Reduced Population Burden of Road Transport–related Major Trauma After Introduction of an Inclusive Trauma System

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Objective: To describe the burden of road transport–related serious injury in Victoria, Australia, over a 10-year period, after the introduction of an integrated trauma system.

Background: Road traffic injury is a leading cause of death and disability worldwide. Efforts to improve care of the injured are important for reducing burden, but the impact of trauma care systems on burden and cost of road traffic injury has not been evaluated.

Methods: All road transport–related deaths and major trauma (injury severity score >12) cases were extracted from population-based coroner and trauma registry data sets for July 2001 to June 2011. Modeling was used to assess changes in population incidence rates and odds of in-hospital mortality. Disability-adjusted life years, combining years of life lost and years lived with disability, were calculated. Cost of health loss was calculated from estimates of the value of a disability-adjusted life year.

Results: Incidence of road transport–related deaths decreased (incidence rate ratio 0.95, 95% confidence interval: 0.94–0.96), whereas the incidence of hospitalized major trauma increased (incidence rate ratio 1.03, 95% confidence interval: 1.02–1.04). Years of life lost decreased by 43%, and years lived with disability increased by 32%, with an overall 28% reduction in disability-adjusted life years over the decade. There was a cost saving per case of A$633,446 in 2010–2011 compared with the 2001–2002 financial year.

Conclusions: Since introduction of the trauma system in Victoria, Australia, the burden of road transport–related serious injury has decreased. Hospitalized major trauma cases increased, whereas disability burden per case declined. Increased survival does not necessarily result in an overall increase in nonfatal injury burden.

Keywords: burden of injury, costs, disability-adjusted life years, outcomes, trauma

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Road traffic crashes claimed the lives of 1.3 million people globally, and accounted for 34% of all years lived with disability (YLDs) attributed to injury, in 2010.[1,2] Over the last 40 years or so, there has been a substantial reduction in road traffic fatality rates in high-income countries,[3] including dramatic improvements in Australia[4] attributed to legislation (eg, mandatory seat belt legislation, compulsory motorcycle and bicycle helmets, reduced speed limits, and random breath testing for alcohol) and widespread public health campaigns. Primary prevention and efforts to improve care of the injured are important for reducing injury burden,[5] but the impact of systems-based approaches to trauma care on burden and cost of road traffic injury has not been evaluated.

Traumatic injury is described as a time-sensitive disease, with rapid provision of high-quality care critical to prevent death and disability.[6] People involved in road traffic crashes often sustain multiple injuries of higher complexity, commonly in rural or remote locations, creating substantial challenges for organization of emergency and health services.[7] Regionalized trauma care, where seriously injured patients are preferentially transported to designated trauma centers, is believed to increase the likelihood of survival.[8–10] These systems ideally include primary prevention, coordination of prehospital and hospital care, and provision of rehabilitation and postdischarge care to reduce preventable prehospital and in-hospital deaths and minimize long-term complications and disability.[6,11]

Evidence supports the view that regionalized trauma care reduces mortality.[7–10] However, most studies have focused only on cases where hospitalization occurred. The exception is Nathens et al,[7] who reported reduced risk of 30-day mortality after motor vehicle crashes in the United States using the fatality reporting system for road trauma. In contrast to mortality outcomes, the evidence for an effect on disability is sparse. Improved survival rates could result in higher or lower rates of severity of disability in survivors. Two prospective studies have shown improved functional outcomes for patients managed at specialized trauma centers.[12,13] A comprehensive investigation of the impact of regionalization of care should ideally include prehospital deaths, in-hospital mortality, and long-term disability.

The state of Victoria, Australia, operated an ad hoc system for delivering trauma care throughout the 20th century, and the annual decline in road traffic fatality rates slowed to 1% per annum in the decade to 2002 compared with 5.3% per annum in the previous decade.[14] In the late 1990s, growing evidence that a high percentage of road trauma deaths could be prevented by improved care triggered the reorganization of trauma care in the state.[15] The change to a regionalized and integrated trauma system was funded by the State Government Department of Health and the state's third party insurer for road trauma, the Transport Accident Commission, with the aims of reducing injury-related mortality and morbidity. The aim of this study was to describe the burden of road transport–related serious injury in Victoria, Australia, over a 10-year period, after the introduction of a regionalized, inclusive trauma system.

