

# Health outcomes associated with emergency department visits by adolescents for self-harm: a propensity-matched cohort study

William Gardner PhD, Kathleen Pajer MD MPH, Paula Cloutier MA, Lisa Currie MS, Ian Colman PhD, Roger Zemek MD, Simon Hatcher MD, Isac Lima PhD, Mario Cappelli PhD

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## ABSTRACT

**BACKGROUND:** Self-harm is increasing among adolescents, and because of changing behaviours, current data are needed on the consequences of self-harm. We sought to investigate the trends related to hospital presentation, readmission, patient outcome and medical costs in adolescents who presented with self-harm to the emergency department.

**METHODS:** We used administrative data on 403 805 adolescents aged 13–17 years presenting to Ontario emergency departments in 2011–2013. Adolescents with self-harm visits were 1:2 propensity matched to controls with visits without self-harm, using demographic, mental health and other clinical variables. Five

years after the index presentation, hospital or emergency department admission rates for self-harm, overall mortality, suicides and conservative cost estimates were compared between the 2 groups.

**RESULTS:** Of 5832 adolescents who visited Ontario emergency departments in 2011–2013 after self-harm (1.4% of visits), 5661 were matched to 10 731 adolescents who presented for reasons other than self-harm. Adolescents who presented with self-harm had a shorter time to a repeat emergency department or hospital admission for self-harm (hazard ratio [HR] 4.84, 95% confidence interval [CI] 4.44–5.27), more suicides (HR 7.96,

95% CI 4.00–15.86), and higher overall mortality (HR 3.23, 95% CI 2.12–4.93;  $p < 0.001$ ). The positive predictive value of self-harm-related emergency department visits for suicide was 0.7%. Adolescents with self-harm visits had mean 5-year estimates of health care costs of \$30 388 compared with \$19 055 for controls ( $p < 0.001$ ).

**INTERPRETATION:** Adolescents with emergency department visits for self-harm have higher rates of mortality, suicide and recurrent self-harm, as well as higher health care costs, than matched controls. Development of algorithms and interventions that can identify and help adolescents at highest risk of recurrent self-harm is warranted.

Intentional self-harm is the deliberate act of injuring oneself, including attempts at suicide and nonsuicidal self-injury.<sup>1</sup>

Some of the consequences associated with adolescent self-harm are increased risk of death,<sup>2</sup> including suicide;<sup>3–7</sup> risk of injury owing to violence;<sup>8</sup> and risks of mental health and substance abuse disorders,<sup>3,6,9–12</sup> as well as other adverse psychosocial outcomes.<sup>13</sup> Although several groups have carried out population-based studies of adolescents<sup>2,4,12</sup> and reported that adolescents with emergency department visits for self-harm have worse outcomes than those with emergency department visits for other reasons, these studies controlled for only a limited number of covariates. Only 1 study<sup>14</sup> reported data on the health care costs associated with adolescent self-harm. Emer-

gency department visits by adolescents for self-harm in Ontario have more than doubled since 2009.<sup>15</sup> Given adolescents' changing environments and influences (e.g., pervasive social media<sup>16</sup>) newer data are needed.

We carried out a population-based study comparing adolescents who presented to the emergency department after self-harm with adolescents who presented for reasons other than self-harm, using a propensity-matching design that controlled for a large number of demographic, mental health and other clinical variables. The primary objective of this study was to test the hypothesis that adolescents presenting to emergency departments after self-harm would have higher 5-year rates of emergency department and hospital readmissions for self-harm,

suicide and overall mortality than adolescents presenting to emergency departments for other reasons. We also hypothesized that adolescents presenting with self-harm would incur more costly medical care over 5 years than those not presenting with self-harm. The secondary objective was to identify demographic, health-related and social predictors of poor outcomes within the self-harm group.

## Methods

### Study design, setting and participants

This is a prospective cohort study of adolescents aged 13 to 17 years (inclusive) who presented to Ontario emergency departments from Jan. 1, 2011, through Dec. 31, 2013, with an Ontario Health Insurance Plan number and were discharged alive. Adolescents with emergency department visits for self-harm were propensity matched to control adolescent patients, using demographic and clinical variables. The self-harm group included adolescents with at least 1 emergency department visit with an *International Classification of Diseases, 10th Revision* (ICD-10) self-harm code.<sup>17</sup> The control group comprised all other adolescents with emergency department visits for other reasons. Participants were followed from the date of the index emergency department visit until death, or 5 years after the index visit.

### Data sources

The National Ambulatory Care Reporting System was the source of data on emergency department visits. We used the Discharge Abstract Database to identify acute care hospital admissions with a self-harm code, as well as specific health care conditions and comorbidities. We used data from the Ontario Health Insurance Plan and the Ontario Mental Health Reporting System to identify patients' health care conditions 1 year before the emergency department visits. The quality of National Ambulatory Care Reporting System data within several Ontario emergency departments has been determined to be good, with agreement rates for ICD-10 codes ranging from 86% to 90%.<sup>18</sup> We identified sociodemographic characteristics using the Registered Person Database. Finally, we identified decedents through the Office of the Registrar General of Ontario Death Database. These data sets were linked using unique encoded identifiers and analyzed at ICES. ICES is an independent, nonprofit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement.

### Measurements

#### Self-harm

Self-harm emergency department visits and hospital admissions were defined as events with ICD-10 codes X6, X7 or X80–X84. We combined self-injury and self-poisoning into a single self-harm variable.

When an adolescent visited the emergency department more than once in 2011–2013, we selected the index visit as follows: if

none of the adolescent's visits were related to self-harm, we selected the first visit; if 1 visit was related to self-harm, we selected that visit; if there were multiple visits related to self-harm, we selected the first.

### Outcomes

#### *Suicides and overall mortality*

We identified suicides and deaths from all causes (overall mortality). We determined suicides using a validated method developed by ICES using ICD9 codes E950–E959 or ICD10 codes X60–84.<sup>19</sup> This method has  $\geq 95\%$  sensitivity for the period under study.

