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Identification of Hospitalizations for Intentional Self-Harm when E-Codes are Incompletely Recorded

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Abstract

Context—Suicidal behavior has gained attention as an adverse outcome of prescription drug use. Hospitalizations for intentional self-harm, including suicide, can be identified in administrative claims databases using external cause of injury codes (E-codes). However, rates of E-code completeness in US government and commercial claims databases are low due to issues with hospital billing software.

Objective—To develop an algorithm to identify intentional self-harm hospitalizations using recorded injury and psychiatric diagnosis codes in the absence of E-code reporting.

Methods—We sampled hospitalizations with an injury diagnosis (ICD-9 800–995) from 2 databases with high rates of E-coding completeness: 1999–2001 British Columbia, Canada data and the 2004 U.S. Nationwide Inpatient Sample. Our gold standard for intentional self-harm was a diagnosis of E950-E958. We constructed algorithms to identify these hospitalizations using information on type of injury and presence of specific psychiatric diagnoses.

Results—The algorithm that identified intentional self-harm hospitalizations with high sensitivity and specificity was a diagnosis of poisoning; toxic effects; open wound to elbow, wrist, or forearm; or asphyxiation; plus a diagnosis of depression, mania, personality disorder, psychotic disorder, or adjustment reaction. This had a sensitivity of 63%, specificity of 99% and positive predictive value (PPV) of 86% in the Canadian database. Values in the US data were 74%, 98%, and 73%. PPV was highest (80%) in patients under 25 and lowest those over 65 (44%).

Conclusions—The proposed algorithm may be useful for researchers attempting to study intentional self-harm in claims databases with incomplete E-code reporting, especially among younger populations.

Introduction

Suicidal behavior has gained increasing attention as a potential adverse outcome of prescription drug use. In October 2004, the U.S. Food and Drug Administration (FDA) issued an advisory regarding a possible increased risk of suicidal thoughts and attempts among children and adolescents taking antidepressants.[1] This warning was prompted by a meta-analysis of data from randomized controlled trials of antidepressants in this age group, in which patients randomized to antidepressants had nearly twice the rate of suicidal ideation

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or behavior relative to those given placebo.[2] More recently, FDA has issued warnings regarding increased suicidality among patients receiving anticonvulsant agents[3] and the smoking cessation drug Chantix (varenicline),[4] and is currently investigating a possible association between Singulair (montelukast sodium) use and suicidality.[5] FDA is now requiring some drug manufacturers to provide data on suicidality before and after approval.[6]

While spontaneous adverse event reports and analyses of RCT data are useful in identifying signals of increased suicidality rates, these data are limited. Information regarding suicidal ideation and behavior was not collected systematically in older trials, and while these safety outcomes can be incorporated into new trials, an increase in risk may be missed due to the relatively low incidence of suicidality and the frequent exclusion of high-risk patients from trials of psychiatric medications. Observational studies in administrative claims data have the potential to provide valuable information on the association between drug use and suicide risk among large patient populations, provided that deliberate self-harm events, the majority of which are suicide attempts,[7] can be identified.

Suicides can be identified using data from the National Death Index,[8] and in instances where the subject dies without reaching an emergency room, must be identified in this manner. However, the majority of suicide attempts are non-fatal and must be identified through alternative means.[9] Intentional self-harm emergency room visits and hospitalizations can be identified in administrative claims databases using external cause of injury codes (E-codes).[10, 11] These codes are part of the International Statistical Classification of Diseases and Related Health Problems (ICD) coding scheme and are used to provide supplemental information about the cause and intent of an injury. E-coding is mandatory in approximately half of the US states, and the completeness of E-coding in state hospital discharge databases typically exceeds 90%[12]. Even higher completeness was reported for Canadian administrative databases. However, insurance claims databases such as Medicare have low rates of E-code completeness, presumably because the billing software used by many hospitals removes E-codes since they have no relevance for hospital payments [13] A recent study reported that only 28% of injury hospitalizations in the 1999 Medicare Provider Analysis and Review (MedPAR) data had an E-code reported,[13] and our own analyses have found similarly low E-coding rates in more recent data from Medicare, Medicaid, and commercial insurers.

The objective of this study was to create an algorithm to identify intentional self-harm hospitalizations in the absence of complete E-codes and evaluate the validity of the results that would be obtained using this algorithm in several hypothetical scenarios.

Methods

Data sources

Data were derived from two large population-based hospital discharge abstract databases. We chose to use two different databases in the interest of gaining some insight regarding the generalizeability of our findings. These data were drawn from two countries with different suicide rates, different practice patterns, and different hospital payment schemes, which may translate into differences in coding practice. In addition, there is variation in the number of diagnosis and procedure codes recorded and the availability of patient-level linkable data on prior inpatient hospitalizations, physician visits, and prescription drug use.

Data from British Columbia (BC), Canada were obtained from the BC Ministry of Health. The database includes records of hospitalizations for all patients in BC's publicly funded healthcare system. Data elements include patient age and sex, up to 25 diagnosis codes including E-codes, up to 5 procedure codes, length of stay, and discharge disposition. An evaluation of this database found good specificity and completeness of diagnosis codes.[14] We used data from 1999 through 2001, a period immediately prior to the transition from ICD-9-CM to ICD-10-CA diagnosis codes in BC.

