

Cost of Public Health Services for Ontario Residents Injured as a Result of a Motor Vehicle Accident

Applied Health Research Question Series

Health System Performance Research Network

**Report Prepared by: Yu Qing Bai, Goncalo Santos,
Walter P. Wodchis**

January 2016

Acknowledgements

The Health System Performance Research Network (HSPRN) is a multi-university and multi-institutional network of researchers who work closely with policy and provider decision makers to find ways to better manage the health system. The HSPRN receives funding from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The views expressed here are those of the authors with no endorsement from the MOHLTC.

Competing Interests: The authors declare that they have no competing interests.

Reproduction of this document for non-commercial purposes is permitted provided appropriate credit is given.

Cite as: **Bai YQ, Santos G, Wodchis WP. *Cost of Public Health Services for Ontario Residents. Applied Health Research Question Series*. Toronto: Health System Performance Research Network; 2016.**

This report is available at the Health System Performance Research Network Website:
<http://hsprn.ca>.

For inquiries, comments, and corrections please email info@hsprn.ca.

Executive Summary

Context

In accordance with the Ontario *Insurance Act*, the Lieutenant Governor in Council has the legal authority to recover certain health care costs incurred by the Ministry of Health and Long-Term Care in treating individuals injured in automobile accidents that occurred in Ontario. The Financial Services Commission of Ontario, an agency of the Ministry of Finance (MOF), is responsible for collecting an annual assessment of health system costs from insurers. The total amount of the assessment is established by regulation and allocated to automobile insurers based on their market share for automobile insurance in Ontario. The Commission has collected about \$142.3 million annually from automobile insurance companies since 2006 and about \$80 million per year from 1996 to 2005. Both of these figures were estimated without the benefit of evidence on the full costs of automobile accidents to the Ontario public health care system. To validate the adequacy of the current assessment amount, the MOHLTC, in collaboration with the MOF, submitted an Applied Health Research Question (AHRQ) to the Health System Performance Research Network (HSPRN), seeking to determine the cost of public health care services provided to Ontario residents injured as a result of a motor vehicle accident. This report will summarize the findings for the submitted AHRQ.

Objectives

The objectives of this study were to:

- 1) Determine the health care cost for individuals injured in motor vehicle accidents.
- 2) Estimate the total annual direct cost to the Ontario public health care system for individuals injured in motor vehicle accidents.
- 3) Provide evidence on the amount recoverable by the provincial government from motor vehicle accident insurers under Ontario's *Insurance Act*.

Methods

The basic design for the study was to identify people who attended at a hospital emergency department or were admitted to acute care hospitals that was recorded by hospital clinical staff to be associated with a Motor Vehicle Accident (MVA), to measure the increase in their health care-related costs in the year after this event (and subsequent years) compared to the year prior to this event, and to compare this difference to the same differences among other individuals in the province of Ontario who had the same age, sex, health conditions and geographic profile. This approach allowed us to estimate the increase in health care costs for individuals with an MVA compared to individuals with similar demographic and health conditions who did not have an MVA event. We call this the attributable cost. We calculated this attributable cost for each individual with an MVA in the first year following the MVA. We also calculated the total system cost associated with attributable costs for all individuals with an MVA in 2012. Using 7 years of observed data and forecasting forward, we estimate 11 years of attributable costs arising due to MVA. We calculated the present value of these costs at the time of the accident.

Findings

The number of Ontario residents that were treated in an emergency department and/or were hospitalized as a result of a motor vehicle accident in Ontario is shown in Table 1 and remained fairly consistent each year in the period from April 1, 2007 to March 31, 2014. The total number of injuries ranged from a high of 70,595 in the 2007/08 fiscal year to a low of 66,625 in the 2012/13 fiscal year.

Our estimate of the average attributable cost of a motor vehicle accident to the Ontario public health care system in the first year following the accident for MVAs based on data from 2007 through to 2012 was \$2,958. Over 75% of this total was devoted to hospital costs, while approximately 20% went to physician costs. There were much lower attributable costs associated with second and subsequent years with second year costs average just under \$600 and declining by approximately \$50-70 per year thereafter. The total present value of MVA-attributable costs over 11 years was \$5,495 per case.

Conclusion

We employed a robust and rigorous approach to estimating total health system costs associated with treatment in the Ontario health care system for motor vehicle accidents. The estimated attributable cost per MVA individual in the first year following a motor vehicle accident in 2011/12 was \$3,134 and averaged \$2,958 over seven years from 2007-2012 (expressed in 2013 CAD currency terms). Costs in subsequent years were considerably lower from the second year onwards and declined slowly over time. The present value of all estimated MVA attributable costs was \$5,495 per case. With a total of 69,724 incident MVA cases in 2013/14 this amounts to a total present value (net actuarial liability) of \$383,099,805 for MVAs that occurred in 2013/14.

