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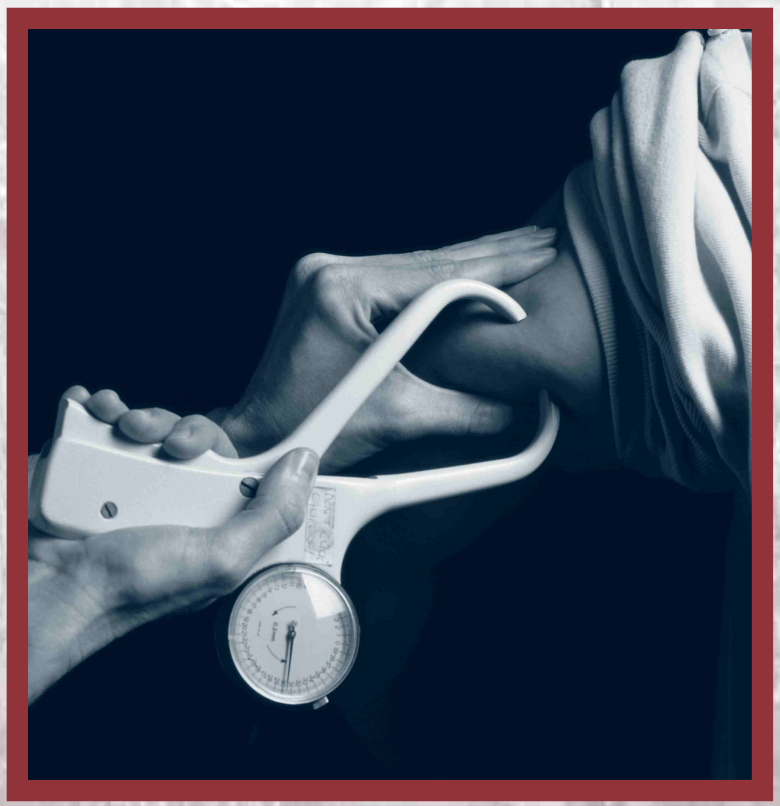

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Sudden infant death syndrome in Canada: Trends in rates and risk factors, 1985–1998

ID Rusen, Shiliang Liu, Reg Sauve, KS Joseph and Michael S Kramer

Abstract

In Canada, sudden infant death syndrome (SIDS) remains the leading cause of postneonatal death. However, SIDS rates have been declining in many countries, including Canada. This decline has been largely attributed to recommendations to avoid placing infants to sleep in the prone position. We examined the postneonatal rate of mortality due to SIDS and to other causes in relation to the initial risk reduction campaign. The postneonatal mortality rate due to SIDS decreased from 0.97 to 0.54 per 1,000 neonatal survivors between 1985–1989 and 1994–1998 (relative risk [RR] = 0.56, 95% confidence interval [CI] 0.51–0.62). The rate of postneonatal mortality due to other causes also decreased during the same period, though to a smaller extent, from 1.19 to 0.86 (RR = 0.72, 95% CI 0.66–0.78). With the exception of seasonality, established risk factors for SIDS remained essentially unchanged between the two time periods. The observed reduction in postneonatal SIDS is consistent with a positive impact of the initial recommendations regarding risk reduction. However, the lack of reliable risk factor data limits the extent to which the decline can be attributed directly to the campaign.

Key words: *postneonatal mortality; sleep position; sudden infant death syndrome*

Introduction

Sudden infant death syndrome (SIDS) is the leading cause of postneonatal mortality in Canada.[1] In 1999, 144 or 26% of all postneonatal deaths were caused by SIDS.[1] However, the incidence of this syndrome has declined markedly in Canada and many other parts of the world.[2] This decline has been largely attributed to recommendations made in the early 1990s against placing infants to sleep in the prone position.[2] In 1993, Health Canada, the Canadian Paediatric Society, the Canadian Foundation for the Study of Infant Deaths and the Canadian Institute for Child Health released their first joint statement on reducing the risk of SIDS.[3] The rate of decline in the Canadian SIDS rate has not been reported in relation to the recommendations and in comparison with rates of infant death due to other causes. Similarly, the consistency of this decline across Canadian provinces and territories has not been examined. Finally, various demographic, perinatal and other factors have been previously associated with an increased risk of SIDS in Canada.[4] The relevance of these risk factors may have changed following adoption of the sleep position recommendations.

The purpose of this study was to examine trends in Canadian, provincial and territorial SIDS rates, as well as changes in the importance of various factors known to be associated with an increased risk of SIDS.

Methods

We used data on all live births from Statistics Canada's live birth database for the years 1985 to 1998 and data from the mortality database for 1985 to 1999. Information in these databases was obtained from birth and death registrations supplied by Canadian provincial and territorial registries of vital statistics.[5] A probabilistic linkage was carried out using previously validated methods to link infant deaths to their respective birth registrations.[6] Uncertain linkages were resolved after manual examination of the relevant birth and death registration documents. Infant deaths for which a birth record could not be found were noted as "unlinked deaths" and retained in the analysis.

Births to mothers residing in Ontario were excluded because of documented problems with data quality[7] and large numbers of unlinked infant deaths. Births to mothers residing in Newfoundland were also excluded, because data from that province were not available at the national level prior to 1991.

The computerized files of Canadian infant death registrations list one underlying cause of infant death. In this study, postneonatal deaths were categorized as being due to SIDS (International Classification of Diseases, Ninth Revision [ICD-9] code 798.0) versus other causes of postneonatal death combined. Limiting the analysis to the postneonatal period (28–364 days of life) captured over 90% of SIDS deaths in Canada while eliminating the uncertain diagnosis of SIDS in the neonatal period.

Author References

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To accurately assess the impact of sleep position recommendations, the appropriate comparison or control group would be postneonatal deaths due to causes with no known intervention during the study period. Previous analysis has demonstrated a marked decrease in infant deaths due to congenital anomalies during the period of interest, likely due to increasing use of prenatal diagnosis and termination of affected pregnancies.[8] Congenital anomalies (ICD-9 codes 740–759) were therefore excluded from the "other causes of death" group.

Traditionally, postneonatal mortality rates are calculated as ratios by dividing the number of postneonatal deaths in a calendar year by the number of live births in the same (index) year. The postneonatal rates of mortality due to SIDS and due to other causes described in this study are based on birth cohorts and represent the proportion of infants who died in the postneonatal period among neonatal survivors in the year of interest. This cohort approach enabled the linkage of postneonatal deaths to risk factors of interest, such as maternal age and gestational age. However, this change in the method of computing postneonatal mortality means that the temporal patterns presented in this study may differ slightly from those reported elsewhere.

We examined the change in the postneonatal mortality rates due to SIDS and due to other causes between two time periods (1985–89 and 1994–98), selected to capture the periods before and after the release of the first Canadian joint statement on reducing the risk of SIDS. In addition to changes in national rates, we calculated changes in the provincial and territorial postneonatal SIDS rates. The significance of temporal changes was estimated using relative risks (RRs) and 95% confidence intervals (CIs).

We examined the population distribution of established demographic and perinatal risk factors for SIDS in the two time periods. The risk factors examined were limited to those available in the Canadian Birth Database. The distribution of these demographic and perinatal characteristics in each time period as well as the percentage change (and 95% CI) between 1985–1989 and 1994–1998 were calculated. We also examined potential changes in the significance of these risk factors for SIDS over the two periods. Both crude and adjusted (using full, unconditional logistic regression model) odds ratios were estimated for postneonatal deaths due to SIDS for each period. (Odds ratios obtained from logistic regression models were interpreted as relative risks as the rare disease assumption was satisfied.) Subsequently, again using logistic regression models, we examined the time period effect on postneonatal SIDS rates sequentially adjusted for key demographic and perinatal risk factors.

Finally, using the Canadian Mortality Database, we examined the proportion of all postneonatal SIDS deaths that occurred in each season (January–March, April–June, July–September, October–December) in the period before and after release of the first joint statement. Chi-square tests were used to determine the statistical significance of seasonal predominance in each of the two periods.

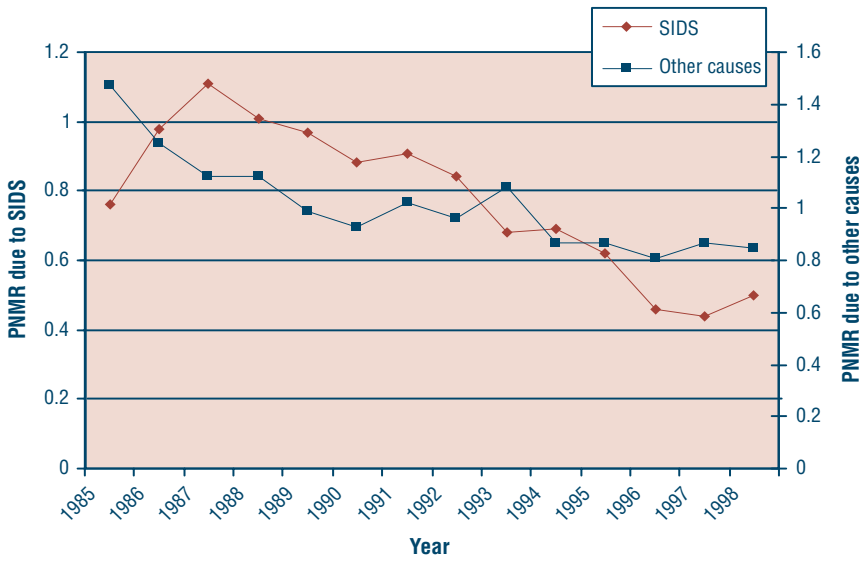
All analyses were carried out using SAS PC version 8 statistical software (SAS Institute, Cary, North Carolina).

Results

During the period 1985–1998, the Canadian postneonatal mortality rate due to SIDS and due to other causes decreased (Figure 1). Between 1985–1989 and 1994–1998, the postneonatal mortality rate due to SIDS decreased markedly from 0.97 to 0.54 per 1,000 neonatal survivors: RR = 0.56 (95% CI 0.51–0.62). The postneonatal mortality rate due to other causes decreased by a smaller magnitude during the same period, from 1.19 to 0.86: RR 0.72 (95% CI 0.66–0.78).

Examination of provincial and territorial postneonatal mortality due to SIDS revealed wide variation of rates in both periods (Table 1). In 1985–1989, Quebec had the lowest postneonatal SIDS rate at 0.47 (95% CI 0.41–0.55), and the Northwest Territories had the highest rate at 2.16 (95% CI 1.24–3.51). In 1994–1998, Quebec and British Columbia had the lowest postneonatal SIDS rates at 0.38 (95% CI 0.32–0.44) and 0.41 (95% CI 0.33–0.50) respectively. Yukon and the Northwest Territories had the highest rates in 1994–1998 at 2.26 (95% CI 0.73–5.26) and 2.18 (95% CI 1.24–3.53) respectively. Most provinces and territories experienced a decline in the

FIGURE 1
Postneonatal mortality rate (PNMR) per 1,000 neonatal survivors due to SIDS and other causes (excluding SIDS and congenital anomalies) in Canada (excluding Newfoundland and Ontario), 1985–1998



Note: Different scales have been used for PNMR due to SIDS and due to other causes to depict the divergent trends over time.

TABLE 1
Trends in postneonatal SIDS deaths per 1,000 neonatal survivors, provinces and territories, Canada (excluding Newfoundland and Ontario), between 1985–1989 and 1994–1998

	1985–1989		1994–1998		
	Postneonatal SIDS deaths	Postneonatal SIDS rate (95% CI*)	Postneonatal SIDS deaths	Postneonatal SIDS rate (95% CI*)	Relative risk of postneonatal death due to SIDS between 1985–1989 and 1994–1998 (95% CI*)
P.E.I.	8	0.82 (0.35–1.62)	4	0.49 (0.13–1.25)	0.59 (0.18–1.97)
Nova Scotia	72	1.18 (0.92–1.48)	25	0.48 (0.31–0.71)	0.41 (0.26–0.65)
New Brunswick	45	0.93 (0.68–1.24)	26	0.63 (0.41–0.92)	0.68 (0.42–1.10)
Quebec	200	0.47 (0.41–0.55)	157	0.38 (0.32–0.44)	0.80 (0.65–0.98)
Manitoba	63	0.74 (0.57–0.95)	50	0.65 (0.48–0.86)	0.86 (0.60–1.25)
Saskatchewan	94	1.10 (0.89–1.34)	61	0.92 (0.71–1.19)	0.84 (0.61–1.16)
Alberta	291	1.36 (1.21–1.53)	153	0.80 (0.68–0.94)	0.59 (0.49–0.72)
BC	318	1.50 (1.34–1.67)	93	0.41 (0.33–0.50)	0.27 (0.22–0.35)
Yukon	3	1.25 (0.26–3.63)	5	2.26 (0.73–5.26)	1.81 (0.43–7.57)
NWT	16	2.16 (1.24–3.51)	16	2.18 (1.24–3.53)	1.01(0.50–2.01)
Canada	1110	0.97 (0.91–1.03)	590	0.54 (0.50–0.59)	0.56 (0.51–0.62)

*CI – confidence interval

postneonatal SIDS rate between 1985–1989 and 1994–1998. However, the extent of the observed decline varied considerably (Table 1); the greatest decline was observed in British Columbia: RR 0.27 (95% CI 0.22–0.35). No province or territory experienced a statistically significant increase in postneonatal mortality due to SIDS between 1985–1989 and 1994–1998.

Examination of the population distribution of key demographic and perinatal risk factors for SIDS revealed some changes over the two periods (Table 2). The proportion of postneonatal survivors with very young maternal and paternal ages as well as advanced maternal and paternal ages increased. There were increases in the proportions of very preterm and preterm births, as well as increases in both the proportion of very low birth weight babies and babies weighing greater than 4,000 grams. Examination of the significance of these risk factors for SIDS demonstrated no change in the associations with specific risk factors after the release of the first Canadian joint statement. In the period 1985–1989, young maternal age, young paternal age, male sex, preterm birth, low birth weight and increasing parity were all associated with an increased risk of SIDS in the postneonatal period. In the period immediately after the release of the joint statement, these factors remained associated with an increased risk of SIDS (Table 3). As demonstrated in Table 4, adjusting for several key demographic and perinatal risk factors had minimal impact on the time period effect on postneonatal SIDS rates.

Examination of the proportion of postneonatal SIDS deaths that occurred in each season revealed a significant seasonal pattern present only in the period before the release of the 1993 joint statement. Between 1985 and 1989, 29.4% of all postneonatal SIDS deaths occurred during January–March, as compared with 25.2%, 20.4% and 25.1% in April–June, July–September and October–December respectively ($p = 0.002$). This winter predominance was no longer significant in 1994–1998, 27.2% of postneonatal SIDS deaths occurring in January–March, as compared with 26.6%, 21.9% and 24.4% in April–June, July–September and October–December respectively ($p = 0.41$).

Discussion

The Canadian postneonatal mortality rate due to SIDS declined markedly between 1985 and 1998. Our analysis demonstrated a similar pattern of decline in the late 1980s and early 1990s for postneonatal mortality due to all other causes of death (excluding SIDS and congenital anomalies). Furthermore, the initial decline in the postneonatal SIDS rate preceded the release of the first joint statement on reducing the risk of SIDS. However, our analysis also demonstrates that the reduction in the postneonatal mortality rate due to SIDS before and after the release of the first joint statement was significantly greater than the reduction in the postneonatal mortality rate due to other causes. This finding is consistent with a positive impact of the initial Canadian efforts to reduce the risk of SIDS and with findings in many other countries, including New Zealand, Australia, Norway, Denmark, Sweden and England and Wales.[2,9,10] Furthermore, more recent provincial/territorial data obtained by the Canadian Foundation for the Study of Infant Deaths suggest that the SIDS rate has declined further in 1999 and 2000.[11]

TABLE 2
Population distribution of selected demographic and perinatal risk factors for SIDS, Canada (excluding Newfoundland and Ontario), 1985–1989 and 1994–1998

	Number (%) of postneonatal survivors 1985–1989	Number (%) of postneonatal survivors 1994–1998	Percentage change 1985–1989 to 1994–1998 (95% CI*)
1. Maternal age (years)			
< 20	73,090 (6.4)	71,080 (6.6)	+3 (+2, +4)
20–24	288,890 (25.2)	221,595 (20.4)	-19 (-19, -18)
25–29	452,434 (39.5)	354,493 (32.7)	-17 (-17, -17)
30–34	255,594 (22.3)	306,635 (28.3)	+27 (+26, +27)
≥ 35	76,612 (6.7)	130,414 (12.0)	+80 (+78, +82)
2. Paternal age (years)			
< 20	11,166 (1.1)	17,164 (1.7)	+62 (+58, +65)
20–24	133,777 (12.9)	111,668 (11.3)	-12 (-13, -12)
25–29	385,435 (37.1)	274,143 (27.8)	-25 (-26, -25)
30–34	327,221 (31.5)	336,968 (34.1)	+8 (+8, +9)
≥ 35	180,059 (17.4)	247,163 (25.0)	+44 (+44, +45)
3. Sex of infant			
Male	587,599 (51.2)	556,314 (51.3)	0 (0, 0)
Female	559,212 (48.8)	527,952 (48.7)	0 (0, 0)
4. Gestational age (weeks)			
20–27	1,894 (0.2)	2,255 (0.2)	+26 (+18, +34)
28–31	6,016 (0.5)	6,308 (0.6)	+10 (+7, +14)
32–33	8,414 (0.7)	8,684 (0.8)	+9 (+6, +12)
34–36	52,770 (4.6)	55,750 (5.1)	+12 (+10, +13)
37–41	1,019,374 (88.9)	987,048 (91.0)	+2 (+2, +2)
≥ 42	58,343 (5.1)	24,393 (2.3)	-56 (-56, -55)
5. Birth weight (grams)			
500–1499	6,800 (0.6)	7,436 (0.7)	+15 (+11, +19)
1500–2499	54,204 (4.8)	51,187 (4.7)	-1 (-2, +1)
2500–3999	949,926 (83.5)	891,292 (82.5)	-1 (-1, -1)
4000–5999	126,836 (11.2)	129,982 (12.0)	+8 (+7, +9)
6. Parity			
1	479,020 (42.7)	458,59l (42.6)	0 (-1, 0)
2	390,722 (34.9)	374,711 (34.8)	0 (-1, 0)
≥ 3	251,496 (22.4)	243,568 (22.6)	+1 (0, +1)

*CI – confidence interval

The positive impact of risk reduction efforts would be further supported by data demonstrating changes in the prevalence of risk factors in the population. In Australia, almost 70% of the reduction in the SIDS incidence was attributed to the reduction in the prone sleep position.[12] In The Netherlands, a relation between changes in prone sleep position and SIDS deaths has also been demonstrated over time.[13] In Canada, no data are available at the national level to make similar assessments in relation to the initial risk reduction campaign. In Australia, changes in other risk factors, such as smoking, were responsible for less than 10% of the observed decline in the SIDS rate.[12] Canadian data on prenatal smoking and infant exposure to environmental tobacco smoke are also very limited for the period of this study. National and regional prenatal smoking rates are available in the period after the release of the first joint statement.[14] However, the absence of comparable data on tobacco use for the period before the initial joint statement further limits the extent to which the observed decline in postneonatal mortality due to SIDS can be attributed to the joint statement on risk reduction.

Our study shows that provincial and territorial SIDS rates vary considerably, as do the observed changes in SIDS rates in relation to the initial risk reduction campaign. This observed variation may be due to regional differences in the prevalence of various risk factors for SIDS in the population. Once again, reliable and comparable interprovincial/territorial data on factors such as sleep position and smoking are not available for either before or after the release of the initial risk reduction statement.

Other possible explanations for the observed variation in provincial/territorial rates include differences in the composition of the regional populations. In several countries, including Canada, Aboriginal populations have been identified as being at particularly high risk of SIDS.[15,16] Moreover, a less marked decline in SIDS rates in certain ethnic and lower socioeconomic subgroups has been attributed to a lower awareness of SIDS prevention opportunities in these groups.[2] National data do not permit comparison of SIDS rates in relation to risk factor information for specific subgroups in the Canadian population, e.g., those with lower socioeconomic status, Aboriginal groups and recent immigrants to Canada. Finally, variation in the postneonatal SIDS rates as well as the observed decline may also be due to provincial/territorial-specific public health efforts.

