

# Cost of stroke in Ontario, 1994/95

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## Special Supplement

## Supplément spécial

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## Abstract

**Background:** Stroke is a major cause of death and disability in Ontario. This study estimates the cost of stroke, which can be used to help policy-makers appreciate the burden this disease places on society.

**Methods:** A prevalence-based study measured disease-related costs in 1994/95 incurred by people with stroke. Direct costs included expenditures on hospital and other institutional care, services of physicians and other health professionals, drugs, research, home care, emergency health services, assistive devices and community support. Indirect costs were measured using the human-capital approach, which examines lost productivity due to premature death and disability.

**Results:** A sensitivity analysis was used to estimate the total cost of stroke in Ontario to be \$857 million, with a low of \$719 and a high of \$964 million. Direct costs were 60% of total costs. Stroke accounted for 3.9% of acute care hospital costs, 5.0% of rehabilitation, chronic care and other institutional costs, and 6.0% of home care costs. It accounted for a relatively minor proportion of physician costs (1.0%) and drug expenditures (0.3%).

**Interpretation:** Stroke has a major economic impact in Ontario. Most direct costs of stroke are borne by the institutional health and community support sectors. These findings may provide guidance to policy-makers when they set priorities for research and prevention activities. Because we used provincial databases containing more detailed information than national databases, cost estimates in this study are more precise than national estimates. Because we used a strict definition of stroke, cost estimates may be considered conservative.

## Résumé

**Contexte :** L'accident cérébrovasculaire (ACV) est une cause importante de décès et d'incapacité en Ontario. Dans cette étude, on estime le coût des ACV, ce qui peut aider les décideurs à comprendre le fardeau que cette maladie impose à la société.

**Méthodes :** Au cours d'une étude de prévalence, on a mesuré les coûts liés à la maladie qu'ont assumés les victimes d'un ACV en 1994-1995. Les coûts directs ont inclus les frais d'hospitalisation et d'autres soins en établissement, les services de médecins et d'autres professionnels de la santé, les médicaments, la recherche, les soins à domicile, les services de santé d'urgence, les appareils fonctionnels et l'appui communautaire. On a mesuré les coûts indirects par la méthode du capital humain, qui permet d'analyser la productivité perdue à cause de la mort prématurée et de l'incapacité.

**Résultats :** On a utilisé une analyse de sensibilité pour estimer que le coût total des ACV en Ontario s'établissait à 857 millions de dollars, soit à au moins 719 millions et au plus 964 millions. Les coûts directs ont représenté 60 % des coûts totaux. Les ACV ont entraîné 3,9 % des coûts des hôpitaux de soins actifs, 5 % des coûts de réadaptation, de soins chroniques et autres coûts institutionnels et 6 % des coûts des soins à domicile. Ils ont représenté une proportion relativement faible des coûts des médecins (1,0 %) et des dépenses de médicaments (0,3 %).

**Interprétation :** L'ACV a une incidence financière importante en Ontario. Les secteurs des soins de santé en établissement et du soutien communautaire assument la majeure partie des coûts directs de l'ACV. Ces constatations peuvent guider les décideurs lorsqu'ils établissent les priorités des activités de recherche et de prévention. Comme nous avons utilisé des bases de données provinciales qui contiennent plus de renseignements détaillés que les bases de données nationales, les estimations des coûts établies à la suite de cette étude sont plus précises que les estimations nationales. Comme nous avons utilisé une définition rigoureuse de l'ACV, on peut considérer que les estimations des coûts sont conservatrices.

Stroke is responsible for 6000 deaths in Ontario each year,<sup>1</sup> 26 000 hospital separations and an estimated 1 million days of hospital care.<sup>2</sup> Although there have been significant reductions in both the age-adjusted incidence of stroke and mortality due to stroke since the 1960s,<sup>3</sup> there is evidence that the rate of hospitalizations due to

stroke has been increasing since the early 1980s, with a shift towards more serious intracerebral hemorrhages and away from cerebral infarction (final report of the Canadian collaborative study of stroke hospitalizations, unpublished report, Jan. 1996).