Table of Contents

Executive Summary	3
Context	6
Objectives	6
Methods	6
Health Care Costs.....	7
Analysis.....	8
Findings	9
Matched Results.....	9
Total Attributable Costs up to 6 years based on MVA cases from 2007-2012.....	12
Present Value of MVA costs.....	13
Limitations.....	15
Conclusion	15
References	16
Appendices	17
Appendix 1: Defining Motor Vehicle Accident-Related Injuries.....	17
Appendix 2: Baseline characteristics of matching variables for matched cohort (fiscal year 2011/12).....	18
Appendix 3: Population attrition by year 2007-2012.....	19

List of Tables

Table 1. Incidence of hospital visit following an MVA in Ontario from April 1, 2007 to March 31, 2014.....	9
Table 2a. Incremental and attributable costs per case by sector.....	10
Table 2b. Total incremental and attributable costs by sector.....	11
Table 3a. Total Attributable Health Care Costs per Case by Year (Adjusted to 2013 CAD).....	13
Table 3b. Total first-year spending on patients injured in motor vehicle accidents from 2007 to 2012. Costs are adjusted to 2013 CAD.....	13
Table 4. Total (Forecasted) Attributable Health Care Costs per Case by Year (Adjusted to 2013 CAD).....	14

List of Figures

Figure 1. A. Attributable costs per motor vehicle accident patient in 2011/12 by health sector in the first and second years following the accident. B. Total health system costs attributable to motor vehicle accidents in Ontario in 2011/12 by health sector in the first and second years following an accident.	12
---	----

Context

In accordance with the Ontario *Insurance Act*, the Lieutenant Governor in Council has the legal authority to recover certain health care costs incurred by the Ministry of Health and Long-Term Care in treating individuals injured in automobile accidents that occurred in Ontario. The Financial Services Commission of Ontario, an agency of the Ministry of Finance (MOF), is responsible for collecting an annual assessment of health system costs from insurers. The total amount of the assessment is established by regulation and allocated to automobile insurers based on their market share for automobile insurance in Ontario. The Commission has collected about \$142.3 million annually from automobile insurance companies since 2006 and about \$80 million per year from 1996 to 2005. Both of these figures were estimated without the benefit of evidence on the full costs of automobile accidents to the Ontario public health care system. To validate the adequacy of the current assessment amount, the MOHLTC, in collaboration with the MOF, submitted an Applied Health Research Question (AHRQ) to the Health System Performance Research Network (HSPRN), seeking to determine the cost of public health care services provided to Ontario residents injured as a result of a motor vehicle accident. This report will summarize the findings for the submitted AHRQ.

Objectives

- 1) Determine the health care cost for individuals injured in motor vehicle accidents.
- 2) Estimate the total annual direct cost to the Ontario public health care system for individuals injured in motor vehicle accidents.
- 3) Provide evidence on the amount recoverable by the provincial government from motor vehicle accident insurers under Ontario's *Insurance Act*.

Methods

The basic design for the study was to identify people who attended at a hospital emergency department or were admitted to acute care hospitals that was recorded by hospital clinical staff to be associated with a Motor Vehicle Accident (MVA), to measure the increase in their health care-related costs in the year after this event (and subsequent years) compared to the year prior to this event, and to compare this difference to the same differences among other individuals in the province of Ontario who had the same age, sex, health conditions and geographic profile. This approach allowed us to estimate the increased in health care costs for individuals with an MVA compared to individuals with similar demographic and health conditions who did not have an MVA event. We call this the attributable cost. We calculated this attributable cost for each individual with an MVA and then also the total system cost associated with attributable costs for all individuals with an MVA.

In statistical terms, we used differences-in-differences estimator with a propensity-matched cohort to estimate the attributable health system costs of motor vehicle accidents in Ontario. To enable a detailed examination of costs in the first two years following an MVA, we identified individuals admitted to acute care and/or had an emergency room visit between April 1, 2011 and March 31, 2012 due to an injury suffered in a motor vehicle accident (MVA, see full list of International Classification of Diseases 10th revision (ICD 10) codes in Appendix 1). Individuals were identified based from the Canadian Institute for Health Information Discharge

Abstract Database (CIHI-DAD) and the National Ambulatory Care Reporting System Emergency Department (NACRS ED) databases, respectively. The index date was the date of the first hospital admission in the study period with an MVA ICD-10 code in any diagnosis field. The use of healthcare resources was tracked for two years after hospital admission with a maximum follow-up date of March 31, 2014. We chose the earlier dates for incident cases in order to enable a two-year follow-up for all individuals involved in motor vehicle accidents. We restricted our sample to Ontario residents without a prior acute hospitalization or emergency department (ED) visit with a motor vehicle accident code in the two years preceding the index event to ensure that we accurately measured attributable costs related to a specific accident.

