Quantifying the Iceberg Effect for Injury

Using Comprehensive Community Health Data

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ABSTRACT

Background: Injury is the leading cause of preventable morbidity and mortality in Canada. The "iceberg" effect in injuries was proposed to address the injury statistics that are often poorly documented. The aim of this investigation was to quantify the severity and magnitude of iceberg effect in Ontario, Canada.

Methods: Data from Vital Statistics (1999, mortality), Canadian Institute for Health Information (2001, hospitalizations), Census (2001, demographic information), National Ambulatory Care Reporting System (2001, emergency department visits), and the Canadian Community Health Survey (2000/01, other injuries) were used to construct the Ontario injury iceberg for ages 12 years and older.

Results: There were 79,577 fatalities in Ontario in 1999; 2,645 were attributable to injuries (crude rate: 2.3 per 10,000). Of the 913,540 hospitalizations (2001), 67,301 were caused by injuries. There were 3,520,253 emergency department (ED) visits (2001) and 959,278 were attributable to injuries. For injuries treated elsewhere, the most common treatment site was the physician's office (23.3%). The most common cause of injuries (CCHS) was falls (37.4%) and exertion/movement (20.5%). There were 1,928,000 injuries causing functional impairment (one injury to five individuals in the population).

Interpretation: The high ratio of injury-related ED visits to deaths illustrated the high volume of injuries that present to the ED. The ratio of injuries resulting in functional impairment to the population demonstrates that such injuries can be problematic, even if not resulting in hospitalization. Constructing the injury iceberg using valid data should assist researchers and decision-makers in priority setting.

MeSH terms: Wounds and injuries; health services; public health; accidents

La traduction du résumé se trouve à la fin de l'article.

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Injury is a significant health concern and numbers have reached considerable levels.[1] Injuries are an important cause of overall mortality and the primary cause of death among those aged 40 and under.[2] In Canada, injury is also the leading cause of Potential Years of Life Lost (PYLL). In Ontario, injury is the leading cause of PYLL for males and the third leading cause for females,[3] accounting for 98,783 Potential Years of Life Lost in 1999.[2]

The economic consequences of injuries are similarly overwhelming. The estimated total economic cost of injury in 1998 was estimated to be $12.7 billion (8% of the total economic burden of illness in Canada.)[4] Also, minor injuries can represent a major public health issue.[5] Traditionally, injuries have been viewed as 'accidents'[6,7] and there has been historical neglect of injury as a public health issue.[4] This study examined and illustrated the phenomenon of the injury pyramid.

Injury pyramid: Iceberg effect

Canadian epidemiologist John Last proposed the iceberg effect in 1963,[8] suggesting that detected injuries are the "tip of the iceberg". For example, the "tip" represents deaths and hospitalizations, which are well documented. The largest part remains unseen ("submerged"). The first component of poorly understood less severe cases comprise injuries that are medically attended in emergency departments (ED) or elsewhere. These injuries may be severe enough to warrant hospitalization, thus admission databases or trauma registries (in severe cases) would capture them; however, a large proportion (90%) are assessed, treated and discharged from the ED or other acute care settings. Patients whose injuries are considered "minor" can be assessed and treated in a variety of locations, including physician's offices and clinics. Non-physicians (e.g., physiotherapists, chiropractors, etc.) also primarily assess and treat injured patients. Clearly, to understand injury, access to more than just mortality and admission data is required.

While mortality and admission data are well documented, in Canada, other locations for injury assessment are poorly recorded. For example, Canadian ED visits are neither uniformly coded nor catalogued. The recent development of the National Ambulatory Care Reporting

TABLE I
Data Sources

Data Source	Information	Year	Description
Vital Statistics, drawn from Provincial Health Planning Database (PHPDB)*	Mortality	1999	Based on all death records
Discharge Abstract Database, produced by Canadian Institute for Health Information (CIHI), drawn from PHPDB	Hospitalizations	2001	All hospitalization records are collected and coded uniformly by CIHI
National Ambulatory Care Reporting System: Discharge Abstract Database, produced by Canadian Institute for Health Information (CIHI), data drawn from PHPDB	Emergency Room/ Ambulatory Care visits	2001	All visits collected and coded uniformly by CIHI
Canadian Community Health Survey (CCHS)	Less severe injuries resulting in functional impairment	2001	Population-based survey, weighted to represent the total Ontario population (detail concerning weighting can be found elsewhere).† A total of 39,000 individual responses were surveyed in Ontario and represented a population of 9.7 million (ages 12+)

* Queen's Printer for Ontario. Provincial Health Planning Database. Health Planning Branch, Ontario Ministry of Health and Long-Term Care. 2000, 2001.
† Statistics Canada. Canadian Community Health Survey, Cycle 1.1. www.statscan.ca/english/concepts/health/cchsinfo.htm. Accessed February 12, 2004.