These trends have significant implications for both the quality of life of people in Ontario and health care systems. In response to these concerns, the Heart and Stroke Foundation of Ontario commissioned this study to estimate the magnitude of the economic cost of stroke. Although estimates of the cost of an illness cannot be used to evaluate the appropriateness of existing services or provide the specific focus for new health care investments to address stroke, they can provide policymakers with general guidelines that can be used to set priorities for research and prevention.

This study differs from previous cost-of-illness studies in 2 respects. First, it used detailed province-specific databases that allowed for a level of precision not attainable with national databases. Second, previous studies<sup>4</sup> examined the broad category of cerebrovascular disease, whereas this study targeted stroke-related events. Other, ill-defined and late effects of cerebrovascular disease have been excluded (ICD-9 codes 437–438), but cerebral infarction, intracerebral hemorrhage, subarachnoid hemorrhage and transient ischemic attacks have been included (ICD-9 codes 430–436).

## Methods

The prevalence approach was used to measure costs, which include all costs relating to stroke that occur within a year, irrespective of the time of onset of the stroke.<sup>5</sup> The cost to society was also used, which includes costs incurred by governments, individuals and employers. Transfer payments between parties were not included. The base year for all cost calculations was 1994/95.

### *Calculation of direct costs*

Direct costs are the value of resources used in the diagnosis, treatment, research and prevention of disease. These costs were calculated by examining, for each category, the total expenditures on health services and the percentage of these expenditures attributable to stroke. The primary source of information on total costs for most categories was the Public Accounts of Ontario, 1994–95.<sup>6</sup> This source itemizes all expenditures of the Ontario Ministry of Health for acute-care, chronic-care and rehabilitation hospitals; medical services; drug benefits for selected groups (e.g., seniors and welfare recipients); assistive devices; home care; emergency health services; community support programs; and other health programs. For pharmaceutical costs, the major source of private health care costs, we used proprietary cost data from Intercontinental Medical Statistics.<sup>7</sup> For research costs, we used estimates from the Medical Research Council of Canada (MRC) for both public and pri-

vate national research expenditures.<sup>8,9</sup> There were no significant expenditures for cardiovascular diseases related to Workers' Compensation Board claims.<sup>10</sup>

For most cost categories, the percentage attributable to stroke was calculated from utilization databases containing diagnostic information. Appendix 1 lists the utilization databases used, the methods for allocating costs and the limitations of each method. We used primary diagnosis as the main criterion for allocating costs by disease. For patients with multiple diagnoses, only a portion of costs incurred was attributable to stroke. Hence, costs have been overestimated for patients with a primary diagnosis of stroke and underestimated for patients in whom stroke is a secondary diagnosis. Another area of controversy relates to costs associated with predisposing factors to stroke, such as hypertension. By convention, such costs are assigned to the underlying factor, not to stroke.

Calculations for certain cost categories deserve special mention and are described in detail below.

## Hospitals

For acute-care hospitals we used 2 methods of costing. Method 1 examined the percent of weighted cases with a primary diagnosis of stroke. The Discharge Abstract Database (DAD)<sup>11</sup> of the Canadian Institute for Health Information contains comprehensive information on each separation from an acute-care hospital in Ontario such as diagnosis on admission, length of stay and patient characteristics. Previous audits have confirmed a good level of reliability for the Ontario data.<sup>12</sup> The DAD also records the resource intensity weight (RIW), a measure that assigns a heavier weight to patients requiring more resources per day because of the complex nature of the case or the longer stay in hospital. Hence, the proportion of hospital activity attributable to stroke is the sum of RIWs for all patients with stroke, divided by the sum of RIWs for all patients with any diagnosis. However, the RIW is limited in that the measures are based on relatively old case-costing data from the United States.

