Effects of cardiovascular and cerebrovascular health events on work and earnings: a population-based retrospective cohort study

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ABSTRACT

BACKGROUND: Survivors of acute health events can experience lasting reductions in functional status and quality of life, as well as reduced ability to work and earn income. We aimed to assess the effect of acute myocardial infarction (MI), cardiac arrest and stroke on work and earning among working-age people.

METHODS: For this retrospective cohort study, we used the Canadian Hospitalization and Taxation Database, which contains linked hospital and income tax data, from 2005 to 2013 to perform difference-in-difference analyses. We matched patients admitted to hospital for acute MI, cardiac arrest or stroke with controls who were not admitted to hospital for these indications. Participants were aged 40–61 years, worked in the 2 years before the event and were alive 3 years after the event. Patients were matched to controls for 11 variables. The primary outcome was working status 3 years postevent. We also assessed earnings change attributable to the event. We matched 19 129 particpants who were admitted to hospital with acute MI, 1043 with cardiac arrest and 4395 with stroke to 1 820 644, 307 375 and 888 481 controls, respectively.

RESULTS: Fewer of the patients who were admitted to hospital were working 3 years postevent than controls for acute MI (by 5.0 percentage points [pp], 95% confidence interval [CI] 4.5–5.5), cardiac arrest (by 12.9 pp, 95% CI 10.4–15.3) and stroke (by 19.8 pp, 95% CI 18.5–23.5). Mean (95% CI) earnings declines attributable to the events were $3834 (95% CI 3346–4323) for acute MI, $11 143 (95% CI 8962–13 324) for cardiac arrest, and $13 278 (95% CI 12 301–14 255) for stroke. The effects on income were greater for patients who had lower baseline earnings, comorbid disease, longer hospital length of stay or needed mechanical ventilation. Sex, marital status or self-employment status did not affect income declines.

INTERPRETATION: Acute MI, cardiac arrest and stroke all resulted in substantial loss in employment and earnings that persisted for at least 3 years after the events. These outcomes have consequences for patients, families, employers and governments. Identification of subgroups at high risk for these losses may assist in targeting interventions, policies and legislation to promote return to work.

Serious acute health events can be life-altering, because survivors can experience lasting reductions in functional status and quality of life. The ability to work and earn income — labour market outcomes — are important patient-centred outcomes[1] for individuals of working age, influencing economic well-being, sense of self and quality of life.[2,3] Health events may start a cascade where new disability causes earnings losses, which contribute to cost-related nonadherence to medication,[4] which contributes to worsened and even new health problems.[5,6] Lost productivity and informal care substantially contribute to the economic and societal consequences of health events.[7] Although interventions to ameliorate these consequences may be beneficial, a necessary first step to inform their design and testing is obtaining accurate data on the size of and risk factors for work and earnings losses after common health events in working-age populations.

Cardiovascular and cerebrovascular diseases are the most common causes of death worldwide.[8] Specifically, the health events of acute myocardial infarction (MI), cardiac arrest and stroke are common causes of admission to hospital, increasing health care costs, disability and death.[9] One-third of acute MIs, one-quarter of strokes and 40% of cardiac arrests occur in people of working age who are aged 65 years or younger.[10–12]

Prior studies of outcomes in the labour market after these health events have had serious methodological limitations or combined multiple health events together. We addressed those limitations using matched controlled population-based cohorts to evaluate separately the effect of acute MI, cardiac arrest and stroke on outcomes in the labour market. Our primary hypothesis was that people of working age who were alive after hospitalization for these conditions experience substantial and enduring decrements in employment and earnings.

Methods

Data sets and linkage

For this retrospective population-based cohort study, we used the Canadian Hospitalization and Taxation Database (C-HAT), a previously described linkage of population-based Canadian hospital and income tax data.[13] In C-HAT, the hospital data derive from the Discharge Abstract Database,[14] whereas the source of tax data is the T1 Family File, which contains yearly tax returns for all Canadians. For this study, we excluded the 3 territories (Northwest Territories, Nunavut and Yukon) and the province of Quebec, where the linkage rates were lower than in the provinces.[13] See Appendix 1, available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.181238/-/DC1, for more details.

