

# Impact of Disability Status on Ischemic Stroke Costs in Canada in the First Year

Nicole Mittmann, Soo Jin Seung, Michael D. Hill, Stephen J. Phillips, Vladimir Hachinski, Robert Coté, Brian H. Buck, Ariane Mackey, David J. Gladstone, David C. Howse, Ashfaq Shuaib, Mike Sharma

**ABSTRACT: Background:** Longitudinal, patient-level data on resource use and costs after an ischemic stroke are lacking in Canada. The objectives of this analysis were to calculate costs for the first year post-stroke and determine the impact of disability on costs. **Methodology:** The Economic Burden of Ischemic Stroke (BURST) Study was a one-year prospective study with a cohort of ischemic stroke patients recruited at 12 Canadian stroke centres. Clinical history, disability, health preference and resource utilization information was collected at discharge, three months, six months and one year. Resources included direct medical costs (2009 CAN\$) such as emergency services, hospitalizations, rehabilitation, physician services, diagnostics, medications, allied health professional services, homecare, medical/assistive devices, changes to residence and paid caregivers, as well as indirect costs. Results were stratified by disability measured at discharge using the modified Rankin Score (mRS): non-disabling stroke (mRS 0-2) and disabling stroke (mRS 3-5). **Results:** We enrolled 232 ischemic stroke patients (age  $69.4 \pm 15.4$  years; 51.3% male) and 113 (48.7%) were disabled at hospital discharge. The average annual cost was \$74,353; \$107,883 for disabling strokes and \$48,339 for non-disabling strokes. **Conclusions:** An average annual cost for ischemic stroke was calculated in which a disabling stroke was associated with a two-fold increase in costs compared to NDS. Costs during the hospitalization to three months phase were the highest contributor to the annual cost. A “back of the envelope” calculation using 38,000 stroke admissions and the average annual cost yields \$2.8 billion as the burden of ischemic stroke.

**RÉSUMÉ: Impact du degré d'invalidité sur les coûts reliés à l'accident vasculaire cérébral ischémique au cours de la première année au Canada.** **Contexte :** Nous n'avons pas de données longitudinales sur l'utilisation des ressources par les patients et les coûts ainsi engendrés suite à un accident vasculaire cérébral (AVC) ischémique au Canada. Les buts de cette analyse étaient de calculer les coûts engendrés au cours de la première année après un AVC et de déterminer l'impact de l'invalidité sur ces coûts. **Méthode :** Le Economic Burden of Ischemic Stroke (BURST) Study est une étude prospective d'une durée de un an chez une cohorte de patients ayant subi un AVC ischémique qui ont été recrutés dans 12 centres canadiens de traitement de l'AVC. Des informations ont été recueillies sur l'histoire clinique, l'invalidité, les choix de santé et l'utilisation des ressources au moment du congé hospitalier, trois mois, six mois et un an plus tard. Les ressources incluaient les coûts médicaux directs (en \$ canadiens 2009) comme les services d'urgence, les hospitalisations, la réadaptation, les frais médicaux, diagnostiques et thérapeutiques, les autres services professionnels, les soins à domicile, les équipements médicaux/accessoires fonctionnels, les changements effectués au lieu de résidence et les aidants rémunérés ainsi que les coûts indirects. Les résultats ont été stratifiés selon l'invalidité telle que mesurée au moment du congé hospitalier au moyen du modified Rankin Score (mRS) : AVC non invalidant (mRS 0-2) et AVC invalidant (mRS 3-5). **Résultats :** Nous avons recruté 232 patients atteints d'un AVC ischémique, dont l'âge moyen était de  $69,4 \pm 15,4$  ans et dont 51,3% étaient des hommes. Cent treize (48,7%) étaient invalides au moment du congé hospitalier. Le coût annuel moyen était de 74 353\$, soit 107 883\$ pour un AVC entraînant une invalidité et 48 339\$ pour un AVC n'entraînant pas d'invalidité. **Conclusions :** Nous avons calculé le coût annuel moyen attribuable à un AVC ischémique et nous avons constaté qu'un AVC invalidant était associé à un coût qui est le double de celui d'un AVC non invalidant. Les coûts engendrés pendant l'hospitalisation et les trois premiers mois étaient ce qui contribuait le plus au coût annuel. À grande échelle, le fardeau annuel de l'AVC pour 38 000 hospitalisations pour AVC s'élève à un coût annuel moyen de 2,8 milliards de dollars.

Can J Neurol Sci. 2012; 39: 793-800

From the Health Outcomes and PharmacoEconomics (HOPE) Research Centre (NM SJS), Regional Stroke Prevention Clinic (DG), Sunnybrook Health Sciences Centre; Department of Pharmacology, University of Toronto (NM); International Centre for Health Innovation, Richard Ivey Business School, Western University (NM); University of Western Ontario (VH), London; Regional Stroke Program, Thunder Bay Regional Health Sciences Centre-Medical Centre (DCH), Thunder Bay; Division of Neurology (MS), University of Ottawa, Ottawa Hospital Research Institute, Ottawa, Ontario; Medicine (Neurology), Dalhousie University (SJP), Halifax, Nova Scotia; Department of Neurology and Neurosurgery (RC), McGill University, Montreal, Montreal; Department of Medicine (AM), Laval University, Quebec City, Quebec; Calgary Stroke Program, Department of Clinical Neurosciences (MDH), Hotchkiss Brain Institute, University of Calgary, Calgary; Division of Neurology (BHB, AS), Faculty of Internal Medicine, University of Alberta, Edmonton, Alberta, Canada.

