RTI #5284 Release Notes

RTI #5284 - A copy of the review of the Queensland Adult Deterioration Detection System, including any documents commenting about the research. - Relevant to QTenders Request for Offer QCHO/010653.

Purpose of release notes

The purpose of these release notes is to provide information and attachments pertaining to the review of the Queensland Adult Deterioration Detection System (Q-ADDS), including any documents commenting about the research. This is relevant to QTenders Request for Offer QCHO/010653 Q-ADDS which closed 9 December 2016, and was awarded to Central Queensland University in August 2017.

Background

- In August 2015, the Office of the State Coroner recommended the following from the findings of an inquest:
    - Conduct research into the validation of the Q-ADDS tool.
    - Conduct research to identify and address the sociocultural factors that influence compliance with existing hospital care escalation systems.

      (https://www.courts.qld.gov.au/__data/assets/pdf_file/0004/435073/cif-wright-vd-carter-jl-20150828.pdf)
- In November 2016, in response to the recommendations, Queensland Health released a Request for Offer (RFO) facilitating an open market procurement process (Tender RFO010653) seeking offers to conduct research to validate the Q-ADDS, and identify and address socio-cultural factors influencing compliance with existing hospital care escalation systems.
- In August 2017, Central Queensland University was awarded the tender and subsequently commenced the research.
- In August 2018, the Department of Health also engaged the University of Chicago, to undertake a comparison study of Q-ADDS and variants of Q-ADDS to other commonly used prediction scoring tools which detect adult clinical deterioration. This research compliments the validation research undertaken by Central Queensland University.

Information to be provided

The following document was held:

- Central Queensland University research results and report:
    - Final Report – Chart Validation Report (Part A) and Socio-cultural Study Report (Part B) (Attachment 1)

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Validating the Queensland Adult Deterioration Detection System (Q-ADDS)

Part A
Chart Validation Report

Part B
Socio-cultural Study Report

Prepared by:

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Executive Summary

Background

Contemporary evidence indicates that changes in physiological observations, recorded as vital signs, commonly precede serious adverse events such as cardiac or respiratory arrest, or unexpected death for up to 48 hours before the adverse event occurs. This suggests that if patients are appropriately monitored, deterioration is able to be recognised as it occurs, meaning treatment can be delivered early and effectively. In light of this, most hospitals now insist that an early warning tool be utilised in order to detect clinically deteriorating patients. In most Queensland health facilities, the early warning tool employed is the Queensland Adult Deterioration Detection System (Q-ADDS). Whilst published studies report the efficacy of early warning tools such as Q-ADDS to identify the deteriorating patient, the tools are only truly valuable when they correctly detect deterioration and staff comply with the escalations system. In light of this, the study set out to address these two important aspects of the Q-ADDS tool.

Significance of the study

Validating the Q-ADDS tool to maximise the ability of the tool to identify clinical deterioration will facilitate early recognition of deterioration of in-hospital patients. This in turn activates potentially lifesaving intervention judiciously, thereby enhancing patient safety and positive patient outcomes. Early intervention prevents unplanned intensive care unit admissions, reduces hospital length of stay times and reduces mortality rates.

Aims of the Study

The overarching aim of this study was to examine the effectiveness of the Queensland Adult Deterioration Detection System (Q-ADDS) to detect adult clinical deterioration within Queensland Hospital and Health Services. This study took a mixed methods approach with distinct methods; a retrospective chart review, quantitative survey (closed and open-ended responses) and a qualitative component using interviews.

The research questions:

RQ1 – Retrospective chart review: How effective is the Q-ADDS scoring system in detecting adult clinical deterioration?

RQ2 - Survey: What are the contributing factors to health professionals' intentions to compliance with the use of Q-ADDS?

RQ2 - Interviews: What are the socio-cultural factors influencing health professionals' compliance with the use of Q-ADDS?

Project Approach

This study adopted a mixed methods approach with two distinct parts.

Part A: Validation study (Retrospective chart review (RCR): Quantitative)

Part A examined the effectiveness of the Queensland Adult Deterioration Detection System (Q-ADDS) to detect adult clinical deterioration within Queensland Hospital and Health Services (HHS) sites. *Part A* retrospectively reviewed existing adult patient observation charts for two distinct groups of patients: index and control groups. The index group consisted of patients with a documented serious adverse event (SAE) during their admission. For this study a SAE was considered as those patients reaching the Medical Emergency Team (MET) threshold and triggering a MET call or, in smaller facilities, those patients requiring transfer out to another facility. The control group consisted of patients who had not experienced an SAE during their admission. Patients from the control group were demographically and diagnostically matched to the index patients as well as to the admitting facility. Groups were compared to determine: how often the Q-ADDS charting system correctly identified clinical deterioration, if the charting system incorrectly identified patient deterioration, and if the Q-ADDS charting system missed deteriorating patients.

Part B: Socio-cultural study (Survey and interviews: Qualitative and Quantitative)

Part B: Socio-cultural study identified the socio-cultural factors influencing health professional compliance with the use of Q-ADDS. Health care professionals working at the study sites, responsible for completing the Q-ADDS charts, were invited to participate in an anonymous online survey. The survey was developed to identify cultural and educational influences affecting completion of the form (including escalation culture). The survey included questions around Q-ADDS chart training and ascertained if present training systems satisfactorily captures all relevant employees. At the completion of the survey, participants could register their interest to participate in a confidential one-on-one interview to explain the factors that influence their compliance with the use of the Q-ADDS.

Summary of findings

Organisational factors impact the use of the Q-ADDS at individual and team levels. Human factors influence the monitoring and recording of observations through to how teams, individuals and the organisation respond. These multifactorial interactions make it problematic when providing a definitive or absolute decision about the performance of the Q-ADDS to predict clinical deterioration. For this reason we adopted a pragmatic approach to provide insight into the socio-cultural factors that influence staff compliance.

The Q-ADDS scoring component of the system is a tool for generating an overall number or score to monitor for clinical deterioration or a serious adverse event (SAE). In this study SAE was considered in the metropolitan setting as patients meeting Q-ADDS threshold and triggering a Medical Emergency Team (MET) response or a transfer out to a higher care facility in the rural facilities. We found that the total Q-ADDS scoring system, when compared to several benchmarks (computer generated 'ideal' models), and compared against individual observations, clearly does provide value when monitoring for clinical deterioration. At the time of the SAE, 78 per cent of people who reach threshold and trigger a MET will have a higher Q-ADDS score than the people who are not having an SAE. While the Q-ADDS scoring system appears to decrease in predictive accuracy at increasingly distal time-points from SAE, it still has an above chance rate of predicting an SAE at all time-points in the 24 hours prior to the SAE. While the overall score performs well, no singular vital sign observation is able to predict whether a person will have an SAE; there was also very little collinearity between the individual observations. The respiratory and heart rates both showed the strongest linear effects in predicting patient category (SAE or no SAE). Differences were noted between Rural and Metropolitan areas with Metropolitan patients recording both an overall higher Q-ADDS score at all-time points preceding the SAE and at the time of the SAE (MET call or transfer out). While not the aim of this study, lower Q-ADDS scores at time of SAE (transfer out) noted in the rural facilities may reflect adequate tracking of patient deterioration and transfer of the patient out of the rural facility prior to the patient meeting Q-ADDS MET call threshold.

The Q-ADDS as a whole is performing well with staff recognising and valuing its contribution to monitoring and escalation of care. While staff have a strong intent to comply with the Q-ADDS, key drivers of compliance were the quality (as opposed to quantity) of training, personal attitudes, and previous compliance with monitoring and escalation. At an individual level, there was complacency around recording and reacting to 'a number' through to acceptance or not accepting the inherent challenges associated with forced nature of compliance and its impact on the activation of individual clinical reasoning skills. Teamwork and communication, within and between professional groups (professional hierarchies), within local areas (wards) and between wards areas all influence monitoring and escalation. Nested within the organisation as a whole, organisational contextual factors such as targeting training to meet the needs of staff (not the quantity of training), workplace satisfaction and resources ultimately influence individual and team compliance.

List of Abbreviations

AIC	Akaike Information Criteria
AUC	Area Under the Curve
CART	classification and decision tree
CCU	Cardiac Care Units
CSCF	Clinical Services Capability Framework
DRG	Diagnostic Related Groups
EAS	Employee assistance service
ED	Emergency Department
EDIS	Emergency Department Information System
EN	Enrolled Nurse
EWS	Early Warning System
GT	Grounded Theory
HBCIS	Hospital Based Corporate Information System
HHS	Hospital and Health Services
HDU	High Dependency Unit
HREC	Human Research Ethics Committee
ICD	International Classification of Diseases
ICU	Intensive Care Unit
LR	Linear Regression
MO	Medical Officer
MET	Medical Emergency Team
MEWS	Modified Early Warning Score
NEWS	National Early Warning System
NSQHS	National Safety and Quality Health Service
PHA	Public Health Act
Q-ADDS	Queensland Adult Deterioration Detection System
RCR	Retrospective Chart Review
RF	Random Forest
RRMA	Rural, Remote and Metropolitan Areas
RN	Registered Nurse
RRT	Rapid Response Teams
SAE	Serious Adverse Events
S & S	sensitivity and specificity
TPB	Theory of Planned Behaviour
TTS	Track and Trigger Systems
URN	Unit Record Number
VIEWS	VitalPAC Early Warning Score

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Background

International health care organisations maintain that recognising and responding to a clinically deteriorating patient is essential if safe and high-quality care standards are to be achieved (Australian Commission on Safety and Quality in Health Care [ACSQHC], 2012; National Institute for Clinical Excellence, 2007; National Patient Safety Agency, 2007; Thompson, 2007). Contemporary evidence indicates that changes in physiological observations, recorded as vital signs, are commonly apparent in the 48 hours preceding a serious adverse event (SAE) such as unexpected admission to intensive care, cardiac or respiratory arrest, or death (Bellomo et al., 2004; Donnelly et al., 2012; Padilla & Mayo, 2017). This suggests that if deterioration is recognised early and is appropriately managed, then complications arising from delays could be reduced (e.g. morbidity, unexpected ICU admissions, extended length of stays in hospital), and some SAEs could potentially be avoided altogether (Bellomo et al., 2003, Bellomo et al., 2004, Ballester et al., 2018).

Changes to parameters such as blood pressure, respiratory rate, level of consciousness, pulse rate and temperature can all provide an indication of a patient's health status (Buist et al., 2004; Franklin & Mathew, 1994; Loughlin, Sebat, & Kellett, 2018). In order to detect any deviation from within normal ranges, track and trigger systems (TTS) or early warning systems (EWS) are routinely used in healthcare facilities. Typically paper-based observation charts, these systems comprise of pre-specified thresholds for seven vital signs including: respiratory rate, oxygen (O_2) saturation, O_2 requirements, blood pressure, heart rate, temperature, and level of consciousness. When patients' vital signs are collected, each physiological parameter is allocated a score, which, when combined, may trigger an escalation in patient care if pre-determined thresholds are met (Day & Oxton, 2014; Wuytack et al., 2017). Depending on the score, escalation strategies can range from increasing the regularity of vital sign observations to triggering a Medical Emergency Team (MET) response.

Worldwide, different versions of EWS exist within different healthcare systems (Downey et al., 2017). These include scoring systems used internationally such as the Modified Early Warning Score (MEWS) and VitalPAC Early Warning Score (VIEWS), which have been validated as good predictors of mortality during hospitalisation (Bleyer et al., 2011). In the United Kingdom, individual hospitals developed their own EWS which resulted in large variations in patient outcomes. This inconsistency in reporting and outcomes contributed to the development of a National system in 2012 (Day & Oxton, 2014). Widely adopted throughout the UK National Health Service, the National Early Warning System (NEWS) has

enhanced the ability of staff to accurately identify deteriorating patients without increasing workload (Royal College of Physicians, 2017).

In Queensland Australia, the Queensland Patient Safety Centre released a strategy paper discussing gaps in the recognition and management of the deteriorating patient and recommended the adoption of a chart system similar to the National ADDS chart system of detection (Patient Safety Care., 2010). Within Queensland, Australia, the most prevalent EWS adopted for use in public hospitals is the Queensland Adult Deterioration Detection System (Q-ADDS).

Initially implemented at Logan hospital emergency department in 2013 (Wynne & Farrel, 2015) the Q-ADDS incorporates both single and multiple parameter systems (Preece et al., 2012; Preece et., 2010). Scores from each set of vital sign observations are summed to provide an overall indication of the patient's condition. Using colour coding, deviation into various colour zones on the chart requires clinicians to follow pre-determined escalation protocols that range from increased observations to activation of a medical emergency team (MET) call and response (Horswill et al., 2010; Preece et al., 2012). The Q-ADDS is also a single parameter trigger system, meaning a single vital sign reaching a specific threshold can also trigger a MET call.

Early warning systems (EWS) have been reported as having a considerable advantage over traditional methods of referral (Marshall et al., 2011). However, a recent review found that despite 20 years of study, there is mixed evidence on the effectiveness of these systems' capacity to reduce patient mortality (Chua et al., 2017; Douglas et al., 2016; Sandroni & Cavallaro, 2011). Despite patients meeting the escalation criteria, there is evidence that EWS are not being triggered due to a delay by clinicians or a failure to activate (Marshall et al., 2011; Sandroni & Cavallaro, 2011). One epidemiology review of adult rapid response team patients in Australia revealed that close to 50% of the activations were delayed (Jones, 2014) and it has previously been found that EWS protocols were not being followed 40% of the time (Petersen et al., 2014).

An Australian Quality and Health Care study revealed that despite the introduction of EWS and MET teams in most public hospitals, 80% of SAEs remain preventable and almost 14% of deteriorating patients are not appropriately treated (Shearer et al., 2012). Shearer et al. (2012) reported that this was explained by factors such as: staff thought the situation was under control, fear of reproach, inadequate patient monitoring, and poor communication. It was concluded that a clearer understanding of the sociocultural factors may better explain the problems associated with using charts such as Q-ADDS. Further to this point, research suggests that intra-professional hierarchical systems within medical facilities are a major

contributor to the failures in the management of patient deterioration (Lippert & Petersen, 2013; Pedersen et al., 2018).

The value of detecting clinical decline early is evident with literature revealing that a high percentage of patients admitted to hospital wards from emergency departments are likely to meet the criteria for an emergency call within hours of arriving on the wards (Considine et al., 2017). Further, it is understood that the in-hospital mortality rate for patients who go on to trigger an emergency review can be as high as 34% (Buist et al., 2004; Buist et al., 2002; Calzavacca et al., 2010; So, et al., 2015). The factors that influence the use of these systems are generally thought to be sociocultural (So et al., 2015)

Based on current knowledge, there is ample evidence that the implementation of EWS (such as the Q-ADDS) does help to identify patients at risk and reduce patient mortality (DeVita et al., 2004; Missen et al., 2018; Wakefield, et al., 2010; Wuytack et al., 2017). However, as the efficiency of the system is dependent on its users, further investigation is required to gain an understanding of compliance with the system. Human error such as: inadequate nursing skills, infrequent patient monitoring, poor documentation, and a lack of timely action have all been shown to contribute to unrecorded patient deterioration (De Meester et al., 2013; Flenady et al., 2017a, 2017b; Fuhrmann et al., 2008). Perceived usefulness is also dependent on the accuracy of the recorder and elimination of user error (Downey et al., 2017; Flenady et al., 2017b).

In addition to cognitive failure (minor error in thinking) or human error (unintentional action or decision) which can result in a failure to recognise the need for to escalate care, professional hierarchies have also found to be strong drivers for differences in compliance between EWS and protocols (Chua et al., 2017; Shearer et al., 2012). Studies have suggested that junior physicians were reluctant to breach the traditional system of patient management while nurses feared being reprimanded if they alerted a MET and bypassed physicians (Boniatti et al., 2014; Douglas et al., 2016; Shapira-Lishchinsky, 2012).

The perception of the general culture within a unit or an organisation is known to influence clinical performance (Braithwaite et al., 2017). A recent study stated that the culture within hospitals has an impact on the work of clinical teams and their compliance to systems, suggesting that the approach of senior leaders can ultimately influence this culture (Mannion & Smith, 2018). Beneficial cultural aspects of a hospital may include influencing factors such as: fostering a learning environment, providing support services, and allowing staff to feel safe enough to speak up when they feel things are wrong (Mannion & Smith, 2018). The degree to which healthcare staff feel part of the general culture within their workplace ultimately influences their attitudes, beliefs, and values (Wakefield et al 2010). Safety culture

has been described as the 'way we do things around here' and this behaviour has been analysed to detect the proportion of clinical staff engaged in patient safety behavioural intent (Wakefield et al., 2010). The Queensland study found that each of the professional subgroups had a unique model of factors which influenced their intention to engage in patient safety behaviours, with senior nurses six times more likely than junior doctors to apply patient safety behaviours (Wakefield et al., 2010). Whilst experienced nurses were more likely to correctly respond to patient deterioration, some studies reported their reluctance to trigger an escalation of patient's care for fear of reprimand from senior physicians (Chen, 2017; Douglas et al., 2016).

Failure to comply with chart systems has been shown to be influenced not only by the collective culture within the unit but also due to specific characteristics of individuals within the unit, however these characteristics are not well understood (Astroth et al., 2017; Chalwin etal., 2016; Jenkins, Thompson, & Barton, 2011; Leach & Mayo, 2013). Nurses have reported physician influence, nurse education, and nurse experience as influencing their decision-making when using EWS (Padilla et al., 2018). The factors most often described include: the perception and experience of the clinician in the decision making process, and how these human factors relate to the culture, and the technology and environment of the workplace (Chua et al., 2017).

Whilst there is extant research highlighting the contribution of socio-cultural factors among health professionals to non-compliance with EWS protocols, more work is required to understand the relationships between these factors and the magnitude of their effect on EWS compliance. Further, little is known about the behaviours and rationales clinicians' employ when deciding to comply or not with tools such as Q-ADDS. Exploring these perceived socio-cultural barriers to compliance with EWS activation may contribute to interventions to the structure, training or deployment of EWS which may potentially decrease adverse patient outcomes.

Based on the research to this point, the overarching study aim was to validate the effectiveness of the Q-ADDS by examining three main questions. How effective is the Q-ADDS scoring system in detecting adult clinical deterioration? What are the contributing factors to health professionals' intentions to comply with the use of Q-ADDS? What are the socio-cultural factors influencing health professionals' compliance with the use of Q-ADDS?

Methods

This mixed methods study adopted a pragmatic approach to answer the research questions. Given the extent of the problem and the paucity of empirical evidence evaluating the

effectiveness of the Q-ADDS, neither quantitative nor qualitative methods alone could adequately address the complexity of the research questions. Therefore, this study has adopted a convergent parallel mixed methods approach with two distinct parts. *Part A: The Validation Study* used a Retrospective Chart Review (RCR) of Q-ADDS charts to examine the effectiveness of the Queensland Adult Deterioration Detection System (Q-ADDS) to detect adult clinical deterioration within 15 Queensland Health Hospital sites.

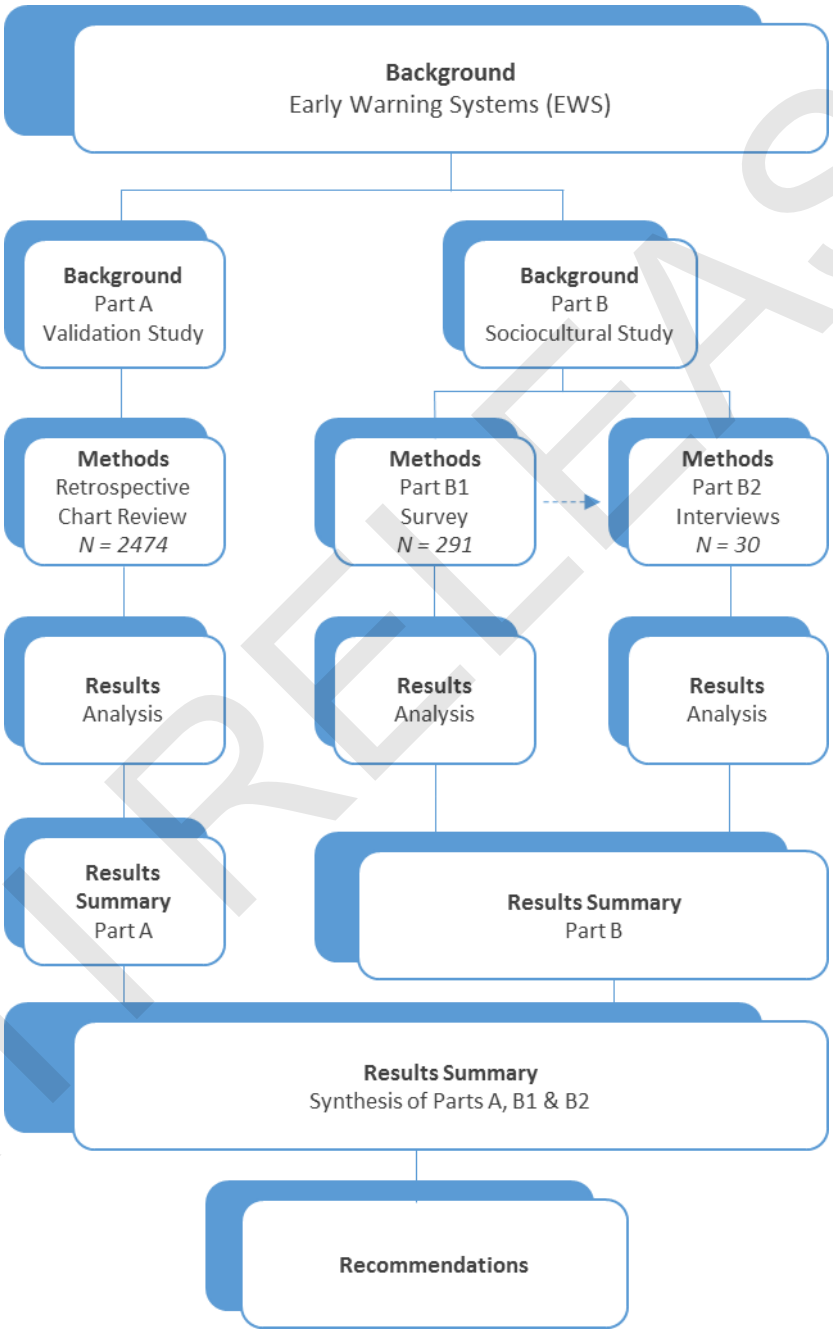

Figure 1: Schematic Diagram of the Research process for the Q-ADDS Validation project.

Part B: The Sociocultural Study component of the study followed an explanatory sequential approach and consisted of a survey with open and closed ended responses (quantitative/qualitative data) (*Part B1*) follow by qualitative Interviews (Part B2) to help explain or elaborate on the findings from the survey Part B1 (Figure 1). Datasets from *Part A* and *B* were analysed separately and then interpretations made to determine whether the results support or contradict each other (convergence of data) and provide a contextualised understanding of the compliance with Q-ADDS as a whole (Creswell et al. 2011).

Part A: Chart Validation Study

Design

Part A consisted of a retrospective chart review (RCR) (Vassar & Holzmann, 2013) of paper-based, pre-recorded adult patient Q-ADDS charts (Madden et al., 2018). Also known as a clinical audit, chart audit or medical record review, a RCR is rapidly gaining support as an appropriate research design to evaluate health care delivery (Vassar & Holzmann, 2013; Madden et al., 2018). There are several benefits to utilising this method to answer research questions: 1) the data are already collected, 2) the data can be of extremely high quality, although this depends on the original data collection methods and storage/retrieval fidelity (Kaji et al., 2014). In order to avoid the common methodological mistakes and omissions, the RCR methodology adopted in this study broadly followed the steps as outlined by Vassar and Holzmann (2013). These steps included:

- well-defined, clearly-articulated research questions
- well-considered sampling needs
- specialised training/briefing packages for all data abstracters
- standardised audit tools ensuring all data were abstracted consistently
- substantiated and well-articulated inclusion and exclusion criteria
- pilot study
- well-considered confidentiality and ethical issues

Part A: Research question

Population and sample

The population for this study was adult patients (over 18 years of age) admitted to Queensland Health Hospitals that use the Q-ADDS. Patient medical records from this overall

population consisted of two patient subgroups, index and control groups. The Index group were patients who reached MET threshold, triggering a MET review. Herewith the Index group will be referred to as severe adverse event (SAE) (regional and metro sites only; *see Table 1*), and/or patients who required transfer to a higher acuity facility during their admission (rural and or remote sites; *see Table 1*). The control group consisted of patients who did not experience a SAE during their admission. This second group were demographically and diagnostically matched to the index patients as well as to the admitting facility.

According to the 2016 Queensland Health report on "The Health of Queenslanders" (Queensland Health, 2016), there were 28,704 deaths in 2014 and the leading broad causes were malignant cancers (8712 deaths) circulatory/cardiovascular diseases (8330 deaths), respiratory conditions (2372 deaths) or total injuries (1930 deaths). A representative sample was chosen from three distinct International Classification of Disease (ICD) categories including: circulatory/cardiovascular, respiratory, and sepsis (*Figure 2*). There was no active recruitment of participants in *Part A*.