Study cohorts

We performed separate analyses for acute MI, cardiac arrest and stroke, using matched cohorts of participants who were exposed and unexposed (control), where exposure was admission to hospital for these health events. We use the term "index year" to indicate the calendar year of the health event for exposed and the matched year for unexposed. We indicate the index year as Y0, the third year following it as Y+3, and so on.

Based on estimation of sample size (Appendix 1), we used the Discharge Abstract Database to identify patients who were admitted to an acute care hospital for acute MI, cardiac arrest or stroke during 3 calendar years (2008–2010). Because of a lower yearly incidence in cardiac arrest, for that event we included 5 years of data (2005–2010) and excluded Manitoba for 2005–2007 owing to incomplete data.

We used the following criteria for inclusion in the exposed cohort: aged 40–61 years in Y0; identified in tax data in Y–2, Y–1 and Y+3; working in Y–2 and Y–1 as indicated by nonzero earnings; admission to hospital with acute MI, cardiac arrest or stroke in Y0; and alive at the end of Y+3. We chose the International Statistical Classification of Diseases and Related Health Problems, 10th Revision codes for the 3 conditions (Supplemental Table 1, Appendix 1) to maximize positive predictive value, by excluding codes that may not represent the entities of interest. We excluded those patients who had the health event of interest during the 3 years preceding Y0 to ensure that labour market outcomes were attributable to the index health event rather than a previous one (Supplemental Table 1, Appendix 1). Unexposed controls for each study year were chosen separately for the 3 conditions. They satisfied the same criteria as the exposed cohorts, except they did not have the primary health event of interest in Y0.

We excluded extreme earners, defined as being in the top and bottom 0.25% of the earnings distribution of the population aged 37–64 years from 2003 to 2013. All those excluded at the low end of the distribution had negative total earnings, indicating net losses from self-employment (Appendix 1).

Matching

Participants who were unexposed were matched to exposed participants using coarsened exact matching, a method that differs from usual exact matching. This method balances within multidimensional strata and using weights, and provides superior balancing compared with propensity score matching (Appendix 1).[15,16] We matched on 11 variables: index year, age, sex, province of residence in Y–1, whether there was any self-employment earnings in Y–1, urban/rural residency in Y–1,[17] total earnings in Y–1, total earnings in Y–2, marital status in Y–1 (married or not, including common law marriage), union membership in Y–1 (as indicated in tax data by payment of union dues) and any nonobstetrical hospital days in Y–1 to Y–3. We used standardized differences to indicate parameter balance between matched exposed and unexposed participants (Supplemental Table 3, Appendix 1).

Outcomes

Our primary outcome was working in Y+3, as indicated by nonzero total earnings in that year. Among 3 secondary outcomes, the main outcome was the pre- to postevent (Y–1 to Y+3) change in total annual earnings attributable to the health events. Total earnings were calculated as the pretax sum of all wages, salaries, net self-employment income, other employment earnings and Indian Act exemption for employment income, indexed to 2012 dollars using the Canadian Consumer Price Index. Two other secondary outcomes were the changes in total annual earnings attributable to the health events from Y–1 to Y+1 and Y+2.

Statistical analysis

We quantified the effect of health events on mean yearly earnings using matched difference-in-difference, ordinary least squares regression. This method compares the pre- to postevent change in earnings of participants who were exposed to admission to hospital, who experienced a health event, to the analogous change for controls who did not. This "double difference" represents the effect on earnings attributable to the health event.[18] Although it is not well recognized in the medical literature, causal inference achieved by combining matching with parametric regression analysis is well-established in other areas.[18–20] To compare proportions of those who were working postevent between exposed and unexposed participants, we used weighted multivariable probit regression on the matched cohorts (Appendix 1).

We performed 3 prespecified subset analyses. For outcomes in Y+3, we restricted analyses to individuals who were working in Y+3, as indicated by nonzero earnings in that year. To reduce confounding caused by false-positive identification of health events, we restricted our criteria for exposure to admission to hospital to include only those whose index hospital lengths of stay were at least 3 days. To reduce the contribution of patients whose health events led to early retirement, we restricted analyses to those who were 40–55 years of age in Y0.

