# Return on Investment in Endovascular Care: The Case of Endovascular Reperfusion Alberta

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**Abstract:** ***Objective:*** We examined the return on investment (ROI) from the Endovascular Reperfusion Alberta (ERA) project, a provincially funded population-wide strategy to improve access to endovascular therapy (EVT), to inform policy regarding sustainability. ***Methods:*** We calculated net benefit (NB) as benefit minus cost and ROI as benefit divided by cost. Patients treated with EVT and their controls were identified from the ESCAPE trial. Using the provincial administrative databases, their health services utilization (HSU), including inpatient, outpatient, physician, long-term care services, and prescription drugs, were compared. This benefit was then extrapolated to the number of patients receiving EVT increased in 2018 and 2019 by the ERA implementation. We used three time horizons, including short (90 days), medium (1 year), and long-term (5 years). ***Results:*** EVT was associated with a reduced gross HSU cost for all the three time horizons. Given the total costs of ERA were $2.04 million in 2018 ($11,860/patient) and $3.73 million in 2019 ($17,070/patient), NB per patient in 2018 (2019) was estimated at −$7,313 (−$12,524), $54,592 ($49,381), and $47,070 ($41,859) for short, medium, and long-term time horizons, respectively. Total NB for the province in 2018 (2019) were −$1.26 (−$2.74), $9.40 ($10.78), and $8.11 ($9.14) million; ROI ratios were 0.4 (0.3), 5.6 (3.9) and 5.0 (3.5). Probabilities of ERA being cost saving were 39% (31%), 97% (96%), and 94% (91%), for short, medium, and long-term time horizons, respectively. ***Conclusion:*** The ERA program was cost saving in the medium and long-term time horizons. Results emphasized the importance of considering a broad range of HSU and long-term impact to capture the full ROI.

**RÉSUMÉ : Retour sur investissement en matière de soins endovasculaires : le cas de la reperfusion en Alberta.** ***Objectif :*** Dans cette étude, nous avons analysé le retour sur investissement (RSI) d'un projet de reperfusion endovasculaire (REV) mené, à l'échelle de la population, dans le cadre d'une stratégie financée par l'Alberta (Canada) pour améliorer l'accès au traitement endovasculaire (TEV) et pour mieux informer les décideurs publics en matière de pérennité. ***Méthodes :*** Nous avons calculé le bénéfice net (BN) comme étant le bénéfice moins les coûts ; le RSI, lui, représente le bénéfice divisé par les coûts. Les patients ayant bénéficiés d'un TEV de même que des témoins ont été identifiés à partir de l'essai clinique ESCAPE. Au moyen des base de données administratives des provinces, nous avons ensuite, en ce qui regarde leur utilisation de services de santé (USS), comparé entre eux les aspects suivants : les soins prodigués au moment de l'hospitalisation, les soins ambulatoires, les visites chez le médecin, les soins de longue durée et la prise de médicaments sur ordonnance. Le bénéfice réalisé a alors été extrapolé en fonction du nombre de patients ayant bénéficié d'un TEV, patients dont le nombre a augmenté en 2018 et en 2019 à la suite de la mise sur pied du projet de REV. Pour ce faire, nous avons utilisé 3 horizons temporels différents : 90 jours (court), douze mois (intermédiaire) et 5 ans (long). ***Résultats :*** Les TEV ont été associés à une réduction des coûts bruts d'USS pour ces trois horizons temporels. Compte tenu que les coûts totaux du projet de REV étaient de 2,04 M $ en 2018 (11,86 $ par patient) et de 3,73 M $ en 2019 (17,07 $ par patient), le BN par patient en 2018 (2019) a été estimé respectivement à -7,313 $ (-12,524 $), à 54,592 $ (49,381 $) et à 47,07 $ (41,859 $) pour les horizons court, intermédiaire et long. Le BN total de la province en 2018 (2019) a par ailleurs atteint, en million de dollars, -1,26 (-2,74), 9,40 (10,78) et 8,11 (9,14) pour ces mêmes trois horizons. Les ratios de RIS ont représenté 0,4 (0,3), 5,6 (3,9) et 5,0 (3,5). Enfin, la probabilité pour ce projet de REV de permettre une réduction de coûts a été respectivement de 39 % (31 %), de 97 % (96 %) et de 94 % (91 %) dans le cas des horizons court, intermédiaire et long. ***Conclusion :*** Ce projet de REV a ainsi représenté une réduction de coûts dans le cas des horizons intermédiaire et long. De tels résultats soulignent l'importance de tenir compte d'un large éventail de services de santé et de prendre en considération leurs impacts à long terme afin de cerner la totalité du RSI.