International Classification of Diseases (ICDs)

A list of International Classification of Diseases (ICDs) was used to guide our data mining (Figure 2*)* when selecting patient groups. Figure 2 shows the complete list of ICDs under the respiratory, cardiac and sepsis headings used in this study to identify patients of interest. The entire list was included so as not to miss any admissions related to respiratory, cardiac or sepsis issues. Another motivation for incorporating the entire list was to ensure the maximum number of index patients were included in the analysis.

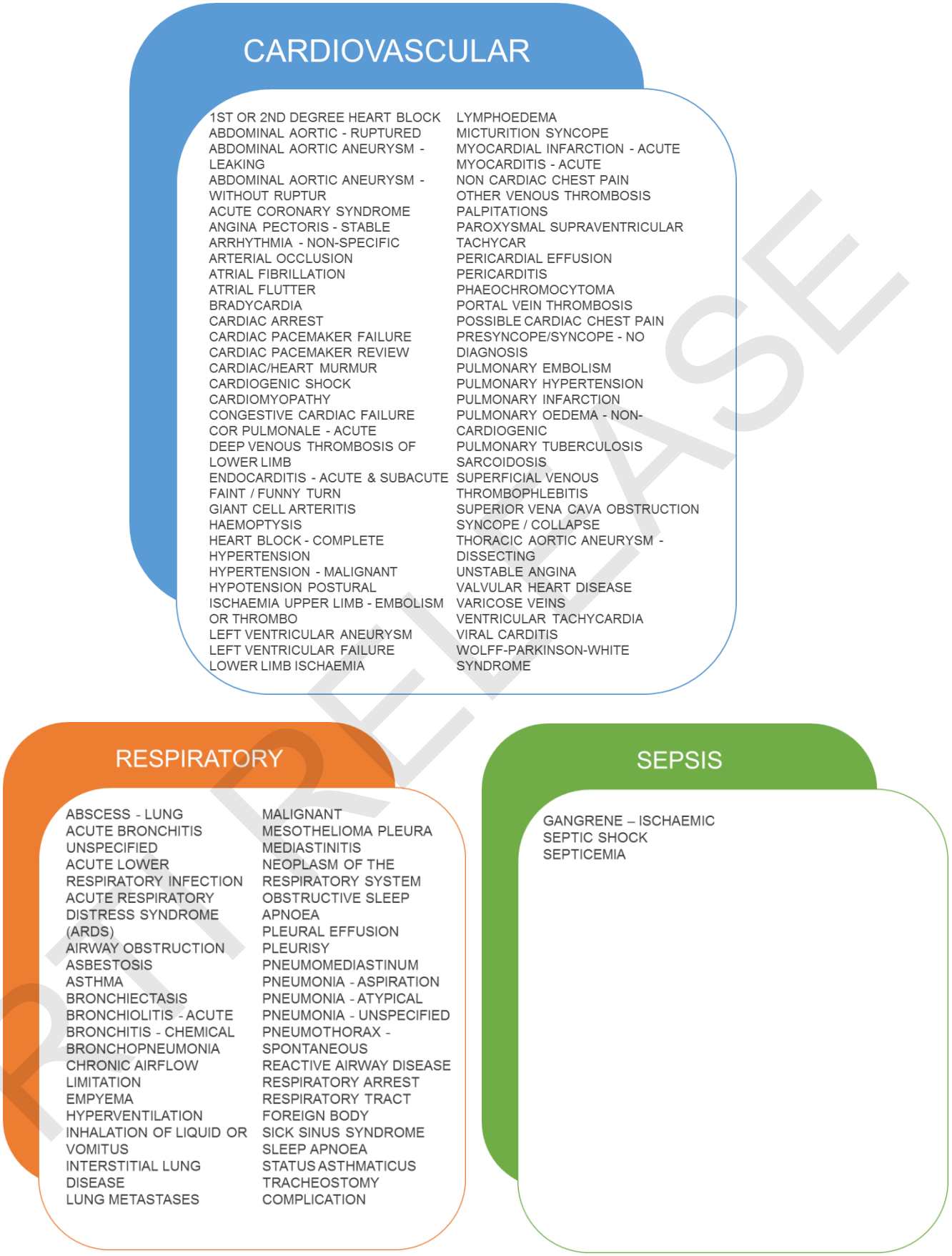

Figure 2*:* The list of ICDs used to guide data mining. This is the complete list of ICDs under the respiratory, cardiac and sepsis headings.

Sampling Study Sites

In order to adequately reflect the diversity of Queensland Health's public sector health services, stratified numbers of charts were required from tertiary, secondary, rural and/or remote facilities, ensuring a comprehensive analysis occurred. The research team considered it integral to the project that data be collected from at least one location in all of Queensland's 15 Adult Hospital and Health Services (HHS). When consideration was given to the inclusion of sites from each region, the Clinical Services Capability Framework (CSCF) (Queensland Health, 2014) and the RRMA (Rural, Remote and Metropolitan Areas) were utilised. RRMA is the oldest remoteness classification system, developed in 1994 by the Department of Primary Industries and Energy, and the then Department of Human Services and Health (DPIE & DHSH, 1994, 1991). RRMA's Index of remoteness is based on distance to service centres as well as a measure of 'distance from other people'. RRMA classifies Statistical Local Area (SLA) as metropolitan ('capital cities' or 'other metropolitan areas'), rural ('large rural centres', 'small rural centres' and 'other rural areas'), and remote ('remote centres' and 'other remote areas'). The RRMA measure of remoteness is based on population estimates from the 1991 census.

The Clinical Services Capability Framework (CSCF) outlines the minimum requirements for the safe provision of health services in Queensland public and licenced private health facilities. Table 1 summarises the clinical services by capability level (Queensland Health Fact Sheet 4 – See Appendix) utilised in this study. Only facilities that use a paper based EWS (funding body requirement) and provide emergency services at a minimum of level 2 were included. Sites that utilise electronic tracking EWS were excluded from the study. Whilst the goal was 15 facilities the final study included 13 QLD Health hospitals (Table 1):

- 1 Major and 3 Large Metropolitan tertiary HHSs (capital cities or other metropolitan areas),
- 2 Large regional HHSs (large rural centres)
- 3 Regional HHSs (small rural centres and other rural areas), and
- 4 Small HHS (remote centres and other remote areas)

Index charts were collected between 1st October 2016 and 30th September 2017. Control charts were subsequently chosen with analogous diagnoses and demographics for each index chart. In total, 2474 patient charts were collected from the 13 sites. This was the maximum available and approximated the number of charts required for most sites (Table 1).

Table 1: The QHHS sites included in the study.

HHS	Pop (2016)	Bed ranges	Annual Admissions (2016/2017) AIHW[#]	% of total admissions	***PART A*** **Charts[&]**		***PART B1*** **Survey**		***PART B2*** **Interviews**
					Target	Achieved	Achieved		Achieved
Innisfail - Small	7847	50 - 99	5993	1.19%	40*	38	Rural / Small Regional	51 *(19%)*	8
Proserpine – Small	3562	<50	5311	1.06%	36*	53			
Longreach – Small	3137	<50	1311	0.26%	10*	33			
Charleville – Small	3728	<50	1417	0.28%	10*	37			
Cooktown – Small Regional	2339	<50	1679	0.33%	10*	20			
Cloncurry – Small Regional	2796	<50	824	0.16%	6*	22			
Charters Towers – Small Regional	8234	<50	1753	0.35%	12*	28			
Rockhampton - Large Regional	80665	200-500	40427	8.06%	326	277	Large Regional	92 *(33%)*	16
Hervey Bay - Large regional	53328	100 - 199	26319	5.25%	174	-			
Toowoomba - Large regional	115868	200-500	52231	10.41%	346	480			
Sunshine Coast Uni Hosp - Large Metro	303389	200-500	74896	11.93%	398	258	Metro	133 *(48%)*	6
Logan - Large Metro	313785	200-500	75300	15.01%	500	488			
Ipswich - Large Metro	200000	200-500	56535	12.27%	376	-			
Redcliffe - Large Metro	49437	200-500	43183	8.61%	286	152			
Gold Coast University Hosp - Major	576918	>500	114391	22.81%	800	588			
TOTAL			**501570**		**3330**	**2474**	**291**		**30**

[#] https://www.myhospitals.gov.au/. *The number of medical records audited in small rural remote HHS's were guided by minimum requirements and availability. [&]The number of charts included both index and control patients.

Sample Size

Sample size calculation for the project was challenging, as the analytic objectives did not precisely match the prototypical inferential scenarios for which power analysis formulas exist. Furthermore, the sampling strategy had to take into account priorities that go beyond simple power analysis for inferential tests, most importantly:

1. Ensuring the sample is representative of the population of interest
2. Practical limitations around the number of cases that can be sourced from smaller hospitals
3. Achieving as precise as possible confidence intervals around descriptive summary statistics of classification performance; e.g. Area Under the Curve (AUC).

Considerations 1 and 2 (above) advise for greater sampling from metropolitan sites than regional sites. It is important to recognise that most available power calculations are based on an inferential test of differences (e.g. whether or not Q-ADDS scores for the index and control groups are significantly different at a given point in time). We were also (and perhaps more) interested in accurately describing the classification performance of the Q-ADDS, under index and control conditions. Thus consideration 3 advises for a larger sample size than would be advised for a straightforward hypothesis test.

Unfortunately, power analysis tools based on desired confidence intervals around classification performance indices (such as AUC) do not exist. Standard between-groups t-test calculations can be used as an approximation. Given the consideration mentioned above, we suggested employing a small to very small effect size for power calculations (Cohen, 1988) of d=0.125 for the total sample. Employing desired alpha of α=0.05 and power of 0.95, this suggests a total sample size of 3330, including both index and control groups. We also adopted sampling from sites in rough proportion to the patient turnover of each site, thus making our sample approximately representative of the Queensland patient population. This also addresses the practical limitation of being able to draw more records from larger sites than smaller sites. Based on these calculations, we developed a stratification document outlining the number of charts per site to be audited. Ultimately, the final number of charts audited was restricted by the number of SAEs occurring at each hospital health service over the predetermined period of time. For example, according to our stratification plan, 38 charts were required from Prosperine HHS, however the number of SAEs for that site were higher than anticipated and we audited 60 charts to ensure we captured all events. Conversely, Rockhampton's HHS stratification allocation was 326 and

the number of actual SAEs for that site determined the final number of charts audited as 277.

Data collection/extraction

The retrospective chart review involved performing an electronic patient record search to identify the desired patients from the three International Classification of Diseases (ICDs). This was conducted by Queensland Health Staff, in consultation with the Q-ADDS project team, and in most cases this person was a QLD Health Licensed Crystal Report operator. The project team members employed by QLD Health applied for access to software at HHSs as required. Patient identifying data was only disclosed to Queensland Health staff. The patient cohort was identified via the use of Emergency Department Information System (EDIS) and Hospital Based Corporate Information System (HBCIS) software, with the eligible medical records tracked by their Unit Record Number (URN) and admission dates. Queensland Health administration staff employed by the project at each study site then collected the identified records and de-identified the appropriate information (vital sign chart). Once the data were de identified, the information was sent to the research team for collation into a master audit tool.

Index Group

Inclusion: major diseases on which to base the inclusion criteria

The targeted patient cohort was identified via the utilisation of Emergency Department Information System (EDIS) and Hospital Based Corporate Information System (HBCIS) software tools. A licensed Crystal Report Developer from Rockhampton CQHHS was able to access the EDIS and HBCIS systems in order to identify the specific patient cohort required for inclusion in the analysis. Large lists of potential participants were delimited via the use of well-considered codes from the published list of Diagnostic Related Groups (DRG).

Utilising this method, patients were selected that identified as having preliminary and/or admitting diagnoses related to:

- circulatory / cardiovascular disease
- respiratory conditions
- sepsis

Once this cohort of patients was identified, their electronic patient records were examined by the Queensland Health licensed operator to develop a pool of potential participants that included the following partially de-identified demographic data:

- Facility
- Age
- Sex
- Diagnosis (primary and secondary)
- Admission type (prior to ICU or transfer admission)
- Time and date of admission to hospital
- Time and date of adverse event

Exclusion: Once the master list of potential participants for each site was developed, Queensland Health staff, working on the Q-ADDS project used HBCIS software to exclude patients based on:

- Patients admitted to hospital for less than 24 hours - given the limited vital signs data collected for these patients.
- Planned High Dependency Unit admissions or intensive care unit transfers – do not comply with index case criteria.
- Patients with treatment limitation orders (not for resuscitation and/or ventilation orders).
- Patients in the maternity ward – a specialised early warning system is used for obstetric patients.
- Sites that use electronic charts – the escalation process is different from the paper chart.
- Patients with early warning charts other than the Q-ADDS chart.

Index Group

Using the HBCIS software, Queensland Health employees both from within and outside of the Q-ADDS project team identified patients that had been admitted with these diagnoses who then went on to experience a severe adverse event (SAE), defined in this study as:

- Reaching Q-ADDS threshold and triggering a medical emergency team (MET) review (regional and metro sites)
- Unplanned transfer to higher level facility (rural and remote sites)

Control Group

For each Index patient, HBCIS software was used to identify a control patient who was demographically and diagnostically matched to the index patients as well as to the admitting facility, and identified as not experiencing any of the SAEs.

Data extracted

A list of potential index and control patients was produced for each site utilising the methods outlined above, identifiable by their Unit Record Number (URN). Both groups were de-identified (given code-numbers) and no reference was or will be made to patient names or identifiable data within any aspect of the research project or subsequent publications. The coding document linking URN numbers and code numbers was destroyed (according to University policy) at the end of each day so there was no possibility of re-identifying patient charts. The only document from each medical record audited was the pre-recorded paper based Q-ADDS chart. Once de-identified (Figure 3), the Q-ADDS document was scanned directly into a password protected laptop to be audited by a trained data abstractor.

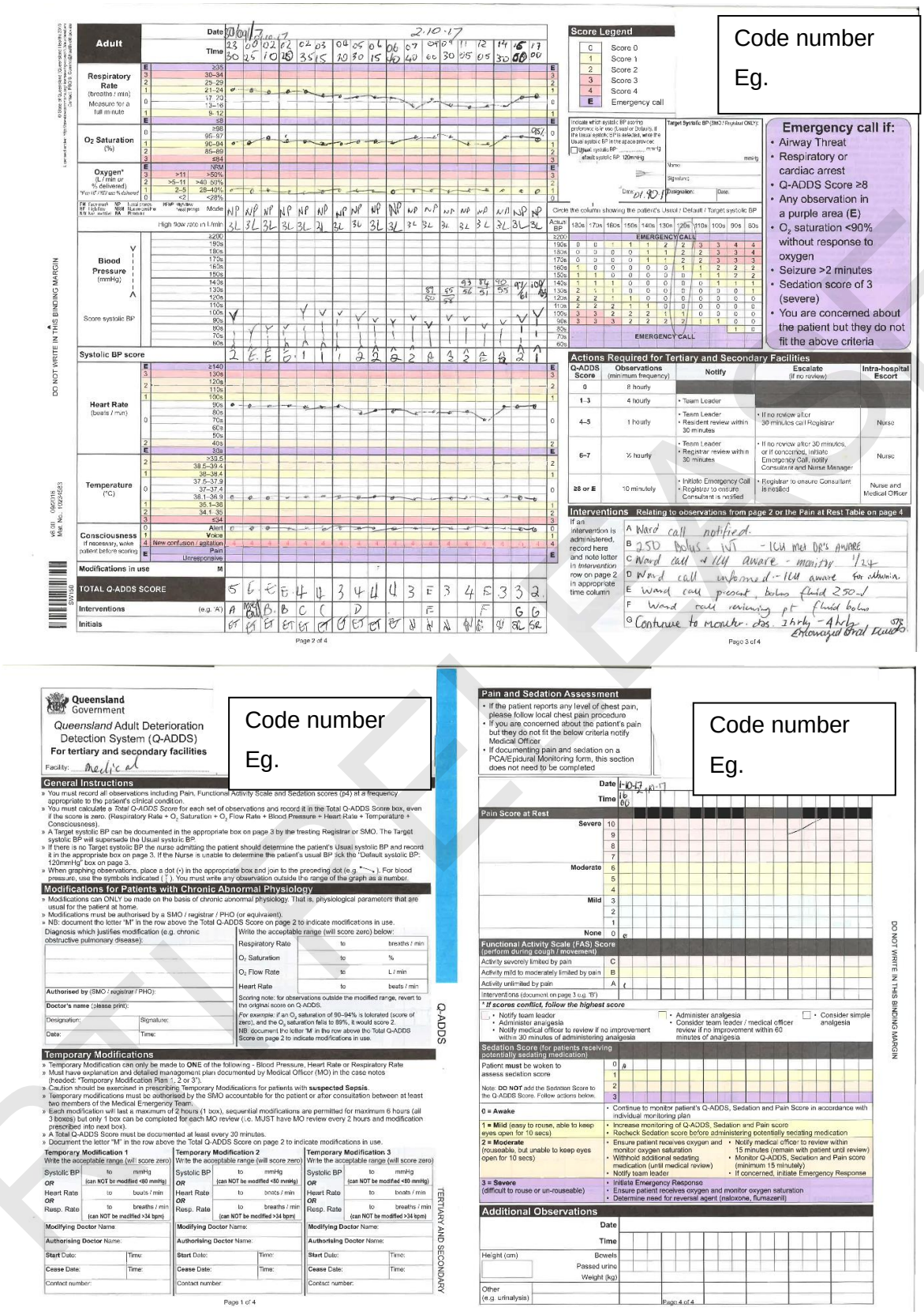

Figure 3: An example of the de-identified Q-ADDS patient charts used during the study.

A pre-determined number of these patient charts were collected from patient records by Queensland Health records staff daily and returned to patient records at the end of each day. To ensure compliance with ethical requirements, no patient charts were left unattended, or remained absent from the records room overnight.

Patient physiological data, as recorded on the vital signs chart were collected for at least 24 hours preceding the severe adverse event (SAE). For those experiencing a SAE in less than 24 hours following admission all physiological data was collected. Twenty four hours was thought sufficient since SAE have been found to occur within 24 hours of abnormal vital signs being observed (Jarvis et al., 2015; Smith et al., 2013). For the control group, physiological data was collected for the period of time aligning with that of the index group whenever possible. Since the frequency of patient monitoring may differ depending on the facility and the severity of illness, the physiological data recorded closest to the 6 hour increment was used (i.e. 0000, 0600, 1200, and 1800). At least four sets of vital signs data were collected for a 24 hour period of time. The following physiological variables were collected:

- respiration rate
- oxygen saturation level ($Sp0_2$)
- oxygen flow rate (L/min)
- blood pressure
- heart rate
- temperature
- level of consciousness

All physiological data was obtained from the retrospective Q-ADDS records, i.e. vital signs collection chart. The collected data was sent to the principal coordinating investigator for inclusion onto the master spreadsheet where missing data was not interpolated but was compensated for using appropriate statistical methods such as multiple imputation or mean value substitution. When all site data had been entered, the completed spreadsheet was sent to the project's statistician to be analysed.

Development of data Abstraction protocol

The training of research assistants/data abstractors plays an important role in ensuring the rigour of the study and quality of data extracted (Vassar & Holzmann, 2013). Hence a data abstraction manual was developed, which included a video of the steps required, illustrations demonstrating the location of information on the Q-ADDS and medical records. Additional information provided included: acceptable shortcuts, shorthand, symbols, a glossary and a

decision tree for unforeseen coding decisions. Data abstractors typically included Queensland Health Agency Nurses to undertake certain aspects within the project such as identification of patients in each group, chart extraction and photocopying of the Q-ADDS charts. When HHSs had limited resources, and recruitment of staff was an issue, Q-ADDS project team members (Queensland Health Employees) attended the site and coordinated the collection of data.

Consistency and accuracy of coding was essential to ensure the rigour of the data extracted (Vassar & Holzmann, 2013). Hence, all research assistants and data abstractors underwent training prior to commencement of data collection. Training included introduction to the data extraction protocol, data extraction tool, ethical considerations with data collection and data security. To increase interrater reliability, objectivity and reduce reviewer bias, abstractors were blinded to the specific objective of the research (Vassar & Holzmann, 2013). Prior to data collection all used the data extraction tool to code the same set of data from simulated patient charts. The research team examined coded data to ensure accuracy; discrepancies in coding and unforeseen coding issues were jointly discussed and clarified. Regular weekly meetings were scheduled where research assistants connected to discuss or clarify any issues encountered during the coding process.

Pilot

Prior to analysing the Q-ADDS charts, a pilot study was conducted to ascertain the best method of collecting analogous data (Vassar & Holzmann, 2013), see *Appendix A* for a detailed description of the pilot study. A key finding from the pilot study was the discovery of a multitude of ways that data were recorded on charts depending on which ward the patient was located in. The different recording methods between charts highlighted the need for a consistent method of data collection. It was for this reason that vital signs were recorded on the final audit sheet as actual values, as opposed to Q-ADDS scores, so that consistent analysis could be facilitated. Our initial audit of charts also identified that, crucially, a high number of cardiac patients are admitted to Cardiac Care Units (CCU) directly from ED, and this cohort were originally included in the Index list. However, once the charts were analysed, it became clear that CCU's Q-ADDS charts have different values and triggers than the Q-ADDS general charts, so they were excluded from the data collection. This excluded a significant number of cardiac patients from overall analysis.

Importantly, it became clear early on that the modifications section of the chart was being interpreted differently depending on which ward the patient was admitted to and which staffing stream were completing or reacting to modifications instructions. This triggered our team to pay particular attention to the completion of the modifications section of the chart.

The pilot study also highlighted that the originally calculated sample size was unrealistic and unachievable. We had based our initial estimates on stratified percentages of overall admission numbers when in fact those numbers exceeded the number of actual SAEs per site. It was decided at this stage of the study that we would include all MET calls (of patients that met our diagnoses criteria over our predetermined period of time) in regional and metro facilities, as well as all transfers out from rural remote facilities over the same period of time.

Data analysis

Area Under the Curve (AUC)

We calculated Area Under the Curve (AUC) classification performance for the Q-ADDS, and compared this with AUCs calculated from each of the observations alone. The Q-ADDs aggregates information from multiple observations, and implements a scoring scheme for combining information from each observation. The Q-ADDS scoring scheme is non-linear (parabolic), in that positive scores can be generated from patient observations that are either too high, or too low, with respect to the normal range. As was the case with the heart rate or systolic blood pressure (BP).

Our evaluation of the Q-ADDS relied heavily on AUC statistics, rather than sensitivity and specificity (S&S) indices. There are several reasons for this choice. First, S&S is difficult to interpret, because it comprises two aspects of classification performance (true negative and true positive rate), rather than a unitary index. Second, S&S scores are highly dependent on the choice of threshold, with the trade-off between these two aspects of classification performance varying greatly on choice of threshold. Although the Q-ADDS has a defined threshold, it is not possible to compare Q-ADDS with other means of classification (either multivariate models or single observations) using S&S because thresholds are not necessarily defined for these indices. The choice of threshold is not purely determined by data analysis, given that it should take into account the relative cost of false negatives and false positives. Thus, it is conceptually and statistically preferable to ‘detach’ the evaluation of the performance of an index from the choice of threshold. The AUC is a robust unitary measure that combines information regarding false positives and negatives and is invariant to choice of threshold.

Linear Regression

For an additional point of reference for evaluating Q-ADDS performance, we defined another classifier using logistic linear regression (LR). This classifier created an optimal predictor, based on a weighted linear combination of all the observations. We created a second LR model with non-significantly fitting predictors removed. Finally, we also considered an

alternative LR model that considered all possible interactions between observations. Although optimised on the data, LR cannot implement non-linear decision rules for individual observations.

We then calculated the standardised beta coefficients from all three LR models:

1. including all linear terms
2. after removing terms that did not yield a significant improvement in fit based on the Akaike Information Criteria (AIC)
3. AIC selected terms, considering all main effects and 2nd order interactions between variables.

Random Forest

To overcome the limitations of LR and non-linear data we used a random forest (RF) machine learning classifier for our categorical outcome variable of “Index or Control”. The RF (Breiman, 2001) is an alternative form of machine learning classifier that can implement non-linear decision rules of arbitrary complexity, including contingent decision rules based on interactions between observations. It is based on bootstrapping, which involves resampling, with replacement, cases from the original dataset many times. For each bootstrap replication, a classification and decision tree (CART) is trained. The predicted output is based on 500 iterations of this procedure, and model predictions are formed by the average of all CART predictions. In principle, the RF should be able to learn a near-optimal decision rule from the available information, which makes it a useful comparison point for evaluating a manual method of scoring such as the Q-ADDS. We created a multivariate RF model, using all the observations used by Q-ADDS, and also created univariate non-linear RF models separately for each observation. In the case of RF predictions made on the basis of only one observation (variable), any differential between the AUC of the simple observation score and corresponding RF can be attributed to the contribution of non-linear effects (e.g. detecting index patients via an Act. Sys. BP that is EITHER <110 OR >140). In classical statistical terms, this can be thought of as the difference in performance between a linear effect (or decision boundary) and a non-linear effect.