We used reweighting methodology to assess heterogeneity effects, and how labour market outcomes of acute MI and stroke differed across substrata of 12 variables (Appendix 1). We did not use this methodology for cardiac arrest because the smaller number of cases led to unacceptable case loss during the reweighting procedure, threatening the generalizability of those results (Supplemental Table 2, Appendix 1).

Analysis was performed using Stata 14 (StataCorp). We considered a p value of less than 0.05 to be significant.

Ethics approval

This study was approved by the Health Research Ethics Board of the University of Manitoba.

Results

The number of individuals hospitalized for health events who survived at least 3 years is 19 129 for acute MI, 4395 for stroke and 1043 for cardiac arrest (Table 1; Supplemental Figure 1,

Table 1: Baseline characteristics for the matched and weighted exposed health event and unexposed control cohorts

	Acute MI (%)*			Cardiac arrest (%)*			Stroke (%)*		
Characteristic	Exposed cohort *n* = 19 129	Matched control cohort *n* = 1 820 644	Std. diff.	Exposed cohort *n* = 1043	Matched control cohort *n* = 307 375	Std. diff.	Exposed cohort *n* = 4395	Matched control cohort *n* = 888 481	Std. diff.
Age in Y0, mean ± SD; yr	53.0 ± 5.5	52.9 ± 5.5	0.012	52.6 ± 5.7	52.5 ± 5.8	0.010	53.1 ± 5.8	53.0 ± 5.8	0.012
Sex, female	3655 (19.1)	347 873 (19.1)	0.000	247 (23.7)	72 792 (23.7)	0.000	1522 (34.6)	307 683 (34.6)	0.000
Province of residence in Y–1	Various	Various	All 0.000	Various	Various	All 0.000	Various	Various	All 0.000
Urban residence in Y–1	16 054 (83.9)	1 527 974 (83.9)	0.000	940 (90.1)	277 021 (90.1)	0.000	3821 (86.9)	772 443 (86.9)	0.000
Married/common law in Y–1	15 299 (79.9)	1 455 164 (79.9)	0.000	852 (81.7)	251 087 (81.7)	0.000	3287 (74.8)	664 491 (74.8)	0.000
Union member in Y–1	5954 (31.1)	566 685 (31.1)	0.000	338 (32.4)	99 610 (32.4)	0.000	1365 (31.1)	275 945 (31.1)	0.000
Any self-employment in Y–1	3101 (16.2)	294 144 (16.2)	0.000	154 (14.8)	45 384 (14.8)	0.000	636 (14.5)	128 572 (14.5)	0.000
Earnings in Y–1, mean ± SD; 2012$	53 263 ± 44 572	53 618 ± 45 883	−0.008	55 192 ± 47 141	55 044 ± 47 162	0.003	47 657 ± 41 9 33	48 131 ± 43 884	−0.011
Earnings in Y–2, mean ± SD; 2012$	54 115 ± 44 527	54 465 ± 45 954	−0.008	54 827 ± 44 332	55 442 ± 46 679	−0.014	48 585 ± 41 944	48 995 ± 43 693	−0.010
At least 1 hospital day in Y–3, Y–2, Y–1	2023 (10.6)	192 543 (10.6)	0.000	199 (19.1)	58 646 (19.1)	0.000	689 (15.7)	139 286 (15.7)	0.000
Had children < 18 yr of age in Y–1	5547 (29.0)	544 634 (29.9)	−0.020	339 (32.5)	97 710 (31.8)	0.015	1182 (26.9)	253 929 (28.6)	−0.038
No. of children < 18 yr in Y–1, of those with children									
Mean ± SD	1.6 ± 0.8	1.6 ± 0.8	−0.020	1.6 ± 0.8	1.6 ± 0.8	0.002	1.6 ± 0.8	1.6 ± 0.8	
Median (IQR)	1 (1–2)	1 (1–2)		1 (1–2)	1 (1–2)		1 (1–2)	1 (1–2)	−0.055
Charlson Comorbidity Score									
Mean ± SD	0.11 ± 0.40			0.29 ± 0.61			0.44 ± 0.87		
Median (IQR)	0 (0–0)			0 (0–0)			0 (0–0)		
Index hospital LOS, d									
Mean ± SD	5.8 ± 6.2			14.3 ± 17.0			12.8 ± 21.4		
Median (IQR)	3 (4–6)			5 (9–18)			3 (6–12)		
In special care unit	14 921 (78.0)			943 (90.4)			958 (21.8)		
Mechanical ventilation	1817 (9.5)			504 (48.3)			251 (5.7)		
Cardiac catheterization	15 475 (80.9)			721 (69.1)					
Coronary revascularization	12 625 (66.0)			464 (44.5)					
Stroke type									
Ischemic							2707 (61.6)		
Hemorrhagic							615 (14.0)		
Not specified							193 (24.4)		

