital, Birmingham, UK

Mahipala, PG  
Office of Director General of Health Services, Ministry of Health, Colombo, Sri Lanka

Memon, MI  
Shaheed Zulfiquar Ali Bhutto Medical University, Islamabad, Pakistan

Mirando, S  
Centre for Perioperative Medicine, Division of Surgery and Interventional Science, University College London, London, UK

Munasinghe, SB  
Network for Improving Critical Care Systems and Training, Colombo 08, Sri Lanka

Padeniya, A  
Department of Clinical Medicine, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka
Appendices

Ponnamperuma, CJ
Institute of Cardiology, National Hospital Sri Lanka, Colombo, Sri Lanka

Priyadarshani, GDD
Network for Improving Critical Care Systems and Training, Colombo 08, Sri Lanka

Ranasinghe, G
Institute of Cardiology, National Hospital Sri Lanka, Colombo, Sri Lanka

Rashan, A
Network for Improving Critical Care Systems and Training, 2nd Floor, YMBA Building, Colombo 08, Sri Lanka

Rathnayake, RMD
Monaragala District General Hospital, Monaragala, Sri Lanka

Rathnayake, S
Information and Communication Technology Agency of Sri Lanka, Columbo, Sri Lanka

Schultsz, C
Department of Global Health - AIGHD Amsterdam UMC, University of Amsterdam, Amsterdam, The Netherlands

Sigera, PC
Network for Improving Critical Care Systems and Training, 2nd Floor, YMBA Building, Colombo 08, Sri Lanka

Stephens, T
Queen Mary University of London, UK

Taqi, A
National Hospital and Medical Centre, Lahore, Pakistan

Thilakasiri, K
Department of Medicine, National Hospital Sri Lanka, Colombo, Sri Lanka

Udayanga, I
Network for Improving Critical Care Systems and Training, 2nd Floor, YMBA Building, Colombo 08, Sri Lanka

Vithanage, TDP
Institute of Cardiology, National Hospital Sri Lanka, Colombo, Sri Lanka

Wagstaff, D
PQIP, National Institute of Academic Anaesthesia Health Services Research Centre, Royal College of Anaesthetists, London, UK

Walker, D
Anaesthesia and Critical Care Medicine, University College London Hospitals, London, UK

Weerasinghe, T
Network for Improving Critical Care Systems and Training, 2nd Floor, YMBA Building, Colombo 08, Sri Lanka
Appendices

Weeratunga, PID
Department of Surgery, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka

Wijerathne, M
Department of Surgery, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka
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PUBLICATIONS

ORCID https://orcid.org/0000-0001-7046-1580
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G Ranasinghe, TD Vithanage, A Beane, S Mendis, Amarasekera, Fernando, M. Rajakanthan, K. Ponnampuruma, Hassan, MH M. Haniffa, Institute of Cardiology, National Hospital of Sri Lanka/ 2019 Sri Lanka STEMI Forum