System (NACRS) is a positive step toward universal ED data collection; however, this database is currently predominantly Ontario-based. In addition, visits to non-hospital-based locations are not routinely collected and catalogued.

Minor injuries seen during clinic visits are not coded at all, except for billing purposes. Injuries that are seen by non-physicians and those which are not medically attended, are also not well identified in any known database.[7] More severe injuries are less numerous, but require more medical attention. Evidently, information is known about the most severe aspects of injuries (death and hospitalization); however, little is known about the most severe, but potentially disabling injuries.

The injury pyramid evolved to illustrate the distribution of injury mortality and morbidity (Figure 1). Most injuries are minor and can be treated without medical attention (represented at the pyramid base). Information regarding this section is difficult to obtain.

The aim of the paper was to quantify the magnitude of injuries in Ontario, Canada using known databases supplemented with comprehensive, population-based survey data. The intention was to quantify the injury pyramid for decision-makers by determining the magnitude, scope and characteristics of the injury problem to facilitate informed, evidence-based decision-making. The top of the pyramid is comprised of mortality, hospitalizations and ED visits, which arise from data sources that are highly robust. The pyramid base is composed of population-based survey data, which have a lower strength of evidence relating to the limitations of survey data as compared to vital statistics and hospital records.

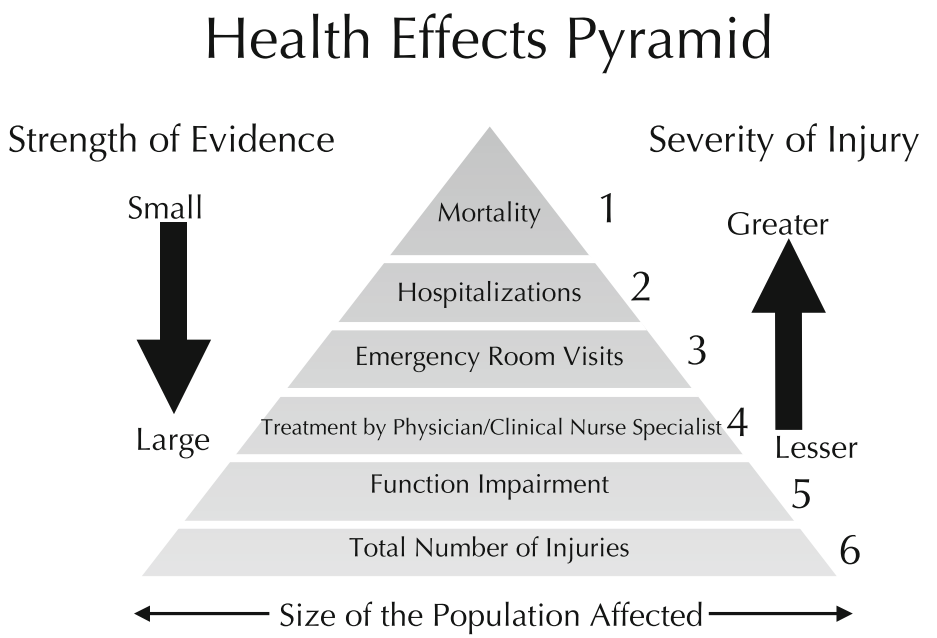

Figure 1. Injury pyramid and public health

METHOD

Data sources

Mortality and hospital data are readily available; however, for complete estimation of the injury pyramid, a population survey was used. The most recent data from the following data sources have been used.

Data selection

The etiology of injury was analyzed using ICD-9 codes 800 to 999; however, poisonings were omitted (960-989).[9] The advent of ICD-10 (mortality data starting in 2000 and hospitalization data starting in 2002) posed a considerable challenge in the analysis of data from differing years. There are marked differences between the ICD-9 and ICD-10 coding systems. Specifically, ICD-10 is significantly more complex, which leads to difficulty when comparing statistics between both systems. Thus, only ICD-9 coded data were used and to conform to the Canadian Community Health Survey (CCHS) data, only individuals age 12 and over were included in all analyses. Also, injuries from the CCHS were defined as those resulting in functional impairment, thus an injury sufficiently serious to limit normal activities.

