A
cute ischemic stroke (AIS) is a leading cause of death
and disability in Canada, with >55,000 new cases
annually, for an annual cost to the Canadian economy of $2.7
billion (Canadian dollars).1

Intravenous thrombolysis with recombinant tissue plasmin-
ogen activator (tPA) is an effective treatment for AIS, with
nearly 40% of tPA-treated patients returning to their pre-
stroke level of function within 90 days.2 Nonetheless, only
1.4% of AIS patients received this medication in Canada
during 1999 to 2001.2 Fortunately, many medical centers are
implementing programs for AIS care that increase the access
to tPA, with centers such as Kingston Regional Stroke Centre
administering tPA to >20% of its stroke patients.3

Economic studies in the United States, Canada, and the
United Kingdom demonstrate that health care costs for tPA-
treated AIS patients are lower than those for their untreated
counterparts because of the decreased need for long-term care
and rehabilitation.4–7 Using a decision-analytic model,
Demaerschalk et al8 estimated that $600 (Canadian) per
patient is saved in Canada during the first year after tPA,
compared with the medical costs for a stroke patient not
receiving tPA.4 From this estimate, we extrapolated the
national and provincial cost savings of increasing the proportion
of stroke patients receiving tPA.

Materials and Methods
We calculated national and provincial cost savings estimates for
tPA-treated AIS patients in the first year after treatment. The
calculations were made with this formula:

\[ \text{National or provincial cost savings in year 1} = \text{(annual incidence of ischemic stroke)} \times (\text{cost savings in year 1 per treated patient}) \times (\text{percentage of tPA-treated patients}) \]

The annual incidence data for ischemic stroke were derived by
multiplying by 0.88 the data for 1999 obtained from the Canadian
Institute of Health Information for all causes of stroke (ICD-9[8]
codes 430 to 438).8 We conservatively estimated a cost savings of
$600 (Canadian) per tPA-treated stroke patient in the first poststroke
year.4 Sinclair et al6 reported a substantially higher savings estimate
of $3800 (Canadian) per tPA-treated patient over a lifetime (maxi-
mum 30 years). The cost-savings in the first year per tPA-treated AIS
patient was converted from $600 (Canadian) for year 2000-based
data to year 2005 Canadian dollars using the Bank of Canada
Consumer Price Index.9 To reflect current and reported proportions
of tPA-treated stroke patients, we tabulated national and provincial
population cost estimates across a range, starting from 1.4% and
including 2%, 4%, 6%, 8%, 10%, 15%, and up to 20%. The 20%
estimated ceiling figure represents what is currently achievable at
stroke centers.3

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A sensitivity analysis was performed using a CI from the 5th to the 95th percentile ($600 to $2004) estimated by Fagan et al. The 1996 United States-based interval was adjusted to 2005 US dollars according to the US Consumer Price Index, then converted to Canadian currency ($0.859/Can $1.00). These values were then multiplied by 0.91 to account for whole economy cost differences between Canada and the United States. This factor was determined by comparing published costs of Canadian and US stroke care.

Results

In 1999, a total of 55,841 ischemic strokes occurred nationwide in Canada (Table 1). The cost savings estimate for 2005 was $678 (Canadian) per tPA-treated AIS patient during the first posttreatment year. On the basis of the Canadian Active Stroke Effectiveness Study (CASES) rate of tPA use (1.4%), the estimated national cost savings for Canada for tPA-treated acute stroke patients after 1 year was $500,000 (Table 1). With an increase to a 2% rate of tPA use, and for every 2 percentage point increase thereafter, $750,000 (Canadian) could be saved during poststroke year 1. If 20% of ischemic stroke patients received tPA, $7.5 million in Canadian health care funds could be saved nationwide the first year.

The estimated 95% CI was $3424 (maximum cost savings) to $1971 (potential loss) in the first year per tPA-treated AIS patient. The results of the sensitivity analysis for the national estimates are illustrated in Table 2. By increasing the 1.4% proportion of tPA use to 20%, the maximum cost-savings to the national economy could be $38 million, with potential losses up to $22 million.

