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Rapid response systems

Impact of a standardized rapid response system on outcomes in a large healthcare jurisdiction☆

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ABSTRACT

Aim: To assess the impact of a standardized rapid response system (RRS) implemented across a large health care jurisdiction on reducing serious adverse events, hospital mortality and unexpected deaths.
Method: We conducted an interrupted time series (2007–2013) population-based study in the state of New South Wales (NSW), Australia to evaluate the impact of introducing a statewide standardized RRS (the between-the-flags [BTF] system) which employed a five-component intervention strategy. We studied 9,799,081 admissions in all 232 public hospitals in NSW. We studied changes in trends for annual rates of multiple key patient-centered outcomes before and after its introduction.
Results: Before the BTF system (2007–2009), there was a progressive decrease in mortality, cardiac arrest rates, cardiac arrests related mortality, and failure to rescue rates, but no changes in mortality rate among low mortality diagnostic related group (LMDRGs) patients. After the BTF program (2010–2013), the same trends continued for all outcomes with an overall (2013 vs 2007) 46% reduction in cardiac arrest rates; a 54% reduction in cardiac arrest related mortality rates; a 19% reduction in hospital mortality; a 35% decrease in failure to rescue rates (all Ps < 0.001) over seven-years. In addition, there was a new 20% ($p < 0.001$) mortality reduction among LMDRG patients (2013 vs 2007).
Conclusions: The BTF program was associated with continued decrease in the overall cardiac arrests rates, deaths after cardiac arrest, hospital mortality and failure to rescue. In addition, among patients in the LMDRC group, it induced a new and significant post-intervention reduction in mortality which was never reported before.

Introduction

Despite 15 years of quality improvement efforts after the landmark Institute of Medicine's "To err is human" report,[1] serious adverse events (SAEs) are still common in acute hospitals, with a conservative estimate of 200,000 in-hospital cardiopulmonary arrests (IHCA)[2] and up to 400,000 potentially preventable deaths each year in the USA.[3] Many such SAEs are preceded by physiological instability and deteriorating vital signs for some hours prior to the event.[4]

Rapid Response Systems (RRS) were developed in an attempt to prevent such SAEs.[5] They consist of two components: first the identification of a deteriorating patient by means of abnormal vital signs and/or observations and, second, the delivery of an appropriately skilled, trained, and experienced rapid response team (RRT) to the patient's bedside. However, despite before/after interventional studies,[5,6] and multi-center observational studies[7,8] supporting the effectiveness of such RRSs, their ability to reduce hospital mortality remains controversial.[9–11]

In 2010, the Clinical Excellence Commission (CEC) of New South Wales (NSW), Australia implemented a standardized RRS ("Between the Flags" [BTF]) in all 232 hospitals in the state of NSW in Australia.[12] The aim of our study was to use a population-based interrupted time series study to examine whether the BTF program

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was associated with specific changes for IHCA incidence, IHCA-related mortality, overall hospital mortality rates, Failure to Rescue Rates (FTR) and mortality rates among Low Mortality Diagnostic Related Group (LMDRG) patients in NSW public hospitals.

Methods

Development and implementation of the BTF program

The detailed development and implementation process have been described previously.[12] In short, the CEC developed a five-component strategy including: (1) a standardized documentation and response observation chart to be used in every hospital with criteria for defining two groups of deteriorating patients: (a) an at-risk but less urgent ('yellow zone') group and (b) an (urgent 'red zone') group (Supplemental Digital Content – Appendix A); (2) a standardized response to deteriorating patients (including minimum skills of the responder and a minimum response time); (3) a governance structure with the chief executive officer of each institution responsible for implementing the program; (4) an educational program aimed at all hospital staff; and (5) a minimum dataset to track the effectiveness of the program. Preparation began in 2009 and the program was launched in January 2010. The implementation process had support from the state health minister, senior health administration, area health authorities and personnel across the entire hospital organization.

