Health Quality and Safety Commission

Business case for investing in a quality improvement programme to reduce harm caused by clinical deterioration

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Glossary

Term	Definition
Cardiac Arrest	Cardiac arrest is a sudden, sometimes temporary, cessation of the heart's functioning
CCO	Critical Care Outreach Team
EWS	Early Warning Scores
MET	Medical Emergency Team
MEWS	Maternity Early Warning Score
PEWS	Paediatric Early Warning Score
RRS	Rapid Response System, includes identification and response
RT	Response Team
RRT	Rapid Response Team

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Executive summary

The health sector has identified that clinical deterioration is not being consistently identified or responded to, leading to preventable harm or inappropriate care. There is concern that preventable patient harm from clinical deterioration will increase due to an aging population, increasing complexity of procedures and reduced length of hospital stay. This concern has prompted some medical staff to improve hospital patient safety systems with the aim of reducing harm and inappropriate care, preventing cardiac arrest and deliver on the expectation that patients are adequately cared for if they deteriorate.

Difficulty in estimating preventable harm

The amount of preventable harm caused from clinical deterioration is difficult to estimate. There is significant variation by hospitals in the rates of in-hospital cardiac arrests and in-hospital deaths. This variation is suggestive that hospitals with higher rates could improve their systems in order to reduce the rates of cardiac arrest and mortality, which in turn implies a level of avoidable harm.

There are, however, a number of factors apart from hospital systems that have been shown to contribute to the rates of cardiac arrest and mortality; these factors make it difficult to draw conclusions from the available data.

The same limitations apply to international comparisons, although those comparisons suggest New Zealand's rates of avoidable harm are not unexpectedly high.

Rapid Response Systems (RSSs) are becoming the gold standard

Rapid Response Systems (RRSs) are becoming the gold standard to reduce harm from clinical deterioration. RRSs build on traditional models of hospital care. RRSs have two parts, as follows:

1. Detection using Early Warning Scores (EWS) used to identify patients with clinical deterioration.

2. Response: Either from ward staff or a Response Team (RT). The response teams may be nurse led (RRTs) or doctor led (METs).

There is significant use of RRSs in New Zealand. All 20 of the district health boards have EWS in place in at least one of their hospitals. Formal/dedicated RTs are in four of the five tertiary hospitals and five of the 15 metropolitan/regional hospitals. There is variation in the RRSs in place and there are some calls to standardise the EWS. The variation in RTs is expected, as the response will be instructed by the hospital size and structure.

There is a strong rationale for why RRSs result in improvements in patient outcomes as follows:

- RRSs improve the detection and treatment of clinical deterioration and therefore reduce adverse outcomes such as cardiac arrests.
- RRSs provide ward staff with guidelines resulting in timely identification of deterioration.

- The protocols around contacting RTs cut across the typical hierarchical hospital structure, resulting in a timely response from staff with training and experience specific to treating clinical deterioration.

But there are difficulties in quantifying benefits

Quantifying the benefits of RTs has proven difficult. Both the international literature and our analysis of New Zealand hospital data provide little robust information on which to quantify the impacts of RRSs.

Our summary of evidence on the impact of RRSs is as follows:

- The largest randomised control trial (RCT) in hospitals that introduced RTs demonstrated the same improvements as those hospitals without RTs, i.e. the rate of in-hospital cardiac arrest and in-hospital deaths reduced by the same magnitude with and without RTs. The result from this long awaited trial was unexpected, and may be due to "contamination" between the groups.
- On the other hand, the largest meta-analysis of RTs reported a reduction of 35 percent in the rate of cardiac arrests; the result was driven by before and after studies. This result from the meta-analysis is put in to question by the RCT.
- In New Zealand, the average rate of in-hospital cardiac arrests is 28 percent lower for DHBs with a RT, compared to hospitals without RTs, when focusing on hospital admissions that do not include any time in an intensive care unit (ICU).
- Our observation is that existing RTs tend to be in the larger hospitals in NZ and this makes sense to us as this is where RTs have been tested. The impact on RTs in smaller hospitals is uncertain, as there is less experience in this setting.

Thus cost-effectiveness is uncertain…

Investment could be made in either or both the detection of, or the response to clinical deterioration. We have therefore undertaken estimates of cost-effectiveness for:

- Improving and standardising EWS in order to improve the accuracy of detecting clinical deterioration.
- Introducing RTs, or improving access to RTs, in order to respond to clinical deterioration.

We estimate that standardising and improving EWS will lead to at least a five percent improvement in the early detection of patients who will die, suffer a cardiac arrest or require an unanticipated ICU admission. The estimated cost of standardising and improving EWS is estimated to be a one off cost of $1.4 million. The majority of this cost is from nurse and doctor training.

The cost-effectiveness of RTs is highly uncertain. The costs are relatively easy to measure, but benefits are highly uncertain. Due to this uncertainty, we posit two scenarios; a conservative scenario and an optimistic scenario. These two scenarios result in a range of a cost-effectiveness ratio of no benefit to $3,900 per cardiac arrest avoided. The optimistic scenario assumes a nationwide annual cost of $279,000 and a reduction of 71 cardiac arrests; this is based on a 35 percent reduction in cardiac arrests in hospitals where the DHB does not have an RT. The cost represents the cost of attending RT calls and excludes possible cost-savings from reducing clinical deterioration. We believe the optimistic result is more likely than the conservative result, based on benefits demonstrated in the before and after studies.

…But we identify a clear investment option with significant patient and systems benefits and moderate cost

We are not attracted to a "do nothing option". Nor are we attracted to large scale standardisation of RTs. We are, however, hopeful of greater standardisation of EWS so patients get what they expect of each and every hospital. In addition, we believe all hospitals should have a team in place to respond to clinical deterioration (or at least have access to a team) and that there should be support and governance in place to help hospitals set up and improve their response teams.

The benefits can be broadly described as benefits to patients (in terms of avoided harm), benefits to clinicians (in terms of systems and guidance) and systems benefits in terms of standardising a core clinical process and effectively deploying resources. Our net benefit assessment is as follows:

- Based on measurable and non-measurable benefits, we believe the benefits from standardisation and improvement of EWS to be material.
- There are considerable systems benefits including enhanced regional co-operation, being able to standardise training and possibly bring that training into undergraduate training and greater consistency of response for the workforce.
- For the public, although we do not measure consumer expectations or Net Trust Scores, patients will clearly expect an ordered, standardised and respectful management of clinical deterioration and end of life hospital processes.

In comparison, most of the costs we identify are concerned with training and training in this topic may simply displace other training. The table opposite sets out three zones of benefit we have identified.

Our conclusion is there is considerable system benefit for minor cost in a critical activity. Patients would expect us to get it right.

Table 1 Prospective benefits of proposed investment option

Benefit description	Significance of benefit/evidence for view	Benefit estimation
Benefits of standardising and improving Early Warning Score (EWS)		
Providing a standardised evidence based tool to assist clinicians in identifying clinical deterioration leads to: 1. Earlier detection of clinical deterioration. 2. Increased effectiveness due to an optimized vital sign chart based on human factors and graphic design principles. 3. Reduced ongoing hospital training costs as training can be done nationally at an undergraduate level and staff moving between hospitals will be familiar with the EWS. [Best value for public health system resources and Improved quality, safety and experience of care]*	Moderate benefits (not substantial as we are looking at marginal improvement from a status quo in which an EWS is used but variably). Evidence for earlier detection is very strong, based on: 1. Evidence of strong relationship between abnormal vital signs used in scoring tools and adverse patient outcomes. 2. Study showing improved performance of scoring tool based on strong evidence and expert review. Strong evidence of benefits of standardised, improved chart design. Assumption of reduced training costs is based on expert opinion.	Best scoring tool evaluated resulted in predicting 80% of cases that resulted in cardiac arrest, unanticipated ICU admission, or death. (Estimate based on responding to 22 percent of EWS values) Evidence suggests improving EWS will result (conservatively) in at least a 5 percent improvement in detecting early clinical deterioration. We have not quantified the reductions in training costs; saving unlikely to be material. However, training could be redeployed and there would be benefits from a collaborative training approach. Benefits will be significant where a hospital has a response team but no existing EWS. Estimated one off cost of implementing a standardised and improved EWS is $1.4 million. Most of this cost is training which might be an off-set rather than an addition.
EWS provides an escalation mechanism that allows clinicians (and patients) to escalate support to colleagues more expert in managing acute deterioration. This is a patient centred safety system. Improving teamwork and communication across hospital teams. Enhanced safety culture through supporting staff to 'speak-up' about patient safety concerns. [Improved quality, safety and experience of care]*	Material contributory benefit as key process for emergency activity at the bedside. Evidence – expert comment.	Not measured as contributory.

Benefit description	Significance of benefit/evidence for view	Benefit estimation
Benefits of Response Teams (RTs)		
Assuring patients of a consistent and appropriate service if their condition deteriorates. [Improved health & equity for all populations]*	Substantial benefit. Patients expect hospitals to offer a consistent expert level of service that responds to clinical deterioration.	The Health and Disability Commissioner expresses concern in his reports. Net Trust Scores would be reduced if variability of application of EWS and RTs were publically understood.
Reduction in adverse events due to appropriate response to different levels of deterioration. Potential for a regional approach that improves systems of care across regions with increased expert support for smaller hospitals. [Improved quality, safety and experience of care and Improved health & equity for all populations and Best value for public health system resources]*	Highly variable benefit across DHBs. Strong evidence based on the meta-analysis and clinical opinion for reduction in cardiac arrests. Weak evidence for reduction in mortality and other adverse events in the literature, but strongly supportive clinical opinion.	Early detection of clinical deterioration makes it easier to treat & potentially reverse. Such patients are less likely to require ICU level support or to continue to deteriorate and result in cardiac arrest. Reduction of up to 71 cardiac arrests per year nationally (assuming a 35 percent reduction in DHBs without a response team). The reduction in cardiac arrests would result in reduced deaths. Net effect is likely to be a better performing system and a much improved patient experience and reduced pressure on system resources. (i.e. may take some pressure off ICU beds but possibly not ICU staff who attend to RT calls.) Estimated cost of avoiding a cardiac arrest from increased use of Response Teams (RTs) is $3,900 (optimistic scenario).

Benefit description	Significance of benefit/evidence for view	Benefit estimation
Benefits of improving shared Goals of Care Plan between consumers and clinicians		
Increasing the number of consumers with Goals of Care Plans at admission leads to: 1. Reduction in unnecessary RT calls. 2. Improved experience of care at the end of life. Reduced distress for consumer, family and clinical staff. [Improved quality, safety and experience of care and Improved health & equity for all populations and Best value for public health system resources]*	Significant evidence. Up to a third of RT calls have end of life issues; and in a number of cases there is no Goals of Care Plan.	Not measured.

*We have listed which of the three aspects in the Commissions Triple Aim framework the benefits relate to.

1. Introduction

We have been commissioned by the Health Quality and Safety Commission (the Commission) to develop a business case for investment in a quality improvement programme to reduce harm caused by clinical deterioration. We have been asked to focus on avoidable clinical deterioration within hospital and likely investment options to reduce harm from clinical deterioration.

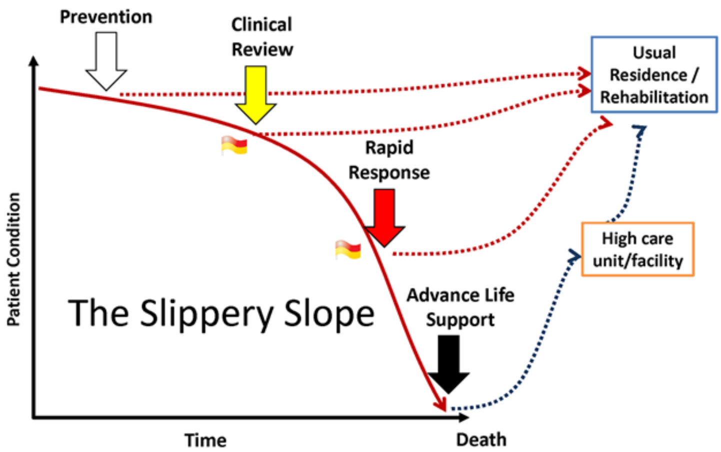
The Commission has identified clinical deterioration is inconsistently identified and responded to, potentially leading to preventable harm or inappropriate care. There is concern that preventable harm from clinical deterioration will increase for a range of factors including an aging population, increasing complexity of procedures and reduced hospital stays. This concern has prompted intensive care specialists to improve hospital systems with the aim of reducing harm and inappropriate care. The Commission's questions are:

- Could more be done?
- What is the impact of doing more?
- How can the Commission add value?

1.1 Clinical deterioration can be expected in hospital situations

The figure below sets out the 'slippery slope' of clinical deterioration. The figure shows how a patient's condition deteriorates over time and how early identification and response limit deterioration and prevent the need for intensive hospital resources such as advanced life support.

Figure 1 Reducing patients deterioration from early identification and response



Source: NSW Clinical Excellence Commission's between the flags programme[1]

One of the key concerns of untreated clinical deterioration is cardiac arrest. Cardiac arrest, or circulatory arrest, is a sudden stop in effective blood circulation due to failure of the heart to contract effectively or at all. More than 80 percent of hospital patients exhibit signs of physiological deterioration in the hours before cardiac arrest[2]. Cases of in-hospital cardiac arrest are associated with survival rates of 24 – 40 percent[3].

The likelihood of cardiac arrest is twice as high for patients in hospital, compared to those in the community[3]. This high hospital rate of cardiac arrest is part of the reason there is an emphasis on reducing in-hospital cardiac arrests but also expected given the medical condition of hospitalised patients.