Data from the United States came from the Nationwide Inpatient Sample (NIS), a publicly available dataset designed to approximate a 20% representative sample of all community hospitals in the United States.[15] The NIS is produced by the Agency for Healthcare Research and Quality (AHRQ) from hospital inpatient discharge records submitted by state health data organizations. The 2003 NIS included data from 37 states. Data elements include hospital location (state), patient age, sex, and race, up to 15 diagnosis codes, up to 15 procedure codes, up to 4 E-codes, length of stay, primary payer, and discharge disposition. Data are subjected to internal consistency checks and formatted uniformly by AHRQ. An analysis of 2001 data by AHRQ found that E-codes were 86% complete for hospitalizations with an injury as a primary diagnosis.[16] Because E-code collection and reporting requirements vary by state, we restricted our analysis to states with E-coding rates above 85% (see Appendix A). We quantified E-coding rates (the proportion of hospital discharges with an injury as a diagnosis that had a valid E-code) according to the method recommended by the State and Territorial Injury Prevention Directors Association, modified to include discharges that had an injury as a secondary rather than primary diagnosis. [17]

Study sample

We identified hospitalizations with a primary or secondary diagnosis of injury or poisoning (800.x – 995.x), excluding cases where the only injury was an adverse effect of surgical or medical care (909.3, 909.5, 995.0 – 995.4, 995.88, 995.89, 995.9x), an adverse food reaction (995.6 – 995.7), or a late effect of a previous injury (905.x – 909.x). We restricted our sample to hospitalizations where an E-code other than E849.x, which denotes place of injury occurrence, was present. We restricted our population to subjects age 10 and over because the rate of intentional self-harm among subjects younger than 10 is less than 2 per 100,000.[9] We included young children in a secondary analysis. Individual patients were allowed to contribute multiple hospitalizations. Cases with an injury as a secondary diagnosis were included in the interest of capturing injury hospitalizations where a condition precipitating or discovered as a result of the injury or a post-injury complication was coded as the primary diagnosis.[18]

Our gold standard for intentional self-harm was the presence of a diagnosis of E950 E958. We excluded E959 (late effects) from this definition as our intent was to identify acute outcomes rather than history of self-harm.

To construct algorithms to identify intentional self-harm cases, we collected information on types of injuries and psychiatric diagnoses recorded and psychiatric evaluations and procedures performed during the hospitalization. We created indicators for the presence of a diagnosis of each of the following psychiatric conditions (see appendix B for ICD-9 diagnosis codes): depression, anxiety disorder, sleep disorder, attention-deficit/hyperactivity disorder, substance abuse, psychotic disorder, dementia, delirium, personality disorders, unspecified non-psychotic mental disorders, adjustment reaction with disturbance other than depressed mood, and other psychiatric disorder. In addition, we created indicators for the presence of a diagnosis of each of the following types of injuries: open wound to elbow, forearm, or wrist; other open wound to upper limb; other open wounds and injuries to blood vessels; intracranial injury, internal injury, or injury to nerves and spinal cord; poisoning by psychotropic agents; poisoning by other drugs; toxic effects; asphyxiation; and other injury. We also collected information on patient age, sex, and race, as these factors may modify the risk of intentional self-harm and the performance of algorithms to identify it. In the BC dataset, we collected information on inpatient or outpatient depression diagnoses in the 180 days prior to the injury hospitalization and antidepressant use during this period, as patient history of depression is likely to affect intentional self-harm risk and may affect the performance of algorithms to identify it. Antidepressant prescriptions were identified in the PharmaNet database that includes drug name, dose, and quantity for all prescription drugs dispensed in British Columbia pharmacies. This information is entered by pharmacists via a province-wide network that assures minimal underreporting and misclassification and is recorded for all dispensings independent of the payor (provincial government, self-pay, commercially insured). PharmaNet data and data on physician services, maintained by the BC Ministry of Health, are linkable by unique patient identifiers to data on hospitalizations. Data on prescription drug use and history of depression diagnoses was not available in the NIS.

Statistical analysis

Each dataset was divided into a 50% development sample and a 50% validation sample. Using the development sample, we explored a series of simple algorithms based on the presence of a psychiatric diagnosis recorded during the hospitalization or on the type of injury reported to identify intentional-self harm hospitalizations. For example, a simple algorithm could assume that the presence of a depression diagnosis indicates that an injury hospitalization was the result of intentional-self harm. Based on these results, we identified more complex definitions (e.g. the presence of a depression or mania or psychotic disorder diagnosis) that might have desirable test characteristics. We created definitions based on the presence of one of a number of individual psychiatric conditions, selecting the individual conditions for inclusion based on their positive predictive values for intentional self-harm, using stricter and more lenient cut-points. The same process was used to create definitions based on the presence of one of a number of specific types of injuries. From these definitions, we created several stricter and more lenient definitions requiring both the presence of specific psychiatric conditions and specific injuries. Our final algorithms were assessed in the validation sample.

We assessed the performance characteristics of each algorithm. Sensitivity was defined as the probability that “true” intentional self-harm hospitalizations (“true” according to the recorded E-code) tested positive according to the algorithm, and were thus identified by it. Specificity was defined as the probability that hospitalization <u>not</u> due to self-harm (i.e., according to the recorded E-code) tested negative (i.e., were correctly ruled out using the algorithm). Positive predictive value (PPV) was calculated as the probability that hospitalizations identified by the algorithm were in fact due to self-harm based on E-codes.

We chose a preferred definition based on very high specificity and relatively high sensitivity. Very high specificity is essential to obtain unbiased ratio estimates for epidemiologic studies[19]. Relatively high sensitivity is desirable – as long as specificity remains high – because the larger the proportion of true cases that can be identified, the greater the power a study will have to identify relationships, especially when studying rare outcomes.[20]

To test the magnitude of the bias that might result from using the preferred algorithm to identify intentional self-harm hospitalizations, we created a sample dataset for a hypothetical study of antidepressant safety. We calculated intentional self-harm hospitalization rate ratios for antidepressant users versus non-users under several realistic scenarios using 1) the “true” event rates and 2) those that would be observed using our algorithm.

We evaluated three different scenarios. The first was based on the BC data; we assumed that intentional self-harm hospitalization rates in the absence of antidepressant treatment are equal to those observed in the general BC population[21] and, in the presence of antidepressant treatment, are elevated at a ratio equal to the increased risk of self-harm events noted in randomized controlled trials (RCT) (a 1.90-fold increase for adolescents and a 1.57-fold increase for adults).[2, 22] Based on the sensitivity and specificity of the algorithm in the BC sample, we calculated the rate of intentional self-harm hospitalizations that would be identified in each treatment arm. The equation is true positives [true intentional self-harm hospitalizations *sensitivity] + false positives [non intentional self-harm hospitalizations * (1− specificity)]. An observed rate ratio was computed and bias was calculated as the rate ratio minus the expected rate ratio from the RCT data.