Incidence density sampling was used to identify a control cohort that had no hospital claim or ED visit for a motor vehicle accident between April 1, 2011 and March 31, 2012 in a 30% randomly selected sample population of Ontario. The control cohort was randomly assigned an index date based on the distribution of index dates in the case cohort. We further excluded those with a hospitalization or ED visit for a motor vehicle accident in the two years preceding this randomly assigned index date. We matched cases with controls on sex, age (± 90 days), index date (± 30 days), and then the logit of the propensity score with the caliper of 0.2 standard deviations using a greedy matching algorithm without replacement. A propensity score is a probability of being exposed, in this case to an MVA. To estimate the propensity score, we conducted a logistic regression of case status including the independent variables age, rurality measured with the Rurality Index for Ontario (RIO), comorbidity at baseline as measured by the Collapsed Aggregated Diagnosis Groups (CADGs), geographic location as measured by the Local Health Integration Network (LHIN) of residence, and neighbourhood income quintile. RIO, LHIN, and neighbourhood income quintile were estimated using the postal code at the index date and census data. The RIO is a measure of rurality based on population and population density, distance to a tertiary hospital, and distance to a quaternary hospital. The RIO ranges from 0 (urban) to 100 (remote) where large urban is 0–9, suburban 10–39, and rural ≥ 40 (Kralj, 2008). The CADGs methodology assigns each individual's diagnoses to one of 32 diagnostic clusters, before further collapsing these 32 clusters into 12 CADGs (Johns Hopkins School of Public Health, 2016). Each diagnosis belongs in only one CADG, but because individuals often have multiple diagnoses, individuals may be represented in multiple CADGs. Individuals within the same combination of CADGs are expected to require similar health resource utilization.

In order to study long-run incremental costs for individuals with MVA, we applied the same study design to years 2007/08, 2008/09, 2009/10, 2010/11, and 2012/13. In each year we identified the number of MVA cases in hospital records and created a matched cohort in that year. We then calculated differences in costs between that year from the prior year for each individual. We calculated differences in health care spending among survivors in each of the subsequent years up to 2012/13 (up to 6 years of follow-up).

Health Care Costs

The primary outcome of interest was the total direct health care cost incurred in the public health care system. Total direct health care costs were calculated for each MVA case and each control. Costs were calculated as the price per encounter and were summed across all encounters for each individual for all health services paid for by public insurance. Encounters

were captured from health system utilization data including inpatient hospitalizations, emergency department visits, same day surgery, fee-for-services (FFS) physician and non-physician services, non-FFS physicians, prescription medications, laboratory, rehabilitation, complex continuing care (CCC), residential long-term care (LTC), mental health inpatient stays, home care services, and assistive devices. All healthcare costs were grouped into five sectors, including physician costs, hospital costs, drug costs, continuing care costs and other health care delivery costs. Physician costs included professional fees paid by the provincial insurance plan directly to physicians in private practice. Hospital costs included amounts paid to healthcare institutions, including those providing acute care, extended and chronic care, rehabilitation and convalescent care, psychiatric care, as well as drugs dispensed in hospitals. Drug costs consisted of the costs for prescriptions dispensed at outpatient pharmacies to individuals eligible for provincial coverage, while continuing care costs include expenditure on home care (inclusive of all professional and personal support and homemaking services) and residential LTC. The other health care delivery costs category included expenditures on assistive device program.

The calculation of cumulative health care system costs was made possible due to the development of a costing methodology by one member of our team (WW) that attributes cost to various types of encounters/services and allows for these costs to be linked to a specific individual over time (Wodchis et al., 2013). These methods have been implemented through a costing macro at the Institute for Clinical Evaluative Sciences (ICES) and used to estimate total health system costs in Ontario (Wodchis et al., 2016). For costs for which there was a service- or product-specific claim and a charge (e.g. for prescriptions, fee-for-service physician visits, home care visits) we used the payment charge that was provided on those claims. Acute care hospitalizations and ED visits both include patient-specific and encounter-specific Resource Intensity Weights (RIWs, also known as ambulatory cost weights in ED). These were multiplied by a cost per weighted case to estimate the total cost for a specific hospital encounter. Ontario also has separate databases to track post-acute rehabilitation and complex continuing care, institutional long-term care as well as inpatient mental health. In each case, we used the appropriate RIW for that particular care setting multiplied by Ontario-specific weighted costs. Capitation payments for primary care physicians in Ontario were also calculated based on the payment rate and the particular model of primary care for each patient's physician in each month of the study period. Long Term Care Home care costs were estimated based on provincial prescribed per diem payments less resident co-payment for basic accommodation rates multiplied by the number of days in LTC.

Analysis

We assessed the quality of matching by comparing the means and proportions of all matching variables between unmatched and matched samples. Standardized differences and variance ratios were assessed, where standardized differences of 0.1 or greater suggest a significant imbalance occurred (Normand et al., 2001; Austin, 2009). See Appendix 2 for a full table of baseline characteristics of matching variables for the 2011/12 matched cohort. We estimated attributable costs using a person-level differences-in-differences approach. We compared the mean cost in each year following a motor vehicle accident (up to six years following in the 2007/08 cohort) to a baseline mean cost in the year prior to the accident for individuals with an MVA (first difference), to the same difference in the control (non-MVA) cohort

(second difference). These differences were calculated not as population averages but as averages based on person-specific matched MVA and non-MVA individuals. All costs were expressed in 2013 Canadian dollars with costs from prior years adjusted using the health-care component of the Canadian consumer price index.