As expected, we found some changes in the population distribution of established demographic and perinatal risk factors for SIDS over the two time periods. In particular, increases in advanced maternal age and increasing rates of preterm birth in the Canadian population have been well documented.[14] With regard to the significance of these established risk factors, we found essentially no change between the two

TABLE 3
Selected demographic and perinatal risk factors for SIDS, Canada (excluding Newfoundland and Ontario), 1985–1989 and 1994–1998

	1985–1989 *Crude relative risks* (95% CI†)	1994–1998 *Crude relative risks* (95% CI)
1. Maternal age (years)		
< 20	4.13 (3.46–4.93)	4.20 (3.28–5.38)
20–24	1.91 (1.64–2.22)	2.53 (2.04–3.13)
25–29	1	1
30–34	0.88 (0.72–1.06)	0.64 (0.48–0.84)
≥ 35	0.91 (0.67–1.24)	0.65 (0.45–0.95)
2. Paternal age (years)		
< 20	3.18 (2.28–4.45)	2.51 (1.74–3.62)
20–24	1.51 (1.29–1.78)	1.29 (1.03–1.61)
25–29	1	1
30–34	0.64 (0.55–0.75)	0.45 (0.36–0.56)
≥ 35	0.61 (0.50–0.75)	0.29 (0.22–0.39)
3. Sex of infant		
Male	1.67 (1.48–1.89)	1.62 (1.37–1.91)
Female	1	1
4. Gestational age (weeks)		
20–27	5.56 (2.88–10.75)	3.85 (1.44–10.30)
28–31	6.43 (4.54–9.11)	6.54 (4.13–10.35)
32–33	3.89 (2.67–5.67)	5.50 (3.58–8.43)
34–36	2.32 (1.90–2.85)	2.60 (2.01–3.37)
37–41	1	1
≥ 42	1.00 (0.75–1.33)	1.15 (0.67–2.00)
5. Birth weight (grams)		
500–1499	6.05 (4.35–8.41)	5.44 (3.43–8.61)
1500–2499	2.47 (2.04–2.99)	3.61 (2.87–4.55)
2500–3999	1	1
4000–5999	0.65 (0.51–0.82)	0.87 (0.65–1.15)
6. Parity		
1	1	1
2	1.48 (1.28–1.71)	1.59 (1.29–1.96)
≥ 3	2.19 (1.89–2.53)	2.82 (2.30–3.46)

* Adjustment using logistic regression for all listed factors did not change the relative risks.

† Confidence interval.

periods. This finding has been reported elsewhere, including The Netherlands and England.[17,18] Of greatest importance was that our consideration of an adjusted time period effect on the decline of postneonatal SIDS rates demonstrated that any changes observed in these demographic and perinatal risk factors over the two periods were not responsible for the marked decline in Canadian SIDS rates. This finding further supports a positive impact of the risk reduction campaign.

Our study also demonstrates that a significant winter predominance in postneonatal SIDS deaths was present before the initial risk reduction efforts but disappeared in the period following the release of the joint statement. This elimination of a seasonal pattern for SIDS deaths has been reported previously. A UK study reported a decrease in the proportion of deaths in the cold months over time, from 34% in 1990–1991 to 27% in 1995–1996.[18] In contrast, the persistence of a seasonal effect, though diminished in magnitude, has been reported for other countries, including Australia.[19] The etiologic nature of a seasonal effect, as well as the reasons for the discrepancies in trends in seasonality, are not fully understood.

Our study has several potential limitations. First, data on causes of death were extracted from death certificates that recorded only a single underlying cause of death. This may result in misclassifying the cause for some infant deaths. Furthermore, if a diagnosis of SIDS is not available at the time of completion of the death certificate, an updated diagnosis must be forwarded to Statistics Canada in time for the publication of mortality statistics. Failure to meet this deadline would result in an underestimate in the number of SIDS deaths.

Second, some transcription and other errors are inevitable in large databases.

Third, as SIDS is a diagnosis of exclusion, its diagnosis may vary depending on the expertise of the coroner/medical examiner to detect alternative diagnoses. For example, a study in Quebec reported that a diagnosis other than SIDS was more likely if the autopsy was performed in a centre with expertise in pediatric pathology.[20]

Fourth, the exact timing of the "intervention" for this study is not well defined. The initial Canadian joint statement was released in 1993 and was followed by promotional campaigns in Canada in 1994 and 1995. Additionally, the American Academy of Pediatrics released a statement on sleep position in the United States in 1992,[21] and recommendations may have been adopted by some Canadians at that time. Finally, the absence of comparable risk factor data at the national level before and after the initial joint statement is an additional limitation of the study.

TABLE 4
Crude and sequentially adjusted relative risks (95% confidence interval [CI]) for time period effect on postneonatal SIDS rates, Canada

Risk factor	Relative risk (95% CI)
Period 1994–1998 vs. 1985–1989 (crude)	0.56 (0.51–0.62)
Period 1994–1998 vs. 1985–1989 Adjusted for	
Maternal age	0.59 (0.53–0.65)
Plus parity	0.59 (0.53–0.65)
Plus infant sex	0.59 (0.53–0.65)
Plus gestational age	0.58 (0.53–0.65)

In conclusion, Canadian postneonatal mortality due to SIDS declined significantly between 1985 and 1998. The reduction in the SIDS rate before and after the initial joint statement on reducing the risk of SIDS was greater than the decline observed in the postneonatal mortality due to other causes. Furthermore, adjusting this time period effect for key demographic and perinatal risk factors for SIDS did not alter the observed decline. These findings are consistent with a positive impact of initial risk reduction efforts. However, the absence of detailed risk factor data at the national and provincial/territorial levels limits the extent to which the SIDS rate reduction can be directly attributed to the initial joint statement. Future risk reduction campaigns should consider the available data sources and gaps to ensure rigorous evaluation.

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A model for non-communicable disease surveillance in Canada: The Prairie Pilot Diabetes Surveillance System

Robert C James, James F Blanchard, Dawn Campbell, Clarence Clottey, William Osei, Lawrence W Svenson and Thomas W Noseworthy

Abstract

The Prairie Pilot Diabetes Surveillance Project was organized to design and test a prototype population-based surveillance system, using administrative data, for a chronic disease exemplar – diabetes mellitus. The Canadian model of a public health surveillance system for chronic conditions described here specifies a process by which administrative and claims data arising from provincial health insurance programs are merged into an annual person-level summary file (APLSF), yielding one summary record for each person insured within each province. The APLSF is the basis for a variety of estimates, including incidence, prevalence, mortality, complication rates and health services utilization. The model was used to produce comparable interprovincial estimates of several parameters with respect to diabetes for the entire population in the provinces of Alberta, Manitoba and Saskatchewan. All processing of identifiable health data occurred within the provinces where the data were generated. Combining results across provinces was based on further aggregation of the summary data from each province and not by pooling of identifiable person-level data. On the basis of preliminary outputs for diabetes mellitus, the model appears to provide coherent estimates of key diabetes parameters and reflects anticipated differences in health services and outcomes, by disease state. Three characteristics of the model recommend it as a resource for non-communicable disease surveillance in Canada: a) it maximizes the utility of existing data; b) it includes both those with and those without the disease in question; and c) it respects provincial legislation regarding personal health data, yet permits reporting of multi-provincial, population-based data.

Key words: *administrative data; chronic diseases; diabetes mellitus; non-communicable disease; population-based data, public health surveillance*

Introduction

Population-based estimates of health and disease are key outputs of public health surveillance activities.[1] What are often unavailable for important chronic conditions, however, are reliable estimates of comorbidities, premature mortality, and both direct and indirect costs; measures of incidence, prevalence, duration and remission; and case-fatality rates.[2] This deficiency reflects a paucity of models for population-based surveillance of chronic diseases. Secondary analysis of population-based data arising from provincial health insurance programs has been proposed as a way of addressing this problem.[3] This is particularly attractive in Canada because of the population perspective provided by provincial and territorial health insurance systems: except for specific exclusions from provincial health plans, such as members of the military and federal police officers, all residents of Canada are insured for health services. Each province or territory organizes its own system of insurance, and each generates some form of unique personal identifier that is used to confirm eligibility for insurance. This identifier is used across ambulatory care and hospital data collection systems.

Several investigators have used administrative data in studies of specific chronic diseases.[4–10] The Manitoba diabetes surveillance system, with academic and governmental participation, has furnished estimates of incidence, prevalence and complication rates as well as projections of the future burden of diabetes.[4,5,11,12] Various Canadian research institutions have offered epidemiologic estimates for a variety of conditions from existing administrative databases, but these projects are typically episodic in nature and research-oriented, and thus do not replace the need for population-based, longitudinal public health surveillance. Moreover, these research projects have not typically been components of multiprovincial or national public health surveillance activities. Unrealized opportunities exist for sustained, multiprovincial and national public health surveillance initiatives using administrative data.

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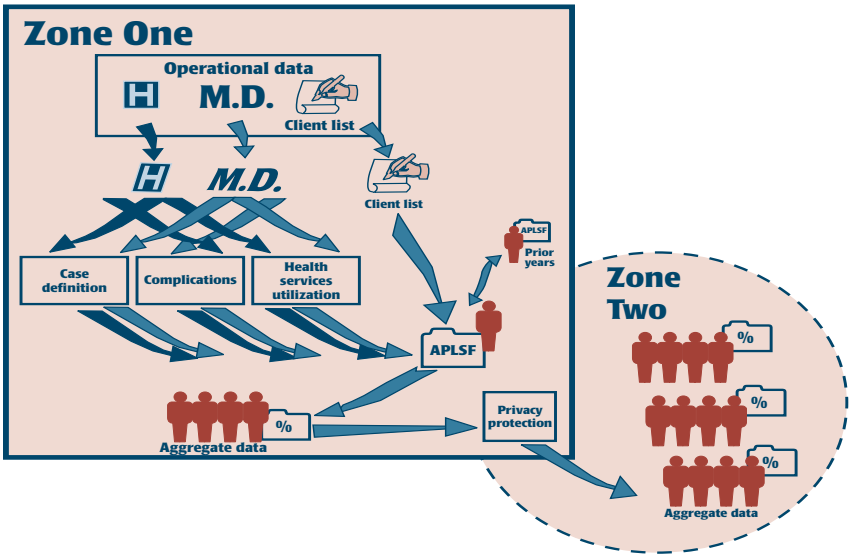
The Prairie Pilot Diabetes Surveillance Group was organized to design and test a population-based and interprovincially replicable approach to surveillance for one chronic condition, diabetes mellitus, based on administrative data. Initially, the group intended to transfer the existing diabetes surveillance system from Manitoba to Saskatchewan and Alberta, thereby facilitating the reporting of multiprovincial data,[4,5] but the work evolved to include a significant broadening of the "Manitoba model". This article reports on the revised model, its attributes and limitations, and presents some of the results of analyses of multiprovincial, population-based diabetes data.

The model

Two distinct zones characterize this surveillance system (Figure 1). Zone One (indicated by the square) is distinguished by the availability of population-based, person-level information, typically acquired through the administration of publicly funded health care services. In Canada, provinces and territories typically hold these data. A limited set of agencies within the federal government are also custodians of personal health data for select populations, including federal prisoners, and members of the military and the national police force. While all these agencies could be members of Zone One, our experience and this article is limited to provinces and territories. Zone Two (indicated by a circle) reflects audiences for surveillance data who do not have access to person-level information; in Canada, Zone Two would include the public, many health-related advocacy groups, the evaluation and planning units of provincial health ministries, and the federal government in its national health policy and planning role. It is important to note that different agencies within a political jurisdiction (such as a province) may be allocated to different zones according to their need to hold individual-level health data.

Within Zone One, the model proceeds through a series of steps to manipulate person-specific transaction data. During this process, the unit of observation evolves from inputs that are person-specific and transaction-based to generate summarized information about individuals; these person-level summaries are then further aggregated to generate information about populations.

FIGURE 1
Schematic representation of chronic disease surveillance model illustrating the use of input files of Medical/ambulatory care data ("M"), Hospital data ("H") and client list to generate an annual Person-Level Summary File (APLSF)



In the model, only aggregated data are transferred from Zone One to Zone Two. This reflects the notion that Zone Two entities do not require person-level health data for their activities. Aggregate datasets are intended to include appropriately stratified counts, rates, sums and other distributional statistics for epidemiologic parameters – for example, incidence and prevalence rates – relevant to the condition under study.

We will now discuss each Zone and the constituent steps in more detail.

Zone One

Within Zone One, four key processes occur: raw data are acquired, the data are manipulated, the key data product – the Annual Person-Level Summary File (APLSF) – is constructed, and various aggregate datasets are generated from the APLSF. Each of these four processes merits detailed discussion.

Data inputs: The model requires that key operational databases supporting health insurance systems within a jurisdiction can be copied and made available for surveillance purposes. At least three key files must exist: a comprehensive list of insured persons (the client list), together with listings of medical/ambulatory care (denoted "M") and hospital services ("H") provided to those individuals. Critical characteristics of these files include a unique person-specific identifier to enable data linkage across files, a list of insured persons that provides a reliable census of those eligible for insurance coverage, and information on age, sex, location, periods of insurance and, for those who are deceased, the date of death. Finally, the ambulatory care and hospital discharge databases must contain diagnostic information. (These conditions are satisfied in many, but not all Canadian provinces/territories; recent developments toward a national electronic health record should encourage national compliance.)

Data manipulation: Once the data have been acquired, the second step involves sorting and linking inputs by personal identifier, and manipulating and summarizing these inputs to provide annual summary information that will support three distinct

activities: 1) case identification, 2) measurement of health services utilization, and 3) detection of complications or comorbidities. These three activities applied over the two service-related inputs create a total of six processes, each with its own distinct logic and outputs. Details regarding how these six data manipulation processes work, including the specification of case definitions and what complications and health services are captured, are not defined by the model itself and need to be developed and validated with each new disease surveillance activity.

Creation of an annual person-level summary file: The outputs from the six processes described are combined with information abstracted from the client list (which typically includes age, sex and the vital status of the individual) and prior years of the summary file to produce an APLSF. (Very occasionally, transaction events cannot be linked back to an individual identified in the client list; these transactions are discarded, and the number of discarded transactions is recorded.) The APLSF file contains one record per person per year for each and every person who was insured within a participating jurisdiction at any point in the year, regardless of whether health services were used in that year. The unit of observation in this file is the individual. Each record in the APLSF would typically include annual counts and sums for selected health services utilization for that individual, dates indicating when selected events, diagnoses or complications occurred within the year, and demographic information.

Aggregation and rate estimation: The APLSF constitutes the basis for producing various aggregate datasets, which would typically include rates, counts and distributional characterizations for population groups stratified by age, sex, geographic region and imputed disease state. Because the APLSF includes a record for every person within a jurisdiction, it provides estimates of the population at risk for specific outcomes.

A variety of possible denominators can be estimated from the APLSF, including mid-year population estimates and person-years-of-observation estimates. External sources of denominator information such as census-based population counts might be preferred in some jurisdictions. Jurisdictions with client lists that do not accurately reflect the population structure may wish to consider census data or other denominator data sources.

Among the types of aggregate estimates that would typically be generated from the APLSF datasets are rate estimates for incidence, prevalence and mortality, together with distributional characterizations of physician fees and days in hospital. Again, these parameters can be stratified by geographic and demographic characteristics, and imputed disease state.

Zone Two

Zone Two is intended to provide a context for the transfer of aggregated data for audiences who are not custodians of person-specific data. Transferring Data Under this model, aggregate datasets being prepared for distribution from Zone One to Zone Two would be checked for residual disclosure risks within Zone One, and only then released into Zone Two. Appropriate stratifications of key demographic variables such as age or geographic region can be defined on an *ad hoc* basis, depending on the variables available from the client list, in such a way as to provide maximum flexibility in reporting results while ensuring the protection of personal privacy. Additional considerations may include consistency of reporting across Zone One agencies.

A wide variety of options exist to ensure the confidentiality of aggregated datasets, including the long-established standard of suppressing cells with small numbers, and several newer methods.[13]

Implementation issues

The model was implemented with the use of SAS® (registered trademark of SAS Institute Inc.). It consisted of a large body of software that was common across the three Zone One participants – the prairie provinces of Alberta, Manitoba and Saskatchewan. A small body of code was also created, specific to each jurisdiction, that supported the use of a common data dictionary across the three jurisdictions (each of which have distinct information technology solutions and data dictionaries) and managed various local details such as filenames and the number of years of input data. (Details on the software are available from the authors on request.) A common body of software across jurisdictions simplified development and deployment, and enhanced comparability.

All processing of identifiable health data occurred within the provinces where the data had been generated. Combining results across provinces was based on further aggregation of the already summarized files produced within each province, not by the pooling of person-level data across provinces. Neither transaction data nor APLSF records were transferred out of their "home" provinces.

Only a small subset of the six input/process pathways envisioned by the model was included in the pilot project. For instance, no assessment of complications or comorbidities was undertaken using diagnostic information found in the medical/ambulatory data. The model, as implemented, was sufficient to replicate the initial Manitoba surveillance model.[4,5]

An example

Methods

Software built to implement the model was provided to the provincial health departments of Alberta, Manitoba and Saskatchewan. The software used a slight variant of the Manitoba case definition for diabetes: adults were held to have diabetes if there was ever a single diagnosis of diabetes in a hospital discharge record or two or more diagnoses of diabetes within medical/ambulatory care data during a two-year period. Blanchard et al.[4] initially advanced this case definition; subsequent studies by Hux and colleagues estimate that it has a 97% specificity and a 86% sensitivity.[14] The denominator for reported rates is derived from estimated person-years of observation – a measure available from the APLSF file. We

report data for the most recent year available to this pilot project (1997 or 1998, depending on the province). Because of the pilot nature of the project, estimates should be considered as illustrative of the outputs generated by the model; substantive findings may be subject to further refinement.

Results and discussion

Figure 2 depicts estimated prevalence rates for diabetes, by sex, combined across the three provinces. The prevalence rate increases smoothly among both males and females until age 75 to 79 years, after which it shows a modest decline. The prevalence rate among females is slightly higher in the 20 to 40 age group, but this is likely an artifact of how gestational diabetes was handled within the pilot. Thereafter, the prevalence rates are higher among males than females.

Figure 3 presents the annual mortality rates for diabetic and non-diabetic populations across the prairies and shows an increase with increasing age in both groups. The mortality rate among those with diabetes is consistently higher than among those without diabetes. A rate ratio can be estimated as the quotient of age- and sex-specific mortality rates in the diabetic population and the same rates in the population without diabetes. Before age 70 years, the rate ratio declines from approximately five in the 40-year age group to approximately two in the 70-year-and-older age groups. The ability to report mortality rates in diabetic and non-diabetic populations and to estimate comparative rate ratios reflects the value of including the entire population in the APLSF and in the aggregate datasets.

The results of this example correspond to anticipated patterns in the epidemiology of diabetes, including greater prevalence with increasing age and higher mortality rates among those with diabetes as compared with the non-diabetic population.