Because intentional self-harm rates are likely to be higher in a depressed population, we conducted a second analysis using intentional self-harm hospitalization rates observed in the BC sample during the first year of antidepressant treatment as the rate among antidepressant users.[10, 11] The rate among depressed non-users was calculated by dividing this rate by the RCT rate ratio. Finally, we calculated observed rates using intentional self-harm and other injury hospitalization rates observed in the general US population[9] and the sensitivity and specificity values calculated from the NIS.

The study is covered by data use agreements with AHRQ (NIS) and the British Columbia Ministry of Health and was approved by the Brigham and Women's Institutional Review Board.

Results

For the period 1999 through 2001, we identified 177,618 hospital discharges of patients ages 10 and over in the BC dataset that had a valid E-code and a primary or secondary ICD-9-CM diagnosis code for an injury other than an adverse effect of medical care, late effect, or adverse food reaction. In the 2003 NIS, we identified 527,798 injury hospitalizations meeting these criteria. After deleting 4,110 with missing age or sex, 254,910 from states with E-code reporting rates less than 85%, and 13,431 hospitalizations without E-codes from remaining states, we were left with a sample size of 245,164.

Characteristics of the hospital discharges randomly allocated to the development sample -- 88,808 of 177,618 BC hospitalizations and 122,574 of 254,910 NIS hospitalizations -- are presented in Table 1. The mean patient age was 55 in BC and 57 in the NIS, with the population roughly split between males and females. Race was not reported in the BC data; in the NIS sample 75.9% of patients were white.. In-hospital death resulted from 1.1% of BC admissions and 2.7% of NIS admissions. Fractures were the most common injury type, accounting for 34.0% of BC admissions and 51.4% of NIS admissions. Substance abuse was the most commonly recorded psychiatric diagnosis (8.0% in BC, 13.7% in NIS), followed by depression (4.1% in BC, 12.2% in NIS) and dementia (3.6% in BC, 8.5% in NIS). A greater proportion of injury hospitalizations in younger subjects were due to intentional self-harm (in BC, 13.8% in age 10 – 25, 10.2% in age 25 – 64; in the NIS, 15.8% in age <25, 12.2% in age 25 – 64) than were in the elderly (0.8% in BC, 0.7% in the NIS).

The performance characteristics of possible algorithms to identify intentional self-harm hospitalizations are presented in Table 2. In the BC data, the presence of a substance abuse diagnosis had the greatest sensitivity (30.7%), indicating that 30.7% of intentional self-harm hospitalizations had a substance abuse diagnosis recorded. Other diagnoses that were commonly assigned to intentional self-harm hospitalizations were depression (sensitivity = 30.4%), mania (19.5%), personality disorder (18.5%), unspecified psych (6.2%), adjustment reaction (6.6%), other psych disorder (6.2), and psychotic disorder (5.9%). The specificity – i.e. the probability that hospitalizations for injuries other than intentional self-harm didn't have the diagnosis coded – was above 96% for all psychiatric diagnoses excluding substance abuse (specificity = 94%). The positive predictive value – i.e. the probability that a hospitalization assigned a psychiatric diagnosis of interest is an intentional self-harm hospitalization – was highest for unspecified non-psychotic mental disorders (78.1%), personality disorder (67.0%), adjustment reaction (66.6%), mania (57.7%) and depression (50.5%). Similar patterns were observed in the NIS data, although depression was recorded with a greater frequency among NIS intentional self-harm cases (sensitivity = 61.1%) and in the overall population (12.2% in the NIS versus 4.2% in BC). Algorithms based on a combination of psychiatric diagnoses had sensitivities ranging from 62.9% to 69.3% in the BC data and 77.6% to 82.1% in the NIS; PPVs ranged from 43.9% to 55.1% in the BC data and 35.5% to 39.4% in the NIS.

Certain types of injuries were frequently recorded among intentional self-harm hospitalizations. In the BC data, 38.3% of intentional self-harm hospitalizations had a diagnosis of poisoning by a psychotropic agent, 53.4% had a diagnosis of poisoning by another drug, 9.2% had a diagnosis of toxic effects of non-medicinal substances, and 7.6% had a diagnosis of an open wound to the wrist, forearm, or elbow. While asphyxiation was an uncommon diagnosis (sensitivity was 1.2%), the PPV for this diagnosis was high – 84.5% -- indicating that the majority of asphyxiation cases resulted from intentional self-harm. Similar patterns were observed in the NIS, although PPVs were lower. An algorithm defining intentional self-harm as a hospitalization for poisoning, toxicity of substances chiefly non-medical in nature, or asphyxiation had a sensitivity of 84.3% in the BC development sample (82.3% in the NIS) and a PPV of 64.9% in the BC development sample (50.8% in the NIS). Including open wound to wrist, elbow or forearm increased the sensitivity to 90.3% (89.4% NIS) but reduced the PPV to 62.0% (47.4% NIS). Algorithms based on type of injury and the presence of psychiatric diagnoses provided an improvement in PPV at the loss of some sensitivity. Defining intentional self-harm hospitalizations as those with a diagnosis of depression, personality disorder, mania, adjustment reaction, or unspecified non-psychotic mental disorder plus a diagnosis of poisoning, toxicity of a substance chiefly non-medical in nature, asphyxiation, or open wound to the elbow, wrist, or forearm yielded a sensitivity of 59.8%, a specificity of 99.4%, and PPV of 88.3% in the BC data; values in the NIS were 71.1%, 98.0%, and 74.1%. Adding ADHD, psychotic disorder, and other mental disorders to the list of allowed psychiatric diagnoses increased the sensitivity to 65% but reduced the PPV to 85.8% in the BC data. In the NIS, the values were 74.2 and 72.3%. In the interest of maintaining a high specificity at the expense of some sensitivity, we elected to omit the ADHD, psychotic disorder, and other mental disorder diagnoses from our final algorithm.