A linear regression model was used to forecast ongoing costs associated with an MVA based on up to 6 years of ongoing costs estimated using the methods described above. First the average cost for each year subsequent to the MVA was calculated from all observed cost data. A linear forecast was then estimated based on years 2-6 until attributable costs were no longer positive. First year costs were not included in the forecast as these include both initial and ongoing costs and the desired value was ongoing cost. We also forecasted the survival of MVA patients over the period matching the cost estimation. We found that costs were positive for 11 years. The present value of total MVA costs over 11 years was calculated by multiplying the annual attributable cost by the probability of continuing to receive care in Ontario over the same period and adding all discounted (present value) costs using a discount rate of 3%.

Findings

Table 1. Incidence of hospital visit following an MVA in Ontario from April 1, 2007 to March 31, 2014.

Year	2007	2008	2009	2010	2011	2012	2013
Total Number of Cases Before Exclusions	70,595	67,105	67,051	70,406	67,077	66,625	69,724
Number of Cases Excluded*	2,107	1,820	1,772	1,763	1,822	1,686	1,649
Number of Cases in Analysis	68,488	65,285	65,279	68,643	65,255	64,939	68,075

*Cases excluded due to accidents within 2 years prior to index date.

The number of Ontario residents that were treated in an emergency department and/or were hospitalized as a result of a motor vehicle accident in Ontario is shown in Table 1 and remained fairly consistent each year in the period from April 1, 2007 to March 31, 2014. The total number of injuries ranged from a high of 70,595 in the 2007/08 fiscal year to a low of 66,625 in the 2012/13 fiscal year. Between 2.4-3.0% of these cases each year were of individuals who had suffered injuries in motor vehicle accidents within the previous two years.

Matched Results

We were able to match 64,328 of the 65,255 cases in 2011/12 for a matching rate of 98.6%. Our estimate of the attributable cost of a motor vehicle accident to the Ontario public health care system in the first year following the accident for MVAs in 2011/12 was \$3,134 (Table 2a). The average total cost and average incremental cost for each MVA patient in the year prior to and in the first and second year after their MVA are shown in Table 2a by health sector (type of health care provider) and overall. This table also provides the same figures for the matched control cohort. Total costs captured by multiplying individual costs by the number of MVAs are reported in Table 2b.

Since the total number of cases (before exclusions) in 2011/12 was 67,077, total spending on patients injured in motor vehicle accidents was an estimated \$210,219,318 in 2011/12 (Table 2b). Over 75% of this total was devoted to hospital costs, while approximately 20% went to physician costs. There were much lower (\$300 per case) attributable costs associated with second year spending for patients injured in motor vehicle accidents in 2011/12, amounting to an estimated total of \$19,895,928.^[1]

Table 2a. Incremental and attributable costs per case by sector.

The costs of cases are represented by "A" while the costs of controls are represented by "B". The prior year costs (A₀, B₀) represents the 2010/11 (prior) fiscal year, used to calculate baseline costs, while years 1 and 2 represent the 2011/12 and 2012/13 fiscal years among individuals, with year 2 costs based on individuals who were still eligible for OHIP in the subsequent year. All costs are adjusted to 2013 CAD.

Sector	Cases 1st year			Control 1st year			Attributable cost (A ₁ - A ₀) - (B ₁ - B ₀)
	Mean cost prior year (A ₀)	Mean cost 1st year (A ₁)	Incremental cost (A ₁ - A ₀)	Mean cost prior year (B ₀)	Mean cost 1st year (B ₁)	Incremental cost (B ₁ - B ₀)	
Physician	\$ 805	\$ 1,384	\$ 579	\$ 702	\$ 667	\$ -35	\$ 613
Hospital	1,118	3,621	2,504	987	1,053	66	2,438
Drug	330	370	40	272	310	38	3
Community care	136	264	128	241	296	55	73
Other	93	99	7	90	90	0	7
Total cost	2,481	5,738	3,258	2,292	2,416	124	3,134

Sector	Cases 2nd year			Control 2nd year			Attributable cost (A ₂ - A ₀) - (B ₂ - B ₀)
	Mean cost prior year (A ₀)	Mean cost 2nd year (A ₂)	Incremental cost (A ₂ - A ₀)	Mean cost prior year (B ₀)	Mean cost 2nd year (B ₂)	Incremental cost (B ₂ - B ₀)	
Physician	\$ 805	\$ 842	\$ 37	\$ 702	\$ 623	\$ -78	\$ 115
Hospital	1,118	789	-328	987	564	-424	95

* In the second year post-MVA, only 63,623 of the original 64,328 matched cases (98.9%) in the 2011/12 cohort were alive and maintained provincial health coverage in Ontario. Applying the same proportion to the total number of cases (before exclusions) yields 66,342 cases in the second year post-MVA. This number was multiplied by the attributable cost per case in year two to estimate total attributable costs in year two.