METHODS

Setting

The state of Victoria, Australia (population 5.6 million), implemented the Victorian State Trauma System between 2000 and 2003.[8] The Victorian State Trauma System encompasses all 138 trauma-receiving hospitals in the state, designated according to capability. Three hospitals (2 adult, 1 pediatric) were designated as major trauma services (level 1 trauma center equivalent). A single ambulance service provides road and air (fixed wing and helicopter) transport of patients. The Victorian State Trauma System meets the criteria for inclusive and regionalized trauma care including designation of a small number of major trauma services, prehospital triage guidelines allowing bypass of smaller centers in favor of direct transport to the specialist major trauma service hospitals, agreed interhospital transfer guidelines, quality assurance programs, a statewide monitoring system, and a governance system capable of impacting change.[6,11]

Data Sources

Victorian State Trauma Registry

The Victorian State Trauma Registry is a statewide, population-based register of all hospitalized major trauma cases in Victoria.[16] Data collection commenced in July 2001. A case is included if any of the following criteria are met: (1) death due to injury; (2) an injury severity score (ISS) more than 12 as determined by the abbreviated injury scale (AIS) (2005 version 2008 update); (3) admission to an intensive care unit (ICU) more than 24 hours and requiring mechanical ventilation for at least part of their ICU stay; and (4) urgent surgery. Isolated hip fracture cases are excluded. The registry collects data from the prehospital and acute care hospital phases, and collects longer-term functional and health-related quality-of-life outcomes for all survivors to hospital discharge via telephone interview at 6, 12, and 24 months after injury.[16,17]

National Coroners' Information System

The National Coroners' Information System is an Internet-based data storage and retrieval system for Australian coronial cases (http://www.ncis.org.au/) and includes every death reported to the Victorian coroner since 2000. In Victoria, legislation requires a death that seems to have been unexpected, unnatural, or violent or to have resulted, directly or indirectly, from an accident or injury to be reported to the coroner. To classify cases as an injury-related death, all cases with a cause of death as "death due to external causes," "still enquiring," and "unlikely to be known" are reviewed, and deaths involving (1) airway obstruction by a foreign body; (2) asbestosis; (3) poisoning and drug/alcohol overdose; (4) medical/surgical complications; and (5) other nontraumatic incidents not excluded by the filters (eg, malignancy) are excluded.

Ethics Statement

The Victorian State Trauma Registry uses an opt-off consent process where all eligible cases are included on the registry and patients (or their next of kin) are provided with a letter and a brochure stating the aims of the registry and data collected.[16–18] The brochure provides the details of how to opt-off and the opt-off rate is less than 1%. An opt-off consent is used because of the impracticability of informed consent, and the potential for selection bias, in the registry setting.[19] Where patients are followed up after hospital discharge by telephone interview, verbal consent to complete the interview is obtained.[17] Access to the National Coroners' Information System data is part of the registry protocol and approved by the custodians of the coroners' data. The Victorian State Trauma Registry protocol, including the described consent process, has been approved by the Human Research Ethics Committee at each participating hospital and the Monash University Human Research Ethics Committee.

Participants

All road transport–related major trauma cases and deaths from July 1, 2001, to June 30, 2011, were extracted from the Victorian State Trauma Registry and the National Coroners' Information System. Road transport cases included motor vehicle, motorcycle, pedestrians, pedal cyclists, and other road transport (eg, heavy vehicle) that occurred on a public road, street, or highway. For the purposes of this study, major trauma was defined as an AIS 2008 version ISS more than 12. Injury diagnoses coded before introduction of the AIS 2008 were mapped from the AIS 1990, 1998 version to the AIS 2008, using a validated map.[20] All prehospital and in-hospital deaths were included.

Procedures and Data Analysis

Incidence of Trauma-Related Mortality and Major Trauma

Population-based incidence rates, and 95% confidence intervals (95% CIs), were calculated for each financial year based on the total population on June 30 for the years 2002–2011. Poisson regression was used to determine whether the incidence rate increased or decreased over the 10-year period. A check for potential overdispersion of the data (variance greater than the mean) was performed to ensure that the assumptions of a Poisson distribution were met. Models were fitted for all road transport–related deaths and for major trauma, and the incidence rate ratio and 95% CI reported.