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## Introduction

In Canada, about 400,000 Canadians are living with the effects of stroke costing the economy more than \$3.6 billion per year.[1] In the province of Alberta, 4500 first ischemic strokes occur annually[2] with a case fatality rate of 14%.[3] Endovascular therapy (EVT), a minimally invasive, catheter-based procedure for reperfusion of acute intracranial large vessel occlusion, has been proven to increase functional independence and reduce mortality among patients with acute ischemic stroke.[4] Accordingly, EVT has been recommended in Canada and globally since 2015.[5,6]

Within Alberta Health Services (AHS), Canada's largest province-wide, fully integrated health system, responsible for delivering health services to nearly 4.4 million people, EVT is available in Calgary (Foothills Medical Centre) and Edmonton (University of Alberta Hospital) only. The Cardiovascular Health & Stroke Strategic Clinical Network™, in collaboration with provincial stakeholders, has been implementing the Endovascular Reperfusion Alberta (ERA) project since 2015, aiming to increase access to EVT for patients with acute ischemic stroke. Strategies to meet the goal included: (i) a revision of emergency medical services triage and transport pathways to establish clear destination policies and a rural field consultation pathway for paramedics and suspected acute stroke patients; (ii) revision of inter-hospital stroke referrals and transport including involvement of STARS air ambulance service; (iii) implementation of appropriate neurovascular imaging protocols in remote stroke centres to determine EVT eligibility; and (iv) a quality improvement process in acute care to reduce the time to treatment.[7]

We conducted a return on investment (ROI) analysis of this project after 5 years of implementation to inform policy regarding sustainability, scale, and spread.

## Methods

We used a decision tree analysis comparing Return (or Benefit, B) and Investment (or Cost, C) (Figure 1). The net benefit (NB) was calculated by subtracting C from B ($NB = B - C$) and the ROI was calculated by dividing B by C ($ROI = B/C$). In this case, B refers to cost avoidance associated with the intervention.[8]

We used a population-wide healthcare system perspective, where C included investments that AHS contributed to the ERA initiative, including costs for stroke observational beds, personnel (nurses and rehabilitation supports), and diagnostic imaging (EVT and computed tomography angiography).[7] B included savings from reductions in EVT patients' health services utilization (HSU), including inpatient, outpatient, long-term care, and physician services, as well as prescription drugs. Of the inpatient services, we included the acute (Savings 1) and the alternative level of care (Savings 2). Of the outpatient services, we included emergency department (ED) visits (Savings 3) and clinic visits (Savings 4). Of the physician services, we included general practitioner (GP) visits (Savings 5) and specialist visits (Savings 6). Of the long-term care services, we included length of stay (LOS) in long-term care facilities (Savings 7). Of prescription drugs, we included drugs dispensed from community pharmacies (Savings 8). In summary, Savings 1–8 each were calculated using the formula: $Savings = N \times (U_1 - U_2) \times C$, where N was the number of EVT patients increased by the intervention; $U_1$ was the HSU of non-EVT patients (control group), $U_2$ was the HSU of EVT patients (intervention group), and $C$ was the unit cost. From this formula, a positive impact ($U_1 - U_2$) indicated a reduction in HSU (thereby savings) for the intervention and vice versa. Therefore, the summation of costs is represented by $B = \sum$ savings 1–8.

The time frame for the number of patients and investments was 2 fiscal years (from April 1st to March 31st) 2018 and 2019. The number of EVT patients increased by the intervention was the total number of EVT patients in each year less 30%. That is if the intervention had not been implemented, 30% of the patients would still have been treated by EVT. Of note, this assumption was based on the number of EVT cases in Alberta before 2015. To estimate both short and long-term impacts of EVT on individual patients, we separately analyzed HSU and associated costs occurring within three time horizons, including short (90 days), medium (1 year), and long-term (5 years) from the patients' EVT enrollment date.