RESULTS

The occurrences of injury mortality, hospitalizations and ED visits are summarized below. Other sites of injury treatment, frequencies of functional impairment and

TABLE II

Injury Type and Relative Frequency (CCHS, 2000/01)*

Injury Type	Frequency	Percent of Total (%)	Percent of Injuries (%)
Fall	486,600	4.9	37.4
Exertion/Move	266,400	2.7	20.5
Sharp Object	119,300	1.2	9.2
Struck/Crushed	114,400	1.2	8.8
Bumped/Pushed	93,400	1.0	7.2
Transport Accident	84,300	0.9	6.5
Hot Object	27,600	0.3	2.1
Physical Assault	17,000	0.2	1.3
Smoke/Fire/Flames	4800	0.1	0.4
Extreme Weather	3000	0.03	0.2
Other	83,400	0.9	6.4
Not Applicable	8,565,400	86.8	
Total	9,865,600	100.0	100.0

* Guidelines for public release of data from the CCHS state that all estimates must be rounded to the nearest 100, thus numbers have been rounded accordingly.

TABLE III

Injury Treatment Site (CCHS, 2000/01)*

Treatment Site	Frequency	Percent Contribution (%)
Emergency Room	483,300	58.0
Physician's Office	192,200	23.3
Walk-in Clinic	75,400	9.2
Outpatient Clinic	25,200	3.1
At Home	11,300	1.4
Appointment Clinic	11,100	1.4
At Work	11,000	1.3
At School	5700	0.7
Community Health Centre	1600	0.2
Telephone Consultation	1400	0.2
Other	25,500	3.1
Total Injuries Treated	824,100	100.0

* Guidelines for public release of data from the CCHS state that all estimates must be rounded to the nearest 100, thus numbers have been rounded accordingly.

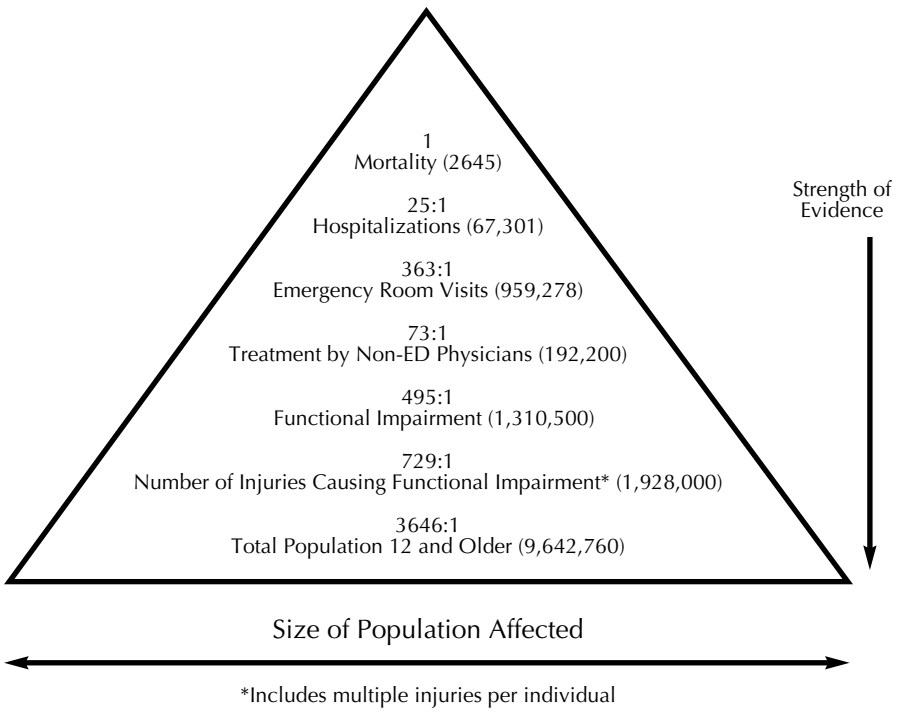

Figure 2. Injury pyramid and public health: The ratio of deaths to selected measures of injury severity

number of injuries causing functional impairment (including multiple injuries per individual) have also been presented.

Mortality (1999): There were 79,577 fatalities; 2,645 (3%) of these fatalities were directly attributable to injuries (Crude Rate: 2.3 per 10,000).