Drug	330	397	67	272	327	55	12
Community care	136	129	-7	241	161	-80	72
Other	93	92	-1	90	84	-6	5
Total cost	2,481	2,248	-233	2,292	1,759	-533	300

Table 2b. Total incremental and attributable costs by sector.

Total incremental costs are the sum of the difference in costs in the year after an MVA compared to costs in the year prior to an MVA for the entire population of individuals with an MVA. Total attributable costs are the difference in incremental costs among cases as compared to controls.

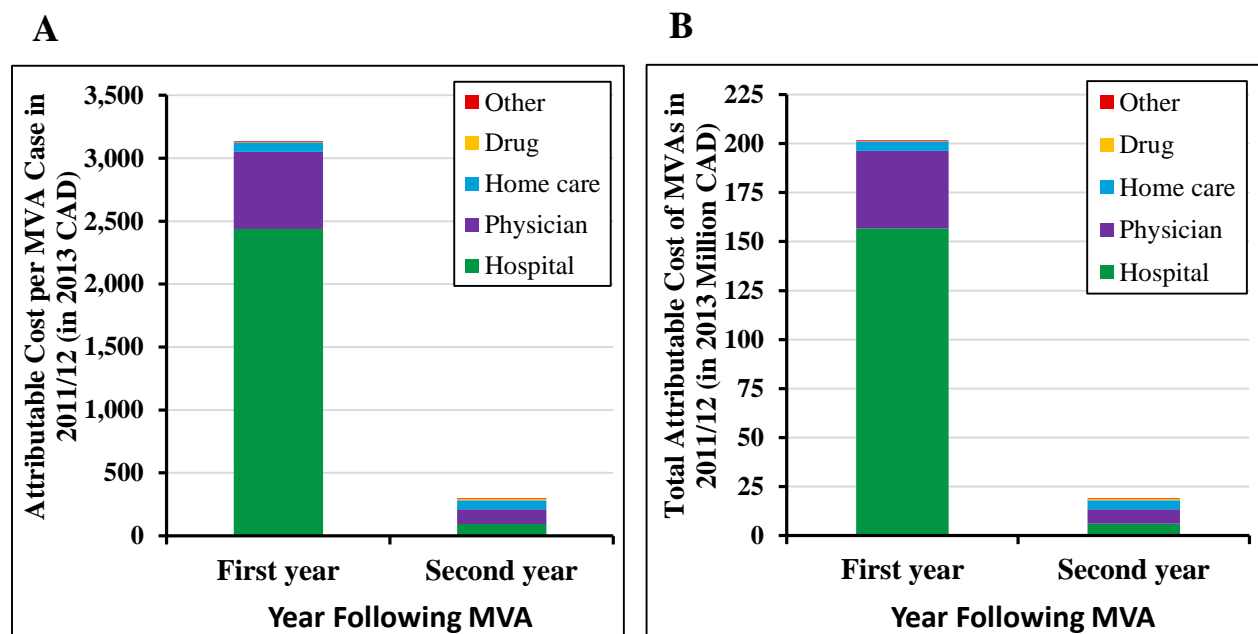
Sector	Cases 1st year, n=67,077	Control 1st year, n=67,077	Total attributable cost (2013 CAD)
	Total incremental cost (2013 CAD)	Total incremental cost (2013 CAD)	
Physician	\$ 38,818,345	\$ -2,326,016	\$ 41,144,361
Hospital	167,938,002	4,421,448	163,516,554
Drug	2,703,737	2,524,568	179,169
Community care	8,593,658	3,696,426	4,897,232
Other	450,101	-19,111	469,212
Total cost	218,503,328	8,297,425	210,205,903

Sector	Cases 2nd year, n=66,342	Control 2nd year, n=66,342	Total attributable cost (2013 CAD)
	Total incremental cost (2013 CAD)	Total incremental cost (2013 CAD)	
Physician	\$ 2,429,141	\$ -5,186,355	\$ 7,615,496
Hospital	-21,775,061	-28,097,678	6,322,618
Drug	4,455,411	3,639,843	815,569
Community care	-493,889	-5,303,088	4,809,199
Other	-53,513	-387,001	331,709

Total cost	-15,438,417	-35,334,345	19,895,928
------------	-------------	-------------	------------

Figure 1 depicts the data reported in Tables 2a and 2b in a graphic form, highlighting several key findings. First, it accentuates the difference between total first-year costs and total second-year costs in 2011/12. Furthermore, it illustrates the shift in health sector resource utilization from the first year following a motor vehicle accident to the second. The first year is characterized by proportionately large hospital and physician costs, while the second year shows more of a balance between the five sectors.