### Statistical Methods Estimating Model Inputs

As all eligible patients were treated with EVT (there have been no observational controls since 2015) and to calculate the long-term impact, we used data from 99 Alberta patients enrolled in the ESCAPE randomized controlled trial in 2013–2014.[1] After calculating the difference in HSU costs between intervention and control groups, we extrapolated it to all patients receiving EVT in Alberta. We linked patients' unique lifetime identifiers to the Alberta Health Administrative Databases for retrieving their HSU. Baseline demographic and comorbidity characteristics were similar (Table 1); therefore, the outcomes between intervention and control patients were compared using a univariate analysis. As the outcomes of interest in this study were HSU and associated costs, we did not consider death as an outcome, but included it in the denominator.[9]

Unit costs ($C_1$ to $C_8$) were estimated among patients in the control group because if EVT had not been performed, the unit costs of patients in the intervention group would have been the same as those of the control group. Specifically, $C_1$ was cost per day of the acute LOS, $C_2$ was cost per day of the alternative level of care LOS, $C_3$ was cost per ED visit, $C_4$ was cost per outpatient clinic visit, $C_5$ was cost per GP visit, $C_6$ was cost per specialist visit, $C_7$ was cost per day of the long-term care LOS, and $C_8$ was cost per prescription drug dispense in the community pharmacies. Unit costs for inpatient and outpatient services were based on the CIHI Case-Mix Group Plus (CMG+) methodology.[10] The cost for each CMG+ group was retrieved from the Alberta Health Interactive Health Data Application.[11] The cost for physician services was

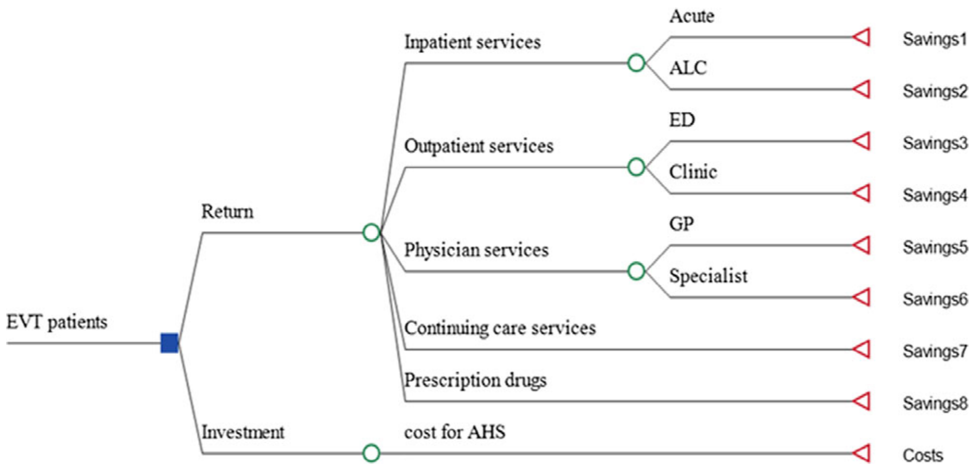


***Figure 1:*** Model structure (AHS, Alberta Health Services; ALC, alternative level of care; ED, emergency department; EVT, endovascular therapy; GP, general practitioner).

**Table 1: Characteristics of patients in Alberta participating in the ESCAPE trial**

| Characteristics | EVT patients | Controls | P-value |
|---|---|---|---|
| N | 52 | 47 | |
| Male: N (%) | 25 (48.1) | 24 (51.1) | 0.233 |
| Age: Mean (SD) | 70.8 (12.7) | 72.7 (14.3) | 0.246 |
| Charlson comorbidity index: Mean (SD) | 2.96 (2.05) | 2.87 (2.09) | 0.415 |

EVT, endovascular therapy; N, number; SD, standard deviation.

defined as paid amounts to physicians from the Alberta Health Care Insurance Plan. Costs for prescription drugs were based on prices per unit of the Alberta Drug Benefit List.[12] The cost per day in a long-term care facility was retrieved from the AHS finance.

