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## Association between unintentional injuries and self-harm among adolescent emergency department patients

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### Abstract

**Background**—Unintentional injury, a leading cause of morbidity among adolescents, may also be a risk factor for deliberate self-harm. To inform clinical and public health prevention efforts in adolescent populations, we examined whether distinct subtypes of unintentional injury were differentially associated with deliberate self-harm.

**Methods**—Statewide, all-payer, individually linkable administrative data on adolescent patients presenting to any California emergency department (ED) in 2010 (n=490,071) were used to investigate longitudinal associations between subtypes of unintentional injury and deliberate self-harm. Adolescents aged 10–19 years presenting with unintentional drug poisoning, other poisoning, fall, suffocation, or cutting/piercing injuries formed the exposure groups; adolescents

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**Dwena Phillips:** Conceptualization, Methodology, Writing: original draft preparation and revision. **Cristina Lidon Moyano:** Conceptualization, Methodology. **Magdalena Cerdá:** Conceptualization, Writing: review and editing. **Paul Gruenewald:** Conceptualization, Writing: Review and editing. **Sidra Goldman-Mellor:** Supervision, Methodology, Funding acquisition, Writing: Original draft preparation and revision/editing.

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presenting with unintentional strike injuries formed the primary referent group. Study patients were followed back in time (2006–2009) to compare the groups' odds of a prior ED visit for deliberate self-harm, as well as forwards in time (2010–2015) to compare their risks of subsequent self-harm.

**Results**—Unintentional drug-poisoning injury was strongly associated with increased likelihood of ED visits for deliberate self-harm, assessed both retrospectively (adjusted OR=4.52; 95% confidence interval [CI] = 3.08, 6.64) and prospectively (adjusted RR=3.74; 95% CI=3.03, 4.60). Positive associations with odds of prior self-harm and/or risk of subsequent self-harm were also observed for patients with unintentional non-drug poisoning, suffocation, and cutting/piercing injuries.

**Conclusions**—Certain subtypes of unintentional injury, particularly drug poisoning, are strongly associated with risk for deliberate self-harm among adolescents, a finding with implications for targeting clinical assessment and intervention in emergency department settings. More research is needed to understand the mechanisms underlying these associations.

## INTRODUCTION

Unintentional and deliberate self-harm injuries are leading causes of morbidity among adolescents in the United States.<sup>1,2</sup> In 2017, adolescents made 3.2 million emergency department (ED) visits for unintentional injury (UI) and 132,000 ED visits for deliberate self-harm.<sup>3</sup> Determining intent among injury patients has long been recognized as a challenge,<sup>4,5</sup> and many “accidental” injuries may actually involve suicidal or self-harm intent.<sup>4–9</sup> This may be particularly true in adolescents, who engage in deliberate self-harm at higher rates than any other age group<sup>3,10</sup> yet frequently deny or lack awareness of self-injurious intent at the time of clinical assessment.<sup>11,12</sup> There is also a small literature reporting that unintentional injury serves as an independent risk factor for subsequent self-harm, including among adolescents.<sup>13–15</sup> A better understanding of the association between unintentional injury and deliberate self-harm could inform clinical and public health prevention efforts aimed at reducing injury morbidity in adolescence.

One question of particular clinical relevance is how distinct subtypes of adolescent unintentional injury are associated with risk for deliberate self-harm, as specificity in this association would have immediate implications for patient screening, treatment and referral protocols. Two prior studies have reported positive associations between experiencing *any* nonfatal UI and risk of subsequent self-harm, but did not investigate how this relationship varied by UI subtype.<sup>14,15</sup> Different UIs occur at markedly different rates – for example, injuries caused by the patient being struck by/against an object are far more common than unintentional poisonings<sup>16</sup> – and some UI subtypes are likely to be more strongly associated with deliberate self-harm than others. Unintentional poisoning, fall, suffocation, and cut/piercing injuries, especially, are relatively infrequent but may be likely to share common etiologic factors with deliberate self-harm (e.g., poor executive functioning, impulsivity, and psychopathology).<sup>17–19</sup>