#### *Repeat self-harm emergency department visits or hospital admission*

We searched the National Ambulatory Care Reporting System and Discharge Abstract Database for the 5 years after the index visit to find records of emergency department visits or hospital admissions with self-harm codes.

#### *Estimates of medical costs*

We calculated the cumulative 5-year cost of all health services captured in ICES — i.e., not just those attributable to self-harm — using a standard ICES macro.<sup>20</sup> These services included inpatient hospital admissions (both acute and psychiatric), physician-related visits and laboratory tests, emergency department visits and other ambulatory care, outpatient prescription drugs (for adolescents covered only under the Ontario Drug Benefit program, which is designed for indigent patients), rehabilitation, home care, complex continuing care, long-term care and assisted devices. The cost estimates do not include outpatient drug costs (except for families receiving public assistance), nonphysician services, out-of-pocket costs of care or services covered by private insurance, including the costs of most care provided by psychologists and social workers, and all care by mental health nurses in schools. Therefore, these estimates are lower bounds on the actual 5-year health care costs incurred by patients.

#### *Covariates of self-harm*

The covariates we used in matching included sex, age, residence and income quintile of the Canadian Census Dissemination Area of residence. They also included clinical covariates found in the National Ambulatory Care Reporting System, Discharge Abstract Database, Ontario Health Insurance Plan and Ontario Mental Health Reporting System databases (Appendix 1, available at [www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.190188/-/DC1](http://www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.190188/-/DC1)). The clinical covariates included mental health and substance misuse diagnostic codes, and a set of non-mental health diagnoses that had been included in a comprehensive epidemiologic study of the covariates of adult self-harm.<sup>21</sup> These clinical covariates could have been recorded for the index visit or any other health care interaction during the year before that visit. Finally, the covariates used in the propensity score included self-harm codes occurring during the prior

year. This means that self-harm that occurred in the year before the emergency department visit was used to propensity-match adolescents with self-harm visits to controls patients. Because of how we selected patients, only those adolescents with emergency department visits in 2011 could have had visits related to self-harm in the prior year.

### Statistical analysis

We used propensity scores to match adolescents with visits related to self-harm to control patients. We carried out a logistic regression to estimate the probability of an emergency department visit related to self-harm (PSCORE) from the covariates listed in Appendix 1. Next, we excluded participants whose PSCORE fell outside the common support interval:

$$\text{common support} = [\min(\text{PSCORE in self-harm group}), \max(\text{PSCORE in no-self-harm group})].$$

The common support interval is the range of propensity scores in which the participants in the self-harm and control groups were comparable.<sup>22</sup> For example, an adolescent in the self-harm group with a propensity score of self-harm that is higher than that of *any* adolescent in the control group has no meaningful propensity score match among the controls. We then sought 2 matched controls for each of the adolescents with visits related to self-harm (case).<sup>22–24</sup> Cases were matched to the same age, sex and rurality as the control patient who was closest to the PSCORE (Appendix 1). Finally, we assessed whether the matched adolescents with and without emergency department visits related to self-harm were balanced on our covariates using the standardized mean difference ( $D$ ),

$$D = [\text{mean}(\text{covariate in self-harm group}) - \text{mean}(\text{covariate in no-self-harm group})] / \text{SD}$$

where SD is the average of the standard deviations for the self-harm and no-self-harm groups. We used stratified Cox proportional hazards regression to compare adolescents with visits related to self-harm to control patients on the time from the index visit to death from any cause. We analyzed time to suicide data similarly, but with death from other causes as a competing risk. We analyzed time from the index visit to an emergency department or hospital readmission for self-harm with death by any cause as a competing risk. We log-transformed lower-bound cost estimates and compared them using paired  $t$ -tests. In addition, we placed patients into 4 groups defined by self-harm visit (yes v. no) and mental health visit (yes v. no) and used a  $2 \times 2$  analysis of variance to compare the log-transformed lower-bound cost estimates. The analyses used SAS version 9.3 (SAS Institute, Cary, North Carolina). Finally, for the outcomes of readmission, mortality and suicide, we calculated the relative risk (RR) and positive predictive value (PPV) associated with self-harm, where

$$PPV = \Pr(\text{outcome} | \text{self-harm}) \text{ and } RR = \Pr(\text{outcome} | \text{self-harm}) / \Pr(\text{outcome} | \text{no self-harm}).$$

### Ethics approval

Approval to complete this study was granted by the Children's Hospital of Eastern Ontario Research Ethics Board.

## Results

### Study cohort

There were 407 647 adolescents who visited an emergency department in Ontario from Jan. 1, 2011, to Dec. 31, 2013. We excluded 569 adolescents (0.1%) because they were not covered by the Ontario Health Insurance Plan. After calculating the propensity scores, we excluded an additional 3273 (0.8%) because they fell outside the common support interval. The resulting 403 805 adolescents comprised the unmatched cohort, as shown in Table 1. The 5832 adolescents with  $\geq 1$  visits related to self-harm (1.4%) were older, more likely to be female and less likely to reside in a rural community than those with 0 visits related to self-harm. Adolescents with visits related to self-harm had higher rates on every mental health or substance abuse variable. Group differences ( $D$ ) for the mental health and self-harm variables were in the range  $0.09 \leq D \leq 1.14$ , with the largest difference being for anxiety–neurotic disorders. Group differences for non-mental health clinical variables ranged from 0.0 to 0.19, with the greatest difference for concussion–traumatic brain injury ( $D = 0.20$  is commonly viewed as a small effect size<sup>25</sup>).

We found matches for 5661 (97.1%) of the adolescents with visits related to self-harm. The 1:2 matching strategy produced 10 731 controls. The resulting groups were balanced on all covariates except suicidal ideation ( $D = 0.17$ ).