RECEIVED MARCH 22, 2012. FINAL REVISIONS SUBMITTED JUNE 27, 2012.

Correspondence to: Nicole Mittmann, HOPE Research Centre, Sunnybrook Health Sciences Centre, 2075 Bayview Ave, E240, Toronto, Ontario, M4N 3M5, Canada.  
Email: nicole.mittmann@sri.utoronto.ca.

Fifteen million people suffer from a stroke worldwide each year. Of these, five million die and another five million are permanently disabled<sup>1</sup>. The economic impact of stroke is substantial and the costs of stroke to society are high. The life time cost of stroke to society has been estimated to be \$20.6 billion (1990) in the US<sup>2</sup>, £8.9 billion (2004) in the UK<sup>3</sup>, \$1.7 billion in Australia (2004)<sup>4</sup>, \$857 million (1994/95) in Canada<sup>5</sup> and \$194 to 239 million (2005) in Argentina<sup>6</sup>. A review of economic studies shows a wide range of per-patient costs from \$468 to \$146,149 (\$US) with few studies examining costs after hospital discharge<sup>7</sup>.

Costs by severity of disease are critical to decision makers when evaluating new treatments. Although stroke is associated with a high economic burden, little is known about the link between costs and level of disability. The objectives of this analysis were to calculate costs in the first year post-stroke and determine the impact of disability on costs.

## METHODOLOGY

The economic BURden of ischemic STroke (BURST) Study was a prospective cohort study of consecutive adults admitted with first-time ischemic stroke at 12 Canadian centres over a one-year time period between 2005 and 2009. Study sites included both academic stroke centres (66.7%) and community (33.3%) hospitals. The research ethics boards at all sites approved this study.

Included were consenting individuals aged 19 years or older with an incident ischemic stroke demonstrated on imaging and who were hospitalized for the event. Patients or caregivers had to be able to communicate well enough to complete study questionnaires verbally. Patients could participate in other non-interventional studies that did not impact resource utilization and had a defined study duration. Patients with co-morbidities such as cancer, dementia or multiple sclerosis were excluded since resource utilization as well as disability could be affected.

The BURST Study patients completed a study questionnaire (in English or French) at four different time periods: hospital discharge, three-months, six-months and one-year post-discharge.

Questionnaires were completed while in hospital, at outpatient clinic visits or by telephone with study site coordinators. The questionnaires were comprised of the patient's clinical history including age, gender, comorbidities and medication use, as well as standardized instruments such as the modified Rankin Score (mRS), Barthel Index and National Institutes of Health Stroke Scale (NIHSS)<sup>8-10</sup>. These instruments respectively measured level of disability, function and stroke severity, and all study stroke coordinators were certified to use the three instruments. BURST Study patients were categorized at discharge as having a non-disabling stroke (NDS); mRS 0-2 or disabling stroke (DS); mRS 3-5. Health preference and depression were also measured using standardized instruments<sup>11,12</sup>. Resource utilization data was comprised of direct and indirect costs. Direct medical costs were associated with emergency services, hospitalizations, rehabilitation, physician services, diagnostics, medications, allied health professional services, homecare, medical/assistive devices, changes to residence and paid caregivers. Indirect costs were lost productivity and unpaid caregivers.

Analyses were conducted from a societal perspective. (Table 1) Resources and costs (2009 CAN\$) associated with the direct and indirect care of ischemic stroke patients were included in the cost calculation. All resources utilized in the management of stroke were measured during four phases: (1) pre-admission; (2) hospitalization to three months; (3) four to six months; and (4) seven months to one year. Unit cost data were obtained from a number of published sources (Table 2).

Medications prescribed upon discharge were costed based on the assumption that they would be continued for the entire one year period. Lost productivity was calculated for patients who reported working before their stroke. Paid and unpaid caregiver time was also calculated based on the average hourly wage reported by Statistics Canada<sup>19</sup>. Health and non-health professional wages were based on average hourly wages from the Labour Market Information website<sup>17</sup>.

Descriptive statistics were used to characterize the dataset. The average overall cost for the ischemic stroke cohort was calculated, by disability and by the four time periods.

**Table 1: Time and costs**

Time Horizon	Costs Included
Pre-admission (Direct Costs)	Transportation, Emergency Visit, Physician Services, Diagnostics and Medications.
Pre-admission (Indirect Costs)	N/A
Hospitalization to 3-months (Direct Costs)	Hospitalization, Rehabilitation, Physician Services, Diagnostics, Medications, Allied Health Professional Services, Homecare, Medical/Assistive Devices, Changes to Residence and Paid Caregiver Time.
Hospitalization to 3-months (Indirect Costs)	Patient Lost Productivity and Unpaid Caregiver Time.
4- to 6-months (Direct Costs)	Hospitalization, Rehabilitation, Physician Services, Diagnostics, Medications, Allied Health Professional Services, Homecare, Medical/Assistive Devices, Changes to Residence and Paid Caregiver Time.
4- to 6-months (Indirect Costs)	Patient Lost Productivity and Unpaid Caregiver Time.
7-months to 1-year (Direct Costs)	Hospitalization, Rehabilitation, Physician Services, Diagnostics, Medications, Allied Health Professional Services, Homecare, Medical/Assistive Devices, Changes to Residence and Paid Caregiver Time.
7-months to 1-year (Indirect Costs)	Patient Lost Productivity and Unpaid Caregiver Time.