Study design and sample

We adopted an interrupted time-series design to assess the change in patient outcomes before and after the implementation of BTF among adult patients (>18 years old). The total number of public hospitals in the state of New South Wales (NSW), Australia (capital: Sydney; population: 7.3 millions) between 1st Jan 2007 and 31st Dec 2013 was 232. Patient outcomes and other related variables were derived from the NSW Admitted Patient Data Collection (APDC) database, which includes demographic and diagnostic information for each public and private hospital admission episode. All admissions to the study hospitals were linked to the NSW Registry of Births, Deaths, and Marriages (RBDM) through the Centre of Health Record Linkage (CHeReL), NSW Ministry of Health. This linked data made it possible to derive 1-year post-discharge mortality of IHCA patients. This outcome is to ascertain whether there is unintended consequence of increasing post-discharge mortality among IHCA patients. The study was approved by the NSW Population & Health Services Research Ethics Committee (HREC/13/CIPHS/12).

Study outcomes

The primary study outcomes were:

1) IHCA rate: the number of IHCA divided by total number of admissions (including same-day admissions).
2) IHCA-related mortality rate: the number of deaths among those patients who suffered a IHCA divided by the total number of admissions.
3) Hospital mortality rate: the number of deaths divided by total number of hospital admissions.
4) Failure-to-rescue (FTR): number of deaths among those elective surgical patients who developed one of six specific complications during hospitalization i.e.: acute renal failure, deep vein thrombosis (and/or pulmonary embolism), pneumonia, sepsis, shock (and/or cardiac arrest), and gastrointestinal bleeding (and/or ulcer).[13]
5) Deaths in low mortality diagnostic related groups (DLMDRG): the incidence of death in low mortality diagnostic related groups per 1000 LMDRG admissions. As previously reported,[13] the LMDRGs was defined by combining all patients admitted under a DRG with a mortality <0.5% in any of the previous 3 years.[14]
6) 1-year post-discharge mortality of IHCA: % of the of deaths within 1-year after discharge alive from hospital among IHCA patients.

Death was defined as a patient documented as 'deceased' within the APDC database.

A cardiopulmonary arrest was identified from the International Classification of Disease Version 10 (ICD 10-AM, v5.0-v5.1) and defined as a state of pulselessness (I.46) and/or cessation of breathing (R09.2) which required cardiac massage, defibrillation or artificial ventilation.

A patient coded as I.46 or R09.2 in any of the 52 non-principal diagnostic fields, but not coded for these as the principal diagnostic field, was defined as having had a cardiopulmonary arrest during hospitalization. This process aimed to differentiate IHCA patients from patients admitted after an out of hospital cardiopulmonary arrest. NSW implemented the ICD10-AM system in 1998. Each NSW public hospital has accredited coders who code data based on the patient charts. There were no changes for relevant diagnostic definitions and coding during the study period.

Statistical analysis

To evaluate changes in baseline characteristics by calendar year (grouped as before (2007–2009), run-in (2010), and after (2011–2013) the implementation of the BTF), we applied the Rao-Scott Chi-square test which takes into account the hospital cluster effect. To assess the possible intervention effect of introduction of the BTF intervention, we used segmentation regression to estimate the monthly outcome trends before the program (T1), the change in the trend (ΔT) after the BTF intervention and the immediate change in outcome after the intervention (Int).[15] To assess changes in each outcome over calendar year, we derived an adjusted trend for each outcome variable including calendar year as a categorical variable (with 2007 as the baseline reference year). We specified a Poisson distribution to directly estimate rate ratios instead of odds ratios in the models.[16] A Huber/White/Sandwich estimator was used to account for hospital cluster effect for all regression models.[17] The adjusted rate ratio for each year (2008 through to 2013) was multiplied by the observed rates for the reference year to obtain yearly risk-adjusted rates. These rates represent the estimated rates for each year if the patient case mix was identical to that in the reference year. In the adjusted model, we included year, age groups, sex, marital status, country of birth, socio-economic status (based on the Socio-Economic Indexes for Areas (SEIFA) developed by Australia Bureau of Statistics[18]), geographical area of hospitals (urban vs rural), private health insurance status and major hospital peer groups. We examined baseline risk groups with the Elixhauser method and patient comorbidities with the Charlson Index based on ICD-10 coding.[19] We did not include baseline risk groups and the Charlson index in the adjusted model given recent reporting of potential biases introduced by these methods.[20] The cases with missing covarites values were excluded from the final modeling. A P value of 0.01 was used as indicative of statistical significance. All the analyses were conducted using Stata™ 14.0 (StataCorp, 2015. College Station, TX).

Results

Demographic characteristics

The demographic characteristics of study patients are presented in Table 1. Among several secular changes, mean age increased, but