For $C_1$ we used the average and for $C_2$, we used the "marginal cost"[13] per hospital day for the stays that were shortened by EVT. The rationale was that during a hospital stay, the cost of health services in the last days of the stay is lower than the average and close or equal to the "hotel cost" because of the high treatment cost in the first few days when major procedures are done. We applied the "hotel cost" as a percentage of the average cost (43.5%) to estimate the marginal cost.[14] "Hotel cost" includes the costs that are related to patient care where no treatment is provided. It includes the share of hospital fixed costs (e.g. admin, facility, and overheads) that are allocated to each bed with a patient. Additionally, it includes meals and cleaning, as well as staff costs that are related to those minimum levels of activities.

### Data Sources

Intervention and control patients were from the ESCAPE trial.[1] The total number of patients treated with EVT in Alberta was obtained from the Quality Improvement & Clinical Research database, a comprehensive pan-Alberta stroke registry.[15] The Alberta Health Administrative databases,[16] which are linkable by the patient's unique lifetime identifiers, were used to identify HSU of the patients. Specifically, inpatient services were retrieved from the Discharge Abstract Database, which contains information about acute inpatient care. Outpatient services were retrieved from the National Ambulatory Care Reporting System, which includes information about ambulatory care, day surgery, and ED settings. Practitioner services were retrieved from the Alberta Health Care Insurance Plan Claims database, which consists of claims to pay medical doctors and other allied practitioners. Long-term care services were retrieved from the Alberta Continuing Care Information System. Prescription drugs were retrieved from the Pharmaceutical Information Network, in which a record is created each time a prescription is dispensed.

### Sensitivity Analysis

In total, there were three scenarios, one for each time horizon (90 days, 1 year, and 5 years). We included both statistically significant and nonsignificant impacts of EVT because the costs of the nonsignificant HSU may still be substantial.[17] Within each scenario, we performed both deterministic and probabilistic sensitivity analyses for the uncertainty of all the input parameters. In the deterministic, we used a one-way sensitivity analysis (each variable varied at a time) using a range from the lower to the higher value of 95% confidence interval of each parameter. We also performed a threshold analysis on the number of EVT patients increased by the intervention to estimate the break-even point. In the probabilistic (all variables varied simultaneously), we assumed cost variations follow a gamma distribution and HSU (count data) variations follow a Poisson distribution.[18] We ran 100,000 samples/trials and reported a probability for the intervention to be cost saving.

All costs/savings were inflated to 2019 Canadian dollars using the Bank of Canada Inflation Calculator.[19] Stata (www.stata.com) and TreeAge Pro (www.treeage.com) were used for data analyses.

## Results

There were 99 patients in Alberta participating in the ESCAPE trial, of whom 52 received EVT and 47 were



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**Table 2: Health services utilization costs and savings per patient by time horizon**