**Table 2: Unit cost table (2009 CAN\$)**

Variable	Unit Cost	Source
tPA (1 vial; 100 mg)	\$2,746.00	Sunnybrook drug formulary <sup>13</sup>
Neurologist consult to administer TPA	\$147.80	Ontario Schedule of Benefits (OSB) OSB code W185 <sup>14</sup>
Emergency transport	\$195.00	Ontario Land Ambulance Program <sup>15</sup>
Emergency physician consult	\$97.60	OSB code H055 <sup>14</sup>
Emergency hospital visit	\$592.46	Ontario Case Costing Initiative (OCCI) 2007/08, Ambulatory Care database <sup>16</sup>
Hospital day for stroke	\$936.95	OCCI, Acute Inpatient database (AID) <sup>16</sup>
Hospital day for acute coronary syndrome (e.g. unstable angina, MI)	\$1,543.09	OCCI, AID <sup>16</sup>
Hospital day for atrial fibrillation	\$1,041.02	OCCI, AID <sup>16</sup>
Neurologist consult	\$147.80	OSB code W185 <sup>14</sup>
Neurologist subsequent visits (2 <sup>nd</sup> and 3 <sup>rd</sup> days)	\$55.45	OSB codes C122+C123 <sup>14</sup>
Neurologist subsequent visits (post-3 days)	\$29.20	OSB code C182 <sup>14</sup>
Neurologist discharge visit	\$55.45	OSB code C124 <sup>14</sup>
CT head scan in hospital	\$520.64	OCCI, Ambulatory Care Database (ACD) <sup>16</sup>
CT head scan-professional fee	\$71.50	OSB code X401 <sup>14</sup>
MRI head scan in-hospital	\$855.77	OCCI, ACD <sup>16</sup>
MRI head scan-professional fee	\$66.90	OSB code X421 <sup>14</sup>
Neurologist visit	\$64.05	OSB code A183 <sup>14</sup>
Family physician visit	\$61.00	OSB code A003 <sup>14</sup>
Cardiologist visit	\$64.05	OSB code A603 <sup>14</sup>
Emergency physician visit	\$97.60	OSB code H055 <sup>14</sup>
Hematologist visit	\$64.05	OSB code A613 <sup>14</sup>
Internist visit	\$64.05	OSB code A113 <sup>14</sup>
Psychiatrist visit	\$64.05	OSB code A193 <sup>14</sup>
Respirologist visit	\$64.05	OSB code A473 <sup>14</sup>
Nurse specialist visit	\$33.74	Labour Market Information (LMI) 2007 <sup>17</sup>
Surgeon visit	\$64.05	OSB code A093 <sup>14</sup>
Ophthalmologist visit	\$64.05	OSB code A223 <sup>14</sup>
Endocrinologist visit	\$64.05	OSB code A113 <sup>14</sup>
Physiatrist visit	\$64.05	OSB code A313 <sup>14</sup>
Dietician visit	\$31.53	LMI 2007 <sup>17</sup>
Average cost per day-inpatient rehabilitation	\$592.19	West Park Healthcare Centre Community Report <sup>18</sup>
Average cost per day-outpatient rehabilitation (PT/OT/speech)	\$40.00	LMI 2007 (assumed 1 hour with PT/OT/speech) <sup>17</sup>
Average cost per day-cardiac rehabilitation program	\$296.10	Toronto Rehabilitation Institute (TRI) (personal communication based on cardiac rehab program billing, 2009)
Average cost per day-neurological rehabilitation	\$300.00	TRI (personal communication based on neuro rehab program billing, 2009)
Average hourly wage (e.g. lost productivity, unpaid caregiver)	\$20.11	Statistics Canada <sup>19</sup>
Private Care-Hourly wage for private nurse	\$33.74	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private occupational therapist	\$36.16	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private physiotherapist	\$36.72	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private speech therapist	\$37.13	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private dietician/nutritionist	\$31.53	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private social worker	\$26.54	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private homecare attendant	\$19.50	Homewell Senior Care (HSC) <sup>20</sup>
Private Care-Hourly wage for private massage therapist	\$86.00	Ontario Massage Therapists' Association 2009 (now Registered Massage Therapists' Association of Ontario) <sup>21</sup>
Private Care-Hourly wage for private water therapist	\$78.00	Ontario Chiropractic Association (OCA) <sup>22</sup>
Private Care-Hourly wage for private acupuncturist	\$46.00	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private art therapist (assumed OT)	\$36.16	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private counsellor	\$23.09	LMI 2007 <sup>17</sup>
Private Care-Hourly wage for private housekeeper	\$14.66	LMI 2007 <sup>17</sup>
Wheelchair	\$2,000.00	Sunnybrook Centre for Independent Living (SCIL) Shoppers Home Healthcare (Personal communication, 2009)
Walker	\$500.00	SCIL Shoppers Home Healthcare (Personal communication, 2009)
Cane	\$39.00	SCIL Shoppers Home Healthcare (Personal communication, 2009)
Orthopedic shoes (custom)	\$1,800.00	Pedorthic Association of Canada <sup>23</sup> ; SCIL Shoppers Home Healthcare (Personal communication, 2009)
Foot/leg brace	\$98.00	SCIL Shoppers Home Healthcare (Personal communication, 2009)
Wheelchair ramp	\$3,107.08	Based on EZ-Access EZ-Install Modular Aluminum Wheelchair Ramp (straight configuration) and free labour <sup>24</sup>
Emergency medical alarm	\$189.99	Based on 2Care4 Medical Ltd.'s Guardian Alert 911 model <sup>25</sup>
Stair lift and installation	\$3,400.00	Based on 2Care4 Medical Ltd.'s Acorn Indoor Hinged Rail Stair Lift model <sup>25</sup>
Shower chair	\$87.00	Based on Invacare unit with back <sup>26</sup>
Hand rails and others (stairs, toilet, shower and bath) plus installation	\$202.61	Based on KOOL-RAY Handrail (63 in., aluminum) for stairs; Moen SecureMount Grab Bar (1-1/4 in., 24 in., stainless steel) for toilet; Moen Bath Grip (9 in.) for shower; Moen Multi-Grip Tub Safety Bar for bath <sup>27</sup>
Door/dresser knob gripper	\$9.79	2Care4 Medical Ltd. <sup>25</sup>
New clothes (e.g., no buttons)	\$100.00	Assumption
Dressing stick	\$11.43	2Care4 Medical Ltd. <sup>25</sup>
Unpaid caregiver (hourly wage/lost productivity)	\$20.11	Statistics Canada <sup>19</sup>
Paid visiting caregiver (hourly wage)	\$19.50	HSC <sup>20</sup>
Paid live-in caregiver (daily wage)	\$210.00	HSC <sup>20</sup>
	plus 5% GST	
	plus 5% GST	