Ethical considerations

Once the patient cohort was identified, the eligible medical records were tracked by their URN and admission dates. It was proposed that the QLD Health administration staff from each study site would obtain the patient records and take the records to a nominated secure ‘Project space’ (desk). Once delivered to the Research Assistant, each URN had a code

number applied, and the code number was entered onto the audit tool. URNs were not referred to again. Once data was extracted, the patient charts were returned to the records room and any documents linking URNs and code numbers were destroyed. De-identified data were transcribed onto a dedicated, password protected computer that contained a specially designed MS Excel spreadsheet, or were scanned onto a password protected hard drive to be audited at a later date. Each site had one password-protected external hard drive, which was used to store the audit tool (Excel spreadsheet) for that particular site and was returned to the project manager upon completion of that site's data collection.

All data were secured in a password protected electronic database. Three backup copies of the processed research data have been kept in separate locations: on a password protected laptop computer, on a password protected external hard drive, and in a secure electronic data storage site such as AARNet Cloudstor (Australian Academic and Research Network). It was not envisaged that any hard copies of data would be produced but if deemed necessary, any hardcopies of de-identified data or processed data can be secured in a locked cabinet at either the CQU premises on the Rockhampton campus.

All records and data produced in the course of this study will be retained for a period of five years after submission of the final publication, in accordance with the CQU Research Code of Conduct, (Central-Queensland-Univeristy, 2012) and the Australian Code for Responsible Conduct in Research, (Australian-Government, 2007) as well as the new storage of data policy. Unidentified data will be retained indefinitely in a secure online facility in line with the Data management policy; section 4.20 states that research which has community or heritage value should be retained indefinitely, and submitted to national collections, as appropriate.

Part B Socio-Cultural Study – Quantitative and Qualitative Study

Design

Part B was an explanatory sequential mixed method study conducted to explore the socio-cultural factors influencing health professionals' compliance with the use of Q-ADDS. The first step of the socio-cultural study involved an initial quantitative survey component (*Part B1*), which is an ideal method to employ when researchers want to find out "how many" and/or "how often" something occurs (Pierce & Sawyer, 2013). The Theory of Planned Behaviour (TPB), a social science theory, was adopted as the conceptual framework to inform the survey development and analysis (Ajzen & Fishbein, 1980). The TPB was chosen because of its proven ability to predict an individual's intent to engage with a specific behaviour. Specifically, the TPB was employed to elucidate the factors that contribute to health care workers' intentions to comply with Q-ADDS (Lydon et al., 2016). In addition the TPB is useful because of its capacity to inform the implementation of clinical guidelines (Kortteisto et al., 2010).

Consistent with the explanatory component of the mixed method study, the quantitative study was followed by qualitative Interviews (*Part B2*) to help explain or elaborate on the quantitative results. The qualitative aspect of the project was also informed by participant responses to a subset of open-ended questions included in the online survey. This approach is ideal when researchers are trying to understand participants' unique perspective, or experience of a specific event or action (Richards & Morse, 2012). Data collected during the interviews provided the researchers with insight into participants' decision-making processes (Silverman, 2016). This presented the opportunity to gain a deeper understanding of the behaviours that health professionals' employ when they decide to use or not use the Q-ADDS. Both the quantitative (*Part B1*) and qualitative (*Part B2*) components were analysed separately. Results were subsequently compared and contrasted to produce a final synthesis of the socio-cultural factors influencing health professionals' compliance with the use of Q-ADDS.

Population

Health care professionals working in any Queensland Hospital and Health Service (QHHS) and responsible for completing the Q-ADDS charts were potential participants.

Study sites

Part B1 – Survey

Health Care Professionals were recruited from as many of the Queensland Hospital and Health Services as possible. To meet eligibility criteria, participants were required to be health care professionals currently working at Queensland Health facilities and responsible for completing the Q-ADDS charts.

Part B2 – Interviews

In order to adequately reflect the diversity of Queensland Health's public sector health services, interviewees were recruited from tertiary, secondary, rural and / or remote facilities, ensuring a comprehensive analysis.

Sample Size

Part B1 – Survey

A total of 291 valid responses were received from Queensland Health staff members, the majority of these were Nursing staff (n=285, 98%) in an equal proportion of Full (n=135, 46%) and Part time employment (n=134, 46%). Broad coverage of the State was achieved with respondents coming from Mossman, Proserpine, Sarina, Townsville and Torres in the far north, Mt Isa in Northwest to Gold Coast, Sunshine Coast, Brisbane (various), Toowoomba and Nambour in Southeast. Coverage also included Mackay, Central Queensland (e.g., Rockhampton, Mt Morgan, and Wide Bay) and further west (e.g., Theodore, Monto, Mareeba, Longreach and Emerald). These locations were coded into Rural/Remote/Small Regional (n = 51, 19%), Large Regional (n = 92, 33%) and Metro (n = 133, 48%) for subsequent analyses. Experience (in profession) ranged from 1-5 years (n = 65, 23%) to 31+ years (n = 58, 20%).

Part B2 – Interviews

It was difficult to ascertain at the outset the number of participants that would be required because theoretical sampling is directed by the concepts and/or categories that arise throughout the data analysis (Foley & Timonen, 2015). Glaser (1978) explains that ideally, once a researcher has an overview of the phenomena being studied, theoretical sampling would be employed to locate participants that meet the specific area of inquiry. Due to this fluid method of recruitment, there is no "ideal" number of participants, and the final number

of interviewees was determined by each person's experiences and their ability to articulate this in an interview setting. The final number of Queensland Health clinicians interviewed was 20 nursing staff and 10 medical staff distributed across 13 of the 15 locations of interest, (Table 1).

Recruitment

A combination of purposive and snowball sampling methods were utilised to recruit potential QLD Health participants, inviting them to participate in an anonymous online survey. Emails sent to all employees via a general QLD Health internal email system, word of mouth, and social media were the primary methods used to disseminate the link to the survey. This combination of purposive and snowball sampling was chosen specifically to maximise the response rate and to minimise selection bias that can occur with non-random sampling methods (Denscombe, 2014).

All recruitment methods above included a link to a recruitment website designed by the research team. The website can be viewed at https://Q-ADDSresearch.wixsite.com/survey. If visitors to the website met the eligibility criteria they were invited to participate in the study. This site includes the information sheet and online consent process. Participants were invited to forward the website URL to other Queensland Health colleagues (snowballing technique).

All responses to the online survey remained anonymous as there are no identifiers used in the survey. All participant responses were coded and de-identified by a single researcher. The survey component was completely anonymous and no names will ever be linked to the survey. At the completion of the survey, participants were asked if they were interested in participating in a one-on-one interview. If they agreed, they were directed to a different survey website, where they could enter their contact details for follow up purposes. When participants were directed to this webpage, they were required to read and acknowledge the consent form before progressing. There was no connection between the data any participant entered on the anonymous survey and any participant's contact details. This is done to ensure the anonymity of responses within the survey proper. One member of the project team was responsible for accessing the list of names of potential interviewee participants and entering the names into a password protected spreadsheet.

Data collection methods

Part B1 – Survey

The initial data collection method was a self-directed survey, accessible to potential participants via an online website (https://Q-ADDSresearch.wixsite.com/survey). This survey was comprised of demographic questions intended to guide theoretical sampling as the project progresses, and well-considered questions guided by the Theory of Planned Behaviour (TPB) constructs.

The Theory of Planned Behaviour (TPB) explains that behavioural intent is influenced by an individual's attitudes towards behaviour (determined by behavioural beliefs and evaluation of behavioural outcomes), subjective norms (informed by normative believes and motivation to comply) and perceived behavioural control (determined by the individual's control beliefs and perceived power) (Fishbein & Ajzen, 1977, 2011). In acknowledgement of this, the survey questions for this research project were developed to gain an understanding of each of the constructs relevant to the research questions guided by TPB. Constructs (independent variables) that might predict behavioural intent to comply accurately with Q-ADDS charting were identified from existing literature (Flenady et al., 2017b; Jansson et al., 2013; McCluskey et al., 2013; Wakefield et al., 2010), and then grouped according to the TPB. Each construct comprises themes abstracted from existing literature regarding barriers and facilitators to compliance with clinical guidelines. The questions under each construct were worded as statements and responses were collected via a seven-point Likert Scale. The final survey was comprised of twenty nine questions measuring responses to questions related to the main constructs as well as ten demographic questions.

Participants were reassured that all responses would be received by one researcher, and that all responses were anonymous. No responses were traceable to personal identities other than by one researcher, and all information received was for research purposes only. The research project manager was the only person with access to information linking participants with responses.

Part B2 – Interviews

Participants could choose to complete the survey on its own, but also had the option of ticking a box to say they were interested in participating in one interviews. No responses were traceable to personal identities other than by one researcher, and all information received was for research purposes only. The most common form of data collection method used in qualitative research is individual participant interviewing (Birks & Mills, 2011; Foley &

Timonen, 2015; Richards & Morse, 2012). The study employed a semi-structured interview technique, with the purpose of collecting rich and detailed information from the participants regarding their compliance with the Q-ADDS charting system. Despite the potential disadvantage of collecting too much information (Weiss, 1995) the research team considered this method to be most appropriate for this study as this method of interviewing facilitated fuller development of information from the participants. As the interviews for this project are referred to as semi-structured, all interviews began with the same grand tour questions:

“Please share with me your experience around factors that influence your compliance with the use of Q-ADDS”

“Can you explain the behaviours that you employ when you decide to use or not use the Q-ADDS?”

“Can you talk about the reasons you decide to use or not use the Q-ADDS?”

The goal of the interviews was to collect rich and detailed information from the participants regarding their compliance with the Q-ADDS charting system. Whilst participants’ responses to the initial pre-determined interview questions guided subsequent questions, all subsequent interview questions were developed without hint of prescriptive outcomes to influence participants’ responses as little as possible.

Data analysis

Part B1 - Survey

Data abstracted from the survey determined the extent of the problem and identified the relationships between the sociocultural factors and health professionals’ intent to comply with the use of the Q-ADDS. This survey also informed the qualitative component in *Part B2.*

As well as the quantitative component, a qualitative method was also employed by including open-ended questions at the end of each section. This approach is ideal when researchers are trying to understand participants’ unique perspective, or experience of a specific event or action (Richards & Morse, 2012). Data that has been collected via qualitative methods provides researchers with insight to participants’ decision making processes and presents the opportunity to gain a deeper understanding of the phenomena under examination (Richards & Morse, 2012; Silverman, 2016).

Responses from the online survey were entered onto an Excel spreadsheet, and descriptive statistics were performed using EpiInfo V.6.0 (CDC, Atlanta, GA, USA) and multiple logistic

regression modelling performed in SPSS V.15.0 (SPSS, Chicago, Illinois). Responses to closed questions under the independent constructs were totalled according to the Theory of Planned Behaviour (TPB) and divided by the total items to regain a score within the original scale 1-7.

Responses to the main construct (Attitudes towards utilising the Q-ADDS charting system appropriately) were sorted into high (responses of >6) and low (<6). Participants with high-level attitudes towards utilising the Q-ADDS charting system appropriately were sorted into groups (guided by individual themes), and an Odds Ratio (OR) for each themed group was then compared against the themed group with the lowest score. All constructs were further analysed to identify significant predictors of high-level attitudes towards utilising the Q-ADDS charting system appropriately.

Qualitative responses to survey

Responses to open-ended questions were entered into a different spreadsheet and collated data was thematically analysed, which Clarke and Braun (2017) explain, is a flexible and valuable method of data analysis that facilitates researchers' ability to identify rich, detailed and complex explanations of data.

Following Braun and Clarke (2006)'s six phases of thematic analysis, our research team: (1) familiarised ourselves with the collated data sets, (2) systematically recoded the data, (3) searched for themes, and (4) ensured that all codes within themes 'work' or 'fit' with each other. We then (5) defined and refined the names of the themes identifying specifics of each, developing clear definitions of each theme that made sense of the data, and finally, (6) we wrote up the results in relation to the research questions and extant literature (

). From beginning to end of all analysis phases, memos were generated that explained the researchers' conception of the relationships between data, providing insight to the coding choices made for each theme. This process facilitated the generation of rich and sensitive themes, all capable of substantive explanatory power.

Part B2 – Interviews

Table 2 Thematic analysis (adapted from Braun and Clarke, 2006).

Phase	Description of the process	Result
Familiarization with the data	Read and re-read data in order to become familiar with what the data entails, paying specific attention to patterns that occur and noting down initial ideas/patterns.	Preliminary "start" codes and detailed notes.
Generation of initial codes	Generate the initial codes by identifying where and how patterns occur. This happens through data reduction where the researcher collapses data into labels in order to create categories for more efficient analysis. Data compilation is also completed here. This involves the researcher making inferences about what the codes mean.	Comprehensive codes of how data answers research question(s).
Searching for themes	Collate codes into themes that accurately depict the data. It is important in developing themes that the researcher describes exactly what the themes mean, what they include and exclude.	List of candidate themes for further analysis.
Reviewing themes	Check if the themes make sense and account for all the coded extracts and the entire data set. If the analysis seems incomplete, the researcher needs to go back and find what is missing. Generate a thematic “map” of the analysis.	Coherent recognition of how themes are patterned to tell an accurate story about the data.
Defining and naming categories	Generate clear definitions and names for each theme. Describe which aspects of data are being captured in each theme, and what is interesting about the themes.	A comprehensive analysis of what the themes contribute to understanding the data.
Producing final report	Decide which themes make meaningful contributions to understanding what is going on within the data. Researchers should also conduct verification of the data to check if their description is an accurate representation.	Description of the findings

Data collected and analysed from the interviews helped explain the behaviours health professionals' employ when they decide to use or not use the Q-ADDS. Data analysis of *Part B2* was also informed by Braun and Clarke's thematic analysis methods. This approach was chosen to reduce the influence that preconceived notions around what constitutes barriers and facilitators to Q-ADDS compliance have to provide an explanation for behaviours. All interviews were audio recorded, transcribed and, before analysis began, transcripts of the interviews were sent to participants for their perusal and confirmation of content. Data was then analysed utilising thematic analysis. Specifically, data was compared between and against other data, stimulating the development of codes. Each transcript (interview) was read independently and content-coded by at least two members of the research team. Team members met regularly to discuss coding and highlighted any areas of discrepancy and contrasted for emerging themes.

Finally, the quantitative (*Part B1*) and qualitative data sets (*Part B2*) were synthesised to provide a contextualised understanding of the compliance with Q-ADDS as a whole.

Ethical Considerations

Throughout the entire project, our team has been guided by the Health Innovation Investment and Research Office (HIIRO) and followed their advice in terms of governance and ethics requirements at all times. The project received ethics approval from the Gold Coast Hospital and Health Service Human Research Ethics Committee (HREC) (HREC/17/QGC/273) on the 12th of October 2017. Submitted concurrently with the overall ethics application, were the 15 Site Specific Assessment (SSA) applications. This process involved seeking approval for our project to attend specific sites listed in *Table 1*. SSA approvals, granted individually, were finalised in September 2018. In terms of the need for Public Health Act (PHA) approval to access private and confidential information, we sought approval from the data custodian responsible for each of the data sets we were accessing from each site (EDIS, HBCIS, MET, Medical Records). The final PHA approval was received by our team in October 2018.

Risk

Given the nature of the research and the professional experience of the participants, the risk was considered to be minimal. One potential risk identified by the research team is that in the course of interviewing, participants may reflect on a personal experience had caused them distress in the past. Due to the voluntary nature of participation and the provision of information, as well as information provided to the participants around the content and ethical standards of the research, we considered this already low risk to be further mitigated.

All participants were advised that if they withdraw prior to data analysis, their interview data and associated transcriptions would be deleted. They were also informed that if they withdrew consent after the commencement of data analysis, withdrawal could not be guaranteed.

Participants were fully informed regarding potential risks and burdens. Participants were able to negotiate a convenient time for an interview. Data remains confidential (interviews) and anonymous (survey). The interviews were conducted by telephone or in a neutral environment of the participant's choice, where the participant felt secure and comfortable. In the event that a participant became distressed the interview was to be terminated and support was to be offered by the interviewer initially, followed by an offer of referral option to *lifeline* and employee assistance service (EAS). The EAS service is a free, short term, confidential service provided by the hospital. If deemed necessary this service could be utilised for confidential counselling and referral service or Critical Incident Stress Debriefing (CISD). There was no need to refer any participants during the interview processes due to distress.

Results Validation Study Part A

Demographics

The aim of this validation study was to examine the effectiveness of the Queensland Adult Deterioration Detection System (Q-ADDS) in detecting adult clinical deterioration. Using a Retrospective Chart Review (RCR) design we examined 2474 patient Q-ADDS charts from 13 Hospitals within 13 Queensland Hospital and Health Service (HHS) areas (Table 1). The final sample was considered representative of patients admitted with the DRGs of Circulatory/Cardiovascular (n = 1232; 44.9%), Respiratory (n = 1099; 50.3%) and Sepsis (n = 117; 4.8%) and was approximately representative of the Queensland patient population. Patient charts accessed n = 1206 control, n = 1265 index for a total of n = 2471 sets of vital signs (n = 3 missing labels, total n = 2474). The baseline data of the index and control patients are presented in Table 3. As these groups were matched there was no significant demographic difference between control and indexed groups. For the total cohort almost half (47%) were over 75 years of age, 39.7% in the 55 to 74 year bracket. More index patients experienced their SAEs during the early (37%, n = 354) and late (37%, n = 352) shifts than in the evening (26%, n = 250).

Table 3: Demographics - the baseline data of the index and control patients

Item	Total n= 2474
Age Grouping	Frequency (%)
18-24	24 (1.0)
25-34	46 (1.9)
35-44	87 (3.6)
45-44	165 (6.7)
55-64	357 (14.6)
65-74	614 (25.1)
75-84	719 (29.4)
85+	437 (17.8)
Gender n=	
Male	1282 (51.8)
Female	1167 (47.2)
Group n=	
Index	1265 (51.2)
Control	1206 (48.8)
DRG n = 2448	
Respiratory	1099 (44.9)
Cardiovascular	1232 (50.3)
Sepsis	110 (4.8)

Identifying factors

Individual vital signs from the index group were examined for correlations between the six sets of recorded observations: respiratory rate (RR), peripheral capillary oxygen saturation (SpO_2), oxygen delivery (O_2 Flow), systolic blood pressure (Act. Sys. B.P.), heart rate (HR), and temperature (Temp). Only 134 records showed non-alert status, yielding insufficient observations for the statistical analyses applied to the other observations level of consciousness (LOC). Overall there were no large correlations observed between individual observations (Table 4). The highest bivariate correlation was between HR and RR (r=0.28). A negative correlation was noted between SpO_2 and respiratory rate (r=-0.22).

Table 4*:* Descriptive statistics and correlations between observations.

	median	mean	SD	IQR	[1]	[2]	[3]	[4]	[5]
RR [1]	18	19.82	4.84	4	-				
SpO_2 [2]	96	94.65	4	4	-0.22	-			
O_2 Flow [3]	0	1.27	4.18	2	0.15	-0.18	-		
Act. Sys. BP[4]	125	127.81	26.51	32	0.07	0.01	-0.05	-	
HR [5]	82	84.77	19.74	25	0.28	-0.16	0.10	-0.02	-
Temp. [6]	36.5	36.64	0.6	0.6	0.21	-0.04	0.04	0.07	0.22

Distribution of observations between groups

Smooth densities were calculated for index and control patient observations, with data aggregated over all times prior to and including SAE (Figure 4). Vertical lines have been added to denote boundaries at which the probability density of the index group exceeds the control group. It is important to note that these cut points do not take into account the prior probabilities of a patient having an SAE or not. In other words, they reflect the boundary at which an observation is more likely to be a SAE patient than not, only when the prior probability of group membership is 50:50 (as was with this study). Practical decision boundaries require taking into consideration prior probabilities of having an SAE, as well as the cost of false negatives and positives.

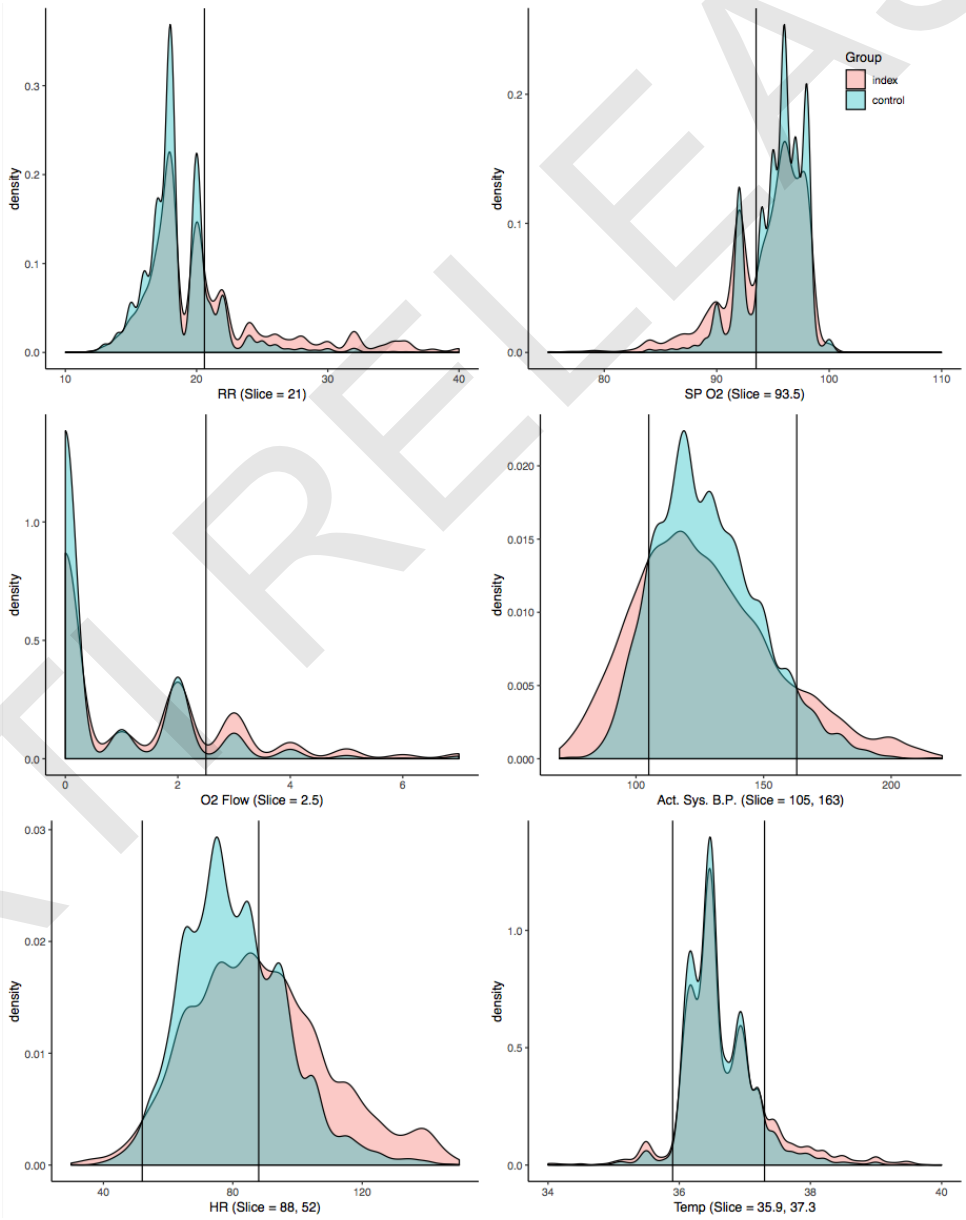

Figure 4*: Smoothened densities of the distribution of each observation by index category.

For most observations, the index patients show a more dispersed distribution, toward either one or both tails. However, the distributions overlap to a large degree, illustrating the relatively low discriminate power of any one observation in differentiating between the two groups. An identical comparison of index and control patient observations was constructed including only data at the SAE time-point (Figure 5). The only major variation was the change in heart rate from 88bpm (all time points) to around 100 bpm, indicating the boundary where the HR is more likely to be an SAE.