Discussion

Policy makers face challenges in balancing the burden of rising health costs with meeting the health needs of an aging population. Doing so requires an understanding of the complex evolving relationships between health care advances and the national economy. Economic analyses in North America and abroad indicate that thrombolysis for AIS is clinically and economically worthwhile. This finding is supported by our estimates that tPA use could save millions of dollars nationally. It also suggests the possibility of even greater savings with modest increases in tPA use. We have already published our estimates, which used similar methods, of the economic benefit of increasing the use of tPA for stroke in the US in 2005.

TABLE 1. Estimated Canadian National and Provincial Cost Savings in First Year After Ischemic Stroke After Treatment With Intravenous Tissue Plasminogen Activator

<table>
<thead>
<tr>
<th>Region</th>
<th>No. of Strokes</th>
<th>Proportion of Ischemic Stroke Patients Who Receive tPA, %</th>
<th>Potential Cost-Savings Nationally, Can $</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>55,841</td>
<td>1.4 2 4 6 8 10 15 20</td>
<td>530,043 757,204 1,514,408 2,271,612 3,028,816 3,786,020 5,679,030 7,572,040</td>
</tr>
<tr>
<td>Province</td>
<td></td>
<td></td>
<td>Potential Cost Savings by Province, Can $</td>
</tr>
<tr>
<td>Ontario</td>
<td>20,275</td>
<td>192,450 274,929 549,858 824,787 1,099,716 1,374,645 2,061,969 2,749,290</td>
<td></td>
</tr>
<tr>
<td>Quebec</td>
<td>14,382</td>
<td>136,514 195,020 390,040 585,060 780,080 975,100 1,462,649 1,950,199</td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>7,291</td>
<td>69,206 98,866 197,732 296,598 395,464 494,330 741,495 988,660</td>
<td></td>
</tr>
<tr>
<td>Alberta</td>
<td>4,210</td>
<td>39,961 57,088 114,175 171,263 228,350 285,438 428,157 570,876</td>
<td></td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>2,299</td>
<td>21,822 31,174 62,349 93,523 124,689 155,872 233,808 311,744</td>
<td></td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>1,723</td>
<td>16,355 23,364 46,728 70,092 93,456 116,819 175,229 233,639</td>
<td></td>
</tr>
<tr>
<td>New Brunswick</td>
<td>1,720</td>
<td>16,326 23,323 46,646 69,970 93,293 116,616 174,924 233,232</td>
<td></td>
</tr>
<tr>
<td>Newfoundland</td>
<td>1,040</td>
<td>9,872 14,102 28,205 42,307 56,410 70,512 105,768 141,024</td>
<td></td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>322</td>
<td>3,056 4,366 8,733 13,099 17,465 21,832 32,747 43,663</td>
<td></td>
</tr>
<tr>
<td>Yukon Territory*</td>
<td>40</td>
<td>⋮ ⋮ ⋮ 1,085 1,627 2,170 2,712 4,068 5,424</td>
<td></td>
</tr>
<tr>
<td>Northwest Territories*</td>
<td>29</td>
<td>⋮ ⋮ 786 1,180 1,573 1,966 2,949 3,932</td>
<td></td>
</tr>
<tr>
<td>Nunavut*</td>
<td>11</td>
<td>⋮ ⋮ ⋮ ⋮ ⋮ ⋮ 746 1,119 1,492</td>
<td></td>
</tr>
</tbody>
</table>

*Ellipses denote estimated savings of Can $678 or the equivalent of 1 or fewer patients receiving thrombolysis.