## RESULTS

Two hundred and thirty-two first-time ischemic stroke patients recruited from across the country were evaluated<sup>A</sup>. At six months, 21.6% of the enrolled population had dropped out of the study, ten due to death. At one year, more than half (55.6%) of the enrolled population were lost to follow up. The evaluated patient population (Table 3) consisted of slightly more men (51.3%) than women and the majority of patients had hypertension and hyperlipidemia. Tissue plasminogen activator (tPA) was given to 36 patients (15.5%). At hospital discharge, 48.7% of the cohort was considered disabled (mRS 3-5). Table 4 presents resource utilization data by phase.

The average overall cost of an ischemic stroke for the 1-year cohort was \$74,353 (range: \$7,525 to \$330,258) (Figure 1). The average cost during the pre-admission period was \$1,882 (\$757 to \$6,937) (N=232). The average cost during the hospitalization to three months period was \$40,624 (\$2,235 to \$202,265) (N=199). The average cost during the four to six months period was \$12,367 (\$0 to \$66,426) (N=182). And the average cost during the seven months to one year period was \$22,373 (\$81 to \$118,250) (N=103). The hospitalization to three months phase of stroke care represented 54.6% of the overall costs during the first year.

Figure 1 also highlights the impact that disability had on stroke costs. During the pre-admission period, average costs were relatively homogeneous when stratified by disability (DS=\$1,852; NDS=\$1,912). During the hospitalization to three months period, there was a three-fold higher average cost for the disabled cohort at \$61,002 compared to the non-disabled cohort at \$20,041. During the four to six months period, there was a two-fold higher average cost for the DS population (\$17,433) over the NDS (\$7,520) population. During the seven months to one year period, there was also a two-fold higher average cost for the DS group (\$32,242) compared to the NDS (\$14,716) group. Overall, the DS cohort at one year had a two-fold increase in average cost (\$107,883) in comparison to the NDS cohort (\$48,339).

Figure 2 presents a series of four graphs with each graph showcasing a phase of the study. In the first phase (pre-admission), emergency services and medications were the cost drivers. In the next phase (hospitalization to three months), hospitalization and rehabilitation costs, when combined, represented 80.8% of the total average cost for this time period. During the four to six months phase, indirect costs (58.3%) and rehabilitation (20.1%) were the major cost drivers. For the last phase, indirect costs (42.3%) remained the top cost driver followed closely by the combined costs of homecare and (paid) caregivers (34.7%).

## DISCUSSION

This study is, to our knowledge, the first multicentre, prospective analysis of costs by stroke disability for ischemic stroke patients. The costs are substantial and predominantly driven by direct medical costs for the first six months. As time progresses, indirect costs represent the bulk of the economic

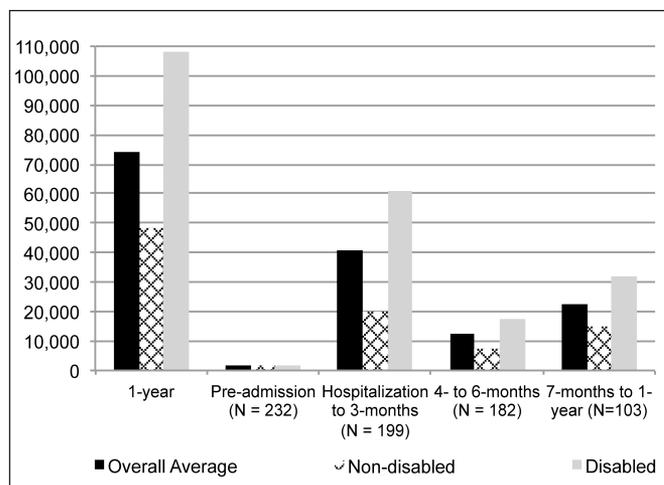


Figure 1: Stroke costs by time

burden. Based on 38,000 stroke admissions per year (personal communication, Mike Sharma), we can estimate the yearly economic burden of at least \$2.8 billion for incident stroke alone. However, the total stroke burden would be significantly higher than this “back of the envelope” calculation since the ongoing costs of prevalent strokes, transient ischemic attacks (TIAs)/minor strokes treated in an outpatient setting, and subarachnoid hemorrhages need to be considered.