### Propensity-matched comparisons of outcomes

Table 2 presents the study outcomes for youths with emergency department visits related to self-harm and those visits unrelated to self-harm in both the unmatched and the matched cohorts. Table 3 reports the time-to-event analyses for self-harm readmissions, overall mortality and suicides. For each outcome, adolescents with  $\geq 1$  visits related to self-harm were likely to have the outcome sooner than matched adolescents with no self-harm visits. Adolescents with visits related to self-harm were more likely to have a subsequent hospital admission or emergency department visit for self-harm within 5 years (RR 4.84, 95% confidence interval [CI] 4.44–5.27). The positive predictive values of a visit related to self-harm were  $\leq 1\%$  for mortality or suicide, whereas that for readmission with self-harm was 28.7%. Figure 1 presents Kaplan–Meier estimates of the time to first repeat emergency department visit or hospital admission for self-harm in the matched cohort. Finally, adolescents with a self-harm visit had \$11 333 greater mean of 5-year cost estimates (lower bound) than the matched controls.

### Self-harm, history of mental health conditions and outcomes

Table 1 shows that most adolescents with visits related to self-harm also have a history of use of mental health services, including 62% having used services owing to anxiety–neurotic disorders. This prompted the question of whether self-harm or

Table 1 (part 1 of 2): Demographic, mental health and clinical covariates of emergency department visits for self-harm\*

| Variable   | Unmatched cohort  |   |                      |      | Matched cohort   |   |                     |      |
|--|---|---|----------------------|------|--|---|---------------------|------|
|  | No. (%)† of adolescents with no self-harm visits<br>n = 397 973 | No. (%)† of adolescents with ≥ 1 self-harm visits<br>n = 5832 | Total<br>n = 403 805 | D    | No. (%)† of adolescents with no self-harm visits<br>n = 10 731 | No. (%)† of adolescents with ≥ 1 self-harm visits<br>n = 5661 | Total<br>n = 16 392 | D    |
| <b>Demographic covariates</b>                                  |   |   |                      |      |  |   |                     |      |
| Age, yr, mean ± SD   | 14.95 ± 1.46  | 15.47 ± 1.26  | 14.96 ± 1.46         | 0.38 | 15.47 ± 1.27   | 15.48 ± 1.26  | 15.48 ± 1.27        | 0.00 |
| Sex, female  | 188 947 (47.5)  | 4602 (78.9)   | 193 549 (47.9)       | 0.69 | 8345 (77.8)  | 4444 (78.5)   | 12 789 (78.0)       | 0.02 |
| Neighbourhood income quintile                                  |   |   |                      |      |  |   |                     |      |
| 1  | 71 924 (18.1)   | 1265 (21.7)   | 73 189 (18.1)        | 0.09 | 2385 (22.2)  | 1225 (21.6)   | 3610 (22.0)         | 0.01 |
| 2  | 73 747 (18.5)   | 1091 (18.7)   | 74 838 (18.5)        | 0.00 | 2028 (18.9)  | 1061 (18.7)   | 3089 (18.8)         | 0.00 |
| 3  | 80 365 (20.2)   | 1183 (20.3)   | 81 548 (20.2)        | 0.00 | 2169 (20.2)  | 1149 (20.3)   | 3318 (20.2)         | 0.00 |
| 4  | 87 268 (21.9)   | 1197 (20.5)   | 88 465 (21.9)        | 0.03 | 2175 (20.3)  | 1163 (20.5)   | 3338 (20.4)         | 0.01 |
| 5  | 84 669 (21.3)   | 1096 (18.8)   | 85 765 (21.2)        | 0.06 | 1974 (18.4)  | 1063 (18.8)   | 3037 (18.5)         | 0.01 |
| Rural  | 69 467 (17.5)   | 906 (15.5)  | 70 373 (17.4)        | 0.05 | 1556 (14.5)  | 887 (15.7)  | 2443 (14.9)         | 0.03 |
| <b>Mental health and substance abuse covariates</b>            |   |   |                      |      |  |   |                     |      |
| Alcohol abuse  | 2564 (0.6)  | 463 (7.9)   | 3027 (0.7)           | 0.37 | 661 (6.2)  | 413 (7.3)   | 1074 (6.6)          | 0.05 |
| Anxiety–neurotic disorders                                     | 55 540 (14.0)   | 3625 (62.2)   | 59 165 (14.7)        | 1.14 | 6434 (60.0)  | 3454 (61.0)   | 9888 (60.3)         | 0.02 |
| Behavioural and emotional disorders                            | 51 188 (12.9)   | 2073 (35.5)   | 53 261 (13.2)        | 0.55 | 3715 (34.6)  | 1941 (34.3)   | 5656 (34.5)         | 0.01 |
| Behavioural syndromes associated with physiologic disturbances | 884 (0.2)   | 52 (0.9)  | 936 (0.2)            | 0.09 | 80 (0.7)   | 49 (0.9)  | 129 (0.8)           | 0.01 |
| Bipolar disorder or manic episode                              | 2953 (0.7)  | 754 (12.9)  | 3707 (0.9)           | 0.50 | 1005 (9.4)   | 664 (11.7)  | 1669 (10.2)         | 0.08 |
| Disorders of personality and behaviour                         | 2170 (0.5)  | 523 (9.0)   | 2693 (0.7)           | 0.40 | 583 (5.4)  | 446 (7.9)   | 1029 (6.3)          | 0.10 |
| Disorders of psychological development                         | 8678 (2.2)  | 388 (6.7)   | 9066 (2.2)           | 0.22 | 593 (5.5)  | 355 (6.3)   | 948 (5.8)           | 0.03 |
| Eating disorders   | 410 (0.1)   | 216 (3.7)   | 626 (0.2)            | 0.27 | 198 (1.8)  | 166 (2.9)   | 364 (2.2)           | 0.07 |
| Intellectual disability  | 978 (0.2)   | 46 (0.8)  | 1024 (0.3)           | 0.08 | 63 (0.6)   | 37 (0.7)  | 100 (0.6)           | 0.01 |
| Mood disorders other than bipolar or mania                     | 12 101 (3.0)  | 2353 (40.3)   | 14 454 (3.6)         | 1.02 | 3968 (37.0)  | 2183 (38.6)   | 6151 (37.5)         | 0.03 |
| Organic mental disorders                                       | 639 (0.2)   | 48 (0.8)  | 687 (0.2)            | 0.09 | 79 (0.7)   | 42 (0.7)  | 121 (0.7)           | 0.00 |
| Other mental health disorders                                  | 149 (0.0)   | 57 (1.0)  | 206 (0.1)            | 0.13 | 51 (0.5)   | 48 (0.8)  | 99 (0.6)            | 0.05 |
| Reaction to severe stress, and adjustment disorders            | 8500 (2.1)  | 1537 (26.4)   | 10 037 (2.5)         | 0.74 | 2402 (22.4)  | 1383 (24.4)   | 3785 (23.1)         | 0.05 |
| Schizophrenia  | 1636 (0.4)  | 282 (4.8)   | 1918 (0.5)           | 0.28 | 415 (3.9)  | 239 (4.2)   | 654 (4.0)           | 0.02 |
| Substance abuse (non-alcohol)                                  | 3906 (1.0)  | 615 (10.5)  | 4521 (1.1)           | 0.42 | 860 (8.0)  | 550 (9.7)   | 1410 (8.6)          | 0.06 |
| Suicidal ideation  | 1807 (0.5)  | 1134 (19.4)   | 2941 (0.7)           | 0.67 | 1195 (11.1)  | 969 (17.1)  | 2164 (13.2)         | 0.17 |
| <b>Clinical covariates</b>                                     |   |   |                      |      |  |   |                     |      |
| Acne   | 45 793 (11.5)   | 805 (13.8)  | 46 598 (11.5)        | 0.07 | 1447 (13.5)  | 785 (13.9)  | 2232 (13.6)         | 0.01 |
| Asthma   | 50 800 (12.8)   | 837 (14.4)  | 51 637 (12.8)        | 0.05 | 1484 (13.8)  | 797 (14.1)  | 2281 (13.9)         | 0.01 |
| Cancers  | 2054 (0.5)  | 34 (0.6)  | 2088 (0.5)           | 0.01 | 48 (0.4)   | 33 (0.6)  | 81 (0.5)            | 0.02 |
| Concussion or traumatic brain injury                           | 60 069 (15.1)   | 1302 (22.3)   | 61 371 (15.2)        | 0.19 | 2243 (20.9)  | 1234 (21.8)   | 3477 (21.2)         | 0.02 |
| Congenital heart disease                                       | 2906 (0.7)  | 34 (0.6)  | 2940 (0.7)           | 0.02 | 70 (0.7)   | 34 (0.6)  | 104 (0.6)           | 0.01 |
| Cystic fibrosis  | 117 (0.0)   | ≤ 5   | 120 (0.0)            | 0.01 | ≤ 5  | ≤ 5   | 6 (0.0)             | 0.01 |
| Diabetes mellitus  | 4121 (1.0)  | 87 (1.5)  | 4208 (1.0)           | 0.04 | 134 (1.2)  | 84 (1.5)  | 218 (1.3)           | 0.02 |
| Down syndrome  | 1268 (0.3)  | 14 (0.2)  | 1282 (0.3)           | 0.01 | 29 (0.3)   | 14 (0.2)  | 43 (0.3)            | 0.00 |
| Eczema   | 80 290 (20.2)   | 1345 (23.1)   | 81 635 (20.2)        | 0.07 | 2318 (21.6)  | 1286 (22.7)   | 3604 (22.0)         | 0.03 |
| Epilepsy   | 4649 (1.2)  | 117 (2.0)   | 4766 (1.2)           | 0.07 | 189 (1.8)  | 107 (1.9)   | 296 (1.8)           | 0.01 |