Risk-Adjusted In-hospital Mortality

Descriptive statistics were used to provide an overview of the pattern of hospitalized road transport–related major trauma patients captured by the Victorian State Trauma Registry by year. A logistic regression model was fitted with in-hospital mortality as the outcome and year as the covariate of interest. The model was adjusted for known predictors of mortality in our population[21] and identified changes in case-mix over time. The covariates used were age, natural logarithm of the ISS, head injury severity according to the AIS severity score (0–2, 3–4, 5–6), comorbid status as measured by the Charlson Comorbidity Index weighting, and road user group, consistent with trauma mortality risk prediction models.[22,23] Adjusted odds ratios and 95% CIs for each financial year, relative to the 2001–2002 year, were calculated.

Disability-Adjusted Life Years

The disability-adjusted life year (DALY) is a common metric for measuring disease burden or "health loss."[24] The DALY combines years of life lost (YLLs) and YLDs to generate DALYs for diseases or conditions.[25] The YLL component is calculated by multiplying the number of deaths by the standard life expectancy at age of death in years. Life expectancy was obtained from the 2008–2010 Australian standard life table. For each year, the number of deaths occurring in each age group and sex was used to establish the YLLs, thereby accounting for differences in age and sex profiles over time.

Patient identifying information was used to cross-check between the National Coroners' Information System and the Victorian State Trauma Registry data to ensure that deaths were only counted once.

The YLD component is calculated as the product of the number of incident cases in the time period multiplied by the average duration of the disease (years expected to life in the disabled state) and a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). Previously published disability weights, including weights from the 2010 Global Burden of Disease Study,[24] have been based on the disability experienced after sustaining a single injury. As the majority of major trauma patients, particularly those injured in road traffic crashes, sustain multiple injuries, weights were developed specifically for this project from the long-term outcome data collected by the Victorian State Trauma Registry. The UK Burden of Injury project approach was followed,[26] except that the injuries sustained by the patients were mapped to 7 injury groups, based on the AIS classification rather than the 10th revision of the *International Classification of Diseases*, and multiple injuries were accounted for in the groupings.

Disability weights were calculated using the EQ-5D. This is a generic measure of health status consisting of 5 questions, which ask about mobility, self-care, usual activities, pain or discomfort, and anxiety or depression.[27] Disability weights were calculated from the EQ-5D responses of 3505 adult Victorian State Trauma Registry cases (road transport and other cause) with an ISS more than 12, who were eligible for 6, 12, and 24-month follow-up between January 2009 and December 2010. This time frame was chosen as it reflects the timing of the introduction of the EQ-5D to the registry follow-up protocol. Responses to the 5 items were converted into a summary social preference index score ranging from less than 0 (representing a health state worse than death) to 1 (best health) using UK tariffs.[28] Proxy responses were substituted where patient responses were not available.[29]

Disability weights were calculated by subtracting the patient (or proxy) score from the relevant age and sex population–matched norm. The average weight at each follow-up time point, in each injury group, was calculated, along with the standard error of the weight, to provide a measure of the level of precision of the estimated disability weight. Short-term weights were the time-weighted mean disability weight for the first 24 months postinjury, whereas the mean 24-month weight was considered the long-term weight for the injury group. All patients (or their proxy respondent) were asked to rate the patient's level of disability before injury and at follow-up on a 5-point scale from none to severe disability.[30] Residual disability at 24 months was confirmed if the level of disability reported at 24 months was greater than preinjury disability, and this was considered permanent for the purposes of calculating YLDs. The proportion of patients with residual disability at 24 months, and the corresponding 95% CI, was reported.

The number of cases in each injury group and age group, separated by sex, was multiplied by the relevant disability weight and duration of disability to calculate YLDs. These calculations were performed separately for each year, thereby accounting for differences in the age, sex, and injury case-mix occurring in each financial year. Total DALYs were calculated by adding the YLDs and YLLs in each year. Consistent with the 2010 Global Burden of Disease study, age discounting was not used.[31] Economic discounting at 3% was used, which is consistent with World Health Organization recommendations for burden of disease studies.[32]

Costs

Establishing an economic cost to the burden of road-related injury requires a dollar cost per DALY. There is no consensus, with the value placed on a healthy year of life varying depending on the circumstances. For this study, 2 measures of cost per DALY were applied. The first was A$50,000 per DALY, which reflects Australian gross domestic product (GDP) per capita and empirical data about what is considered acceptable value for money in Australia.[33] The second was A$151,000 per DALY, which is the value of a statistical life year (VSLY) in 2007 recommended by the Australian Government Department of Finance and Deregulation after a review of approaches to cost-benefit analysis.[34] The VSLY is an estimate of the social willingness to pay to reduce premature death, which is considered the appropriate way to estimate the value of reduced risk of physical harm.