We show that a DS had a greater than two-fold increase in the average cost compared to a NDS. This finding has implications for outcome measurement in stroke intervention trials. In the past, the mRS has been treated as an ordinal scale and the interpretation of mRS scores and ranges has been the subject of a number publications<sup>28-30</sup>. We recommend that future cost-effectiveness evaluations of new ischemic stroke therapies focus on mRS distributions.

Despite the influence of stroke disability on costs, pre-admission costs for all levels of disability were generally similar. This likely reflects the standardized rapid assessment of stroke in the era of thrombolysis regardless of severity. The hospitalization to three months phase of stroke care represented 54.6% of the overall costs during the first year. The cost drivers in this phase, namely hospitalization and rehabilitation, were similar in scale to those reported in other cost of illness studies<sup>31</sup>. When comparing the DS and NDS groups in this phase, there was a three-fold increase in cost for DS patients compared to NDS, consistent with longer lengths of stay in hospital and greater rehabilitation requirements<sup>32</sup>.

The BURST Study included costs associated with lost productivity and unpaid caregivers as part of the indirect costs which represented 28.0% of the overall one year cost of ischemic stroke. Lost productivity was valued only for patients who reported that they were working prior to their incident stroke (N=56) and afterwards either reduced their work hours or stopped working. If all patients aged 64 years and younger

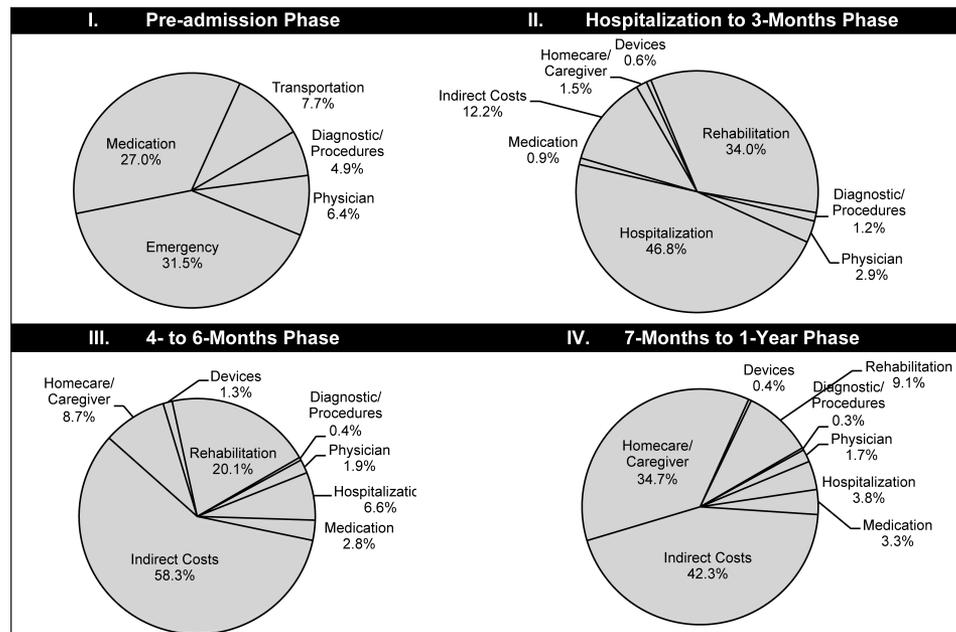
<sup>A</sup> 25.4% of the cohort lived in Western Canada (Vancouver, Calgary, Edmonton; N=4 sites); 34.7% in Ontario (Ottawa, Toronto, Thunder Bay, London; N=4 sites) and 40.1% in Eastern Canada (Quebec City, Montreal, Halifax, Saint John; N=4 sites).

**Table 3: Demographic information**

Variable	Results
Number (N) of patients at discharge	232
Patient data at 3-months [N (%)]	199 (85.8%)
Patient data at 6-months [N (%)]	182 (78.4%)
Patient data at 1-year [N (%)]	103 (44.4%)
Male: female ratio (%)	51.3: 48.7
Mean age (years) ± SD (range) [median]	69.4 ± 15.4 (27-97) [70.5]
Co-morbidities [N (%)]:	
Hypertension	134 (57.8%)
Dyslipidemia	120 (51.7%)
Diabetes	54 (23.3%)
Atrial fibrillation	44 (19.0%)
Angina	18 (7.8%)
Transient ischemic attack	15 (6.5%)
None	54 (23.3%)
mRS distribution [N (%)]:	
mRS=0	23 (9.9%)
mRS=1	43 (18.5%)
mRS=2	53 (22.8%)
mRS=3	49 (21.1%)
mRS=4	54 (23.3%)
mRS=5	10 (4.3%)
mRS 0-2 (non-disabling)	119 (51.3%)
mRS 3-5 (disabling)	113 (48.7%)

(N=87) were assumed to not be able to work due to their stroke, this would have resulted in a lost productivity value of \$36,198 per patient per year, increasing the average overall cost and making lost productivity a significant cost driver. In regards to unpaid caregiver costs, calculations were based on an average number of hours per day multiplied by the average hourly wage for Canadians for up to three unpaid caregivers. It was assumed that unpaid caregivers would assist BURST patients just in the last 30 days of the first three months phase due to the time spent in acute and rehabilitation institutes. In the remaining two phases (four to six months and seven months to one year), it was assumed that unpaid caregivers were available for the entire time period (90 days and 180 days, respectively). As a result, unpaid caregiver costs increased over time.