| Health services | Control (#) | EVT (#) | Difference (#) | Unit cost ($) | Savings per patient ($) |
|---|---|---|---|---|---|
| **Within 90 days of enrollment** | | | | | |
| *Inpatient services* | | | | | |
| Acute LOS | 22.94 | 20.21 | 2.72 | 3816.94 | 10,399.76 |
| Subacute LOS | 4.36 | 9.29 | −4.93 | 1660.37 | −8180.25 |
| *Outpatient services* | | | | | |
| ED visits | 1.21 | 1.56 | −0.34 | 1300.90 | −448.71 |
| Clinic visits | 5.47 | 6.00 | −0.53 | 255.46 | −135.89 |
| *Physician services* | | | | | |
| GP visits | 16.19 | 16.35 | −0.15 | 69.06 | −10.68 |
| Specialist visits | 34.89 | 34.27 | 0.62 | 120.26 | 75.09 |
| Prescription drug dispenses | 5.57 | 10.04 | −4.46 | 53.50 | −238.82 |
| LTC LOS | 34.47 | 19.04 | 15.43 | 200.00 | 3085.93 |
| **All** | | | | | **4546.43** |
| **Within 1 year of enrollment** | | | | | |
| *Inpatient services* | | | | | |
| Acute LOS | 38.60 | 27.77 | 10.83 | 3197.21 | 34,614.66 |
| Subacute LOS | 36.62 | 20.65 | 15.96 | 1390.79 | 22,201.38 |
| *Outpatient services* | | | | | |
| ED visits | 2.00 | 2.13 | −0.13 | 1071.09 | −144.18 |
| Clinic visits | 23.70 | 22.75 | 0.95 | 290.76 | 276.84 |
| *Physician services* | | | | | |
| GP visits | 48.45 | 39.77 | 8.68 | 60.07 | 521.26 |
| Specialist visits | 60.83 | 51.15 | 9.68 | 112.13 | 1085.00 |
| Prescription drug dispenses | 62.30 | 49.44 | 12.86 | 42.99 | 552.62 |
| LTC LOS | 99.89 | 63.17 | 36.72 | 200.00 | 7344.11 |
| **All** | | | | | **66,451.68** |
| **Within 5 years of enrollment** | | | | | |
| *Inpatient services* | | | | | |
| Acute LOS | 49.70 | 44.50 | 5.20 | 2861.34 | 14,885.05 |
| Subacute LOS | 62.13 | 37.48 | 24.65 | 1244.68 | 30,677.54 |
| *Outpatient services* | | | | | |
| ED visits | 4.32 | 4.79 | −0.47 | 845.71 | −396.90 |
| Clinic visits | 40.85 | 35.94 | 4.91 | 305.32 | 1498.76 |
| *Physician services* | | | | | |
| GP visits | 127.32 | 107.96 | 19.36 | 51.71 | 1001.00 |
| Specialist visits | 95.72 | 105.29 | −9.57 | 107.22 | −1025.57 |
| Prescription drug dispenses | 404.72 | 297.63 | 107.09 | 28.87 | 3092.13 |
| LTC LOS | 245.09 | 199.10 | 45.99 | 200.00 | 9197.78 |
| **All** | | | | | **58,929.79** |

ED, emergency department; EVT, endovascular therapy; GP, general practitioner; LOS, length of stay; LTC, long-term care.

non-EVT treated (Table 1). In the EVT group, males accounted for 48.1%, the mean age was 70.8 (SD=12.7), and the mean Charlson comorbidity index[20] was 2.96 (SD = 2.05). In the control group, the corresponding numbers were 51.1%, 72.7 (SD = 14.3), and 2.87 (SD = 2.09). All the differences between intervention and control groups were not statistically significant.

Table 2 shows differences in HSU and costs between EVT and control groups by time horizon. Generally, EVT was associated with a reduced cost for all time horizons. The most gross savings



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**Table 3: Net savings and return on investment ratio by time horizon and fiscal year**

| | FY 2017/18 | | | FY 2018/19 | | |
|---|---|---|---|---|---|---|
| **90 days** | **90 days** | **1 year** | **5 years** | **90 days** | **1 year** | **5 years** |
| Total cost (M$) | 2.04 | | | 3.73 | | |
| Number of EVT cases | 172 | | | 218 | | |
| Cost per EVT case ($) | 11,860 | | | 17,070 | | |
| Gross cost savings per EVT case ($) | 4546 | 66,452 | 58,930 | 4546 | 66,452 | 58,930 |
| Net cost savings per EVT case ($) | 7313 | 54,592 | 47,070 | 12,524 | 49,381 | 41,859 |
| Net cost savings per year (M$) | 1.26 | 9.40 | 8.11 | 2.74 | 10.78 | 9.14 |
| ROI | 0.4 | 5.6 | 5.0 | 0.3 | 3.9 | 3.5 |

EVT, endovascular therapy; FY, fiscal year; M, million; ROI, return on investment.

per patient ($66,452) were found in the medium term, followed by the long term ($58,930), and least in the short term ($4,546).

Within the medium term, patients treated with EVT used less services than their control group counterparts in all services included in this study, except for ED visits. Specifically, per patient, acute LOS was reduced by 10.83 days, alternative level of care LOS by 15.96 days, outpatient clinic by 0.95 visits, GP by 8.68 visits, specialist by 9.68 visits, prescription drugs by 12.86 dispenses, and long-term care LOS by 36.72 days, while ED increased by 0.13 visits.