In method 2, total acute-care hospital costs were calculated by multiplying the total number of patients with stroke by the average cost per case, which was derived from a small, nonrepresentative sample of Ontario hospitals participating in a case-costing pilot exercise (unpublished data) sponsored by the Joint Policy and Planning Commission of Ontario. Data were available for only 3 of the 7 ICD-9 codes of interest (ICD-9 430, 431 and 436). Thus, the average cost per stroke was calculated as the weighted average of the average costs of these 3 ICD-9 codes.

## Physician services

For physician services, detailed data on utilization by diagnosis were unavailable in Ontario. Although fee-for-service physicians do record a diagnostic code for patient assessments, they do not record one for lab tests, diagnostic procedures or

surgery. Furthermore, the diagnostic data in Ontario are not subject to any quality assurance measures. Therefore, to estimate the percentage of physician-services costs attributable to stroke, we used detailed unpublished data from Manitoba Health, which collects diagnostic information on all fee-for-service claims.

## Drugs

Data from Intercontinental Medical Statistics (IMS) were used to calculate drug costs. IMS monitors prescribing volumes and practices by surveying physicians across the country. Their Canadian Drug Therapeutic Index<sup>13</sup> indicates, for any given drug, the frequency with which it is prescribed for a particular ICD-9 diagnosis by a physician in an outpatient setting. Their Canadian Compuscript Index,<sup>7</sup> which tracks total sales for each drug in retail pharmacies, is based on surveys of prescriptions sold in Canada. Using these 2 sources we were able to calculate the total outpatient costs for drugs to treat stroke. (Inpatient drug costs are included under hospital costs.)

The Ministry of Health budget lists expenditures on the Ontario Drug Benefit Program (ODBP) and related programs. These programs reimburse a select group of outpatients for drug expenses (for example, the elderly and social assistance recipients). These expenditures have been excluded to prevent double counting IMS data. Because ODBP administration costs are not captured by IMS, a portion of these costs were assigned to stroke based on the proportion of prescription drugs attributable to stroke.

Only prescription drugs are included in the IMS total; hence, some stroke-related over-the-counter drug costs (e.g. ASA) may not have been captured by this study. The IMS database also does not record dispensing fees. We estimated total dispensing fees in Ontario by multiplying the total number of prescriptions by the typical dispensing fee in Ontario, and applied the proportion of drug costs related to stroke, as calculated above, to this total.

## Research

Because much medical research is funded by national agencies such as the Heart and Stroke Foundation of Canada, and studies are often conducted on a multicentre, interprovincial basis, we estimated the national cost of research related to stroke and assigned a portion to Ontario based on relative population size. We reviewed a registry of grants provided by MRC with staff of the Heart and Stroke Foundation and classified each into 1 of 3 categories: Group I, exclusively stroke-related; Group II, basic research related to stroke and other cardiovascular diseases; and Group III, basic research related to stroke, cardiovascular and other diseases. Stroke was assigned 100% of Group I costs and 20% of Group II costs on the basis that stroke represents approximately 20% of cardiovascular mortality and disease burden.<sup>12</sup> Similarly, 10% of Group III costs were assigned to stroke.

## Administrative and overhead costs

There are many levels of administrative and overhead costs in the provincial health budget. An example of overhead is the cost of overall management of the health care system. We used a stepdown allocation scheme<sup>14</sup> to assign overhead to different departments within the Ministry. Overhead costs within individual departments were allocated in the same fashion to the programs supported by those departments. We treated the health promotion programs listed in Public Accounts<sup>6</sup> as overall health system overhead because information on the percentage of such expenditures attributable to specific disease categories was unavailable.