**Table 1 (part 2 of 2): Demographic, mental health and clinical covariates of self-harm emergency department visits\***

| Variable                       | Unmatched cohort   |  |                             |          | Matched cohort  |  |                            |          |
|--------------------------------|--|--|-----------------------------|----------|---|--|----------------------------|----------|
|                                | No. (%)† of adolescents with no self-harm visits<br><i>n</i> = 397 973 | No. (%)† of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 5832 | Total<br><i>n</i> = 403 805 | <i>D</i> | No. (%)† of adolescents with no self-harm visits<br><i>n</i> = 10 731 | No. (%)† of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 5661 | Total<br><i>n</i> = 16 392 | <i>D</i> |
| Inflammatory polyarthropathies | 2156 (0.5)   | 36 (0.6)   | 2192 (0.5)                  | 0.01     | 62 (0.6)  | 33 (0.6)   | 95 (0.6)                   | 0.00     |
| Migraine                       | 15 306 (3.8)   | 419 (7.2)  | 15 725 (3.9)                | 0.15     | 732 (6.8)   | 400 (7.1)  | 1132 (6.9)                 | 0.01     |
| Neuromuscular conditions       | 1477 (0.4)   | 14 (0.2)   | 1491 (0.4)                  | 0.02     | 36 (0.3)  | 14 (0.2)   | 50 (0.3)                   | 0.02     |
| Obesity                        | 10 340 (2.6)   | 209 (3.6)  | 10 549 (2.6)                | 0.06     | 352 (3.3)   | 202 (3.6)  | 554 (3.4)                  | 0.02     |
| Psoriasis                      | 2361 (0.6)   | 36 (0.6)   | 2397 (0.6)                  | 0.00     | 62 (0.6)  | 35 (0.6)   | 97 (0.6)                   | 0.01     |
| Sickle cell anemia             | 607 (0.2)  | 6 (0.1)  | 613 (0.2)                   | 0.01     | 8 (0.1)   | 6 (0.1)  | 14 (0.1)                   | 0.01     |
| Spina bifida                   | 286 (0.1)  | ≤ 5  | 289 (0.1)                   | 0.01     | ≤ 5   | ≤ 5  | 8 (0.0)                    | 0.00     |
| <b>History of self-harm</b>    |  |  |                             |          |   |  |                            |          |
| Self-injury                    | 402 (0.1)  | 124 (2.1)  | 526 (0.1)                   | 0.19     | 164 (1.5)   | 109 (1.9)  | 273 (1.7)                  | 0.03     |
| Self-poisoning                 | 778 (0.2)  | 260 (4.5)  | 1038 (0.3)                  | 0.29     | 338 (3.1)   | 236 (4.2)  | 574 (3.5)                  | 0.05     |

Note: *D* = standardized group difference, SD = standard deviation.  
 \*In cells containing "≤ 5," the actual count and percentage were suppressed to prevent reidentification of patients.  
 †Unless stated otherwise.