Within the long term, patients treated with EVT used less than their counterparts in six services and used more in two services. Specifically, per patient, acute LOS was reduced by 5.20 days, alternative level of care LOS by 24.65 days, outpatient clinic by 4.91 visits, GP by 19.36 visits, prescription drugs by 107.09 dispenses and long-term care LOS by 45.99 days, while ED was increased by 0.47 visits and specialist was increased by 9.57 visits.

Within the short term, patients treated with EVT used less than their counterparts in three services and used more in five services. Specifically, per patient, acute LOS was reduced by 2.72 days, specialist by 0.62 visits, and long-term care LOS by 15.43 days, while alternative level of care LOS was increased by 4.93 days, ED by 0.34 visits, outpatient clinic by 0.53 visits, GP by 0.15 visits, and prescription drugs by 4.46 dispensed prescriptions. Despite the increased HSU observed in five areas, a gross savings of $4,546 per patient was observed.

The total estimated costs for ERA were $2.04 million in 2018 and $3.73 million in 2019 (Table 3). Dividing these costs by the number of EVT patients increased by the ERA (172 in 2018 and 218 in 2019), the cost per patient was $11,860 in 2018 and $17,070 in 2019. Subtracting these costs from the gross savings, the net savings per patient were −$7,313, $54,592, and $47,070 for short, medium, and long-term, respectively, in 2018. Corresponding net savings per patient in 2019 were −$12,524, $49,381, and $41,859. Multiplying the net savings per patient with the number of patients, the total net savings for the province for short, medium, and long term were, respectively, −$1.26, $9.40, and $8.11 million in 2018 and −$2.74, $10.78, and $9.14 million in 2019. ROI ratios were, respectively, 0.4, 5.6 and 5.0 in 2018, and 0.3, 3.9 and 3.5 in 2019.

**Table 4: Range of cost savings and probability for the ERA to be cost saving (ROI > 1)**

| Year/time horizon | Cost-savings ($ Million) Mean | Low | High | Probability |
|---|---|---|---|---|
| *Fiscal year 2017/18* | | | | |
| 90 days | −1.26 | −6.38 | 3.86 | 39% |
| 1 year | 9.40 | 0.88 | 17.93 | 97% |
| 5 years | 8.11 | −1.72 | 17.93 | 94% |
| *Fiscal year 2018/19* | | | | |
| 90 days | −2.74 | −9.23 | 3.75 | 31% |
| 1 year | 10.78 | −0.02 | 21.60 | 96% |
| 5 years | 9.14 | −3.32 | 21.60 | 91% |

ERA, Endovascular Reperfusion Alberta; ROI, return on investment.

Sensitivity analyses showed, for 2018, the range of net savings was −$6.38 to $3.86 million, $0.88 to $17.93 million, and −$1.72 to $17.93 million; and the probability for ERA to be cost saving was 39%, 97%, and 94%, in the short, medium, and long-term time horizons, respectively (Table 4). The corresponding numbers in 2019 were −$9.23 to $3.75 million, −$0.02 to $21.60 million, and −$3.32 to $21.60 million; and 31%, 96%, and 91%. The threshold analysis showed the break-even point for the medium and long-term time horizons was 86% in 2018 and 80% in 2019. That is the intervention would be cost saving if it increased the number of patients treated with EVT by 14–20%.

## Discussion

The novelty of the result is the demonstration that investment in EVT stroke treatment on a population-wide basis is cost saving and results in a rapid ROI in less than a year. Using a modeling technique together with real-world data to estimate NB and ROI of the ERA implementation in Alberta, we show that the ERA implementation was cost saving and a dominant strategy. During 1–5 years of follow-up of patients, the net savings per patient were from $42,000 to $55,000 and ROI from 3.5 to 5.6, meaning that every invested dollar would return $3.5–$5.6. The probability for ERA to be cost saving was from 91% to 97%. The impacts of ERA were found to be smaller in the shortest time horizon, indicating that if only 90-day time horizon had been used, the benefits of ERA implementation would have been underestimated. As a one-time intervention, it is reasonable that the impact peaked and then decreased over time. For example, the enhanced recovery after surgery intervention for colorectal, pancreas, cystectomy, liver, and gynecologic oncology procedures, had the lowest impact at 30 days, peaked at 90 days, and then decreased at 365 days, after the surgery.[21] Similarly, the EVT had the lowest impact at 90 days, peaked at 1 year and then decreased at 5 years. This follows the episodic nature of stroke such that survivors to one year do not have substantially different health care needs than age-matched controls.