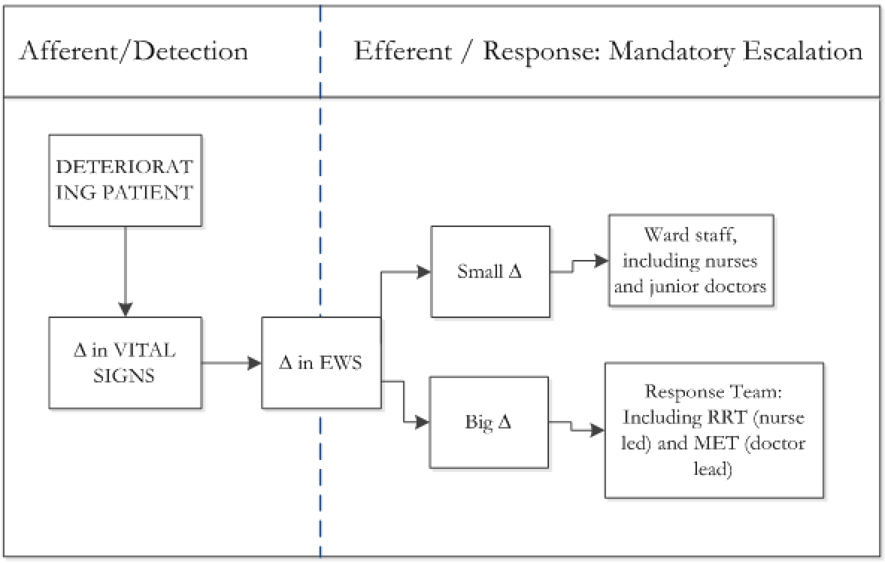
Earlier detection of and response to clinical deterioration helps prevent the need for patients needing to be admitted to high resources wards such as ICUs as well as improving outcomes for patients.

1.2 Reducing harm from clinical deterioration

RRSs are becoming the gold standard systems to reduce harm from clinical deterioration. RRSs build on traditional models of hospital care. Not all hospitals have RRSs, and RRSs exist in varying forms.

The first of two parts in RRSs is the afferent/detection limb. If the vital indicators of a patient change, EWS detect deterioration and trigger a response. The response to escalation is the second part in RRSs, referred to as the efferent limb. Small amounts of clinical deterioration, as measured by small changes in EWS, are dealt with by ward staff such as nurses and junior doctors. When there is a big change in EWS a response team is utilised. A response team is comprised of staff with training and experience in treating clinical deterioration. Figure 2 details the structure of an RRS.

Figure 2 Rapid Response System (RRS)



1.2.1 EWS - Identifying patients with clinical deterioration

The collection of patient's vital signs has been a long-standing practice across the world. Systems to identify clinical deterioration have been gaining traction and are used in a number of hospitals[2]. Systems to identify clinical deterioration are often referred to as EWS. In 2011, all 20 DHBs in New Zealand reported the use of systems to identify clinical deterioration[4].

Systems to identify clinical deterioration are varied, but all feature common (clinical) elements. All systems use vital signs such as respiratory rate, heart rate, systolic blood pressure and conscious level. Other vital signs used include oliguria, polyuria, oxygen saturation and oxygen administration[4].

Vital signs are recorded on observation charts. When vital signs are outside of an acceptable range then, ideally, a response such as a review by a response team (RT) is triggered. A response can also be trigged if the patient, family, whānau or carer has concerns.

Key benefits of using systems to identify patients with clinical deterioration include:

- Objective criteria are used to determine when a response is needed. This helps evidence based clinical decision making, and is particularly useful for staff with less experience, authority or seniority (e.g. recent graduates).
- Breaking through silos, i.e. nurses and junior doctors are encouraged to escalate treatment without input from senior doctors. An increase in ability to rapidly respond to patient needs.

There are differences in the complexity of EWS and different thresholds trigger a change in patient management. There is some variation in the thresholds used by different hospitals and sometimes different departments of hospitals. For example, the upper limit for heart rates that trigger a maximal response ranges from 120 to 140 beats per minute.

EWS usually refer to scoring systems for adult patients. There are EWS that are specifically for children (paediatric patients) and patients who are pregnant (or recently delivered); these are referred to as paediatric EWS (PEWS) and maternity EWS (MEWS). In this report, we have focussed on EWS for adult patients, as these are the focus of the literature and are often the first system to be addressed when hospitals are improving their systems.

1.2.2 Response Teams (RTs) – Treating identified patients

There is a much wider range of responses to patients identified with clinical deterioration, the response depends largely on:

- The type and size of the hospital; and
- The time of day when a response is triggered.

Larger hospitals are more likely to have a Response Team (RT); these teams have dedicated staff that see and treat patients with clinical deterioration. Critical care outreach teams are typically staffed by ICU staff and are often nurse led[5].

There is a variety of systems used to respond to patients with clinical deterioration, with some hospitals employing multiple systems. We have described all of them under the rubric of RTs. In addition to the make-up of the staff, RTs differ in the range of work they do; e.g., RTs often follow up patients who have been discharged from ICU. Some of the common systems we have identified in use are:

- Clinical teams that are activated to respond to acutely unwell ward patients, predominantly nurse led, more generally called Rapid Response Teams (RRTs).
- Medical Emergency Teams (METs) – physician led teams than can initiate intensive care level support at the patient's bedside.
- Clinical Care Outreach – nurse led teams that also focus on providing education to ward staff and support to patients and their families.
- Patient at Risk (PAR) teams – Nurse led teams, similar to RRTs.

There is little evidence that one configuration of RT is better than the other.

Process used to produce this report

We included the following steps in order to develop this report:

- Confirm the scope of the report with the Commission.
- Facilitate a one-day workshop to discuss the issue of harm from clinical deterioration and what more could be done to prevent harm. The workshop was attended by clinicians from around New Zealand and staff from the Commission. The majority of clinicians work in intensive care.
- Research to collect information about the current amount of harm, the evidence for ways to reduce harm and analysis of the impact of making different changes.
- We had further correspondence with a number of the clinicians. This enabled us to test ideas and collect further information regarding the current systems in place and how these systems could be improved.
- The draft report was reviewed by the Commission and a number of clinicians.
- Presentation to clinical leaders.
- Further discussion with the Commission on benefit profile.
- Report finalised.

1.3 Structure of the report

This remainder of the report is structured into the following key sections:

- Avoidable harm from clinical deterioration in New Zealand.
  - National and international variation in in-hospital mortality and cardiac arrest rates.
  - Lack of NZ wide reporting.
- New Zealand experience.
  - Systems currently in place.
  - NZ case studies.

- Effectiveness of programmes to reduce harm from clinical deterioration.
  - Effectiveness of Early Warning Scores.
  - Mixed evidence for the reduction in harm from clinical deterioration.
- Investment options.
- Cost-effectiveness of programmes to reduce clinical harm from clinical deterioration.
  - Early Warning Scores (EWS).
  - Response Teams (RTs).
- Further comment and reflections.

2. Avoidable harm from clinical deterioration

Preventable harm caused by clinical deterioration is difficult to estimate. There is significant variation between hospitals in the rates of in-hospital deaths and in-hospital cardiac arrests. This variation is suggestive that hospitals with higher rates could improve their systems in order to reduce the rates of cardiac arrest and mortality, which in turn implies a level of avoidable harm. However, there is a number of factors apart from hospital systems that has been shown to contribute to rates of cardiac arrest and mortality; these factors include:

- Patient characteristics (age, co-morbidities, etc.);
- Unplanned admission;
- Admission rate per population;
- Size of hospital; and
- Existence of an intensive care unit.

Attribution of variability and assessment of what is preventable is difficult without being able to accurately account for factors affecting rates of in-hospital cardiac arrests and mortality. Our international comparisons do not suggest New Zealand's rates are high.

There are standardised methods used to compare mortality between hospitals and changes over time, for example the hospital standardised mortality ratio (HSMR) used in the UK[6] and Canada[7,8]. There is no publically available reporting of mortality in New Zealand and we have not attempted to measure mortality in a standardised way due to the limitations of the scope of this project. However, the data underlying HSMR calculation is available in Ministry of Health national collections. The Health Round Table calculates the HSMR for New Zealand hospitals; this information is shared with DHBs, but is not made publically available.

Another form of avoidable harm (i.e. in addition to in hospital cardiac arrests and mortality) from clinical deterioration is a reduction in serious adverse effects. Auckland hospital reported 82 serious events in the year ending June 2014, a number of the events was due to a delay in escalation of treatment[9]. The findings for Wairarapa, Hutt Valley and Capital & Coast District Health Boards were the same, the annual number of Serious and Sentinel Events was 51 for these three DHBs and, again, a number of these events were due to unexpected clinical deterioration[10].

2.1 Lack of detailed NZ wide reporting

The best source of information on the amount of harm caused by clinical deterioration currently in place is the National Minimum Data Set (NMDS)[11]. From the NMDS we have identified the number of deaths and cardiac arrests occurring in hospitals across New Zealand. The limitations of this data set include the difficulty identifying the events that were preventable and identifying the events where there was no response, or a late response to clinical deterioration.

Other datasets include:

- New Zealand Resuscitation Council National CPR registry.
- Medical Emergency Team (MET) data by hospital.
- ANZIS core ICU core data set.

These data sets are summarised below.

New Zealand Resuscitation Council National CPR registry

The New Zealand Resuscitation Council collects information about those who collapse in New Zealand, this information makes up the National CPR Registry.

Data collection uses an Utstein template – an international standard that enables national and international comparisons. Analysis of the data allows researchers to inform and improve the resuscitation outcomes for those who suffer cardiac arrest.

When the data from this registry was compared with data from Wellington hospital, the number of the cardiac arrests in the registry was only 10-20% of those recorded by Wellington hospital.

Medical Emergency Team (MET) data by hospital

Some hospitals record information relating to their Medical Emergency Team (MET). Information typically includes:

- Number and timing of calls to the MET, and
- Number of calls resulting in cardiac arrest.

The limitation of these datasets is that they are limited to a few hospitals and the events they record are limited to where the ICU department is involved.

ANZICS CORE ICU data set

24 of New Zealand's 30 ICUs in NZ supply data to ANZICS[12,13]. This dataset is limited to outcomes within ICU. The amount of detail supplied by NZ ICUs varies.

The ANZICS core data set is made up of four data registries:

- Adult Patient Database (APD).
- ANZICS Paediatric Intensive Care Registry (ANZPICR).
- Critical Care Resources (CCR) Registry.
- Central Line Associated Bloodstream Infection (CLABSI) Registry.

2.2 Observed national and international variation of in-hospital mortality

2.2.1 Variation in mortality by hospitals across New Zealand

There is variability in mortality across hospitals in New Zealand. A significant amount of this variability is explained by patient characteristics and admission type. Currently, we have not identified data in New Zealand which would allow robust conclusions as to which hospitals mortality rates are significantly higher or lower than expected. Therefore, it is difficult to draw conclusions about either how much mortality is avoidable or how much mortality is due to untreated clinical deterioration.

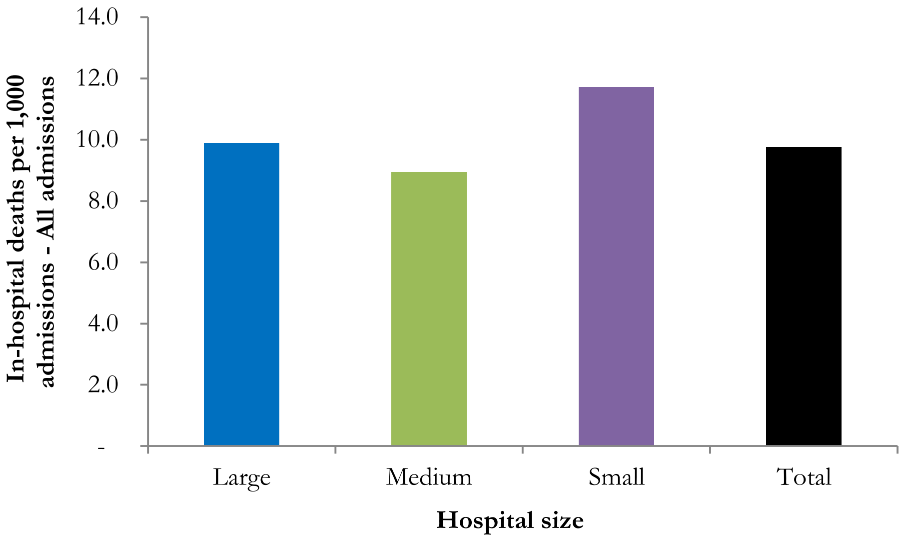
We provide the data we identified; the data is instructive of the issue of clinical deterioration these systems seek to deal with. We used the national minimum data set (NMDS) to estimate the rate of in-hospital deaths. The statistics below are based on admissions at public hospitals for the year ending June 2013. We have included information from hospitals with at least 1,000 admissions per year, these hospitals account for 99 percent of public hospital admissions and over 95 percent of hospital bed days.

Crude mortality in New Zealand

In NZ hospitals, the average mortality rate from all causes in 2012/13 was 9.7 per 1,000 admissions. This mortality rate is based on 8,600 in-hospital deaths and 886,000 admissions.

Small hospitals had the highest mortality rate, 11.7 deaths per 1,000 admissions. The mortality rate for small hospitals was 20 percent higher than the national average. The difference in-hospital mortality rate by size of hospital is illustrated in Figure 3 below.

Figure 3 Crude mortality for New Zealand public hospitals in 2012/13, by hospital size*



*Hospital size is based on the number of admissions; small 1,000 to 15,000, medium 15,000 to 30,000, large over 30,000.

The mortality rate for hospitals is highly variable, with some small hospitals having mortality rates over double the national average and one hospital having a mortality rate four times greater than the national average. However, some of this variation is to be expected due to differences in patient characteristics and the type of admission, age, co-morbidities and unplanned admissions are strong predictors of mortality. A study of hospitalisation in Canada revealed that each year of the patients' age increases the risk of death by five percent[14].

We compare the un-adjusted mortality rate with the mortality rate of patients aged over 70 years old to illustrate the impact of adjusting for patient characteristics and admission type.

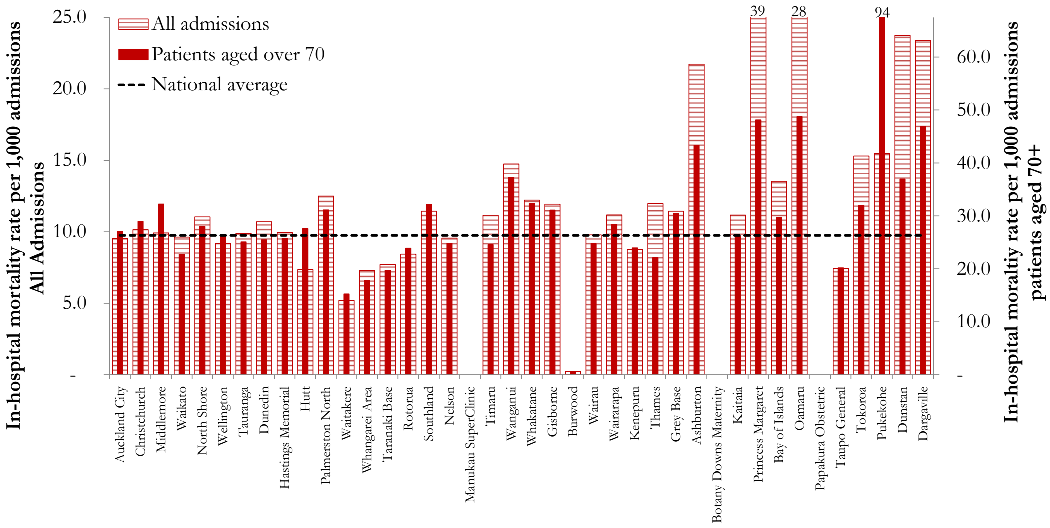
Focusing on patients aged over 70 years old captures 76 percent of deaths in hospital for 26 percent of admissions (see Figure 4 below). The mortality rate for all admissions is shown in the wider bars that are shaded red and white. The mortality rate of patients aged over 70 is illustrated by the narrower solid red bars. An important factor this adjustment does not account for is the difference in ethnicity, as the life expectancy differs significantly for different ethnicities (this effect may be larger in New Zealand, compared with other countries).