Note: IQR = interquartile range, LOS = length of stay, MI = myocardial infarction, SD = standard deviation, std. diff. = standardized difference = $(\text{mean}_2 - \text{mean}_1)/[(SD_1^2 + SD_2^2)/2]^{1/2}$, Y0 = calendar year of index health event, Y–1 = previous year before health event, Y–2 = 2 years before the health event, Y+3 = third calendar year after Y0.
*Unless specified otherwise.

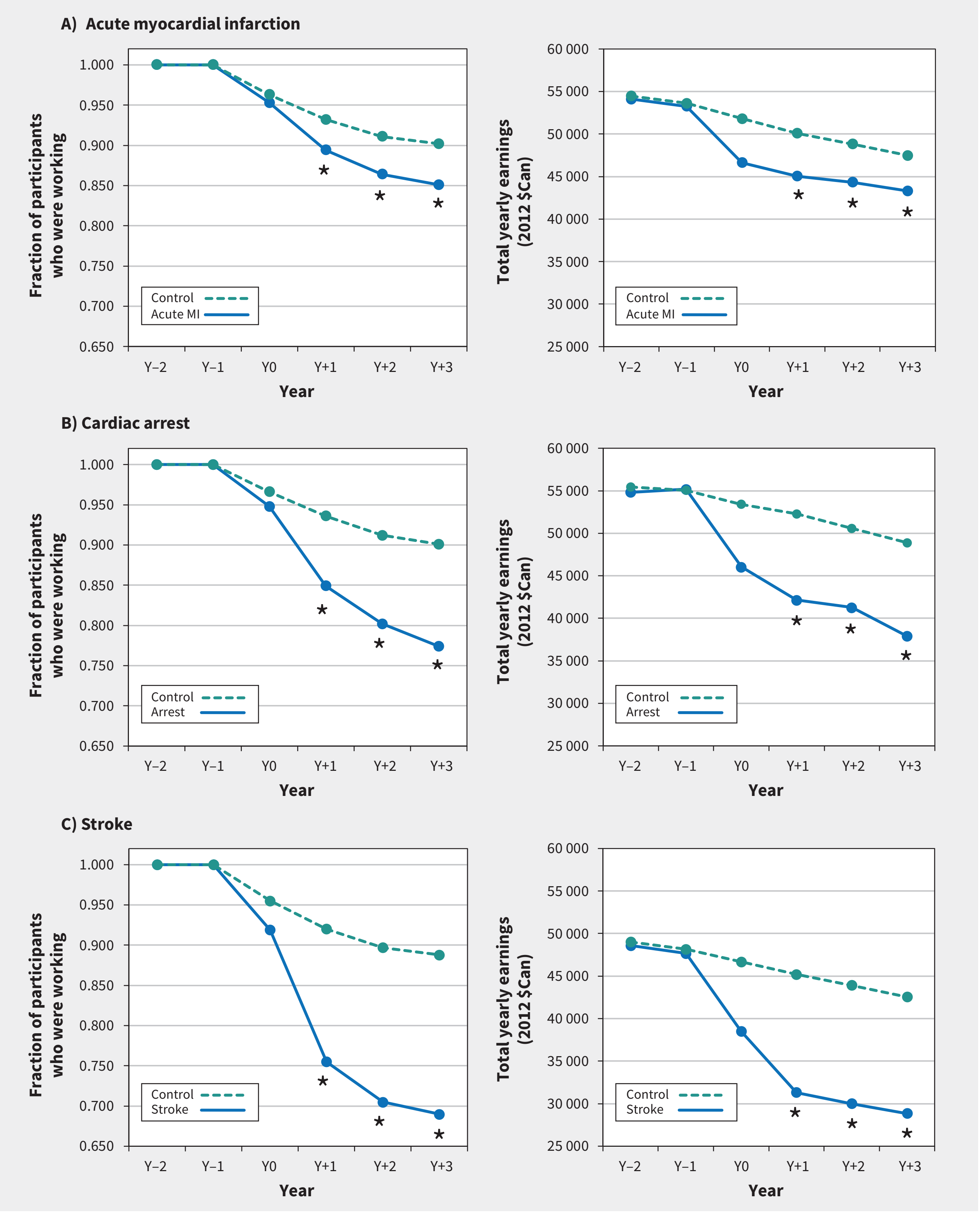

Figure 1: Temporal evolution of labour market outcomes (left-hand side panels: fraction of participants who were working; right-hand side panels: average total yearly earnings) for matched, weighted health events (A) acute myocardial infarction, (B) cardiac arrest and (C) stroke, and unexposed control cohorts. Note: Y0 = calendar year of index health event, Y–1 = previous year before health event, Y–2 = 2 years before the health event, Y+1 = first calendar year after Y0, Y+2 = second calendar year after Y0, Y+3 = third calendar year after Y0. *$p < 0.001$ between health event (exposed) and unexposed control cohorts.

Appendix 1). The number of matched controls exceeded 370 000 for all 3 cohorts (Table 1). Matching eliminated differences between exposed and unexposed groups (Table 1; Supplemental Table 3, Appendix 1).

Compared with unexposed controls, 3 years postevent, 5 to 20 percentage points fewer of those who had the health events were working, and their mean annual earnings were reduced by $3834–$13 278 (Figure 1, Table 2; Supplemental Table 4, Appendix 1; $p < 0.001$ for all differences). The size of effects were greatest for stroke and smallest for acute MI. The annual income decrements represent decrements in relative earnings of 8.1% for acute MI, 22.8% for cardiac arrest and 31.2% for stroke. The reductions in rates of employment and earnings were evident by the first postevent year (Figure 1; Supplemental Table 5, Appendix 1) and were sustained.

