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A booming economy means a bursting trauma system: association between hospital admission for major injury and indicators of economic activity in a large Canadian health region



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Abstract

BACKGROUND: Injury epidemiology fluctuates with economic activity in many countries. These relationships remain unclear in Canada.

METHODS: The annual risk of admission for major injury (Injury Severity Score ≥ 12) to a high-volume, level-1 Canadian trauma center was compared with indicators of economic activity over a 16-year period using linear regression.

RESULTS: An increased risk of injured patient admissions was associated with rising mean gross domestic product (GDP [millions of chained 2002 dollars]) (.36 person increase per 100,000 population/\$1,000 increase in GDP; $P = .001$) and annual gasoline prices (.47 person increase per 100,000 population/cent increase in gasoline price; $P = .001$). Recreation-related vehicle injuries were also associated with economic affluence. The risk of trauma patient mortality with increasing mean annual GDP ($P = .72$) and gasoline prices ($P = .32$) remained unchanged.

CONCLUSION: Hospital admissions for major injury, but not trauma patient mortality, were associated with economic activity in a large Canadian health care region.

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Economic development generally leads to improvements in the health indices of a given population.^{1,2} As a result, increased population wealth would be expected to reduce the injury burden in resource-rich countries. Interestingly,

some studies have demonstrated an adverse relationship between injury rates and economic growth.^{1,2} Although conclusions of the literature as a whole are mixed, those publications examining data from developed countries such as the United States have reported that sustained economic development is associated with increased motor traffic-related crashes and injuries.^{1,2} Other studies have also reported variable associations between the rising price of automobile gasoline and both motor vehicle and motorcycle-related injuries.³⁻⁶

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Table 1 Mean age, injury severity score, and hospital and intensive care unit length of stay over the study period

Characteristic (mean)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Age (years)	41.0	41.6	40.4	42.9	42.3	42.8	42.4	42.1	42.5	43.8	46.8	44.4	45.4	46.9	47.6	48.7
ISS	22.6	22.7	23.1	22.7	22.9	22.5	22.9	23.0	22.4	22.5	22.9	22.4	22.9	22.5	23.1	22.7
Hospital LOS (d)	17.3	17.0	16.6	15.0	17.0	13.5	15.2	13.5	14.1	13.6	13.2	12.9	16.5	14.9	14.3	12.6
ICU LOS (d)	2.7	2.6	2.8	2.5	2.8	2.5	2.6	2.7	2.0	2.7	2.1	1.8	1.9	2.4	2.1	1.6

ICU = intensive care unit; ISS = Injury Severity Score; LOS = length of stay.

Although injury is the leading cause of hospitalization and principal cause of death, for individuals between 1 and 44 years in Canada,^{7,8} the relationship between injury epidemiology and economic development remains unclear in comparison to the United States. The Province of Alberta houses the busiest trauma center in Canada (Foothills Medical Centre [FMC]),⁹ and has one of the highest and most rapidly growing gross domestic products (GDPs) in the world. As a result, the dominant goal of this study was to examine the association between both trauma patient admissions and mortality in comparison with numerous indicators of economic activity in the city of Calgary, Alberta, Canada. Given that all-terrain vehicle-, fall-, and recreational sport-related injuries in our region^{7,10-13} anecdotally appear to be linked to economic affluence, the relationship between mechanisms of injury and indicators of economic development was also evaluated.

Methods

Study population and data sources

This ecological study combined aggregated, population-level data from the Alberta Trauma Registry with summary variables obtained via the Canadian Socioeconomics Database (CANSIM) from Statistics Canada (<http://www5.statcan.gc.ca/cansim/home-accueil?lang=eng>). The study population consisted of all adults

(≥ 16 years old) admitted to the FMC after major trauma (Injury Severity Score ≥ 12) during a 16-year period (1995 to 2010). The FMC is a University-affiliated, level I trauma center, which provides tertiary care services to southern Alberta, southwest British Columbia, and southeast.

Using the Alberta Trauma Registry, standard trauma admission (FMC) epidemiology and outcomes data were collected. Data obtained from CANSIM included the annual Calgary population size, as well as several yearly fiscal indicators of Alberta provincial economic activity, including mean GDP (measured in millions of chained 2002 Canadian dollars) and the mean of quarter-yearly estimates of regular, unleaded gasoline prices (measured in Canadian cents/L).