When moving from all admissions to only admissions for patients over 70, some of the effects on the rate of mortality per hospital include:

- Hutt hospital adjusts from 25 percent below the national average to slightly above the national average.
- Princess Margaret in Christchurch adjusts from over four times the national average to under double the national average.
- Pukekohe Hospital (an 18 bed facility in Franklin District) adjusts from the sixth highest mortality rate to the highest mortality rate (over double any other hospital). This outlier result may be due to small numbers or because many patients are in end of life/palliative care. In 2012/13, Pukekohe had 233 admissions for patients aged over 70, of which 22 admissions resulted in the patient dying.
- Waitakere crude mortality rate is low which, again, could be expected given the balance of services provided.

Hospitals that solely perform day procedures or provide maternity services have very low mortality rates.

Figure 4 Crude Mortality rate for New Zealand public hospitals†



† Restricted to hospitals with over 1,000 admissions, ordered by number of admission (for all age groups)

This example of making a simple adjustment to the measurement of mortality rate highlights the caution needed when analysing mortality rates, and how rates differ by hospital, by patient group and over time. We reiterate, it is difficult to draw conclusions about the variability of mortality by hospital across New Zealand, due to the absence of mortality rates adjusted by patient characteristics and the type of admission.

2.3 International comparison of mortality rate

International comparisons are equally difficult.

NZ has a much lower crude in-hospital mortality rate than either Canada or the UK. Part of this difference is likely due to the relatively young average age of NZ patients attending hospitals and the relatively high number of admissions. Although the ability to make international comparisons is limited, the available data does not suggest New Zealand's in-hospital mortality rate is high. (See Table 2 below.)

The Canadian experience of rising crude mortality and falling Hospital Standardised Mortality Ratio (HSMR) illustrates the importance of adjusting for patient demographics and admission type when looking at mortality rates over time. Over the previous six years, factors associated with in-hospital crude mortality and the risk factors for mortality have steadily been increasing. Over the same period HSMR has been falling which indicates risk-adjusted mortality rates are falling[7].

For Australia numerous studies have been published describing mortality rates calculated for deaths in hospitals for a variety of conditions and using a number of different methods. Methods vary significantly between jurisdictions. The data elements provided by the jurisdictions are governed by Australian national minimum data requirements, such as the requirements for the National Hospital Morbidity Database (NHMD). Beyond these minimum requirements, the data collected by each jurisdiction can range in number and complexity[I]. In addition, an unknown amount of work by governments and industry on in-hospital mortality is effectively hidden and commonly referred to as 'grey literature', i.e. materials that are either unpublished, or published but not in the peer reviewed literature[15].

One commonly-used method for calculating in-hospital mortality in Australia is the risk-adjusted Canadian referred mortality (RACM) model.[II] Logistic regression modelling of in-hospital mortality is used to calculate expected mortality: adjusting risk according to principal diagnosis, age, sex, comorbidity, length of stay, emergency or elective admission status and whether transferred from another hospital. The expected mortality estimate for each hospital is then combined with observed deaths to calculate risk-adjusted HSMRs.

I For example, Victoria has been the only jurisdiction collecting data on comorbidities present on admission (known as C-codes) for several years.

II The RACM model is also used Canada, England and the Netherlands.

Table 2 Comparison of in-hospital mortality rates by country

Country	Time period	Crude mortality rate, deaths per 1,000 admission	Hospital Standardised Mortality Ratio	Contributing factors			
				Average age	Palliative care	Length of stay, mean days	Admissions per 1,000 population*
New Zealand	2013/14	9.7	N/A	46		3.1	198
Canada[7]	April 2008 – March 2010	40.5	91.0	53	3.32 percent	7.28	82
UK	2012/13	15[16]	99.3†	52[17]		5.2[17]	267

*Admission per 1,000 population

Canadian rate of 82 is based on 2.8 million in-patient hospitalisations in acute care hospitals in 2010-11[18] and a Canada population of 34.3 million in 2011[19]

UK rate of 267 is based on 15.4m discharge episodes[16] and an England population of 53.9m[20]

†The UK HSMR is based on Sapere analysis of the un-weighted average of HSMR of each trust. Data from Dr Foster Intelligence and is based on the 2013/14 year[21]

2.4 In-hospital cardiac arrests

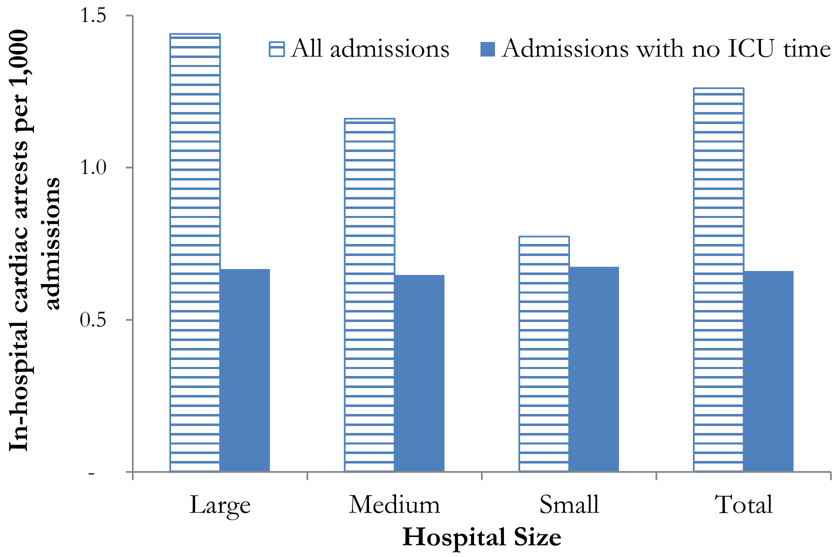
In this analysis, cardiac arrest refers to when a patient has cardiac arrest documented as a diagnosis (although we have excluded events were cardiac arrests is the primary diagnosis in order to exclude the cardiac arrests that happened prior to hospital admission). The cardiac arrests included in this analysis are included regardless of whether a cardiac arrests call is made and resuscitation is attempted.

In 2012/13, the average rate of all cardiac arrests in public hospitals was 1.3 per 1,000 admissions. This rate was made up of 886,000 admissions and 1,120 cardiac arrests. Large hospitals had nearly twice the rate of cardiac arrests compared with small hospitals, 1.4 versus 0.8 cardiac arrests per 1,000 admissions.

Large hospitals likely have higher rates of cardiac arrests due to more vulnerable patients requiring more intensive care. These patients are often transferred to these larger hospitals as they provide more specialist resources such as intensive care units (ICUs), cath labs for patients and other more complex interventions. Across New Zealand, nearly half of all cardiac arrests occur in patients who spent time in the ICU during their hospitalisation. The rate of cardiac arrests is similar across hospitals if patients admitted to ICU are excluded. Avoidance of time in ICU is of particular interest due to the reduced intensive monitoring and associated costs.

Figure 5 below illustrates the differences in the rates of cardiac arrest by hospital size. Larger hospitals have higher rates of cardiac arrest, as shown by the shaded bars. The solid blue bars depict cardiac arrest rates being almost the same by hospital size when focusing on hospital admissions with no ICU time.

Figure 5 Cardiac arrests rates by hospital size†

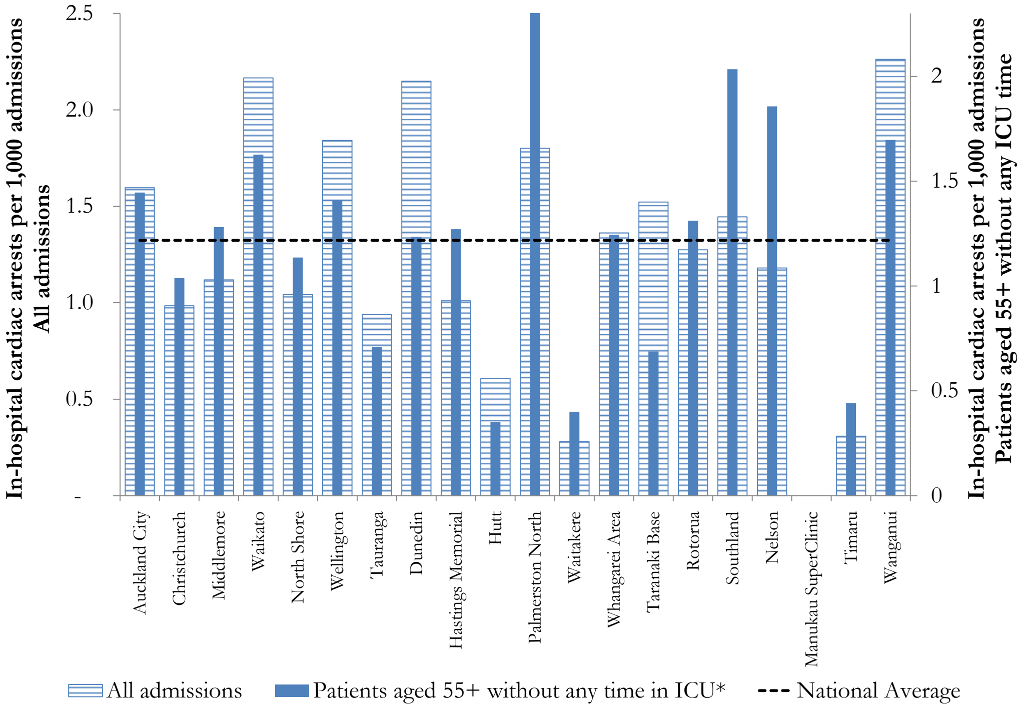


† Hospital size is based on the number of admissions; small 1,000 to 15,000, medium 15,000 to 30,000, large over 30,000.

The variation in rates of cardiac arrest by hospitals across New Zealand exists even when hospitals are a similar size. Part of this variation can be explained by ICU utilisation (as described above) and the age of patients. Patients aged 55 or over account for 44 percent of hospital admissions and 76 percent of hospital cardiac arrests. However, this percentage drops to 44 percent of cardiac arrests and 44 percent of hospital admissions when hospital admissions including time in ICU are excluded. It is difficult to compare the variation in smaller hospitals as cardiac arrests are relatively infrequent. Looking at a year's worth of data per hospital may not represent the 'average rate'; as one or two cardiac arrests would affect the rate significantly.

Figure 6 below shows the rates of cardiac arrest by hospital, in hospitals with at least 15,000 admissions. The figure reports two measures of cardiac arrest, the rate of cardiac arrest for all admissions (shown by the shaded bars) and the rate for admissions where the patient was aged 55 or over and was not admitted to ICU during the admission (shown by the narrow solid bars). The national average for both measures is depicted by the dotted black line.

Figure 6 Cardiac arrest rate for New Zealand public hospitals†



† Restricted to hospitals with over 15,000 admissions, hospitals ordered by the number of admissions.
*Patients aged 55+ without any time in ICU account for 44% of cardiac arrests and 44% of admissions.

Key observations from comparison of rates of in-hospital cardiac arrest by hospital are as follows:

- The rates of cardiac arrests for some hospitals (Waikato, Dunedin and Wanganui) are approximately 50 percent higher than the national average.
- When restricting the rates of cardiac arrest for patients aged over 55 and to admissions that had no ICU time:
  - Dunedin rate is the same as the national average, compared with having one of the highest rates when no adjustment for age and ICU is made.
  - Taranaki has a rate of cardiac arrest half of the national average, compared with having the national average when no adjustment for age and ICU is made.
  - Nelson goes from below the national average to having one of the highest rates.

There is a number of reasons for the variability of the reported rate of cardiac arrests, these reasons include:

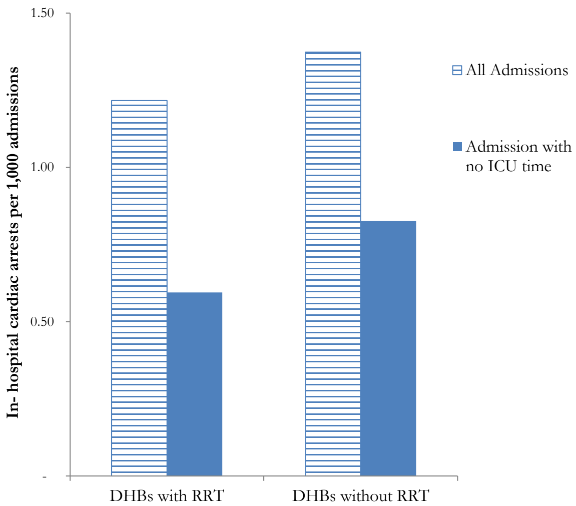
- Difference in patients' characteristics.
- Differences in the way hospitals report on cardiac arrests.
- Variance in the proportion of patients having do not resuscitate (DNR) orders; this effects the number of cardiac arrest calls.

If a patient has a do not resuscitate (DNR) order, then a cardiac arrest call is not made when the patient deteriorates. If a cardiac arrest call is not made then the cardiac arrest event is not included in the ICU data set. Therefore, if there is an improvement in patients getting appropriate care, it could lead to more DNR orders and less cardiac arrests calls. In this scenario, the total number of cardiac arrests may not decrease.