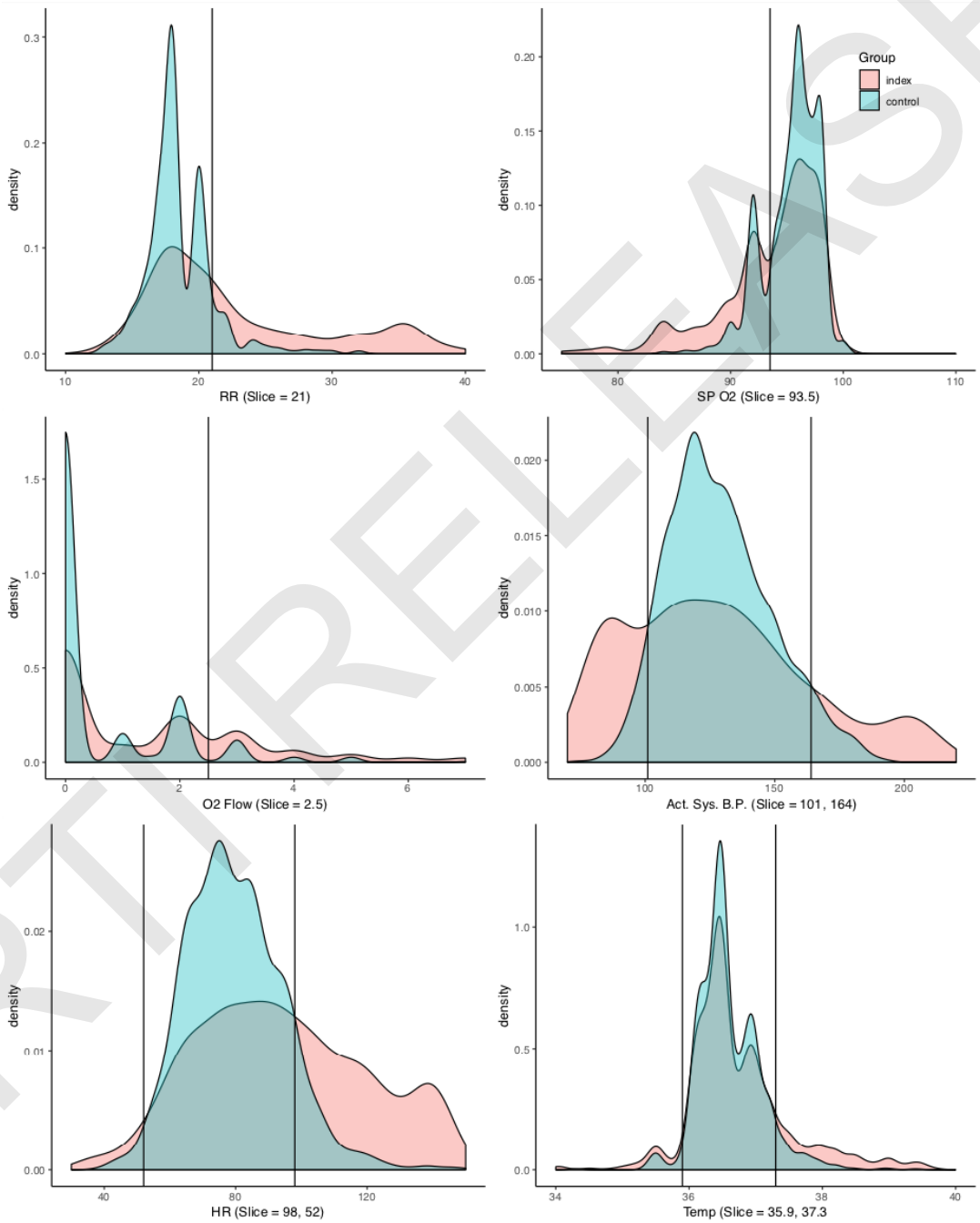

Figure 5*:* Smoothed densities of the distribution of each observation by index category, including only cases at the SAE time point.

When examining changes in vital signs in the 24 hours preceding the SAE time point, the RR distribution remains relatively constant, with only a small difference in terms of greater positive dispersion in index patients until the time of the SAE, at which point the median RR of the index group increased markedly (Figure 6). One explanation for this observation may be human error when recording the respiratory rate as opposed to actual deterioration in the patient's condition (Flenady et al., 2017a, 2017b). The median of the SpO_2 of the index group was lower than the control group and the lower tail of the distribution was broader. This difference does not appear to change markedly with respect to time preceding SAE, but it is approximately consistent across all measured time points. O_2 flow also did not vary markedly with respect to the SAE; both groups had similar requirements over time. However, the 75th percentile of the control group dropped from 2 to 1 at the last two time points. This suggests that over time, the control group required less oxygen and maintained a median of around $SpO_2$96%. In contrast, the index group consistently required similar levels of oxygen but with a trend toward lower SpO_2. The actual recorded systolic BP (Act Sys BP) of the index group was slightly more variable up to 6 hours pre-SAE and had a slightly lower median score. This is due to the variation in the upper BP and lower BP. Heart rate was significantly higher for the index group at all times; these differences increased at time of SAE. Temperature showed no systematic differences between the two groups.

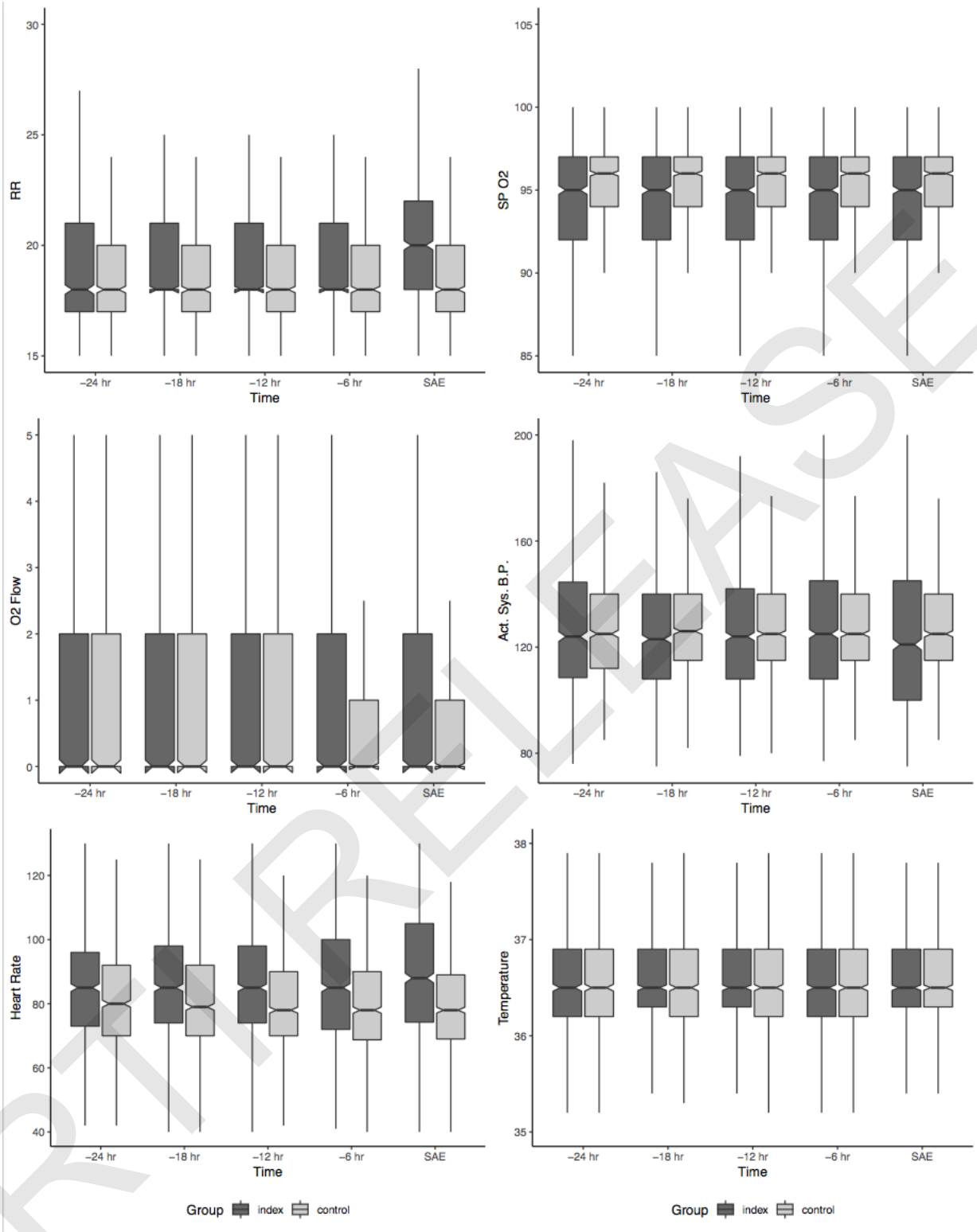

Figure 6*:* Boxplots of distribution of observations by group and time. Lines indicate +/- 1.5*IQR. Boxes indicate the IQR (25th to 75th percentile). Notches indicate the CI of the median (horizontal line).

Assessing discriminative power of the Q-ADDS at different times prior to SAE

We found that RR and HR showed the strongest linear effects in predicting patient category (index/control) across all three models (Table 5).

Table 5: Standardised beta weights for simultaneous logistic regression models predicting index case status from observations.

	Model		
	(1)	(2)	(3)
RR	**0.082** (0.005)**	**0.081** (0.005)**	**0.084** (0.005)**
SpO_2	-0.031** (0.005)	-0.031** (0.005)	-0.033** (0.005)
O_2 Flow	0.038** (0.006)	0.038** (0.006)	0.050** (0.008)
Act. Sys. B.P.	-0.011* (0.005)	-0.011* (0.005)	-0.012** (0.005)
H.R.	**0.074** (0.005)**	**0.073** (0.005)**	**0.074** (0.005)**
Temp.	-0.005 (0.005)		-0.013* (0.005)
RR: O_2 Flow			-0.014** (0.004)
SpO_2: Act. Sys. B.P.			0.017** (0.005)
SpO_2: HR			0.010* (0.005)
SpO_2: Temp.			-0.010* (0.005)
Act. Sys. BP: HR			-0.011* (0.005)
Act. Sys. BP: Temp			0.016** (0.005)
HR : Temp			0.020** (0.004)
Constant	0.496** (0.005)	0.496** (0.005)	0.494** (0.005)
Observations	10,991	10,991	10,991
Log Likelihood	-7,507.676	-7,508.216	-7,473.743
Akaike Inf. Crit.	15,029.350	15,028.430	14,975.490
Note:	*p<0.05; **p<0.01		

To explore the optimal model fit, the dataset as a whole was used as opposed to individually on the subset of the data comprising each preceding time point. We compared the performance of various indices in classification of index and control patients, at each of the time offsets. For indices that involves fitting to data (e.g. logistic regression (LR), random forest (RF) models), the model fitting was done for the dataset as a whole, not individually on the subset of the data comprising each particular time offset. The RF prediction aggregated information from all observations into a single index of criticality.

The first section of Table 6 compares classification performance of the Q-ADDS for index versus control patients at each relative time point against LR models (2) and (3), as well as the RF model. LR models were generally inferior to the Q-ADDS, although the discrepancy in performance became smaller at more distal times to the SAE. The Q-ADDS performed slightly better than the RF at SAE, but the RF performed better at all previous time points (Table 6).

Table 6: Area Under the Curve (AUC) classification performance of index versus controls for Q-ADDS, logistic regression, random forest, and individual observations. Linear and non-linear (RF) prediction performance is provided for each observation.

	-24 hr	-18 hr	-12 hr	-6 hr	SAE
Multivariate					
Q-ADDS	.595 (.013)	.630 (.012)	.645 (.011)	.680 (.011)	**.873 (.008)**
LR (2)	.602 (.013)	.629 (.012)	.629 (.012)	.649 (.011)	.744 (.011)
LR (3)	.608 (.013)	.636 (.012)	.635 (.012)	.658 (.011)	.750 (.010)
RF	**.668 (.012)**	**.675 (.011)**	**.674 (.011)**	**.723 (.010)**	.869 (.007)
Univariate					
RR	.548 (.013)	.577 (.012)	.586 (.012)	.609 (.011)	.684 (.011)
RR (RF)	.542 (.010)	.566 (.010)	.575 (.009)	.595 (.009)	.686 (.009)
SpO_2	.546 (.013)	.570 (.012)	.561 (.012)	.553 (.012)	.610 (.012)
SpO_2 (RF)	.543 (.011)	.559 (.010)	.562 (.010)	.557 (.010)	.600 (.010)
O2 Flow	.570 (.012)	.586 (.011)	.587 (.010)	.604 (.010)	.650 (.010)
O2 Flow (RF)	.563 (.012)	.583 (.011)	.582 (.010)	.600 (.010)	.643 (.010)
Act. Sys. BP.	.520 (.013)	.528 (.012)	.525 (.012)	.481 (.012)	**.462 (.012)**
Act. Sys. BP(RF)	.565 (.013)	.559 (.012)	.580 (.012)	.578 (.012)	**.686 (.011)**
HR	**.579 (.013)**	.588 (.012)	.594 (.012)	.603 (.012)	.675 (.011)
HR (RF)	.573 (.013)	**.596 (.012)**	**.594 (.011)**	**.609 (.011)**	**.702 (.011)**
Temp.	.516 (.013)	.523 (.012)	.531 (.012)	.509 (.012)	.538 (.012)
Temp. (RF)	.522 (.013)	.506 (.012)	.546 (.012)	.537 (.012)	.566 (.012)

Both the Q-ADDS and the RF models aggregate information from multiple observations into a single metric of risk of SAE. The distribution of Q-ADDS score and RF scores for the index (orange) and control (blue) groups, using all data, or only observation at SAE, are presented (Figure 7 & Figure 8). Concurring with the AUC results presented above, the degree of overlap between the two groups is approximately similar, with the RF (representing approximately 'ideal' classification) out-performing the Q-ADDS only marginally. Discrimination (or lack of overlap of the distributions) is better at SAE compared to incorporating the entire dataset (Figure 7, Figure 8, Table 6).

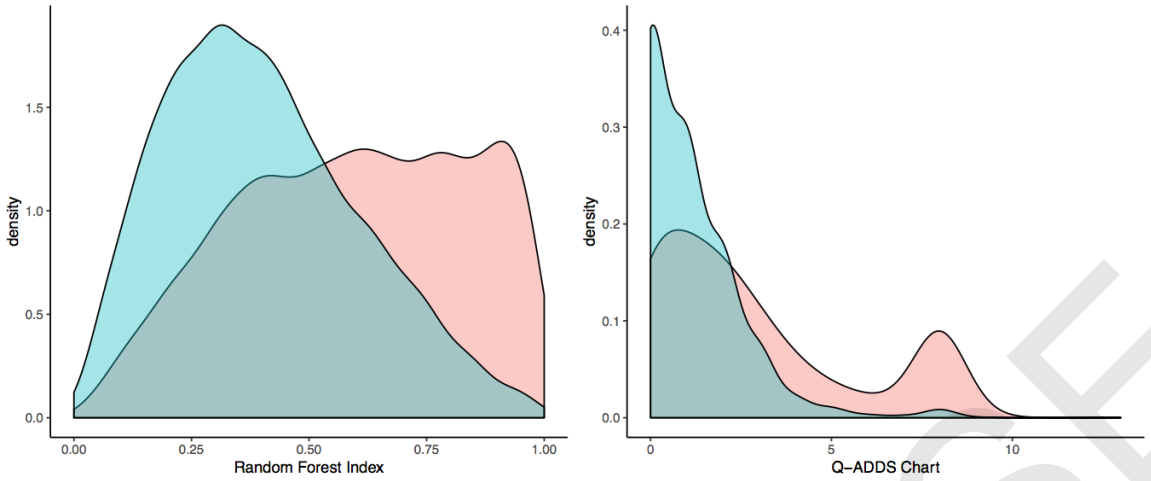

Figure 7*:* Distribution of Q-ADDS chart scores and Random Forest predictions for each group.
Note: index (orange) and control (blue) groups

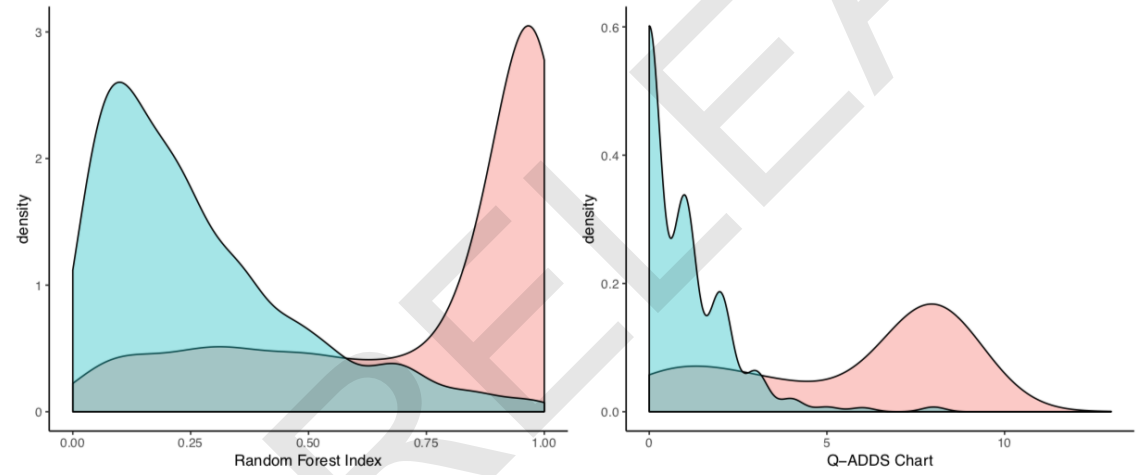

Figure 8: Distribution of Q-ADDS chart scores and Random Forest predictions for each group, including only cases at the SAE time point. *Note: index (orange) and control (blue) groups*

The second section of Table 6 (Univariate) compares both linear and non-linear (RF-based) classification performance of each of the single observations. Not surprisingly, all univariate measures performed worse than the multivariate indices at each time offset. At SAE, the best single predictor of index status was HR (RF AUC = .702). The largest differential between linear and non-linear performance at SAE was Act. Sys. BP (.686 versus .462).

Better than chance classification performance can be seen for all multivariate and univariate predictors at -24 hr to SAE. However, the classification performance is relatively low. The best performing predictor, the multivariate RF, achieved an RF of .668 at -24 hr, which indicates that a randomly chosen index patient will have a greater score on this index than a randomly chosen control patient approximately 67% of the time.

Assessing observations with respect to Random Forest predictions

To evaluate scoring of observations in more detail, it would be ideal have access to ground-truth data that described the true level of criticality – or risk of experiencing a SAE of a patient at each point in time. In lieu of this, the predictions of the RF model can provide a helpful surrogate. The RF predictions can be thought of the best estimate of the likelihood of a patient ultimately experiencing a SAE, given the information available from the observations. Thus, the RF prediction aggregates information from all observations into a single index of criticality.

Given that each observation feeds into this estimate as input, using the RF predictions to evaluate observations should be thought of as only a descriptive technique. Nevertheless, comparing individual observations with RF estimates can provide some insight into the method of scoring observations that is best supported by the current data. Figure 9 shows a generalised additive model (GAM) smooth fit line of each observation to the predicted probabilities generated by the RF.

A similar analysis, including observations only at the SAE time point (Figure 10). These plots illustrate the empirical relationship of each index to our best estimate of the underlying degree of condition severity. What is apparent from these plots is that the relationship appears to be generally piecewise linear. For example, risk with respect to RR is relatively flat up to about 20 bpm, then increases approximately linearly as bpm rises to about 35 bpm. The same is evident with the actual systolic BP where risk increases with recordings lower than 110 mmHg. The scoring guidelines for the Q-ADDS may be compared to these estimates of the relative risk of SAE.

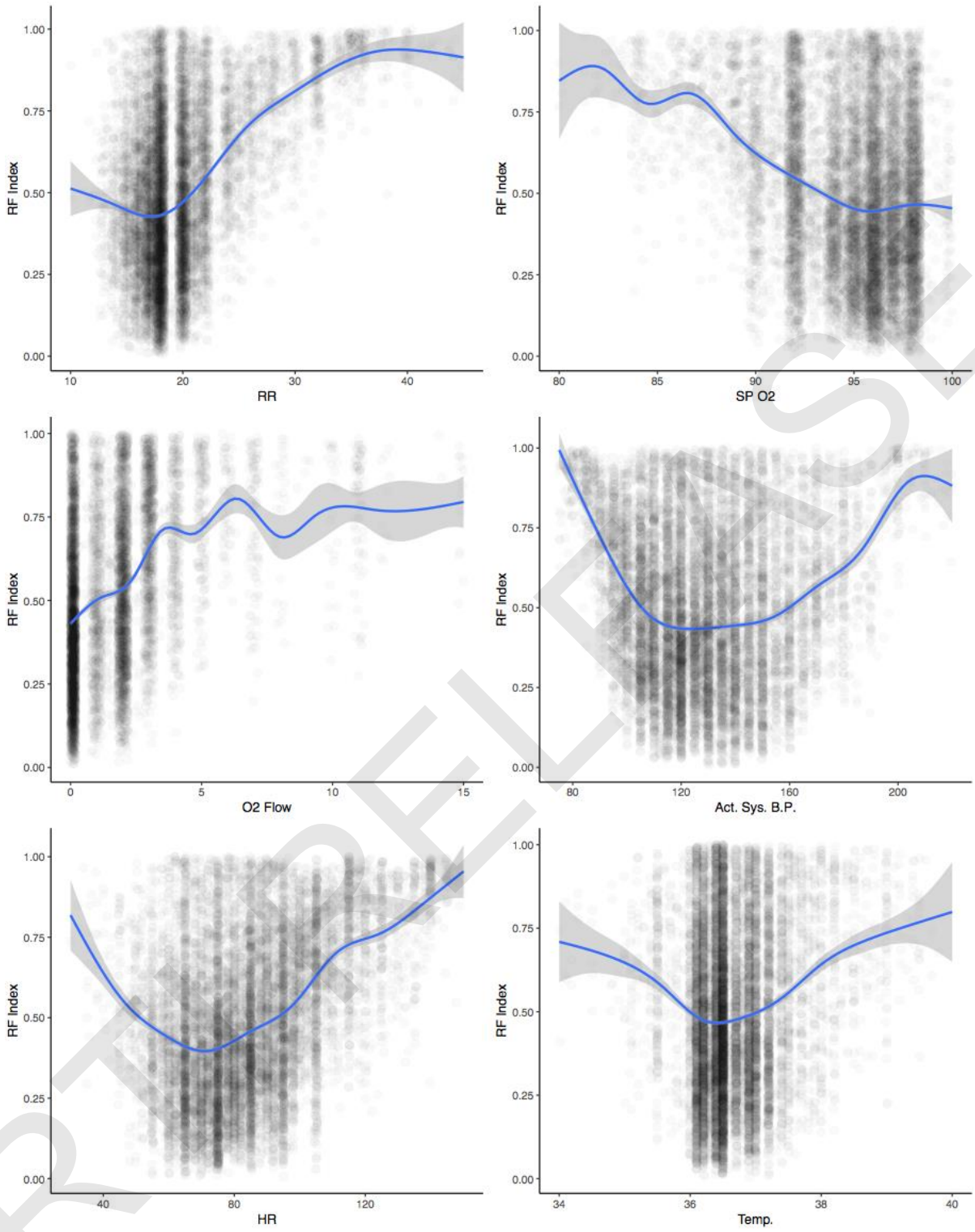

Figure 9*:* Comparison of observations with the Random Forest index: bivariate density and smoothed fit lines.

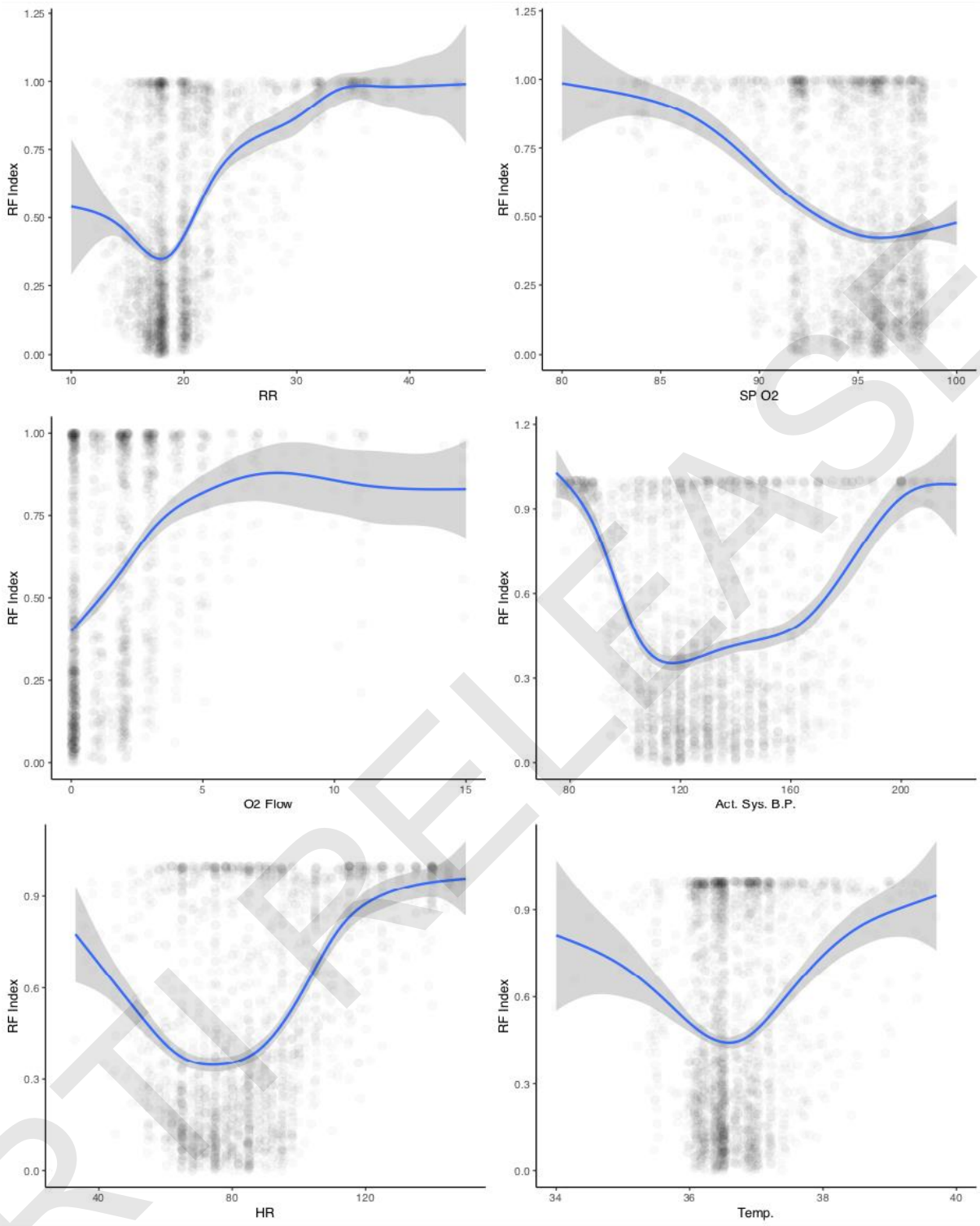

Figure 10*:* Comparison of observations with the Random Forest index: bivariate density and smoothed fit lines, including data only at the SAE time point.