Prespecified subgroup analyses are shown in Table 2. Even participants working in Y+3 had reduced annual earnings attributable to the 3 health events; expressed as fractions of the reductions for the entire cohorts, these decreases were 65.8% for acute MI, 73.8% for cardiac arrest and 71.0% for stroke. When we excluded participants whose hospital stays were less than 3 days, the effects of acute MI and stroke were larger than for the main analysis. When we excluded participants over 55 years of age, the effects of acute MI and stroke were smaller than for the main analysis.

There was marked heterogeneity in the effects of acute MI and stroke on employment decline, with larger average effects for participants of older age, lower baseline earnings, comorbid disease, longer index hospital stay and requirement for mechanical ventilation during hospital stay (Table 3). Employment decline was greater for those participants with hemorrhagic stroke than for those with ischemic strokes. However, sex, marital status and self-employment status were not important effect modifiers. For acute MI, employment decline did not depend on whether the participant received cardiac catheterization or revascularization during the index hospital stay.

Larger effects on earnings were seen for participants with acute MI and stroke with comorbidity, longer index hospital length of stay and need for mechanical ventilation during the hospital stay (Table 3; Supplemental Table 6, Appendix 1). Although absolute earning declines attributable to health events increased with higher baseline income for participants with acute MI and stroke, those in lower baseline earnings terciles had greater fractional declines (acute MI 13.4%, 9.0% and 6.4%; stroke 43.4%, 32.3% and 26.4%).