2.4.1 Cardiac arrests by hospitals with and without critical care outreach teams differ materially

Nine of the 20 DHBs in NZ have dedicated response teams (RTs). The RTs are in the larger hospitals. In some DHBs, RTs offer offsite support to smaller hospitals. We have compared the rate of in-hospital cardiac arrests in DHBs with and without RTs. DHBs with RTs had slightly lower rates of cardiac arrests to those without RT. When comparing admissions with no ICU time, DHBs with RTs have a cardiac arrests rates 28 percent lower; 0.59 compared with 0.83 cardiac arrests per 1,000 admissions (see Figure 7 below). The lower rate of cardiac arrests in DHBs with RTs when there is no ICU admission is illustrated by the different heights of the solid blue bars.

Figure 7 In-hospital Cardiac arrests by DHB with and without Response Teams (RTs)



We compared the rate of cardiac arrests in small hospitals in DHBs with and without RT. We found that DHBs with RTs had much lower rates of cardiac arrests at their small hospitals (in the year ending June 2013). As discussed above, it is difficult to draw conclusions from this result, as the number of cardiac arrests is low, with 20 arrests in hospitals where the DHB has an RT and 58 arrests in hospitals with no RT in the DHB. Further, some small hospitals are maternity hospitals, which have much lower rates of cardiac arrests.

2.4.2 National collection data is reasonably accurate

We compared the cardiac arrest rates from the national collection data with the rates reported by Wellington, Waikato and Middlemore hospitals. We found the number of cardiac arrests from both sources to be similar. This similarity gives us confidence that data from the national collection we have based our analysis on is reasonably accurate.

2.4.3 Lack of international data on in-hospital cardiac arrests

We collected clinical trial data on in-hospital cardiac arrests but were unable to identify data reported at a country level. As discussed, these reported rates need to be treated with some caution as they may not be comparable to New Zealand rates.

New Zealand's rate of in-hospital cardiac arrest of 1.3 per 1,000 admissions is lower than the average rate of cardiac arrest reported in the largest meta-analysis for RT undertaken to date. The meta-analysis reports a rate of cardiac arrests for hospitals with and without RT of 2.0 and 3.7 per 1,000[35].

The rates of cardiac arrest at the end of the study period in the largest RCT for RTs are similar to those currently in New Zealand. The RCT reported cardiac arrest rates of 1.31 and 1.64 for hospitals with and without RTs[38].

Our analysis focused on the financial year 2013/14, i.e. the year ending June 2014. We created further fields to enable the analysis. These fields are:

- Public hospital: used to limit the analysis to public hospitals. Public hospitals were identified by a facilities list supplied to us by the Ministry of Health.
- Size of hospital: used to categorise the hospitals in to small, medium, or large. We used the number of admissions in 2013/14 to determine hospital size. We used the following values to determine the size of hospital small 1,000 to 15,000, medium 15,000 to 30,000, large over 30,000. Hospitals that had under 1,000 admissions were excluded from the analysis.
- Cardiac arrest is the primary diagnosis: used in an attempt to remove the cardiac arrests that happened outside of hospital from the count of in-hospital cardiac arrests. The assumption is that if the primary diagnosis is cardiac arrest, it is likely that the arrest occurred outside of hospital. If the ICD-10 code for the primary diagnosis was I46, then the record/admission was excluded from the analysis.

When we estimated the rates of in-hospital mortality we used the 'all hospital admissions' data set. When we estimated the rate of cardiac arrests, we used the 'cardiac arrest' data set to estimate the number of cardiac arrests and used the 'all hospital admissions' data set to estimate the number of admissions.

Data was extracted from the Ministry of Health's National Minimum Dataset (NMDS). The NMDS records information regarding hospital admissions. The data was extracted by Ministry of Health staff and provided to us. We received two datasets, the first dataset included all hospital admissions apart from emergency department short stays, and the second dataset was restricted to admissions where cardiac arrest was recorded as a diagnosis.

Dataset One:

- Financial year.
- DHB region of domicile.
- Facility code.
- Facility name.
- Sex code.

- Prioritised ethnic code.
- Age group – 5 year age bands.
- ICU flag – Set to ICU if the patient spent some time in ICU during their admission.
- Discharged dead – Set to 'Discharged Dead' if the event end type is 'DD' or 'ED'.
- Number of discharges.
- Sum of bed days.

The selection criteria used: Financial year 2011/12 to 2013/14. Excluded ED short stay.

Dataset Two:

This data set was the same as the all hospital admissions data set described above, with the following changes.

Additional fields:

- Length of stay.
- AR-DRG code current.
- AR-DRG current code description.
- Primary diagnosis ICD-10 v.6.

Additional selection criteria: Any of the prognosis codes includes the ICD-10-AM-VI code I46.

3. New Zealand practice in rapid response systems varies

There is widespread use of Rapid Response Systems (RRSs) in New Zealand.

All 20 of the district health boards have Early Warning Scores (EWS) in place in at least one of their hospitals. Formal/dedicated RTs are in in place in four of the five tertiary hospitals and five of the 15 metropolitan/regional hospitals.

There is variation in the EWS systems in place in New Zealand. Our EWSs use between five and eight vital signs in determining when to respond. The values for each vital sign that lead to a maximal response (i.e. call to MET) differ by DHBs. There are calls from hospital staff to standardise the EWSs based on evidence based measures.

Variation in RTs is expected as the staff composition of the team needs to take into account hospital size and structure.

New Zealand hospitals adopting an RRS have subsequently reduced cardiac arrest rates. Waikato hospital reduced cardiac arrests by 40 percent in the year following the introduction of an EWS. Wellington hospital has continually extended the use of EWS and RT in recent years and over the same period there has been a 75 percent reduction in cardiac arrest rates. Middlemore hospital had a 50 percent reduction in cardiac arrests following the introduction of a Patient at Risk (PAR) team.

3.1 Systems to identify clinical deterioration are in place, but EWS vary

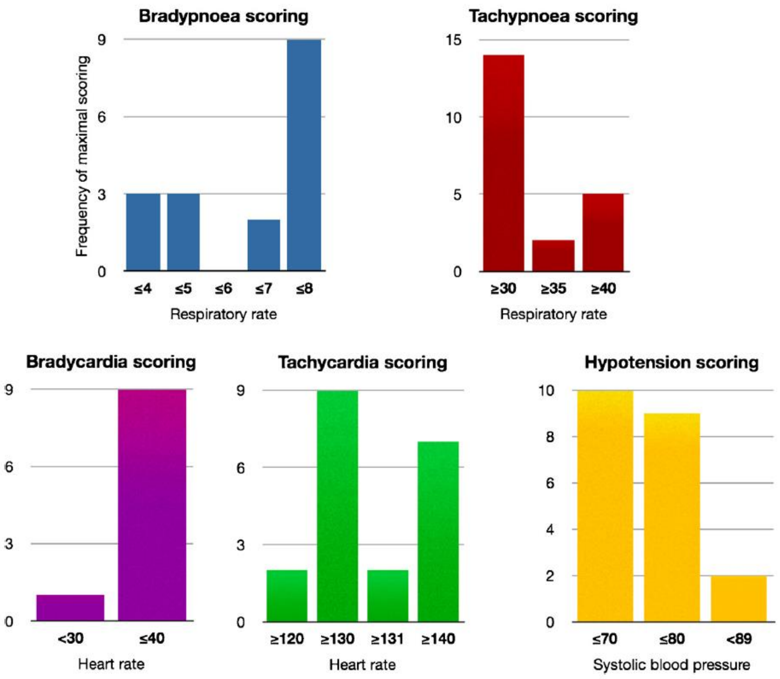
A study in 2012 (published in 2014) found all of New Zealand's 20 District Health Boards (DHBs) use early warning systems to assess clinical deterioration and determine when to respond. All DHBs use a combination system using both single parameter and aggregate scores to trigger escalation of care.

Key differences across the DHBs are the values that trigger a response and the type of response to clinical deterioration[4]. A total of nine different vital signs were assigned scores across the 21 systems identified (one DHB had two systems). Each system used between five and eight vital signs to determine when to respond. The values for each vital sign triggering a call to an RT differed by DHBs (see Figure 8 below). For example, bradypnoea triggered a response when it fell to eight breaths/minute in nine hospitals, but in three hospitals breaths per minute had to fall to four breaths/minute in order for a response to be triggered (assuming other vital signs were in an acceptable range). The range of values triggering a response is less variable for other vital sign measures such as heart rate and blood preassure[4]. There were also differences in the scoring systems to determine when a combination of vital signs triggered a response[4].

In 16 of the 21 systems, there was allowance for clinicians to alter the EWS score and thus when a MET is required[4].

A limitation of the study was that it is based on the documentation of clinical practice supplied to the authors and the results may not accurately reflect actual practice[4].

Figure 8 Difference in vital sign values used by DHBs that trigger a maximal response.



Frequency of maximal scoring refers to the number of DHB systems that use the value on the x-axis as the score which triggers a maximal response.
Source: Psirides et al 2013[4]

3.2 Systems to respond to clinical deterioration have been established

A study in 2012 found nine of New Zealand's 20 acute care hospitals had Critical Care Outreach (CCO) teams. Most of the tertiary hospitals (four of five) had CCO and a third of metropolitan and regional hospitals (five of 15) had CCO. There has been a recent increase in CCO, before 2005 there was only one in place[5].

Table 3 New Zealand Hospitals with Critical Care Outreach

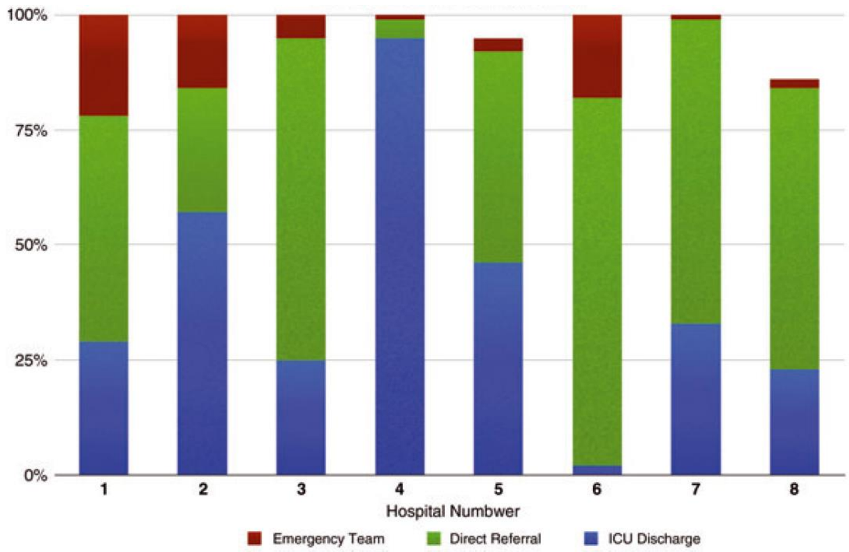
Hospital Type	Number of hospitals	Number of hospitals with CCO
Tertiary	5	4
Metropolitan and regional	15	5
Total	20	9

Source: Pedersen et al 2014, reproduced by Sapere[5]

There was a wide variation in the composition and referral type to CCO at different hospitals. Four of the nine hospitals provided a 24 hour service seven days week. Three of the hospitals had CCO operating seven days a week but did not provide overnight cover. Two of the hospitals did not have a formal CCO established and operated on an ad-hoc basis.

Two CCO had an MET linked and an EWS escalation pathway. For these CCO, MET calls accounted for 16 to 22 percent of referrals. For the seven CCO without a formalised MET, emergency calls accounted for 4.2 percent (range one to 18 percent) of referrals[5] (see graph below for details). The type of referrals to COO varied by hospital. For example, the proportion of referrals for ICU follow up was 95 percent at one hospital and 5 percent at another (hospitals 4 and 6 in the graphs below)[5].

Figure 9 Referral type by Critical Care Outreach



Source: *Pedersen et al 2014*[5]

Of the 11 hospitals reporting they did not have CCO, five reported limited financial resources as a barrier to setting up CCO and four hospitals did not see the need for CCO.

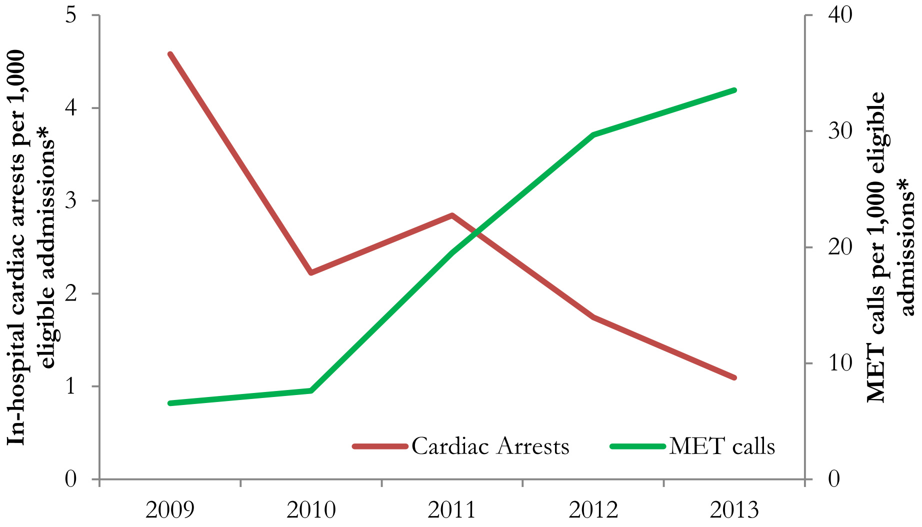
3.3 NZ case studies show strong results

3.3.1 Wellington hospital

Wellington hospital has made increased efforts to identify and respond to clinical deterioration since 2008. A Patient At Risk (PAR) team was introduced in the medical ward in 2008. PAR was rolled out to the all adult wards by 2010, available 24 hours a day seven days a week. PAR became available to paediatric patients in 2012. New observational charts were instituted in all adult wards by 2012 and mandatory escalation pathways were introduced in all adult wards (cardiology, cardiothoracic, general surgical, vascular and ear, nose and throat). In addition to these changes, there were additional beds created and other service reconfigurations made to help reduce harm from clinical deterioration.

These efforts to identify and respond to clinical deterioration were associated with a reduction in cardiac arrests and an increase in calls made to the medical emergency team (MET). Cardiac arrests refers to when a cardiac arrests results in CPR; this measure of cardiac arrests excludes cases of cardiac arrest were the patient had a do not resuscitate order. The rate of cardiac arrests responded to by the MET in 2009 was 4.6 per 1,000 eligible admissions, and in 2013 this fell to 1.1[III]. The rate of calls to the MET has increased from 6.5 per 1,000 eligible admissions in 2009 to 34 in 2014. The changes in cardiac arrests and MET calls and are shown in the graph below.