The annual stroke costs from the BURST Study are higher than those reported in three older Canadian studies. Chan and colleagues<sup>5</sup> conducted a prevalence based analysis to measure the cost of (all) strokes (1993 CAN\$) in Ontario using 1994/95 administrative data. The estimated total cost of stroke in this cohort was \$857 million (range \$719 to \$964 million). Direct costs were responsible for 62% of the total cost in whereas in the BURST Study, 72% of the \$74,353 average annual cost was attributable to direct costs. Goeree and colleagues<sup>32</sup> determined the cost of stroke (including TIAs) at a single center over a one-year time period. Using 2004 CAN\$, the average annual costs for TIAs were \$17,769, followed by \$53,576 for ischemic strokes and \$56,573 for hemorrhagic strokes. Smurawska and colleagues<sup>33</sup> retrospectively examined medical records of first ever acute stroke admissions to a tertiary care centre. Based on 285 consecutive stroke patients, the average cost per stroke admission was \$27,500 (1991-1992 CAN\$). However, this was before the introduction of thrombolytic therapy, and the analysis was limited to only the acute care hospitalization period.



**Figure 2: Disaggregated direct medical costs and indirect costs by phase**

**Table 4: Resource utilization data**

Variable	Results
<b>Pre-admission phase (N=232)</b>	
Emergency department visit <sup>A</sup>	232 (100.0%)
Discharge medications [N (%)]:	
Antihypertensive	156 (67.2%)
Antiplatelet/anticoagulant	218 (94.0%)
Diagnostic scan distribution [N (%)]:	
Both CT and MRI	60 (25.9%)
CT head	129 (55.6%)
MRI head	43 (18.5%)
TPA administered [N (%)]	36 (15.5%)
<b>Hospitalization to 3-months phase (N=199)</b>	
Average hospital length of stay $\pm$ SD (min, max)	18.2 $\pm$ 18.6 (0 – 102)
Received rehabilitation <sup>B</sup> [N (%)]	135 (67.8%)
Average rehabilitation length of stay $\pm$ SD (min, max)	35.2 $\pm$ 28.8 (1 – 118)
Unpaid caregiver [N (%)]	141 (70.9%)
<b>4- to 6-months phase (N=182)</b>	
Received rehabilitation <sup>C</sup> [N (%)]	69 (37.9%)
Average rehabilitation length of stay $\pm$ SD (min, max)	24.4 $\pm$ 7.2 (9 – 36)
Unpaid caregiver [N (%)]	112 (61.5%)
Homecare [N (%)]	25 (13.7%)
Paid caregiver [N (%)]	16 (8.8%)
<b>7-months to 1-year phase (N=103)</b>	
Rehabilitation <sup>D</sup> [N (%)]	30 (29.1%)
Average rehabilitation length of stay $\pm$ SD (min, max)	29.6 $\pm$ 8.8 (24 – 48)
Unpaid caregiver [N (%)]	54 (52.4%)
Homecare [N (%)]	17 (16.5%)
Paid caregiver [N (%)]	3 (2.9%)

<sup>A</sup>Hospital admission was one of the BURST Study inclusion criteria so all 232 patients were first seen in the emergency department. However, only 172 (74.1%) patients were transported to the emergency department by ambulance. <sup>B</sup>Inpatient rehabilitation accounted for 88.9% of all rehabilitation during the hospitalization to 3-months phase. <sup>C</sup>Outpatient rehabilitation accounted for 75.4% of all rehabilitation during the 4- to 6-months phase. <sup>D</sup>Outpatient rehabilitation accounted for 86.7% of all rehabilitation during the 7-months to 1-year phase.

The BURST Study population was representative of the demographic distribution of ischemic stroke patients in hospitals participating in the Registry of the Canadian Stroke Network<sup>34</sup>. tPA utilization in BURST patients (15.5%) was also in line with a recent report on the quality of care published by the Canadian Stroke Network<sup>35</sup>. Use of discharge medications, namely antiplatelets, antihypertensives and antidiabetic drugs were representative of other studies and countries evaluating medication use post ischemic event<sup>34,36</sup>.

In regards to stroke prevention, The INTERSTROKE study found that 90% of strokes could be attributed to ten risk factors<sup>37</sup>. Controlling for these risk factors means that we could prevent 90% of strokes, leading to an important reduction in health system resources and costs to society.

Our study had a number of limitations. We could not directly measure the attributable cost of stroke because of the lack of a comparator group. However, since patients were enrolled during their hospitalization for their ischemic event, we could attribute preadmission and acute care costs to that event. In the two follow-up questionnaires (completed at six months and one year), patients were asked to report only resources attributed to their stroke. Secondly, the information collected was patient-reported (or caregiver-reported in some cases) in which there could have been subject to recall bias or double-counting. Thirdly, the number of deaths could not be accurately reported due to the large number of patients lost to follow-up. Finally, the high proportion of patients lost to follow-up between six months

and one year was due to the fact that not all sites participated in completing the one year questionnaire with patients.

## CONCLUSIONS

This study highlights the importance of studying the economic impact of stroke management. The BURST Study calculated the average overall cost (direct and indirect) for a cohort of ischemic stroke patients for the first year after an ischemic stroke as \$74,353 (2009 CAN\$). Results showed that disability doubled the cost burden and cost drivers were identified by each phase over the one year time period.

Costs by severity of disease are critical to decision makers when evaluating new therapies. If the therapies decrease the severity of a stroke, not only will patient outcomes and functioning improve, but the overall cost of the condition will decrease, which should translate into more positive cost-effective ratios.