Thus, our final algorithm classifies a hospitalization due to injury as resulting from intentional self-harm if a diagnosis of depression, personality disorder, mania, adjustment reaction, or unspecified non-psychotic mental disorder is recorded as well as a diagnosis of poisoning, toxicity of a substance chiefly non-medical in nature, asphyxiation, or open wound to the elbow, wrist, or forearm.

The performance of the derived algorithms in the validation sample varied by patient characteristics, as shown for the more restrictive algorithm above in Table 3. In both BC and the NIS, the specificity was highest for hospitalizations among patients age <25, resulting in the highest PPV in this group (92.2% in BC, 83.4% NIS). The low prevalence of intentional self-harm hospitalizations among all injury hospitalization in subjects aged > 65 resulted in a low PPV in this group (65.8% in BC, 48.6% in NIS). The PPV was slightly lower in males. In the BC sample, which included history of depression diagnosis or antidepressant prescription in the past 180 days, PPV was slightly lower in subjects with no antidepressant use (87.5% versus 88.9% for those with past antidepressant use in BC) and differed little by prior history of depression diagnosis. Results from a secondary analysis including children younger than 10 were essentially identical.

Figure 1 summarizes the bias in estimated relative rates of intentional self-harm that might result from using the algorithm to identify intentional self-harm hospitalizations in a hypothetical study of antidepressant safety conducted under three scenarios. In the first example (Figure 1a) based on data from the general BC population where intentional self-harm hospitalizations accounted for 10% – 23% of injury hospitalizations depending on age and antidepressant use, intentional self-harm rate ratios comparing antidepressant use to non-use were underestimated by about 0.07 (1.83 versus 1.90 for adolescents, 1.50 versus 1.57 for non-senior adults). In the second example, based on patients initiating antidepressants in BC where rates of self-harm are substantially higher and intentional self-harm hospitalizations are highly prevalent among injury hospitalizations (62 – 76% of injury hospitalizations in those under 25, 24 – 33% in non-senior adults), bias was reduced to −0.007 and −0.03. Figure 1c depicts the results from an analysis based on rates of intentional self-harm and other injury hospitalizations observed in the general US population[9] and the sensitivity and specificity values calculated from the NIS. Although the prevalence of intentional self-harm hospitalizations among all injury hospitalizations was comparable to that in the BC general population, the reduced specificity of the algorithm in the US data led to greater bias. Rate ratios were underestimated by 0.12 – 0.13.

Discussion

In an analysis of 1999 – 2001 hospital data from the province of British Columbia and 2003 data from the US Nationwide Inpatient Sample, we found that intentional self-harm hospitalizations could be identified with reasonable sensitivity and high specificity without the use of external cause of injury codes (E-codes). Our preferred algorithm, which identified intentional self-harm hospitalizations based on the presence of a diagnosis of depression, personality disorder, mania, adjustment reaction, or unspecified non-psychotic mental disorder in combination with a diagnosis of poisoning, toxicity of a substance chiefly non-medical in nature, asphyxiation, or open wound to the elbow, wrist, or forearm had a sensitivity of 59.8%, a specificity of 99.4%, and a positive predictive value of 88.3% in the BC data to predict E-codes for intentional self-harm among a population aged 10 and over. In the NIS, the values were 71.1%, 97.9%, and 74.1%. While the algorithm will underestimate rates of intentional self-harm due to its moderate sensitivity, based on current E-code completeness rates in administrative data, the algorithm will detect twice as many cases as would be found using E-codes alone. Because intentional-self harm is a relatively rare outcome, this increase in statistical power is likely to be important.

The proposed algorithm had the highest positive predictive value (PPV) in patients age 10 to 25 and a reasonable PPV in patient age 25 – 64. The PPV was low in patients aged 65 and over, in part due to the low prevalence of intentional self-harm hospitalizations in this age group; among subjects age 65 and over, fewer than 1% of injury hospitalization were due to intentional self-harm according to recorded E-codes. The low prevalence of intentional self-harm hospitalizations is likely due to several factors. While the suicide rate in this population is high and the case fatality rate (CFR) is higher than in younger populations (44% CFR in age 65+ versus 3% in adolescents and 8% in non-senior adults),[9] the rate of hospital visits for nonfatal self-harm among seniors is very low relative to that among adolescents and non-senior adults.[23] In addition, the rate of hospitalization for other types of injuries is higher in subjects 65 and over than in younger age groups. [9]. The lower PPV in seniors suggests the algorithm may be of greatest use in adolescent and non-senior adult populations.

Several limitations should be considered. We used recorded E-codes from hospital discharge records as the gold standard for defining intentional self-harm hospitalizations. However, these E-codes are likely not 100% accurate. In a 1996 study from the state of Washington, agreement between hospital discharge data and chart review for intent of injury was 95% and for mechanism of injury was 87%, as measured by kappa statistics.[24] A study conducted in a Canadian teaching hospital found that rates of deliberate self-poisoning were underestimated by E-codes relative to medical chart review, particularly among subjects over the age of 55.[25] The under-coding of intentional self-harm E-codes among older adults may in part explain the low specificity of our algorithm in seniors. A direct validation of the algorithm against medical chart review would be preferable to fully assess its validity.