In Alberta, bi-plane angiography, imaging equipment, expertise, personnel and systems of care already existed to manage neuro-interventional procedures. Building on top of this infrastructure was a smaller investment that could contribute to the ROI.

The finding that EVT is cost-saving is internationally consistent. In Canada, Sevick et al. reported that EVT is cost-effective if the time-horizon is 1 year or more,[22] and Xie et al. reported a similar benefit using a cost-utility analysis.[23] In the US, by comparing the cost of EVT with the average reimbursement from insurance, Brinjikji et al. concluded that the improved patient outcomes associated with EVT may result in decreases in long-term costs.[24] Another study found a net financial gain of US$500 per patient associated with EVT, compared to the net financial loss of US$1800 in the control group.[25] Recently, Kunz et al. found that EVT leads to long-term cost-savings.[26] In England, McMeekin et al. also found that EVT benefits are highly likely to be cost-saving over 5 years.[27]

There are several limitations to be acknowledged. First, as there are no controls in the same time periods with the EVT patients to compare, we used ESCAPE trial[1] data which is a few years older and modelled the impact of EVT as similar in 2018–2019. Improvements in diagnosis and treatment for stroke over the years could result in our estimates being under or overestimated. Similarly, our estimates could be under or overestimated because the efficacy of EVT in the ESCAPE trial is possibly different from the effectiveness of EVT in the real-world ERA implementation.[28] However, with the sensitivity analysis, we believe that this bias was minimized. Second, as the sample size was small, variations of differences in HSU costs between EVT and control group were wide. Therefore, the variation of net savings was wide. However, the probabilistic sensitivity analysis showed a high probability for ERA to be cost-saving, especially in longer time-horizons. Third, the savings could be underestimated as deaths were included in HSU calculations given EVT could reduce mortality; that is, EVT patients would live longer and therefore would use more health services than their counterparts. Fourth, as the costs of the ERA project did not include potential additional physician billings and the costs associated with a greater number of rapid evaluations (e.g. imaging and nursing) for non-stroke and non-EVT eligible ischemic stroke patients, the NB estimated in this study could be overestimated. Finally, our estimated savings would have been larger if societal costs had been included given it is evident that out-of-pocket costs,[29] as well as indirect costs of lost productivity for stroke survivors and their caregivers, are substantial.[30–32]

In conclusion, a population-wide investment in EVT is a dominant, cost-saving strategy. Our results have emphasized that it is important to consider a broad range of HSU and long-term impact to capture the full return on investment.

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## Disclosures

Dr Demchuk reports personal fees from Medtronic, outside the submitted work. In addition, Dr Demchuk has a patent Circle NVI issued. Dr Hill reports grants from Covidien (Medtronic LLC), during the conduct of the study; personal fees from Sun Pharma, grants from Boehringer-Ingelheim, grants from NoNO Inc., grants from Medtronic LLC, grants from Biogen Inc., outside the submitted work; In addition, Dr Hill has a patent US Patent office Number: 62/086,077 licensed to Circle Neurovascular Inc., and a patent US Patent office Number: US 10,916,346 licensed to Circle Neurovascular Inc. and owns stock in Pure Web Incorporated, a company that makes, among other products, medical imaging software, is a director of the Canadian Federation of Neurological Sciences, a not-for-profit group, a director of the Canadian Stroke Consortium, a not-for-profit group, is a director of Circle NeuroVascular Inc., and has received grant support from Alberta Innovates Health Solutions, CIHR, Heart & Stroke Foundation of Canada, National Institutes of Neurological Disorders and Stroke. Dr Goyal reports grants and personal fees from Medtronic, personal fees from Stryker, personal fees from Mentice, personal fees from Microvention, outside the submitted work. All the other authors have nothing to disclose.

## Statement of Authorship

All authors participated in study conception and design, and interpretation of results. All the co-authors contributed to the project implementation and data collection. The first author analyzed data and drafted the first version of manuscript. The last author supervised the whole process. All authors revised and approved the manuscript before submission and take responsibility for contents of the article.

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