## Calculation of indirect costs

Indirect costs were calculated using the human-capital approach, which measured earnings lost because of disability or premature death from stroke. The estimation of indirect costs is controversial; no measure of the economic value of life is completely objective. A review of the relative merits of different evaluation methods is beyond the scope of this paper, but is discussed elsewhere in greater detail.<sup>15,16</sup>

We calculated lost earnings using Statistics Canada survey data on national pre-tax individual earnings for different groups according to age and sex.<sup>17</sup> Transfer payments and investment income were excluded from these calculations because there is no net loss to society in these areas when a person dies. The economic value of premature death was the average lost earnings up to the age of 75. It was assumed that economy and wages would grow by 2% per year and future earnings were adjusted accordingly. Hence, the cost of premature death for an individual were calculated as follows:

$$\sum_{n = A_d}^{75} \frac{I_n (1+g)^{(n-A_d)}}{(1+r)^{(n-A_d)}}$$

where

$I_n$  = average 1994 earnings for individuals at age  $n$

$g$  = growth rate of economy (estimated at 2%)

$r$  = discount rate for future income

$A_d$  = age at death.

The cost of premature death for the population was calculated as the number of deaths from stroke in each age-sex group, obtained from national vital statistics data,<sup>1</sup> multiplied by the lost future income stream for each age-sex group.

Several adjustments were made to the Statistics Canada earnings data. First, employee benefits are of value but were not captured in the survey. Because many employers offer part-time employees 20% in lieu of benefits, benefits were estimated to be

20% of average earned income. Second, household and other untraded labour are not recorded in income surveys, yet represent important economic output. Empirical studies have estimated the value of such labour to be 0.4 to 0.6 times the earned wage.<sup>18,19</sup> From Statistics Canada surveys,<sup>17,20</sup> the number of people not working in each age–sex group was calculated. People who worked part-time or who were unemployed were assumed to have implicit earnings of 0.4 to 0.6 times the difference between earnings of employed people in their age–sex group and their own earnings. Third, the existence of disabled people in the sample led to a downward bias in the estimate of income of healthy individuals. To correct this error, disability payments reported by the Canada Pension Plan (CPP), the Quebec Pension Plan and the Canadian Health Life and Health Insurance Association were added to the average earned income figures.<sup>21–23</sup>

We used 2 methods to estimate disability costs. In the first, we used survey data to estimate the number of people in Ontario with a partial or complete disability. A study done by Health and Welfare Canada<sup>4</sup> assigned weights of 0.4 and 0.5 to individuals reporting partial or complete disability; we used these weights to estimate lost earnings for people at these levels of disability.<sup>5</sup> Hence, for each age–sex group, the foregone income was calculated as disability rate  $\times$  population  $\times$  disability weight  $\times$  annual earnings.

The 1990 Ontario Health Survey (OHS)<sup>24</sup> provided detailed information on cause and level of severity of disability. However, this data source was relatively old. To assess its validity, we compared overall disability rates with those calculated in

the 1994 National Population Health Survey (NPHS),<sup>25</sup> which is more current but lacks the detail of the OHS. In the NPHS, 0.28% of people reported restricted activity due to circulatory disease; in the 1990 OHS, 0.27% of respondents had paralysis or a speech problems due to stroke.

The second method for measuring disability costs was based on estimates of disability payments for stroke paid out by the CPP and private insurance companies.<sup>21–23</sup> Although insurance plans vary, disability payments generally replace only two-thirds of original income. Total disability payments for cardiovascular disease were multiplied by a factor of 3/2 to take into account the two-thirds benefit limit. Even with this adjustment, the estimates remain conservative because of the existence of payment ceilings in many plans.

An extensive sensitivity analysis was conducted to estimate baseline, low- and high-cost scenarios. The different assumptions used for each scenario are listed in Table 1. In cost categories where 2 methods were used, estimates were used for the low- and high-cost scenarios and the baseline was taken as the average of the 2 values. In cost categories where only 1 method was used, we arbitrarily assumed a range of high and low estimates of  $\pm 15\%$  of the baseline.