Physician service records are not available for the hospitalizations included in the NIS. Because most hospital physicians are salaried rather than paid on a fee-for-service basis in British Columbia, complete records are not available for BC hospitalizations either. It may be possible to improve the performance of these algorithms by including diagnoses and procedures recorded in physician service claims. Although our samples included patients admitted to the hospital through the emergency department, we did not have data to test the algorithms in treated-and-released emergency department (ED) visits. Because 42% of cases are seen in the ED only,[9] this will be an important area of research. Also, we tested the algorithm only on data using ICD-9-CM coding. Canadian hospitals began migrating to ICD-10-CA, a Canadian clinical modification of the tenth revision of the ICD, in the early and mid-2000s, and it will be useful to test the algorithm in this context. Finally, because our algorithm is based on a limited number of injury types, it will systematically miss self-harm by other methods such as drowning, firearm, fire, blunt trauma, jumps, motor vehicle, and open wound to an area other than the wrist, forearm, or elbow. Together, methods other than those included in the algorithm accounted for 10% of E-coded self-harm injuries in the BC sample and 11% in the NIS sample.

In summary, we have developed and tested an algorithm that identifies intentional self-harm hospitalizations with very high specificity and reasonable sensitivity, particularly in younger patients, relative to the gold standard of the presence of an intentional self-harm E-code. Use of this algorithm in a hypothetical study of the effects of antidepressant use on suicidality resulted in little bias in relative risk estimates. While steps should be taken to ensure high E-code rates in insurance databases, in the meantime this algorithm may be of value in studies of deliberate self-harm that rely on claims databases from Medicaid, or commercial insurers where E-codes are substantially under-recorded.

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Appendix A: States by region

Northeast: Connecticut*#, Maine, Massachusetts*#, New Jersey*#, New Hampshire*, New York*#, Pennsylvania*#, Rhode Island*#, and Vermont*#.

South: Florida*, Georgia*#, Maryland*#, North Carolina*#, South Carolina*, Virginia*, West Virginia*, Alabama, Kentucky*, Mississippi, Tennessee*#, Arkansas, Louisiana, Oklahoma and Texas*

Midwest: Ohio*, Indiana*, Michigan*, Illinois*, Wisconsin*#, Iowa*, Kansas*, Missouri*#, Minnesota*, Nebraska*#, South Dakota*, and North Dakota.

West: Alaska, Arizona*, California*#, Colorado*#, Hawaii*, Idaho, Montana, New Mexico, Nevada*, Oregon*, Utah*#, Washington*#, and Wyoming.

*States included in 2003 NIS

#States with E-coding rate > 85%

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Figure 1 illustrates the bias resulting from using the algorithm to identify intentional self-harm hospitalizations in a hypothetical study of antidepressant safety. "True rates" of self-harm and other injuries were calculated for three different scenarios based on RCT evidence, as described below. Observed rates were calculated from the true rates based on the sensitivity and specificity of the algorithm. The observed rate equals true positives [true intentional self-harm hospitalizations *sensitivity] plus false positives [non intentional self-harm hospitalizations * (1- specificity)]. An observed rate ratio was computed and bias was calculated as this rate ratio minus the true rate ratio from the RCT data.

Figure 1a assumes that intentional self-harm hospitalization rates in the absence of antidepressant treatment are equal to those observed in the general population of British Columbia and that antidepressant use leads to a 1.9-fold increase in these rates in an adolescent population and a 1.57-fold increase in an adult population based on randomized controlled trial (RCT) evidence. Sensitivity and specificity estimates were derived from the BC data analysis.

Figure 1b assumes higher intentional self-harm hospitalization rates, as might be observed in a depressed population. The rate among antidepressant users was calculated from British Columbia observational data; the rate among depressed non-users was calculated by dividing this rate by the RCT rate ratio. Sensitivity and specificity estimates were derived from the BC data analysis.

Figure 1c is comparable to figure 1a, but uses intentional self- harm and other injury hospitalization rates observed in the general US population and the sensitivity and specificity values calculated from the NIS analysis.

a. BC General Population

a1. Ages 10 - 24

	True rates: self-harm per 100,000 PY	True rates: other injury per 100,000 PY	Observed Rate: self-harm per 100,000 PY
controls	137.43	852.76	85.15
antidepressant users	261.12	852.76	155.8
true rate ratio	1.9		
observed rate ratio			1.83
bias -- absolute (%)			-0.07 (-3.7%)

a2. Ages 25 - 64

	True rates: self-harm per 100,000 PY	True rates: other injury per 100,000 PY	Observed Rate: self-harm per 100,000 PY
controls	126.11	1096.39	86.97
antidepressant users	197.99	1096.39	130.85
true rate ratio	1.57		
observed rate ratio			1.505
bias -- absolute (%)			-0.065 (-4.1%)

b. BC Antidepressant Users and Controls

b1. Ages 10 - 24

	True rates: self-harm per 100,000 PY	True rates: other injury per 100,000 PY	Observed Rate: self-harm per 100,000 PY
depressed controls	1412.57	852.76	80.71
antidepressant users	2683.89	852.76	152.75
true rate ratio	1.9		
observed rate ratio			1.893
bias -- absolute (%)			-0.007 (-0.4%)

b2. Ages 25 - 64

	True rates: self-harm per 100,000 PY	True rates: other injury per 100,000 PY	Observed Rate: self-harm per 100,000 PY
depressed controls	342.37	1096.39	218.99
antidepressant users	537.52	1096.39	338.13
true rate ratio	1.57		
observed rate ratio			1.544
bias -- absolute (%)			-0.026 (-1.7%)

c. US General Population

c1. Ages 10 - 24

	True rates: self-harm per 100,000 PY	True rates: other injury per 100,000 PY	Observed Rate: self-harm per 100,000 PY
controls	135.15	602.73	112.34
antidepressant users	256.78	602.73	198.75
true rate ratio	1.9		
observed rate ratio			1.769
bias -- absolute (%)			-0.131 (6.9%)

c2. Ages 25 - 64

	True rates: self-harm per 100,000 PY	True rates: other injury per 100,000 PY	Observed Rate: self-harm per 100,000 PY
controls	69.48	317.13	65.09
antidepressant users	109.09	317.13	94.71
true rate ratio	1.57		
observed rate ratio			1.455
bias -- absolute (%)			-0.115 (7.3%)

Figure 1.