The goal of the current study was to examine longitudinal, within-individual associations between key unintentional injury subtypes and deliberate self-harm in an adolescent ED

patient population. We identified distinct groups of adolescents presenting with the UI subtypes of interest and compared their relative frequencies of both *prior history* of any deliberate self-harm ED visit as well as their *subsequent risk* for self-harm. We focused on adolescents presenting with the UI subtypes identified above as most plausibly linked to deliberate self-harm behavior: poisonings, falls, suffocation, and cutting/piercing injuries. We compared each of these groups to two separate referent groups. The first referent group was adolescents with unintentional strike injuries, which we chose because strike injuries (many of which are sports-related)<sup>19</sup> are the leading cause of unintentional injury among adolescents.<sup>1,15</sup> The second referent group was all adolescents seen for any other condition, including both other injuries and non-injury complaints. These separate analyses allowed us to examine how the magnitude of any excess risk among adolescent UI patient subtypes changed based on the composition of the comparison group.

## METHODS

### Data

This study used nonpublic individual-level ED data from all California state-licensed hospitals for the years 2006 through 2015, provided by the California Office of Statewide Health Planning and Development (OSHPD). For this study, the dataset consisted of ED records for all adolescent patients aged 10 to 19 years with a unique identifier (encrypted social security number) and a California residential zip code in 2010 (n=490,071). Adolescents with missing sex and/or age were excluded. Unique identifiers were used to link multiple ED visits per patient for several years, including encounters at any ED in the state prior (2006–2009) and subsequent (2010–2015) to the adolescent’s index visit to an ED in 2010 (defined below).

### Definition of the study groups

We defined five patient exposure groups using each patient’s primary International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) External Cause of Injury code (E-code) at his or her index visit, defined as the first visit to the ED with an unintentional injury in 2010. The five exposure groups comprised patients with: (1) unintentional drug poisoning (ICD-9-CM codes E850-E858); (2) unintentional poisoning from non-drug substances (E860-E869); (3) unintentional fall injury (E880-E888); (4) unintentional suffocation injury (E910-E915); and (5) unintentional cutting/piercing injury (E920). For the first analyses, the reference group was defined as adolescent patients whose first ED visit in 2010 included a primary E-code diagnosis of E917, an injury caused by the individual striking against or being struck unintentionally by objects or persons (hereafter termed “strike-injury reference patients”). This type of injury is the leading cause of nonfatal UI among youths aged 10–19.<sup>16,20</sup> The second set of analyses compared the five UI exposure groups to all other adolescent ED patients who presented for any other condition in 2010 (“general reference patients”). Each reference patient’s index visit was defined as his or her first visit in 2010.

## Outcome measures

The study outcome was ED visits for deliberate self-harm, assessed in both follow-back and follow-forward analyses. A deliberate self-harm ED visit was defined as one with a primary diagnostic position of ICD-9-CM code of E950.0-E958.x. Codes E950–958 do not distinguish between events involving self-inflicted injury with intent to die and those involving no lethal intent (i.e., non-suicidal self-injury); therefore, our case definition captured both kinds of injury events. We assessed both patients' odds of a *prior* self-harm visit (follow-back analyses) and their *prospective* risk of any self-harm visit (follow-forward analyses). Observation for follow-back analyses began on January 1, 2006 (the earliest year high-quality ED data are available) and ended on December 31, 2009. Observation for follow-forward analyses began on the date following each patient's index visit and ended on Sept. 30, 2015, to avoid diagnosis misclassification problems related to the mandatory transition from ICD-9-CM to ICD10-CM coding on Oct. 1, 2015.<sup>21</sup>

## Covariates

**Characteristics at index visit**—Patient-level characteristics assessed at index visit included age, sex, race/ethnicity (collapsed into White, Black, Hispanic, Asian/Pacific Islander, or other), and payer type (collapsed into private insurance, Medicaid, self-pay, or other).