## Results

The baseline estimate of the total cost of stroke in Ontario in 1994/95 was \$857 million, with a high estimate of \$964 million and a low estimate of \$719 million (Table 2). Direct costs were

**Table 1: Data sources and methods of estimating the costs of stroke for each cost category**

Cost category	Low estimate	Baseline estimate	High estimate
Hospitals	JPPC case-cost method	average of low and high estimates	CIHI cost method
Other institutions	baseline less 15%	based on stroke % calculated for chronic-care institutions	baseline plus 15%
Physicians, lab services, other professional services	baseline less 15%	stroke % calculated from Manitoba Health data on physician service by diagnosis	baseline plus 15%
Drugs	baseline less 15%	based on IMS audit	baseline plus 15%
Research	weights of 0.15 and 0.05 for Group II and III grants	weights of 0.2 and 0.1 for Group II and III grants	weights of 0.25 and 0.15 for Group II and III grants
Assistive devices	baseline less 15%	stroke % calculated from provincial database	baseline plus 15%
Home care	baseline less 15%	stroke % calculated from provincial database	baseline plus 15%
Emergency health services	one-third of high estimate	one-half of high estimate	% of ambulance admissions with diagnosis of stroke
Other community-support services	stroke % for chronic care	average of high and low estimates	stroke % for home care
Lost productivity, disability	disability payment method	average of high and low estimates	disability survey method using OHS; 0.6 weight adjustment for household labour
Lost productivity, premature death	no adjustment for household labour	0.4 weight adjustment for household labour	0.6 adjustment for household labour

Note: JPPC = Joint Policy and Planning Commission of Ontario; CIHI = Canadian Institute for Health Information; IMS = Intercontinental Medical Statistics; OHS = Ontario Health Survey.

\$529 million, or 62% of total costs. Institutional care, including acute- and chronic-care hospitals, rehabilitation hospitals and residential-care facilities, accounted for a large proportion (73%) of direct costs.

Stroke accounted for 2.7% of total direct health care expenditures in Ontario (Table 3). The proportion of costs attributable to stroke varied considerably among cost categories. Stroke had the highest profile among home-care and community-support services, accounting for 6.0% and 5.5% of provincial expenditures respectively. In contrast, a relatively small proportion of costs for drugs and medical services were attributable to stroke.

Costs related to premature death were \$229 million and accounted for the largest proportion (71%) of indirect costs. The cost of premature death was sensitive to changes in the discount rate and ranged from \$298 million (2% discount) to \$193

**Table 2: Cost of stroke in Ontario by cost category, 1994/95**

Cost category	Estimates (in \$ million)		
	Low	Baseline	High
<b>Direct costs</b>			
Acute-care hospitals	252.2	263.0	273.7
Rehabilitation hospitals	56.0	65.9	75.8
Residential-care facilities	50.5	59.5	68.4
Medical services	45.7	53.8	61.9
Drugs and professional fees	7.3	8.6	9.9
Research	4.8	8.8	12.8
Assistive devices	0.2	0.2	0.2
Home care	40.5	47.6	54.8
Emergency health services	5.0	8.3	16.6
Other community support	11.7	13.0	14.2
<b>Total direct costs</b>	<b>474.0</b>	<b>528.7</b>	<b>588.3</b>
<b>Indirect costs</b>			
Disability	87.5	99.2	111.0
Premature death	157.0	228.9	264.8
<b>Total indirect costs</b>	<b>244.5</b>	<b>328.1</b>	<b>375.8</b>
<b>Total costs</b>	<b>718.5</b>	<b>856.8</b>	<b>964.0</b>

**Table 3: Cost of total direct health care in Ontario and percentage attributable to stroke, 1994/95**

Cost category	Cost (\$ million)	% attributable to stroke
Acute-care hospitals	6 801.9	3.9
Rehab hospitals	1 321.1	5.0
Residential-care facilities	1 192.2	5.0
Medical services	5 310.6	1.0
Drugs and professional fees	2 802.4	0.3
Research	408.3	2.2
Assistive devices	82.2	0.3
Home care	790.1	6.0
Emergency health services	303.4	2.7
Other community support	235.3	5.5
<b>Total, direct costs</b>	<b>19 248.0</b>	<b>2.7</b>

million (10% discount). The cost of disability was \$99 million, with a range of  $\pm$  \$12 million.