FIGURE 2
Estimated annual age- and sex-specific prevalence of diabetes mellitus for the Prairie provinces, as determined from administrative data

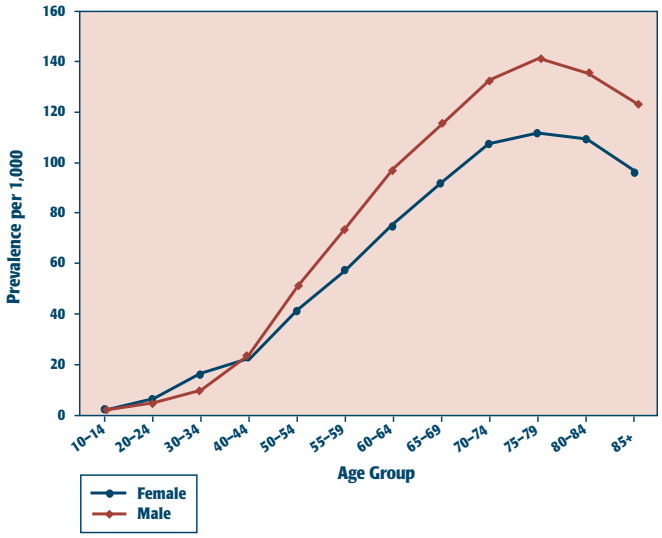
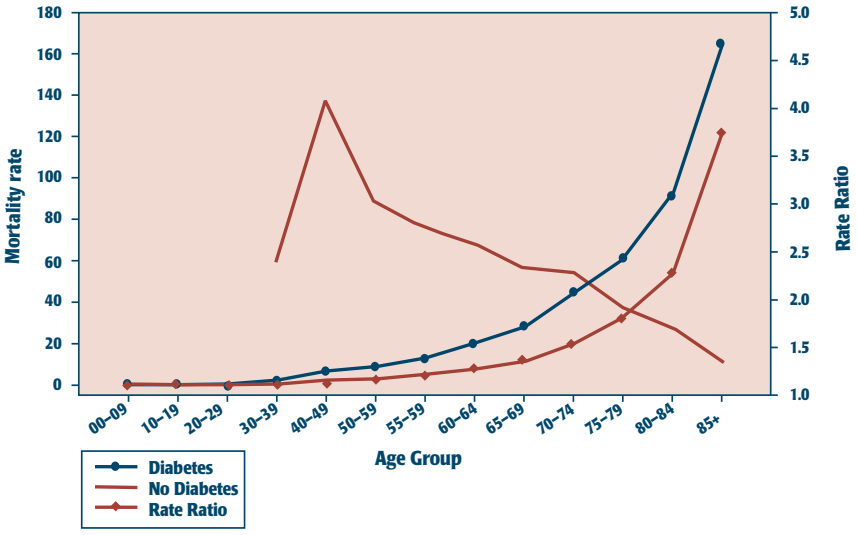


FIGURE 3
Rate ratio is the quotient of the age- and sex-specific mortality rate among those with diabetes divided by the age- and sex-specific mortality rate among those without diabetes



Discussion

Chronic disease prevention and management require continuing, comparable, systematic surveillance. In countries that are federations, it is important that surveillance be comparable across provinces or states. While several health research centres have reported epidemiologic estimates for specific conditions from time to time, these reports are not public health surveillance activities and are typically episodic, research-oriented and single-jurisdiction analyses. To date, these efforts have not been adapted to address the technical and policy challenges of ongoing surveillance across jurisdictions. Models that address the technical, policy and jurisdictional challenges of comparable interprovincial chronic disease surveillance have not previously been reported. We have described such a model and report preliminary results from a prototype surveillance system for diabetes mellitus.

The model has three salient characteristics that recommend it for public health surveillance of chronic conditions: it maximizes the utility of existing data; it includes both those with and without a disease, thereby allowing population-based determination of differential outcomes and health services utilization; finally, it defines distinct and appropriate roles for custodians of personal health data and for those who are not custodians. In this way, it suggests distinct roles for provinces, territories and the federal government that are consistent with Canadian legislative and constitutional realities.

Not only does the model generate a registry of persons with a diagnosis of a disease of interest, but it also moves beyond the standard registry approach to include non-cases and to capture complications, health services and health outcomes. This approach allows for the estimation of etiologic fractions for various outcomes and rate ratios for health services utilization, which can be linked back to the specific conditions of interest. For example, under this model, it should be possible to estimate the proportion of the population burden of a complication, such as lower-limb amputation, which occurs in those with diabetes. Existing case-only registers do not typically include non-cases and thus do not allow for these sorts of analyses.

The model has limitations. The quality of diagnostic and other information in hospital and medical/ambulatory files must always be considered. The provincial health insurance registries of insured persons must be relatively complete. Innacurate population estimates from lists of insured persons, or incomplete diagnostic information can lead to erroneous epidemiologic estimates.

It should also be recognized that administrative data focus largely on diagnoses, procedures and resource utilization rather than risk factors, behaviour or other relevant clinical parameters. The advent of electronic medical records may redress important gaps in data availability and quality. Primary data collection and representative surveys focused on specific disease cohorts may be useful methods of obtaining covariates that are missing from the administrative data.

Summarization of personal health information in annual files represents an additional limitation, in that it obscures the ordering of occurrences within each year. When summarization frustrates specific analyses, access to the non-summarized transaction data should remain an option.

At this time, the model does not specify a mechanism by which to transfer person-specific health summaries across Zone One agencies. This may mean that migrants with prevalent conditions may be misclassified as incident cases in their destination jurisdiction under this model. The model would be enhanced (and its estimates made more robust) by a method to transmit summary person-level health information across Zone One agencies, particularly when individuals migrate between provinces or territories.

The model can also be criticized for not providing person-specific data to the federal government. While our manipulation of data within Zone One agencies resolves several technical barriers to such transfers, we decided to limit person-specific data to Zone One agencies on the basis of our assessment of the Canadian policy environment. Although nominal data transfers occur among provinces, territories and the federal government, these data concern conditions already scheduled in public health legislation or regulations. We are unaware of nominal data transfers across Zone One agencies or to the federal government that relate to non-scheduled diseases such as diabetes.

In our experience, provincial and territorial legislative requirements toward data sharing vary widely, as does the willingness to share identifiable, personal health data. In particular, we recognize that there are important and, as yet, not fully answered policy questions regarding data sharing between Zone One entities and with the federal government. The protection provided under the federal *Statistics Act* might allow for centralization of data across provinces if an epidemiologic rationale could be identified that would require consolidation of data. Ensuring that cases are not double-counted or misclassified as incident cases when individuals migrate from jurisdiction to jurisdiction may be an important facet of such an argument. Provincial privacy commissioners need to play a central role in this issue.

The key attribute of this model is its potential generalizability to conditions other than diabetes. Opportunities clearly exist to test this model on other non-communicable diseases and other episodic conditions, notably injuries. Several other important chronic conditions may also be amenable to this approach. However, using this method to augment the number of conditions under surveillance should be complemented by ongoing validation of case definitions, enhancements to the quality of the input health data, active programs of research around the limitations and strengths of such models, programs of linked primary data collection and careful analysis of the outputs from such models. Taken together, these should provide important opportunities to quantify trends in chronic diseases in Canada.

This model does not obviate the need for representative surveys. Indeed, the utility of both survey data and administrative data are enhanced when these methods are integrated. For example, linked survey and administrative data provide opportunities to compare self-report with administrative data. Questions regarding conditions that do not generate specific diagnostic codes will not be answered from diagnostic information, but representative surveys incorporating biological samples would be helpful. Close coordination of administrative data and survey methods are strongly encouraged.

This model and the results are a proof of concept, demonstrating that multiprovincial public health surveillance based on administrative data can be achieved without cross-jurisdictional sharing of personal health data. Continued validation of input data and validation of the approach for new conditions will be important. The results suggest, however, that this initiative may be an important early contribution towards a national multidimensional picture of population health status, although these methods alone will not yield the entire portrait. Finally, the methods form a foundation of policy, skills, and technology that can and should be used as the impetus to expand public health surveillance capacity across the country.

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Refining the measurement of the economic burden of chronic diseases in Canada

John Rapoport, Philip Jacobs, Neil R Bell and Scott Klarenbach

Abstract

This article presents an analysis of the economic burden of a number of chronic diseases in Canada. In the analysis, we adjusted our measure of utilization of physician and hospital services for co-existing chronic diseases, which we found to be widely prevalent and to have an impact on resource use. Using data from the 1999 National Population Health Survey, we developed resource use rankings for several chronic conditions and decomposed these measures into prevalence and per-person utilization components. Our results indicate that, for the diseases with the greatest impact, resource use measures are driven more by disease prevalence than intensity of resource use. The diseases with the highest overall degree of resource use are back pain, arthritis or rheumatism, high blood pressure and migraines for people under 60; and arthritis or rheumatism and high blood pressure for people over 60. Our methods can be used to forecast the overall relative impact of resource use due to disease prevalence and per-person resource use intensity for various conditions.

Key words: *chronic disease; economics; utilization*

Introduction

Numerous studies in the published and gray literature* have reported on the economic burden of chronic conditions. Several of these allowed for a comparison between different conditions,[1] but most authors focus on one specific chronic condition and confine their focus to the services that are particular to that disease.[2–5] Few of these economic burden studies identify a cost *per patient*,[6] which is important if the estimates are to be used for projecting expenditures or for assessing the impact of interventions (i.e., the usual purposes given for conducting these studies). Furthermore, although guidelines relating to disease costing have been available for a long time,[7,8] investigators do not often use common methods or data sources. Most importantly, they seldom adhere to a concept that incorporates comorbid disease. Not accounting for the additional or attributable effect of comorbidities on utilization and cost may lead to bias in estimates of resource utilization.

This study takes a different approach to estimating chronic disease burden: we look at person-level data from a nationwide population survey and, using a common metric, examine the relation between chronic disease and utilization of physician and hospital services, adjusting for comorbidities. We use the National Population Health Survey (NPHS), a national, population-based survey that provides information on the presence of a number of different chronic conditions and the characteristics of individuals with and without these diseases.

Method

All data in the analysis were obtained from the NPHS, a general health survey conducted by Statistics Canada in 1998–1999. We used the general health component of the survey, which included 17,244 individuals. The NPHS asks a series of questions on self-reported chronic disease, defined as conditions that have lasted or are expected to last six months or more and that were diagnosed by a health professional. The following chronic diseases were investigated in our analysis: asthma, arthritis or rheumatism, back problems (excluding arthritis), high blood pressure, migraine headaches, chronic bronchitis or emphysema, sinusitis, diabetes, epilepsy, heart disease, cancer, stomach or intestinal ulcers, effects of a stroke, urinary incontinence, bowel disorder such as Crohn's disease or colitis, Alzheimer's disease or any other dementia, cataracts, glaucoma, and thyroid condition. We created dummy variables that indicated the presence or absence of each of these conditions. We also created a separate variable that indicated the total number of chronic diseases reported by each respondent.

* Defined as "foreign or domestic open source material that is usually available through specialized channels and may not enter normal channels or systems of publication, distribution, bibliographic control, or acquisition by booksellers or subscription agents" (US Interagency Gray Literature Working Group, 1995)

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The utilization of physician and hospital services was measured by the number of physician consultations per year and the number of nights spent as a hospital patient per year. In the NPHS public use data file, physician visits by respondents with over 30 encounters per year are combined in an open-ended category; we assigned a value of 31 to these. The same was done with hospital nights, which were also reported in the NPHS data file as an open-ended upper category of above 30. The following additional demographic variables were included as control variables: age, sex, household income, and education as a dummy variable indicating post-secondary educational status.

Analysis was confined to people over age 20. Descriptive statistics on utilization were calculated within four age strata: 20–39, 40–59, 60–79 and over 80. Chronic disease prevalence and regression analyses were performed separately for people under age 60 and people aged 60 and over.

Four utilization variables were used as dependent variables. Physician services were measured by the number of visits per year. Because the highest category for this variable was open-ended and because very high users can have a disproportionate effect on overall utilization, an additional dependent variable, a dummy variable indicating more than 12 annual visits, was also used. Similarly, hospital utilization was captured by means of a dummy variable indicating any hospitalization during the year, as well as by a dependent variable representing the number of nights in the hospital.

For each dependent variable two regressions were performed. The first included as independent variables the demographic control variables and the number of chronic diseases. In the second regression the number of chronic diseases was replaced by the group of dummy variables for the specific chronic diseases. Linear regression was used for the continuous dependent variables, and logistic regression was performed for the dummy dependent variables. Observations were weighted using sampling weights from the NPHS data file. The regression with nights in the hospital as a dependent variable was computed only for those patients who reported a hospitalization.

TABLE 1
Number of chronic diseases and utilization of physician and hospital services in the 1998–1999 National Population Health Survey

Number of chronic conditions	Number of people (%)	Total physician consultations (%)	Total hospital days (%)
Age 20–39			
0	3,292 (62)	9,623 (47)	625 (38)
1	1,407 (27)	6,501 (32)	587 (36)
2	424 (8)	2,439 (12)	263 (16)
3	127 (2)	1,056 (5)	91 (6)
4	42 (1)	445 (2)	60 (4)
5	10 (<1)	125 (1)	3 (<1)
6–10	6 (<1)	101 (<1)	14 (1)
Total	**5,308**	**20,290**	**1,643**
Age 40–59			
0	2,060 (44)	4,552 (24)	332 (16)
1	1,419 (30)	5,550 (29)	449 (21)
2	681 (14)	3,717 (19)	433 (21)
3	319 (7)	2,621 (14)	482 (23)
4	141 (3)	1,323 (7)	101 (5)
5	58 (1)	696 (4)	151 (7)
6–10	42 (<1)	683 (3)	151 (7)
Total	**4,720**	**19,142**	**2,099**
Age 60–79			
0	601 (20)	1,311 (8)	226 (6)
1	756 (25)	3,166 (20)	602 (16)
2	719 (24)	3,997 (25)	1,065 (28)
3	435 (15)	3,092 (19)	590 (16)
4	244 (8)	2,089 (13)	602 (16)
5	126 (4)	1,129 (7)	345 (9)
6–10	114 (3)	1,289 (8)	327 (8)
Total	**2,995**	**16,073**	**3,757**
Age 80+			
0	77 (12)	323 (8)	138 (7)
1	160 (24)	674 (16)	282 (15)
2	147 (22)	941 (23)	366 (20)
3	111 (17)	847 (20)	385 (21)
4	80 (12)	634 (15)	322 (17)
5	45 (7)	369 (9)	180 (10)
6–10	39 (5)	360 (9)	201 (11)
Total	**659**	**4,148**	**1,874**

A summary measure of resource use, by condition, was derived for physician services. To estimate the number of physician consultations attributable to *each* chronic disease we multiplied the regression coefficient for the disease's dummy variable by the number of people who reported having the disease. All analyses were performed using SPSS® (Statistical Package for the Social Sciences: SPSS Inc., Chicago, Illinois) version 10.

Results

Table 1 presents a stratification by the number of chronic diseases and compares the percentage of people in each stratum with the percentage of physician and hospital use. As seen in this table, chronic disease comorbidities are commonplace, and with the move to higher age groups, their prevalence grows. In the lowest age group, 20–39 years, people with one or more chronic diseases use more than "their share" of services, and those with no chronic disease use less than "their share". In the older age groups the percentage of services used exceeds the percentage of people only for two or more chronic diseases.

Prevalence by specific chronic condition is shown in Table 2. In the under 60 age group three chronic diseases are found in 10% or more of people: back problems (15%), arthritis or rheumatism (12%) and migraine headaches (10%). In people aged 60 and over, there are seven chronic diseases with 10% prevalence or higher. The prevalence of arthritis or rheumatism (46%) and high blood pressure (35%) is about twice as high as the next most prevalent disease. Table 3 shows the regression analysis using number of chronic diseases in the equations for physician services. The number of chronic diseases is a highly significant predictor of utilization ($p < 0.001$) in all the regressions. In the younger age group an additional chronic disease is associated with 1.74 more physician visits per year, and in the older age group the increase in physician visits predicted is 1.29. The number of chronic diseases is also a statistically significant predictor of very high physician use (more than 12 visits per year). The odds ratios in the logistic regressions reported in Table 3 suggest that an additional chronic disease is associated with a 76% increase in the chance that a person under 60 is a high user of physician services and with a 51% increased chance in a person over 60.

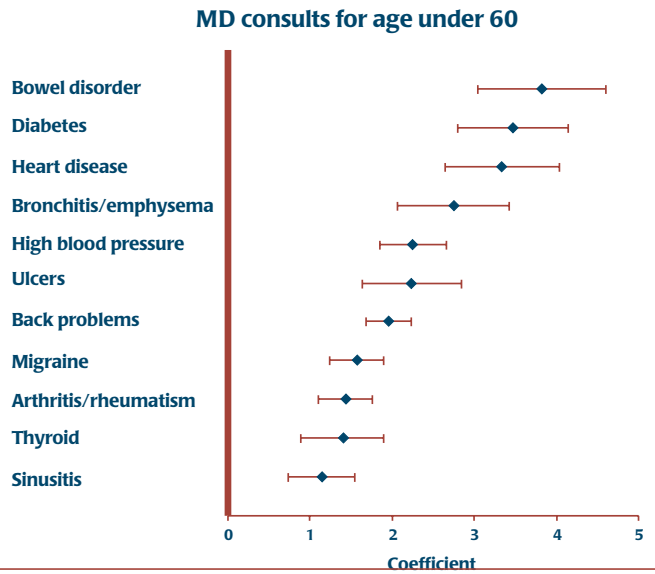
The confidence intervals shown in Figures 1 through 4 are for the coefficients or odds ratios of the chronic disease dummy variables when the number of chronic diseases is replaced with the set of specific chronic disease variables in the regressions. Only those variables whose

TABLE 2
Prevalence of specific chronic conditions* in the 1998–1999 National Population Health Survey

	Age < 60 (*n* = 10,068)		Age ≥60 (*n* = 3,688)	
	No. with condition	Percentage	No. with condition	Percentage
Arthritis/rheumatism	1,167	12	1,679	46
High blood pressure	747	7	1,287	35
Back problems	1,513	15	654	18
Heart disease	194	2	585	16
Cataracts	61	1	551	15
Diabetes	220	2	394	11
Thyroid disorder	404	4	355	10
Asthma	832	8	321	9
Urinary incontinence	133	1	248	7
Sinusitis	619	6	242	7
Bronchitis/emphysema	227	2	206	6
Ulcers	314	3	194	5
Cancer	85	1	171	5
Glaucoma	60	1	169	5
Migraine	963	10	159	4
Stroke	44	>1	145	4
Bowel disorder	174	2	111	2
Alzheimer's disease	15	>1	41	1
Epilepsy	63	1	33	1

* Listed in order of prevalence in the ≥60 age group.

FIGURE 1
Confidence intervals for coefficients of chronic disease variables* (among those aged < 60) for physician consultations



* Variables listed in order of size of coefficient; omitted chronic diseases did not have statistically significant coefficient.

TABLE 3
Regression results for physician services

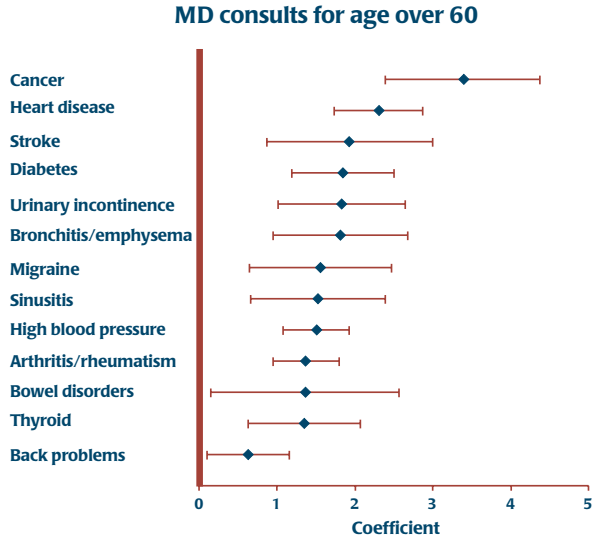
Dependent variable →	Physician consultations (linear regression) Number of consultations				Physician consultations (logistic regression) At least 12 consultations or less than 12			
	Under age 60		Over age 60		Under age 60		Over age 60	
	Coefficient	*p* value	Coefficient	*p* value	Odds ratio	*p* value	Odds ratio	*p* value
Independent variables ↓								
Constant	4.49	< 0.001	-1.8	0.07	0.12	< 0.001	0.01	< 0.001
Age	-0.02	< 0.001	0.06	< 0.001	0.99	0.004	1.02	0.03
Male	-1.39	< 0.001	0.64	0.002	0.50	< 0.001	1.58	0.002
Income	-0.008	< 0.001	-0.0002	0.97	0.99	< 0.001	0.99	0.13
Post-secondary education	0.06	0.57	-0.37	0.08	1.06	0.54	0.89	0.45
Number of chronic diseases	1.74	< 0.001	1.29	< 0.001	1.76	< 0.001	1.51	< 0.001
Adjusted R^2	0.15		0.16					
N	9,511		3,352		9,512		3,353	

coefficient confidence interval excludes 0 in the linear regression or whose odds ratio confidence interval excludes 1 in the logistic regression are shown. Despite fairly large confidence intervals, these data indicate that some diseases consistently have larger effects on utilization of physician services than others. Heart disease has a large effect in both age groups. Cancer in the older age group and bowel disorders in the younger age group seem noteworthy for their large effects on utilization.

Regression analysis of hospital utilization is presented in Table 4, with confidence intervals for regression coefficients and odds ratios shown in Figures 5 through 8. An additional chronic disease raises the probability of any hospitalization in the previous year by 44% in the younger age group and by 27% among people over age 60. Although the explained variation is quite low (adjusted R^2 < 10%) in the regression for hospital nights, the number of chronic diseases has a statistically significant coefficient in both age groups. An additional chronic disease is associated with 0.77 more hospital nights in the younger age group and 0.60 hospital nights in the older age group.