RESULTS

Incidence of Road Transport–Related Mortality and Hospitalized Major Trauma

There were 7828 hospitalized road transport–related major trauma (ISS >12) cases in Victoria over the 10 years; 4562 motor vehicle occupants, 1426 motorcyclists, 1199 pedestrians, and 641 other road users. The incidence of hospitalized road transport–related major trauma increased over the decade (incidence rate ratio 1.03, 95% CI: 1.02–1.04; $P < 0.001$) (Fig. 1).

There were 3436 road transport–related deaths in Victoria over the 10-year period; 2347 motor vehicle occupants, 528 pedestrians, 457 motorcyclists, and 104 other road users. There was a significant reduction in the population incidence of all road transport–related

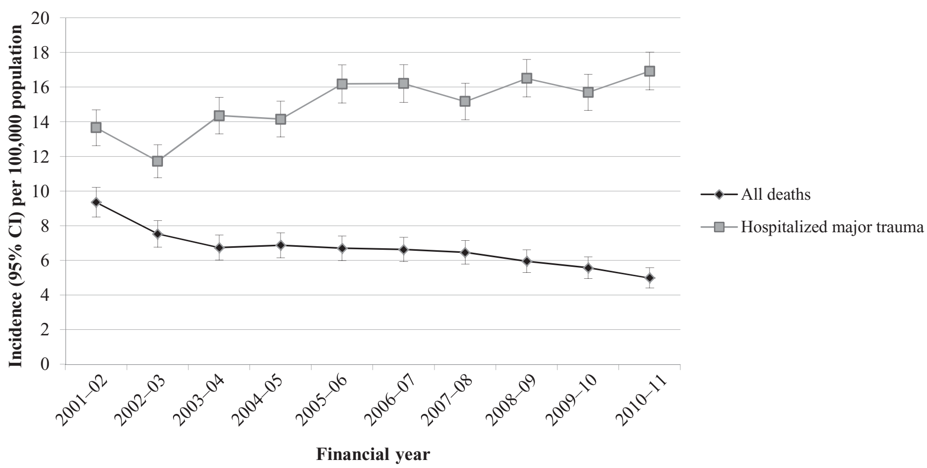

FIGURE 1. Incidence of transport-related deaths and hospitalized major trauma in Victoria (July 2001 to June 2011).

TABLE 1. Pattern of Hospitalized Road Transport–Related Major Trauma (ISS >12) in Victoria by Year