Costs by individual ICD-9 code have been broken down for acute-care hospitals (Table 4), where the use of codes is likely the most accurate. From this analysis, the largest expenditures were for strokes due to arterial occlusion (ICD-9 codes 433 and 434), accounting for 37% of stroke-related costs, and for those due to acute but ill-defined cerebrovascular disease (ICD-9 code 436), accounting for 40% of stroke costs.

## Discussion

This study estimates the cost of stroke in Ontario at \$857 million, within a range of \$719 to \$964 million. We used a conservative definition of stroke to avoid confusion with nonspecific cerebrovascular diseases. In doing so, however, we likely omitted certain legitimate cases of stroke. Hence, results should be interpreted as representing the lower boundary of actual costs.

Institutional care accounted for almost three-quarters of all direct costs of stroke. Furthermore, stroke accounted for 3.9% of acute-care hospital expenditures and 5.0% of chronic, rehabilitation and other institutional care. The relatively high costs related to stroke in the institutional sector is partly due to longer stays in hospital of these patients compared with those for other diseases, and heavy use of nursing services.<sup>26</sup>

Due to its frequently long-term, debilitating effects, it was not surprising that stroke accounted for a large proportion of the province's budget for home care and community support. This finding has implications for policy-makers who are currently engaged in shifting care from institutional to community settings. Because stroke already accounts for high institutional costs, shifting expenditures to the community could potentially increase the percentage of expenditures in community care to an even higher level. If this is the case, policy-makers may wish to consider a greater degree of specialization of stroke-related services in the community sector.

**Table 4: Costs of stroke in Ontario acute-care hospitals, 1994/95**

ICD-9 code	Description	Total cost (\$ million)*	No. of cases
430	Subarachnoid hemorrhage	15.5	893
431	Intracerebral hemorrhage	21.8	1 622
432	Other and unspecified intracranial hemorrhage	6.8	564
433	Occlusion and stenosis of precerebral arteries	17.6	2 270
434	Occlusion of cerebral arteries	83.2	5 442
435	Transient cerebral ischemia	18.0	4 194
436	Acute but ill-defined cerebrovascular disease	110.8	8 586
<b>Total</b>		<b>273.7</b>	<b>23 571</b>

ICD-9 = International Classification of Diseases, ninth revision.

\*Costs are based on the Discharge Abstract Database of the Canadian Institute for Health Information. The total cost figure corresponds to the high estimate for acute-care hospitals in overall calculations of stroke costs.

Physician costs for stroke were relatively small. However, this cost may be underestimated because diagnostic data from Manitoba underrepresent hospital-based physicians, where many stroke-related costs are incurred. However, one study that examined the use of inpatient services by patients with stroke at an Ontario teaching hospital found that physician costs accounted for only 6% of total hospital costs.<sup>26</sup> These results also suggest that the care of patients with stroke is a relatively minor part of the practice volume of physicians.

Stroke accounted for a relatively small proportion (< 1%) of Ontario's drug costs. This is not surprising, since few drugs other than antiplatelet agents and anticoagulants are available to manage stroke. Although many patients with stroke take antihypertensives, by convention such drugs were associated with hypertension and were therefore excluded. Thus, this study errs on the conservative side. It should also be noted that drug costs for stroke may increase as new medications come into use. Both the thrombolytic agent tissue-plasminogen activator (t-PA) and neuroprotective agents are currently in the final stages of clinical testing and approval.

Although the human-capital approach is the most widely used method in cost-of-illness studies,<sup>27</sup> it has many limitations. First, it does not account for intangible costs, such as pain or suffering. Second, it carries an implicit valuation of the relative worth of different individuals in society. For example, the life of an elderly person or woman is assigned a lower value than a middle-aged man. Thus, distributing health resources on the basis of such a value system may be contrary to societal objectives. Third, the willingness-to-pay approach is favoured by many economists because it is more consistent with modern neoclassical welfare economic theory on consumer behaviour.<sup>16</sup> Willingness to pay is difficult to measure, but generally yields higher estimates than the human-capital approach. All of these limitations suggest that the human-capital approach provides a relatively conservative estimate of indirect costs.