In Table 5 the product of regression coefficient times number of people with the disease is calculated to estimate the total physician consultations attributable to the disease. In the younger age group, four conditions (back problems, arthritis or rheumatism, high blood pressure and migraine) each account for more than twice as many consultations as the other conditions. Except for high blood pressure, this is largely a result of the frequency with which these conditions occur, rather than the resource impact factor. The resource use coefficient is high for diabetes, heart disease, and bowel disorder, but the frequency of people with these conditions is not high in people under 60. Arthritis or rheumatism and high blood pressure are also at the top of the list in the older age group, in both cases because of the numbers with the disease. Fewer people have heart disease, but its relatively high resource factor (2.3) results in a higher overall measure of visits saved if the disease were eliminated.

FIGURE 2
Confidence intervals for coefficients of chronic disease variables* (among those aged ≥60) for physician consultations



* Variables listed in order of size of coefficient; omitted chronic diseases did not have statistically significant coefficient.

TABLE 4
Regression results for hospital services

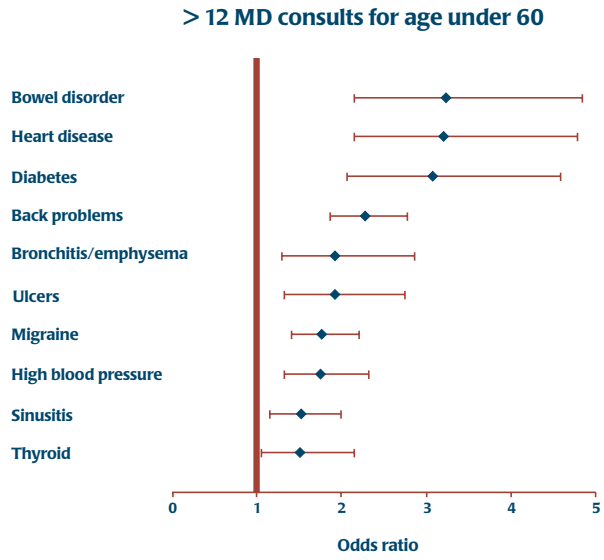
Dependent variable →	Hospitalization or not (logistic regression)				Hospital nights (linear regression)			
	Under age 60		Over age 60		Under age 60		Over age 60	
	Odds ratio	*p* value	Odds ratio	*p* value	Coefficient	*p* value	Coefficient	*p* value
Independent variables ↓								
Constant	0.18	< 0.001	0.006	< 0.001	2.42	0.01	-6.37	0.17
Age	0.98	< 0.001	1.04	< 0.001	0.05	0.01	0.23	< 0.001
Male	0.51	< 0.001	1.38	0.006	1.28	0.01	1.23	0.19
Income	0.99	< 0.001	1.0	0.13	-0.01	0.07	-0.05	0.02
Post-secondary education	0.91	0.30	1.06	0.61	-0.81	0.09	-0.56	0.57
Number of chronic diseases	1.44	< 0.001	1.27	< 0.001	0.77	< 0.001	0.60	0.03
Adjusted R^2					0.08		0.06	
Total degrees of freedom					693		484	

Discussion

In this article we developed an analysis of the economic burden of chronic diseases using a common measure of burden for all conditions. This measure was decomposed into two separate components – per-person utilization and disease prevalence – and adjusted for the numbers and types of chronic disease comorbidities. We concentrated our measure on the use of physician services using data from the NPHS, a population based Canadian survey, because of small samples for hospital services.

Given the frequency with which we observed concurrent chronic diseases in individuals of all age groups as well as the influence of multiple diseases on utilization, adjustment for comorbidity is appropriate. Our results demonstrate that, after such adjustment, chronic diseases differ in the extent to which their presence is associated with increased utilization. The order of magnitude of the variation in per capita effect is three to four times. For example, in the younger age group sinusitis increases per capita physician use by about one consultation per year whereas bowel disorder increases it by about four consultations per year. In the older age group, thyroid disease increases per capita physician use by about one day while stroke increases it by about three days.

FIGURE 3
Confidence intervals for odds ratios of chronic disease variables* (among those aged < 60) in logistic regression, > 12 physician consultations



* Variables listed in order of size of odds ratio; omitted chronic diseases had prevalence < 1% or a confidence interval including 1.

As we did not specifically study disease characteristics and their effects on physician utilization, generalizations regarding this are speculative. Our data did not include the specific reasons for physician visits. However, our findings of the ordering of diseases by regression coefficients in Figures 1 and 2 can be explained by presumptive drivers of utilization for specific diseases. Disorders that typically require minimal monitoring and are unlikely to progress once appropriately diagnosed and treated, such as thyroid disorders, are associated with less frequent physician visits. Urinary incontinence and migraine, which may be accompanied by troublesome symptoms, but are not typically associated with dire

TABLE 5
Total physician consultations as derived from the product of the regression coefficient and the number of people with the disease

Disease*	Coefficient	Number of people with the disease	Physician visits saved**
		Under age 60	
Back problems	1.96	1,513	2,965
Arthritis/rheumatism	1.43	1,167	1,669
High blood pressure	2.25	747	1,681
Migraine	1.57	963	1,512
Diabetes	3.47	220	763
Sinusitis	1.14	619	706
Ulcers	2.23	314	700
Bowel disorder	3.82	174	665
Heart disease	3.34	194	648
Bronchitis/emphysema	2.75	227	624
Thyroid disorder	1.40	404	566
		Over age 60	
Arthritis/rheumatism	1.37	1,679	2,300
High blood pressure	1.50	1,287	1,931
Heart disease	2.30	585	1,345
Diabetes	1.85	394	729
Cancer	3.39	171	580
Thyroid disorder	1.35	355	479
Urinary incontinence	1.82	248	451
Back problems	0.63	654	412
Bronchitis/emphysema	1.81	206	373
Sinusitis	1.52	242	368
Stroke	1.93	145	280
Migraine	1.55	159	246
Bowel disorder	1.36	111	151

consequences or the need for frequent monitoring, are also ranked lower. Disorders that are identified as being associated with heavy physician utilization, such as cancer, diabetes mellitus and heart disease, may be progressive in nature despite treatment, may have dire consequences including death, and may require frequent revisions to therapy. High blood pressure, by itself an asymptomatic disease, requires observation and possible alterations to therapy over time, and appears in the middle of the list.

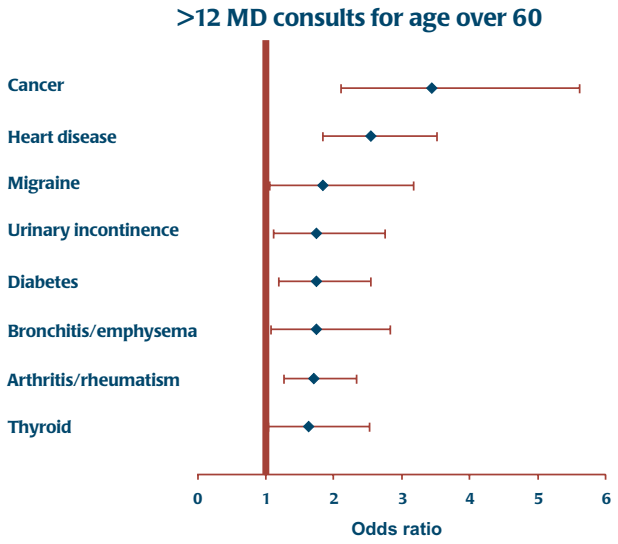
An important finding from the perspective of composite resource utilization is that the overall effect on utilization of a specific disease seems more driven by the number of people who have it than by the per capita effect. At the top of the list for total effect are disorders such as musculoskeletal disease and high blood pressure, which have high prevalence although their per capita effect on utilization is moderate or low.

Decomposing utilization into prevalence and a coefficient of use may allow a clearer evaluation of the potential impact of numerous changes on resource use. For example, the prevalence of diabetes is low compared with other chronic diseases examined here. However its widely predicted rise in the coming decade, combined with the high coefficient of utilization found in the present study, may substantially increase its future ranking.

Typically, the regression coefficient for number of chronic diseases as well as for specific chronic diseases is smaller in the over 60 age group than in the younger group. This is true for both physician and hospital utilization. Possible reasons are that these diseases are treated more aggressively in the younger population, or that older people have lived with them longer and are better at self-care or at using alternative health care services. Another possibility is that since younger people have relatively few chronic diseases the presence of one creates much anxiety and thus a tendency to seek added care. In the older group, in contrast, the incremental effect of an additional disorder on the demands for physician care may be less when several other chronic diseases are already present.

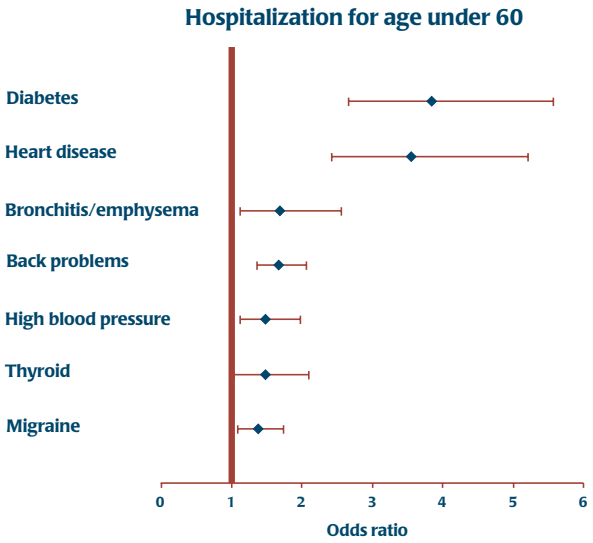
There is no other measure of the economic burden of the conditions identified in this study that is categorized in the same groupings that we used. Nevertheless, there are some data in the Health Canada report *Economic Burden of Illness in Canada, 1998*[1] that allow us to assess our results, although this report covers all disease and not just chronic conditions. In this document, the burden of physician costs for musculoskeletal disorders is ranked quite low (see Figure 8). In our analysis, musculoskeletal disorders (arthritis/rheumatism and back pain) are ranked highest for the under 60 group, and arthritis/rheumatism was ranked highest for the over 60 group. Several heart disease categories were rated as high for the over 60 group, and this corresponded with the Health Canada rankings. However, respiratory conditions were of lower rank in our analyses.

FIGURE 4
Confidence intervals for odds ratios of chronic disease variables* (among those aged ≥60) in logistic regression, > 12 physician consultations



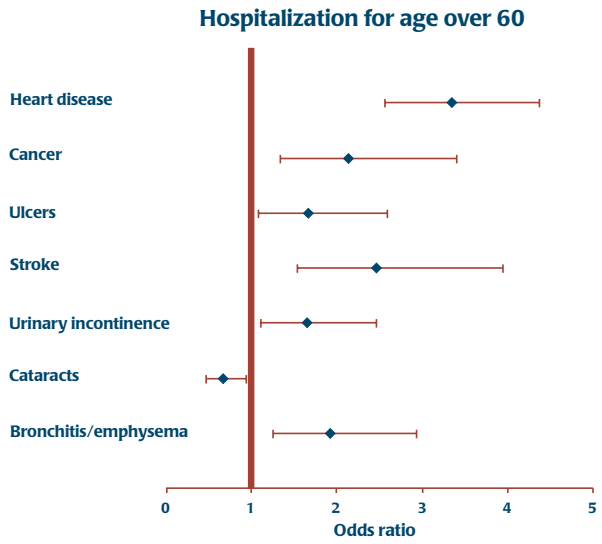
* Variables listed in order of size of odds ratio; omitted chronic diseases had prevalence < 1% or a confidence interval including 1.

FIGURE 5
Confidence intervals for odds ratios of chronic disease variables (among those aged < 60) in logistic regression, hospitalization



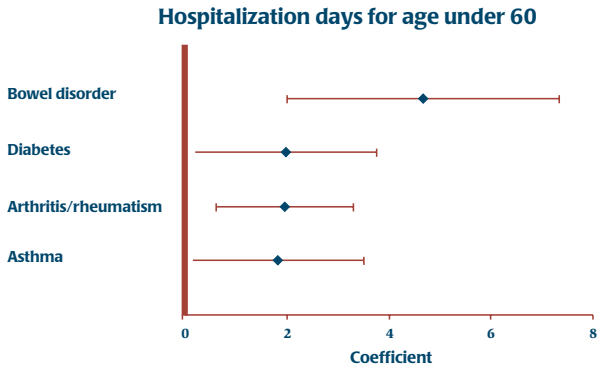
* Variables listed in order of size of odds ratio; omitted chronic diseases had prevalence < 1% or a confidence interval including 1.

FIGURE 6
Confidence intervals for odds ratios of chronic disease variables* (among those aged < 60) in logistic regression, hospitalization



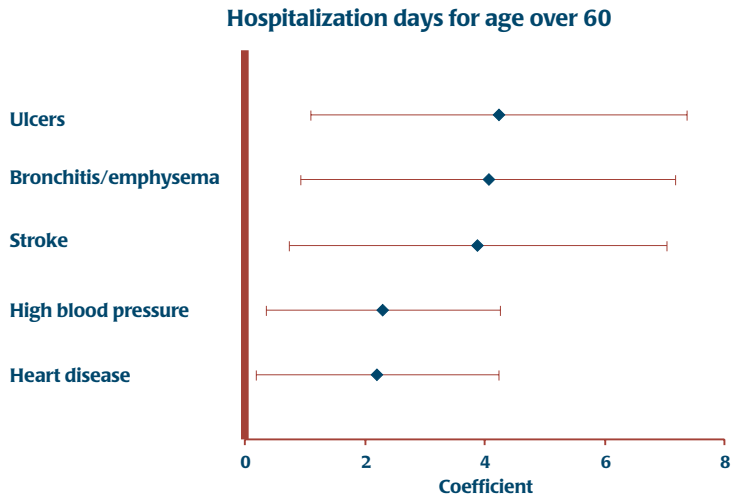
* Variables listed in order of size of odds ratio; omitted chronic diseases had prevalence < 1% or a confidence interval including 1.

FIGURE 7
Confidence intervals for coefficients of chronic disease variables* (among those aged < 60) for hospital days



* Variables listed in order of size of coefficient; omitted chronic diseases did not have statistically significant coefficient.

FIGURE 8
Confidence intervals for coefficients of chronic disease variables* (among those aged ≥60) for hospital days



* Variables listed in order of size of coefficient; omitted chronic diseases did not have statistically significant coefficient.

The confidence intervals reported are, of course, dependent on the sample size and the particular estimation technique used. The use of bootstrapping estimation would have produced wider confidence intervals. The larger sample size in the 2000/01 Canadian Community Health Survey (not available to us when the analysis was conducted) would have produced smaller confidence intervals.

Our analysis does not attempt to study the entire economic burden of chronic disease in Canada, but, rather, only some aspects of the direct burden due to health services utilization. One of the prime shortcomings of our analysis is the omission of hospitalization in estimation of the overall economic burden of chronic disease. The main reason for its omission was the small samples of patients in specific disease groups, with the consequent loss of statistical power. However, even just focusing on physician services, our analysis indicates that the adjustment for comorbidities will have an impact on economic burden rankings. As well, we believe that decomposing the analysis will provide a more precise approach to measuring the concepts of economic burden and attributable costs.

Acknowledgements

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Rates of claims for cumulative trauma disorder of the upper extremity in Ontario workers during 1997

Dianne Zakaria, James Robertson, John Koval, Joy MacDermid and Kathleen Hartford

Abstract

Surveillance of work-related cumulative trauma disorder of the upper extremity (CTDUE) requires valid and reliable claim extraction strategies and should examine for confounding and interaction. This research estimated crude and specific rates of CTDUE claims in Ontario workers during 1997 while acknowledging misclassification and testing for confounding and interaction. Lower and upper limit event estimates were obtained by means of an algorithm applied to the Ontario Workplace Safety and Insurance Board (OWSIB) database and were combined with "at-risk" estimates obtained from the Canadian Labour Force Survey (LFS). Poisson regression was used to evaluate confounding and interaction. The method used to identify CTDUE claims had a substantial impact on the magnitude of rates, female to male rate ratios, the most commonly affected part of the upper extremity and the highest risk occupational categories. Poisson regression identified sex interactions. It allowed rigorous evaluation of the data and indicated that rates should be examined separately for men and women. Researchers should clearly define extraction strategies and examine the impact of misclassification.

Key words: *algorithm misclassification; cumulative trauma disorder; Poisson regression; rates; sex interactions; surveillance; upper extremity; workers' compensation*

Statement of problem

Cumulative trauma disorder of the upper extremity (CTDUE) is an umbrella term used to describe injuries that result from repeated use of the upper extremity over time rather than from a specific incident.[1] Common examples of CTDUE include carpal tunnel syndrome, tendinitis and epicondylitis. Although the proportion of work-related claims attributable to cumulative trauma appears minimal, ranging from less than 1% to 8.7%,[2,3] CTDUE claims are more costly and work disabling than acute upper extremity claims[4–6] or workers' compensation claims in general.[3,7] Hence, accurate identification of high-risk groups is important to ascertain risk factors, initiate appropriate control activities and monitor their effectiveness.

However, an extensive review of the literature has revealed that the range in rates and rate ratios is substantial when work-related cumulative trauma disorders are considered.[8] A significant contributor to this variation may be the method of defining and extracting claims. Consequently, to provide more meaningful and comparable surveillance information, analyses should attempt to use well defined, valid and reliable extraction strategies. Furthermore, general conclusions on differences in the rate of CTDUE claims across gender, age groups, part of upper extremity or occupation should acknowledge confounding and interaction. For example, a statement regarding increased risk of CTDUE claims among women relative to men based solely on gender-specific rates may be inappropriate if male and female populations differ with respect to composition factors associated with the risk of CTDUE, such as age or occupation.

Rationale for present research

This research had three important objectives. First was the estimation of crude and specific rates of first-allowed, lost-time CTDUE claims among workers covered by the Ontario Workplace Safety and Insurance Board (OWSIB) during the 1997 calendar year. A first-allowed claim is a newly registered, accepted claim for a previously unreported injury or disease, and lost-time refers to the loss of wages.[9] The second objective was to provide insight into the cause of the substantial variation in published rates and rate ratios by examining the impact of two different methods of defining and extracting CTDUE claims. The last was to demonstrate how Poisson regression could be used to identify and address confounding and interaction.

Methods

Identifying CTDUE claims

An algorithm[10] was used to identify CTDUE claims in the OWSIB database. This algorithm used coded information regarding "nature of injury or disease", "part of body"

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and "event or exposure" to classify claims into one of three mutually exclusive categories: "definite", "possible" and "non-CTDUE". The definite category was developed to capture those claims that occurred gradually over time through voluntary actions of the worker but did not produce visible trauma. The possible category was used to capture those claims that could be related to a specific incident involving voluntary actions or free bodily motion but did not produce visible trauma. Finally, the non-CTDUE category captured those claims related to a specific, untoward event producing visible trauma.

Examination of agreement between the algorithm and claim review revealed that 96.3% of claims in the algorithm definite category, 29.1% of claims in the algorithm possible category and 2.8% of claims in the algorithm non-CTDUE category were actually defined as definite CTDUE by claim review. To acknowledge algorithm misclassification, two methods of identifying CTDUE claims were used. The lower limit estimate used algorithm definite CTDUE claims. According to claim review, this category contained a homogeneous group of definite CTDUE claims. The upper limit estimate was obtained by combining algorithm definite claims and algorithm possible upper extremity claims. The upper limit estimate resulted from the following reasoning: although the claimant may be able to attribute his or her injury to a particular incident, such as voluntary lifting, pulling or pushing, this incident may have been the proverbial "straw that broke the camel's back". That is, the identified incident may have been sufficient insult to an already compromised site rather than the only insult to a healthy site.

Estimating the population at risk

The Canadian Labour Force Survey (LFS) was used to obtain estimates of the population at risk of a CTDUE injury. This involved extracting the class of worker most likely to be insured by the OWSIB and using actual hours worked to estimate full-time equivalents at risk.[11]

Rate estimation

All first-allowed, lost-time claims occurring in those aged 15 years or greater with a date of injury or disease in the 1997 calendar year (105,556) were sorted by the algorithm into definite (3,279), possible (9,520), or non-CTDUE claims (92,757). Since the OWSIB and 1997 LFS collected information regarding sex, age, and occupation and the OWSIB collected additional information regarding part of body, specific rates were calculated by combining information from the two data sources. The following body part categories were used: "upper extremity", "neck & shoulder/shoulder & upper arm", "elbow & forearm", and "wrist & hand". Previous research examining these categories has indicated almost perfect agreement (kappa $\geq$ 0.81) between the OWSIB coders and claim review.[10] The definite rates used algorithm definite claims while the definite plus possible rates combined algorithm definite and possible upper extremity claims. Rate standard errors were calculated according to Armitage and Berry[12] and were used for standard 95% confidence intervals (CI).