Bias in Rate Ratios Calculated Using the Algorithm to Identify Outcomes

Table 1

Patient characteristics in the 50% development sample of hospital discharges with a primary or secondary injury diagnosis

	British Columbia		US Nationwide Inpatient Sample	
	N (%)	**Patients with intentional self- harm E-code – N (row %)**	**N (%)**	**Patients with intentional self- harm E-code – N (row %)**
Total N	88,808	6,127 (6.9)	122,574	9,345 (7.6)
Age				
10–25	11,887 (13.4)	1,643 (13.8)	16,375 (13.4)	2,599 (15.8)
25–64	41,160 (46.4)	4,187 (10.2)	52,112 (42.5)	6,369 (12.2)
65+	35,761 (40.3)	297 (0.8)	54,094 (44.1)	377 (0.7)
Sex				
Male	45,458 (50.9)	2,307 (5.1)	58,626 (47.8)	3,781 (6.5)
Female	43,650 (49.2)	3,820 (8.8)	63,955 (52.2)	5,564 (8.7)
Geographic region				
Northeast US	0 (0%)	N/A	46,330 (37.8)	3,313 (7.2)
South US	0 (0%)	N/A	30,211 (24.7)	2,492 (8.3)
Midwest US	0 (0%)	N/A	11,067 (9.0)	1,030 (9.3)
Western US	0 (0%)	N/A	34,973 (28.5)	2,510 (7.2)
BC	(100%)		0 (0)	N/A
Length of stay – median	4.0	N/A	3.0	N/A
In-hospital death	965 (1.1)	30 (3.1)	3,243 (2.7)	135 (4.2)
Race				
White	Unknown	N/A	80,540 (75.9)	6,055 (7.5)
Black	Unknown	N/A	11,353 (10.7)	869 (7.7)
Other	Unknown	N/A	14,278 (13.4)	1,140 (8.0)
Type of injury				
Fracture	30,179 (34)	195 (0.6)	63,030 (51.4)	181 (0.3)
Open wound to wrist, elbow, or forearm	1,342 (1.5)	93 (6.9)	2,607 (2.1)	784 (30.1)
Open wound to upper extremity	5,309 (6.0)	298 (5.6)	3,568 (2.9)	131 (3.7)
Open wound to lower extremity or injury to blood vessels	7,488 (8.4)	170 (2.3)	15,797 (12.9)	397 (2.5)

	British Columbia		US Nationwide Inpatient Sample	
	N (%)	**Patients with intentional self- harm E-code – N (row %)**	**N (%)**	**Patients with intentional self- harm E-code – N (row %)**
Intracranial injury, internal injury, injury to nerves and spinal cord	756 (0.9)	28 (3.7)	19,964 (16.3)	257 (1.3)
Burns	2,946 (3.3)	2,348 (79.7)	2,027 (1.7)	77 (3.8)
Poisoning by psychotropic agent	5,230 (5.9)	3,273 (62.6)	5,540 (4.5)	3,721 (67.2)
Poisoning by other drugs	1,021 (1.1)	566 (55.4)	10,102 (8.2)	5,053 (50.0)
Toxic effects of non-medicinal substances	1,065 (1.2)	464 (43.6)	2,367 (1.9)	861 (36.4)
Asphyxiation	84 (0.1)	71 (84.5)	70 (0.1)	55 (78.6)
Other injuries	40,842 (46)	374 (0.9)	110,754 (90.4)	9,125 (8.2)
Presence of mental health diagnoses				
Psychiatric procedure	210 (0.2)	95 (45.2)	1,497 (1.2)	449 (30.0)
Depression	3,685 (4.1)	1,861 (50.5)	14,985 (12.2)	5,710 (38.1)
Anxiety	564 (0.6)	169 (30)	2,977 (2.4)	506 (17.0)
Mania	2,067 (2.3)	1,192 (57.7)	3,069 (2.5)	1,418 (46.2)
Sleep disorder	116 (0.1)	*	1,448 (1.2)	115 (7.9)
Attention Deficit Hyperactivity Disorder	197 (0.2)	88 (44.7)	723 (0.6)	293 (40.5)
Substance Abuse	7,103 (8.0)	1,883 (26.5)	16,841 (13.7)	3,822 (22.7)
Psychotic Disorder	2,307 (2.6)	361 (15.6)	3,011 (2.5)	677 (22.5)
Dementia	3,213 (3.6)	38 (1.2)	10,474 (8.5)	57 (0.5)
Delirium	2,033 (2.3)	77 (3.8)	2,936 (2.4)	301 (10.3)
Personality Disorder	1,688 (1.9)	1,131 (67)	1,298 (1.1)	853 (65.7)
Adjustment reaction, non-depressed	607 (0.7)	404 (66.6)	1,115 (0.9)	630 (56.5)
Unspecified nonpsychotic mental disorder	598 (0.7)	467 (78.1)	825 (0.7)	603 (73.1)
Other mental disorder	1,112 (1.3)	379 (34.1)	1,374 (1.1)	339 (24.7)
Presence of chronic conditions				
Cancer	6,968 (7.8)	66 (0.9)	4,448 (3.6)	96 (2.2)
HIV	118 (0.1)	16 (13.6)	595 (0.5)	110 (18.5)

*cell sizes less than 12 are not reported

Table 2

Operating characteristics of alternative algorithms to identify intentional self-harm cases among injury hospital discharges – development sample