Figure 10: Wellington hospital, MET calls and cardiac arrests 2009 to 2013



**The admissions included in the data set are those where the patients is on a ward with an Early Warning System. The number of admissions is approximately half of those recorded in the National Minimum Dataset.*
Source: Data supplied by Wellington hospital; Graph produced by Sapere.

3.3.2 Waikato hospital

In April 2010, Waikato hospital introduced an early warning score. In the year of implementation, there was a 40 percent reduction in cardiac arrests, compared with the year prior[22].

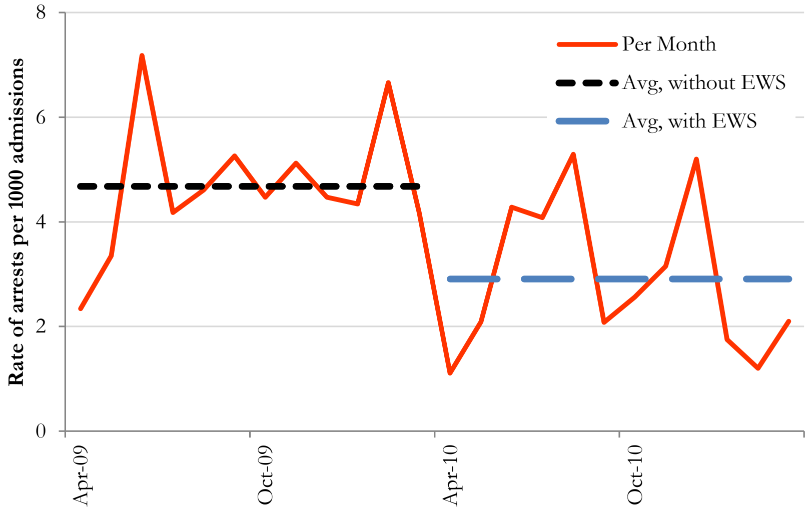
There were 168 cardiac arrests during the 24 month period April 2009 and March 2011. The incidence rate of cardiac arrests per 1000 admissions was 4.67 during 2009-2010 and 2.91 during 2010-2011 (mean difference of 1.77, 95%CI 0.59-2.94); this is shown in the figure below. Hospital cardiac arrest data is from the New Zealand Resuscitation Council National CPR registry. There was no significant increase in the number of medical emergency calls (7.5 calls versus 9.1 calls per month)[22].

We estimate that the cardiac arrest rate in the year ending June 2013 to be 2.2 per 1,000 admission[IV]. This is a further improvement beyond the study period.

[III] The rate of cardiac arrests supplied in the Wellington hospital data set is 1.1 per 1,000 admissions. The rate calculated using data extracted by the National Minimum data set is 1.8. This difference is likely due to the Wellington data set restricting data to wards using EWS, which is approximately half of admissions.

[IV] The rate of 2.2 cardiac arrests per 1,000 admissions is based on data extracted from NMDS and analyses by Sapere.

Figure 11 Reduction in Cardiac Arrests following the introduction of an EWS at Waikato hospital



Source: data from Drower et al 2013[22]; graph produced by Sapere.

3.3.3 Middlemore hospital

In 2007, Middlemore implemented an Early Warning Scoring System (EWSS) aimed at early recognition and intervention of physiological deterioration in adult ward patients called the Physiologically Unstable Patient Scoring System (PUP EWSS).

The PUP EWSS is part of a multi-tiered approach to the unstable patient. It uses a system that allocates scores to vital signs outside of predetermined parameters. The cumulative score 'triggers' a graded response ranging from increasing frequency of observations to triggering a medical emergency team (MET) call. Two senior ward nurses were employed as clinical nurse specialists to augment the scoring system under the umbrella of the quality improvement unit, covering 7am to 7pm from Monday to Friday. After hours and public holidays, an existing team of senior nurses (clinical nurse advisors) responded to the deteriorating patient.

In 2009, the two nursing groups merged to form the Patient at Risk (PAR) team under the auspices of the critical care unit. The PAR team provides a two staff, twenty four hour, seven-day per week nurse led critical care outreach service (CCOS). The team responds to triggers in the afferent limb of the response setup such as elevated PUP scores or other objective or subjective concerns regarding a patient, and provides follow-up of patients discharged from the intensive care unit (ICU) and high dependency unit (HDU). The team is also part of the MET responding to emergency calls throughout the adult areas of the hospital and follow-ups of this second patient group (excluding ICU, HDU, emergency department, and operating room). Members of the team are experienced senior nurses. Each nurse is assessed by the ICU Nurse Practitioner (NP) according to these competency requirements, with yearly Advanced Cardiac Life Support (ACLS) certification.

The impact of introducing the Patient At Risk (PAR) team has recently been published. The rates of in-ward cardiac arrest call rates before PAR was established (2008) were compared to the rates once PAR was established (2011 – 2012). The rate of cardiac arrest calls halved once PAR was established, the rate of cardiac arrests was 1.8 per 1,000 admissions before

PAR and 0.9 once PAR was established. There was no change in the number of medical emergency team calls. The authors concluded PAR team composition may be effective in providing care to the deteriorating patient[23].

International practice

There is a number of international organisations that recommend that hospitals improve systems to better identify and respond to clinical deterioration. We have not identified any recommendations not to improve the systems, or recommendations not to adopt an Early Warning Score (EWS) or Response Team (RT). When deciding whether the international recommendations are suitable for the New Zealand context, we need to consider that the settings between countries differ, including the systems currently in place in New Zealand.

We summarise recommendations from Australia, United Kingdom, and the United States.

Australian recommendations

Australian recommendations from the Australian Commission on Safety and Quality in Healthcare.

In 2010, the Australian Commission on Safety and Quality in Healthcare issued 'National Consensus Statement: Essential Elements for Recognising and Responding to Clinical Deterioration'[24]. The eight elements covered in the consensus statement are:

- Clinical Process.
- Measurement and documentation of observation.
- Escalation of care.
- Rapid response systems.
- Clinical communication.
- Organisational prerequisites.
- Organisational supports.
- Education.
- Evaluation, audit and feedback.
- Technological systems and solutions.

In 2012, the Australian Commission released a report on a National Safety and Quality Health Service (NSQHS) Standard for the 'Recognising and Responding to Clinical Deterioration in Acute Health Care'[25]

South Australia

In 2013, the Department for Health and Ageing, Government of South Australia released clinical guidance for 'Recognising and Responding to Clinical Deterioration'[26]. Their guidance covers:

- Establishing governance systems,
- Recognising clinical deterioration and escalating care,
- Responding to clinical deterioration,
- Communicating with Patients and Carers,
- Advanced Care Directives and Resuscitation Plans, and
- Education and training.

Western Australia

In 2014, the Department of Health Western Australia released a report detailing the core principles that must be followed. The policy covers the detection on and response to clinical deterioration[27]. The policy aligns with the Australian Commission on Safety and Quality's Consensus Statement.

UK recommendations

UK National Institute for Health and Care Excellence (NICE).

In 2007, the National Institute for Health and Care Excellence (NICE) released guidance on the topic of 'Acutely ill patients in hospital Recognition of and response to acute illness in adults in hospital'[28]. They found evidence that patients were not entering a place of safety when entering hospitals and patients who are unwell, or become unwell, may receive sub-optimal care. The resulting recommendation covered a number of aspects including:

- Providing patient centred care.
- Recording a set of physiological observation (minimum set given).
- 'Track and trigger system' (similar to EWS).
- Recording the patients monitoring and management plans.
- Importance of hospital staff training.

They noted that there was a lack of evidence in order to identify a best model or response to clinical deterioration. They considered the optimal configuration of response should be agreed and delivered locally.

NICE are planning to review their guidance on this topic in December 2015[29].

UK Royal College of Physicians

The Royal College of Physicians developed a National Early Warning Score (NEWS). They made a number of recommendations[30], including:

Routine clinical assessment of all adult patients (aged 16 years or more) should be standardised across the NHS with the routine recording of a minimum clinical data set of physiological parameters resulting in a National Early Warning Score (NEWS).

NEWS is used to improve the following:

1. The assessment of acute illness,
2. The detection of clinical deterioration, and
3. The initiation of a timely and competent clinical response.

American recommendations

"We suggest hospitals consider the introduction of an EWSS/response team/MET system to reduce the incidence of in-hospital cardiac arrest and in-hospital mortality" was made in a recent draft recommendation made by the American Heart Association (AHA) and International Liaison Committee on Resuscitation (ILCOR). They note that there is low quality evidence but the recommendation places a high value of the prevention of in-hospital cardiac arrest and death relative to the incremental cost of the system[31].

4. Evidence of programmes to reduce clinical harm

The use of patient vital signs in Early Warning Scores (EWS) have been shown to be good predictors of in-hospital cardiac arrests and mortality.

When systems are put in place to respond to clinical deterioration, then those systems usually result in a reduction of in-hospital cardiac arrests and mortality. The largest meta-analysis reported a 35 percent reduction in cardiac arrests. The reduction in mortality was less clear. The reduction in harm reported in the meta-analysis was derived from results of before and after studies[35].

The evidence is not straight forward, however. When hospitals with and without rapid response teams were compared in an randomised controlled trial (RCT); the reduction in in-hospital cardiac arrests and mortality was the same[38]; this comparison raises the question whether RTs are the cause of reduced harm from clinical deterioration observed in before and after studies.

4.1 EWS effective in identifying at risk patients

Strong relationship between abnormal vital signs and adverse patient outcomes

The most comprehensive study of the relationship of abnormal vital signs and adverse patient outcomes is a study of 1.15 million individual vital sign observations in 42,430 admissions on 27,722 patients[32]. Key results of the study were:

- Definitions of critical values of vital signs;
- Risk of harm for given vital signs;
- Timing of abnormal vital signs - with half occurring after 48 hours; and
- The validation of specific EWS.

The study reported the range of values for each vital sign associated with either a 5/10/or 20 percent probability of death. Values with a five percent probability of mortality were defined as critical vital signs. For low systolic blood pressure, if the patient had an observation of 80 to 84 mmHG during their hospital admission, then they had a five percent probability of mortality; if blood pressure was as low as 55-59mmHg, they had a twenty percent probability of mortality. The relationship of vital signs and mortality are shown in the table below[32].

The presence of a single critically abnormal vital sign was associated with a mortality of 0.92 percent versus a mortality of 23.6 percent for three simultaneous critical vital signs[32].

Table 4 Relationship between vital signs and mortality

Vital sign	5% mortality	10% mortality	20% mortality
Systolic blood pressure (mm Hg): low	80 to <85	65 to <70	55 to <60
Diastolic blood pressure (mm Hg): low	20 to <30		
Diastolic blood pressure (mm Hg): high	120 to <130		
Mean arterial pressure (mm Hg): low	40 to <50		
Heart rate (bpm): high	120 to <130	140 to <150	150 to <160
Temperature (°C): low	34.4 to <35	33.9 to <34.4	
Temperature (°C): high	38.9 to <39.4	39.4 to <40	
Respiratory rate (bpm): high	24 to 28	28 to 32	36 to <40
Respiratory rate (bpm): low	10 to 12	4 to 8	
Oxygen saturation (%)	90 to <91	81 to <82	
Level of consciousness	Not alert	Sedated	No response
Glasgow coma score	14	13	

[a] Blank cells indicate that no vital sign range achieved corresponding level of mortality. None of the high systolic blood pressure, high mean arterial pressure, and low heart rate categories were associated with a mortality >5%.

Source: Bleyer et al 2011[32]

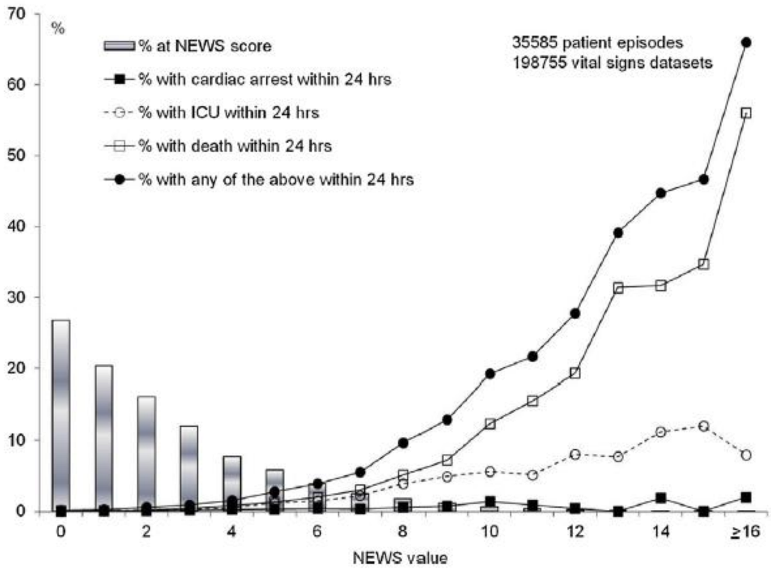
Strong performance of the UK National Early Warning Score (NEWS)

The UK National Early Warning Score (NEWS) was retrospectively applied to 198,755 vital signs datasets from 35,585 patient episodes that occurred between 2006 and 2008. The authors concluded that NEWS performed well with an Areas Under the Receiver-Operating Characteristic (AUROC) curve 0.873, when the NEWS was used to predict cardiac arrest, unanticipated ICU admission, or death. The NEWS was found to perform better than 33 other EWS systems. The figure below shows the strong correlation between NEWS score and the probability of an adverse outcome; for example a NEWS score of 10 was associated with a 20 percent chance of cardiac arrest, unanticipated ICU admission, or death[33].

NEWS was compared to the best performing EWS from their set.

The authors estimate the updated EWS can detect 5 percent more cases for the same amount of effort (i.e. reviewing the same number of cases). This observation was based on the identifying 80 percent of cases with NEWS compared with 75 percent with the other EWS, in both cases based on responding to 22 percent EWS values[33].

Figure 12 Relationship of NEWS score and adverse outcomes



Source: Smith et al 2013[33]

Observation chart design affects the recognition of abnormal vital signs

45 health professionals (doctors and nurses) and 46 non-health professionals completed 48 trials in which they viewed realistic patient observations recorded on six hospital observation charts of differing design quality. Findings suggest that observation chart design has a substantial impact on the decision accuracy and response times of both health professionals and novices in recognising abnormal patient observations[34].