Review of rural and metropolitan Q-ADDS charts

We conducted analyses to determine whether Q-ADDS performance differed with respect to locality (rural/remote sites with regional/metro sites). We grouped the Rural/Small Regional HHS (Table 1) as Rural and the Large Regional, Large Metro and Major as Metro. *Table 6* provides odds ratios (OR) and model summaries for binomial models predicting index (vs control) status from locality and Q-ADDS. Models (1) and (2) include observations from all available time points prior to SAE. Models (3) and (4) includes only observations at SAE. In interpreting the OR it must be kept in mind that approximately equal numbers of index and control patient records were sourced from both rural and metropolitan sites. The significant interactions show differential functioning of the Q-ADDS between localities. This effect is made clearer when the mean is compared for the Q-ADDS scores for index and control patients across metropolitan and rural sites. Q-ADDS scores tend to be relatively much higher in index patients in metropolitan compared to rural sites. Scores of control patients also tend to be marginally higher in metropolitan sites.

Table 7*:* Rural/Metro Odds ratios and model summaries for binomial models predicting index (vs control) status from locality and Q-ADDS.

	All data		At SAE	
	(1)	(2)	(3)	(4)
Rural (vs Metro) [A]	1.383 *t = 4.705****	1.905 *t = 7.990****	4.613 *t = 9.204****	6.994 *t = 10.656****
Q-ADDS Score [B]	1.525 *t = 34.728****	1.563 *t = 34.454****	2.123 *t = 23.359****	2.208 *t = 22.477****
A * B		0.732 *t = -7.693****		0.566 *t = -5.749****
Constant	0.452 *t = -27.451****	0.435 *t = -28.078****	0.120 *t = -23.087****	0.111 *t = -22.990****
Observations	11,091	11,091	2,332	2,332
Log Likelihood	-6,794.860	-6,769.301	-883.903	-872.299
Akaike Inf. Crit.	13,595.720	13,546.600	1,773.806	1,752.597

Note: *p < 0.1; **p < 0.05; ***p < 0.01

An AUC-based comparison of Q-ADDS and statistical classifiers of index versus control status for regional and metropolitan locations is provided (Table 8). The largest difference with respect to locality is for Q-ADDS at SAE. AUC for metropolitan locations is .910, and .543 at rural locations.

Table 8*:* Area Under the Curve (AUC) classification performance at metropolitan and regional sites of index versus controls for Q-ADDS, logistic regression and random forest classification.

Time	Locality	Q-ADDS	LR (2)	LR (3)	RF
-24 hr	Metro.	.604 (.013)	.617 (.014)	.622 (.014)	.688 (.013)
-24 hr	Rural	.512 (.045)	.534 (.047)	.542 (.047)	.495 (.047)
-18 hr	Metro.	.645 (.012)	.644 (.012)	.655 (.012)	.694 (.012)
-18 hr	Rural	.520 (.039)	.491 (.041)	.502 (.041)	.485 (.041)
-12 hr	Metro.	.651 (.012)	.640 (.012)	.645 (.012)	.688 (.012)
-12 hr	Rural	.585 (.036)	.553 (.039)	.556 (.039)	.560 (.039)
-6 hr	Metro.	.695 (.011)	.666 (.012)	.672 (.012)	.732 (.011)
-6 hr	Rural	.542 (.035)	.547 (.038)	.551 (.038)	.623 (.037)
SAE	Metro.	**.910 (.007)**	.767 (.011)	.778 (.011)	.896 (.007)
SAE	Rural	**.543 (.035)**	.570 (.039)	.567 (.039)	.587 (.039)

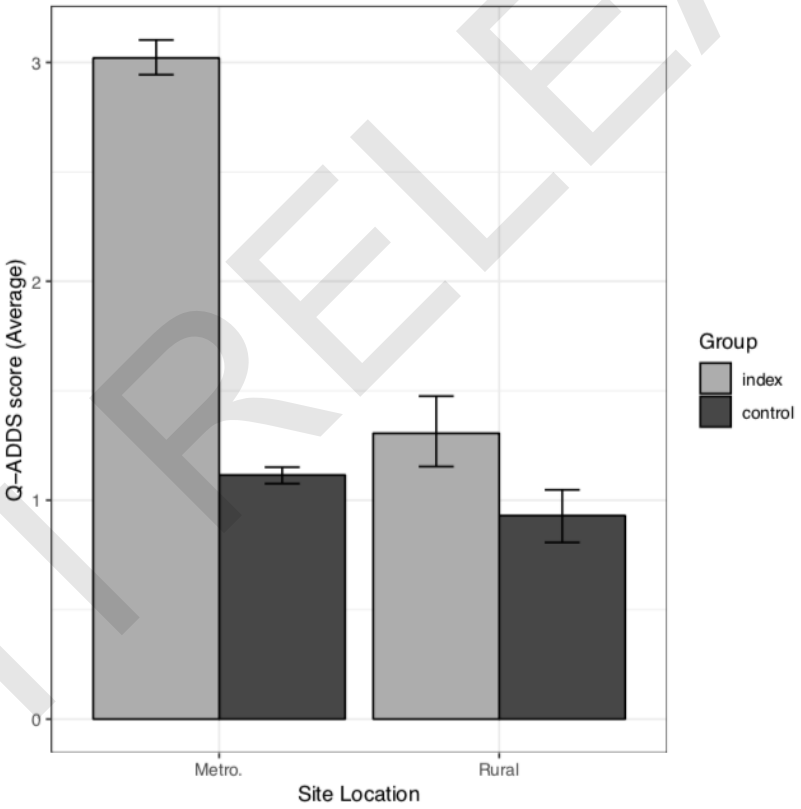

Figure 11*:* Comparison of mean Q-ADDS scores for index and control patients across metropolitan and rural sites. Error-bars indicate (bootstrapped) 95% confidence intervals.

Summary of Results – Synthesis of Part A

- SAE are less likely to occur at night
- Males over the age of 75 are more likely to have an SAE

Individual observations

- No one observation type alone is able to predict whether a person will have SAE
- RR and HR showed the strongest linear effects in predicting patient category (index/control)
- HR: A higher heart rate was significantly higher for the index group at all times, becoming more so at the time of SAE
    - HR increases consistently as index patients get closer to an SAE.
- RR: RR remained stable until time of SAE when there was a steep rise in RR was observed. Likewise we modelled that the risk with RR is low until around 20 bpm after which it steeply rises to 35 bpm. RR may be an indicator of risk of SAE or potentially an indicator that staff not accurately recording RR.
    - Very few patients were recorded to be breathing at a rate of 19 suggesting recorder error
    - Therefore it is possible that RR would follow similar stepwise patterns to HR if they were recorded accurately
    - This may have implications for the improving the predictive power of the Q-ADDS
- Over time (distal to admission) the control group required less oxygen and maintained a median of around SpO_2 of around 96%. In contrast the index group consistently required similar levels of oxygen but with a trend towards a lower SpO_2.
- Actual Systolic BP was slightly more variable up to -6 hour pre-SAE
- Observations are related to different degrees with the outcome (Index / Control)
    - HR is highly correlated and is a strong predictor
    - Temp is weakly correlated and is a weak predictor

The Q-ADDS model (RR, SpO_2, O_2, Actual SBP, HR, T)

- The Q-ADDS is good at predicting whether a patient is at risk of serious adverse event particularly at the time of SAE (AUC 0.873 p=0.008). This means that a randomly chosen index patient will have a higher score than a randomly chosen control patient 87% of the time.
    - The Q-ADDS also has an above chance rate of predicting an SAE at all time-points up to 24 hours prior.
    - At 24 hours preceding the SAE any randomly chosen index patient will have a greater Q-ADDS score than any randomly chosen control patient approximately 67% of the time (AUC .668).
    - Any one observation how discriminate power in discriminating between the Control or Index groups
    - In comparison to other individual observations HR performed best at 24 hours before SAE on the Q-ADDS (AUC .579). This was slightly better than the RF (AUC .573 *p*=.013).
    - There is a deterioration in the Q-ADDS' ability to predict an SAE the more distal in time from the SAE.
- A Random Forest algorithm (an approximation of the 'ideal' classification) is a better predictor of SAE at all time-points prior to SAE for individual observations.
    - there is capacity to improve the discriminatory power (sensitivity + specificity) of the tool to bring the AUC up from 0.595 (Q-ADDS) to 0.688 ('Ideal model') at 24h preceding the event by:
        - Changing to scoring / combinations of observations
        - A computational investigation of alternative scoring methods that more closely approximate the Random Forest predictor would help to elucidate this.

Rural – Metro comparisons

- There are differential functioning of the Q-ADDS between Rural and Metro localities.
- The Q-ADDS at SAE performed better in metropolitan locations (AUC 0.910) versus regional locations AUC 0.543)
- Q-ADDS scores of both index and control patients are higher in Metro
- The average total Q-ADDS score at SAE are significantly lower for Rural suggesting that these sites transfer out prior to SAE.

Results Socio-Cultural Study Part B

Part B1 - Survey - Quantitative Component

A total of 291 valid responses were received from Queensland Health Staff members, the majority of these were Nursing staff (n=285, 98%) in an equal proportion of Full (n=135, 46%) and Part time employment (n=134, 46%). Broad coverage of the State was achieved with respondents coming from Mossman, Proserpine, Sarina, Townsville and Torres in the far north, Mt Isa in Northwest to Gold Coast, Sunshine Coast, Brisbane (various), Toowoomba and Nambour in Southeast. Coverage also included Mackay, Central Queensland (e.g., Rockhampton, Mt Morgan, Wide Bay) and further west (e.g., Theodore, Monto, Mareeba, Longreach and Emerald). These locations were coded into Rural/Small Regional (n=51, 19%), Large Regional (n=92, 33%) and Metro (n=133, 48%) for subsequent analyses. Experience (in profession) ranged from 1-5 years (n=65, 23%) to 31+ years (n=58, 20%).

Training

The majority of respondents indicated having received Q-ADDS training (n=239, 82%), although non-significant there was a trend whereby those in Large Regional areas were less likely to have received training (χ^2=4.829, p=0.089). When asked to rate the sufficiency of training received personally across seven aspects of Q-ADDS, respondents indicated lowest confidence in ‘complete the pain and sedation section’ and ‘use the target/default systolic blood pressure section’. Participants rated the adequacy of training for other staff (new, locum, continuing education and student) as much lower than their own; this was particularly the case for casual / locum staff.

When asked how frequently they complied with Q-ADDS documentation 53% (n=135) indicated ‘Always’, with a further 40% indicating ‘Usually’. The pattern of compliance was significantly related to receiving Q-ADDS training (χ^2=10.166, p<0.05) and can be seen in Figure 12. Interestingly, receiving training had no impact on self-rated accuracy across the range of Q-ADDS requirements (e.g., Pain and sedation scores, respiratory and heart rates, temperature, BP etc) with the exception of Total Score (p<0.05) with those without training indicating completing this aspect with less accuracy.

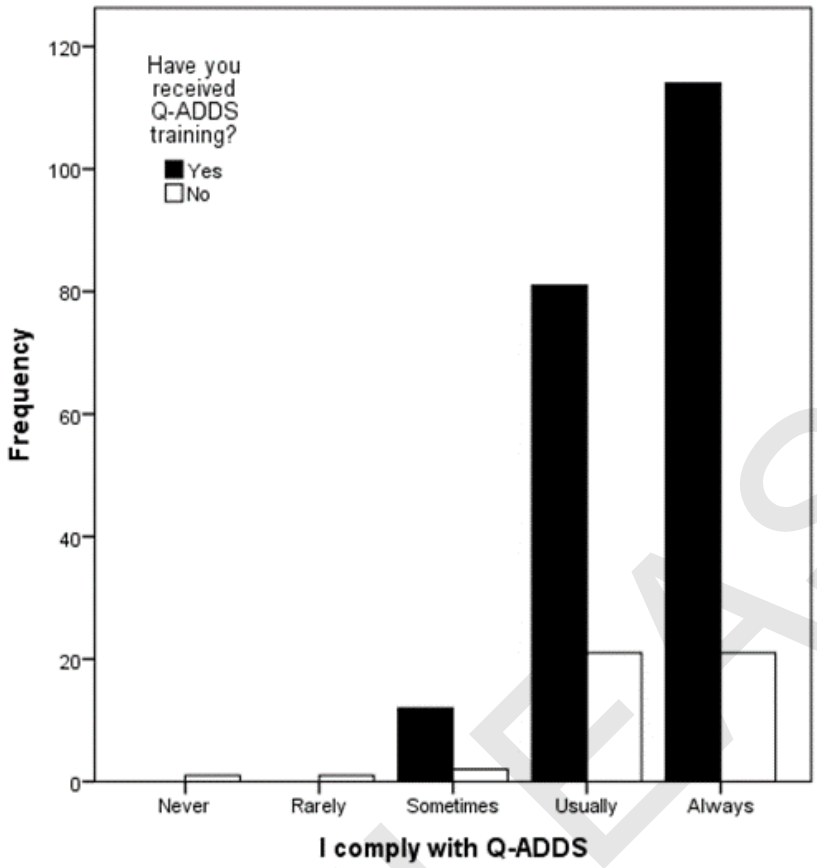

Figure 12: Self-reported compliance with Q-ADDS as a function of receiving training in Q-ADDS.

Attitude towards Q-ADDS

Personal beliefs about Q-ADDS (QATTITUDE) were assessed via eight Likert based questions, the answers to these items were summed following re-coding of two items so that lower scores indicate stronger support for/belief in the value of the Q-ADDS tool (Cronbach alpha = 0.847), average score was 16.34 (range 8-40). QATTITUDE proved to correlate strongly with perceived working environment (r = -0.312, p < 0.001) and sufficiency of training (r = -0.347, p < 0.001) in that those who were happier at work and/or had received sufficient training tended to value the Q-ADDS tool to a greater extent. Perceptions of colleague's attitudes towards Q-ADDS were also assessed via a series of eight items, answers across these were summed (OTHERattQ-ADDS, Cronbach alpha = 0.871) with lower scores indicating more positive peer evaluations of Q-ADDS. A strong, positive, correlation was observed between the participants own attitude toward Q-ADDS and how they believed their peers feel about Q-ADDS (r = 0.54, p < 0.000).

Overall support for/endorsement of Q-ADDS also affected accuracy ratings for Sedation score (p < 0.05), BP (p < 0.05), Level of consciousness (p < 0.01), Total score (p < 0.001) and Documenting interventions (p < 0.05) with higher accuracy relating to greater support.

Strict adherence to Q-ADDS escalation requirements was noted by just over half of the respondents (52%, n = 132) with no significant difference in compliance with escalation by training, location or experience. Attitude to/support for Q-ADDS did impact compliance; escalation requirements with lower support were linked to significantly lower compliance (F (2,250) = 8.176, p < 0.001).

Future intent to comply

Participants were asked to indicate how often they intended to comply with six Q-ADDS related requirements over the next month. These six requirements were: complete chart as per guidelines, add total score for each set of observations, comply with actions as outlined in chart, escalate care as indicated on the chart, accurately document all vital signs and graph observations. While there was a high level of intention to comply across all items both intention to escalate care and intention to graph observations were noticeably lower. To facilitate subsequent analyses a composite score (QADDIntent, Cronbach alpha = 0.847) was calculated.

Predicting intent to comply with Q-ADDS in the next month using Theory of Planned Behaviour (TPA) variables

To assess the utility of demographic (e.g., employment status, location and experience) and TPB relevant variables (i.e., personal attitude towards Q-ADDS and peer attitude towards Q-ADDS) on intention to comply with Q-ADDS in the coming month an initial multiple, linear, regression was conducted. The QADDIntent composite score was entered as the dependent variable with Employment status, Location, Experience, Unit/service area, training in Q-ADDS, past compliance with Q-ADDS generally and escalation procedures, work environment, QATTITUDE, Q-ADDS accuracy, OTHERattQ-ADDS and CONTROLQAADS entered as independent variables (this regression equation predicted approximately 28.8% of the variance in Intention scores). Interestingly only previous compliance to Q-ADDS generally and escalation procedures specifically, personal attitude towards Q-ADDS (QATTITUDE) and Q-ADDS training loaded significantly onto this first equation. Following the procedure outlined by Field (2013) a second, forward (stepwise) regression was then performed entering only these predictor variables (with order of entry dictated by standardized B weights from equation one). All of the entered predictor variables loaded on the resultant model, which explained 31.5% of the variance in Intention to comply scores (Adjusted R2 = 0.326, F (4,247) = 29.407, p < 0.001). Durbin-Watson (2.038) and VIF (1.0-1.3) scores indicated a robust equation which meets underlying assumptions. Cross-validation of the model was performed via calculation of Stein's equation (adjusted R2 =

0.313), given that this value was very similar to the observed R2 value good cross-validity can be assumed (Field, 2013). Examination of the standardized B values indicated that the strongest predictor of intention to comply with Q-ADDS requirements in the coming month was previously compliant behaviour (0.325, $p < 0.001$), followed by personal attitude toward/support of Q-ADDS (-0.193, $p < 0.001$), previous compliance with escalation procedures (0.171, $p < 0.01$) and having received Q-ADDS training (0.135, $p < 0.05$) (Figure 13). In looking at the summary table previous compliance with Q-ADDS requirements generally (when loaded as the sole predictor variable) proved to explain approximately 23% of the variance underscoring the importance of this behaviour in predicting future intentions to comply.

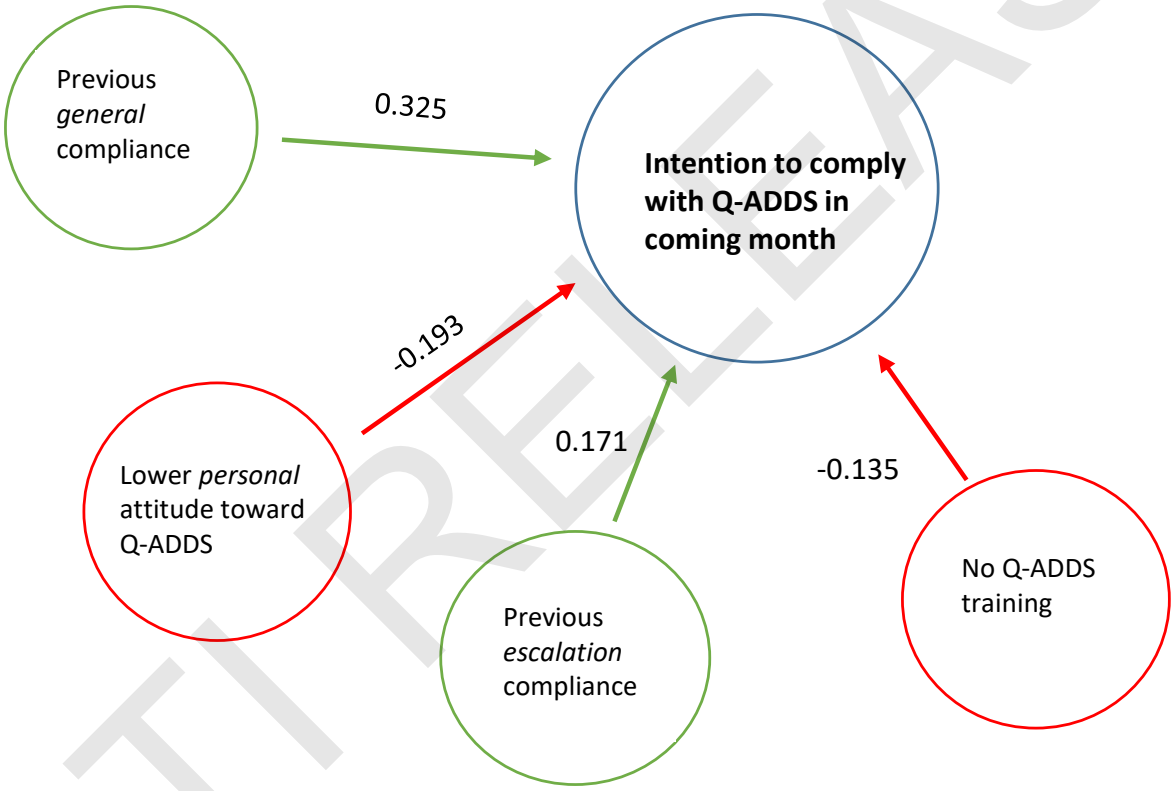

Figure 13: Model showing variables found to significantly predict intention to comply with Q-ADDS requirements in the future

Part B1 Survey – Qualitative Component (responses to open questions)

Demographics

A subset of the survey sample (n=181) responded to up to 15 open-ended questions presented periodically throughout the survey. The majority of respondents were full time (46%, n=80) or part time (47%, n=83) employees, with only 14 respondents working on a casual or agency basis (7%). Similarly to the total sample, qualitative respondents represented a broad distribution of years' experience (1-5 years = 18%; 6-10 years = 20%; 11-20 years = 21%; 21-30 years = 19%; over 31 years = 21%). Large regional respondents were represented slightly more frequently among qualitative respondents (35%, n = 62) than in the total sample, though this difference was not significant. Metro (44%, n = 77) and small regional (15%, n = 27) respondents were slightly under-represented in the qualitative sample, though similarly these differences were not statistically significant.

Training

Responses indicate that the training received was not sufficient for correct compliance of the Q-ADDS. There was an overwhelming response that no formal training was provided and that staff learned to use the tool on the job and that ad-hoc, on-the-job training is leading to misuse of the Q-ADDS. Others responded that when training occurs, it is not in depth enough and does not meet the needs of diverse staffing cohorts. Respondents stated that more training is required specifically for the BP and modifications sections of the document and that training is required before and after introduction of every updated version. Casualization of workforce (all levels) was an issue in terms of training, with many participants stating casual staff (nursing and medical) should receive Q-ADDS training prior to commencing on a new ward.

Interestingly, participants mentioned that as there are no outcome measures (consequences) for noncompliance there is no accountability. This altered their perception of how the Q-ADDS was used. Respondents clearly stated they want more regular, broader education to ensure that staff are compliant and to emphasise the chart's importance.

Work satisfaction and its influence on compliance

Generally, work satisfaction was reported as having an influence on compliance with the Q-ADDS, with hierarchy issues, poor perception of management, casualization of staff and high patient-staff ratios contributing to the satisfaction levels of staff. Professional hierarchy within the workplace was considered the main issue in terms of work satisfaction and this was reflected at different organisational levels. Comments from Assistants in Nursing (AINs),

Enrolled Nurses (EENs), Registered Nurses (RNs) and Medical Officers (MOs) regarding workplace hierarchy and the impact that has on Q-ADDS escalation processes (failure to escalate or response to escalation) were prevalent in the data. Although many considered that their team worked well together, there was a perception that external management (not on the floor or from the same ward) do not value staff. Perceptions regarding management were occasionally flagged and a common theme was that poor management leads to change from below rather than above, resulting in inconsistent, chaotic change. The issue of casualization within the workplace was reported as a potential issue as casual staff often do not feel connected to any particular team and compliance may therefore be altered in some cases. With regards to patient and clinician relationships, it was reported that when there was a high patient-staff ratio this resulted in decreased work satisfaction. There was also a general perception that patients do not value staff.

Perception of the Q-ADDS charting system

The general perception of Q-ADDS was that it is effective when used correctly and was a useful tool for new staff and for less experienced staff. However, many respondents indicated that Q-ADDS inhibits the development of clinical skills and/or critical thinking skills and further, that Q-ADDS undermines clinical assessment skills and clinical judgement in more experienced staff. This was evident when more experienced staff articulated concerns that more junior staff tended to look at numbers rather than patients for signs of deterioration. Of minor note, there was mention that the chart is too busy or complex and tries to achieve too many objectives. Respondents repeatedly reported that medical officers do not document appropriately, do not complete the modifications section correctly and do not respond appropriately to escalation, often dismissing concerns when they are raised.