	British Columbia development sample				NIS development sample			
		Algorithm operating characteristics				Algorithm operating characteristics		
	% hospital discharges with diagnosis coded	Sensitivity	Specificity	Positive Predictive Value	% hospital discharges with diagnosis coded	Sensitivity	Specificity	Positive Predictive Value
Algorithms Based on Presence of Inpatient Diagnoses								
Individual Psychiatric Diagnoses								
Attention-deficit/hyperactivity disorder (ADHD)	0.22	1.44	99.87	44.67	0.59	3.14	99.62	40.53
Depression	4.15	30.37	97.79	50.5	12.22	61.1	91.81	38.1
Mania	2.33	19.45	98.94	57.67	2.5	15.17	98.54	46.2
Other psychiatric disorder	1.25	6.19	99.11	34.08	1.12	3.63	99.09	24.67
Personality disorder	1.90	18.46	99.33	67	1.06	9.13	99.61	65.72
Psychotic disorder	2.60	5.89	97.65	15.65	2.46	7.24	97.94	22.48
Adjustment reaction other than depressed mood	0.68	6.59	99.75	66.56	0.91	6.74	99.57	56.5
Unspecified non-psychotic mental disorder	0.67	7.62	99.84	78.09	0.67	6.45	99.8	73.09
Substance abuse	8.00	30.73	93.69	26.51	13.74	40.9	88.5	22.69
Combinations of Psychiatric Diagnoses								
Depression, personality disorder, mania, adjustment reaction, or unspecified non-psychotic mental disorder	7.88	62.92	96.2	55.1	15.02	77.58	90.14	39.37
or ADHD or psychotic disorder or other psychiatric disorder	10.9	69.32	93.42	43.86	17.64	82.07	87.67	35.46
Injury Type								
Open wound to wrist, elbow, or forearm	1.2	7.57	99.27	43.57	2.13	8.39	98.39	30.07
Other open wound to upper extremity	1.51	1.52	98.49	6.93	2.91	1.4	96.96	3.67
Open wound to lower extremity, injury to blood vessels	5.98	4.86	93.94	5.61	12.89	4.25	86.4	2.51
Poisoning by psychotropic agent	3.32	38.32	99.28	79.7	4.52	39.82	98.39	67.17
Poisoning by other drugs	5.89	53.42	97.63	62.58	8.24	54.07	95.54	50.02

	British Columbia development sample				NIS development sample			
		Algorithm operating characteristics				Algorithm operating characteristics		
	% hospital discharges with diagnosis coded	Sensitivity	Specificity	Positive Predictive Value	% hospital discharges with diagnosis coded	Sensitivity	Specificity	Positive Predictive Value
Toxic effects of non-medicinal substances	1.15	9.24	99.45	55.44	1.93	9.21	98.67	36.38
Aphyxiation	0.09	1.16	99.98	84.52	0.06	0.59	99.99	78.57
Combinations of Injury types								
Poisoning, toxicity of substance chiefly non-medical in nature, or asphyxiation	8.96	84.33	96.62	64.9	12.36	82.32	93.41	50.76
or open wound to wrist, elbow, or forearm	10.04	90.29	95.9	62.02	14.38	89.4	91.81	47.4
Combinations of injury type and presence of psychiatric diagnoses								
Depression, personality disorder, mania, adjustment reaction, or unspecified non-psychotic mental disorder – PLUS – poisoning, toxicity of substance chiefly non-medical in nature, asphyxiation, or open wound to elbow, wrist or forearm	4.5	57.25	99.41	87.83	7.3	70.75	97.93	73.86
Depression, personality disorder, mania, adjustment reaction, unspecified non-psychotic mental disorder, ADHD, psychotic disorder or other mental disorder – PLUS – poisoning, toxicity of substance chiefly non-medical in nature, asphyxiation, or open wound to elbow, wrist or forearm	5.09	62.61	99.17	84.85	7.85	74.08	97.62	71.94

Definitions of algorithm operating characteristics:

Sensitivity: probability that intentional self-harm hospitalization has diagnosis/diagnoses coded and is detected by algorithm

Specificity: probability that non intentional self-harm hospitalization does not have diagnosis/diagnoses coded and is ruled out by algorithm

Positive predictive value (PPV): probability that hospitalization detected by the algorithm is a true intentional self-harm hospitalization, based on gold standard of external cause of injury codes (E-codes)

Table 3

Operating characteristics of the preferred algorithm by patient characteristics in the 50% validation sample. The preferred algorithm defines intentional self-harm hospitalizations as those with a diagnosis of depression, personality disorder, mania, adjustment reaction, or unspecified non-psychotic mental disorder plus a diagnosis of poisoning, toxicity of a substance chiefly non-medical in nature, asphyxiation, or open wound to the elbow, wrist, or forearm.

	British Columbia (N = 88,810)					US – Nationwide Inpatient Sample (N= 122,590)				
	Hospital discharges		Algorithm operation characteristics			Hospital discharges		Algorithm operation characteristics		
	% due to intentional self-harm	% meeting algorithm criteria	Sensitivity	Specificity	Positive Predictive Value	% due to intentional self-harm	% meeting algorithm criteria	Sensitivity	Specificity	Positive Predictive Value
All subjects	6.90	4.74	59.81	99.4	88.32	7.55	7.24	71.06	97.97	74.06
By age										
< 25	13.82	8.63	57.12	99.22	92.24	16.08	13.7	71.04	97.29	83.4
25 – 64	10.17	7.2	61.05	99.09	88.69	12.0	11.79	71.47	96.35	72.77
65+	0.83	0.64	56.6	99.78	65.79	0.72	0.96	64.63	99.5	48.57
By sex										
Female	8.75	6.45	63.62	99.18	88.42	8.68	8.93	76.93	97.53	74.71
Male	5.11	3.11	53.45	99.61	88.13	6.33	5.42	62.34	98.43	72.88
By antidepressant use in the past 180 days										
Use	19.40	14.89	68.25	97.95	88.92	N/A				
No use	4.14	2.4	50.65	99.69	87.45	N/A				
By depression diagnosis in the past 180 days										
Diagnosis	16.68	12.94	68.19	98.12	87.92	N/A				
No diagnosis	5.72	3.66	56.58	99.55	88.51	N/A				

Definitions of algorithm operating characteristics:

Sensitivity: probability that intentional self-harm hospitalization is detected by algorithm

Specificity: probability that non intentional self-harm hospitalization is ruled out by algorithm