4.2 Mixed evidence for the reduction in harm from clinical deterioration

The biggest meta-analysis of RTs reported a reduction of 35 percent in the rate of cardiac arrest. This result was driven by before and after studies[35]. However, this improvement is put in to question by the RCT that showed hospitals had similar improvement in cardiac arrests regardless of the implementation of RT[38].

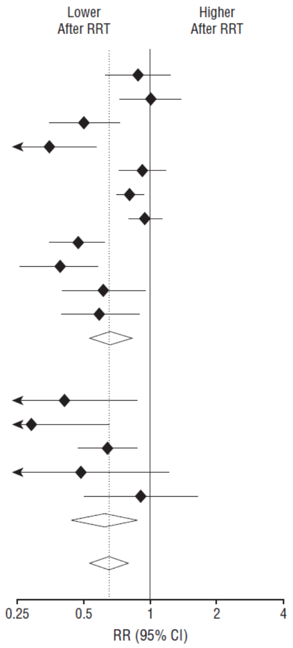
Meta-analysis shows a reduction of in-hospital cardiac arrests – on average

A meta-analysis of 18 studies, including 1.2 million admissions, found the average effect of RTs is a 34 percent and 38 percent reduction in the rates of cardiac arrests for adults and children respectively (both results statistically significant). The average effect of mortality for adults was no reduction, and the reduction in mortality for children was not robust to sensitivity analysis[35]. There is some discussion of this meta-analysis. One commentator suggested a reduction in mortality was not observed because the meta-analysis was under powered[2] (i.e. did not include enough patients) and included the wrong outcome measure for a key study[36].

There was heterogeneity between studies, i.e. the results of the studies were not consistent. Seven studies showed a statistically significant reduction in adult cardiac arrests while four did not. The four studies that did not show a statistically significant result also reported smaller reductions in cardiac arrests[35]. There was also a large range in the results for child cardiac arrests and mortality rates. The figure below summarises the studies included in the analysis of the average effect of cardiac arrests for both adults and paediatric patients. This meta-analysis included studies published between 1996 and 2008.

Figure 13 Meta-analysis of relative risks of rapid response teams effect on cardiac arrest rates

	Control Group		Intervention Group			
	Patients, No.	Deaths, No.	Patients, No.	Deaths, No.	Weight, %	RR (95% CI)
Adult Studies						
Bristow et al (hospital 1 vs 2)[20]	13059	66	18338	69	7.29	0.88 (0.62-1.23)
Bristow et al (hospital 1 vs 3)[20]	19545	99	18338	69	7.64	1.00 (0.73-1.37)
Buist et al[28]	19317	73	22847	47	6.97	0.50 (0.35-0.73)
Bellomo et al[27]	21090	63	20921	22	5.71	0.35 (0.22-0.57)
Kenward et al[33]	53500	139	53500	128	9.71	0.92 (0.72-1.17)
DeVita et al[29]	143776	930	55248	290	8.54	0.81 (0.71-0.93)
Hillman et al[31]	56756	93	68376	90	9.28	0.94 (0.79-1.13)
Jones et al[30]	16246	66	104001	198	8.00	0.47 (0.35-0.62)
Dacey et al[13]	5667	44	17090	52	6.57	0.39 (0.26-0.58)
Baxter et al[12]	7820	43	11271	38	6.20	0.61 (0.40-0.95)
Chan et al[9]	24193	147	24978	77	6.58	0.59 (0.40-0.89)
Overall Adult (I^2=80.5%, P<.001)	**380969**	**1763**	**414908**	**1080**	**82.49**	0.66 (0.54-0.80)
Pediatric Studies						
Brilli et al[36]	16255	25	9615	6	0.25	0.41 (0.00-0.86)
Sharek et al[35]	22037	53	7257	5	2.50	0.29 (0.10-0.65)
Zenker et al[14]	22561	181	11682	60	7.72	0.64 (0.47-0.87)
Hunt et al[38]	7504	16	7503	8	2.45	0.49 (0.18-1.20)
Tibballs and Kinney et al[37]	104780	20	138424	24	4.58	0.91 (0.50-1.64)
Overall Pediatric (I^2=10.2%, P=.35)	**173137**	**295**	**174481**	**103**	**17.51***	0.62 (0.46-0.84)
Overall (I^2=73.9%, P<.001)	**554106**	**2058**	**589389**	**1183**	**100.00**	0.65 (0.55-0.77)



Source: Chan et al 2010[35]

Large observational studies show an association with increased use of rapid response systems and reduced harm

A study of 9,221,138 hospital admissions in 82 public acute hospitals in New South Wales, using data from 2002 to 2009 found[37]:

- RRS uptake increased from 32 percent to 74 percent.
- Cardiopulmonary arrest decreased by 52 percent; 3.72 down to 1.85 events per 1000 admissions.
- Mortality rate decreased by 23 percent; 17.63 down to 14.36 events per 1000 admissions.

This study reinforces the association of RRS and the reduction of harm from clinical deterioration. However, this study does not show that RRS were the cause of reduced harm. A number of factors could have been responsible for the reduced harm.

Controlled trials show no benefits from introducing medical emergency teams (METs)

We identified two controlled trials[38,39] assessing the benefits of medical emergency teams (METs); neither study found a reduction in cardiac arrests or mortality.

The largest controlled trial was an RCT assessing the changes in a composite measure. This study is referred to as MERIT. The composite measure included cardiac arrests, unplanned ICU admission and unexpected mortality. 23 Australian hospitals were included; 12 were randomly chosen to introduce MET and 11 did not implement MET. The baseline composite measure was measured over two months; MET was implemented over four months and the results were collected in the 6 months following implementation[38].

The RCT found MET increased incidence for an emergency team response, but there was a similar incidence of the composite primary outcome in the control and MET hospitals (5.86 versus 5.31 per 1000 admissions, p=0.640). A reduction in the rate of cardiac arrests (p=0.003) and unexpected deaths (p=0.01) was seen from baseline to the study period for both groups combined[38].

The authors of the MERIT study provided the following possible explanations for the finding MET systems are an ineffective intervention:

- *The MET is potentially effective but was inadequately implemented in our study,*
- *We studied the wrong outcomes,*
- *Control hospitals were contaminated as a result of being in the study,*
- *The hospitals we studied were unrepresentative, or*
- *Our study did not have adequate statistical power to detect important treatment effects.*

The authors explain why each of these explanations could be the cause of the result[38].

After the study had been completed, a retrospective analysis was undertaken to determine the relationship between early emergency team calls (defined as calls not associated with cardiac arrest or death) and the rate (events/1000 admissions) of adverse events. For every ten calls, the updated EWS can detect 5 percent more cases. For an increase in the proportion of early emergency team calls there was a reduction of 2.0 per 10,000 admissions in unexpected cardiac arrests (95 percent confidence interval -2.6 to -1.4), a 2.2 reduction in overall cardiac arrests (95 percent CI -2.9 to -1.6), and a 0.94 reduction in unexpected deaths (95 percent CI -1.4 to -0.5). The authors conclude '*This inverse relationship provides support for the notion that early review of acutely ill ward patients by an emergency team is desirable*'[40].

The smaller controlled trial we identified compared the outcomes in three Australian hospitals, where one hospital had a MET that could be called for abnormal physiological parameters or staff concern and the other two hospitals had conventional cardiac arrest teams. The study compared the case-mix-adjusted rates of cardiac arrest, unanticipated admission to intensive care unit (ICU) or death. The rate of unanticipated ICU admissions was less at the hospital with the MET. There was no significant difference in the rates of cardiac arrest or total deaths between the three hospitals[39].

It is clear to us hospitals need to adopt high quality Early Warning Scores (EWS) with the following components if they have not already:

- A graphically designed observation chart designed to easily identify clinical deterioration.
- An evidence-based Early Warning Score scoring system identifying when a response is necessary based on high quality evidence.
- A mandatory escalation pathway:
  - Allowing any member of staff (regardless of seniority) to call the Response Team (RT).
  - Ensuring (escalation responders) the RT supports ward staff when a response is triggered.
  - Accounting for the wishes of patients and their whanau.

The principle of how to respond to clinical deterioration should be the same for all hospitals and should result in an appropriate and timely response regardless of the hospital the patient is in.

The various levels of response, and the teams, will be dependent on the size and type of hospital. The proposed RT for a large hospital will likely include a team being available to attend to patients 24 hours a day. For smaller hospitals, the response team is likely to be one person onsite during the day with 24-hour virtual support from a larger hospital.

5. Investment options

In this section, we provide a summary of the options that the Commission has in order to help reduce the harm from clinical deterioration.

In this instance, our reading of the literature is benefit and actions need to be quite situational and, therefore, there is no one right way for the Commission to approach this issue. Our advice is therefore posited at informing choice on a spectrum of options.

Options for investment include:

- Take no action.
- Raise the issue of preventable harm from clinical deterioration.
- Standardise Early Warning Scores (EWS) used across hospitals.
- Promote Response Teams (RTs), in addition to standardising EWS.
- Specify Response Teams (RTs), in addition to standardising EWS.

5.1 A spectrum of options

Within each of these options, there is a spectrum to how much the Commission is involved. These options are detailed below.

5.1.1 Take no action

The Commission has already heightened the issue of Rapid Response Systems (RRS) and the workshop it held in December 2014 showed that ICU clinicians are keen and are willing to lead. Nine out of 20 DHBs have formalised responses in their biggest hospitals. All hospitals have some form of systems and processes that assist with identifying and responding to clinical deterioration. However, existing systems and processes could be improved. It is unclear how much preventable harm is currently occurring.

If the Commission was to take no action, we expect the sector to continue to make improvements and reduce the harm from clinical deterioration. However, the rate of improvement is likely to be much slower than if a national body such as the Commission promoted change.

5.1.2 Raise the issue of preventable harm from clinical deterioration

The Commission could further this initial step by promoting the issue by arranging seminars, sponsoring speakers, making additions to quality conferences, etc. This light handed approach is likely to have low costs but result in low benefits.

5.1.3 Standardise Early Warning Scores (EWS) used across hospitals

EWS vary significantly across New Zealand. These differences include – but are not limited to – the scoring system, usage by hospital staff and the frequency patients' vitals are recorded.

Options for standardising include:

- Provide minimum standards; including parameters to include.
- Provide a straw man, consensus based EWS for them to use/modify (similar to what Capital & Coast is using).
- Monitor how well EWS are implemented, i.e. is it merely EWS compliance related, or is it fully endorsed?

Based on cost effectiveness, and from our understanding of the clinical situation, we have a strong preference for investment at this point in standardised EWS.

5.1.4 Promote Response Teams (RTs), in addition to standardising EWS

Clinicians have communicated (at the December 2014 workshop) responses to clinical deterioration will be different by different hospital. The main driver for differences is the size of the hospital; larger hospitals have ICUs staffed 24 hours a day, whereas small hospitals tend to have less specialised staff and have less senior staff on site at night.

The Commission could recommend or specify (based on clinical input) what the response could or should be different for different types of hospitals. This could include:

- Standard principle of providing appropriate level care for patients.
- Minimum level of training or experience of the person responding:
  - Different for different EWS scores, i.e. when a patient experiences a big change in EWS they will have a more trained or experienced person respond.
- For smaller hospitals, a variable after hours response; e.g. in the middle of the night, ward staff may contact staff from a larger hospital rather than their own hospital. Again, this will depend on the EWS score. Availability of response team, particularly at night and in the weekends is important as hospitals are much more heavily staffed during traditional working hours but the likelihood of an adverse event (e.g. cardiac arrest) is just as likely during the night as during the day.

We observe this proposition would be very difficult to implement because of situational variety meaning difficulty of structured advice.

5.1.5 Specify Response Teams (RTs) structure, in addition to standardising EWS

The Commission could become highly directive and could specify the following parameters:

- Which hospital department leads/runs the RT.
- Composition of staff in the team.

- Number of staff in team.
- Hours of operation.
- Other duties/work the team is responsible for.

This option would seem unlikely. However, if pursued, would likely have to be specified at the hospital level. Differences on how the hospital runs and how the ICU interacts with the rest of the hospital make the RT very situational. For example, in some hospitals the RT is responsible for responding to calls regarding clinical deterioration and also following up with patients who have been discharged from ICU.

5.2 Optimal path is a tight/loose strategy

The optimal path is, we believe, the following:

- A "tight" strategy – of standardisation of EWS.
- A "loose" strategy of working co-operatively with DHBs to garner the benefits of a situational appropriate response framework.

We recommend the Commission goes with the 'Promote Response Teams (RTs), in addition to the 'Standardising EWS' option for the following reasons:

- Standardised evidence based on EWS will increase detection of clinical deterioration.
- Future training requirements will reduce, avoiding EWS training when staff move between hospitals.
- Increases local accountability by expecting clinicians to check whether systems for appropriate response are in place.

Investment could be made in either or both the detection or response to clinical deterioration. We have therefore undertaken estimates of cost-effectiveness for:

- Improving and standardising Early Warning Scores (EWS) in-order to improve the accuracy of detecting of clinical deterioration.
- Introducing RTs or access to RTs, in order to respond to clinical deterioration.

Table 5 Assessment matrix

Investment option	Improvement for patients	Clinical perspective	Evidence	Cost	Implementable
Do nothing	✘	✘✘	✘	✔✔	n/a
Raise the issue	✔	✔	?	✔✔	✔✔
Standardise EWS	✔✔	✔✔	✔✔	✘	✔✔
Promote RTs	✔✔	✔✔	✔	✘	✔
Specify RTs	✔✔	✘	✘	✘✘	✘✘

6. Early Warning Scores – benefits are clear

We estimate standardising and improving EWS will lead to at least a 5 percent improvement in the detection of patients who will die, suffer a cardiac arrest or require an unanticipated ICU admission. The estimated cost of standardising and improving EWS is estimated to be a one-off cost of $1.4 million. The majority of this cost is nurse and doctor training.

6.1 Lack of existing cost-effectiveness analyses

We have not identified any analyses for the cost-effectiveness of EWS. But we identified one estimate of the cost of implementing an early warning system, a 2014 report published by York University stated *'No formal evaluations of cost effectiveness of early warning systems (electronic or paper based) were identified.'*[41]. The cost on the initial phase of implementing Maternity EWS across Ireland has been estimated to be $360,000, with an on-going cost of $75,000[V]. These costs are for nationwide staff time required for training. The cost of observation and recording time in to the MEWS was considered negligible. The authors '*anticipated that IMEWS implementation will lead to reduced ICU admissions however there is currently no available evidence to support this assumption*' [42].