Prevention index

Since focussing intervention efforts on the highest risk occupations will have little impact on claim numbers if the at-risk populations are small, a prevention index was used to prioritize occupations for intervention purposes.[3] All occupations were ranked according to their frequency of CTDUE claims and their CTDUE claim rate. The index is the mean of these two ranks. For example, an occupation that ranks first with respect to frequency of claims and claim rate will have a prevention index equal to one, making it worthy of increased attention and resources from a population, public health perspective.

Poisson regression modelling: the effect of sex, age, part of upper extremity and occupation on the rate of CTDUE claims

For each estimation method, claim counts of cumulative trauma disorder providing the most detail on sex, age, part of upper extremity and occupation as well as at-risk estimates were used in Poisson regression. Age was coded as a categorical variable because a curvilinear relation has been suggested.[13] On the basis of previous research, the following interactions were considered:

1. sex*age, as the highest risk age category may not be consistent across sex;[13]
2. sex*part of upper extremity, as the female to male rate ratio for CTDUE seems to vary depending on whether the whole upper extremity or just carpal tunnel syndrome is considered;[6,14–17]
3. sex*occupation, as the effect of occupation may not be consistent across sex;[18,19] and
4. part of upper extremity*occupation, as different jobs may be at risk for different subgroups of CTDUE.[20–28]

The model fitting process was executed as per Hosmer and Lemeshow.[29] Briefly, all four explanatory variables were included in the initial model. An overall likelihood ratio test was conducted on the full main effects model to determine whether at least one of the explanatory variables was an important predictor of the log of the CTDUE rate. If the overall likelihood ratio test was statistically significant, a stepwise backward elimination procedure was applied using the partial likelihood ratio test at an alpha level of 0.10.[30] A variable was removed if the likelihood ratio test p value was greater than 0.10 *and* its removal did not change the magnitude of any of the remaining regression coefficients by 10% or more. The latter requirement prevented the removal of important confounders[29] with the 10% standard recommended by Koval.[31] Once the main effects model had been established, interactions were added, one at a time, and their significance (alpha = 0.05) was examined using a partial likelihood ratio test. The significant interaction with the smallest p value decided how the initial model was split. The modelling process was then repeated on the sub-models. Model fit was examined by means of the Goodness of Fit test, regression diagnostics and pseudo-coefficients of determination.

TABLE 1
Crude and sex-specific CTDUE (cumulative trauma disorder of the upper extremity) claim rates by part of upper extremity in Ontario workers, 1997

		CTDUE Rate Estimation Method*		
	Part of upper extremity	Algorithm definite (confidence intervals)	Algorithm definite + possible (confidence intervals)	Inflation factor
All	Upper extremity**	81.68 (78.46, 84.91)	254.82 (247.80, 261.84)	3.12
	Neck/shoulder/upper arm	12.18 (11.08, 13.29)	117.76 (113.68, 121.83)	9.67
	Elbow/forearm	20.68 (19.21, 22.14)	37.59 (35.56, 39.63)	1.82
	Wrist/hand	45.81 (43.53, 48.09)	89.38 (85.97, 92.79)	1.95
Men	Upper extremity	67.38 (63.79, 70.97)	254.99 (246.79, 263.18)	3.78
	Neck/shoulder/upper arm	10.24 (8.92, 11.56)	125.64 (120.46, 130.82)	12.27
	Elbow/forearm	19.02 (17.21, 20.83)	38.38 (35.75, 41.01)	2.02
	Wrist/hand	36.32 (33.76, 38.87)	81.58 (77.58, 85.59)	2.25
Women	Upper extremity	101.35 (96.16, 106.55)	254.54 (245.44, 263.63)	2.51
	Neck/shoulder/upper arm	14.85 (12.99, 16.71)	106.91 (101.56, 112.27)	7.2
	Elbow/forearm	22.96 (20.63, 25.28)	36.51 (33.54, 39.47)	1.59
	Wrist/hand	58.87 (55.04, 62.71)	100.05 (94.90, 105.21)	1.70

* Rates are expressed per 100,000 employee full-time equivalents with 95% confidence intervals.
** The upper extremity category included the following: neck & shoulder, shoulder & upper arm, elbow & forearm, wrist & hand, upper extremity unspecified, and multiple upper extremity locations.

Results

Crude and part of upper extremity-specific rates

The definite plus possible crude CTDUE claim rate was 3.12 times greater than the definite rate, but the increase in the rate was inconsistent across part of upper extremity (Table 1). Hence, the part of upper extremity rate ranking varied across estimation method. CTDUE claims accounted for 3.11% to 9.69% of all first-allowed, lost-time claims in those aged 15 years or greater.

Sex and part of upper extremity-specific rates

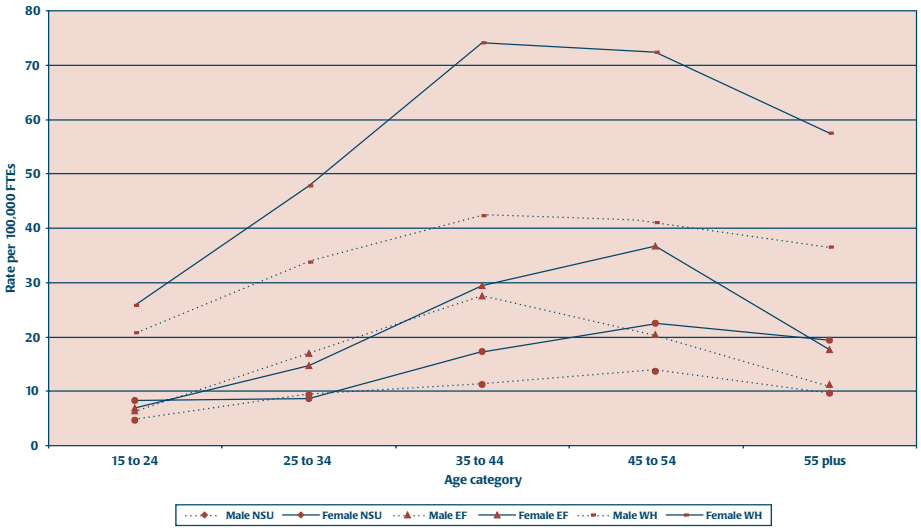
Female to male rate ratios differed across estimation method (Table 1). Using the definite estimation method, female to male rate ratios ranged from a low of 1.21 for the elbow & forearm to a high of 1.62 for the wrist & hand. Using the definite plus possible estimation method, female to male rate ratios ranged from a low of 0.85 for the neck & shoulder/shoulder & upper arm to a high of 1.23 for the wrist & hand.

Sex, part of upper extremity and age-specific rates

Using the definite estimation method, both sexes demonstrated a parabolic relation between age and rate for each part of the upper extremity (Figure 1). The rates generally peaked in the 35 to 44 and 45 to 54 age group for men and women respectively, and the female to male rate ratio was usually the greatest in the 45 to 54 age group.

Using the definite plus possible estimation method, women continued to show a parabolic relation for all parts of the upper extremity whereas men demonstrated a parabolic relation for the elbow & forearm

FIGURE 1
CTDUE claim rates by sex, part of upper extremity (NSU = Neck & Shoulder/Shoulder & Upper Arm; EF = Elbow & Forearm; WH = Wrist & Hand) and age using the definite estimation method



only (Figure 2). These parabolic relations were not as pronounced as in the definite method. Although male rates did not consistently peak in a particular age group, female rates again peaked in the 45 to 54 year age group and female to male rate ratios were greatest in the 45 to 54 year age group.

Sex, part of upper extremity and occupation-specific rates

Occupational categories with the highest rates or prevention indexes were not always consistent across sex and part of upper extremity subgroups, or rate estimation method. However, regardless of estimation method, the occupational categories "textiles, furs & leather goods" and "other machining occupations" generally occurred in the top five highest rates and prevention indexes for both sexes across part of upper extremity, and "metal products, not elsewhere classified" generally occurred in the top five prevention indexes for both sexes across part of upper extremity (Figure 3).

Poisson regression modelling

For both rate estimation methods, separate models were run for men and women because of significant interactions by sex (Tables 2 and 3). A part of upper extremity*occupation interaction could not be tested in the sex-specific models as a result of sparse data. For both sexes, each explanatory variable was a statistically significant ($\alpha = 0.05$) predictor of the rate of CTDUE claims in the presence of the remaining variables.

Men and women demonstrated a parabolic relation between the rate of CTDUE claims and age, peaking in the 35 to 44 and 45 to 54 year age categories respectively. The parabolic relation was less pronounced in the definite plus possible estimation method, particularly for the men.

Using the definite rate estimation method, the rates of elbow & forearm and neck & shoulder/shoulder & upper arm claims were significantly less than was the rate of wrist & hand claims, with rate ratios of approximately 0.5 and 0.25 respectively. When using the definite plus possible rate estimation method, the rate ratios for part of upper extremity were not consistent across sex. Although men and women demonstrated a significantly lower rate of elbow & forearm claims relative to the wrist & hand, the rate of neck & shoulder/shoulder & upper arm claims was significantly greater than the wrist & hand in men, with no practically important difference noted in women.

The five occupational categories with the highest rate ratios, according to the point estimates, are bolded in Tables 2 and 3. When the effect of occupation across sex was compared, there were indications of both qualitative and quantitative interactions. With a qualitative interaction, an exposure's effect is opposite across subgroups, whereas with a quantitative interaction, an exposure's effect varies in

FIGURE 2
CTDUE claim rates by sex, part of upper extremity (NSU = Neck & Shoulder/Shoulder & Upper Arm; EF = Elbow & Forearm; WH = Wrist & Hand) and age using the definite + possible estimation method

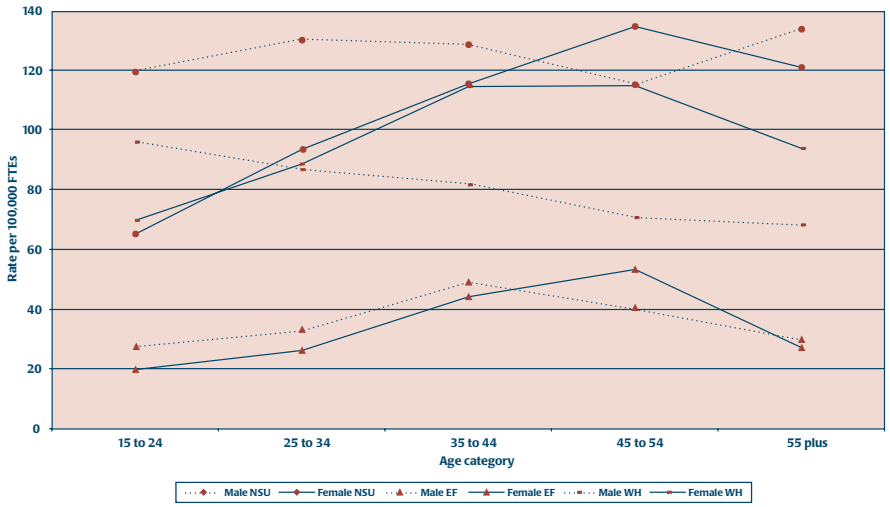
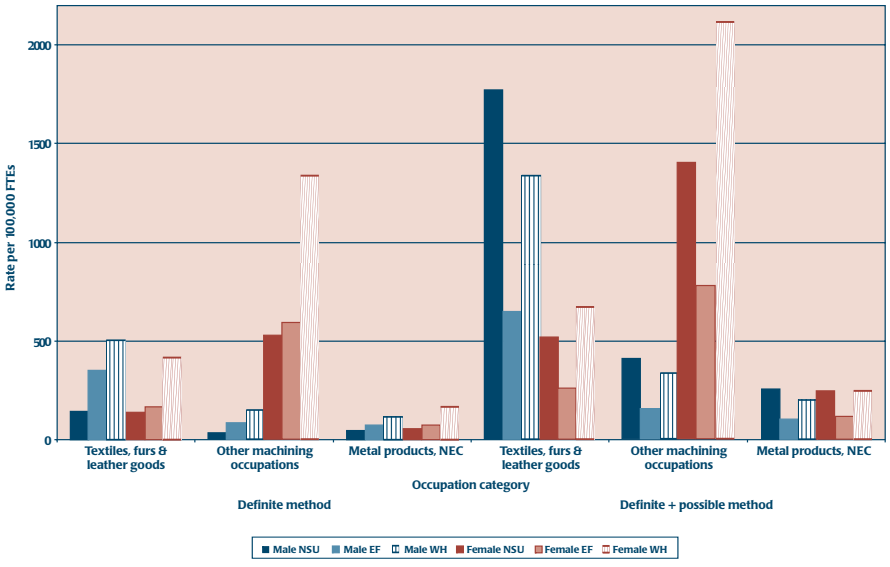


FIGURE 3
CTDUE claim rates by sex, part of upper extremity (NSU = Neck & Shoulder/Shoulder & Upper Arm; EF = Elbow & Forearm; WH = Wrist & Hand) and occupation by estimation method



magnitude across subgroups.[31] As an example of a qualitative interaction in the definite Poisson regression models, the rate of CTDUE claims in the occupation "other processing" was significantly less than that of "metal products, nec" among men (rate ratio = 0.373, 95% CI 0.271– 0.502), whereas among women it was significantly greater (rate ratio = 1.782, 95% CI 1.263–2.481). As an example of quantitative interaction, the rate of CTDUE claims in "textiles, furs, and leather goods" was 4.249 times greater (95% CI 3.339–5.363) than that of "metal products, nec" among men, whereas among women it was 2.185 times greater (95% CI 1.718–2.791).

When model fit for the definite estimation method was examined, the goodness of fit test, regression diagnostics and pseudo-coefficient of determination suggested that the male model fit the data well. For the female model, the goodness of fit test was borderline significant. Examination of the standardized residuals identified one extreme outlier. When the observation producing this residual was removed from the data set and the model re-fitted, the goodness of fit test p value increased (Deviance = 615.210, degrees of freedom = 577, p = 0.1313), but the model parameters remained virtually the same, suggesting that the outlier was not influential. Hence, the original model was considered to fit the data well. When model fit for the definite plus possible estimation method was examined, the goodness of fit test and regression diagnostics suggested poor model fit for both sexes.

Discussion

Part of upper extremity-specific rates

The crude CTDUE claim rate derived using the definite method, 81.68 per 100,000 full-time equivalents (FTEs) (Table 1), was congruous with the rate for Ontario in 1991.[14] However, acknowledging the algorithm misclassification inflated the crude rate by a factor of 3.12 to 254.82 per 100,000 FTEs. Similarly, the proportion of all first-allowed, lost-time claims

TABLE 2
Poisson regression modelling of the definite CTDUE (cumulative trauma disorder of the upper extremity) claim rate by sex in Ontario workers, 1997

Characteristic	Rate ratio (95% likelihood ratio confidence interval) Men (n = 585)	Women (n = 627)
*Age		
15 to 24	0.355 (0.279, 0.446)	0.333 (0.263, 0.417)
25 to 34	0.760 (0.667, 0.866)	0.607 (0.530, 0.695)
35 to 44	1 (–––––––––-)	1 (–––––––––)
45 to 54	0.954 (0.831, 1.094)	1.061 (0.937, 1.200)
55 plus	0.706 (0.569, 0.867)	0.717 (0.579, 0.880)
*Part of upper extremity		
Wrist & hand	1 (–––––––––)	1 (–––––––––)
Elbow & forearm	0.525 (0.467, 0.591)	0.401 (0.355, 0.451)
Nck & shoulder/shoulder & upper arm	0.274 (0.235, 0.317)	0.261 (0.226, 0.300)
*Occupation		
Metal products, NEC	1 (–––––––––-)	1 (–––––––––)
Government officials & administrators	0.037 (0.006, 0.115)	0.434 (0.247, 0.712)
Other managers & administrators	0.004 (0.001, 0.011)	0.014 (.006, 0.027)
Management & administration related	–	0.053 (0.031, 0.086)
Physical & life sciences	0.067 (0.017, 0.176)	0.164 (0.050, 0.391)
Math, statistics, systems analysis & related	0.033 (0.012, 0.071)	0.050 (0.015, 0.119)
Architects & engineers	0.007 (0.000, 0.033)	0.072 (0.004, 0.324)
Architecture & engineering related	0.118 (0.050, 0.232)	0.082 (0.005, 0.368)
Social sciences & related	–	0.101 (0.057, 0.165)
University teaching & related	–	0.033 (0.002,0.149)
Elementary/secondary school teaching & related	–	0.007 (0.001, 0.022)
Other teaching & related	–	0.041 (.007, 0.130)
Nursing, therapy & related	0.035 (0.002, 0.155)	0.130 (0.091, 0.184)
Other medicine & health	–	0.149 (0.085, 0.245)
Artistic & recreational	0.034 (0.008, 0.090)	0.027 (0.004, 0.086)
Stenographic & typing	0.631 (0.036, 2.802)	0.270 (0.198, 0.366
Bookkeeping, account-recording & related	0.018 (0.001, 0.081)	0.240 (0.181, 0.316)
Office Machine & EDP operator	0.085 (0.014, 0.265)	0.363 (0.235, 0.542)
Material recording, scheduling & distribution	0.115 (0.065, 0.187)	0.171 (0.080, 0.319)
Reception, information, mail & message	0.554 (0.355, 0.824)	0.374 (0.264, 0.521)
Library, file, correspondence clerks & related	0.108 (0.046, 0.211)	0.265 (0.199, 0.353)
Sales, commodities	0.098 (0.064, 0.143)	0.293 (0.219, 0.391)
Sales, services & other sales	0.074 (0.032, 0.146)	0.045 (0.016, 0.100)
Protective services	0.037 (0.013, 0.080)	0.194 (0.076, 0.404)
Food & beverage preparations/lodging & accomodation	0.219 (0.144, 0.318)	0.258 (0.190, 0.349)
Personal, apparel & furnishings service	0.303 (0.120, 0.623)	0.266 (0.180, 0.385)
Other service	0.328 (0.241, 0.439)	0.944 (0.701, 1.265)
Farmers & farm management	–	1.432 (0.081, 6.416)

TABLE 2 (continued)
Poisson regression modelling of the definite CTDUE (cumulative trauma disorder of the upper extremity) claim rate by sex in Ontario workers, 1997

Characteristic	Rate ratio (95% likelihood ratio confidence interval)	
	Men ($n = 585$)	Women ($n = 627$)
*Occupation (continued)		
Other farming, horticultural & animal husbandry	0.360 (0.226, 0.545)	0.760 (0.457, 1.199)
Fishing, hunting, trapping & related	**3.284 (0.544, 10.246)**	–
Forestry & logging	**1.103 (0.547, 1.965)**	–
Mining & quarrying	**1.208 (0.815, 1.727)**	–
Food, beverage & related processing	1.093 (0.833, 1.416)	**2.051 (1.566, 2.687)**
Other processing	0.373 (0.271, 0.502)	1.782 (1.263, 2.481)
Metal shaping & forming	0.795 (0.624, 1.005)	0.952 (0.466, 1.730)
Other machining occupations	**1.120 (0.900, 1.388)**	**8.894 (6.625, 11.892)**
Electrical, electronic & related equipment	0.185 (0.123, 0.269)	0.943 (0.679, 1.296)
Textiles, furs, and leather goods	**4.249 (3.339, 5.363)**	**2.185 (1.718, 2.791)**
Wood products, rubber, plastics & related & other	0.812 (0.652, 1.005)	1.773 (1.362, 2.311)
Mechanics & repairmen	0.381 (0.306, 0.473)	1.031 (0.435, 2.056)
Excavating, grading, paving & related	0.159 (0.075, 0.290)	–
Electrical power, lighting & wire communication	0.352 (0.231, 0.514)	**1.868 (0.660, 4.124)**
Other construction	0.370 (0.288, 0.470)	1.289 (0.503, 2.696)
Motor transport operators	0.105 (0.071, 0.150)	0.030 (0.002, 0.133)
Other transportation operators	0.601 (0.359, 0.942)	**1.970 (0.831, 3.927)**
Material handling	0.221 (0.155, 0.307)	0.524 (0.366, 0.738)
Other crafts & equipment operators & NEC	0.218 (0.137, 0.330)	0.999 (0.646, 1.493)
Goodness of fit test		
Deviance	516.1675, df = 539, $p = 0.7534$	633.2577, df = 578, $p = 0.0553$

Note: Reference categories are indicated by the estimate 1. Occupation was coded as per the Labour Force Survey 1997. The top five point estimates have been bolded for the occupation construct. Dashes indicate a lack of events in the occupation category or an at-risk estimate of zero.
NEC = not elsewhere classified; EDP = electronic data processor.
* Statistically significant ($p < 0.0001$) predictor of the rate of CTDUE claims in the presence of the remaining variables.

attributable to CTDUE varied substantially, from 3.11% to 9.69%. These findings indicate that considerable variation in rates and proportions can be ascribed to the method used to define and extract claims. The variation was so great that the neck & shoulder/shoulder & upper arm, which was at lowest risk using the definite method, was at greatest risk using the definite plus possible method (Table 1). Thus, by acknowledging potential misclassification, attention is drawn to the vulnerability of the neck & shoulder/shoulder & upper arm and risk factors previously associated with this area.[20]

Sex and part of upper extremity-specific rates

The overall female to male rate ratio calculated using the definite method, 1.5 (Table 1), is comparable to that noted for Ontario in 1991,[14] but acknowledging the potential misclassification reduced the ratio to 1.0. Despite the equality of the overall definite plus possible rates, female to male rate ratios continued to vary across part of upper extremity. Men had a higher neck & shoulder/shoulder & upper arm claim rate, and women had a higher wrist & hand claim rate. Several reasons may account for this differential. First, men and women had different occupational distributions and thus were exposed to different job-related risk factors in 1997 ($\chi^2 = 1334310$, df = 48, $p < 0.0001$). Second, there may be sex differences in tasks within the same job title.[18,19] Finally, there are many sex differences not examined by this research.[8]

Sex, part of upper extremity and age-specific rates

When the definite method is used, a parabolic relation between the rate of CTDUE claims and age was demonstrated (Figure 1). This is counterintuitive, as one would expect the rate of CTDUE claims to increase with age as a result of the degenerative effect of aging and confounding with duration of exposure.[8] The decreased rate after the peak may be the result of the healthy worker survivor effect;[32–34] workers progressing to physically less stressful jobs with seniority; or OWSIB policy, which indicates that recurrences or associated disorders should be documented on the initially established claim.[9]

With algorithm misclassification taken into account, the male rate varied little with age for the neck & shoulder/shoulder & upper arm and demonstrated a statistically significant linear decline for the wrist & hand ($F_{1,3} = 98.79$, $p = .0022$, $r^2 = 0.97$) (Figure 2). The varying effect of age may be the consequence of the type of claims falling into the algorithm possible category. These claims were primarily from males; generally diagnosed as sprains, strains, tears; mainly affected the neck & shoulder/shoulder & upper arm and wrist & hand; and predominantly resulted from some form of overexertion. Perhaps the high force component of these injuries negates the need for prolonged exposure that is associated with age.