Barriers to compliance (Monitoring)

When examining compliance when filling in the chart, several issues were raised, including claims that the Q-ADDS does not allow for partial completion, undermines clinical judgement and does not facilitate accurate documentation. Partial completion of Q-ADDS is often required when following correct protocols regarding specific infusions or procedures or when maintaining close observations on one vital sign. Because there is currently no accommodation for partial completion, and it is seen to be non-compliant to not complete every vital sign, staff are conflicted and respond to this by doing one of the following:

- Do not do the vital sign round at all because they only want to check one vital sign
- Do one vital sign and do not chart it
- Do the vital sign they want to check and tick and flick the remainder

It was reported that staff are allowing their clinical judgement to override the need to complete the Q-ADDS. Well over a quarter of respondents said that not all vital signs should be collected at each round. On the contrary, some staff suggested that pain and/or sedation score sections need to be included on all Q-ADDS iterations. Concerns were voiced that the chart did not contain enough space for documentation, but on the other hand, other respondents said double documenting is an issue (on Q-ADDS as well as in the patient's notes in the chart). Full documentation compliance was also hindered in some cases by limited physical resources or equipment.

When asked about the use of the Q-ADDS moving forward, overwhelmingly participants stated that they will continue to use both graphing and numbers (despite this being incorrect, the chart should only be used to graph) due to their belief that graphing is subjective. Further to this, it was stated that doctors always ask for a value and are not concerned with Q-ADDS score and this problem of communication was provided as a reason for non-compliance.

Barriers to compliance (Escalation)

When considering the perceived barriers to Q-ADDS escalation compliance, staff were very vocal about their desire to employ their own clinical judgement to override published escalation processes. For example, it was reported that when clinicians' judgement tells them something different to the Q-ADDS score, they may override score interventions or escalations. Staff reported delaying escalation due to their perceived clinical acuity of patients and reported delaying escalation whilst waiting for interventions to take effect.

In other cases, the escalation processes were not followed correctly when staff believed that modifications had been written out incorrectly or were absent when staff felt they were required. In these cases, staff stated that seemingly overinflated Q-ADDS scores were ignored and no escalation processes were activated as they waited for the modifications to be added (or corrected) to the chart. Of note, staff felt that this forced non-compliance (avoiding escalation while awaiting modifications) had repercussions on the hierarchical dynamics of a work unit. Alternatively, Q-ADDS scores were sometimes deliberately miscalculated to ensure escalation processes were not triggered as many respondents said that they believe that many MET calls triggered in response to a high Q-ADDS score are not warranted.

Professional hierarchy in the workplace was reported as an issue to compliance, with staff feeling undervalued or made to feel as though their clinical skills are inadequate by more senior staff. Most importantly, this may impact their decision to escalate a patient's care. Concerns about negative judgements from the review team if a MET is called means that

often staff will inform more senior staff on the floor (transferring risk) rather than triggering the MET call.

Facilitators of compliance

When asked what made them compliant with using Q-ADDS, the majority of respondents stated that patient safety motivates them to be compliant. Whilst patient safety was the largest driver, all respondents mentioned at least one of the following three motivators:

- Patient safety
- Maintenance of their registration
- That it is the right thing to do.

Synthesis of survey results

Model of compliance

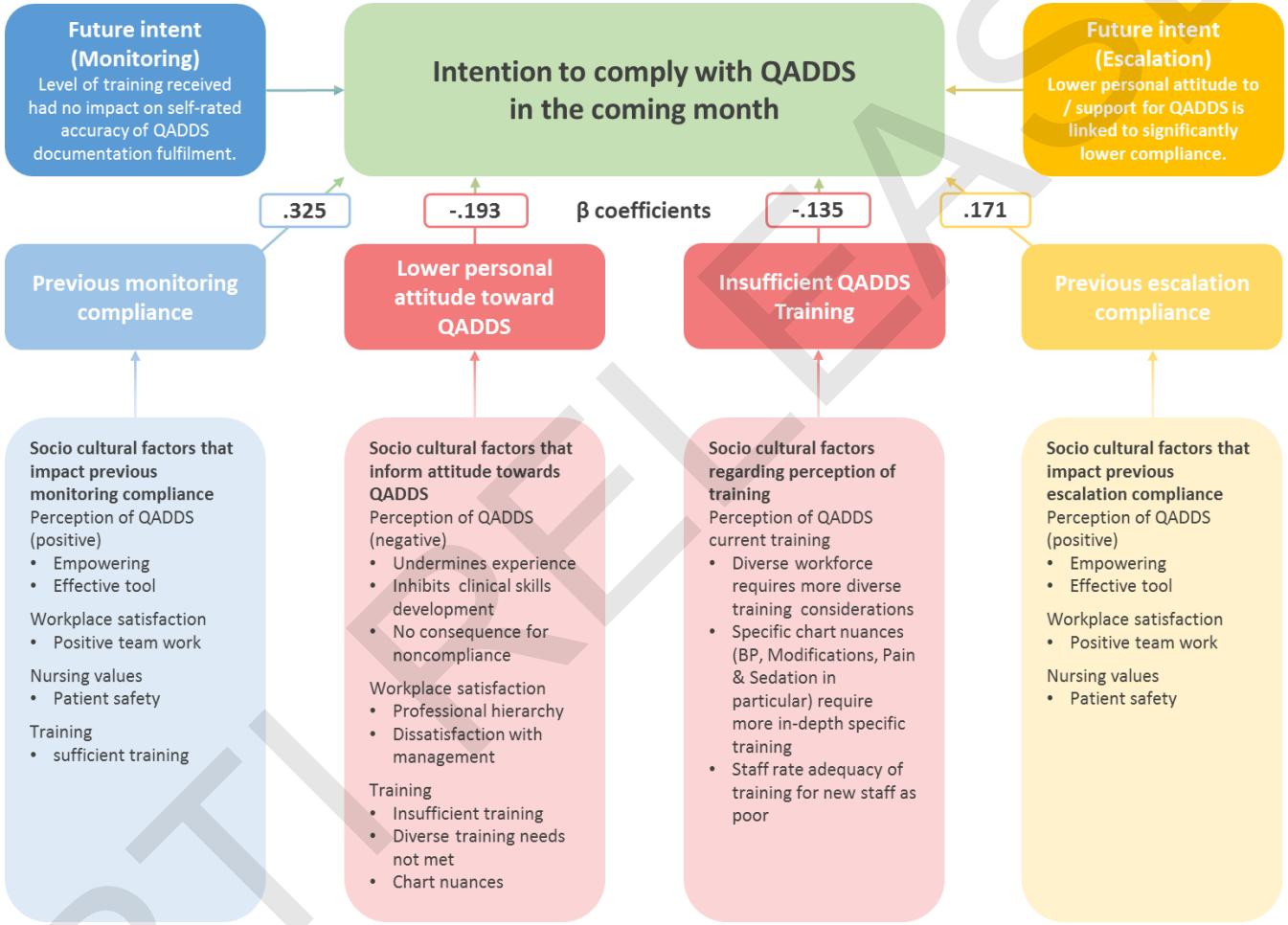

Figure 14: Strength of the contributions (β coefficient) of the key drivers of intention to comply with Q-ADDS in the coming month (outcome). Lower personal attitude toward Q-ADDS (β = -0.19, p < 0.05) and insufficient Q-ADDS training (β = -0.14, p < 0.05) were both negative predictors of the outcome. Previous monitoring compliance (β = 0.33, p < 0.05) and previous escalation compliance (β = 0.17, p < 0.05) were positive predictors of the outcome.

Summary of main findings from Survey

- Previous compliance is the highest predictor of intent for future compliance
- Previous compliance (monitoring and/or escalation) is impacted by the following socio cultural factors:
    - Positive or negative attitude of Q-ADDS
    - Workplace satisfaction or dissatisfaction
    - Nursing values
    - Positive or negative perception of Q-ADDS training

Part B2 - Interviews (qualitative component)

A total of 30 QLD hospital staff volunteered to participate in a telephone interview with the aim to explore staff experiences with the Q-ADDS tool. Of these, 10 Doctors (M = 8; F = 2) and 20 Nursing Staff (M = 2; F = 18) of varying degrees of experience were recruited. Participants ranged in experience from 1 year post-graduation up to 40 years post-graduation. Nursing participants had a range of roles based on differences in experience (1 Enrolled Nurse; 13 Registered Nurse; 6 Nursing Management (e.g. CN/NUM/NE/CC). Participants were located across rural/remote (n = 8; 4 Medical, 4 Nursing), regional (n = 16; 4 Medical, 12 Nursing), and metro (n = 6; 2 Medical, 4 Nursing).

Two key processes related to the use of Q-ADDS emerged: (1) routine use of Q-ADDS for patient monitoring; and (2) escalation of patient's deterioration with or without the engagement of the Medical Emergency Team (MET). These processes are well documented in literature focused on the use of early warning detection tools, of which Q-ADDS is an example (Credland et al., 2018; Le Lagadec & Dwyer, 2017; Leonard-Roberts et al., 2018; McGaughey et al., 2017). Early warning detection tools are used to detect at-risk patients, to alert the treating staff, and to communicate with the MET when necessary (Le Lagadec & Dwyer, 2017; Petersen et al., 2017).

Compliance or non-compliance with Q-ADDS monitoring and escalation policies were related to decision-making factors present or absent on the three levels: (1) *the individual clinician*, (2) *the team*, and (3) *the organisation*. Considering that the participants primarily focused on the nursing staff when identifying compliance and non-compliance behaviours, *the individual clinician* refers to a Registered Nurse. T*he team* refers to a particular hospital ward or a particular clinical team. It is in the team context that behaviours of medical officers can be unpacked. *The organisation* denotes the hospital and health service tied to a geographical area.

It is well recognised that delivery of healthcare occurs at different practice levels (Grol & Grimshaw, 2003). The staff works individually and as a team to enact processes and behaviours that are legitimised and regulated by the organisation (Australian Commission on Safety and Quality in Health Care, 2018; May, 2013). In turn, the organisational practices are also shaped by the individuals and teams (May, 2013).

This analysis explores the three levels of decision making in engaging with Q-ADDS. First, routine use of Q-ADDS for patient monitoring is examined at individual and team levels. Second, the escalation of patients' deterioration is discussed with reference to the individual and the team. Third, the role of the organisation is examined with respect to promoting Q-

ADDS compliance and responding to non-compliance. Finally, the report concludes with a discussion of findings.

The routine use of Q-ADDS for Patient Monitoring

The Individual Clinician

Participants spoke about the routine use of Q-ADDS for patient monitoring. The main focus was on the nursing staff who are responsible for patient observations, charting, and notifying the senior staff if required. Three approaches of the routine use of Q-ADDS emerged: complacent, reactive, and proactive. While participants spoke about medical officers' behaviours and attitudes, they occurred in the context of team processes once the nursing clinician's initial assessment was completed. Thus, a decision was made to examine the medical officers' in the 'team' section.

The complacent approach

A complacent approach to routine use of Q-ADDS emerged, based on clinicians' reflections of their colleagues' behaviours rather than their own. Incomplete documentation of the Q-ADDS chart suggestive of doing incomplete patient observations are commonly cited. Research also shows that these are prevalent non-compliance behaviours in early warning systems (Credland et al., 2018; Derby, Hartung, Wolf, Zak, & Evenson, 2017; Flenady, Dwyer, & Applegarth, 2016; Flenady, Dwyer, & Applegarth, 2017). Participants' in this study suggested explanations for these errors of omission vary. P16_RN comments: *there are lots of people who think things don't matter or they have something more important to do*. P12_RN is of the view that *staff don't know how to use it (Q-ADDS)*. Time constraints are commonly proposed as reasons for non-compliance, especially when more frequent observations are required for the deteriorating patient (e.g. P16_RN, P14_RN, P22_RN, P10_RN, P39_RN, P37_RN, P41_RN). Based on personal experience, P22_RN elaborates how the 'complacent approach' in doing patient observations plays out in practice and emerges due to competing work demands: *depends how busy I am, how many other patients I'm looking after and if they are sicker… if I don't have time to do a full set of vital signs…. I'll stick my head in and ask how they are. How do you feel? You can look at someone to see if they're breathing, their airways, skin colour, they can report if they're feeling better or worse.* Prior research also has produced similar findings related to reasons for non-compliance (Credland et al., 2018; Flenady et al., 2016).

Concern about the lack of engagement with the Q-ADDS among some nursing clinicians is raised. P16_RN observes: *they (junior staff) fill it out but aren't paying attention, they count*

them (boxes) and don't understand what they've ticked… so they don't do anything about it. P16_RN is concerned that for some junior staff, filling out Q-ADDS is a mere box ticking exercise rather than a thorough assessment informed by clinical reasoning. Similar concerns are documented that over-reliance on early warning scores may prevent junior clinicians from fully developing professional judgement as an aspect of decision making when faced with a deteriorating patient (Downey et al., 2017). However, complacency among the senior staff towards the use of Q-ADDS is also apparent. P10_RN explains: *there is some open hostility to the form from… staff who've been around for 20-30 years. They'll tell you day in and day out that the form's a load of shit and takes away from clinical judgement*. The presence of polarised attitudes among clinicians towards Q-ADDS is evident in the data. Some clinicians perceive that Q-ADDS 'dumbs down' clinical practice whereas others see it as a tool of 'empowerment'. Similar attitudes have been documented towards other early warning systems (Downey et al., 2017). This trend is unpacked in further analysis.

The reactive approach

Participants express that Q-ADDS can be an empowerment tool for the junior staff. P26_RN, a self-proclaimed 'Q-ADDS Nazi' with two years of post-qualifying experience expresses: *I love using Q-ADDS, for me it does pick up and identify deterioration.* P08_RN agrees: *it helps the more junior people who might not understand what's going on behind the parameters, it gives them a concise idea of how sick their patient is*. P14_RN indicates that the tool assists with instigating action: *you do see the 1-3, they do notify team leader, it's one of the things you do see most of*.

When using Q-ADDS however, P04_MO observes that 'junior nurses might react rather than do it proactively'. The 'reactive approach' refers to using the form in a more concrete sense, and reacting to the patients' Q-ADDS score by triggering action without formulating clinical assessment. P14_RN remarks: *the more junior nurses do say "I have a 5, this is what I need to be doing".* The junior staff are then encouraged *not to just report on a 5, but to break it down and think what's caused the 5 and start thinking about the individual as part of the score.* The support from the senior staff is vital for the junior clinicians to use Q-ADDS as a tool for more in-depth assessment.

The proactive approach

Ideally, the individual clinician engages with Q-ADDS proactively by applying clinical reasoning. Le Legadec and Dwyer (2017) observe that the systems are only as efficient as the staff employing them. The participants express that the more senior staff tend to adapt the proactive approach. P42_MO compares and contrasts the reactive and proactive

approach: *the more junior nursing staff are a lot more inclined to hit the MET call button if they're not comfortable with the situation, whereas the nursing staff who have been there a little bit longer, if a patient has a systolic blood pressure of say 85 and they are really close to being MET call criteria, they are happy to sort of say well it's most likely post-op hypotension, go and get a doctor and give them fluids and it's all great.* P42_MO suggests that in the proactive approach, the nurse is confident in managing the deterioration alone, whereas in the reactive approach, the nurse transfers the risk.

Senior nurses seem to use their discretion when using Q-ADDS. P41_RN expresses: *I know personally what I can do with that form and what I can't do. Or what I should and shouldn't*. P22_RN also reports that she uses Q-ADDS score as 'a very rough guide'. As a nurse with 28 years of experience, P22_RN asserts*: this is a blunt tool, I know how to deal with this patient and get the help that I need when I need it*. The nurses' remarks are consistent with prior research findings that experienced nurses use a complex interaction of intuition, protocols and clinical judgement to recognize patient deterioration (T. Flenady et al., 2016; Leonard-Roberts et al., 2018; McGaughey et al., 2017).

For the senior nurses, however, tension may arise between drawing on their practice wisdom and maintaining Q-ADDS compliance. P32_RN points out that the proactive approach can overlap with the complacent approach: *the more senior staff tend to get complacent with it a little bit, so when they get a score between 1 and 3 often the very experienced staff won't phone the team leader*.

The Team

Q-ADDS compliance requires to be enforced on the team level so that individuals integrate consistent use of Q-ADDS into their routine practice. Staff require reminding that Q-ADDS compliance is everybody's responsibility as members of a team. P40_RN who is an experienced clinician expresses: *my manager keeps saying to me "this isn't a tool just for you, it's to cover everybody*". As earlier indicated, the senior nurses can become complacent with completing the tool. In turn, the junior ones as P10_RN points out 'end up doing whatever the unit culture is' and as P14_RN observes 'can be influenced by the area or the people they're working with'.

Awareness of being monitored fosters compliance. P16_RN remarks: 'I do it because I'm told to'. P39_RN reflects: *one of our grads, she escalated but she didn't document any interventions and the score of 6 and hadn't documented a thing about it. We actually pulled her in about it, early on her shift and sat her down and had a big chat about it. I know for a fact that she's then spoken to other people about that talk and so now people are on alert.*

The team leaders are also the role models in modelling the desired behaviour. P39_RN explains: 'I feel like I need to lead by example'. Similarly, P14_RN states: *I've got to be educating people so I know it would look bad if I didn't follow the process myself*.

The team leaders are required to exercise perseverance in enforcing the procedures and reminding staff about their professional responsibility and accountability to promote patient safety. P14_RN expresses: *we keep reinforcing it… its harsh and it does sound harsh but at the end of the day, patient safety is paramount.* As P32_RN states, the reinforcement can be as simple as 'constantly telling people' that 'If there's a number then you have to write an intervention'. P24_RN comments on the importance of these actions: *once there's a proper understanding of the form, we rarely come across the same problems from individual nurses*. Yet, the extent to which staff are cautioned for non-compliance varies among the teams. In P36_RN' experience: Q-ADDS *is not valued* [and] *there's no penalties for not filling it out*. The comments suggest that the team culture can either foster or hinder compliance around the appropriate use of Q-ADDS. According to Carlstrom and Ekman (2012), culture is a link between the individual and collective behaviours. On the team level, the culture reinforces the accepted set of behaviours (Carlstrom & Ekman, 2012).

Some medical officers' report using Q-ADDS as part of a routine practice of reviewing patients and assessing whether or not chronic modifications are required. For P05_MO, Q-ADDS became a reminder that "*yeah, this patient has low BP all the time, we should modify*". Similarly, P15_MO expresses that Q-ADDS is a helpful 'formula to follow' given that 'medical registrars obviously will be a lot more comfortable to modify physiology if they think it's necessary'.

Yet, in the narratives, double standards are apparent in meeting expectations related to maintaining Q-ADDS documentations between doctors and nurses. A pervasive issue relates to medical officers not completing Q-ADDS modifications in responding to heightened patient's scores. P08_RN reports: *we find those modifications are poorly added to charts by the doctors. Unless the doctors are prompted by the nurse, they normally don't write the modifications*. P17 MO acknowledges: *often it is how encouraged we are by nursing staff to fill it out. We're often prompted multiple times before we get round to doing it. But that's good because then obviously they're prompting us based on their use of Q-ADDS*. Korner et al (2016) suggest that medical doctors' positive evaluation of the team processes in comparison to these of nurses can be indicative of the presence of professional silos in which they exercise power.

Medical officers' reluctance to introduce modifications creates follow-up work. P05_MO explains: *there might be more communication between nursing and medical staff. Some of*

the communications might not have been necessary if the medical team modified the score earlier for chronic conditions. P37_RN contextualises how this issue plays out in practice*: even if the doctors say yeah, its ok, they need to write yeah that's ok and they need to follow that up regularly. They don't do that. They'll go don't worry about it, it's ok, but it's not*. P37_RN suggests that the communication can be characterised by ambiguity and mixed messages which place the nursing staff in a difficult position around Q-ADDS compliance. P24_RN practising in a small rural hospital indicates that new doctors in that particular hospital get inducted into following the processes: *we do more education on that with our doctors than any other part of it. Especially with junior doctors. Most are coming from (names) major hospitals where they don't realise that those modifications are a lot more important out here than in Brisbane, where you have a MET team or doctor more readily available*.

While the nurse clinicians identify medical officers' non-compliance around introducing modifications as raising some disruptions to the workflow, narratives of the medical officers' suggest that the non-compliance can stem from the lack of specialized knowledge rather than deliberate defiance. P19_MO states: *you modify obs based on your gut feel ... but they* [patients] *slip out of that range*. P15_MO highlights that medical officers require appropriate experience and competence to make modifications: *my background training is in the ICU so we are a lot more comfortable with modifying physiology parameters... In other departments, say the surgical department, maybe because they are less knowledgeable with medical physiology, they will be more reluctant to modify ADDS and things like that. It depends on individual doctors and their level of competence.* P15_MO suggests that not all medical officers should make modifications.

When uncertain, medical officers can consult with their seniors. P01_MO comments on the process: *residents will generally nearly always defer that to a registrar or if the registrar can't physically do it they will phone advice for it. As far as registrars asking consultants I think that's fairly variable based on experience or some people do just modify it so the issue goes away, which is not advisable, others seek consultant advice before doing it.* Participants also indicated that the consultants are not consistently readily available.

At times, medical officers respond to situations where there are tensions between patients' safety and compliance with Q-ADDS procedures. P19_MO cautions that clinical reviews should not be driven by the pressure to 'modify obs to get a number out of there to stop mediating about that patient'. P01_MO explains: *the teams aren't comfortable with modifying the Q-ADDS parameters until the person's had enough time to be observed to make sure that they are not deteriorating. So the risk is if you modify too many parameters there's not*

really any room left and you end up having a real acute deterioration… it's dangerous if people don't have lots of experience with modifications and I think it's dangerous if people modify most of the parameters. P09_MO further advises that 'consultants have some scope to go outside of written guidelines if we consider that the clinical scenario warrants it'. Ultimately, patients' safety is paramount and Q-ADDS serves the purpose of ensuring that the patient gets a timely intervention when required.

Escalation of patient's deterioration with or without the engagement of the Medical Emergency Team (MET)

The Individual

Nurses have a key role in detection of patients who are deteriorating. Early recognition of abnormalities can aid in the prevention of deterioration (Martin, Heale, Lightfoot, & Hill, 2018). In turn, failure to recognize and act results in suboptimal care for the patients (Martin et al., 2018). Upon reaching a threshold Q-ADDS score, the nurse is required to notify the medical officer. P34_RN indicates how Q-ADDS can be an empowering tool for the nurse in initiating the escalation: *it gives you the confidence to say "you need to come review this patient immediately, because they're scoring a 5.*

At times, nurses are reluctant to initiate the escalation and in P38_RN's words 'sit on the fence'. P38_RN elaborates: *it might be just a lower blood pressure and they're a little bit hesitant… but obviously we want that to occur so someone is then aware of it so we can then do the necessary intervention at that point in time so we don't see continued slope of deterioration with that patient*. P01_MO reflects on the nurse's predicament: *it's hard for them (nurses) to have a balance as well because policies, and its clearly documented, what should happen and then they don't want to be doing things out of their scope of practice, on the whole most nurses won't sit on things for a long time without getting help.* The escalation gets initiated because the clinical situation requires additional support and skills that fall outside the nursing scope of practice.

Initiating the escalation can be stressful especially after hours in rural/remote facilities where there is no medical officer onsite. Participants indicate that calling the medical doctor can be an emotionally charged event as the doctors can minimise the concerns and refuse to help. P37_RN indicates that the doctors' commonly respond with '*why are you doing that, stop calling me'.* P14_RN agrees: *they [medical officers] do challenge you when you ring up. "I haven't got time"...We actually challenge them, and say 'what's their name' because we have to document that they haven't actioned it. As soon as you say that, a lot of them change the process straight away.* These examples suggest that the nurse clinicians are

required to be assertive and confident to manage differential power dynamics that the medical doctors assume in this space. Similarly, Leonard-Roberts et al (2018) observe that the nurse's role in escalation requires navigation through layers of complexity. Based on personal experience, P40_RN suggests that nurses at times do not comply with Q-ADDS procedure of calling the doctor due to the convoluted nature of the process: *I don't know if they would admit to it, but they might write… the intervention might be notify the MO. Nil concerned. If patient is asymptomatic, nil concerns. And sometimes I wonder if people don't ring? Sometimes I don't, but I don't know if I want you to know that*.

The team

Two polarised accounts emerge of the escalation. Depending on the interpersonal dynamics, the escalation can either be a poorly or a well-managed process. These are examined next.

Escalation as a poorly managed team process

Communication difficulties can obstruct responding to deteriorating patients in a timely manner (Credland et al., 2018; McGaughey et al., 2017). P16_RN based in a large regional hospital indicates that 'nurses have to cherry-pick doctors' as some 'come with an attitude proportionate to the exorbitant amount of money they're being paid'. This problem is echoed by P37_RN based in another regional hospital where there is 'the whole culture of no team work' including 'no conversations about what is the best thing for this person'. The nurse clinicians identify the presence of professional hierarchies and silos as barriers in complying with Q-ADDS protocols on the team level. This issue is a well-recognised obstacle in delivering effective healthcare because of the fragmentation that follows when it comes to decision-making and poor communication (Credland et al., 2018; Korner et al., 2016).