The cost of implementing standardised EWS in New Zealand is likely to be significantly higher, as general EWS covers a much higher proportion of the hospitals wards than maternity EWS; however, the cost to train each clinician is likely to be lower as we are assessing modifying existing EWS rather than starting from scratch.

6.2 Estimated impact of improving and standardising EWS

The best estimate of the impact of improving EWS is from the estimated impact of the UK National Early Warning Score (NEWS). When NEWS was compared to the best performing 33 published EWS the authors had identified, the authors estimated the updated EWS can detect five percent more cases for the same amount of effort (i.e. reviewing the same number of cases); cases include cardiac arrest, unanticipated ICU admission, or death[33].

The NEWS was developed using an iterative process. The process included using datasets to determine optimal cut-off for the scoring bands and a collaborative approach to obtain clinical opinion. This rigorous process lead to the NEWS out performing any other EWS identified[33]. Some of the EWS in New Zealand have been developed using rigorous

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V The reported initial cost of MEWS was €234,025; the on-going cost was reported as €49,086. Results were translated in to NZD using an exchange rate of 0.65.

approaches including both detailed analysis of datasets and robust clinical opinion, while some EWS have been developed with much less resource[VI]. The difference in approach taken to develop EWS in New Zealand is likely to be a significant contributor to the differences in EWS used across New Zealand[4]. The variation in New Zealand EWS leads us to believe that there could be improvements made. And that the five percent improvement estimated in the UK setting could be obtainable in New Zealand.

It is difficult to quantify the changes in patient outcomes from improving the rate of identifying cardiac arrest, unanticipated ICU admission, or death. Some of these cases will not be preventable; and some should not be prevented. The extent the avoidable cases can be avoided will depend on the response. The availability of systems to provide appropriate care varies by hospital.

In addition to improving the scoring system, there will likely be value in improving:

- How often EWS are used.
- Acceptance of using EWS and the associated escalation pathway, i.e. creating a culture that supports the use of EWS.
- The response to clinical deterioration.

6.3 Quantifying cost and resource impact

We estimate the set up cost of improving and standardising EWS in public hospitals across New Zealand to be $1.4m. This cost is mostly made up of the training costs of nurses and doctors. We estimate no additional on-going costs as the existing EWS have associated training costs.

The set up costs include:

- Develop evidence based scoring tool based on desired sensitivity and specificity.
- Determine hospital specific response for each level of score.
- Design chart graphic design expertise.
- Print charts/create electronic chart.
- Train staff.

A summary of these costs is in Table 6 below.

VI Our observation on the amount of resource used to develop EWS in New Zealand was made at a workshop in December 2014. Clinical staff (predominantly ICU staff) from a number of DHBs were present.

Table 6 Estimated set up cost of updated EWS

Step	Impact	Estimated financial impact
Develop evidence based scoring tool based on desired sensitivity and specificity	Get input and feedback from DHB representatives.	\$5,000 – \$48,000
Determine hospital specific response for each level of score	Cost of representatives from each part of the hospital. Response determined at 46 hospitals.	\$207,000
Chart design	Small impact if existing chart is used.	Negligible
Print charts/create electronic chart	Some of the existing observational charts may be wasted in the transition.	Negligible
Train staff	Train half the nurses in DHB hospitals for 3 hours.	\$1,098,000
Total		**\$1.4m**

Develop evidence based scoring tool based on desired sensitivity and specificity

This activity would require clinical advice from clinicians from across the country. International evidence should be able to give guidance as the impacts of using difference inputs for the scoring systems, i.e. how does changing the cut offs of the parameters effect the number of observations trigger a response and the effect on how many adverse outcomes can be identified before they happen. Local experts would need to consider the applicability of the international estimates to the New Zealand setting. NZ experts will also be able to provide feedback on the resource implications of changing the cut-off for responses.

Capital & Coast has already developed an evidence based scoring system based on NEWS; its scoring system is based on studies using a lot of observations in order to determine suitable cut-offs in order to have a high performance. Capital & Coast's scoring system could be used as the starting point.

If there is general agreement with adopting the Capital & Coast scoring system nationally, then this step would have very little resource implications. However, if there was significant debate or if it was thought the chart should be modified then it would take time and resource. We estimate the cost to be between, \$5,000 and \$48,000 depending on the acceptance of the Wellington EWS. These costs are detailed in Table 7 below.

Table 7 Cost of developing evidence based scoring tool based on desired sensitivity and specificity

Resource	Impact	Cost
Scenario: Minor changes to Wellington EWS		
Project lead	20 hours	$1,000
Clinical experts	10 hours for each expert 2 experts	$4,000
Total		**$5,000**
Scenario: Significant changes to Wellington EWS		
Face to face meeting for one rep from each DHB	8 hours per person and flights	$32,000
Project lead	160 hours	$8,000
Clinical experts	20 hours for each expert 2 experts	$8,000
Total		**$48,000**

Determine hospital specific response for each level of score

The response to EWS will be different in the context of each hospital. In a larger hospital there is more likely to be more variation in the response, with low scores resulting in review by ward staff and high scores resulting in intervention from an RT with staff training specific to responding to clinical deterioration, staffed 24 hours a day. Small hospitals will have fewer options for response and may need to modify existing support roles to fit the RT framework; smaller hospitals can be supported by larger hospitals.

It is uncertain whether there will be much change from current practice, as all DHBs already have a scoring system and a determined response.

We estimate the total costs for each of 46 hospitals to determine the adequate response to the score to be $207,000. This assumes hospital staff are provided with the relevant background information including best practice guidelines and how other hospitals with similar characteristics respond to clinical deterioration. The cost estimate is further detailed in Table 8 below.

We strongly recommend taking time to evaluate each hospital's context in any plan for moving forward.

Table 8 Cost estimate of determining hospital specific response for each level of score

Input	Description	Value
Number of hospitals	Public hospitals with at least 1,000 admissions per year.	46
Number of staff involved	Should include representatives from the different in-patient ward.	3-10 per hospital, average of 5 per hospital*
Time needed	2 hours for prep. 1 hour for initial meeting. 2 hours for follow up meetings and/or correspondence.	6 hours
Average hourly rate	Likely to be fairly senior staff, either charge nurses or senior medical officers (SMOs).	$150
Total		**$207,000**

*Sapere estimate; bigger hospitals will need to include more people and will therefore likely require more time to come up with a solution.

Chart design

The EWS can be improved and standardised without looking at vital sign chart design. However, improving and standardising the initial chart design will make identifying clinical deterioration easier. Easy to read formatting and colour coding of the observation chart means better identification of issues and speedier reading. Capital & Coast has developed a vital sign chart with this in mind and, if the format was acceptable, then there would be very little, or any resource required and money could be spent on incremental improvement.

Print charts/create electronic chart

Printing observation charts is part of the existing budget. There may be some additional cost during the transition as old charts may no longer be used. This cost is likely to be minimal.

If the hospital is recording observations electronically, then there will be a cost to updating the electronic system. This cost is expected to be negligible, as an EWS would already be built in to the electronic system. An electronic system would clearly provide a very good audit record for clinical governance purposes.

Training staff

The amount of training needed depends on changes to chart design, scoring system and response changes; these changes will differ by hospital. Updating EWS will only require one off training as staff will already be being trained to use the current EWS. Hospitals typically have nurse educators and doctors have routine training sessions, so the training resource is already in place, but would need to be freed up.

We estimate the costs training nurses and doctors how to use a new EWS will be $1,098,000 based on training half the nurses and doctors in public hospitals for three hours. The estimate is further detailed in Table 9 below. This cost may not be a real cost as training may be able to incorporated in to the time nurses and doctors are currently paid; however the EWS training may displace other training.

We estimated that staff will require three hours of training. This estimate is half that used in estimates for setting up the Irish maternity EWS (MEWS) [42]; we used half the amount of time as all district health boards in New Zealand already have EWS in place.

Our estimate of the training costs associated with standardising EWS is further detailed in Table 9 below.

Table 9 Staff training costs of EWS

Input	Description	Value
Number of nurses	We estimate half of hospital nurses will use EWS and therefore need to be trained. In the year ending June 2013 there were 18,630 [43] nurses classified as working for 'DHB – Acute'.	9,315
Number of doctors	We estimate half of hospital doctors will use EWS and therefore need to be trained. In 2012, there were 8,212 working in New Zealand.	4,106
Number of trainees per trainer	Based on estimated from Irish National Clinical Effectiveness Committee[42].	5
Time per training session		1.5 hours
Total nurse hours	(Number of nurses + 1 trainer per 5 nurses) * 1.5 hours.	16,767 hours
Hourly rate for nurses time	Average nurse salary*.	$29
Total doctor hours	(Number of doctors + 1 trainer per 5 doctors) * 1.5 hours.	7,391 hours
Hourly rate for doctors	Average doctor salary.	$83
Total		**$1,098,000**

*Average nurse and doctors salaries are based on the average salary paid by Counties Manukau DHB in the year ending June 2013[44].

If EWS are standardised across the country, then some of the training could be undertaken at an undergraduate level. This would reduce the training burden on hospitals, and would likely result in less overall training costs.

7. Response teams (RTs) – benefits are more difficult to read

The cost-effectiveness of RTs is highly uncertain; most of the uncertainty is predictably related to the uncertainty of benefits. Due to this uncertainty, we estimate two scenarios – a conservative and optimistic scenario. These scenarios result in a range of cost-effectiveness from no benefit to $3,900 per cardiac arrest avoided. The optimistic scenario assumes an annual cost of $279,000 and a reduction of 71 cardiac arrests; the material assumption in this optimistic scenario is a 35 percent reduction in cardiac arrests in hospitals currently without a RTs. We believe the optimistic result is more likely than the conservative result, this belief is driven by the benefits demonstrated in the before and after studies.

7.1 Lack of existing cost-effectiveness analyses

There is a lack of existing cost-effectives analysis for RRS. The United States Agency for Healthcare Research and Quality[45] and a lead author (Hillman)[2] on the topic of RRS have both recently commented on the lack of cost-effectiveness studies.

We identified two studies seeking to quantify the cost and benefits of RTs. One study compared the cost and QALYs resulting from different compositions of RTs with cardiac arrest teams. The reliability of the results is questionable as some of the key assumptions are not clearly stated and the results are not reported in a standardised way[46]. The other study described the impact of forming a nurse led rapid response team from existing staff. This study shows that in medium sized hospitals RTs can be utilised without increased resources. However, the study failed to show a reduction in the rate of cardiac arrests (failure to show a reduction in cardiac arrests may have been due to data collection issues) [47]. The two studies are further described in Table 10 below.

Table 10 Existing analyses for Response Teams

Study	Reported Results/Conclusion	Comment
Comparison of cost and QALYs resulting from different compositions of Response Teams (RTs), compared with standard cardiac arrest teams[46]. Outcomes based on 10 studies included in the meta-analysis by Chan et al[35].	RTs were more effective than cardiac arrest teams at reducing cardiac arrests. Mortality was unchanged. The study concluded two of the three RT compositions led to cost-savings compared to cardiac arrest teams.	The reliability of the results is questionable. Some of the key assumptions are not clearly stated and the results are not reported in a standardised way. In addition, the cost estimates are reasonably uncertain and variable.
Impact of forming a nurse led rapid response team (RRT). The RRT was made up of existing staff. The American hospital had 275 beds[47].	The rate of cardiac arrest initially fell from 1.84 to 1.7 per 1000 discharges in the first two years of the RRT. However, after there was a change to the way cardiac arrests were recorded, the reported rate rose to 3.4.	This case study shows that in medium sized hospitals rapid response teams can be utilised without increased resources. This study failed to show a reduction in cardiac arrests. A key finding was that more of the cardiac arrests occur in ICU; however, this may have been due to the increase in ICU beds.

7.2 Estimated impact of RTs is uncertain

When evaluating the impact of RTs, the entire RRS needs to be considered, as the response can only happen if there is identification. There is a strong rationale for why RRSs should result in improvements in patients' outcomes. RRSs should improve the detection and treatment of clinical deterioration and therefore reduce adverse outcomes such as in-hospital cardiac arrests. RRSs provide ward staff with guidelines that should result in timely identification of deterioration. In addition, the protocols around contacting RTs for assistance can cut across the typical hierarchical hospital structure, resulting in a timely response from staff with training and experience specific to treating clinical deterioration. However, quantifying the benefits of RTs has proven difficult. Both the internationally literature and our analysis of the New Zealand hospitals provide little robust information on which to quantify the impacts of RRSs.

Summary of the information that could be used quantify the impact of RRS:

- Biggest randomised control trial (RCT) showed hospitals that introduced RTs had the same improvements as those hospitals without RTs, i.e. the rate of in-hospital cardiac arrests and in-hospital deaths reduced by the same magnitude with and without RRTs.
- Biggest meta-analysis of RTs reported a reduction of 35 percent in the rate of in-hospital cardiac arrests; the result was driven by before and after studies. This improvement is put into question by the RCT that showed hospitals had similar improvements in cardiac arrest rates overtime regardless of the implementation of RT.

- In New Zealand, the average rate of cardiac arrests is 28 percent lower in hospitals with RT, compared with hospitals without RTs, when focusing on hospital admissions that do not include any time in ICU. Note that all DHBs report having EWS systems in place.
- The existing RTs tend to be in the larger hospitals in NZ and larger hospitals are where RTs have been tested. The impact on RTs in smaller hospitals is uncertain, as there is less experience in this setting.

Due to the uncertainty of the benefit, we have modelled two scenarios, setting the lower and upper bounds of value: one using conservative assumptions of no added benefit and another attributing the full benefit reported in the meta-analysis.

- **Conservative case assumptions:** Our conservative assumptions are that there will be an increased cost from implementing RT, but there will be no reduction in in-hospital cardiac arrests. This scenario is based on the results of the RCT finding hospitals that introduced RT had the same reduction in adverse events as hospitals that did not implement RT.
- **Optimistic case with favourable assumptions:** When using favourable assumptions, we estimate implementing RTs in NZ public hospitals that do not currently have them will result in a reduction of 71 cardiac arrests per year nationwide. This is based on:
  - RT reducing the rate of in-hospital cardiac arrests by 35%, as reported in the meta-analysis.
  - There being 11 DHBs which do not have RTs, at the hospitals in these DHBs there are 204 cardiac arrests per year that occurred during admission when there is no time spent in ICU. We have included cardiac arrests regardless of whether the patient had a do not resuscitate (DNR) order; this may be a slight overestimate as some of the studies in the meta-analysis excluded these cases (although many studies in the meta-analysis include patients with DNR orders).