Hospitalizations (2001): There were 913,540 hospitalizations; 67,301 (7%) of these hospitalizations were directly attributable to injuries (Crude Rate: 736 per 10,000).

Emergency department visits (2001): There were 3,520,253 ED visits; 959,278 (27%) of these were attributed to injuries (Crude Rate: 2,725 per 10,000).

Injuries treated elsewhere: Overall, 192,200 injuries were treated by physicians in 2001. The most common cause of injury as reported in the CCHS was falls (37.4%), followed by exertion or movement (20.5%) (see Table II). Injuries were also examined by treatment site (excluding hospitalization). The most frequently cited treatment site was ED (58.6%) and physician's office (23.3%) (Table III). The data provided through the CCHS differ significantly as compared to the NACRS information, and suggest that the CCHS under-reports emergency visits.

Functional impairment: It is estimated that 1,310,500 individuals (13.3%) had an injury that caused activity limitations. This total incorporates the total number of individuals who were injured.

Total number of injuries: There were a total of 1,928,000 injuries that resulted in functional impairment. This total incorporates multiple injuries per individual.

DISCUSSION

These results suggest that acute injuries are most commonly (59%) seen and assessed in EDs. Another important source of injury care is the physician's clinic (23%); however, no administrative databases exist to collect data in this setting except billing records. Injuries are less commonly seen in other settings, such as walk-in clinics. Findings are somewhat surprising, suggest-

ing that patients self-select EDs for injury care and less frequently select other alternatives such as walk-in and outpatient clinics. Moreover, evidence here suggests patients do not consider telephone consultations in health-care delivery (e.g., Telehealth Ontario) an important option when injured. Finally, these data suggest ED-based injury surveillance would be an appropriate measure of injury phenomenon in Ontario.

As measured by the CCHS, the most common cause of non-fatal injuries includes falls (37%) and exertion (20%), illustrating the minor nature of many injuries. It is interesting to note that transport injuries, which are generally more severe in nature, only account for 6% of non-fatal injuries. Moreover, recent literature suggests that suicide and motor vehicle/non-traffic crashes were the leading cause of PYLL in 1999.[10] Thus, the impact of suicide and motor vehicle collisions, noted primarily by hospitalizations and mortality, would not be fully captured by a population-based survey. Finally, the less violent nature of injuries in Canada is reflected by the low assault injury incidence (1%). Although several studies have evaluated the prevalent causes of injuries presenting in EDs (falls, being struck by an object, and motor vehicle collisions),[11,12] the paucity of research on injury causes that do not present to the ED makes comparisons difficult. Although the CCHS is the most inclusive, population-based source of health behaviour data currently available, it must be considered in light of inherent limitations.*

Examination of the injury pyramid is quite revealing. The ratio of hospitalizations to mortality of 25:1 emphasizes that fatal injuries are relatively common among serious injuries. The high ratio of injury-related ED visits to deaths illustrates the volume of visits that result from injury in the ED (363:1); however, the decreased ratio between those seen by non-ED physicians and ED visits suggests that these events largely present to the ED.

A similar study involving injuries (1996-1998) reported 1 death for every 10 hospitalizations and 147 ED visits. Thus, the data reported here (1 death per 25 admissions and 363 ED visits) illustrate a somewhat flattened injury pyramid as compared to a similar USA model.[13] This difference may be due to a variety of factors including serious injuries arising from penetrating trauma and assault in the USA. For example, it has been suggested that firearms-related mortality might surpass motor vehicle collisions-related mortality, possibly reflecting the lack of firearms injury prevention as compared with vehicular collision prevention.[14] Other factors affecting injury severity include seat-belt use and bicycle helmet use.[15,16]

These results have also highlighted the high frequency of injuries that cause functional impairment (1,928,000). Considering this number relative to the provincial population (12+, 9,642,760), this translates to a crude approximation of one (functionally impairing) injury for every five people. It is apparent that action-limiting injuries are relatively common in Ontario. There is a noted burden on the health care system from intentional and non-intentional injuries. Prevention of such injuries can help lessen the burden on the health care system and society.