## ACKNOWLEDGEMENTS

The authors thank the BURST study site investigators including Dr. Peter Bailey, Dr. Gordon Gubitz and Dr. Phillip Teal, as well as the coordinators for their tireless efforts of quality data collection and Ms. Grace Bannon, Ms. Michelle Chu, Ms. Shazia Hassan, Ms. Peggy Kee and Ms. Kieran Manion for their assistance in data analysis and manuscript editing.

## FUNDING

This investigator driven study received funding from the Canadian Stroke Network and unrestricted funding from AstraZeneca Canada.

## DISCLOSURES

Dr. Nicole Mittmann has acted as an advisor and consultant to AstraZeneca Canada. Ms. Soo Jin Seung has acted as a consultant to AstraZeneca Canada.

## REFERENCES

1. The Internet Stroke Center. Stroke Statistics [Internet]. Dallas: Internet Stroke Center, UT Southwestern Medical Center, Department of Neurology and Neurotherapeutics; c1997-2012 [updated 2012; cited 2012 May 14]. Available from: <http://www.strokecenter.org/patients/about-stroke/stroke-statistics/>.
2. Talyor TN, Davis PH, Torner JC, Holmes J, Meyer JW, Jacobson MF. Lifetime cost of stroke in the United States. *Stroke*. 1996;27(9):1459-66.
3. Saka O, McGuire A, Wolfe C. Cost of stroke in the United Kingdom. *Age Aging*. 2009;38(1):27-32.
4. Dewey HM, Thrift AG, Mihalopoulos C, et al. Lifetime cost of stroke subtypes in Australia: findings from the North East Melbourne Stroke Incidence Study (NEMESIS). *Stroke*. 2003;34(10):2502-7.
5. Chan B, Hayes B. Cost of stroke in Ontario, 1994/95. *Can Med Assoc J*. 1998;159(6 Suppl.):S2-S8.
6. Christensen MC, Previgliano I, Capparelli FJ, Lerman D, Lee WC, Wainsztein NA. Acute treatment costs of intracerebral hemorrhage and ischemic stroke in Argentina. *Acta Neurol Scand*. 2009;119(4):246-53.
7. Luengo-Fernandez R, Gray AM, Rothwell PM. Costs of stroke using patient-level data: a critical review of the literature. *Stroke*. 2009;40(2):e18-e23.
8. Collin C, Wade DT, Davies S, Horne V. The Barthel ADL Index: a reliability study. *Int Disability Studies*. 1988;10(2):61-3.
9. Wilson JT, Hareendran A, Hendry A, Potter J, Bone I, Muir KW. Reliability of the modified Rankin Scale across multiple raters: benefits of a structured interview. *Stroke*. 2005;36(4):777-81.
10. Josephson SA, Hills NK, Johnston SC. NIH Stroke Scale reliability in ratings from a large sample of clinicians. *Cerebrovasc Dis*. 2006;22(5-6):389-95.
11. Horsman J, Furlong W, Feeny D, Torrance G. The Health Utilities Index (HUI): concepts, measurement properties and applications. *Health Qual Life Outcomes*. 2003;1(54):1-13.
12. Williams JB. A structured interview guide for the Hamilton Depression Rating Scale. *Arch Gen Psychiat*. 1988;45(8):742-7.
13. Sunnybrook Health Sciences Centre. Drug formulary [Internet]. Toronto: Sunnybrook Health Sciences Centre ; c2008 [cited 2010 Aug 17]. Available from: <http://drugformulary/drugsearch.cfm>.
14. Government of Ontario. Ministry of Health and Long Term Care [homepage on the Internet]. Toronto: Queen's Printer for Ontario; c2008. Ontario Health Insurance (OHIP) Schedule of benefits and fees [modified 2012 May 11; cited 2010 Aug 17]. Available from: [http://www.health.gov.on.ca/english/providers/program/ohip/sob/sob\\_mn.html](http://www.health.gov.on.ca/english/providers/program/ohip/sob/sob_mn.html).
15. Government of Ontario. Ministry of Health and Long Term Care. [homepage on the Internet]. Toronto: Queen's Printer for Ontario; c2008. Ambulance service charges [updated 2012 Jan 12; cited 2010 Aug 17]. Available from: [http://www.health.gov.on.ca/english/public/program/ehs/land/service\\_qa.html](http://www.health.gov.on.ca/english/public/program/ehs/land/service_qa.html).
16. Ontario Case Costing Initiative (OCCI). OCCI Costing Analysis Tool [Internet]. Toronto: Ontario Case Costing Initiative; [updated 2011 Jun; cited 2010 Aug 17]. Available from: <http://www.occp.com/mainPage.htm>.
17. Government of Canada. Labour Market Information [Internet]; Ottawa: Government of Canada; [updated 2009; cited 2010 Aug 17]. Available from: <http://www.labourmarketinformation.ca/standard.aspx?ppid=82>.
18. West Park Healthcare Centre. West Park Healthcare Centre [homepage on the Internet]. [Toronto (ON)]; West Park Healthcare Centre; [updated 2012 Apr 16]. Community Report; 2005 Nov 5 [cited 2010 Aug 17]. Available from: [http://www.westpark.org/media/PDF/CommRep\\_Nov05web.pdf](http://www.westpark.org/media/PDF/CommRep_Nov05web.pdf).
19. Statistics Canada. Statistics Canada [homepage on the Internet]. Ottawa: Statistics Canada; [modified 2012 Apr 30]. Table 2 Average hourly wages of employees aged 15 and older, job permanence and union coverage, by sex, Canada, annual, 1998 to 2008 [modified 2010 Mar 8; cited 2010 Aug 17]. Available from: <http://www.statcan.gc.ca/pub/11-008-x/2010001/t/11133/tbl002-eng.htm>.
20. Homewell Seniors Care. Senior Care Services [Internet]. Seattle: Homewell Senior Care, Inc.; c2010 [cited 2010 Aug 17]. Available from: <http://www.homewellseniorcare.com/services/care-services.php>.
21. Registered Massage Therapists' Association of Ontario. Advancing the profession for a healthier you [homepage on the Internet]. Etobicoke: Registered Massage Therapists' Association of Ontario; c2012. Understanding massage therapy and fees; [cited 2010 Aug 17]. Available from: [http://www.rmtao.com/Message\\_Therapy/your\\_message\\_dollars/understanding\\_rmt\\_fees.htm](http://www.rmtao.com/Message_Therapy/your_message_dollars/understanding_rmt_fees.htm).
22. Ontario Chiropractic Association (OCA). Home [homepage on the Internet]. Toronto: OCA; c2012. OCA recommended fee schedule; 2012 Jan 1 [cited 2010 Aug 17]. Available from: [https://d2oovpv43hgkeu.cloudfront.net/publicresources/oca\\_recommended\\_fee\\_schedule.pdf](https://d2oovpv43hgkeu.cloudfront.net/publicresources/oca_recommended_fee_schedule.pdf).
23. Pedorthic Association of Canada. Experts in custom orthotics to relieve sore feet caused by metatarsalgia, overpronation, plantar fasciitis, heel pain [homepage on the Internet]. Winnipeg: Pedorthic Association of Canada; c2012. Position statement on custom-made footwear and stock orthopaedic footwear; [updated 2011 Oct 24; cited 2010 Aug 17]. Available from: [http://www.pedorthic.ca/files/CustomFootwearWebsite\\_000.pdf](http://www.pedorthic.ca/files/CustomFootwearWebsite_000.pdf).