Interpretation

We quantified sustained inability to work and economic losses for participants from acute MI, cardiac arrest and stroke, and highlighted the subgroups at greatest risk. Three years after admission to hospital for any of these health events, participants who survived were less likely than the matched participants who were unexposed to be working, and had greater losses in annual earnings. The size of annual earnings losses attributable to these health events were substantial, with relative decrements of 8%–31%. These losses were not limited to those who became unable to work; those working in the third postevent year had

Table 2: Changes attributable to health events in the third year after versus the year before hospital admission for the health event

Model	No. of participants	Pre- to postevent absolute change attributable to the health event: Percent employed, estimate (95% CI)	Pre- to postevent absolute change attributable to the health event: Annual earnings, estimate (95% CI); $2012
Acute MI			
Baseline model	1 839 773	−5.0 (−5.5 to −4.5)	−3834 (−4323 to −3346)
Subsets: working in Y+3	1 692 408		−2525 (−3025 to −2024)
Index hospital LOS ≥ 3 d	1 677 713	−5.5 (−6.1 to −4.9)	−4136 (−4676 to −3597)
Age ≤ 55 yr	1 372 022	−4.4 (−4.9 to −3.8)	−3584 (−4182 to −2985)
Cardiac arrest			
Baseline model	308 418	−12.9 (−15.3 to −10.4)	−11 143 (−13 324 to −8962)
Subsets: working in Y+3	285 994		−8220 (−10 710 to −5729)
Index hospital LOS ≥ 3 d	288 566	−13.2 (−15.7 to −10.6)	−11 348 (−13 661 to −9035)
Age ≤ 55 yr	233 933	−12.6 (−15.4 to −9.7)	−13 203 (−16 089 to −10 318)
Stroke			
Baseline model	892 876	−19.8 (−21.2 to −18.5)	−13 278 (−14 255 to −12 301)
Subsets: working in Y+3	817 741		−9430 (−10 610 to −8249)
Index hospital LOS ≥ 3 d	784 202	−22.1 (−23.5 to −20.6)	−14 462 (−15 519 to −13 404)
Age ≤ 55 yr	648 242	−18.8 (−20.8 to −17.2)	−14 015 (−15 279 to −12 752)

Note: CI = confidence interval, LOS = length of stay, MI = myocardial infarction, Y0 = calendar year of index health event, Y+3 = third calendar year after Y0. $p < 0.001$ for all 21 comparisons.

Table 3: Stratified changes attributable to health events in the third year after versus the year before hospital admission*†

