



## A trauma quality improvement programme associated with improved patient outcomes: 21 years of experience at an Australian Major Trauma Centre



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### ABSTRACT

**Introduction:** Quality improvement programmes are an important part of care delivery in trauma centres. The objective was to describe the effect of a comprehensive quality improvement programme on long term patient outcome trends at a low volume major trauma centre in Australia.

**Methods:** All patients aged 15 years and over with major trauma (Injury Severity Score > 15) admitted to a single inner city major trauma centre between 1992 and 2012 were studied. The outcomes of interest were in-hospital mortality and transfer to rehabilitation. Time series analysis using integer valued autoregressive Poisson models was used to determine the reduction in adjusted monthly count data associated with the intervention period (2007–2012). Risk adjusted odds ratios for mortality over three yearly intervals was also obtained using multivariable logistic regression. Crude and risk adjusted mortality was compared before and after the implementation period.

**Results:** 3856 patients were analysed. Crude in-hospital mortality fell from 16% to 10% after implementation ( $p < 0.001$ ). The intervention period was associated with a 25% decrease in monthly mortality counts. Risk adjusted mortality remained stable from 1992 to 2006 and did not fall until the intervention period. Crude and risk adjusted transfer to in-patient rehabilitation after major trauma also declined during the intervention period.

**Conclusion:** In this low volume major trauma centre, the implementation of a comprehensive quality improvement programme was associated with a reduction in crude and risk adjusted mortality and risk adjusted discharge to rehabilitation in severely injured patients.

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### Introduction

Substantial evidence currently exists supporting the relationship between adequately resourced trauma centres operating within regionalised trauma systems and improved mortality in severely injured patients [1,2]. A study in Victoria Australia, demonstrated a decrease in risk adjusted patient mortality over five years after the implementation of a state-wide trauma system [3]. A pre and post implementation study across four years in the

Netherlands also demonstrated a 16% reduction in risk adjusted in-patient mortality [4]. There are few studies that examine long term trends in mortality. An inclusive state-wide trauma system in Delaware was associated with a 25% absolute reduction in crude mortality for severely injured patients (Injury Severity Score > 24) over ten years [5]. Investigators at the R Adams Cowley Shock trauma centre also studied trends in mortality over ten years between 1997 and 2008 and found a small decrease in mortality in patients with an Injury Severity Score between 17 and 24 [6].

Whilst the emphasis in trauma care evaluation has focused on systems across regions, few studies have investigated the impact of quality improvement processes within individual trauma centres over the long term. Variations in outcomes have been demonstrated across many trauma centres of similar capabilities and may reflect differing approaches to quality improvement [7]. A study by Sarkar et al. [8] from Michigan USA evaluated the effect of a

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comprehensive performance improvement programme and demonstrated a 12% reduction in trauma mortality (ISS > 24) over five years at a Level 1 trauma centre. A recent study across four countries identified differences in quality improvement processes used in low volume compared to high volume trauma centres (greater than 240 patients per year with an ISS > 15) [9]. Low patient volume trauma centres were associated with higher use of benchmarks associated with triage, patient flow and effectiveness of care. Higher patient volume centres reported higher use of benchmarks related to medical errors and adverse events.

It is unclear whether such quality improvement programmes can result in improved patient outcomes that are achievable and sustainable in the Australian context. A State-wide trauma system in New South Wales, Australia with a population of over 7 million people, was established in 1992 [10]. There are currently seven designated adult Major Trauma Centres, six of whom are located in metropolitan Sydney. As a consequence of this concentration of trauma centres, most of these would be considered low to medium volume trauma centres under current international standards [9].

The objective of this study was to describe the effect of a comprehensive quality improvement programme on long term patient outcome trends at one of these Major Trauma Centres. We sought to analyse longitudinal trends using two statistical methods – logistic regression of aggregated data and multivariable time series analyses. Information gained may help confirm the importance, effectiveness and sustainability of rigorous quality assurance processes at trauma centres, particularly those within trauma systems where lower patient volume trauma centres predominate.