Figure 1. A. Attributable costs per motor vehicle accident patient in 2011/12 by health sector in the first and second years following the accident. B. Total health system costs attributable to motor vehicle accidents in Ontario in 2011/12 by health sector in the first and second years following an accident.



Total Attributable Costs up to 6 years based on MVA cases from 2007-2012

Identifying MVA accidents using the same coding and performing similar calculations for each of the fiscal years from 2007 through to 2012 we were able to identify the ongoing attributable costs for subsequent years over a period of up to 6 years for MVA individuals compared to matched non-MVA individuals. These results are reported in Table 3a. The costs for subsequent years are estimated based on differences in costs among MVA cases still alive in each year matched to controls who also survived. In all years we observe the same general pattern with initial year costs averaging approximately \$3,000, second year costs average just under \$600 and decline by approximately \$50-70 per year thereafter. First-year attributable costs tended to be about five times larger than second-year costs, except in 2011/12, when

second year costs were lower than for second year costs in earlier years. This latter estimate may be important as 2011/12 was the study year chosen for the principal analyses reported above. It is unclear whether the 2011/12 second year costs represent a new trend in lower second year costs, incomplete costs data (incurred but not reported) or whether they represent a stochastic deviation from average second year costs.

Table 3b provides the total first-year spending on patients injured in motor vehicle accidents from 2007 to 2012 ranged from \$215,392,773 (in 2007/08) to \$185,080,524 (in 2012/13).

Table 3a. Total Attributable Health Care Costs per Case by Year (Adjusted to 2013 CAD).

Year	2007	2008	2009	2010	2011	2012
Attributable cost (adjusted to 2013 CAD)						
1st year	\$3,051	\$2,895	\$2,950	\$2,940	\$3,134	\$2,778
2nd year	672	579	611	583	300	-
3rd year	521	554	608	307	-	-
4th year	461	492	442	-	-	-
5th year	477	297	-	-	-	-
6th year	310	-	-	-	-	-

Table 3b. Total first-year spending on patients injured in motor vehicle accidents from 2007 to 2012. Costs are adjusted to 2013 CAD.

Year	2007	2008	2009	2010	2011	2012
Number of Cases Before Exclusions	70,595	67,105	67,051	70,406	67,077	66,625
Total First-Year Cost (2013 CAD)	215,392,773	194,261,855	197,812,720	207,016,100	210,219,318	185,080,524

Present Value of MVA costs

To estimate the total present value of all future attributable health care costs for MVA, a forecast of costs was estimated to capture all continuing incremental costs that would be attributable to the initial MVA. First the average cost (expressed in 2013 CAD) for each year subsequent to the accident was calculated from all observed cost data reported in Table 3a. A linear forecast was then estimated based on years 2-6 until attributable costs were no longer

positive. The forecasted costs were positive until twelve years after the initial accident. First year costs were not included in the forecast as these include both initial and ongoing costs and the desired value was ongoing cost. To calculate expected future costs, the probability of continued survival and receipt of health care services needed to be addressed. The survival of patients was estimated based on the survival of the entire population of MVA (including patients who were excluded from cost analyses because they had a recent prior MVA, those who were matched and included in the incremental cost analyses as well as individuals who were not matched and not used to estimate incremental costs as reported in the first row of Table 1). We identified the population who survived and continued to be eligible for health care insurance coverage in Ontario using the ICES Registered Persons Database. Population counts are reported in Appendix 3. We used these data to measure the proportion of the MVA population who continued to be eligible for health care insurance.

The final analysis calculated the present value of all immediate and future costs using a discount rate of 3%. The present value of total future costs attributable to an accident calculated from the average of all data included in this study was \$5,495 in 2013 CAD. Annual average costs and forecasted costs are shown in Table 4. Using this figure and the total number of cases in 2013, the total expected costs for MVAs that occurred in 2013 (69,724 from Table 1) is \$383,099,805.

Table 4. Total (Forecasted) Attributable Health Care Costs per Case by Year (Adjusted to 2013 CAD).

Year	Average Attributable Annual Cost (actual 2007-2012)	Proportion of MVA Population Eligible for Health Care Coverage [†]	Present Value of Future Costs (3% discount) [‡]
1st year	2,958	1.0000	\$5,495
2nd year	549	0.9848	
3rd year	498	0.9771	
4th year	465	0.9697	
5th year	387	0.9626	
6th year	310	0.9556	
Forecasted Data (linear trend based on years 2-6)			
7th year	265	0.9481	
8th year	206	0.9408	
9th year	147	0.9335	
10th year	89	0.9262	
11th year	13	0.9189	
Thereafter	zero		

[†] Accounts for loss of eligibility for insurance due to mortality and departure from province observed in study period. From Appendix 3.

[‡] Calculated as present value of (average attributable annual cost X [multiplied by] proportion of population eligible).