	Employed percentage points, estimate (95% CI)		Total yearly earnings, estimate (95% CI); $2012	
Variable	**Acute MI**	**Stroke**	**Acute MI**	**Stroke**
Age group, yr	‡			
40–49	−4.1 (−5.0 to −3.3)	−17.3 (−19.8 to −14.7)	−3512 (−4402 to −2622)	−13 249 (−15 084 to −11 415)
50–55	−4.9 (−5.8 to −4.1)	−21.1 (−23.6 to −18.7)	−3505 (−4299 to −2711)	−13 293 (−15 119 to −11 467)
56–61	−6.0 (−7.0 to −5.0)	−21.5 (−23.9 to −19.1)	−4426 (−5303 to −3546)	−12 878 (−14 526 to −11 230)
Sex				
Male	−4.8 (−5.4 to −4.2)	−19.8 (−21.6 to −18.0)	−3727 (−5305 to −3546)	−13 500 (−14 695 to −12 306)
Female	−5.4 (−6.7 to −4.0)	−19.2 (−21.7 to −16.8)	−3520 (−5416 to −1624)	−12 257 (−14 351 to −10 163)
Y–1 earnings, terciles				
Low	−8.5 (−9.6 to −7.5)	−28.1 (−30.5 to −25.6)	−2710 (−3222 to −2198)	−7752 (−8575 to −6929)
Middle	−4.4 (−5.1 to −3.6)	−17.7 (−19.8 to −15.5)	−4099 (−4734 to −3464)	−13 871 (−15 204 to −12 538)
High	−1.7 (−2.6 to −0.8)	−9.6 (−12.3 to −6.9)‡	−6070 (−7936 to −4204)	−23 780 (−27 963 to −19 598)
Y–1 marital status				
Single	−5.9 (−7.3 to −4.6)	−23.7 (−26.8 to −20.6)	−3742 (−5138 to −2347)	−14 367 (−16 870 to −11 864)
Married or common law	−4.8 (−5.4 to −4.3)	−19.1 (−20.7 to −17.4)	−3957 (−4489 to −3425)	−12 720 (−13 833 to −11 607)
Any Y–1 self-employment				
No	−5.4 (−5.9 to −4.8)	−22.1 (−23.9 to −20.4)	−3990 (−4513 to −3468)	−13 434 (−14 605 to −12 263)
Yes	−3.3 (−4.5 to −2.0)	−14.0 (−17.4 to −10.6)	−3300 (−5109 to −1490)	−11 753 (−15 237 to −8270)
Charlson Comorbidity Index				
0	−4.6 (−5.2 to −4.1)	−16.3 (−17.9 to −14.7)	−3525 (−5109 to −1490)	−11 547 (−12 682 to −10 412)
≥ 1	−11.1 (−13.4 to −8.9)	−30.4 (−33.5 to −27.3)	−8288 (−10 373 to −6204)	−18 823 (−21 006 to −16 641)
Index hospital LOS, terciles				
Lowest	−3.1 (−3.9 to −2.3)	−9.9 (−12.2 to −7.6)	−2623 (−3374 to −1872)	−7362 (−9108 to −5615)
Intermediate	−5.3 (−6.2 to −4.3)	−17.7 (−20.3 to −15.2)	−4204 (−5128 to −3280)	−11 513 (−13 364 to −9662)
Highest	−7.1 (−8.1 to −6.2)	−34.7 (−37.6 to −31.7)	−5291 (−6301 to −4281)	−22 374 (−24 533 to −20 216)
Special care unit				
No	−4.6 (−5.7 to −3.5)	−16.4 (−18.0 to −14.8)	−3703 (−4748 to −2657)	−11 636 (−12 824 to −10 447)
Yes	−5.0 (−5.6 to −4.5)	−28.6 (−32.0 to −25.2)	−3915 (−4476 to −3354)	−18 356 (−20 779 to −15 933)
Mechanical ventilation				
No	−4.5 (−5.0 to −4.0)	−17.8 (−19.5 to −16.1)	−3629 (−4159 to −3099)	−12 470 (−13 761 to −11 179)
Yes	−9.6 (−11.5 to −7.7)	−45.1 (−52.2 to −37.9)	−7572 (−9457 to −5687)	−26 198 (−31 409 to −20 987)
Cardiac catheterization				
No	−5.0 (−6.1 to −3.8)	NA	−4034 (−5177 to −2892)	NA
Yes	−5.0 (−5.6 to −4.5)		−3743 (−4294 to −3192)	
Revascularization				
No	−5.1 (−6.0 to −4.2)	NA	−3434 (−4313 to −2554)	NA
Yes	−5.0 (−5.7 to −4.4)		−3926 (−4537 to −3315)	
Stroke type		‡		
Ischemic	NA	−20.0 (−21.9 to −18.0)	NA	−13 823 (−15 285 to −12 362)
Hemorrhagic		−25.0 (−29.1 to −20.8)		−15 910 (−18 887 to −12 933)

Note: CI = confidence interval, LOS = length of stay, MI = myocardial infarction, NA = not applicable, Y0 = calendar year of index health event, Y–1 = previous year before health event.
*Each row is a separate analysis.
†These analyses were not performed for cardiac arrest because the much smaller number of cases led to unacceptable case loss during the reweighting procedure, threatening the generalizability of those results (Supplemental Table 2, Appendix 1).
‡By seemingly unrelated estimation among the categories.

earnings decrements of 5%–20%. The earnings losses were well-established by the first year postevent and changed little to the third postevent year, creating a widening gap in cumulative earnings between those who had and had not had these health events. The effects showed marked heterogeneity. Foremost was that the size of the effects differed greatly between the 3 conditions, being three- to fourfold greater for stroke than acute MI. This likely reflects greater degrees of health-related disability arising from stroke and cardiac arrest than from acute MI. There were also differences in the effect attributable to acute MI and stroke by some of the characteristics of the participants and the index admissions to hospital; a number of these gradients were greater than twofold in size, including those associated with comorbidity, index hospital length of stay, need for mechanical ventilation and pre-event earnings.