## Materials and methods

### *Design – single centre trauma registry study over 21 years*

**Setting** – the study was conducted at an inner City Major Trauma Centre in Sydney, Australia's largest city. There are currently around 200 major trauma presentations (ISS > 15) per year. Although a State-wide trauma system was implemented in 1992, there was only one part time trauma director prior to 2006 at this institution, and no structured trauma education programme or quality improvement processes. In 2007 a comprehensive trauma quality improvement programme was initiated after the appointment of three trauma Co-Directors – an Emergency Physician, Colorectal Surgeon and Orthopaedic Surgeon. The programme consisted of implementation of a tiered trauma team activation protocol, mandatory notification criteria for Trauma Surgeon and Emergency Physician on-call, a structured trauma education and case review programme, massive transfusion protocol and implementation of a number of quality benchmarks consistent with those described in previous studies (9). These quality benchmarks, or key performance indicators formed the basis of trauma case reviews conducted by trauma clinical nurse consultants on every admitted trauma patient and reported at monthly committee meetings. In 2009 a hospital wide 'Code Crimson' for expedited surgical management of haemorrhage in trauma was initiated.

All trauma patients requiring in-patient rehabilitation are transferred to external rehabilitation facilities, including brain injury units outside this institution and there have been no major changes to referral patterns over the past 20 years.

A single trauma data manager has prospectively collected data on all trauma admissions to this institution into the trauma registry since 1991.

**Study population** – all adult patients (age  $\geq 15$  years) with major trauma (ISS > 15) presenting to this hospital between January 1992 and December 2012 were included. Cases were

excluded if information on patient outcomes were missing. All deaths in the emergency department were included, excluding those who had absent vital signs on arrival to hospital and did not receive treatment in the emergency department.

**Data collected** – data collected for this study included demographics (age, sex), mechanism of injury, mode of arrival, vital signs on arrival to the emergency department, injuries and injury severity score and patient outcomes. Injuries and injured body regions were classified using the Abbreviated Injury Scale [11] (AIS) 1990 and 1998 versions prior to 2009 and 2005 version thereafter. Severe head injuries were defined as any head injury with an AIS severity score of three or more. Period of presentation was divided into three yearly intervals to enable long term risk adjusted trends to be presented.

**Outcomes** – the primary outcome was in-hospital mortality. All deaths in the Emergency Department were included. The secondary outcome was transfer to in-patient rehabilitation facilities in patients surviving to hospital discharge, as a proxy marker of functional impairment requiring ongoing medical care.

### *Statistical analysis*

A univariate analysis to compare before and after periods with respect to patient characteristics and outcomes was performed. Two statistical methods were used to analyse the effect of the intervention period on major trauma mortality. Firstly the effects of the intervention period on monthly in-hospital mortality counts was analysed using integer valued autoregressive Poisson models, adjusting for age (age  $\geq 65$  years, seasonality (warmer months from October to March)) and any underlying linear trend. The intervention period was considered a binary variable (before and after). The distribution of monthly deaths was assumed to follow a Poisson distribution. This modelling technique has been shown to be superior to other time series methods such as autoregressive integrated moving average models where counts are relatively low [12]. To graphically represent the trend in adjusted monthly mortality counts, we plotted predicted monthly mortality values based on the above autoregressive Poisson model, and fitted segmented linear trend lines for the values in the before and after periods respectively.

Secondly, risk adjusted mortality and rehabilitation trends (in survivors to hospital discharge) were determined using multivariable logistic regression with data aggregated into three-year intervals, compared to reference years (2004–2006) just prior to the intervention period, and a priori defined variables based on a previous studies [3,13] and known to vary across time at this institution [14]. Three year aggregated data intervals were used due to the relatively small number of major traumas at this institution and the need to adjust mortality using a large number of covariates. Binary variables were severe head injury (Head Abbreviated Injury Scale score  $\geq 3$ ), transfer from another health facility, hypotension (systolic blood pressure < 90 mmHg on arrival to emergency department) and Intensive Care Unit admission. Age, ISS and mechanism of injury were categorised into clinically relevant categories as shown in Table 1. All analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC) except for time series analysis which was performed using STATA 10.1 (Statacorp, College Station, TX).

## Results

A total of 3873 cases were identified of which 17 had missing outcome data, leaving 3856 cases analysed. The mean age was 48 years (SD 22) and 74% were male. The number of major trauma admissions each year has increased slowly from around 150 patients per year prior to year 2000 to around 200 patients per year

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