7.2.1 Quantifying cost and resource impact

The cost of providing RTs in 19 hospitals (within 11 DHBs) currently without RTs is estimated to be $279,000. We assume RTs are run out of the largest hospital within a region with smaller hospitals contacting the larger hospital for support, if needed. This costing is based on:

- A cost of $113 per RT call responded to;
- 247,000 admissions; and
- A rate of RT calls of 10 per 1,000 admissions.

The cost of RTs will depend on a number of factors including:

- Staffing composition of team:
  - Includes mix of doctors and nurses.
  - Level of experience/skills.
- Rate of RT call outs.
- Reduction in cardiac arrest calls.

Cost of response team

The costs per response is estimated to be $113 (this includes overheads costs of 100%). This is based on half an hour of senior nurse or senior doctor time and an average hourly cost of $113 of 100 percent.

The time to respond to a RT call has been estimated to be 0.5 hours[46]. RT calls are attended by either a senior nurse or a senior doctor, we have assumed an equal weighting of nurses and doctors responding.

The average hourly rate of a senior nurse is estimated to be $43. This estimated hourly range is based on the midpoint of the salaries for a 'Designated Senior nurse' in the DHB collective agreement (salaries effective from March 2014)[48]. The average hourly rate for a senior doctor is estimated to be $183. This estimate is based on an average salary of a senior medical officer working at Counties Manukau DHB[44] and assumes a working week of 50 hours.

Number of RT calls

We estimate there would be an additional 2,470 RT calls made if RTs were provided in hospitals where RTs are not currently in place. This estimate is based on 247,000 admissions and rate of 10 RT calls per 1,000 admissions. 247,000 is the number of admissions in hospitals without RTs in the year ending June 2013. The estimate of 10 RT calls per 1,000 admissions is based on experience in NZ and abroad; the experience used to inform this estimate is summarised in Table 11 below. The rates of RT calls vary substantially by hospital. We have opted with the midpoint as this is likely to match with the average effect of RTs applied from the meta-analysis.

Table 11 Estimates of rate of RT calls

Rate of RRT calls per 1,000 admissions	Source
10	Sapere estimate, based on our best estimate given rate at various hospitals.
8.7	Average in the nine hospitals with RT included in the largest randomised control trial for RT[38].
2.7 – 40	Range of the rates within the studies that were included in the largest meta-analysis of RTs[35].
17	Wellington hospital 2013 (the rate for admission where the patient was in a ward that had an EWS was 30, i.e. almost double that in ward without EWS). (Number of admissions is based on Sapere analysis of the NMDS, Number of RT calls are based on values provided by Wellington hospital).
4.9	Waikato hospital in the first year after EWS was introduced[22].
10	Middlemore hospital 2013. (Number of admissions is based on Sapere analysis of the NMDS*, Number of RT calls are based on values provided by Middlemore hospital).

7.3 Limitations of the costing estimate

Our simple estimate of the costs for RTs has limitations. There is significant uncertainty in both the cost per RT call and the number of RT calls. Further, the costs assume that nurse time can be bought in small increments, i.e. we assume that establishing an RT does not require nurses to be employed for the sole purpose of responding to RT calls. This assumption is somewhat valid as workload in responding to RTs in a small to medium size hospital is not enough to justify a dedicated role. However, there are concerns about the impact on nurses' core role when they are required to respond to an RT call[49].

We have identified one report of a medium size hospital staffing an RT from existing staff which meant introducing the RT was cost neutral (see Table 10 for details). This cost neutrality may be attainable, but it is uncertain if this approach would lead to improved patient outcomes due to removing nurses' time away from other health care services.

We have not included any cost offsets from RTs. There could be cost-savings from RTs freeing up ward staff, however this impact is likely to be negligible. There could be savings from avoiding further clinical deterioration which results in less treatment and less patient recovery time (i.e. reduced length of stay and fewer ICU admissions) although these effects have not been quantified.

Despite these limitations in costs estimates, there is limited benefit in trying to define these further given the uncertainty of the impact of RTs.

7.4 Cost-effectiveness result for RTs

The cost-effectiveness of RTs is highly uncertain; most of the uncertainty is related to the uncertainty of the benefits. Due to this uncertainty, we have estimated a conservative and optimistic scenario. This results in a range of a cost-effectiveness ratio of no benefit (i.e. dominated) to $3,900 per cardiac arrest avoided. The optimistic scenario assumes a cost of $279,000 and a reduction of 71 cardiac arrests.

We believe that the optimistic scenario is more likely than the conservative assumption. Evidence is mixed. There is some evidence to suggest that response teams do not further reduce in-hospital cardiac arrests. Clinical opinion and before and after studies suggest response teams do further reduce cardiac arrests. Our observation on NZ practice and case studies is there are material gains yet to be had.

The results of the cost-effectiveness of RTs is further detailed in Table 12 below.

Table 12 Cost-effectiveness of Response Teams

Scenario	Additional cost (per year)	Additional benefits (per year)	Cost-effectiveness ratio
Conservative: No benefit	$279,000	None	N/A
Optimistic: 35 percent reduction in cardiac arrests in hospitals without RT	$279,000	71 less cardiac arrests	$3,900 per cardiac arrest avoided

8. Further comment and reflections

There is a number of matters requiring amplification beyond a disciplined reading of the literature.

8.1 There is clear debate around the applicability of the evidence

In our experience, before and after studies provide a good basis for assessing the effect on front line practice. There is a considerable point of confusion from a randomised controlled trial where, we strongly suspect, the control group was contaminated. In our view, after talking with and listening to clinicians, we believe reliance on the RCT would significantly set back development of a national response to medical deterioration. From our perspective, after several months of consideration of the evidence, we are of the view the combination of a highly relevant meta-analysis, New Zealand specific case study evidence and clinical opinion (with deep understanding of New Zealand practice) is compelling. However, we moderate our view on benefits to acknowledge many benefits are captured in the system already. We are looking at a situation of incremental improvement on all efforts to date rather than a system wide "green-fields" development. Our assumption of improvement, in hospitals where there is no rapid response, is a very conservative assumption. We are confident there is further benefit in marginal improvements across larger hospitals.

8.1.1 Clinicians are clear about the benefits of standardisation

Clinicians are much stronger on the need to reduce variation in practice and ensure EWS are up-to-date and response systems are in place through all DHB hospitals. Particular concerns were expressed about after hours cover and evidence of more variable practice in small and medium sized hospitals. They are also much more optimistic on evidence and benefits.

8.2 From a patients perspective – we will be doing what they expect us to do

Abstract terminology such as "adverse events" shrouds the impact on patients of failure to detect or act on clinical deterioration. Patients are not able to look into hospital systems in particular because of deep asymmetry of information. However, if they were to look into the system, and see the level of variability of practice, and fully understand the implications of an avoidable cardiac arrest, then patient trust would be significantly damaged. We can best see the issue through the work of the Health and Disability Commissioner.

Patient harm from avoidable clinical deterioration

The Health & Disability Commissioner has reviewed a number of cases were harm to patients occurred, and failure to detect and or treat clinical deterioration was a significant contributing factor. Below are short summaries of two of the Commissioner's reports.

Patient story: 50-year old man

Below is a summary of a hospitalisation in September 2004 that resulted in the patient's death.

> *'Mr A, a 50-year-old man with no previous hospital admissions, was admitted to a major hospital on 23 September 2004 with classical signs of a chest infection. His chest X-ray and blood tests were not reviewed for almost 30 hours, despite an assessment during that time by a senior registrar and a consultant physician. As a consequence, his medical condition was inadequately managed. His condition deteriorated, and within 48 hours he was dead.*
>
> *Before and after Mr A's chest infection was diagnosed, clinical staff provided a poor standard of care. There was inadequate communication, documentation, and monitoring of Mr A's condition. Mr A was deprived of the opportunity to benefit from simple interventions that might have saved his life.*
>
> …
>
> *…there were a number of examples of individual and organisational failures. Although some of the failures could, on their own, be viewed as mild, they contributed to the poor standard of care that Mr A received.' Pages 91-92*[50].

Patient story: 92 year old woman

On 10 May 2011, Mrs A, aged 92 years, was referred to Canterbury District Health Board's Older Person's Health Specialist Service. She had presented to her family doctor a few weeks earlier with low back pain and restricted mobility. The events that followed are summarised below:

- Hospital 1: 11 May - 7 June (27 days):
  - Spinal X-ray showing a compression deformity at the T12 vertebra.
  - Assessed as a high falls risk.
  - Started on slow release morphine because of her increasing pain.
  - Her mood was very low.
  - Discharged early on 7 June 2011, despite her deterioration, which included increased levels of pain between 3 and 7 June, and a fall on 6 June.
- Rest home: 7-10 June (3 days):
  - Rest home was not contacted by DHB staff the day before or the day of discharge.
  - Acutely admitted to the medical ward of another hospital, Hospital 2, with abdominal pain.
- Hospital 2: 10-16 June (6 days):
  - Unwitnessed fall early on 11 June, and the sensor clip she was wearing was found not to have batteries in it.

- MRI Test Results led to an incidental finding of a T12 fracture and spinal canal narrowing.
- Transferred back to Hospital 1 on 16 June 2011 for rehabilitation.

- Hospital 1: 16-27 June (11 days):
  - After discussions with family and neurosurgeons, a conservative approach to care was taken. The hospital assessor arranged a placement for private hospital level care.
- Private hospital: 27 June:
  - Mrs A died a few weeks later.

The findings of the commissioner were summarised as:

> *'The DHB team caring for Mrs A failed to interpret and recognise the signs of a declining patient who was in pain, particularly in the days leading up to her 7 June 2011 discharge from Hospital 1. This failure was a significant contributing factor to Mrs A not undergoing medical review between 28 May 2011 and 7 June 2011. Consequently, the level of assessment of Mrs A's degree of vertebral trauma in this period was affected. There were nursing deficiencies in falls management, and a lack of clarity and rigor in the assessment of Mrs A's suitability for discharge to rest home care. The DHB's care and management of Mrs A was below standard. Accordingly, Canterbury DHB breached Right 4(1) of the Code' page 2*[51].

8.3 Part of a wider system

There is a number of complex issues related to the identification and response to clinical deterioration. These issues include:

- Goals of Care Plan;
- Variation in practice leading to variation in patient experience;
- Levels of staffing, with respect to sufficient staffing to adequately identify clinical deterioration, particularly levels of overnight staff;
- Ensuring appropriate governance;
- Creating a collaborative patient focused culture;
- Implementing electronic recording and monitoring of patients vitals; and
- Clinical hand over.

We have not explicitly included the issues listed above when estimating the costs and benefits of investing in systems to identify and respond to clinical deterioration. The complexity of the issues highlights the need for a "systems" perspective in implementation. In particular, there is an opportunity cost in having staff respond to an RT call and a hospital would need to be sufficiently aware (e.g. through productive ward programmes) of resourcing before attempting to set up a RT.

8.4 Listening to patient's/whanau wishes

The aim of the Goals of Care Plan is to ensure that patients receive care appropriate to their condition and are not subjected to burdensome or futile treatments. In some instances, "cure" is not the solution or the patient's wish. Plans are based on a shared discussion including patients, whanau and clinicians.

Capital & Coast estimate around 30 percent of MET calls relate to palliative care or end of life matters where a MET call may not be appropriate. Up to one-third of response team calls have issues around end-of life care[52]. This increases the importance of having Goals of Care Plans. However, a study of response calls (MET calls) at Wellington hospital found that the proportion of patients who had documented plans was low[53]. At the clinician workshop, clinicians from across New Zealand reported response teams are often inappropriately called for patients who do not want further intervention, or the response team is called when the team looking after the patient does not know what the patient's treatment goals are.

The direct effect of increased use of Goals of Care Plans would be to reduce the harm from inappropriate care given when a patient experiences clinical deterioration. There would also be wider benefits in terms of patients being more involved in the choice of their care. From a workforce perspective, a strong focus on Goals of Care Plans could relieve pressure on critical response team resource.

A clear precursor of formalising the way we have conversations with patients at end of life is standardisation of our response to clinical deterioration. Moreover, that standardisation of response systems is a gateway for strengthening use of Goals of Care Plans.

8.5 Implementation and Evaluation

8.5.1 Implementation

Implementation of a system to identify clinical deterioration, i.e. Early Warning Scores (EWS), is relatively straightforward as it can be the same for each hospital. Establishing a treatment escalation protocol and setting up response teams will need to be tailored to each hospital settings – further the protocols will likely differ depending on the staffing available at different times of the day.

Hospitals looking to implement or improve their Rapid Response Systems (RRSs) can look to the experiences of hospitals in New Zealand that already have well developed systems and guidelines that have been developed internationally.

Clinicians report the Australian 'National consensus statement: Essential elements for recognising and responding to clinical deterioration'[24] is a good guideline that New Zealand could use or build on.

The Commission's experience in developing and implementing a National Medication Chart[54] would help in developing a standardised EWS. Similarly, the Commission's work relating to advanced care planning could help inform work on Goals of Care Plan.

Barriers to successful implementation at a programme level might include:

- Over simplification.
- Change fatigue[VII].
- Culture, including current hierarchy and operating in “silos".

These barriers were identified at the one-day workshop we facilitated. The workshop was to discuss the issue of harm from clinical deterioration and was attended by clinicians from around New Zealand.

8.5.2 Evaluation

In this section, we discuss the need for improved data collection and key measures that could be used to evaluate the success to RRSs.

Improved data collection

The amount of existing data makes it difficult to accurately evaluate the success of implementing and improving RRSs. However, if there was better data capture then future improvements could be estimated. Also better data capture would allow a comparison of hospitals which may help identify hospitals that are doing well at reducing harm from clinical deterioration.

At the workshop of intensive care clinicians from across NZ, there was strong consensus for improved reporting of outcomes relating to clinical deterioration.

Measures for evaluating RRS

A key measure for evaluating RRSs in the literature is the rate of cardiac arrest; it is best if the measure focuses on cardiac arrests that are more likely to have been avoided.

The measure also needs to focus on avoidable harm perhaps by focusing on cases where a patient wants to be resuscitated if a cardiac arrest happens. Therefore, we recommend measuring cardiac arrests where there is an attempted resuscitation as well as measuring all cardiac arrests.

[VII] Some hospitals have recently changed their EWS, so there is likely to be resistance from these hospitals to change again in the near future.

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