Statistical analyses

Count data were summarized as frequencies or proportions. After normalizing the annual number of major FMC trauma admissions to Calgary population size, the estimated relationship between the proportion or risk of hospital admissions for major injury and indicators of Alberta provincial economic activity (mean annual GDP and unleaded, regular gasoline prices) were examined using linear regression. We also examined the association between these same indicators and the yearly risk of trauma patient mortality among patients admitted to the FMC. We considered two-sided *P* values < .05 to represent statistical significance. All examined associations were transformed

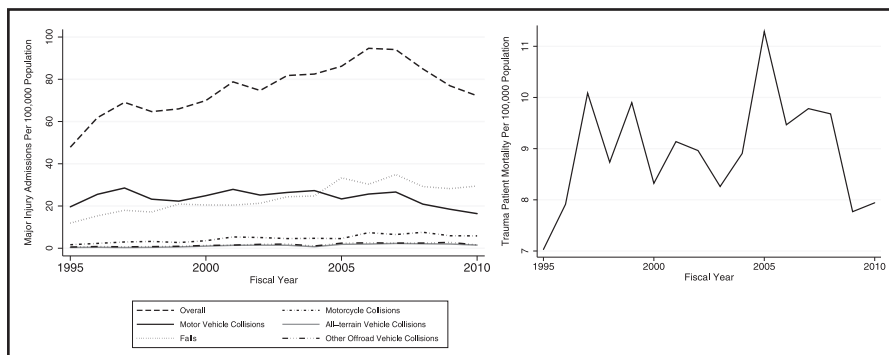


Figure 1 Changes in mean trauma patient hospitalization (left) and overall mean trauma patient mortality (right) between the fiscal years 1995 and 2010 in Alberta.

from a risk into the expected mean change in trauma patient admissions (or the expected mean change in mortality) per unit increase in the measured economic indicator (associated confidence intervals were 95% [CIs]). All statistical testing was performed using Stata/IC version 12.0 (Stata Corp, College Station, TX).

Results

Major trauma admissions and indicators of economic activity

Over the 16-year study period, among a mean population of 1.1 million people residing in Calgary (and 2.4 million in the wider FMC catchment area), 12,879 patients with severe injuries were admitted to the FMC, representing a median of 827 patients hospitalized for major injury per year. Mean yearly patient ages, Injury Severity Score, and hospital and intensive care unit lengths of stay are shown in Table 1.

An overview of the changes in mean overall and mechanism-specific trauma patient hospitalization and mortality across the study period are shown in Fig. 1. The rate of hospitalization for major injury among the population of Calgary increased from 47.8 per 100,000 in 1995 to 72.2 per 100,000 in 2010, and was mostly comprised of motor vehicle collisions and falls. Although the mean number of trauma admissions for motor vehicle collisions was higher than for falls in 1995 (19.6 per 100,000 vs 11.9 per 100,000, respectively), this relationship reversed after 2004, with fall-related admissions (29.5 per 100,000) becoming more common than motor vehicle collision admissions (16.4 per 100,000) in 2010. These changes were associated with a slightly fluctuating, but overall unchanged risk of trauma patient mortality over the study period (Fig. 1).

Changes in economic activity during the study period are shown in Fig. 2. Mean Alberta GDP (CANSIM) increased from \$122,299 (millions of chained 2002 dollars) in the fiscal 1995 year to \$187,037 in 2010. This increase was accompanied by a rise in mean Alberta gasoline prices from \$49.83 cents/L in 1995 to \$105.47 cents/L in 2010.

Association among trauma center admission, trauma patient mortality, and provincial indicators of economic activity

An increase in the occurrence of trauma center admissions for major injury was associated with a rise in both mean annual Alberta GDP (.36 person increase per 100,000 population/\$1,000 [millions of chained 2002 dollars] increase in GDP; 95% CI, .18 to .54; $P = .001$) and mean annual Alberta gasoline prices (.47 person increase per 100,000 population/cent increase/L in gasoline price; 95% CI, .24 to .70; $P = .001$) (Fig. 3). Motorcycle-, all-terrain/off-road vehicle-, recreational sport-, and fall-related injury mechanisms were each positively and significantly associated with rising mean Alberta GDP and gasoline prices (Table 2).

In contrast to injury admissions and mechanisms, mortality did not display a significant relationship with provincial indicators of economic activity over the study period (ie no change in the overall risk of mortality after major injury was observed with increasing mean annual Alberta GDP [$P = .72$] or gasoline prices [$P = .32$]).

Comments

In this ecological study comparing aggregated data from the Alberta Trauma Registry and Statistics Canada, the risk of major injury hospital admissions was positively associated with increasing mean Alberta GDP and gasoline prices. Among all injury mechanisms, motorcycle, all-terrain/off-road vehicle, recreational sports, and falls were also each positively and significantly associated with rising mean Alberta GDP and gasoline prices. Interestingly, rising mean GDP and gasoline prices were not associated with any change in the overall trauma patient mortality.