Unemployment and lost earnings owing to common health events have broad societal relevance, with consequences for patients, families, employers and governments. For those who are affected, the financial effects of such health events extend as far as causing bankruptcy.[21] As discussed, earnings losses can start a cascade that further worsens health. Lost opportunity costs of unpaid care provided by family members to survivors who are debilitated amount to one-quarter or more of the direct health care costs.[7] Even larger are the costs of lost productivity owing to debility among those who survive cardiovascular health events, variously borne by employers and governments.[7,22] Our study provides high-quality data needed for accurate, bottom-up calculations of the cumulative economic consequences of these common health events.[22] In addition, our identification of high-risk subgroups may assist in targeting interventions, policies and legislation to promote return to work,[23–25] which itself is associated with well-being and life satisfaction among those having these health events.[26]

Previous studies have attempted to quantify labour market outcomes associated with acute MI,[27–32] stroke[28,29,33–36] and cardiac arrest[37] but had substantial methodological limitations. We and others[28] observed declines over time in employment and earnings among unexposed controls, which is relevant because most previous studies have lacked such controls, leading to a possible overestimation of effects attributable to the health events. Of the 3 studies that included unexposed controls, 1 was a single-centre study of stroke.[33] The other 2 assessed combined cohorts of acute MI and stroke,[28] or acute MI, stroke and cancer,[29] making interpretation difficult given the large difference in labour market outcomes we observed between those 2 health events. In the previous study most comparable to ours, Fadlon and Nielsen applied matched difference-in-difference analysis to a population-based sample of 92 000 survivors of either acute MI or stroke in Denmark over 31 years. They reported that excess losses of employment and earnings at 3 years postevent were 17% and 19%, respectively.[28] Another population-based Danish study reported greater rates of working after an acute MI among men, patients who were married, patients with higher socioeconomic status and fewer chronic comorbid conditions, and after percutaneous but not surgical revascularization.[32] Differences with our findings could relate to a lack of unexposed controls in this Danish study.

Our study has several strengths. Using matching with difference-in-difference regression is a powerful combination that reduces bias caused by both observed and unobserved characteristics,[38] and has been extensively used for causal inference in observational data.[18–20] Using recent population-based data that includes most of the Canadian population over multiple years obviates concerns about generalizability. Finally, assessing outcomes over the 3 years after health events allowed us to look beyond transient labour market consequences of health events.

Limitations

There are also limitations. First, our findings may not be generalizable to other countries. National differences in social supports including health, disability and unemployment insurance may substantially influence labour market responses of individuals to illness and injury.[39] Second, because we excluded patients who died within 3 years of their health events, and those residing in Quebec and the territories, our findings may not apply to such cohorts. Similarly, as only admissions to hospital for acute care were examined, our findings may not apply to emergency department and other types of contact that did not lead to hospital admission. Third, we were unable to assess heterogeneity for variables not included in the hospital and tax data; variables such as level of physical activity, which may affect risk of disease and subsequent functional capacity, could not be assessed. Finally, although individual earnings comprise 87%–97% of total income for Canadians in the age groups we studied,[40] they do not represent the entire economic landscape for some individuals; other sources of income can include spousal or other household earnings, investment income, disability and other insurance payments, and other financial support. However, even if other sources of income cushion the direct financial consequences of health events, being employed is associated with life satisfaction,[2,3] and unemployment per se is a risk factor for all-cause mortality.[41]

Conclusion

Our findings add individual-level details to the current understanding of the economic consequences of cardiovascular and cerebrovascular disease.[39] The loss of earnings attributable to these health events represent some of the total costs of caring for such conditions.[42] Because these effects differ by health event and possibly by country, much work remains to form a more complete understanding of how acute illnesses influence labour market outcomes.[43]

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