Descriptor	2001—2002 (n = 663)	2002—2003 (n = 578)	2003–2004 (n = 714)	2004–2005 (n = 711)	2005–2006 (n = 824)	2006–2007 (n = 844)	2007–2008 (n = 804)	2008–2009 (n = 896)	2009–2010 (n = 857)	2010–2011 (n = 937)
Age, mean (SD)	35.7 (19.0)	37.1 (21.0)	38.7 (20.0)	38.8 (20.3)	39.2 (20.4)	37.5 (19.5)	39.4 (20.2)	40.3 (20.6)	42.3 (21.2)	41.9 (20.8)
Sex, n (%) male	467 (70.4)	408 (70.6)	489 (68.5)	479 (67.4)	567 (68.8)	597 (70.7)	630 (69.7)	635 (70.9)	585 (68.3)	706 (75.4)
CCI weight, n (%)										
0	553 (83.4)	440 (76.1)	534 (74.8)	523 (73.6)	596 (72.3)	590 (69.9)	497 (61.8)	564 (62.9)	532 (62.1)	626 (66.8)
1	86 (13.0)	95 (16.5)	139 (19.5)	141 (19.8)	171 (20.8)	212 (25.1)	262 (32.6)	259 (28.9)	265 (30.9)	230 (24.6)
>1	24 (3.6)	43 (7.4)	41 (5.7)	47 (6.6)	57 (6.9)	42 (5.0)	45 (5.6)	73 (8.2)	60 (7.0)	81 (8.6)
Road user group, n (%)										
Motor vehicle	406 (61.2)	365 (63.1)	424 (59.4)	432 (60.7)	493 (59.8)	487 (57.7)	473 (58.8)	486 (54.2)	464 (54.1)	532 (56.8)
Motorcycle	119 (18.0)	81 (14.0)	119 (16.7)	118 (16.6)	139 (16.9)	159 (18.8)	158 (19.7)	190 (21.2)	171 (20.0)	172 (18.3)
Pedestrian	105 (15.8)	98 (17.0)	115 (16.1)	120 (16.9)	135 (16.4)	127 (15.1)	111 (13.8)	131 (14.6)	125 (14.6)	132 (14.1)
Other road user	33 (5.0)	34 (5.9)	56 (7.8)	41 (5.8)	57 (6.9)	71 (8.4)	62 (7.7)	89 (9.9)	97 (11.3)	101 (10.8)
Direct transport to major trauma service, n (%)										
Yes	363 (54.8)	329 (56.9)	468 (65.6)	494 (69.5)	579 (70.3)	626 (74.2)	573 (71.3)	631 (70.4)	618 (72.1)	717 (76.5)
ISS group										
13–15	139 (21.0)	153 (26.5)	177 (24.8)	169 (23.8)	189 (22.9)	178 (21.1)	193 (24.0)	197 (22.0)	233 (27.2)	250 (26.7)
16–19	163 (24.6)	146 (25.2)	187 (26.2)	184 (25.9)	217 (26.3)	218 (25.8)	204 (25.4)	247 (27.6).	214 (25.0)	237 (25.3)
20–28	188 (28.3)	142 (24.6)	168 (23.5)	161 (22.6)	195 (23.7)	217 (25.7)	195 (24.2)	232 (25.9)	228 (26.6)	242 (25.8)
>28	173 (26.1)	137 (23.7)	182 (25.5)	197 (27.7)	223 (27.1)	231 (27.4)	212 (26.4)	220 (24.5)	182 (21.2)	208 (22.2)
Head injury severity score, n (%)										
AIS <3	350 (52.8)	310 (53.6)	388 (54.3)	412 (58.0)	512 (62.1)	438 (51.9)	458 (57.0)	517 (57.7)	509 (59.4)	599 (63.9)
AIS 3–4	244 (36.8)	208 (36.0)	262 (36.7)	222 (31.2)	243 (29.5)	323 (38.3)	255 (31.7)	299 (33.4)	265 (30.9)	260 (27.8)
AIS 5–6	69 (10.4)	60 (10.4)	64 (9.0)	77 (10.8)	69 (8.4)	83 (9.8)	91 (11.3)	80 (8.9)	83 (9.7)	78 (8.3)
ICU* stay, n (%)										
Yes	427 (64.9)	358 (62.3)	420 (59.1)	435 (61.4)	451 (54.9)	480 (57.0)	428 (53.2)	439 (49.1)	416 (48.7)	459 (49.1)
Hospital length of stay†										
Median (IQR)	12 (6–20)	11 (7–22)	11 (6–20)	10 (6–20)	10 (6–17)	10 (5–18)	9 (5–15)	9 (5–17)	9 (5–16)	9 (5–16)
In-hospital death, n (%)										
Yes	95 (14.3)	76 (13.2)	61 (8.5)	74 (10.4)	81 (9.8)	81 (9.6)	74 (9.2)	72 (8.0)	67 (7.8)	77 (8.2)

*Data missing for n = 20 cases.
†Data missing for n = 305 cases.

deaths (incidence rate ratio 0.95, 95% CI: 0.94–0.96; $P < 0.001$) (Fig. 1).

Risk-Adjusted In-hospital Mortality

The pattern of hospitalized road transport–related major trauma changed over time (Table 1). The mean age of injured patients increased, as did the proportion of cases with substantial comorbidities. There was no clear change in the ISS of patients, but the proportion with an intracranial injury (AIS head Injury Severity Score ≤ 2) decreased over time (Table 1). Direct transport from the scene of injury to a major trauma service increased from 55% of cases in 2001–2002 to 77% of cases in 2010–2011, whereas the proportion admitted to ICU decreased from 63% in 2001–2002 to 39% in 2010–2011 (Table 1).