In this environment, the nurse who is initiating the escalation can experience a double bind where a concern for patient safety is identified and acted upon but the concern is trivialised by the medical officer. P10_RN reflects: *when they (medical officers) do respond it's quite often with an eye roll and sometimes a begrudging modification is put in place, sometimes not. And often we're going off verbal orders, which when it gets to coroners court it doesn't hold up.* The comment suggests that the outcome of initiating the escalation can be negative to the nurse who gets undermined in the process and unhelpful in addressing the concern. The fear of reprisal or not wanting to raise a false alarm are common barriers to initiating escalation (Credland et al., 2018).

Escalation of deterioration during the night shifts can be especially tricky. P37_RN reports: *the nurses in the middle of the night go; I'm really worried about my patient so I'm doing*

more regular observations. But now I need a new Q-ADDS form, but the doctor won't come up and do his modifications for me. So where do I stand? P37_RN also indicates that it is the nurses rather than the medical officers that are held accountable for the inconsistencies in documentation that are identified during the audit: *the audit gets done and they're going, your Q-ADDS tool has no modifications on it…there is never an audit into whether the doctor modified the tool correctly…The doctors are the only ones who put 'not for met call' on there. The doctors are the ones who do the modifications incorrectly*.

Consequently, the nursing clinician may face a professional and ethical dilemma due to the ambiguity of medical officers' instructions. P16_RN provides an example: *I've rung the doctor, they didn't do the mods that they written on the charts that they would do. I could do a MET call, but they've written in the chart that this is their mods.* In P16_RN's experience, escalations can introduce additional complication without any real progress in clinically responding to the deteriorating patient. P16_RN adds that poor communication can extend to the more extreme cases of the dying patient: *they'll* [medical officers] *write that the patient is dying and not think to tell anyone to stop charting on the Q-ADDS*.

Medical officers not responding to the escalation process in a timely manner is a common issue. The nursing clinician's decision to escalate the non-response to the MET team can meet with an adversarial reaction. P16_RN explains: *80% of the time the doctor in charge would just look at them and say "everyone else can leave, I'll manage this". So you, as the little nurse who called the MET call, gets the side eye. And you'll be like, "well they met the criteria and if you're not willing to do modifications, what do you expect me to do". There's the sense that the only notification isn't "great we can fix this early", it's "why the f…k did you call us for this*". McGaughey et al (2017) observe that the presence of hidden informal norms where patients are referred up through the appropriate levels authority often leave the ward staff reluctant to breach these norms. Despite the recognition that medical staff should not be critical of the ward staff who do not activate the MET appropriately because this can affect team morale and productivity (Sundararajan, Flabouris, & Thompson, 2016), this issue seems to persist. In P16_RN's workplace with 'a lot of fly in and fly out senior doctors', clear communication pathways between the nursing and medical staff seem to be absent.

In P16_RN's view, MET calls act as 'behaviour modification' for the medical officers 'so that they learn'. P16_RN explains: *doctors are very bad at including MET call in either the do or don't section. So that's always very unclear.* P10_RN observes that the medical officers are held accountable for their indecision when the MET arrives: *they [medical officers] have to answer to a MET team as to why they hadn't reviewed the patient in a more timely manner.* Working on the MET team, P1_MO confirms the gaps in following the process: *sometimes*

you feel like "oh well the home team should've done this", often the nurses have contacted the home team and they haven't come and done it so that's their option, and I think that's appropriate from the callout if they are not getting anywhere, it can sometimes stimulate it to action. P1_MO acknowledges the usefulness of getting that second opinion: *sometimes it is good to have someone else who doesn't know the patient who hasn't been sitting on it for days*.

Yet, involvement of the MET does not necessarily end the confusion associated with maintaining compliance with Q-ADDS policies when responding to a deteriorating patient. P16_RN describes a formation of the negative feedback loop related to the documentation that can ensue: *we then get to the point that the medical teams are aware that the patient's deteriorating but they often leave without writing any modification for Q-ADDS and then in the next set of observations they score the same thing. If we're going by the form we then should be going through the whole process of a MET call again, but verbally, it's very clear that it's been seen and there's no acute change and why would we call again, they've just been seen, the doctor has just left*. Here, P16_RN reiterates the challenges of working in an environment which does not strictly comply with the Q-ADDS documentation requirements. Similarly, Petersen et al (2017) find that collaboration with the medical emergency team can be problematic, since many nurses find the team to have negative attitudes.

From the MET's perspective, maintaining an absolute compliance to Q-ADDS is both unrealistic and counterproductive considering the limitations of the tool in accurately detecting deterioration. P09_MO comments: *there's room to improve the tool in terms of stopping the false alarms, because they're very burdensome to a middle sized hospital that is big enough to have lots of acuity but not big enough to have a dedicated MET team. Our MET team comes out of ICU and we have no additional man power of funding to deal with MET numbers from 2 to 10 per day*. P09_MO raises the tensions that exist between Q-ADDS concrete compliance, dealing with false alarms and the availability of limited hospital resources in responding to every call. The resources and staffing are well recognised issues related to compliance (Credland et al., 2018; McGaughey et al., 2017).

In extreme cases, the teams stop engaging with Q-ADDS when they determine that the patient is on the dying pathway. P19_MO explains: *we had a guy recently who has passed away but whilst we were doing observation, he was quite a long while in hospital because he had quite severe respiratory disease, but we were still quite actively manage him. He would repeatedly at times record saturations that were ridiculously low and clearly false… His signal wasn't great, but I can't remember the number of times his button was pushed. In the end, to deal with that, we had to stop observing it, which is really a horrific response to the*

tool. P19_MO elaborates how the patient's lack of response to the interventions can lead to making the decision of stopping the observations.

Escalation as a well-managed team process

In contrast to escalation being a poorly managed process, the well-managed approach is characterised by good communication between all clinicians involved (Martin et al., 2018). Communication among the different team members is a routine practice. P40_RN expresses: *We've got great communication with our doctors most of the time. So we'll contact them if we think mods need to change but generally we only get them for chronic patients*. P01 MO comments on the interdisciplinary team dynamics related to Q-ADDS compliance: *I am pretty much very compliant with it and the nurses are very good at notifying teams when patients need review according to the Q-ADDS or if there's something abnorma*l.

There is also a sense that nursing and medical staff work together in a supportive environment. P32_RN reports: *For a 3, it's just letting the doctor know, generally, making sure they come down and review. So yeah that's something I do. I reinforce that with the nurses on the floor who do it as well*. Interdisciplinary collegiality is evident when there is some articulated concern about a patient well before it reaches a more crises threshold. P42_MO comments: *even though I don't technically have to review the patient until the score's a 4, the nurses are comfortable to come and tell me it's rising for whatever reason so it gives me a chance to get on top of it before it is an issue*. P42_MO is an intern and the comment suggests that the nurses communicate some concerns in advance to give the more inexperienced staff more time. Martin et al (2018) observe that this communication and sharing of patient information can prevent adverse events from occurring.

In cases of emergency, the doctors respond in a timely manner. P34_RN explains: *if we can, before we hit that staff alarm, if we can escalate straight to SMO, senior doctor in ED. And I would say that my experience is that 99.99% of the time, they will come immediately.* There is also an acceptance of different pathways for escalating concern. P04_MO comments: *we don't have that level of specific communication pathway. Go straight to the phone. But I find it ok. It doesn't matter who they communicate with*.

In the well managed escalation, junior staff are well supported. P32_RN comments: *I teach people… "You have got a form here that will back you up, it is policy and protocol that you use the Q-ADDS form".* P05_MO agrees that Q-ADDS becomes a useful communication tool: *You call up an MO or registrar and ask them to review the patient that has a score of 6 and if any particular parameter is elevated. It makes this communication easier. Less*

experienced staff might go through the whole story and don't give the right information. The language becomes easier. "A score of 6, you need to see this patient". This MO indicates acceptance and a non-judgemental approach toward the junior staff who initiate escalation and focus on the patient Q-ADDS score rather than their clinical assessment.

The remote setting of the hospital can be an advantage to facilitating collegiality within the team and patient-centred care. P26_RN based in a small hospital describes her workplace: *it's one of the best places I've had with doctor's interactions out here… all our doctors who work in A&E also work in the community as a GP so they know the patient so they are comfortable with putting in mods and say this is the baseline for this patient and you shouldn't be concerned*. Yet, there is an indication that interdisciplinary collegiality and communication is a result of cultural shifts within the team. P24_RN from another small rural hospital comments: *nurses have felt uncomfortable calling a doctor because the patient has had a normal blood pressure all day and now we've checked it again and it's out of range, but its too late to phone the doctor. But they're slowly getting out of that, mainly because it is becoming more frequent that we're getting doctors to stop and consider* modifications *before they go home.* P24 suggests that having the medical officers simply checking in at the end of the shift can improve the staff morale, interdisciplinary communication and potentially improve the quality of care. P24_RN adds: *hearing senior nurses talking to doctor during hand over, it forms part of their conversation, not just talking about the way the patient is looking, or what obs. are doing, they're talking about how it relates on Q-ADDS form and how it's been tracking*. So, Q-ADDS can act as an interdisciplinary communication aid in understanding patients' health needs and fostering the interdisciplinary partnerships.

The organisational context

In the analysis so far, the focus has been on compliance as related to the individual's behaviours and attitudes as well as the team's processes. This last section considers the role of the broader organisational and operational factors in Q-ADDS compliance or non-compliance. Reflecting on the implications of introducing Q-ADDS as part of routine practice: P09_MO states: *we're not missing those patients that used to come to ICU many hours after they started deteriorating… but it's been a significant expense to the running of the hospital.*

Provision of education and training is required on the organisational level to promote consistent practices (Credland et al., 2018). P24_RN explains the importance of the training: *when it* [Q-ADDS] *first came in for us we didn't have any education at the time, so we were hearing snippets of information, and so only when it was actually delivered to us did we understand what we're trying to achieve with it*. P12_RN comments as an educator: *we did a*

lot of training around introducing the Q-ADDS and explaining how the tool worked and how it will enhance clinical judgement.

However, the basic training that legitimises the use of Q-ADDS on an organisational level, does not warrant compliance on the ward level (McGaughey et al., 2017). P09_MO reflects: *they didn't follow protocol, so we had a big advertising/education campaign …directed at the nurses to say you must call a MET call, and directed at the doctors to say you must not criticise the nurses when they call a MET call.* The campaign pertained to the interdisciplinary problems during escalation of deterioration that were earlier discussed. Traditionally, inter-professional education is thought to facilitate breaking down the professional silos (Korner et al., 2016). Yet, P09_MO expresses that the institutional educational campaign had unintended consequences: *our MET call numbers went up and up and up, went from 2 or 3 a day, to 10 a day and some of them are totally ridiculous*. Provision of organisational training without the back up support creates additional challenges around appropriately responding to signs of patients' deterioration that as discussed earlier continue to be problematic.

Inconsistencies with using Q-ADDS routinely and for escalations vary not only between the individuals but also the hospital teams. P15_MO reports: *depending on which ward you are on, the cut-offs are different and can be quite arbitrary as to what triggers the MET call…and depending on who the nurses are*. These different practices have implications on the interdisciplinary processes and how the MET is utilised. There is no mention of organisational framework to address this issue. The underutilisation of the temporary modifications section in Q-ADDS remains a whole-of-organisation problem. P12_RN who participated in the rolling out of Q-ADDS acknowledges that 'the temporary modifications, I don't think it's really well used'. Provision of training for the medical officers is not a feasible solution. P01_MO states: *there's no real training on what people should modify modifications for. I guess it's hard to train for that because it's going to be different for different pathologies and it's really an experience thing. There probably needs to be education about the consequences of modifying all the parameters*.

There is a tension between Q-ADDS compliance being a labour intensive process and the availability of resources. Lack of resources is a reason for under-monitoring (Petersen et al., 2017). Having sufficient staffing at all times is a structural barrier to compliance especially in the rural and remote areas**.** P09_MO explains: *you'll have rural hospitals in your district where there's one doctor for the whole town who can't review the patient every two hours*. P16_RN who works in an Emergency Department of a large regional hospital comments on the workplace: *they haven't had stable management in our ED for nearly 10 years.* Staffing

shortages and the associated instability within the teams and wards are a big challenge for hospital and health services. Furthermore, staffing allocations are driven by established operational processes rather than the patients' needs at a given time. P34_RN reports: *we don't use trends to estimate nursing hours... So whether we end up with 7 or 17 patients, we have the same amount of staffing. So when you have 17 patients and are bed-locked and you have a heavy workflow. Similarly, after hours staffing allocations can affect the extent to which the staff is compliant with Q-ADDS.*

Participants in senior positions point out the presence of additional resources to support the clinicians' Q-ADDS compliance. Yet, the distribution of these resources vary across locations. P09_MO indicates: *a lot of these rural and remote areas you have the benefit of ringing QCC with video conferencing and you can ask to speak to a RN. If you don't want to speak to a doctor because you're uncomfortable. They have really experienced RNs on those teams and you can dial in with the patient in the room too*. However, the interviewed clinicians did not discuss accessing QCC as part of managing patients and the deterioration. P12_RN who is based in a major hospital also indicates that an additional position was created to support the Q-ADDS compliance: *in our hospital we have an extra support person called the CTC (Clinical Team Coordinator) and their primary job is to help recognise deteriorating patients. So often staff will call the CTC if unable to get a timely medical review (for example when doctors are in theatre), - they'll contact the CTC and they'll help to escalate their concerns*. Yet, it seems that this position has been created in selected hospitals. In their narratives, the participants did not refer to that particular role, so understanding its impact on compliance is outside the scope of this analysis.

Discussion

This analysis uncovered that compliance and non-compliance of Q-ADDS processes occurs on the individual and team levels. These behaviours need to be considered nested within organisational contexts. Unsurprisingly, following Q-ADDS procedures in practice does not necessarily lead to the expected outcomes that are explicated in Q-ADDS document's flow chart. McGaughey et al. (2017) observe that in practice, implementation of healthcare policies tends to be non-linear. Implementation takes place in complex systems and relies on the individuals' competence and teams' processes of enacting certain practices (May, 2013). The findings show that integrating the use of Q-ADDS into the routine practice requires substantial time. Le Legadec and Dwyer (2017) observed that it may take years for systems to be optimally utilised since the staff require time to gain an understanding of the system and confidence in its reliability.

Participants in the current study identified that health clinicians make the same errors that have been identified in previous research. The typical errors or non-compliance behaviours commonly relate to inconsistent documentation and patient observations (Credland et al., 2018; Derby et al., 2017; Flenady et al., 2016; Flenady et al., 2017). Competing work priorities, time constraints and staffing shortages all play a role (McGaughey et al., 2017; Sundararajan et al., 2016). Escalation of patient deterioration can also be an emotionally charged process where the help is not provided in a timely manner. Scholars strongly recommend that novel research endeavours focus on understanding the social, cultural and inter-professional issues related to compliance and non-compliance behaviour related to the engagement with EWSs (Credland et al., 2018; McGaughey et al., 2017). The current study sought to generate some insights to this knowledge gap.

The results are presented through a nurse-centric lens. This is because when asked about compliance behaviours, participants tended to focus on the nurse rather than the doctor. This bias perhaps reflects a tendency to look at compliance and non-compliance as situated within the nursing profession. Consequently, in this current study, there is more rich data focused on the nurse rather than the medical officer. Concerning compliance with the Q-ADDS process, it was identified that clinical reasoning is necessary to interpret the Q-ADDS score and to decide on the appropriate course of action. Clinical reasoning is essential when using any early warning detection system (Downey et al., 2017; Le Lagadec & Dwyer, 2017). Consistent with prior research, senior nurses are more comfortable with managing patients' deterioration than junior nurses (Leonard-Roberts et al., 2018; McGaughey et al., 2017). The experienced nurses tend to assume leadership in providing role-modelling and education to

the junior nursing staff, as well as holding the medical officers accountable in exercising some Q-ADDS compliance.

This study identifies challenges that medical officers may encounter related to compliance with Q-ADDS processes while maintaining patients' safety. Common is the resistance from the medical officers to make modifications for deteriorating patients due to the limited health information about a patient coupled with a reluctance to simply guess a suitable modification. There is a recognition that making modifications can be potentially unsafe for the patient. In addition, it is risky to assume that all medical officers have the experience and competence to make the modifications. In practice, the ambiguous directions from medical officers can create confusion among teams and disturb workflow.

The findings highlight the importance of communication. Depending on the team processes, the escalation can either be a well or a poorly managed process. In the former, the nurse escalates the patient deterioration in a supportive and collegial environment and is able to receive the necessary help for the patient. There is a clear sense of interdisciplinary collaboration. In the latter case, the escalation is a stressful process due to the imposed presence of professional hierarchies and the patient does not necessarily receive timely help. Due to initiating the escalation, the nurse clinician may be drawn into a double-bind and experience ostracism by medical staff for expressing concern about the patient. Korner et al., (2016) emphasise that health professionals often have complementary backgrounds and skills and share common goals toward achieving patient outcomes. Developing a shared model for cooperation within an inter-professional team is important for accomplishing complex tasks (Korner et al., 2016). More research is required to understand how the partnership could be improved and be mutually beneficial when managing a deteriorating patient. The current study identifies that there is often an ambivalent relationship between the medical officers in the home team and the MET. Further research could shed more light on the complexities of the relationship to identify ways of fostering better partnerships focused on optimizing patients' outcomes.

The hospital and health services engage in continuous improvement activities to address the identified limitations of the process and increase staff compliance. With the different quality improvement strategies being implemented, new challenges can be anticipated. The organisations need to balance responding to old challenges and striving to ensure that the initiatives are mostly beneficial. As improvements are made to the Q-ADDS compliance and deterioration management, the organisation has to ensure that the availability of resources, staffing in particular, is proportionate to the business requirements and the process.

Synthesis of interview results

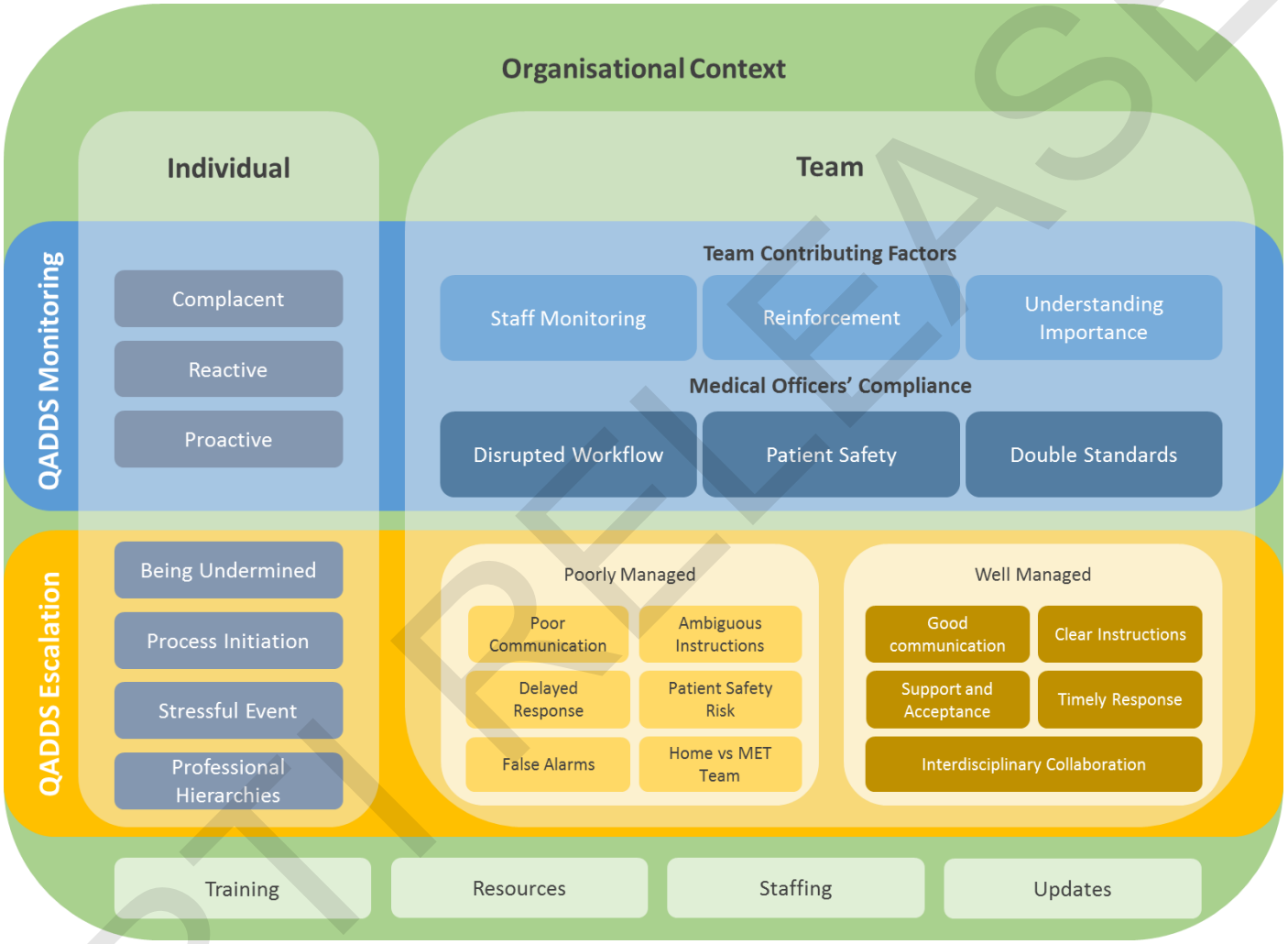

Figure 15: Schematic diagram showing the interpolation between Q-ADDS clinical processes (monitoring and escalation; as identified in *Part B1* as significant drivers of compliance) and organisational strata (individual, team). These elements are nested within the organisational context, which influences all aspects of Q-ADDS compliance as identified by clinician interviews in *Part B2*.

Summary of main findings from Interviews

- Individuals' compliance with Q-ADDS monitoring is exhibited in one of three ways: complacently, reactively or proactively.
    - Complacent compliance incorporates missing or irregular documentation or failure to escalate
    - Reactive compliance is when clinicians respond to Q-ADDS numbers or scores and disregard patient physiology
    - Proactive compliance occurs when clinicians incorporate Q-ADDS scores and clinical reasoning to decide on the appropriate course of action
- Depending on the efficacy of communication, teams' escalation compliance can either be poorly managed or well managed experiences.
- Individuals' and teams' compliance with Q-ADDS monitoring and escalation is impacted by the following socio cultural factors:
    - Positive/negative personal attitude towards Q-ADDS
    - Workplace satisfaction or dissatisfaction
        - Professional hierarchy
        - Interdisciplinary collaboration
    - Positive/negative perception of Q-ADDS training
- Organisational factors that impact compliance include training, resources, staffing levels.

Conclusions and Recommendations

Part A

- Respiratory rate is an important predictor of SAE, however is potentially recorded inconsistently. Education is warranted here as accurate recording of the RR may improve early detection.
- Further exploration as to why fewer SAEs occur during night duty hours.
- A different sampling method (random sampling of patients as opposed to selecting SAE and matching) would potentially provide improved predictions for the SAE.
- Exploration as to why Q-ADDS scores at time of SAE are lower in rural settings to explore if this is because patients are being transferred out because of the need for early escalation due to distance from intensive care facilities.

Part B

- Targeted training opportunities are necessary to meet the diverse needs of the population, with a focus on the following areas:
    - Completing patients' usual/default Blood Pressure
    - Correct use/fulfilment of the temporary and permanent modifications section
    - Access to Q-ADDS training modules to address casual staff and transient nature of the workforce
- Provisions should be included for partial completion of the Q-ADDS document.
- The modification section facilitates MOs to employ clinical judgement/reasoning but there is limited scope for RNs.
- Consider different models of response teams or tiers to reduce workload around responses to escalation and response
- The current study identifies that there are professional tensions between medical officers in the home team and the MET. Further research could potentially shed more light on how to foster better partnerships between these teams to optimise patient outcomes.

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APPENDIX A Part A Chart Review – Pilot study

Different versions of Q-ADDS

A high percentage of serious adverse events (SAEs) occurring less than 24 hours after admission were discovered, therefore a high number of Emergency Department Q-ADDS were collected to ensure adequate data were collected prior to the SAE occurring. As the two tools are different, and have different triggers, it was decided to exclude data from the ED Q-ADDS. This is turn limited the ability to collect 24 hours' worth of data prior to the SAE.