Previous investigators have reported that although traffic collisions are typically associated with rising economic growth, the relationship between economic development and traffic collision mortality depends on the developmental status of a given country.^{1,2} In low-income countries, traffic-related crashes, injuries, and deaths increase in proportion to economic growth.^{1,2} It

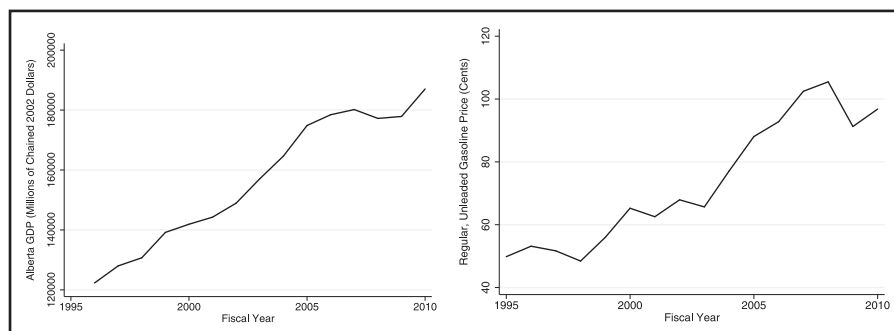


Figure 2 Changes in mean GDP (left) and regular, unleaded gasoline prices (right) between the fiscal years 1995 and 2010 in Alberta. GDP was measured in millions of Canadian chained 2002 dollars, while gasoline prices were measured in Canadian cents/L.

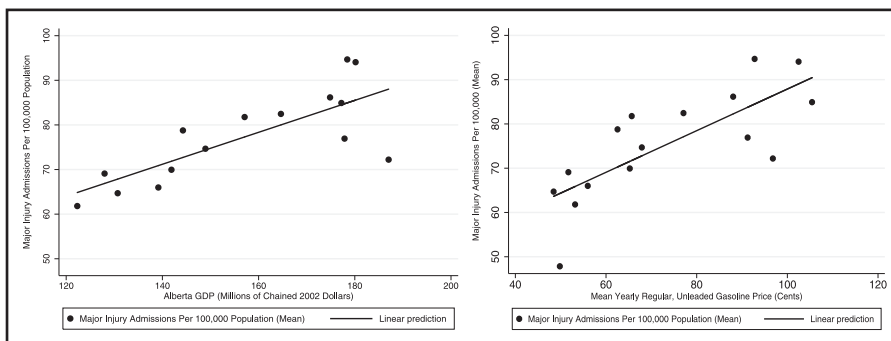


Figure 3 Association between major injury admissions per 100,000 population and mean Alberta GDP (left) and regular, unleaded gasoline prices (right) between the fiscal years 1995 and 2010 in Alberta. GDP was measured in millions of Canadian chained 2002 dollars, while gasoline prices were measured in Canadian cents/L.

has been suggested that this trend may be related to rising motor vehicle ownership and/or an associated increases in the “hazardousness” of driving.^{1,2} Among high-income countries however, traffic crashes and injuries also increase with economic growth, but mortality no longer appears linked to economic growth at a GDP threshold of approximately \$1,500 to \$8,000 per capita.^{1,2}

This paradoxical relationship between both traffic crashes and trauma patient mortality, with economic growth could potentially be explained by increased motor vehicle ownership accompanied by adaptations in the population that result in improved injury outcomes.¹ More specifically, although economic development may lead to rising motor vehicle ownership and/or an associated increase in the “hazardousness” of driving, improved trauma systems simultaneously result in enhanced patient outcomes and overall stability in trauma patient mortality.^{1,2} Although it is unknown if these concepts can be generalized to alternate (ie non-motor vehicle collision) injury mechanisms, the increasing wealth of the Alberta population may have resulted in more recreational vehicle purchases and therefore exposure hours, leading to subsequent injuries.^{1,14} Stability in the mortality rate associated with this injured group is likely reflective of the ability of the Alberta trauma system to expand and adapt in an effort to maintain superb care.

Although the precise mechanism by which rising mean Alberta GDP and gasoline prices are coupled to an increased risk of fall-, motorcycle-, and all-terrain/off-road vehicle-related injuries in this study is unknown, several additional explanations can be proposed. Our anecdotal impression is that a significant proportion of the increase in falls admitted to our center during times of economic growth may be secondary to increased demands placed upon builders, electricians, painters, and other trade workers during times of vigorous construction within our city. The observed associations between both rising GDP and gasoline prices with admissions to hospital after motorcycle mechanisms are also interesting. This increase in collisions could potentially be because of an increased number of riders using motorcycles during times of high gasoline prices,^{5,15} combined with increased disposable funds associated with rising GDP for high-income earners. More specifically, increased motorcycle usage is uniquely and concurrently responsive to both ends of an economic spectrum (low-income earners are subject to fluctuations in the price of gasoline with regard to their ability to afford larger motor-vehicle costs, and high-income earners clearly have more disposable money to purchase “toys” during periods of economic growth). Although the transition from motor vehicle to motorcycle usage for transportation has been shown to