**Table 2: Outcomes of emergency department visits\***

| Outcome  | Unmatched cohort   |  |                             |          | Matched cohort  |  |                            |          |
|--|--|--|-----------------------------|----------|---|--|----------------------------|----------|
|  | No. (%)† of adolescents with no self-harm visits<br><i>n</i> = 397 973 | No. (%)† of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 5832 | Total<br><i>n</i> = 403 805 | <i>D</i> | No. (%)† of adolescents with no self-harm visits<br><i>n</i> = 10 731 | No. (%)† of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 5661 | Total<br><i>n</i> = 16 392 | <i>D</i> |
| Readmissions to emergency department or hospital for self-harm | 7252 (1.8)   | 1718 (29.5)  | 8970 (2.2)                  | 1.88     | 637 (5.9)   | 1626 (28.7)  | 2263 (13.8)                | 0.66     |
| Suicides   | 199 (0.1)  | 43 (0.7)   | 242 (0.1)                   | 0.29     | 10 (0.1)  | 42 (0.7)   | 52 (0.3)                   | 0.12     |
| Deaths   | 937 (0.2)  | 61 (1.0)   | 998 (0.3)                   | 0.16     | 34 (0.3)  | 58 (1.0)   | 92 (0.6)                   | 0.09     |
| Lower-bound estimates of 5-year health care costs, mean ± SD   | 9271 ± 32 829  | 31 698 ± 64 011  | 9595 ± 33 593               | 0.44     | 19 055 ± 53 767   | 30 388 ± 61 312  | 22 969 ± 56 742            | 0.20     |

Note: *D* = standardized group difference, SD = standard deviation.  
 \*In cells containing "≤ 5," the actual count and percentage were suppressed to prevent reidentification of patients.  
 †Unless stated otherwise.

a history of mental health conditions are predictors for worse 5-year outcomes. Table 4 shows that 4655 (28.4%) of adolescents in our matched comparison groups had a mental health code associated with the index emergency department visit or any other medical service in the last year (history of a mental health condition). The confidence intervals for hazard ratios (HRs) for self-harm were > 4 for readmissions (HR 6.81, 95% CI 6.08–7.64), overall mortality (HR 4.26, 95% CI 2.57–7.05), and suicides (HR 11.48, 95% CI 4.79–27.5). Having a history of a mental health condition was associated with a shorter time to readmission for self-harm (HR 1.92, CI 1.65–2.24), but not for overall mortality (HR 1.38, 95% CI 0.69–2.79) or suicides (HR

1.69, 95% CI 0.48–5.98). We found that both self-harm ( $p < 0.001$ ) and history of a mental health condition ( $p < 0.001$ ) were associated with increased lower-bound costs. However, among those adolescents with visits related to self-harm, mental health history was not associated with increased lower-bound costs.

#### Factors associated with readmission after emergency department visits related to self-harm

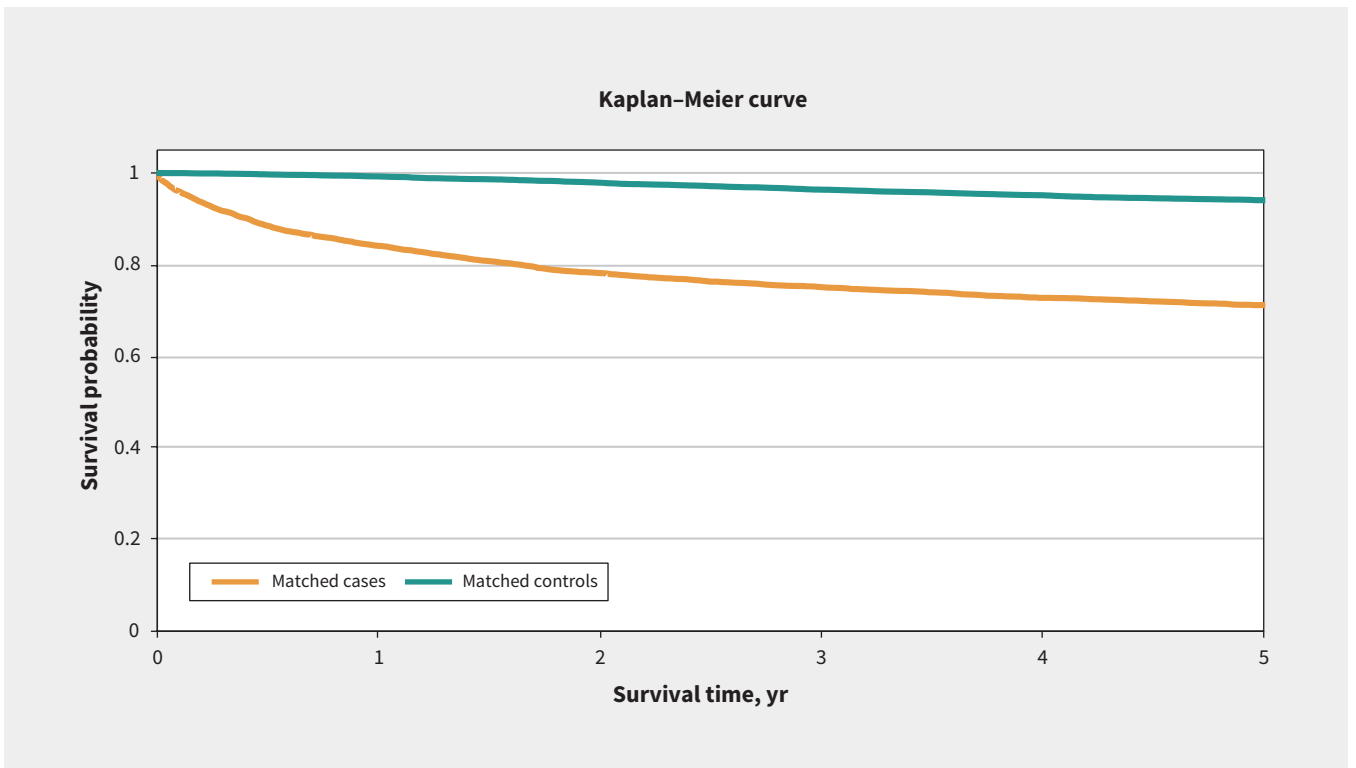
Finally, we carried out an exploratory analysis to identify factors associated with readmissions to the hospital or emergency department within the cohort of 5661 adolescents with an