Limitations

The costs reported here capture the vast majority of health care costs for publicly funded health care services provided to those injured in a motor vehicle accident (MVA) in Ontario, but the results of this research do not include all publicly funded health care services. In particular we have not fully captured all costs associated with the treatment, rehabilitation and on-going care needs of individuals who may have suffered a closed head injury or acquired brain injury (ABI). Care for ABI is commonly paid for through broader funding envelopes to other agencies and/or facilities and not through CCAC contracted services. In the Public Accounts of Ontario 2013-14, about \$49M was identified as funding for ABI (acquired brain injury) services. Some proportion of these costs are required as a result of injuries sustained in an MVA but are not included here because individual usage is not tracked using the databases that we have access to. Because care for ABI is commonly paid for through broader funding envelopes to other agencies and/or facilities and not through CCAC contracted services included in the present report, this type of care along with any other health services not specifically contained within the defined data sources, are not included in this report. Outpatient rehabilitation services are also not recorded in provincial administrative databases and are therefore not included in the cost estimates reported here. We are also unable to ascertain costs for community support services such as meals on wheels where health card numbers are not recorded at the point of service. Costs for services provided by charitable organizations such as the March of Dimes or Cheshire community service agencies are also not included in the estimates in this report (these organizations receive government funding). Other caveats to the methods for allocating publicly funded health care services can be found in the costing methodology report (Wodchis et al., 2013). Patients' own costs and costs borne by private insurance are not measured or reported in the analyses in this report.

We also acknowledge differences between the incidence of MVAs included in this report and those reported in the Ontario Road Safety Annual Report (ORSAR) (Ontario Ministry of Transportation, 2015). ORSAR includes data collected from police reports from MVAs as recorded by police services and do not report on data from health care providers. The vast majority of historical ORSAR data were collected on paper-based forms by local police services. The current report is based on patient encounters with health care providers where health care providers recorded the cause for the encounter as being related to an MVA.

Conclusion

We employed a robust and rigorous approach to estimating total health system costs associated with treatment in the Ontario health care system for motor vehicle accidents. The estimated attributable cost per MVA individual in the first year following a motor vehicle accident in 2011/12 was \$3,134 and averaged \$2,958 over seven years from 2007-2012 (expressed in 2013 CAD currency terms). Costs in subsequent years were considerably lower from the second year onwards and declined slowly over time. The present value of all estimated MVA attributable costs was \$5,495. With a total of 69,724 incidents in 2013/14 this amounts to a total present value (net actuarial liability) of \$383,099,805 for MVAs that occurred in 2013/14.

References

Austin PC. (2009). Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. *Stat Med.* 28(25): 3083-107

Johns Hopkins School of Public Health. (2016). Johns Hopkins ACG Case-Mix Adjustment System. Available at: <http://www.acg.jhsph.edu>

Kralj B. (2008) Measuring Rurality - RIO2008_BASIC: Methodology and Results. *Ontario Medical Association.* Available at: <https://www.oma.org/Resources/Documents/2008RIO-FullTechnicalPaper.pdf>

Ontario Ministry of Transportation. (2015). Ontario Road Safety Annual Reports (ORSAR). Available at: <http://www.mto.gov.on.ca/english/publications/ontario-road-safety-annual-report.shtml>

Normand S.L. T., Landrum M.B., Guadagnoli E., Ayanian J.Z., Ryan T.J., Cleary P.D., McNeil B.J. (2001). Validating recommendations for coronary angiography following an acute myocardial infarction in the elderly: A matched analysis using propensity scores. *Journal of Clinical Epidemiology.* 54:387–398

Wodchis WP, Bushmeneva K, Nikitovic M, McKillop I. (2013). Guidelines on Person-Level Costing Using Administrative Databases in Ontario. Working Paper Series. Vol 1. Toronto: *Health System Performance Research Network.*

Wodchis WP, Austin PC, Henry DA. (2016). A 3-year study of high-cost users of health care. *CMAJ.* doi: 10.1503/cmaj.150064

Appendices

Appendix 1: Defining Motor Vehicle Accident-Related Injuries

International Classification of Diseases (ICD), 10th Revision codes

V02: Pedestrian injured in collision with two- or three-wheeled motor vehicle

V03: Pedestrian injured in collision with car, pick-up truck or van

V04: Pedestrian injured in collision with heavy transport vehicle or bus

V09: Pedestrian injured in other and unspecified transport accidents

V12: Pedal cyclist injured in collision with two- or three-wheeled motor vehicle

V13: Pedal cyclist injured in collision with car, pick-up truck or van

V14: Pedal cyclist injured in collision with heavy transport vehicle or bus

V19: Pedal cyclist injured in other and unspecified transport accidents

V20-V29: Motorcycle rider injured in transport accident

V30-V39: Occupant of three-wheeled motor vehicle injured in transport accident

V40-V49: Car occupant injured in transport accident

V50-V59: Occupant of pick-up truck or van injured in transport accident

V60-V69: Occupant of heavy transport vehicle injured in transport accident

V70-V79: Bus occupant injured in transport accident

V80.3: Rider or occupant injured in collision with two- or three-wheeled motor vehicle