The in-hospital mortality rate for major trauma cases in Victoria was 9.7%. Adjusting for key differences in case-mix over time and known predictors of mortality, there was a significant and sustained reduction in the adjusted odds of mortality after the 2002–2003 financial year (Fig. 2).

Disability-Adjusted Life Years

Of the 3505 Victorian State Trauma Registry cases eligible for follow-up from January 2008 to December 2010, EQ-5D responses were available from 3170 cases at any of the time points; 2864 at 6 months, 2935 at 12 months and 2771 at 24 months postinjury. The short- and long-term disability weights calculated from the responders to the EQ-5D at follow-up and the proportion of cases still reporting disability at 24 months postinjury are shown in Table 2. The highest disability weight, and prevalence of disability at 24 months, was for spinal cord injury (Table 2).

Over the decade, the total DALYs attributed to road transport–related serious injury in Victoria was 102,208, which resulted in a total cost of A$5.1 billion using the per capita GDP estimate of a DALY value or A$15.4 billion using the VSLY. There was a 43% reduction in YLLs and a 32% increase in YLDs. The overall result was a 28% reduction in DALYs over the decade (Table 3). The overall cost saving per case in 2010–2011 was A$209,750 (GDP per capita), or A$633,446 (VSLY), when compared with the 2001–2002 financial year (Fig. 3).

DISCUSSION

Our study investigated the burden of road transport–related trauma over a 10-year time frame using a variety of measures of mortality and morbidity. During this period, there was a significant reduction in the incidence of death and an increase in the incidence of hospitalized major trauma. There was a rapid and sustained reduction in risk-adjusted mortality for hospitalized road-related major trauma, and the overall DALY burden of serious injury fell by 28%. The estimated annual cost of health loss, based on the VSLY, decreased from $1.85 billion to $1.34 billion. The finding of a reduction in risk-adjusted mortality for hospitalized patients, and overall reductions in deaths, is indicative of the positive contribution of the trauma system to reducing road transport–related injury burden in Victoria.

Nathens et al[7] studied the association between implementation of an organized trauma system on mortality after motor vehicle crashes across all states in the United States from 1979 to 1995. These authors found a reduction in overall mortality rates after system introduction, but the effect did not appear for 10 years, suggesting that the results related to maturation of the trauma system and refinement of policies and referral patterns.[7] We observed a reduction in risk-adjusted mortality shortly after complete implementation of the system and evidence of sustained reduction since the 2003–04 financial year. A feature of the Victorian State Trauma System, which

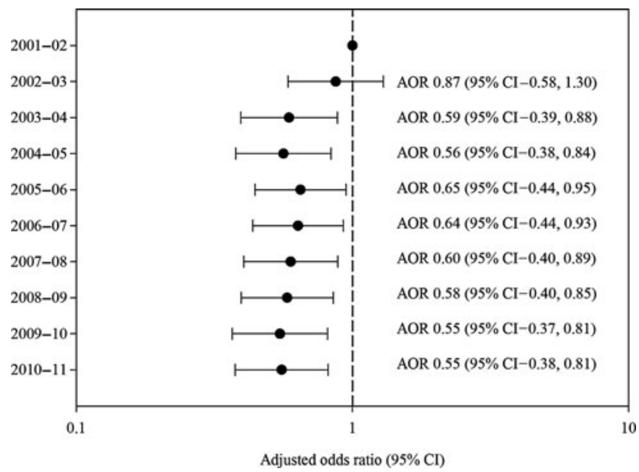

FIGURE 2. Adjusted odds of mortality for hospitalized road transport–related major trauma in Victoria (July 2001 to June 2011).