**Table 3: Association of self-harm with 5-year outcomes; propensity-matched comparisons\***

| Outcome  | No. (%) of adolescents with no self-harm visits<br><i>n</i> = 10 731 | No. (%) of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 5661 | Time-to-event analyses |                       | RR (95% CI)       | Positive predictive value |
|--|--|---|------------------------|-----------------------|-------------------|---------------------------|
|  |  |   | HR (95% CI)            |                       |                   |                           |
| Readmissions to emergency department or hospital for self-harm | 637 (5.9)  | 1626 (28.7)   | 5.52 (5.05–6.04)       |                       | 4.84 (4.44–5.27)  | 28.7                      |
| Overall mortality  | 34 (0.3)   | 58 (1.0)  | 3.25 (2.12–4.96)       |                       | 3.23 (2.12–4.93)  | 1.0                       |
| Suicides   | 10 (0.1)   | 42 (0.7)  | 8.00 (3.99–16.04)      |                       | 7.96 (4.00–15.86) | 0.7                       |
|  | <b>Mean ± SD</b>   | <b>Mean ± SD</b>  | <b><i>t</i></b>        | <b><i>p</i> value</b> | <b><i>D</i></b>   |                           |
| Lower-bound estimates of 5-year health care costs, \$          | 19 055 ± 53 767  | 30 388 ± 61 312   | 31.96                  | < 0.001               | 0.20              | N/A                       |

Note: CI = confidence interval, *D* = group difference, HR = hazard ratio, N/A = not applicable, RR = relative risk.

\*Hazard ratio is from the Cox proportional regression (meaning, the hazard rate for adolescents with ≥ 1 self-harm visits divided by the rate for the matched controls) for that outcome. The positive predictive value is the proportion of youths with ≥ 1 self-harm visits who have the outcome. Relative risk is the probability of the occurrence of the outcome within 5 years for adolescents with ≥ 1 self-harm visits divided by the probability of the outcome for the matched controls. *t* statistic is the comparison of the average log-transformed lower-bound costs, with statistical significance *p*.



**Figure 1:** Time to next emergency department visit or hospital admission for self-harm among propensity-matched pairs.

emergency department visit for self-harm. Table 5 shows that adolescents with emergency department visits related to self-harm who were readmitted were more likely to be younger ( $p < 0.001$ ), female ( $p < 0.001$ ) and to reside in a rural community ( $p = 0.002$ ). They were more likely to have had a concussion or traumatic brain injury ( $p = 0.002$ ) or epilepsy ( $p < 0.001$ ), and less likely to have diabetes ( $p < 0.001$ ). Readmitted adolescents were also more likely to have had a history of abusing alcohol ( $p < 0.001$ ) or other substances, to have a history of nearly every men-

tal health concern and to have had a history of self-harm before the index emergency department visit ( $p < 0.001$ ).

### Interpretation

Over a 5-year follow-up of a cohort of adolescents who presented to emergency departments in Ontario, those whose visits were related to self-harm were more than 3 times more likely to die from any cause and almost 8 times more likely to die by

**Table 4: Five-year outcomes by self-harm and history of mental health conditions\***

| Outcome   | No. of adolescents with no history of mental health conditions<br><i>n</i> = 11 737 |  | No. of adolescents with history of mental health conditions<br><i>n</i> = 4655 |  | Time-to-event analyses |   |   |
|---|---|--|--|--|------------------------|---|---|
|   | No. (%)† of adolescents with no self-harm visits<br><i>n</i> = 7693                 | No. (%)† of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 4044 | No. (%)† of adolescents with no self-harm visits<br><i>n</i> = 3038            | No. (%)† of adolescents with ≥ 1 self-harm visits<br><i>n</i> = 1617 | Self-harm HR (95% CI)  | History of mental health conditions HR (95% CI) | Self-harm × mental health history HR (95% CI) |
|   | Mean ± SD   | Mean ± SD  | Mean ± SD  | Mean ± SD  | <i>p</i> value         | <i>p</i> value                                  | <i>p</i> value                                |
| Readmissions to ED or hospital for self-harm          | 365 (4.7)   | 1144 (28.3)  | 272 (9.0)  | 482 (29.8)   | 6.85 (6.11–7.69)       | 1.92 (1.64–2.24)                                | 7.17 (6.25–8.34)                              |
| Overall mortality                                     | 22 (0.3)  | 49 (1.2)   | 12 (0.4)   | 9 (0.6)  | 4.26 (2.57–7.05)       | 1.38 (0.69–2.79)                                | 1.94 (0.88–4.25)                              |
| Suicides  | 6 (0.1)   | 36 (0.9)   | ≤ 5  | 6 (0.4)  | 11.48 (4.79–27.5)      | 1.69 (0.48–5.98)                                | 4.76 (1.51–15.00)                             |
| Lower-bound estimates of 5-year health care costs, \$ | 16 079 ± 44 011   | 30 600 ± 58 891  | 26 591 ± 72 310  | 29 859 ± 67 002  | < 0.001                | < 0.001   | < 0.001                                       |

Note: CI = confidence interval, ED = emergency department, HR = hazard ratio.  
 \*Time-to-event analyses were Cox regressions of the time to the outcome regressed on whether the adolescent had a self-harm emergency department visit (self-harm column), whether the adolescent had a mental health code associated with the index emergency department visit or any other medical service in the last year (history of mental health conditions column), and the interaction between those markers (self-harm × mental health history column). In the cell with “≤ 5,” the actual count and percentage were suppressed to prevent reidentification of patients. The bottom row of the table reports a 2 × 2 analysis of variance for the logs of the lower-bound 5-year cumulative costs.

suicide than propensity-matched controls who did not present with self-harm. Adolescents who presented with self-harm were almost 5 times more likely to have repeat emergency department visits or hospital admissions related to self-harm, with about 1 in 3 having a repeat admission. Moreover, adolescents with self-harm had a difference in health care costs that was more than \$11 000 higher (lower-bound estimate) than that of controls. Our findings are consistent with previous research<sup>3–7,26</sup> and show that over and above an elevated suicide risk, having an emergency department visit related to self-harm is a predictor for recurrent visits to the emergency department and greater use of health services.