V80.4: Rider or occupant injured in collision with car, pick-up truck, van, heavy transport vehicle or bus

V80.5: Rider or occupant injured in collision with other specified motor vehicle

V86: Occupant of special all-terrain or other motor vehicle designed primarily for off-road use, injured in transport accident

Excludes: vehicle in stationary use or maintenance (W31.-)

V87: Traffic accident of specified type but victim's mode of transport unknown

Excludes: collision involving: pedal cyclist (V10-V19), and pedestrian (V01-V09)

Excludes: V87.9

V88: Nontraffic accident of specified type but victim's mode of transport unknown

Excludes: collision involving: pedal cyclist (V10-V19), and pedestrian (V01-V09)

Excludes: V88.9

V89: Motor- or nonmotor-vehicle accident, type of vehicle unspecified

Appendix 2: Baseline characteristics of matching variables for matched cohort (fiscal year 2011/12).

This table shows that the 2011/12 case cohort is very similar to its matched control cohort in sex, age, probability of being exposed to an MVA, comorbidity, geographic location, rurality, and neighbourhood income quintile.

Variable	Class	Case Mean (SD)/%	Control Mean (SD)/%	Standardized Difference	Variance Ratio
Total Number of Cases		64,328	64,328	-	-
Matching Variables					
Sex	% Male	48.61	48.61	0	1.00
Age		38.33(19.38)	38.33(19.38)	0	1.00
Propensity score		4.06(0.4)	4.06(0.4)	0.01	0.99
CADG ¹					
	Acute minor	71.02	70.26	0.02	0.98
	Acute major	62.1	62.19	0	1.00
	Likely to recur	57.37	56.56	0.02	0.97
	Asthma	6.54	5.89	0.03	0.81
	Chronic medical unstable	18.41	16.82	0.04	0.83
	Chronic medical stable	34.78	32.84	0.04	0.89
	Chronic specialty stable	3.91	3.58	0.02	0.84
	Eye, dental	5.98	5.3	0.03	0.79
	Chronic specialty unstable	6.61	5.95	0.03	0.81
	Psychosocial	33.02	33.46	0.01	1.03
	Prevention, Administration	35.23	35.06	0	0.99
	Pregnancy	3.76	4.66	0.04	1.53
LHIN ²					
	1. Erie St. Clair	4.69	4.73	0	1.02
	2. South West	8.59	8.47	0	0.97
	3. Waterloo Wellington	5.4	5.36	0	0.98
	4. HNHB ⁴	11.25	11.3	0	1.01
	5. Central West	7.53	7.58	0	1.01
	6. Mississauga Halton	7.5	7.49	0	1.00
	7. Toronto Central	6.61	6.58	0	0.99
	8. Central	12.6	12.69	0	1.02
	9. Central East	12.79	12.94	0	1.02
	10. South East	4.31	4.28	0	0.98
	11. Champlain	8.34	8.34	0	1.00
	12. North Simcoe Muskoka	3.65	3.58	0	0.96
	13. North East	4.78	4.75	0	0.99
	14. North West	1.97	1.92	0	0.95
RIO2008		11.37(17.4)	11.1(17.86)	0.01	1.05

³		4)			
Income quintile					
	1	21.86	21.82	0	1.00
	2	21.24	21.43	0	1.02
	3	20.5	20.43	0	0.99
	4	20.09	20.05	0	1.00
	5	16.31	16.27	0	1.00

¹ Collapsed Aggregated Diagnosis Groups (CADG) characterize the degree of comorbidity in patients and populations.

² Local Health Integration Networks (LHINs) are health authorities responsible for the provision of public health care services to a population in a defined geographic area within the province of Ontario.

³ Rurality Index of Ontario (RIO) [large urban 0–9, suburban 10–39, rural ≥ 40]

⁴ Hamilton Niagara Haldimand Brant (HNHB) LHIN

Appendix 3: Population attrition by year 2007-2012

This table provides the total number of individuals with an MVA in each year from 2007 through 2012 and the total number alive and eligible for health insurance in Ontario in each subsequent year up until 2012. Used to calculate present value costs in Table 5.

Number of Eligible Cases							Average Proportion of MVA Population Eligible for Coverage
MVA Year	2007	2008	2009	2010	2011	2012	
1st year	70,595	67,105	67,051	70,406	67,077	66,625	1.0000
2nd year	69,776	66,386	66,379	69,639	66,367	-	0.9892
3rd year	69,077	65,797	65,868	69,101	-	-	0.9807
4th year	68,521	65,266	65,311	-	-	-	0.9724
5th year	67,984	64,709	-	-	-	-	0.9637
6th year	67,413	-	-	-	-	-	0.9549