The presented data demonstrate the depth of the injury pyramid. This also has significant implications for the primary care setting where the patient may require several visits and ongoing care. First, information *must* be accurately transmitted to the primary care provider in order to follow up injuries seen in the ED. Second, these data need to be acted upon in the primary care setting where injury prevention strategies throughout the life cycle must be developed and promoted. Finally, ED and primary care providers will be able to use these data to promote advocacy as it relates to education, legislation, and technologies to prevent and minimize the severity of injuries. Specifically, prevention of repeat occurrences in susceptible individuals could be beneficial. For example, the need to target poisoning prevention in children visiting ED has recently been cited to prevent repeat occurrences.[17] Prevention of falls, which can also lead to hospitalization and activity restriction, is a further illustration of the need for injury prevention in primary care.[18]

Lost productivity from injuries is a major reason for concern. Recent literature suggests that occupational injuries in the USA resulted in an estimated $145 billion in direct and indirect costs in 1992.[19] Another study noted the cost of motor vehicle collisions to be 1.4% of the gross national product.[20] Therefore, considering the cost of injuries and the fact that little research has analyzed their full extent, an accurate picture of the full spectrum of injuries is vital.

Limitations and suggestions for future research

Data for those less than 12 years old were excluded. Given the importance of injury as a health issue in ages 0-12,[21] we recognize that results under-represent the full effects of injury burden. Data were also obtained through a number of sources, thus differing years of data sources were used (mortality, 1999; hospitalization data, CCHS and NACRS, 2001); however, selected years were as close as possible. With regards to the ED visits, these data were somewhat incomplete. A small collection of Ontario EDs (9 of 168) failed to submit data for 2001, while others only submitted partial data; however, the *majority* (95%) of hospitals reported their ED data.

Also, the CCHS did not include homeless people, people living in institutions or living on reserves; these groups tend to be over-represented in injury data.[22,23] Injury frequency may also be underestimated because when estimating treatment location frequency and injury cause, participants were surveyed in reference to their most serious injury only. The total number of injuries, however (using the CCHS), considers multiple visits. In contrast, hospitalization or ED data include multiple visits resulting in comparatively higher number of visits.

CONCLUSION

Notwithstanding the limitations of the current data, this is the first comprehensive examination of the injury pyramid in a Canadian regional setting. It provides detailed information on the iceberg effect in injuries and provides valid information for regional injury prevention planning, provincial comparisons, and an illustration for similar analyses nationally. Also, further attention should be paid to capturing data

* For a detailed description of the methodologies of the CCHS, the reader is referred directly to Statistics Canada, CCHS Cycle 1.1 http:// www.statscan.ca/english/concepts/health/cchsinfo.htm.

for minor, but functionally impairing, injuries.

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RÉSUMÉ

Contexte : Les blessures corporelles constituent la principale cause de morbidité et de mortalité au Canada. On a proposé la théorie de l'effet « iceberg » pour mieux comprendre les données statistiques relatives aux blessures, souvent peu documentées. Cette étude vise à quantifier la gravité et l'importance de l'effet iceberg dans la province de l'Ontario, au Canada.

Méthodes : Les statistiques de l'état civil (1999, mortalité), de l'Institut canadien d'information sur la santé (2001, hospitalisations), et du recensement (2001, données démographiques), du Système national d'information sur les soins ambulatoires (2001, nombre de visites aux services d'urgence) et de l'Enquête sur la santé dans les collectivités canadiennes (ESCC) (2000-2001, autres blessures) ont servi à la construction de l'effet iceberg en Ontario, pour les personnes de 12 ans et plus.

Résultats : En 1999, on a signalé 79 577 décès en Ontario, dont 2 645 attribuables à des blessures (taux brut : 2,3 pour 10 000). Des 913 540 hospitalisations relevées (2001), 67 301 étaient attribuables à des blessures. De même, des 3 520 253 visites des services d'urgence (SU) (2001), 959 278 étaient dues à des blessures. Les blessures qui ne sont pas traitées dans les services d'urgence l'étaient de façon prédominante dans un cabinet de médecin (23,3 %). Les chutes représentaient la principale cause de blessures (ESCC) (37,4 %), suivie de la fatigue et des mouvements (20,5 %). On constate que 1 928 000 blessures ont entraîné une invalidité fonctionnelle (dans la population, une personne sur cinq a subi des blessures).

Interprétation : Le taux élevé de visites aux services d'urgence pour cause de blessures et de mortalité témoignent du nombre important de blessures traitées par les services d'urgence. Le taux de blessures entraînant des invalidités fonctionnelles permet de conclure que les blessures peuvent poser problème et ce, même si elles ne donnent pas lieu à une hospitalisation. La construction de l'effet iceberg, à l'aide de données valides, devrait aider les chercheurs et les décideurs dans l'établissement des priorités.