TABLE 3
Poisson regression modelling of the definite + possible CTDUE (cumulative trauma disorder of the upper extremity) claim rate by sex in Ontario workers, 1997

Characteristic	Rate ratio (95% likelihood ratio confidence interval)	
	Men ($n = 660$)	Women ($n = 633$)
*Age		
15 to 24	0.826 (0.753, 0.906)	0.544 (0.480, 0.616)
25 to 34	0.965 (0.901, 1.034)	0.824 (0.758, 0.895)
35 to 44	1 (————————)	1 (————————)
45 to 54	0.855 (0.790, 0.924)	1.046 (0.963, 1.135)
55 plus	0.849 (0.762, 0.944)	0.776 (0.678, 0.884)
*Part of upper extremity		
Wrist & hand	1 (————————)	1 (————————)
Elbow & forearm	0.469 (0.432, 0.509)	0.375 (0.341, 0.412)
Neck & shoulder/shoulder & upper arm	1.541 (1.452, 1.636)	1.098 (1.026, 1.176)
*Occupation		
Metal products, NEC	1 (————————)	1 (————————)
Government officials & administrators	0.051 (0.020, 0.103)	0.323 (0.206, 0.482)
Other managers & administrators	0.006 (0.003, 0.010)	0.015 (0.009, 0.024)
Management & administration related	0.010 (0.004, 0.021)	0.039 (0.026, 0.057)
Physical & life sciences	0.088 (0.042, 0.160)	0.081 (0.025, 0.190)
Math, statistics, systems analysis & related	0.013 (0.005, 0.029)	0.024 (0.007, 0.056)
Architects & engineers	0.019 (0.008, 0.039)	0.033 (0.002, 0.146)
Architecture & engineering related	0.086 (0.046, 0.145)	0.079 (0.013, 0.245)
Social sciences & related	0.094 (0.051, 0.156)	0.201 (0.151, 0.263)
University teaching & related	–	0.065 (0.020, 0.154)
Elementary/secondary school teaching & related	0.019 (0.006, 0.044)	0.053 (0.036, 0.077)
Other teaching & related	0.014 (0.001, 0.061)	0.216 (0.134, 0.329)
Nursing, therapy & related	**1.398 (1.115, 1.733)**	0.859 (0.736, 1.006)
Other medicine & health	0.080 (0.028, 0.172)	0.180 (0.127, 0.248)
Artistic & recreational	0.061 (0.034, 0.102)	0.056 (0.026, 0.102)
Stenographic & typing	0.766 (0.190, 1.996)	0.167 (0.129, 0.214)
Bookkeeping, account-recording & related	0.054 (0.025, 0.102)	0.209 (0.171, 0.255)
Office machine & EDP operator	0.034 (0.006, 0.104)	0.200 (0.134, 0.286)
Material recording, scheduling & distribution	0.379 (0.311, 0.457)	0.337 (0.233, 0.473)
Reception, information, mail & message	1.007 (0.811, 1.237)	0.351 (0.275, 0.445)
Bookkeeping, account-recording & related	0.054 (0.025, 0.102)	0.209 (0.171, 0.255)
Office machine & EDP operator	0.034 (0.006, 0.104)	0.200(0.134, 0.286)
Material recording, scheduling & distribution	0.379 (0.311, 0.457)	0.337 (0.233, 0.473)
Other service	0.624 (0.537, 0.723)	1.451 (1.207, 1.746)
Farmers & farm management	–	0.769 (0.044, 3.413)
Other farming, horticultural & animal husbandry	0.451 (0.354, 0.567)	0.757 (0.542, 1.034)

Regardless of estimation method and part of upper extremity, the female to male age-specific rate ratios commonly peaked in the 45 to 54 age group, indicating that this age period is of particularly high risk for women. This vulnerability may be related to the hormonal changes or hormone replacement therapy associated with menopause.[8]

Sex, part of upper extremity and occupation-specific rates

Congruous with previous research, the effect of occupation on the CTDUE claim rate was not consistent across sex[16,17] or part of upper extremity.[20–28] Potential reasons for the first interaction have been discussed. The latter interaction suggests that different occupations are characterized by different typical duties that may stress different parts of the upper extremity. For both men and women, the occupational categories "textiles, furs & leather goods" and "other machining occupations" generally ranked in the top five highest rates and prevention indexes for each part of the upper extremity across estimation methods. These occupational categories had relatively stable rates and collectively accounted for 2.1% of the employee FTEs in 1997. The importance of the occupational category "metal products, nec" was identified through the prevention index. Although this occupational category did not consistently appear among the highest rates for each part of the upper extremity across estimation methods, it generally ranked in the top five prevention indexes because it accounted for a large proportion of employee FTEs in 1997 – i.e. 3.5%. All these occupational categories would be worthy of greater scrutiny to determine which specific occupations and associated duties or work organization factors are responsible for the increased risk.

Poisson regression modelling

Poisson regression modelling allowed a more rigorous evaluation of the data than did the calculation and comparison of specific rates. In fact, this is one of the primary advantages of Poisson regression: to identify and quantify systematic trends that are

TABLE 3 (continued)
Poisson regression modelling of the definite + possible CTDUE (cumulative trauma disorder of the upper extremity) claim rate by sex in Ontario workers, 1997

Characteristic	Rate ratio (95% likelihood ratio confidence interval)	
	Men ($n = 660$)	Women ($n = 633$)
*Occupation (continued)		
Fishing, hunting, trapping & related	1.094 (0.182, 3.392)	–
Forestry & logging	1.020 (0.653, 1.510)	1.337 (0.076, 5.961)
Mining & quarrying	0.742 (0.538, 0.995)	–
Food, beverage & related processing	**1.131 (0.954, 1.335)**	**1.844 (1.519, 2.238)**
Other processing	0.612 (0.518, 0.721)	**1.748 (1.375, 2.208)**
Metal shaping & forming	0.853 (0.733, 0.990)	1.350, 0.891, 1.965)
Other machining occupations	**1.629 (1.436, 1.847)**	**7.254 (5.846, 8.972)**
Electrical, electronic & related equipment	0.195 (0.150, 0.248)	0.708 (0.549, 0.906)
Textiles, furs, and leather goods	**6.903 (6.044, 7.873)**	**2.259 (1.908, 2.682)**
Wood products, rubber, plastics & related & other	0.887 (0.774, 1.015)	1.555 (1.285, 1.881)
Mechanics & repairmen	0.502 (0.440, 0.572)	1.510 (0.936, 2.305)
Excavating, grading, paving & related	0.181 (0.117, 0.266)	–
Electrical power, lighting & wire communication	0.491 (0.390, 0.611)	1.252 (0.533, 2.458)
Other construction	0.460 (0.397, 0.531)	1.522 (0.879, 2.449)
Motor transport operators	0.463 (0.403, 0.530)	0.164 (0.084, 0.286)
Other transportation operators	**2.242 (1.868, 2.674)**	**4.578 (3.118, 6.504)**
Material handling	0.741 (0.647, 0.847)	0.676 (0.539, 0.844)
Other crafts & equipment operators & NEC	0.550 (0.453, 0.664)	0.885 (0.646, 1.191)
Goodness of fit test		
Deviance	1134.1943, df = 609, $p < 0.0001$	1197.1515, df = 583, $p < 0.0001$

Note: Reference categories are indicated by the estimate 1. Occupation was coded as per the Labour Force Survey 1997. The top five point estimates have been bolded for the occupation construct. Dashes indicate a lack of events in the occupation category or an at-risk estimate of zero.

NEC = not elsewhere classified; EDP = electronic data processor.

* Statistically significant ($p < 0.0001$) predictor of the rate of CTDUE claims in the presence of the remaining variables.

not easily appreciated in a large volume of data.[35,36] Poisson regression usually identified statistically significant sex*part of upper extremity, sex*age and sex*occupational category interactions, which were reflected in the specific rates (Table 1, Figures 1, 2 and 3). Hence, using conventional standardization techniques to make comparisons across sex or occupation would not convey the complexity of the differences.[37] Thus, Poisson regression indicates that male and female rates should be examined separately.

Several factors may have contributed to poor model fit when misclassification was acknowledged (Table 3). First, the final model presented assumed no interactions, but Figures 2 and 3 suggested potential age*part of upper extremity and part of upper extremity*occupation interactions respectively. Adequate data did not exist to test the latter interaction, but the former interaction was statistically significant ($p < 0.05$) for both the men and women. Second, the models did not include any work organization or detailed ergonomic measures previously associated with CTDUE. Third, the definite plus possible method of estimation may have combined claims with different risk factors into one overall rate to be predicted by the same model. For example, algorithm definite claims tended to be related to repetitiveness whereas algorithm possible claims were primarily related to overexertion.[10] Thus, although the overall Poisson regression models and each of their components were statistically significant when using the definite plus possible rate estimation method, the observed summary measures for the effect of age, part of upper extremity and occupational category may not be accurate across worker subgroups.

Choice of estimation method

Estimation method had a dramatic impact on the conclusions. If information on the cost and disability associated with claims falling into the algorithm definite and possible categories was available, attention could be focused on the estimation method that identified the most costly and disabling claims.

Limitations

Several limitations need to be acknowledged. First, the specificity of the occupational categories was limited by the level of detail used in the LFS. Consequently, some occupations at high risk may be masked by the aggregation, but an elevated risk despite the aggregation is certainly worthy of increased attention. Hence, this type of surveillance activity can be used to stimulate more detailed epidemiologic investigations, target resources for ergonomic evaluations and prevention, and evaluate control activities.[38,39]

Second, exposure was quantified using broad occupational categories rather than accurate measurements of risk factors. This crude measure of exposure probably contributed to the poor fitting models. Third, first-allowed, lost-time claims were used rather than all first-allowed claims, because only the former were adequately coded for algorithm application. Hence, the rates reflect those injuries significant enough to

result in a loss of wages. It is possible that occupational categories identified as low risk may have a substantial occurrence of CTDUE claims that do not result in lost wages.

Finally, as the rates became more and more specific, stability was compromised by a decreasing number of events and smaller population at-risk estimates.[40] One solution to this problem could be the combining of data from consecutive calendar years to increase the number of events and population at-risk estimates for the more specific rates. However, when choosing which years to combine, changes in OWSIB policy or claim coding and LFS methodology should be considered.

Conclusions

The method used to identify CTDUE claims had a substantial impact on the magnitude of rates, female to male rate ratios, the most commonly affected part of the upper extremity and the highest risk occupational categories. Adjusting for the potential misclassification of an extraction algorithm increased the crude rate of CTDUE claims in OWSIB-covered workers by a factor of 3.12, decreased the female to male rate ratio from 1.50 to 1.00 and identified the neck & shoulder/shoulder & upper arm as being just as vulnerable as the wrist & hand. The 45 to 54 year age category was noted to be a particularly high-risk period for women. The occupational categories "textiles, furs & leather goods", "other machining occupations" and "metal products, nec" were identified as being worthy of greater investigation. Consistent with previous research, Poisson regression identified sex interactions indicating that rates in men and women should be examined separately.

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Rates and external causes of blunt head trauma in Ontario: Analysis and review of Ontario Trauma Registry datasets

William Pickett, Kelly Simpson and Robert J Brison

Abstract

Contemporary studies of blunt head trauma and its determinants are important for prevention. It is also important to understand the strengths and limitations of the common sources of data used for the ongoing study of these injuries. Using the Ontario Trauma Registry, we described frequent patterns of blunt head trauma and identified priorities for prevention and research. A review of methodological issues that arose during the analysis of these trauma registry data is also provided. Blunt head trauma cases were identified within two data sets of the Ontario Trauma Registry. The Minimal Data Set is population-based and contains acute care injury hospitalizations, and the Comprehensive Data Set contains "major injuries" treated at a lead trauma hospital. Injury control priorities varied by age group, sex and data set and these are profiled in the manuscript. The results indicate the importance of examining multiple sources of surveillance data in establishing injury control priorities. The methodological review demonstrated the need to critically examine the completeness and accuracy of trauma registry data in arriving at decisions about priorities.

Key words: *blunt head trauma; head injury; injury surveillance; neurotrauma prevention*

Introduction

Contemporary studies of blunt head trauma and its determinants are important to the prevention of these injuries and their clinical management. These forms of neurotrauma contribute to high levels of morbidity, long-term disability, mortality, and associated economic burdens.[1–3] Injuries are generally preventable, non-random events,[4] therefore prevention efforts aimed at reducing the magnitude and minimizing the consequences of these head injuries are important. Formal quantification of the magnitude of the problem and assessment of injury patterns are necessary steps in the development of prevention efforts, and basic epidemiological analyses are helpful in this regard.

Reported incidence rates for head injury range from 17 to 444 per 100,000 population annually.[5–16] Definitions and terminology used in the study of these injuries vary, which contributes to the disparity in results and makes it difficult to compare study findings.[17,18] Published case series use definitions of head trauma that range from mild to severe forms.[19] Potential sources of cases vary from records of emergency department and outpatient visits to those that describe hospitalizations and deaths.[18] Common patterns of injury experienced vary with the severity of the cases under study. For example, the proportion of head injuries attributable to motor vehicle crashes increases with severity of injury[18,20–23] whereas falls result in severe head trauma less often but are a recurrent cause of minor head injury.[3,18,22]

There are no published studies describing contemporary rates and patterns of head injury for a large Canadian population. Existing studies are limited to non-peer review reports,[15,16] smaller scale studies,[7,24,25] or have restricted their focus to specific age groups[21,26–29] or sports related causes of injury.[30] Existence of a provincial trauma registry in Ontario provided a practical opportunity to describe the occurrence of blunt head trauma for a large Canadian population. This study fills a void in the existing neurotrauma literature by comparing the descriptive epidemiological results of two data sets and also by providing a means for comparison with the injury experiences within other jurisdictions.

In this analysis, we examined two data sets associated with the Ontario Trauma Registry. The Minimal Data Set contains records for all acute care hospitalizations in the province of Ontario and the Comprehensive Data Set contains records for "major injuries" treated at any Ontario lead trauma hospital. Comparison of records from these data sets provides an opportunity to investigate whether different injury prevention and research priorities emerge from these two "windows" of surveillance. This in turn may have implications for policy and associated priorities for prevention. (Note: deaths occurring outside of hospital caused by head injury and outpatient visits for treatment of head injury were not considered in this analysis. These injuries may

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have patterns of occurrence that are distinct from the hospitalized injuries examined here, and offer different opportunities for prevention).

Our specific objectives were to: 1) calculate rates and describe contemporary patterns of blunt head trauma for the province of Ontario; and, 2) compare priorities for focused prevention and research initiatives derived from the Minimal and Comprehensive Data Sets. We also took this opportunity to discuss methodological issues that arose during the use and application of data from this registry. These issues are relevant to researchers using trauma registry data and can be used to form the basis of future studies investigating data quality.

Methods

Data sources

The Ontario Trauma Registry is a provincial initiative funded by the government of Ontario and managed by the Canadian Institute for Health Information.[31] The goal of the Ontario Trauma Registry is to "facilitate the reduction of injuries by clearly identifying, describing, and quantifying the nature and scope of injuries in the province of Ontario."[31]

Inclusion and exclusion criteria for the Ontario Trauma Registry are fully documented in technical reports from the Canadian Institute for Health Information.[31,32] In short, injuries contained in the Minimal and Comprehensive Data Sets include those that resulted from the transfer of energy. All cases are coded according to International Classification of Diseases 9th Revision (ICD–9) external cause of injury codes (E codes) and nature of illness codes (N codes).[33]

The Minimal Data Set contains records for all acute care injury hospitalizations in Ontario. The Comprehensive Data Set contains records for "major injuries", defined as an Injury Severity Score (ISS) greater than 12,[34] treated at a lead trauma hospital in Ontario. Patients included are those who are admitted as inpatients, treated in the emergency department, or who die in the emergency department after treatment of a major injury is initiated in a lead trauma hospital. Hospitals included in the Comprehensive Data Set are situated in major urban Ontario centres as follows: Hamilton, Kingston, London, Ottawa, Sudbury, Thunder Bay, Toronto, and Windsor.

A portion of the records included in the Minimal Data Set are contained in the Comprehensive Data Set, but the latter contains detail about the external causes and circumstances of injury events beyond that which is available in the Minimal Data Set. The two data sets are not mutually exclusive although each contains potentially different injury patterns that are helpful for prevention. Individual identifiers that would allow one to link the two datasets for research purposes are not made available by the Registry to external researchers such as ourselves.

Case selection

The following ICD–9 diagnostic codes are consistent with blunt head trauma, and records for cases were abstracted from the Minimal and Comprehensive Data Sets if at least one these codes were present in any diagnostic field (up to 16 and 27 diagnostic fields were available for review in the Minimal and Comprehensive Data Sets, respectively): 1) N800 (fracture of the vault of the skull); 2) N801 (fracture of the base of the skull); 3) N803 (other and unqualified skull fractures); 4) N804 (multiple fractures involving skull of face with other bones); 5) N850 (concussion); 6) N851 (cerebral laceration and contusion); 6) N852 (subarachnoid, subdural and extradural hemorrhage, following injury); 7) N853 (other and unspecified intracranial hemorrhage, following injury); 8) N854 (intracranial injury of other and unspecified nature). Data abstracted from the Minimal Data Set were for the fiscal years of 1994/95 through 1998/99, while data from the Comprehensive Data Set were for 1994/95 through 1997/98.

Statistical analysis

Annual age-standardized hospitalization rates of blunt head trauma were calculated for cases from the Minimal Data Set (MDS) of the Ontario Trauma Registry. Age-specific rates (five-year age groups) were first calculated by sex using cumulative counts of injuries over five years from the MDS in the numerator (1994/95 through 1998/99 estimates), and Ontario denominator data for the same time period (1994–1998 population estimates) from the Canada Census of Population.[35] The demographic structure of the 1991 general population of Canada[35] was used in the calculation of age standardized rates for the five year period of study. Confidence intervals surrounding these rates were calculated according to procedures outlined by Breslow and Day.[36] Mean annual age-specific rates were calculated by sex and by ten-year age group.