Another limitation of this study is that all private costs may not have been captured, such as ancillary hospital care (e.g., semiprivate room coverage), uninsured assistive devices, over-the-counter medications (e.g., ASA) and modifications to households to improve accessibility for patients with stroke. Again, these exclusions will result in a conservative estimate of costs. Another reason these estimates are conservative is that many people with brain hemorrhages die before they get to hospital, and the real cause of death may not be reported and captured in the indirect cost estimates.

## Interpretation

This study illustrates the economic burden of stroke in Ontario. Although the methodology used has limitations, the results tend to err on the conservative side. It does provide an indication of the *potential* benefit to society if a program existed that was able to eliminate stroke. However, in setting priorities for research or prevention programs, policy-makers

must evaluate the *actual* benefits that these programs would provide and compare these benefits with costs. Hence, cost-of-illness estimates are only the first step in the problem-definition phase of policy analysis, and are of limited usefulness in the development of policy solutions. Further research and work by the Heart and Stroke Foundation and other organizations is needed to identify and implement the most cost-effective strategies for preventing stroke and reducing its impact on society.

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## References

1. *Causes of death, 1994*. Ottawa: Canadian Centre for Health Information, Statistics Canada; 1996. Cat no 84-208.
2. *Hospital morbidity and surgical procedures 1993-94*. Ottawa: Health Statistics Division, Statistics Canada; 1996. Cat no 82-216-XPB.
3. *Cardiovascular disease in Canada 1993*. Ottawa: Heart and Stroke Foundation of Canada.
4. Wigle DT, Mao Y, Wong T, Lane R. *Economic burden of illness in Canada, 1986*. Ottawa: Health and Welfare Canada; 1991.
5. Rice DP. Cost-of-illness studies: fact or fiction? *Lancet* 1994;344:1519-20.
6. *Public Accounts of Ontario, 1994-95*. Toronto: Ontario Ministry of Finance.
7. Canadian Compusercript Index, Intercontinental Medical Statistics, 1995. Mississauga (ON): Intercontinental Medical Statistics, 1995.
8. *Report of the President, 1995*. Ottawa: Medical Research Council of Canada.
9. *1995-96 estimate: part III, expenditure plan*. Ottawa: Medical Research Council of Canada.
10. *Statistical supplement to the annual report 1992*. Toronto: Worker's Compensation Board of Ontario.
11. *Discharge abstract database, 1994-95*. Ottawa: Canadian Institute for Health Information.
12. *Report on the 1990 Ontario Data Quality Reabstracting Study*. Ottawa: Canadian Institute for Health Information.
13. *Canadian Drug Therapeutic Index*. Mississauga (ON): Intercontinental Medical Statistics, 1995.
14. Drummond MF, Stoddart GL, Torrance GW. *Methods for the economic evaluation of health care programmes*. Toronto: Oxford University Press; 1997.
15. Robinson JC. Philosophical origins on the economic valuation of life. *Milbank Q* 1986;64:133-55.
16. Hodgson T, Meiners M. Cost of illness methodology: a guide to current practices and procedures. *Milbank Q* 1982;60:429-62.
17. *Income distributions by size in Canada, 1994*. Ottawa: Household Surveys Division, Statistics Canada; 1994. Cat no 13-207.
18. Schuppher MJ, Buxton MJ, Ferbuson BA, Spiegelhalter DJ, Kirby AJ. Screening for diabetic retinopathy: a relative cost-effectiveness analysis of alternate modalities and strategies. *Health Econ* 1992;1:39-51.
19. Torgerson DJ, Donald C, Reid DM. Private vs. social opportunity cost of time: valuing time in the demand for health care. *Health Econ* 1994;3:149-55.
20. *Earnings of men and women, 1994*. Ottawa: Household Surveys Division, Statistics Canada; 1994. Cat no 13-217.
21. *Canada Pension Plan/Old Age Security statistical bulletin*. Ottawa: Human Resources Development Canada; July 1996.
22. *Le régime de rente du Québec: statistiques 1995*. Quebec: Régie des Rentes du Québec.
23. Canadian Life and Health Insurance Association. *Health insurance benefits in Canada, 1995*.
24. *Ontario health survey, 1991*. Toronto: Ontario Ministry of Health.
25. *National Population Health Survey, Public use file, 1994*. Ottawa: Statistics Canada.
26. Smurawska LT, Alexandrov AV, Bladin CF, Norris JW. Cost of acute stroke care in Toronto, Canada. *Stroke* 1994;25(8):1628-31.
27. Scitovsky AA. Estimating the direct costs of illness. *Milbank Q* 1982;60(3):463-91.
28. *Ontario home care reports, table 16-R*. Toronto: Ontario Ministry of Health; 1995.