Because a high number of the cardiac patients are admitted to CCU directly from ED, we originally included them in our Index list. However, once we had pulled charts for the pilot site we realised that CCU's Q-ADDS charts have different values and triggers than the Q-ADDS general charts, so we had to exclude that cohort from our data collection. This excludes a significant number of cardiac patients. Figures 16 through 18 show the variations in recording and trigger points between the different areas. Differences among the charts include:

- Higher trigger points on all the RR scores on the ED chart
- More specific O_2 measures on the CCU chart, triggering a response at different intervals than other Q-ADDS charts
- A NRM scores an E call on the General Q-ADDS charts, and not on the ED and CCU charts
- LOC on the general includes a value for new confusion, whereas the ED chart does not

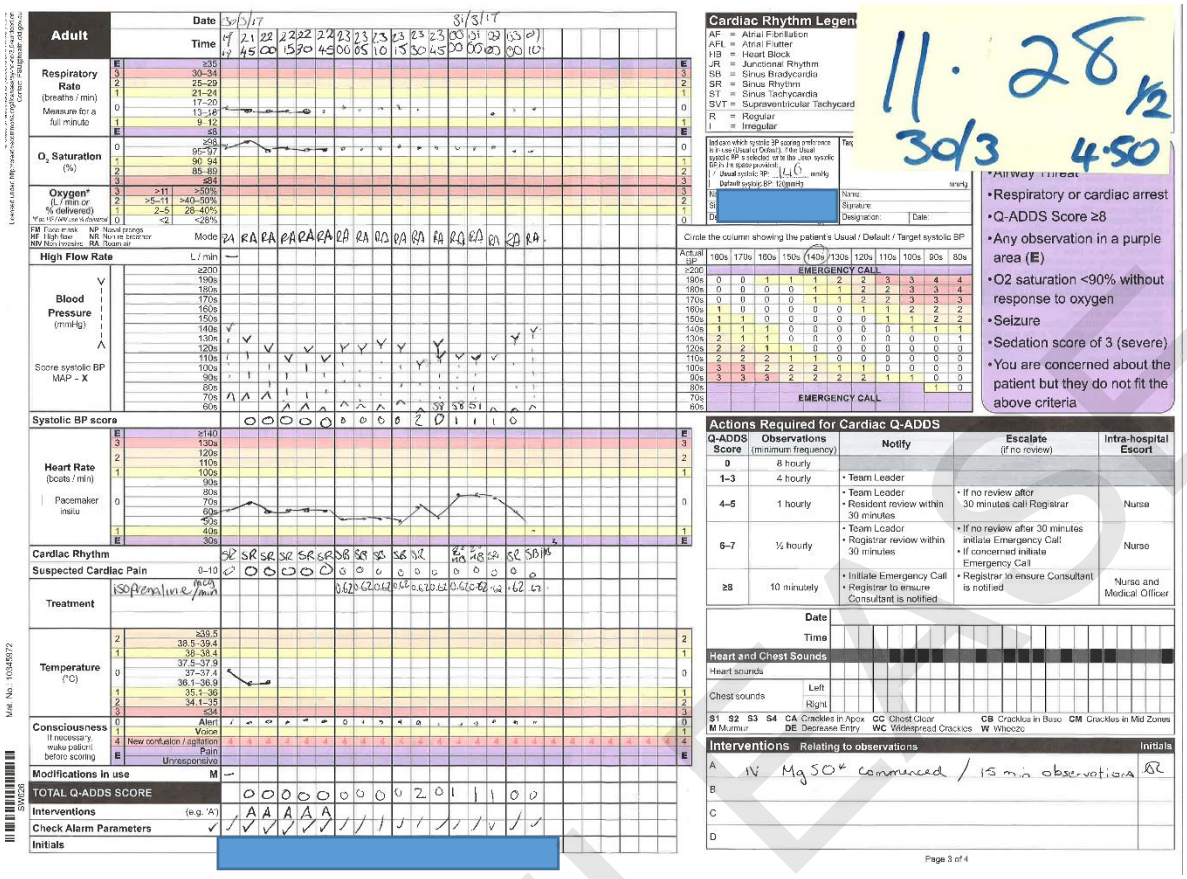

Figure 16: An example of the Q-ADDS chart used in Cardiac departments.

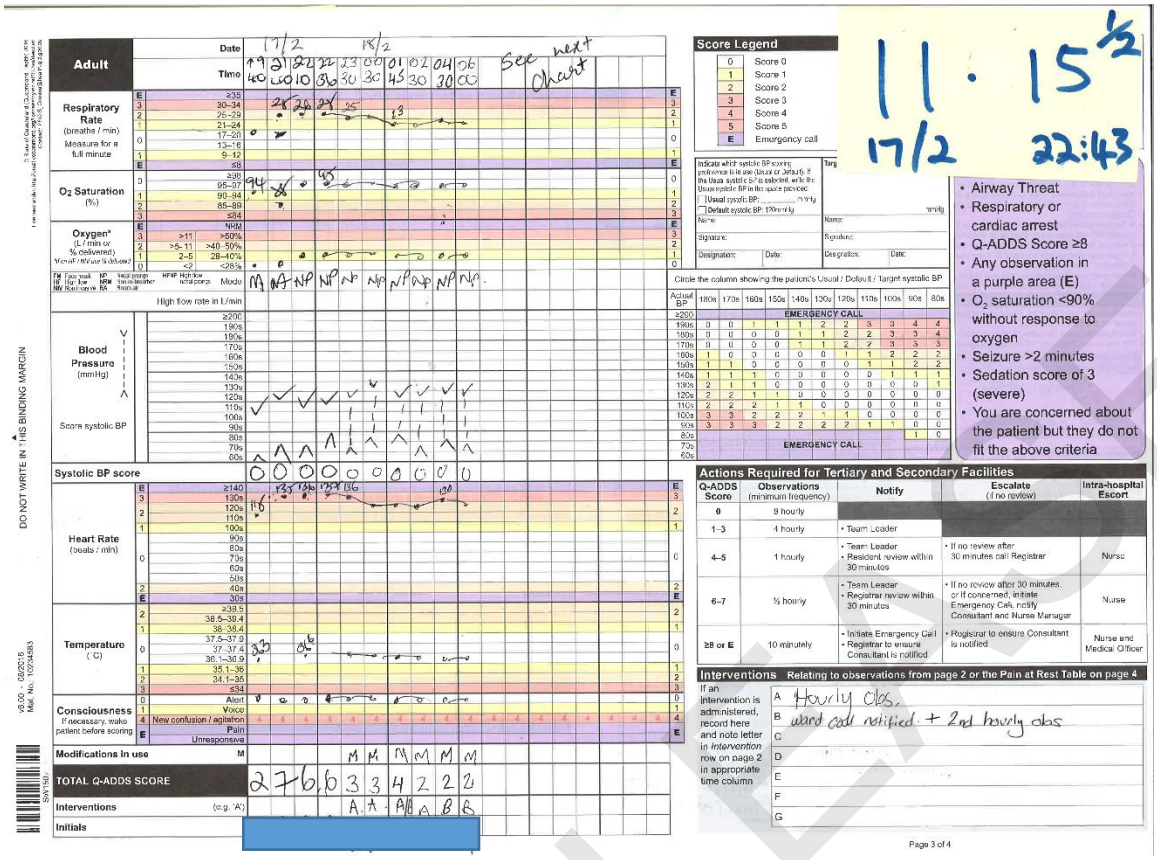

Figure 17: An example of the Q-ADDS chart used in Emergency departments.

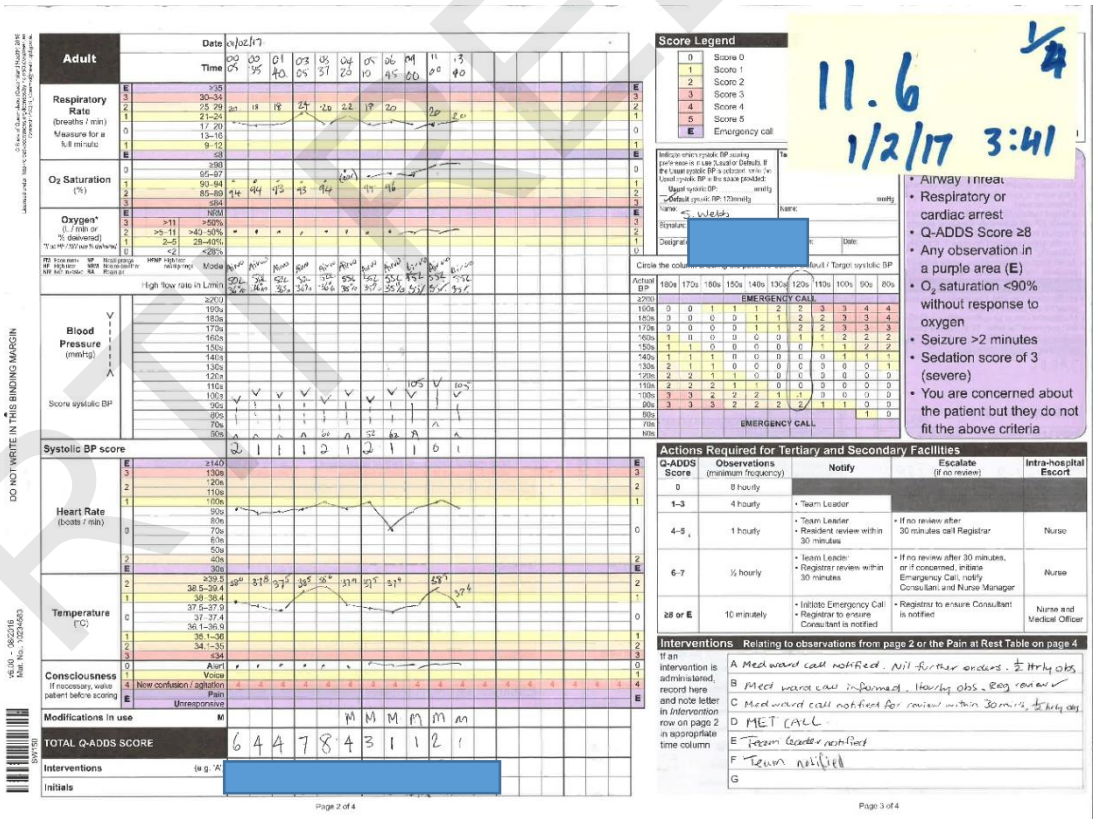

Figure 18: An example of the Q-ADDS used in general hospital wards.

Modifications

Data entry for each chart took longer than anticipated due to the use of the temporary and chronic modifications tables. Each set of vital signs collected (max of 12 per chart) required the data collector to confirm if any of the time point values are affected by a chronic or temporary modification. This was time consuming as each time point must be checked for accuracy (Figure 1912). See example below:

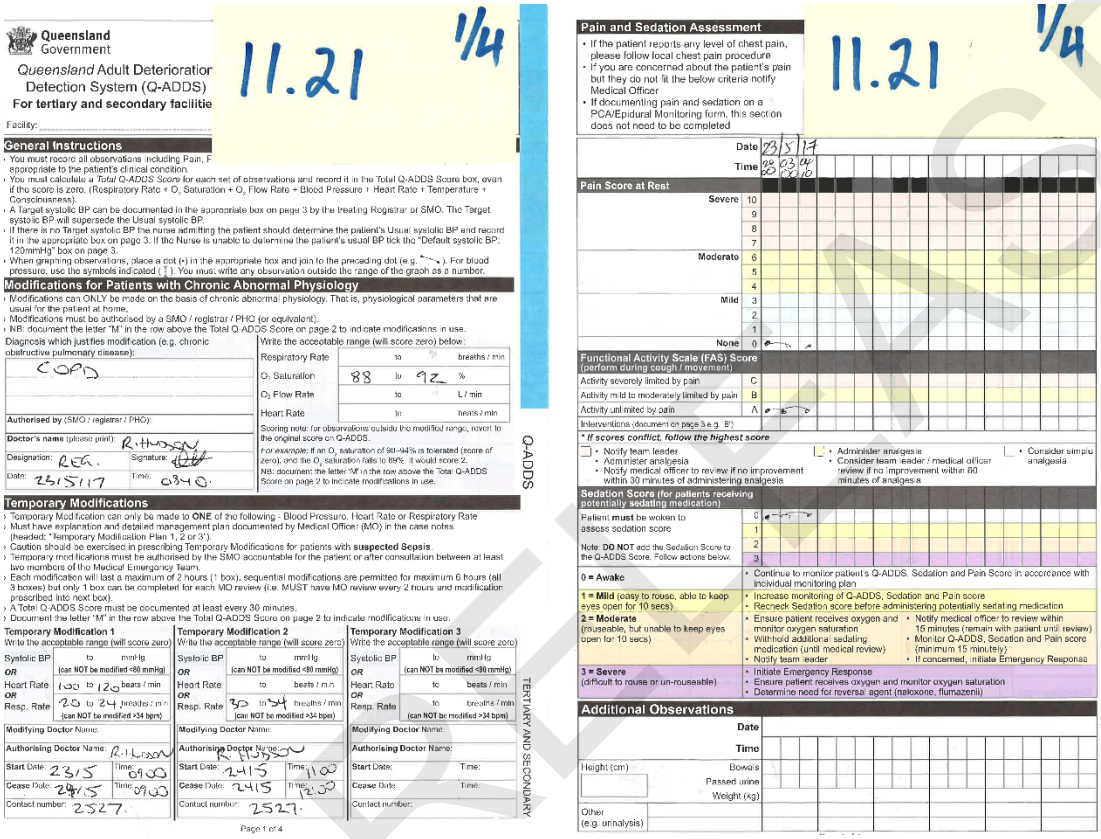

Figure 19: Examples of the use of the modification section in the Q-ADDS chart.

APPENDIX B Clinical Services Capability Framework – Fact Sheet 4

Clinical services capability framework

Fact sheet 4

Outline of current service levels

The Clinical Services Capability Framework (CSCF) for public and licensed private health facilities[1] is a complex but intentionally comprehensive document outlining minimum requirements for the safe provision of health services in Queensland public and licenced private health facilities. It has been organised in modular format. Table 1 summarises the clinical services by capability level outlined in the CSCF.

The Fundamentals of the framework underpin the CSCF. It contains information common to all modules as well as a glossary defining terminology contextualised for the CSCF, with the purpose of these important references being to ensure terminology used in the CSCF modules is interpreted correctly. The Fundamentals of the framework must be read and understood with the corresponding module/s.

Table 1 Clinical services capability framework service types by capability level

Module	Section/subsection/subspecialty	CSCF level					
		1	2	3	4	5	6
Fundamentals of the framework	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cancer Services Preamble	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Children's Services Preamble	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Alcohol & Other Drug services	Ambulatory	✓	✓	✓	✓	✓	✓
	Emergency	✓	✓	✓	✓	✓	✓
	Inpatient • Adult • Child & Youth			✓	✓ ✓	✓ ✓	✓
Anaesthetic services	N/A			✓	✓	✓	✓
Anaesthetic services—children's	N/A			✓	✓	✓	✓
Cancer services—children's	N/A				✓	✓	✓
Cancer services—Haematological malignancy	N/A			✓	✓	✓	✓
Cancer services—Medical Oncology	N/A			✓	✓	✓	✓
Cancer services—Radiation Oncology	N/A					✓	✓
Cancer services—Radiation Oncology children's	N/A					✓	✓
Cardiac services	Cardiac (coronary) care unit services				✓	✓	✓
	Cardiac diagnostic & interventional services			✓	✓	✓	✓
	Cardiac medicine services			✓	✓	✓	✓
	Cardiac rehabilitation services: • Inpatient • Outpatient • Ongoing prevention and maintenance (where programs provided)				✓ ✓ ±	✓ ✓ ±	✓ ✓ ±
	Cardiac surgery services						✓
	Cardiac outreach services						✓
Emergency services	N/A	✓	✓	✓	✓	✓	✓
Emergency services—children's	N/A				✓	✓	✓
Geriatric services	Emergency geriatric care	✓	✓	✓	✓	✓	✓
	Geriatric acute inpatient			✓	✓	✓	✓

[1] As updated from time to time

Module	Section/subsection/subspecialty	CSCF level					
		1	2	3	4	5	6
	Ambulatory	✓	✓	✓	✓	✓	✓
	Cognitive impairment				✓	✓	✓
	Consultation liaison			✓	✓	✓	✓
	Geriatric evaluation and management			✓	✓	✓	✓
	Interim care		✓	✓			
	Geriatric rehabilitation			✓	✓	✓	✓
	Ortho-geriatric				✓	✓	✓
Intensive care services	N/A				✓	✓	✓
Intensive care services—children's	N/A				✓	✓	✓
Maternity services	N/A	✓	✓	✓	✓	✓	✓
Medical services	N/A	✓	✓	✓	✓	✓	✓
Medical services—children's	N/A	✓	✓	✓	✓	✓	✓
Medication services	N/A	✓	✓	✓	✓	✓	✓
Medical imaging services	N/A	✓	✓	✓	✓	✓	✓
Mental Health services	Adult services • Ambulatory • Acute inpatient • Non-acute inpatient	✓	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓
	Child & youth services • Ambulatory • Acute inpatient • Non-acute inpatient	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓
	Older persons services • Ambulatory • Acute inpatient	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓
	Statewide & other targeted services • Adult forensic • Child & youth forensic • Deafness & mental health • Eating disorder • Emergency • Evolve therapeutic • Homeless health outreach • Perinatal & infant • Transcultural				 ✓ ✓ ✓	 ✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓ ✓
Neonatal services	N/A	✓	✓	✓	✓	✓	✓
Nuclear medicine services	N/A				✓	✓	✓
Palliative care services	N/A	✓	✓	✓	✓	✓	✓
Pathology Services	N/A	✓	✓	✓	✓	✓	✓
Perioperative services	Acute pain services					✓	✓
	Day surgery services			✓	✓		
	Endoscopy services			✓	✓	✓	✓
	Operating suite services incorporating sterilising services		✓	✓	✓	✓	✓
	Post-anaesthetic care services including children's post-anaesthetic care			✓	✓	✓	✓
Rehabilitation services	N/A	✓	✓	✓	✓	✓	✓
Renal services	N/A	✓	✓	✓	✓	✓	✓
Surgical services	Adult elective and emergency surgical services (with focus primarily on elective surgery) including: • Specialist outpatient clinic services • Extended care units/23-hour surgical units • Outreach services		✓	✓	✓	✓	✓
	Surgical oncology services		✓	✓	✓	✓	✓
Surgical services—children's	N/A		✓	✓	✓	✓	✓

APPENDIX C – Part B information sheet

Information sheet

This information sheet is available on the recruitment website, and was sent to all participants once they agree to an interview. This document is the most recent version (Study Information Sheet v.03) and was been submitted to the ethics committee as a separate document.

Queensland Adult deterioration detection system (Q-ADDS) Survey

About the Study

Background

International healthcare organisations maintain that recognising and responding to a clinically deteriorating patient is essential if safe and high-quality healthcare standards are to be achieved. Accordingly, Queensland Health Hospital Services (QHHS) now employ the Queensland Adult Deterioration Detection System (Q-ADDS) in nearly all of its facilities. This tool requires nurses to measure and record scores for each vital sign observed. There is published evidence that supports the effectiveness of early warning systems to identify the deteriorating patient in an in-hospital setting. Significantly, the tool can only truly contribute to improved patient safety outcomes when clinicians comply with the Q-ADDS documentation and escalation protocols.

Purpose of this research:

The purpose of this study is to identify the socio-cultural factors influencing health professionals' compliance with the use of Q-ADDS. Results from this study are intended to provide explanations about why clinicians choose to comply, or not comply with documentation and escalation protocols associated with the Q-ADDS tool. Understanding human behaviours that inhibit optimal clinical practice will contribute to the development of solutions aimed at improving compliance with the Q-ADDS, and ultimately, improving patient safety outcomes.

About the Research Team

Our research team is comprised of industry experts and university academics.

Chief Investigator
Trudy Dwyer, PHD, RN, NR(Cert), ICU (Cert), BHScn, GCFLrn, MClinED
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Coordinating Principal Investigator/Project Manager
Tracy Flenady, RN, BNursing (Distinction), PHD candidate
Senior Research Officer, CQUniversity (CQU)

Nurse Researcher, Central Queensland Hospital Health Service (CQHHS)

Project Investigator
Tania Signal, B.Soc.Sci (Waikato), M.Soc.Sci Hons 1st Class (Waikato) D.Phil (Waikato)
Associate Professor Psychology, CQUniversity, (CQU)

Project Investigator/Statistician
Matthew Browne, PHD
Associate Professor Psychology, CQUniversity, (CQU)

Project Investigator
Dr Danielle Le Lagadec, BSc, BSc(Hons), MSc, PHD, RN
Researcher, School of Nursing, Midwifery and Social Sciences, CQUniversity

Project Investigator
Julie Kahl, RN, BHScn; M.ClinEd (Nursing (in progress), Grad Dip Paediatric, Child and Youth Health Nursing; Grad Cert Acute Illness in Children; B.H.SC (Nursing); Cert 4 in Workplace Training and Assessment
District Director, Education and Research unit, Central Queensland Hospital Health Service (CQHHS)

Benefits of this study

It is hoped that the project will provide researchers with reasons that explain why health professionals responsible for documenting on the Q-ADDS sometimes fail to use it correctly. Once these reasons are understood, strategies can be developed and implemented addressing this issue, with the intent of improving the accuracy of early warning scores for all patients, potentially improving patient outcomes.

Are you eligible?

To be eligible to participate you need to be;

- an enrolled nurse, registered nurse or medical doctor currently working in Queensland Health hospital AND
- responsible for documenting vital signs on the Q-ADDS or modifying the Q-ADDS

What will be required?

Your participation in the research is voluntary and confidential. There are two ways you can participate.

1. You can complete a self-administered questionnaire (Link to this is at the top of the page under the tab Complete Survey). The survey asks a series of closed and open questions, and is totally anonymous.
2. We are also conducting interviews with QLD Health nurses and medical doctors, and would love to hear what you have to say about the topic of inquiry. One of the survey questions asks if you are willing to be contacted for an interview. If you are willing to participate in an interview, you will need to include your phone number and/or your email address so we can contact you.

What kind of questions will be asked?

The questionnaire contains demographic questions and open questions inviting you to write responses regarding your experience and the factors influencing compliance with the Q-ADDS. If you choose to participate in an interview, with an independent researcher, you will be asked questions that focus on your experience when complying with the Q-ADDS. An example of the type of question you will be asked is: “Please share with me your experience around factors that influence your compliance with the use of Q-ADDS”

How much time is required?

The online survey will take as little as fiteen minutes depending on your answers. The face to face or phone interviews are expected to be concluded within 60 minutes. Participants may be contacted for follow up clarification, which would most likely involve a brief phone call.

What are the benefits and risks to participants?

The benefit to you for participating in this research is the opportunity to speak in your own words about your experiences. Your information, together with information from other participants, will provide a unique insight into this topic area. It is not envisaged there will be any risk to you for your participation. In the unlikely event of negative outcomes or experiences, contact details for the university can be found below. Participation or non-participation in the research project will not affect your employment, participation is voluntary and therefore it is your choice to participate or not to participate in this research.

Confidentiality

All participant responses will be received by one researcher, who will de-identify the results as soon as they are received. This means that as survey results or interview transcripts are received, they will be given code names and/or numbers. There will be no use of participant names at any stage of the project. All information received is for research purposes only, and to confirm, only the primary researcher will be able to link participant responses with individual identities. All information collected, once de-identified, will be stored on a password protected computer for a period of five years post the final publication date, and then deleted and/or destroyed.

When interviews are voice recorded, the recording will be assigned a number and sent to a transcriber. All copies of the transcribed interview will only be identifiable by that number. All data for this project will be securely stored for five years following the final publication from the project in accordance with the CQUniversity policy. After this time, recorded files will be deleted and any printouts will be shredded.

Please remember that participation is voluntary and your responses to the survey will be entirely anonymous and interview questions confidential. There can be no legal or professional sanction as a result of participation.

About the survey platform

This survey will be submitted via SurveyMonkey, which is based in the United States of America. Information you provide in this form, including any personal information, will be transferred to SurveyMonkey's server in the United States of America. By completing this form, you agree to this transfer. The collection, use and disclosure of your personal information will be subject to the privacy laws of the United States of America as well as SurveyMonkey's privacy policy. You should consult the SurveyMonkey privacy policy for more details, which can be found *here*.

Findings of this project

The findings of this research will form the basis of a report for the Department of Health. Over the course of this project, findings may be presented at conferences and form the basis of journal articles. At the end of the project, a summary of the findings will be uploaded to this website should you wish to come back and check it out.

Consent

You will be required to complete and acknowledge an online consent form if you are participating in interviews. The consent form will be included in the online survey if you indicate you are willing to participate in an interview. Please read it carefully and ask the researcher any questions you have before acknowledging that you understand and agree with the interview process.

Can you change your mind about being involved?

You have the right to withdraw from this research at any time without penalty. Should you withdraw prior to data analysis, your interview file will be deleted and any transcripts made will be shredded. Should you withdraw after data analysis has begun, withdrawal of your specific data cannot be guaranteed due to the nature of how it is analysed. However, should you withdraw after this time, no reference to any actual words or statements you have made during your interview will be made in any document or presentation of the findings.

What if I feel distressed during or after the study?

It is not anticipated that completing this survey will cause distress, however if you were to find any of the questions upsetting, please remember that you can discontinue the survey or simply skip those items. Should you require any support you could consider making contact with Lifeline (Ph: 13 11 14) or Beyondblue (1300 22 46 36).

What happens if you have any concerns or complaints?

Any concerns or complaints about the conduct of this study should be directed to the:

HREC Coordinator
Gold Coast University Hospital
1 Hospital Boulevard
SOUTHPORT QLD 4215
Email: GCHEthics@health.qld.gov.au
Phone: 07 5687 3879

Any complaint will be investigated promptly and you will be informed of the outcome.

Where to from here?

Please contact a member of the research team if you have any further questions.
Tracy Flenady - t.flenady@cqu.edu.au
Trudy Dwyer – t.dwyer@cqu.edu.au

If you know any other Queensland Health staff who might be interested in participating in this research please consider forwarding this link to them via email or social media.