TABLE 2. Estimated Canadian National Cost Savings and Losses in First Year After Ischemic Stroke in Patients Who Receive Intravenous Tissue Plasminogen Activator*

<table>
<thead>
<tr>
<th>Proportion of Ischemic Stroke Patients Who Receive tPA, %</th>
<th>Financial impact, Can $</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.4 2 4 6 8 10 15 20</td>
</tr>
<tr>
<td>Maximum cost savings</td>
<td>2,676,794 3,823,992 7,647,983 11,471,975 15,295,967 19,119,958 28,679,938 38,239,917</td>
</tr>
<tr>
<td>Possible loss</td>
<td>1,540,877 2,201,252 4,402,504 6,603,757 8,805,009 11,006,261 16,509,392 22,012,522</td>
</tr>
</tbody>
</table>

*N=55,841 ischemic stroke cases per year nationally.
These savings reflect a small proportion of the overall cost of stroke; however, the savings are attributable to positive outcomes such as reduced disability and long-term care needs. Furthermore, these estimated savings could substantially offset the cost of establishing organized stroke care systems to increase access to tPA. In Ontario, Canada, the Coordinated Stroke Strategy (an acute stroke care system) was estimated to cost $15.3 million annually. Potential secondary gains from increasing tPA use include faster reallocation of hospital beds, reduced equipment and home modification needs, and reduced caregiver burden.15,16

The maximum proportion of ischemic stroke patients who receive tPA was selected on the basis of estimates in the medical literature and on the best performance of North American stroke centers. Estimates of the proportion of stroke patients who present to a hospital within the first 3 hours are as high as 62%.17–20 Estimates of the proportion of stroke patients who are eligible for tPA (who present in <3 hours) and receive tPA are as high as 35%.19,20 Therefore, we propose a maximum figure of 0.35×62% = 22%. Our analysis has a few limitations. First, the stroke incidence data (1999) and the cost data (2000–2001) are outdated, and neither reflects the actual levels for the year 2006. We estimated, in earlier published work, that using outdated cost data likely results in an underestimate of the potential cost-savings.14 Second, the consumer index-based corrections likely do not reflect the actual changes in stroke care costs during this period. Third, the 95% CIs were derived from US cost data. Although these data were adjusted to mitigate time- and nation-based differences, the estimates may deviate substantially from actual costs. Fourth, the direct costs of stroke care may have changed since 2000. For example, according to the Heart Disease and Stroke database of the Canadian Institute for Health Information, the average length of stay in a hospital after a stroke declined across Canada by nearly 5 days between 1994 and 1999.21 Fifth, the generalizability of the cost data, which were derived from Ontario-based sources, may have limited application to other geographic locations in Canada. Finally, the 95% CI suggests that the costs of treating with tPA may actually exceed the savings rather than the reverse.

At the Caro Research Institute, an economic analysis was developed that estimated that widespread access to organized stroke care could prevent disability in 60,000 Canadians and save $8 billion net in health care costs over 20 years.22 In addition to the use of tPA, this optimal care included organized stroke units, rehabilitation strategies, improved public awareness of stroke, and prevention therapies. The potential savings for enhancing the proportion of acute stroke patients who receive tPA to 20% is $800 million in 20 years, representing 10% of the overall $8 billion estimate.

The challenge ahead lies in improving access to thrombolysis, a highly rated indicator of “best practice” stroke care identified by the Canadian Stroke Quality of Care Study expert panel.23 Research on barriers limiting tPA use, strategies to mitigate these barriers, and the experience of advanced stroke centers suggest that increasing the use of tPA is feasible.24,25 Efforts should be made to educate the public and paramedics about early recognition of stroke, to develop acute stroke therapy training programs for emergency departments, and to re-engineer hospital systems to optimize thrombolytic efficiency.24,25 Several Canadian initiatives are underway to coordinate interdisciplinary stroke teams to reduce morbidity and mortality in stroke patients, to control hospital costs, and to mitigate the need for long-term health care; these include the establishment of designated regional and district stroke centers, regular hospital feedback to identify gaps in care and encourage improvement toward feasible standards, and government-sponsored auditing.23,26

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References


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