TABLE 2. Disability Weights and Duration of Disability by Injury Group (n = 3170)

Injury Group	n	Disability Weights (SE) 6 mo	12 mo	24 mo	Final Short-Term Weight	Final Long-Term Weight	% (95% CI) With Disability at 24 mo
Isolated head injury	623	0.245 (0.017)	0.238 (0.016)	0.272 (0.016)	0.257	0.272	63.8 (59.3–68.3)
Head and other region injuries	915	0.269 (0.012)	0.247 (0.012)	0.252 (0.012)	0.255	0.252	66.9 (63.5–70.2)
Spinal cord injury	108	0.644 (0.042)	0.547 (0.040)	0.550 (0.038)	0.572	0.550	93.6 (88.7–98.6)
Spinal column and/or extremity injuries only	140	0.296 (0.031)	0.250 (0.032)	0.215 (0.034)	0.244	0.215	60.7 (50.3–71.2)
Chest/abdominal injuries only	91	0.142 (0.033)	0.101 (0.036)	0.107 (0.035)	0.114	0.107	45.3 (34.1–56.6)
Chest and spinal column/extremity injuries	630	0.225 (0.014)	0.190 (0.014)	0.174 (0.014)	0.191	0.174	61.4 (57.2–65.6)
Other/multitrauma not involving neurotrauma	663	0.257 (0.014)	0.231 (0.013)	0.214 (0.013)	0.229	0.214	64.8 (60.8–68.8)

SE indicates standard error.

TABLE 3. Disability-Adjusted Life Years and Costs of Road Transport–Related Deaths and Major Trauma (July 2001 to June 2011)

	Deaths and In-Hospital Major Trauma Survivors (N)	Summary Measure									
		YLLs	YLDs	DALYs	% YLD per Case	YLD per Survivor	DALY per Case	Total Cost—GDP per Capita (million A$)	Cost per Case—GDP per Capita (A$)	Total Cost—VSLY (million A$)	Cost per Case—VSLY (million A$)
Financial Year											
2001–2002	1022	9788	2456	12,244	20.1	4.3	12.0	612.2	599,018	1849.8	1.81
2002–2003	873	8363	2116	10,479	20.2	4.2	12.0	524.0	600,206	1582.4	1.81
2003–2004	988	7182	2639	9821	26.9	4.0	9.9	491.1	497,027	1483.0	1.50
2004–2005	982	7390	2651	10,041	26.4	4.2	10.2	502.0	511,234	1516.1	1.54
2005–2006	1084	7626	2912	10,538	27.6	3.9	9.7	526.9	486,050	1591.2	1.47
2006–2007	1108	7626	3124	10,750	29.1	4.1	9.7	537.5	485,127	1623.3	1.47
2007–2008	1072	7352	2888	10,240	28.2	4.0	9.6	512.0	477,629	1546.3	1.44
2008–2009	1147	6962	3227	10,189	31.7	3.9	8.9	509.4	444,133	1538.5	1.34
2009–2010	1094	6138	2923	9061	32.3	3.7	8.3	453.1	414,133	1368.2	1.25
2010–2011	1136	5612	3233	8845	36.5	3.8	7.8	442.2	389,268	1335.5	1.18
Overall	10,506	74,039	28,169	102,208	27.6	4.0	9.7	5,110.4	486,425	15,433.3	1.47

possibly shortened the time frame for impact in effect, was the implementation of center designation concurrently with trauma triage and transfer guidelines. During the study, there was a 20% increase in patients transferred directly to a trauma center from the scene of injury. This has previously been associated with reduced mortality risk.[35]

Increased survival could, potentially, increase the nonfatal burden, as more survivors live with impaired health. However, we found that although the overall number of road transport–related major trauma patients rose over the decade and the proportion of DALYs attributed to YLDs increased, the burden per case was lower. This finding reflects the reduction in YLLs, a major contributor to DALY calculations, and a shift toward an ageing cohort of patients where life expectancy with disability is shorter. Previous studies have shown improved functional outcomes for patients managed at trauma centers,[12,13] further supporting the potential for trauma systems to reduce overall burden of injury.

The impact of the reduction in DALYs was a substantial reduction in the cost of health loss related to road transport–related trauma in Victoria, ranging from A$209,750 per case using the GDP per capita approach to A$633,446 per case using the VSLY approach. The lower GDP per capita amount is often criticized for equating the value of life with the value of production, and in the transport literature, there is a clear preference for the use of the VSLY.[36–38] The VSLY approach estimates the willingness to pay to reduce the risk of death by a known probability and extrapolates to infer the willingness to pay for a "statistical life." In principle, the approach permits the inclusion of all relevant elements of well-being in the estimated VSLY, potentially providing a better estimate of the overall reduction in burden.