Positive predictive value (PPV): probability that hospitalization detected by the algorithm is an intentional self-harm hospitalization

Appendix B

ICD-9 Diagnosis Codes Used to Define Psychiatric Conditions and Injuries

Psychiatric Conditions		
Depression	293.83	organic affective syndrome, depressive type
	296.2x	major depressive episode, single episode
	296.3x	major depressive disorder, recurrent episode
	296.90	unspecified affective psychosis (e.g., melancholia NOS)
	298.0x	depressive type psychoses
	300.4x	neurotic depression
	309.0x	brief depressive reaction
	309.1x	prolonged depressive reaction
	309.28	adjustment reaction with anxiety and depression
	311	depressive disorder not elsewhere classified
Anxiety disorder	300.0x	anxiety states
	300.2x	phobic disorders
	300.3x	obsessive-compulsive disorders
Sleep disorder	307.4x	specific disorders of sleep of non-organic origin
	347.xx	cataplexy and narcolepsy
	780.5x	sleep disturbances
Mania	296.0x	manic disorder, single episode
	296.1x	manic disorder, recurrent episode
	296.4x	bipolar affective disorder, manic
	296.5x	bipolar affective disorder, depressed
	296.6x	bipolar affective disorder, mixed
	296.7x	bipolar affective disorder, unspecified
	296.8x	bipolar affective disorder, other and unspecified
	296.99	other specified affective psychoses (e.g., mood swings)
Attention-deficit/hyperactivity disorder	312.xx	
	314.xx	
Substance abuse	291.0x	alcohol withdrawal delirium
	291.1x	alcohol amnestic syndrome
	291.2x	other alcoholic dementia
	291.3x	alcohol withdrawal hallucinosis
	291.4x	idiosyncratic alcohol intoxication
	291.5x	alcoholic jealousy
	291.8x	other specified alcoholic psychosis
	291.9x	unspecified alcoholic psychosis
	303.xx	alcohol dependence syndrome
	305.0x	alcohol abuse
	292.0x	drug withdrawal syndrome

	292.1x	paranoid and/or hallucinatory state induced by drugs
	292.2x	pathological drug intoxication
	292.8x	other specified drug-induced mental disorders
	292.9x	unspecified drug-induced mental disorder
	304.xx	drug dependence
	305.2x-305.9x	non-dependent abuse of drugs
Psychotic disorder	290.8x	other specified senile psychotic conditions
	290.9x	unspecified senile psychotic condition
	295.xx	schizophrenia
	297.xx	paranoid states
	298.1x-298.9x	other non-organic psychoses
	299.xx	psychoses with origin specific to childhood
	780.1x	hallucinations
Dementia	290.0x	senile dementia
	290.1x	presenile dementia
	290.2x	senile dementia with delusional or depressive features
	290.3x	senile dementia with delirium
	290.4x	arteriosclerotic dementia
	291.1x	alcoholic amnestic syndrome
	291.2x	other alcoholic dementia
	292.82	drug induced dementia
	294.0x	amnestic syndrome
	294.1x	dementia in conditions classified elsewhere
	294.8x	other specified organic brain syndromes (chronic)
	294.9x	unspecified organic brain syndrome (chronic)
	330.xx	cerebral degenerations usually manifest in childhood
	331.0x	Alzheimer's disease
	331.1x	Pick's disease
	331.2x	senile degeneration of brain
	331.7x	cerebral degeneration in diseases classified elsewhere
	331.8x	other cerebral degeneration
	331.9x	cerebral degeneration, unspecified
Delirium	290.11	presenile dementia with delirium
	290.3 x	senile dementia with delirum
	290.41	arteriosclerotic dementia with delirium
	291.0x	alcoholic delirium
	292.81	drug-induced delirium
	293.0x	acute delirium
	293.1x	subacute delirium
	293.8x	other specified transient organic mental disorder
	293.9x	unspecified transient organic mental disorder
	348.3x	encephalopathy, unspecified

	349.82	toxic encephalopathy
Personality disorders	301.xx	
Unspecified non-psychotic mental disorder	300.9	
Adjustment reaction with disturbance other than depressed mood	309.2x-309.9x	
Other psychiatric disorder	300.1x	hysteria
	300.5	Neurasthenia
	300.6	Depersonalization disorder
	300.7	Hypochondriasis
	300.8x	somatoform disorder
	302.xx	sexual deviations and disorders
	306.xx	physiologic malfunction arising from mental factors
	307.0x-307.3x	special symptoms or syndromes, not elsewhere classified
	307.5x-307.9x	special symptoms or syndromes, not elsewhere classified
	308.xx	acute reaction to stress
	310.xx	nonpsychotic mental disorders due to organic brain damage
	313.xx	disturbance of emotions specific to childhood or adolescence
	315.xx	specific delays in development
	316.xx	psychic factors associated with diseases classified elsewhere
Injuries		
Fracture	800 – 829	
Open wound to elbow, forearm, or wrist	881	
Other open wound to upper limb	880 – 887, excluding 881	
Other open wounds, injuries to blood vessels	870 – 879	Open wound to head, neck, trunk
	890 – 897	open wound to lower limb
	900 – 904	injury to blood vessels
Intracranial injury, internal injury, injury to nerves and spinal cord	850 – 854	Intracranial injury excluding skull fracture
	860 – 869	Internal injury
	950 – 957	Injury to nerves and spinal cord
Poisoning by psychotropic agents	969	
Poisoning by other drugs	960 – 979 excl. 969	
Toxic effects	980 – 989	
Asphyxiation	994.7	

Other injury	830 – 839	Dislocation
	840 – 848	Sprains and strains
	905 – 909	Late effects
	910 – 919	Superficial injuries
	920 – 924	Contusion
	925 – 929	Crushing injury
	930 – 939	Foreign body
	940 – 949	Burns
	958 – 959	Traumatic complications
	996 – 999	Complications of medical/surgical care
	990 – 995	Other/unspecified