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## Appendix 1: Data sources for direct costs of stroke in Ontario

Direct cost category	Items included	Method for allocating portion of costs to stroke	Data source for cost allocation calculations	Main limitations
Acute-care hospitals	all related expenses (e.g., staff, supplies, drugs, overhead, administration); excludes physician fee-for-service claims for hospital services	method 1: % of total weighted cases	CIHI, DAD <sup>11</sup>	case weighting based on RIWs derived in US
		method 2: average case cost × number of cases	CIHI, DAD <sup>11</sup> for number of cases; JPPC case-cost project for cost/case	case-costing data based on limited sample of hospitals; data available on only 3 of 7 ICD-9 codes
Rehabilitation and chronic-care hospitals	rehabilitation and chronic-care (stand-alone) hospitals and wards of acute-care hospitals	% of total bed days	CIHI, DAD <sup>11</sup>	no RIWs available
Residential care	nursing homes and homes for the aged	% of total bed days for rehabilitation and chronic care	CIHI, DAD <sup>11</sup>	no utilization data by diagnosis available; % attributable to stroke assumed same as for rehabilitation and chronic-care hospitals
Physician and other health professional services	physician services; other fee-for-service health professionals; nonhospital-based lab services; community health centres; independent health facilities; underserved area program; northern travel grant program	% of physician expenditures	Manitoba Health physician database	validated data for Ontario unavailable; data from Manitoba; subject to quality assurance measures but generalizability not validated
Drugs	professional (dispensing) fees and drug expenditures for outpatients and patients in residential care	% of prescriptions	% prescriptions from CDTI; <sup>13</sup> dispensing fees from CPhA	CDTI based on survey of physicians with small sample size
		volume of drugs prescribed for stroke × cost/drug	volume of drugs from CDTI; <sup>13</sup> Cost/drug from Compuscript <sup>7</sup>	
Research	national stroke research expenditures with portion allocated to Ontario based on relative population size	% of grants attributable to stroke (see text)	operating grant and personnel award database, MRC	allocation of portions of grants to stroke requires some clinical judgement
Home care services	nursing and other health-professional and home-making services	% of total home care days	Ontario Home Care Reports <sup>28</sup>	
Assistive devices	assistive devices funded by Ministry	% of total expenditures	Ministry of Health database	private expenditures on assistive devices not captured
Emergency health services	ambulance services and related infrastructure	% of hospital admissions by ambulance with primary diagnosis of stroke	CIHI, DAD <sup>11</sup>	% of ambulance calls for cases not requiring hospitalization that are attributable to stroke is not known
Other community services	community-based long-term care services	average of % of expenditures for chronic care and % for home care	CIHI, DAD; <sup>11</sup> Ontario Home Care Reports <sup>28</sup>	no diagnosis-specific utilization data for this category available

Note: CIHI = Canadian Institute for Health Information; DAD = Discharge Abstract Database; RIW = resource-intensity weight; JPPC = Joint Planning and Policy Commission of Ontario; ICD = International Classification of Diseases; CDTI = Canadian Diagnostic and Therapeutic Index database, Intercontinental Medical Statistics; CPhA = Canadian Pharmaceutical Association; MRC = Medical Research Council of Canada.