Key strengths of this study were the inclusion of multiple burden measures, and the use of population-level datasets, to provide a comprehensive overview of the impact of regionalization of trauma care on injury burden in a defined trauma setting. Nevertheless, there were limitations. Trauma systems are multifaceted, involving primary, secondary, and tertiary prevention.[6] Given the observational nature of the study, attributing the gains seen to particular aspects of the trauma system was not possible. Furthermore, calculation of the disability weights involved a cohort of patients at the latter end of the study time frame. Although follow-up rates were high, the potential for biased estimates of the disability weights due to loss to follow-up remains, although a previous study showed little to no impact on annualized disability weights using different approaches to handling loss to follow-up.[26] Applying the weights to all years of the study ensured that the effect of any bias was consistent across the study time frame, but removed the potential to establish whether the disability weights changed over time. Finally, although estimates of the cost of health loss were determined using a dollar cost per DALY approach, comprehensive measures of the direct and indirect costs were not calculated.

CONCLUSIONS

Since the introduction of a regionalized, inclusive trauma system in Victoria, Australia, there has been a significant decline in the incidence of mortality, reduced risk-adjusted mortality for hospitalized road transport–related major trauma patients and an overall reduction in burden related to road transport–related injury as measured by DALYs. Although the number of hospitalized transport-related major trauma cases has increased over time, disability burden per case has declined, suggesting that an increase in lives saved does not necessarily result in an overall increase in nonfatal injury burden. The results of this study contribute to a growing evidence base that implementation of inclusive trauma systems can play an important role in reducing the population burden of road traffic injury.

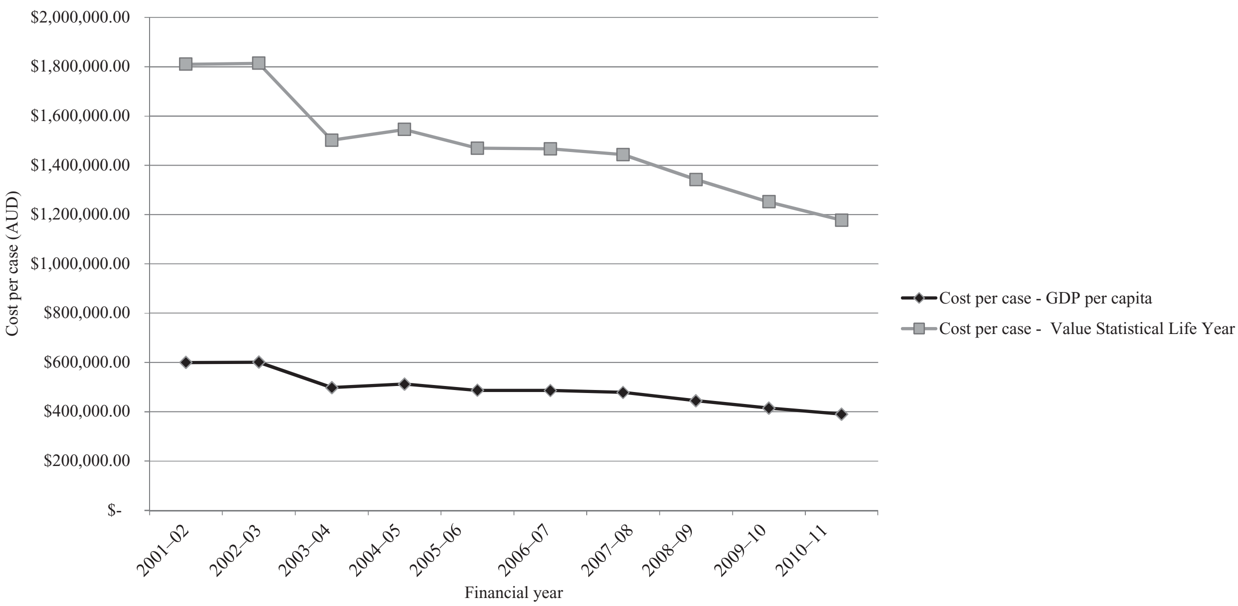

FIGURE 3. Health loss cost per road transport–related death or major trauma case (A$).

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