Patterns of head injury in the Minimal and Comprehensive Data Sets were described via frequencies and cross-tabulations that examined external causes (primary E Code only), age group (< 20, 20–59, 60 +), sex, and most responsible diagnosis (Minimal Data Set only). The ages were broadly classified into three age groups because similar injury patterns were observed within these categories. Using the Minimal Data Set, specific rates were calculated for the external causes by age group and sex, then by region of Ontario (Southwest, Central South, Central West, Toronto, East and North). It was not possible to calculate rates for the Comprehensive Data Set as it is not a population-based data source (only data from the lead trauma hospitals are included). All analyses were conducted in SPSS (v.11.0, Chicago, IL).

Results

For the years under study, approximately 12% of patients in the Minimal Data Set and 70% of patients in the Comprehensive Data Set sustained at least one head injury. Annual age-standardized hospitalization rates for head injury declined over time, from 85.3 per 100,000 in 1994/95 (95% CI: 83.6–87.0) to 62.7 per 100,000 in 1998/99 (95% CI: 61.2–64.1; Figure 1). Males experienced higher injury rates than females within each age group (Figure 2). Rates of head trauma were highest for both sexes among the elderly (70 + age group) although a modest peak was observed among males aged 10–19 years.

FIGURE 1
Age standardized rates of head injury hospitalization in Ontario, 1994/95 through 1998/99 (from the Minimal Data Set of the Ontario Trauma Registry)

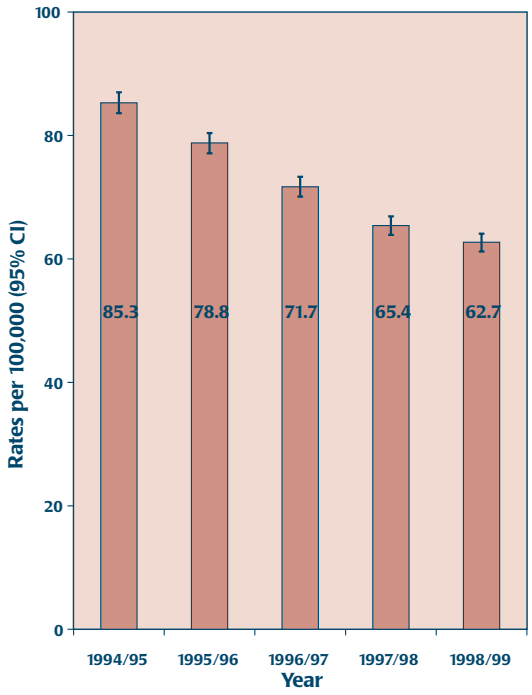
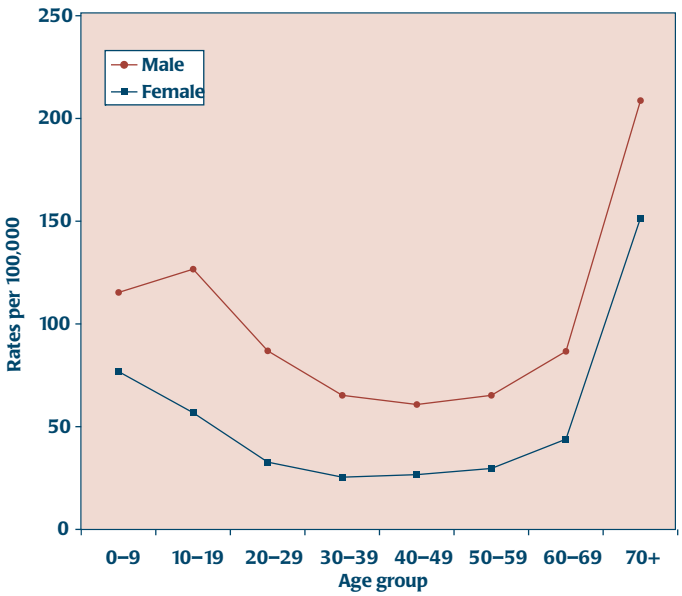


FIGURE 2
Age-specific rates of head injury hospitalization in Ontario, overall 1994/95 through 1998/1999 (from the Minimal Data Set of the Ontario Trauma Registry)



Leading external causes of injury differed between the Minimal and Comprehensive Data Sets (Table 2). In the Minimal Data Set, unintentional falls were the leading external cause of blunt head trauma (19,423/40,392; 48.1%) followed by transport incidents (14,249/40,392; 35.3%) and unintentionally being struck by or against an object or person (2,721/40,392; 6.7%; Table 1). In the Comprehensive Data Set, transport incidents were the primary external cause of injury (4,938/8,512; 58.0%) followed by unintentional falls (2,413/8,512; 28.3%) and injury purposely inflicted by another person (497/8,512; 5.8%).

Frequencies of blunt head trauma also differed by age group (Table 2). In the Minimal Data Set, there was a larger proportion of head injuries among those less than 20 years of age (14,024/40,392; 34.7%) when compared with the Comprehensive Data Set (1,822/8,512; 21.4%). Similar proportions (approximately 26%) of head injuries were seen among the elderly (60+ age group) in both data sources. Unintentional falls were most common among the elderly and transport incidents were most common among the 20–59 age group (in both data sets).

Specific annual rates of blunt head trauma by external cause varied between age/sex groups (Table 3). With some exceptions, unintentional fall injury rates were highest in the oldest age groups in both sexes. Rates of transport injury were highest among young males, and there was a male predominance in most categories of transport injuries, struck by or against objects, and intentional forms of injury, irrespective of age. There were also striking variations in regional rates of blunt head trauma in the Minimal Data Set (Table 4). Overall rates of injury were highest in Northern Ontario and lowest in Toronto. This pattern held true for all external causes of injury.

Finally, in the Minimal Data Set, 40.3% (11,920/29,570) of the records had a most responsible diagnosis of N854 (intracranial injury of other and unspecified nature) and 19.2% (5,670/29,570) had a diagnosis of N850 (concussion; Table 5).

TABLE 1
External causes of head injury from the Minimal Data Set (MDS) and Comprehensive Data Set (CDS) of the Ontario Trauma Registry

External cause of injury	MDS 1994/95 through 1998/99			CDS 1994/95 through 1997/98		
	No.	% of total	% of subtotal	No.	% of total	% of subtotal
Fall (unintentional) – subtotal	**19,423**	**48.1**		**2,413**	**28.3**	
Fall on same level from slip, trip, or stumble	4,458		23.0	418		17.3
Fall on or from stairs or steps	3,385		17.4	604		25.0
Fall on or from ladders or scaffolding	809		4.2	217		9.0
Fall from or out of building or other structure	553		2.8	179		7.4
Fall on same level from collision, push, or shove	430		2.2	21		0.9
Fall into hole or other opening in surface	86		0.4	15		0.6
Other fall from one level to another	3,934		20.3	288		11.9
Other & unspecified fall	5,768		29.7	671		27.8
Transport incident (unintentional) – subtotal	**14,249**	**35.3**		**4,938**	**58.0**	
Motor vehicle incident	12,196		85.6	4,679		94.8
Occupant	*8,666*			*3,269*		
Pedestrian	*1,919*			*912*		
Motorcyclist	*604*			*246*		
Pedal cyclist	*556*			*190*		
Other & unspecified	*451*			*62*		
Other road vehicle	1,715		12.0	164		3.3
Pedal cyclist	*1,355*			*132*		
Rider of animal	*227*			*25*		
Pedestrian	*78*			*5*		
Other & unspecified	*55*			*2*		
Vehicle incidents not elsewhere classifiable	164		1.2	27		0.5
Water transport incidents	113		0.8	30		0.6
Railway	35		0.2	28		0.6
Air & space transport incidents	26		0.2	10		0.2
Struck by, against (unintentional) – subtotal	**2,721**	**6.7**		**213**	**2.5**	
Against or by objects/persons	2,311		84.9	134		62.9
Falling object	410		15.1	79		37.1
Injury purposely inflicted by another person – subtotal	**2,520**	**6.2**		**497**	**5.8**	
Unarmed fight or brawl	1,447		57.4	195		39.2
Child battering, other maltreatment	159		6.3	68		13.7
Other & unspecified	914		36.3	234		47.1
Self-inflicted injury – subtotal	**230**	**0.6**		**193**	**2.3**	
Jump from high place or before a moving object	100		43.5	95		49.2
Firearms or explosives	71		30.9	59		30.6
Other & unspecified	59		25.7	39		20.2
Other & unspecified	**1,249**	**3.1**		**258**	**3.0**	
Total	**40,392**	**100.0**	**100.0**	**8,512**	**100.0**	**100.0**

TABLE 2
External causes of head injury by age group from the Minimal Data Set (MDS) and Comprehensive Data Set (CDS) from the Ontario Trauma Registry

	MDS 1994/95 through 1998/99 Number of injuries Age group			CDS 1994/95 through 1997/98 Number of injuries Age group *		
External cause of injury	**<20**	**20–59**	**60+**	**<20**	**20–59**	**60+**
Fall (unintentional)	**6,341**	**4,567**	**8,515**	**242**	**796**	**1,374**
Fall on same level from slip, trip, or stumble	1,072	986	2,400	21	94	303
Fall on or from stairs or steps	963	921	1,501	39	208	357
Fall on or from ladders or scaffolding	50	476	283	3	130	84
Fall from or out of building or other structure	227	269	57	43	110	25
Fall on same level from collision, push, or shove	325	88	17	9	8	4
Fall into hole or other opening in surface	37	41	8	3	9	3
Other fall from one level to another	2,709	501	724	107	82	99
Other & unspecified fall	958	1,285	3,525	17	155	499
Transport incident (unintentional)	**5,071**	**7,409**	**1,769**	**1,282**	**2,943**	**711**
Motor vehicle incident	3,779	6,752	1,665	1,179	2,810	688
Occupant	*2,282*	*5,262*	*1,122*	*748*	*2,102*	*419*
Pedestrian	*831*	*669*	*419*	*278*	*393*	*240*
Motorcyclist	*166*	*411*	*27*	*38*	*205*	*3*
Pedal cyclist	*344*	*173*	*39*	*98*	*76*	*15*
Other & unspecified	*156*	*237*	*58*	*17*	*34*	*11*
Other road vehicle	1,097	532	86	67	78	19
Pedal cyclist	*921*	*373*	*61*	*55*	*62*	*15*
Rider of animal	*109*	*112*	*6*	*10*	*13*	*2*
Pedestrian	*42*	*27*	*9*	*1*	*2*	*2*
Other & unspecified	*25*	*20*	*10*	*1*	*1*	*0*
Vehicle incidents not elsewhere classifiable	144	19	1	22	5	0
Water transport incidents	37	70	6	8	22	0
Railway	7	24	4	6	20	2
Air & space transport incidents	7	12	7	0	8	2
Struck by, against (unintentional)	**1,644**	**882**	**195**	**85**	**102**	**26**
Against or by objects/persons	1,554	606	151	70	49	15
Falling object	90	276	44	15	53	11
Injury purposely inflicted by another person	**627**	**1,770**	**123**	**124**	**345**	**26**
Unarmed fight or brawl	322	1,068	57	24	161	9
Child battering, other maltreatment	151	6	2	68	0	0
Other & unspecified	154	696	64	32	184	17
Self-inflicted injury	**28**	**170**	**32**	**19**	**149**	**25**
Jump from high place or before a moving object	8	88	4	5	83	7
Firearms or explosives	10	42	19	5	40	14
Other & unspecified	10	40	9	9	26	4
Other & unspecified	**313**	**639**	**297**	**70**	**136**	**52**
Total	**14,024**	**15,437**	**10,931**	**1,822**	**4,471**	**2,214**

* There were 5 cases with missing ages.

TABLE 3
Age-specific rates of head injury by sex and external causes, from the Minimal Data Set (MDS) of the Ontario Trauma Registry

	MDS 1994/95 through 1998/99 Annual rate of injury (per 100,000 population)					
	Males Age group			Females Age group		
External cause of injury	**<20**	**20–59**	**60+**	**<20**	**20–59**	**60+**
Fall (unintentional)	**52.2**	**20.2**	**105.6**	**32.7**	**8.8**	**84.3**
Fall on same level from slip, trip, or stumble	9.0	3.6	27.7	5.3	2.6	25.4
Fall on or from stairs or steps	7.3	3.9	19.2	5.6	2.0	14.4
Fall on or from ladders or scaffolding	0.5	2.8	6.4	0.2	0.2	0.5
Fall from or out of building or other structure	2.2	1.5	1.3	0.9	0.2	*
Fall on same level from collision, push, or shove	3.3	0.4	0.1	1.1	0.1	0.2
Fall into hole or other opening in surface	0.3	0.2	*	0.2	*	*
Other fall from one level to another	21.9	2.4	9.1	14.4	0.8	7.1
Other & unspecified fall	7.8	5.3	41.7	5.1	2.8	36.5
Transport incident (unintentional)	**43.3**	**31.6**	**26.0**	**24.5**	**15.4**	**14.3**
Motor vehicle incident	32.0	28.9	24.0	18.5	13.8	13.9
Occupant	*18.5*	*21.9*	*16.5*	*12.1*	*11.4*	*9.0*
Pedestrian	*6.6*	*2.7*	*5.1*	*4.5*	*1.5*	*4.2*
Motorcyclist	*2.0*	*2.3*	*0.6*	*0.2*	*0.3*	*
Pedal cyclist	*3.5*	*0.9*	*0.9*	*1.1*	*0.2*	*
Other & unspecified	*1.4*	*1.1*	*0.8*	*0.7*	*0.4*	*0.5*
Other road vehicle	9.6	2.1	1.7	5.0	1.3	0.4
Pedal cyclist	*8.8*	*1.7*	*1.3*	*3.4*	*0.6*	*0.2*
Rider of animal	*0.3*	*0.2*	*0.1*	*1.2*	*0.5*	*
Pedestrian	*0.3*	*0.1*	*	*0.3*	*0.1*	*0.1*
Other & unspecified	*0.2*	*0.1*	*0.2*	*0.1*	*	*
Vehicle incidents not elsewhere classifiable	1.3	0.1	*	0.7	*	–
Water transport incidents	0.3	0.3	0.1	0.2	0.2	*
Railway	0.1	0.1	*	*	*	*
Air & space transport incidents	0.1	0.1	0.1	*	*	*
Struck by, against (unintentional)	**15.6**	**4.4**	**3.3**	**6.3**	**1.2**	**1.3**
Against or by objects/persons	14.8	2.9	2.3	5.9	0.9	1.2
Falling object	0.7	1.5	1.0	0.5	0.3	0.1
Injury purposely inflicted by another person	**6.8**	**9.5**	**2.3**	**1.5**	**1.7**	**0.6**
Unarmed fight or brawl	3.8	5.8	1.2	0.4	1.0	0.2
Child battering, other maltreatment	1.3	*	*	0.7	*	*
Other & unspecified	1.7	3.8	1.0	0.3	0.7	0.4
Self-inflicted injury	**0.3**	**0.7**	**0.7**	**0.1**	**0.3**	*
Jump from high place or before a moving object	0.1	0.3	*	*	0.2	*
Firearms or explosives	0.1	0.2	0.5	–	*	–
Other & unspecified	0.1	0.2	0.2	0.1	0.1	*
Other & unspecified	**2.5**	**3.2**	**5.0**	**1.7**	**0.9**	**1.9**
Total	**120.6**	**69.6**	**142.9**	**66.8**	**28.3**	**102.5**

* Suppressed due to small numbers.

TABLE 4
Regional rates of head injury by external causes, from the Minimal Data Set (MDS) of the Ontario Trauma Registry

External cause of injury	MDS 1994/95 through 1998/99 Annual rate of injury (per 100,000 population) Region of Ontario						
	South West	Central South	Central West	Central East	Toronto	East	North
Fall (unintentional)	**42.2**	**41.2**	**34.1**	**32.5**	**26.9**	**28.8**	**48.1**
Fall on same level from slip, trip, or stumble	8.5	7.2	8.1	9.2	7.7	5.9	9.4
Fall on or from stairs or steps	6.7	8.1	5.7	5.6	5.0	4.8	7.9
Fall on or from ladders or scaffolding	2.2	1.8	1.3	1.4	1.1	1.0	2.0
Fall from or out of building or other structure	1.4	1.0	0.8	0.7	0.9	0.7	1.4
Fall on same level from collision, push, or shove	1.1	0.7	0.9	1.0	0.5	0.4	1.1
Fall into hole or other opening in surface	0.3	0.2	0.1	0.2	0.1	0.1	0.2
Other fall from one level to another	9.0	8.2	7.7	6.9	4.6	5.6	9.7
Other & unspecified fall	13.1	14.1	9.7	7.6	7.1	10.2	16.4
Transport incident (unintentional)	**34.9**	**29.1**	**22.6**	**25.6**	**16.6**	**20.0**	**35.4**
Motor vehicle incident	30.4	24.7	18.8	21.9	14.4	17.3	29.6
Occupant	*23.2*	*17.0*	*13.2*	*16.6*	*8.0*	*12.2*	*22.7*
Pedestrian	*3.2*	*3.7*	*2.9*	*2.6*	*4.8*	*2.5*	*3.4*
Motorcyclist	*1.6*	*1.7*	*0.9*	*1.0*	*0.5*	*1.0*	*1.4*
Pedal cyclist	*1.3*	*1.6*	*0.9*	*0.9*	*0.7*	*0.8*	*1.0*
Other & unspecified	*1.1*	*0.8*	*1.0*	*0.8*	*0.4*	*0.7*	*1.1*
Other road vehicle	3.8	4.1	3.3	2.9	1.9	2.1	4.9
Pedal cyclist	*2.9*	*3.4*	*2.7*	*2.1*	*1.5*	*1.6*	*3.9*
Rider of animal	*0.6*	*0.5*	*0.4*	*0.6*	*0.1*	*0.3*	*0.6*
Pedestrian	*0.2*	*	*0.1*	*0.2*	*0.2*	*0.1*	*0.2*
Other & unspecified	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*	*0.1*	*0.2*
Vehicle incidents not elsewhere classifiable	0.3	0.2	0.3	0.4	0.1	0.4	0.4
Water transport incidents	0.2	0.1	0.1	0.2	0.1	0.2	0.4
Railway	0.1	*	0.1	*	0.1	*	0.1
Air & space transport incidents	0.1	–	*	0.1	0.1	*	*
Struck by, against (unintentional)	**7.1**	**5.3**	**4.4**	**5.0**	**2.1**	**3.8**	**9.6**
Against or by objects/persons	6.1	4.8	3.9	4.3	1.9	3.0	7.5
Falling object	1.0	0.5	0.5	0.7	0.3	0.8	2.1
Injury purposely inflicted by another person	**5.2**	**5.7**	**3.4**	**3.5**	**3.4**	**3.0**	**10.5**
Unarmed fight or brawl	3.4	3.6	2.0	2.3	1.2	1.4	7.0
Child battering, other maltreatment	0.3	0.4	0.2	0.2	0.2	0.3	0.4
Other & unspecified	1.5	1.7	1.1	1.0	2.0	1.3	3.1
Self-inflicted injury	**0.5**	**0.4**	**0.4**	**0.3**	**0.5**	**0.3**	**0.3**
Jump from high place or before a moving object	0.1	0.1	0.1	0.1	0.4	0.1	*
Firearms or explosives	0.3	0.2	0.1	0.1	0.1	0.1	0.2
Other & unspecified	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Other & unspecified	2.3	2.1	3.6	1.7	1.6	1.8	2.7
Total	**92.3**	**83.8**	**68.5**	**68.7**	**51.2**	**57.8**	**106.7**

* Suppressed due to small numbers.

Note: Records are coding according to place of residence. There were 787 records with a residence code outside of Ontario, 114 transients, and 34 with unspecified residence.