Although having an emergency department visit related to self-harm was associated with a high relative risk of mortality or suicide, the positive predictive values of self-harm for these outcomes were ≤ 1%. The high relative risk of suicide tells us that it is several times more common among adolescents with visits related to self-harm than for control patients. The positive predictive value of a self-harm-related visit is low because suicides are also uncommon among these adolescents. Therefore, predicting these outcomes remains challenging.<sup>27–29</sup> The increasing prevalence among adolescents of visits related to self-harm in the emergency department setting combined with the low positive predictive value of self-harm for suicide means that deploying intensive suicide prevention efforts for all visits related to self-harm would be resource intensive<sup>30</sup> yet prevent few suicides.

However, almost 1 in 3 adolescents with visits related to self-harm were later readmitted to a hospital or emergency department, and their clinical trajectory was more expensive than that of their matched control patients. Moreover, among

adolescents who presented after self-harm, and who later had recurrent admissions for self-harm, serious and complex mental conditions were common, most prominently anxiety and mood disorders, as well as substance abuse issues, and concussion or traumatic brain injury.

These findings suggest 2 directions for future research. First, the positive predictive value of a visit after self-harm for future readmissions after self-harm, in addition to the findings that mental health and other conditions also predict readmissions, suggest that it may be possible to develop an algorithm that could accurately predict the risk of readmission. Second, our results suggest that adolescents who present at the emergency department after self-harm would benefit from assessment for mental health or substance misuse disorders. If adolescents presenting with self-harm have mental health or substance misuse issues, they should be connected to evidence-based community services for treatment. However, further research is needed on better methods to deliver mental health assessments in the emergency department setting<sup>31</sup> as well as developing care pathways connecting the emergency department with appropriate community mental health services.<sup>32</sup>

### Limitations

The matched groups were not balanced on suicidal ideation and our findings should not be interpreted as speaking to the effects of self-harm on suicidality. As in any observational study, the groups may also have differed on unmeasured variables, leading to confounding of the results. This study used administrative data and is subject to weaknesses of such data, including the lack of validation of many specific mental health or other clinical codes.<sup>18,33–38</sup> In Appendix 1, we argue it is likely that ICD-10 codes

**Table 5: Variables associated with a self-harm readmission to emergency department or hospital for a youth with a self-harm index visit to the emergency department\***