24. Discount Ramps. Loading ramps, hauling, transport, & skateboarding ramp superstore [homepage on the Internet]. West Bend: Discount Ramps.Com; c2000-2012. Portable & fixed mobility wheelchair ramps; [cited 2010 Aug 17]. Available from: <http://www.discountramps.com/wheelchair-ramps.htm>.
25. 2 Care 4 Medical Ltd. Medical supplies equipment [homepage on the Internet]. Smith Falls: 2 Care 4 Medical Ltd; c2012. Stairlifts [cited 2010 Aug 17]. Available from: <http://www.2care4medical.com/index.cfm?&CFID=41682208&CFTOKEN=58264111>.
26. Invacare. Leading manufacturer of home and long term care products [homepage on the Internet]. Elyria: Invacare Corp.; c2012. Products & services; [updated 2012, May 17; cited 2010 Aug 17]. Available from: <http://www.invacare.com/cgi-bin/imhqprd/default.jsp>.
27. The Home Depot. Home improvement, home renovation, tools & hardware [homepage on the Internet]. City unknown: Homer TLC Inc.; c2012. Bath safety; [cited 2010 Aug 17]. Available from: <http://www.homedepot.ca/catalog/bath-safety/173266>.
28. Koziol JA, Feng AC. On the analysis and interpretation of outcome measures in stroke clinical trials: lessons from the SAINT I study of NXY-059 for acute ischemic stroke. *Stroke*. 2006;37(10):2644-7.
29. Saver JL, Gornbein J. Treatment effects for which shift or binary analyses are advantageous in acute stroke trials. *Neurology*. 2009;72(15):1310-15.
30. Shuaib A, Lees KR, Lyden P, et al. NXY-059 for the treatment of acute ischemic stroke. *N Engl J Med*. 2007;357(6):562-71.
31. Cadilhac DA, Carter R, Thrift AG, Dewey HM. Estimating the long-term costs of ischemic and hemorrhagic stroke for Australia: new evidence derived from the North East Melbourne Stroke Incidence Study (NEMESIS). *Stroke*. 2009;40(3):915-21.
32. Goeree R, Blackhouse G, Petrovic R, Salama S. Cost of stroke in Canada: a 1-year prospective study. *J Med Econ*. 2005;8(1-4):147-67.
33. Smurawska LT, Alexandrov AV, Bladin CF, Norris JW. Cost of acute stroke care in Toronto, Canada. *Stroke*. 1994;25(8):1628-31.
34. Kapral MK, Fang J, Hill MD, et al. Sex differences in stroke care and outcomes: results from the Registry of the Canadian Stroke Network. *Stroke*. 2005;36(4):809-14.
35. Canadian Stroke Network. Canadian Stroke Network [homepage on the Internet]. Ottawa: Canadian Stroke Network; 2011. The quality of stroke care in Canada; 2011 Jun 16 [cited 2011 Jul 11]. Available from: <http://www.canadianstrokenetwork.ca/index.php5/news/the-quality-of-stroke-care-in-canada-2011/>.
36. Sweileh WM, Sawalha AF, Zyoud SH, Al-Jabi SW, Abaas MA. Discharge medications among ischemic stroke survivors. *J Stroke Cerebrovasc Dis*. 2009;18(2):97-102.
37. O'Donnell MJ, Xavier D, Liu L, et al. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. *Lancet*. 2010;376(9735):112-23.