TABLE 5
Most responsible diagnosis for head injury cases from the Minimal Data Set (MDS) of the Ontario Trauma Registry

	MDS 1994/95 through 1998/99	
Total number of head injury cases	40,392	
Total number of cases with a most responsible diagnosis of head injury	29,570	
Most responsible head injury diagnosis	**No.**	**%**
N800 (fracture of the vault of the skull)	1,803	6.1
N801 (fracture of the base of the skull)	3,090	10.4
N803 (other and unqualified skull fractures)	891	3.0
N804 (multiple fractures involving skull of face with other bones)	137	0.5
N850 (concussion)	5,670	19.2
N851 (cerebral laceration and contusion)	1,433	4.8
N852 (subarachnoid, subdural and extradural hemorrhage, following injury)	3,603	12.2
N853 (other and unspecified intracranial hemorrhage, following injury)	1,023	3.5
N854 (intracranial injury of other and unspecified nature)	11,920	40.3

Discussion

Epidemiological patterns and trends

This study represents one of the first large-scale epidemiological analyses of contemporary neurotrauma data in Canada. One of the two data sets maintained by the Ontario Trauma Registry (Minimal Data Set) is population-based, while the second (Comprehensive Data Set) can be used to identify frequent patterns of severe forms of head injury treated in a lead trauma hospital. When considered together, results from these analyses are helpful in identifying priorities for focused prevention and research efforts. The results also provide a basis for comparison with other populations.

The magnitude of the head injury problem observed in Ontario, although substantial, fell within the range of rates published elsewhere.[5–16] The age- and sex-specific injury trauma rates observed were also consistent with trends observed elsewhere, in that rates among males exceeded those among females in every age group.[6,10,11,18,20] The excess rates of injury observed in Northern Ontario suggest that head trauma is an especially important problem in rural and remote parts of the province.

The annual rate of hospitalized injuries due to head trauma declined over the study period. While it is tempting to attribute this temporal decline to existing prevention efforts, the decline may also relate to contemporary medical practice, for example changes in access to diagnostic modalities (e.g., computerized tomography imaging) or admission practices with hospital restructuring and rationalization.[3] Upon further investigation the number of "major injuries" in the Comprehensive Data remained stable whereas the number of injury hospitalizations in the Minimal Data Set declined (data not shown). This provides evidence that major head injuries are not declining.

The results indicate the value of examining multiple sources of surveillance data in order to identify leading priorities for prevention. When all hospitalizations for Ontario were examined via the Minimal Data Set, unintentional falls were the leading external cause, representing 48.1% of the reported injuries. This was followed by transport injuries (35.3%), being struck by or against objects (6.7%), and injuries purposely inflicted by another person (6.2%). When the more serious injuries captured via the Comprehensive Data Set were examined, the priorities changed with transport injuries accounting for 58.0% of the injuries observed. Other causes of injury remained important but their relative frequency of occurrence generally decreased. This reinforces the importance of considering the source of injury data when establishing priorities for intervention. By extrapolation, different priorities are likely to emerge if data are obtained from primarily outpatient (e.g., emergency department) sources, versus hospital inpatient or fatality-based records.

Based on the injury frequencies and rates presented here, common external causes that are obvious priorities for focused etiologic and preventive work include: 1) transport injuries (all ages); 2) falls in the elderly (60+ years); 3) unintentionally being struck by an object or person (among those less than 60 years of age); 4) injuries purposely inflicted by another person (e.g., assaults); 5) all external causes of injury in northern and remote areas of Ontario. Caution must be exercised in viewing these as priorities, as others might emerge if different criteria (e.g., evidence surrounding the ability to intervene) and other types of surveillance data (e.g., mortality) are applied to their development.

Strengths, limitations, and methodological issues

Strengths and weaknesses of this epidemiological analysis warrant recognition. Obvious strengths include the large number of cases available for analysis, the population-based features of the Ontario Trauma Registry, and the importance of the topic. Limitations include the use of data collected for administrative purposes as a basis for epidemiological analyses. Several methodological issues require consideration.

First, while there is a centralized agency responsible for record keeping (the Canadian Institute for Health Information or CIHI), and CIHI has training and quality control mechanisms in place for the coding of medical records, this process involves hundreds of hospital medical records departments and potential coders. There is clearly room for error here, and the extent of misclassification of these records should be better understood if the patterns of injury are to be interpreted correctly.

Second, some cases included in the Minimal Data Set are also contained in the Comprehensive Data Set. These data sets and the patterns derived from them cannot be considered mutually exclusive. In this analysis it was not possible to link the data sets. The creation of two mutually exclusive data sets could lead to more refined epidemiological analyses. Despite this limitation there were differences observed between the data sets and these differences would only be enhanced should the two data sets be refined.

Third, blunt head trauma commonly occurs in conjunction with other injuries[7,11] and on some occasions the latter may influence the likelihood of hospitalization. Patients included in the Minimal and Comprehensive Data Sets may not be included solely due the effects of their head trauma. This may lead to less focused epidemiological descriptions of injury.

Fourth, it is also possible that patients have experienced multiple head injuries. There is no standard method for presenting the natures of injuries from multiple diagnostic fields. In the analysis of the Minimal Data Set, the most responsible diagnosis was used in order to describe leading natures of head injury. Our rationale for using the most responsible diagnosis is that it represents the diagnosis that was considered, upon discharge, as most responsible for the patient's stay. There is no equivalent "most responsible" diagnosis contained in the Comprehensive Data Set; as such it was not possible to compare diagnoses between the two data sets. This disparity represents an important challenge for comparative research.

Fifth, 40.3% of cases in the Minimal Data Set had a most responsible diagnosis of "intracranial injury of other and unspecified nature". This lack of specificity is a methodological concern because it introduces an element of uncertainty to the injury patterns observed. Diagnoses are coded on the hospital discharge summary by trained medical records personnel. In this study it was not possible to verify the diagnoses as one would need access to each medical record. Analogously, the Comprehensive Data Set contains several variables that could potentially provide a more detailed description of head injury severity. These variables include standard trauma measures such as the Glasgow Coma[37] and Outcome[38] Scales. Unfortunately, a high proportion of head trauma cases in the Comprehensive Data Set reported inappropriate or missing values for these scales (30% for the Glasgow Coma Scale at the admitting hospital, 37% for the Glasgow Outcome Scale), which obviously limits their utility as descriptors. Possible reasons for inappropriate or missing values for the Glasgow Coma Scale include: 1) the patient being intubated or under the influence of paralytic agents, which makes it impossible to administer the scale; 2) the Glasgow Coma Scale can be difficult to administer under other medical circumstances; and, 3) these scales may have less perceived clinical value for minor head injuries. The extent of missing data is of obvious importance for research, and this should be addressed as the Ontario Trauma Registry is refined and improved.

Conclusion

Blunt head trauma represents an important health issue and its epidemiology warrants further investigation. This study, while a basic form of epidemiological research, provides new data that are valuable for quantifying the magnitude of the problem, outlining leading injury patterns, and identifying specific high-risk groups. Research investigating the entire spectrum of blunt head trauma, from mild forms of injury to fatalities, would be helpful for informing injury prevention and research priorities. Methodological research aimed at enhancing the completeness and accuracy of data available through trauma registries is also warranted.

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Book Review

Successful Aging and Adaptation with Chronic Diseases

Leonard W Poon, Sarah Hall Gueldner and Betsy M Sprouse, editors
New York, Springer Publishing Company, 2003
III + 252 pp.; ISBN 0-8261-1975-1; $53.80 (US)

In important concept papers published in *Science*[1] and the *Gerontologist*[2] in 1987 and 1997 respectively, Rowe and Kahn argued that the idea of successful aging separates the effects of disease from the aging process itself. In their book entitled *Successful Aging: The MacArthur Foundation Study*,[3] these authors define successful aging as follows: avoiding disease and disability, maintaining physical and mental functioning, and being actively engaged with life.

The Poon et al. book combines the concept of successful aging with the concept of adaptation to chronic disease. This is consistent with commentaries that have followed the Rowe and Kahn[1] work, such as Riley et al's[4] ideas on the importance of "social structural opportunities necessary for realizing success" and Baltes and Baltes[5] model of selection-optimization-compensation, which relates to doing the best with what you have. Baltes and Baltes give the example of the pianist Arthur Rubinstein. He explained his ability to continue concert performances in old age by limiting his repertoire (selection), practising much more than he had been used to practising (optimization), and giving the impression of great speed when it was called for by deliberately reducing the tempo of preceding passages (compensation).

In the Poon et al. book, some of the chapters contain investigators' reports from five studies, and other chapters provide commentaries on these study reports.

The first two chapters discuss the results of surveys in which people were asked about their successful aging, and take into account chronic health conditions. Chapter 1 is based on a 1999 follow-up survey of people 65 to 99 years of age who are part of the Alameda County Study, a longitudinal study of determinants of health and functioning that began in 1965. This chapter provides interesting information about the operational definitions that investigators have used in "successful aging" analyses, including the Manitoba Study of Aging definition. Regression analyses show that aging successfully is associated with not smoking, being physically active, avoiding obesity, protecting hearing, maintaining good personal relationships, and being active in community groups.

Chapter 2 reports on a survey of residents and staff of assisted living accommodation that explores reciprocity among older adults. These facilities, in Rhode Island, southeastern Massachusetts and Connecticut, were "high-end" facilities according to the authors. The sites had large entrance lobbies, spacious dining rooms with vaulted ceilings, on-site meal preparation and wait staff, ice cream parlours with sitting areas, pubs with pool tables, an exercise room, hairdressing room, library with computer access, a private dining room for resident-reserved functions, large common room with television, on-site health care staff, and local transportation. All sites also had an activities director and were built specifically for the services they provide. Reciprocity was operationally defined in this study with the use of Likert questions that combined ideas of successful aging with doing things for others, and a Reciprocity Index was developed for the first time. This index should be further studied for the robustness of its measurement properties in studies of other groups, since it has not been developed to a point where facility managers can use it.

Chapter 3, by Robert Kahn, provides a commentary on both of these studies and links them to theories on successful aging and adaptation to chronic disease that have been presented since his work with Rowe in the late 1980s. Kahn's chapter is a thoughtful discussion of the concepts and their research implications. According to Kahn and others whom he cites, community policies are important in supporting successful aging. Through them, communities can provide resources that increase seniors' opportunities and thus facilitate behaviours that contribute to successful aging. Early diagnosis of symptoms, for example, is more likely when there is easy access to family physicians. Neighbourhood walks in the summer and mall walks in the winter for physical activity are more tempting when neighbourhoods and malls are attractive and safe. Involvement in voluntary organizations, often recommended for older people, may require convenient and inexpensive public transportation. The issue of community policies is not covered in the five studies reported in the Poon et al. book.

Health expectancy, or expected length of life without disease and disability, is the topic of Chapter 4. Using data from the 1994 US National Health Interview Survey, the authors report health expectancies for different groups according to their ability to carry out activities of daily living (ADL), their self-assessed health, different chronic diseases, gender, and race. These results challenge the societal notion that old age is fraught with disability. For example, at age 65, of the 17.4 years of life expectancy, 10.5 years are estimated to be lived "disability free". For most of the disabled years, older people will require assistance with instrumental activities of daily living (IADL) tasks rather than experiencing the more severe disability posed by ADL restrictions.

Chapter 5 reports the findings of a MacArthur Foundation Research Network on Successful Aging survey in 1988-1989 and a follow-up survey in 1991-1992 involving the same high functioning men and women 70 to 79 years of age. Their functioning level was known, as they had participated in the Established Populations for the Epidemiological Study of the Elderly (EPESE), conducted in the early 1980s. The authors report on the risk and protective factors pertaining to physical functioning. One of the exciting findings reported has to do with levels of functioning and patterns of change in functioning over time. These were influenced by potentially modifiable factors – physical activity, social support, self-efficacy beliefs, and psychological symptoms – independent of the presence of chronic conditions or other aspects of health status and of differences in socio-demographic characteristics.

Chapter 6 is a commentary on the health expectancy and high functioning studies reported in the previous two chapters. The authors of Chapter 6 point out that the health expectancy focus on disease as disability, as reflected in ADL and IADL demands, is consistent with the Rowe and Kahn concept of successful aging. They also assert that the subjective assessment of personal health may reflect active engagement with life, at least to a degree deemed acceptable to the older adult respondent. With regard to the Baltes and Baltes' conceptualization of successful aging as "selective optimization with compensation", the authors of Chapter 6 assert that optimization cannot be captured in years lived with disease or years lived with disability. They argue that the high functioning study's comprehensive examination of lifestyle factors and individual change over time, however, begins to reveal some elements of optimization, for example, physical activity patterns. Analyses of this type will be possible in Canada with the proposed Canadian Longitudinal Study on Aging, which has received initial funding from the Canadian Institutes of Health Research (CIHR) and high levels of interest from CIHR's Institute on Aging and other CIHR institutes.

In Chapter 7, Poon and his colleagues provide a systematic review of the topic of coping with chronic health conditions. The aim was to determine how such conditions affect older individuals and what strategies are effective in coping with them. They conclude that health coping is disease-, context-, and individual-specific. The literature reports both positive and negative effects of coping with chronic disease. An example of a positive effect was the finding that belief in the controllability/curability of the disease is related to better functioning. An example of a negative effect is that more avoidance is associated with greater symptom severity. The authors of this chapter selected 483 of the studies that reported on the impact of coping strategies on chronic disease. Rather than classify studies on the basis of their research design, the authors classified them according to coping strategies for 12 chronic diseases and whether these strategies were a) effective and regularly used, b) ineffective or infrequently used, or c) in need of further research or gave no indication of effectiveness.

The authors of Chapter 8 focus on what is known about the impact of concurrent chronic diseases among people with cardiovascular disease. They report on a study that examined the impact of concurrent chronic diseases on people with arthritis, high blood pressure, diabetes, hearing problems, lung problems, osteoporosis, problems with vision, urinary or bladder problems, cancer, and stroke. The chapter ends with a proposed model of the effects of coping with co-morbidity. A number of theoretical issues are raised, but it is difficult to imagine a study design that would enable investigators to tease out all the issues included in the proposed model.

Chapter 9 reports on a study of independent community living of people who were in a senior membership program at a community hospital in northeastern United States. The 122 participants, 55 years of age and older, were asked to report their multiple chronic conditions. The number of conditions reported was not associated with age groupings. Focus groups were then held to explore the range of experiences and strategies that these older adults employed to get through daily life while suffering from multiple chronic conditions. The authors propose a model for managing everyday living with multiple chronic conditions that is based on the literature reviews in Chapters 7 and 8 and the in-depth interviews with the 122 study subjects. This model needs to be tested in future studies, which will have to overcome a number of issues related to the concepts outlined in the model, such as "encountering chronicity", "feeling challenged", "living with it", "monitoring", and "continuing on".

Chapter 10 is a commentary on the content of Chapters 7 to 9. This chapter calls for more research on understanding how people cope with concurrent chronic conditions by establishing patterns of disease management. That is, some individuals may have similar patterns that could be shown to be "standard" trajectories of how they cope through time. Different models are also proposed here connecting "chronic stress", "external demands", "appraisal", and "coping". While the conceptualization of these models is clearly presented, future research must use measures that validly tap into these concepts.

The book ends with a chapter (Chapter 11) on "ways of knowing". It comments on the different methodological approaches used by the chapter authors and refers to their philosophy of science positions of positivism, postmodernism and/or neo-modernism. The authors conclude that this book on successful aging and adaptation to chronic disease benefits from the incorporation of all these approaches.

My overall conclusion is that this is a valuable book offering a useful understanding of theories related to successful aging and adaptation to chronic disease. In addition, those conducting research on the topics covered in the book will find that it provides excellent descriptions of the methods used and methodological critiques of these methods.

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We are extremely grateful to the following people for their enormous contribution to *Chronic Diseases in Canada* as peer reviewers in 2003.

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Jean-Marie Berthelot
Duncan Hunter
Sam Sheps
Murray Kaiserman

Calendar of Events

April 26–30, 2004 **Melbourne, Australia**	The 18th World Conference on Health Promotion and Health Education	Australian Centre for Health Promotion Conference Program and Registration Office The Meeting Planners 91–97 Islington Street Collingwood, VIC 3066 Australia Tel.: +61 3 9417 0888 Fax: +61 3 9417 0899 E-mail: Health2004@meetingplanners.com.au < www.meetingplanners.com.au >
May 5–7, 2004 **Orlando, Florida, USA**	2004 National ASTDHPPHE/CDC Conference on Health Education and Health Promotion and Society for Public Health Education Midyear Conference	Centers for Disease Control and Prevention and the Society for Public Health Education < www.dhpe.org/nationalconference >
May 11–14, 2004 **Chicago, Illinois, USA**	2004 Centers for Disease Control and Prevention Diabetes Translation Conference: Diabetes Prevention and Control: Together we can Improve Lives	CDC Division of Diabetes Translation PO Box 8728 Silver Spring MD 20910 USA Tel.: 1 877 CDC DIAB (877) 232-3422) Fax: (301) 562-1050 E-Mail: diabetes@cdc.gov < www.cdc.gov/diabetes/conferences/conf2003/index.htm >
May 14–18, 2004 **Rio de Janeiro, Brazil**	International Osteoporosis Foundation World Congress on Osteoporosis	IOF Secretariat 73, Cours Albert Thomas 69447 Lyon Cedex 03 France Fax: +33 4 72 36 90 52 E-mail: info@osteofound.org < www.osteofound.org/wco/2004/index.php >
May 18–22, 2004 **New York City, USA**	American Society of Hypertension 19th Annual Meeting and Scientific Exposition	The American Society of Hypertension Registration Supervisor C/o Harry Hansen Management Inc. 151 Herricks Road, Suite 101 Garden City Park, NY 11040 USA Tel.: (516) 739-2510 Fax: (516) 739-3803 E-mail: ash@hhmi.ws < www.ash-us.org/annual_meeting >
May 21–26, 2004 **Orlando, Florida, USA**	American Thoracic Society International Conference 2004	Tel.: (847) 940-2155 < www.thoracic.org/ic/ic2004/registration.asp >
May 26–29, 2004 **Prague, Czech Republic**	European Association for the Study of Obesity 13th European Congress on Obesity	Congress Secretariat: Guarant Ltd. Opletalova 22 110 00 Praha 1 Czech Republic Tel.: +420 2 8400 1444 Fax: +420 2 8400 1448 E-mail: eco@guarant.cz < www.eco2004.cz >

June 9–11, 2004 **Birmingham, UK**	4th International Multidisciplinary Meeting on Chronic Obstructive Pulmonary Disease – COPD4	Conference Organisers and Event Managers Executive Business Support Ltd. Suite 4, Sovereign House 22 Gate Lane Boldmere Sutton Coldfield West Midlands UK B73 5TT Tel.: 0845 226 3068 or +44 (0)121 354 2882 Fax: +44 (0)121 355 2420 E-mail: enquiry@execbs.co.uk < www.copdconferences.org/default.asp >
June 9–12, 2004 **Berlin, Germany**	The European League against Rheumatism Annual European Congress of Rheumatology	< www.eular.org/eular2004/index.cfm >
June 13–16, 2004 **Milan, Italy**	Positioning Technology to Serve Global Heart Health 5th International Heart Health Conference	The International Advisory Board of the International Heart Health Conference Rossella Salvoni AISC and MGR – AIM Group Via Ripamontei 129 20141 Milano, Italy Tel.: +39 02 56601.1 Fax: +39 02 56609045 E-mail: 5ihh@aimgroup.it < www.aimgroup.it/s004/5ihh >
September 1–4, 2004 **Cairns, Queensland, Australia**	6th International Diabetes Conference on Indigenous People – Dreaming Together Experience	Diabetes Queensland Conferences Secretariat Indigenous Conference Services Australia PO Box 152 Emu Park QLD 4710 Australia Tel.: +61 7 4938 7558 Fax: +61 7 4938 7553 E-mail: icsa2@bigpond.com < www.geocities.com/indigenousconferences >
September 4–8, 2004 **Glasgow, Scotland**	European Respiratory Congress 14th Annual Congress 2004	Congrex Sweden AB C/o ERS 2004 PO Box 5619 SE –114 86 Stockholm Sweden Tel.: +46 8 459 66 00 Fax: +46 8 661 91 25 E-mail: ers2004@congrex.se < www.ersnet.org >
October 1– 5, 2004 **Seattle, Washington, USA**	26th Annual Meeting of the American Society for Bone and Mineral Research	2025 M Street, NW, Suite 800 Washington, DC 20036-3309, USA Tel.: (202) 367-1161 Fax: (202) 367-2161 E-Mail: asbmr@dc.sba.com < http://www.asbmr.org/meeting/index.cfm >
October 12–15, 2004 **Quebec, Quebec**	2nd International Conference on Local and Regional Health Programmes	Association pour la santé publique du Québec Colloque Québec 2004, 2600, boulevard Laurier, Tour Belle Cour, bureau 2680, Sainte-Foy (Québec) G1V 4M6 E-mail: info@colloquequebec2004.com < www.colloquequebec2004.com >

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