| Variable   | No. (%)† of adolescents with no self-harm readmissions<br>n = 4035 | No. (%)† of adolescents ≥ 1 self-harm readmissions<br>n = 1626 | Total<br>n = 5661 | D    | p value |
|--|--|--|-------------------|------|---------|
| <b>Demographic covariates</b>                                  |  |  |                   |      |         |
| Age, yr, mean ± SD   | 15.56 ± 1.23   | 15.29 ± 1.31   | 15.48 ± 1.26      | 0.21 | < 0.001 |
| Sex, female  | 3107 (77.0)  | 1337 (82.2)  | 4444 (78.5)       | 0.13 | < 0.001 |
| Neighbourhood income quintile                                  |  |  |                   |      |         |
| 1  | 888 (22.0)   | 337 (20.7)   | 1225 (21.6)       | 0.03 | 0.107   |
| 2  | 751 (18.6)   | 310 (19.1)   | 1061 (18.7)       | 0.01 |         |
| 3  | 808 (20.0)   | 341 (21.0)   | 1149 (20.3)       | 0.02 |         |
| 4  | 856 (21.2)   | 307 (18.9)   | 1163 (20.5)       | 0.06 |         |
| 5  | 732 (18.1)   | 331 (20.4)   | 1063 (18.8)       | 0.06 |         |
| Rural  | 593 (14.7)   | 294 (18.1)   | 887 (15.7)        | 0.09 | 0.002   |
| <b>Mental health and substance abuse covariates</b>            |  |  |                   |      |         |
| Alcohol abuse  | 259 (6.4)  | 154 (9.5)  | 413 (7.3)         | 0.11 | < 0.001 |
| Anxiety–neurotic disorders                                     | 2295 (56.9)  | 1159 (71.3)  | 3454 (61.0)       | 0.30 | < 0.001 |
| Behavioural and emotional disorders                            | 1226 (30.4)  | 715 (44.0)   | 1941 (34.3)       | 0.28 | < 0.001 |
| Behavioural syndromes associated with physiologic disturbances | 30 (0.7)   | 19 (1.2)   | 49 (0.9)          | 0.04 | 0.118   |
| Bipolar disorder or manic episode                              | 404 (10.0)   | 260 (16.0)   | 664 (11.7)        | 0.18 | < 0.001 |
| Disorders of personality and behaviour                         | 219 (5.4)  | 227 (14.0)   | 446 (7.9)         | 0.29 | < 0.001 |
| Disorders of psychological development                         | 201 (5.0)  | 154 (9.5)  | 355 (6.3)         | 0.17 | < 0.001 |
| Eating disorders   | 91 (2.3)   | 75 (4.6)   | 166 (2.9)         | 0.13 | < 0.001 |
| Intellectual disability  | 18 (0.4)   | 19 (1.2)   | 37 (0.7)          | 0.08 | 0.002   |
| Mood disorders other than bipolar or mania                     | 1396 (34.6)  | 787 (48.4)   | 2183 (38.6)       | 0.28 | < 0.001 |
| Organic mental disorders                                       | 33 (0.8)   | 9 (0.6)  | 42 (0.7)          | 0.03 | 0.294   |
| Other mental health disorders                                  | 27 (0.7)   | 21 (1.3)   | 48 (0.8)          | 0.06 | 0.021   |
| Reaction to severe stress, and adjustment disorders            | 826 (20.5)   | 557 (34.3)   | 1383 (24.4)       | 0.31 | < 0.001 |
| Schizophrenia  | 138 (3.4)  | 101 (6.2)  | 239 (4.2)         | 0.13 | < 0.001 |
| Substance abuse (nonalcohol)                                   | 351 (8.7)  | 199 (12.2)   | 550 (9.7)         | 0.12 | < 0.001 |
| Suicidal ideation  | 520 (12.9)   | 449 (27.6)   | 969 (17.1)        | 0.37 | < 0.001 |
| <b>Clinical covariates</b>                                     |  |  |                   |      |         |
| Acne   | 567 (14.1)   | 218 (13.4)   | 785 (13.9)        | 0.02 | 0.525   |
| Asthma   | 555 (13.8)   | 242 (14.9)   | 797 (14.1)        | 0.03 | 0.269   |
| Cancers  | 24 (0.6)   | 9 (0.6)  | 33 (0.6)          | 0.01 | 0.854   |
| Concussion or traumatic brain injury                           | 836 (20.7)   | 398 (24.5)   | 1234 (21.8)       | 0.09 | 0.002   |
| Congenital heart disease                                       | 24 (0.6)   | 10 (0.6)   | 34 (0.6)          | 0.00 | 0.929   |
| Cystic fibrosis  | ≤ 5  | ≤ 5  | ≤ 5               | 0.04 | 0.146   |
| Diabetes mellitus  | 46 (1.1)   | 38 (2.3)   | 84 (1.5)          | 0.09 | < 0.001 |
| Down syndrome  | 9 (0.2)  | ≤ 5  | 14 (0.2)          | 0.02 | 0.563   |
| Eczema   | 906 (22.5)   | 380 (23.4)   | 1286 (22.7)       | 0.02 | 0.456   |
| Epilepsy   | 56 (1.4)   | 51 (3.1)   | 107 (1.9)         | 0.12 | < 0.001 |
| Inflamed bowel   | 24 (0.6)   | 11 (0.7)   | 35 (0.6)          | 0.01 | 0.723   |
| Inflammatory polyarthropathies                                 | 24 (0.6)   | 9 (0.6)  | 33 (0.6)          | 0.01 | 0.854   |
| Migraine   | 274 (6.8)  | 126 (7.7)  | 400 (7.1)         | 0.04 | 0.203   |
| Neuromuscular conditions                                       | 8 (0.2)  | 6 (0.4)  | 14 (0.2)          | 0.03 | 0.242   |
| Obesity  | 134 (3.3)  | 68 (4.2)   | 202 (3.6)         | 0.05 | 0.114   |
| Psoriasis  | 21 (0.5)   | 14 (0.9)   | 35 (0.6)          | 0.04 | 0.139   |
| Sickle cell anemia   | ≤ 5  | ≤ 5  | 6 (0.1)           | 0.02 | 0.514   |
| Spina bifida   | ≤ 5  | ≤ 5  | ≤ 5               | 0.01 | 0.86    |
| <b>History of self-harm</b>                                    |  |  |                   |      |         |
| Self-injury  | 47 (1.2)   | 62 (3.8)   | 109 (1.9)         | 0.17 | < 0.001 |
| Self-poisoning   | 134 (3.3)  | 102 (6.3)  | 236 (4.2)         | 0.14 | < 0.001 |

Note: D = standardized group difference, ED = emergency department, SD = standard deviation.

\*The p value is the statistical significance of the covariate in a logistic regression predicting the occurrence of a self-harm readmission during the 5 years after the index visit.

†Unless stated otherwise.



for self-harm and mental health have high specificity but lower sensitivity, meaning that both are underestimated in these data. Cases of self-harm that are missed and appear in the control group would mean that the estimated differences in outcomes underestimate the true differences.

As noted, our estimates of the medical costs for adolescents were lower bounds on these costs. However, adolescents who self-harmed likely also incurred social costs, including poorer academic performance, involvement with juvenile justice and reduced adult earnings.<sup>13</sup> Thus, the real costs of caring for adolescents who present to the emergency department with self-harm are likely substantially larger than reported here. Moreover, emergency department health administrative records may miss many adolescents with mental health conditions. Some emergency departments are unable to carry out mental health assessments. In addition, National Ambulatory Care Reporting System records require only that the main problem leading to the visit be recorded, so diagnoses relating to mental health are sometimes missed when the patient has an emergent medical issue.<sup>39</sup> Therefore, our results may understate the associations between mental health conditions and 5-year adverse outcomes. Finally, adolescents in Ontario may differ from those in other jurisdictions and the exposures affecting adolescents today may have changed since 2011–2013.

## Conclusion

An adolescent emergency department visit related to intentional self-harm increases risk of repeated self-harm and suicide, as well as increased health costs over the next 5 years. In light of the increasing rates of self-harm emergency department visits for adolescents, further research is needed on the social determinants of self-harm and could focus on developing algorithms and interventions that can identify and help the adolescents at highest risk of recurrent self-harm.

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**Affiliations:** School of Epidemiology & Public Health (Gardner, Currie, Colman), University of Ottawa; Children's Hospital of Eastern Ontario Research Institute (Gardner, Cloutier, Zemek, Cappelli); Departments of Psychiatry (Pajer) and Pediatrics (Zemek), University of Ottawa; The Ottawa Hospital Research Institute (Hatcher, Lima); ICES uOttawa (Lima), Ottawa, Ont.

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**Correspondence to:** William Gardner, [wgardner@cheo.on.ca](mailto:wgardner@cheo.on.ca)