Table 2 Association between trauma patient admission and provincial indicators of economic activity

Mechanism	Mean change/100,000 population per 1,000 increase in GDP*			Mean change/100,000 population per cent increase in gasoline price		
	Estimated mean change [†]	95% CI of the mean change	P value	Estimated mean change [†]	95% CI of the mean change	P value
All-terrain vehicle	.026	.017-.036	<.001	.031	.022-.040	<.001
Falls	.26	.21-.32	<.001	.31	.23-.38	<.001
Motor cycle collision	.065	.041-.088	<.001	.079	.056-.10	<.001
Motor vehicle collision	-.076	-.16-.0080	.073	-.053	-.15-.044	.259
Other off-road vehicles	.028	.016-.039	<.001	.032	.021-.044	<.001

GDP = gross domestic product.
 *GDP measured in millions of chained 2002 Canadian dollars.
[†]May be interpreted as the estimated mean change in the number of trauma patient admissions per 100,000 population per 1,000 increase in GDP or per cent increase in regular, unleaded gasoline price.

potentially result in a demographic shift,⁵ it is unclear how this impacts our study population. Similar to motorcycles, the rationale for the observed increases in all-terrain vehicle injuries concurrent with rising economic growth is related to the belief that economic affluence leads to more disposable time and income for “toy-related” mechanisms. In a geographically open and rugged province such as Alberta, we believe that this is a pattern particularly sensitive to all-terrain and off-road recreational vehicles.

Our study has several limitations. First, as a result of the aggregated or ecological nature of the data, our results can only be interpreted as associations on a population level and therefore not causative at the individual level. Second, although we adjusted the growth in Calgary population size with time, our analyses otherwise constituted simple pairwise comparisons, and therefore were unadjusted for other potential confounding factors that could explain our observations. Third, our data set was unable to account for the possibility that the observed relationships were because of maturation (ie factors associated with the passage of time, such as a gradual increase in trauma admissions and economic activity over time).

Conclusions

In this ecological study, the overall rate of trauma patient admissions was positively associated with increasing mean GDP and gasoline prices. Among the mechanisms responsible for admission to hospital, motorcycle, all-terrain/off-road vehicle, recreational sports, and falls were positively and significantly associated with rising mean Alberta GDP and gasoline prices. To our knowledge, this is the first investigation to demonstrate that off-road vehicle-related injuries are associated with economic affluence (ie “toy-related” mechanisms). Although rising mean GDP and gasoline prices were positively associated with an increased risk of major injury admissions, they were simultaneously associated with an unchanged risk of overall trauma patient mortality. This may relate to improvements in regional trauma care/trauma systems or potentially to changes in population driver characteristics.

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Discussion

Robert Rush, M.D.: The authors describe the increasing incidence of a disease (trauma) with increasing or improving socio-economic status, which to me seems to be a conundrum – or, an intricate and difficult problem or logical postulation that evades resolution. They suggest that as we gain affluence, we purposely expose ourselves to more risk. Why? For the fun? For the thrill? As part of our mission to be better citizens? Human nature? However, as the authors point out, we have seen this before in other regions of the world. I suppose that increasing wealth does not make us any smarter when it comes to fun and risk exposure.

As a society we develop mechanisms for hurting ourselves in advance of developing mechanisms and strategies for keeping us safe. Or so it appears. Putting money into prevention is seemingly more expensive and less fun than going out and throwing ourselves down an Olympic ski run or riding perilously through the beautiful and rugged terrain of Western Canada on an All-Terrain Vehicle (ATV). Maybe with this study improving injury prevention strategies can receive more attention, especially if there is money to pay for the interventions from the economic boom described herein. With the increasing costs of medicine, we must continue to take on this responsibility as a society – disease and injury prevention – and reward for it! It would be interesting to correlate these statistics with the Foothills Medical Center's budget for the care of the injured patient. Assuming the patient population of Calgary increased similarly over this period,

one would assume the tax base also went up and I wonder how much of the piece of this surplus revenue the hospital received and how much was put into injury prevention programs – or maybe that would be the argument to your city and provincial governments that you need more now that this study has been completed. Or perhaps, due to the exceptional care of these patients demonstrated by similar

or improved mortality and decreased length of stay despite a marked increase in admissions, they will conclude that you can do more with less – as that is certainly what the US government is telling us lately under the sequestration military medicine is going through as we speak. I certainly think this exceptional study argues for the former.