**Patient visit histories**—For each patient, we constructed a visit history variable indicating the total number of ED visits made in the four years prior to 2010 (2006–2009), which was used in both the follow-back and prospective risk analyses. We considered this variable a measure of patients' overall propensity to use the ED, which would influence their subsequent likelihood of visiting the ED for unintentional injury and deliberate self-harm injury.<sup>14</sup> Patient visit history of any self-harm visit (ICD-9CM codes E950.0-E958) was also included as a covariate in the prospective risk analyses, to control for the fact that families and providers may be more likely to recommend that an adolescent engaging in self-harm behavior go to the ED if he or she has previously received ED treatment for a similar crisis.

## Statistical Analyses

For the follow-back analyses, each unintentional injury group's odds of a prior deliberate self-harm visit was compared to that of the reference group using logistic regression models. Covariates for this model included patient demographic characteristics assessed at index visit and total ED visit history. For the follow-forward analyses, we estimated risk ratios (RR) and their 95% confidence intervals (95% CI) to assess whether risk of having a subsequent self-harm visit differed between the five UI exposure groups when compared to the reference group. Covariates for this model included patient demographic characteristics assessed at index visit, patient's total ED visit history, and the prior self-harm visit history variable, to account for the fact that prior serious self-harm is strongly predictive of ED utilization for subsequent self-harm.<sup>14</sup> Risk ratio models used robust standard errors and included an offset term comprising each patient's follow-up time in days, to account for patients' repeated observations over time and their varying index visit dates.

For both models, the five unintentional injury groups of interest were first compared to the strike-injury reference group. We then replicated both analyses using the general reference group. STATA 15 (College Station, Texas) was used for all analyses.

## RESULTS

Patient characteristics assessed at index visit and during 2006–2009 for the five unintentional injury exposure groups, and the strike-injury reference group, are shown in Table 1. Of the five exposure groups, unintentional falls (n=39,591) and unintentional cutting (n=11,679) were the most common injuries. On average, patients in the exposure groups were 14.8 years old at index visit and 36.8% were female. However, unintentional drug poisoning patients were slightly older, with an average age of 16.3 years (SD=2.3); fall patients were the youngest, with an average age of 14.4 years (SD=2.9). Females were the minority in all injury groups except for the unintentional drug poisoning group, in which females made up 55.4% of the group. Although the relative proportions differed by patient group, the majority of patients were either White or Hispanic, and most used either private insurance or Medicaid. Patients in the strike-injury reference group were slightly less likely than the exposure-group patients to be female, but were similar in other respects.

Percentages of each UI exposure group with a prior or subsequent ED visit for deliberate self-harm, and results from multivariate models using strike-injury patients as the referent group, are shown in Table 2 and Figure 1. Patients in the unintentional drug-poisoning group were most likely to experience the outcomes: 2.7% had a prior self-harm visit and 7.0% made a subsequent self-harm visit. Compared to strike-injury patients, patients in the unintentional drug-poisoning group had four-fold higher odds of a prior self-harm visit (OR = 4.52, 95% CI = 3.08, 6.64) and 3.7-fold higher risk of a subsequent self-harm visit (RR = 3.74, 95% CI = 3.03, 4.64). Patients in the unintentional suffocation and cutting/piercing injury groups, meanwhile, had nearly two-fold higher odds of a prior self-harm visit. These patients also exhibited elevated risk of subsequent self-harm, but at a smaller magnitude compared to unintentional drug-poisoning patients. Patients with index injuries for poisoning from non-drug substances had elevated risk for subsequent but not prior self-harm.

We then re-ran all analyses using the general reference group comprised of all other adolescent ED patients (n=434,228). The most common primary diagnoses among this reference group included sprains and strains (7.2%), abdominal pain (6.8%), and upper respiratory infections (2.7%). Less than 1% (n=3,679, or 0.9%) had a prior deliberate self-harm visit, and 2.2% (n=9,714) made a subsequent self-harm visit. With these patients as the referent group, associations between unintentional drug poisoning and both self-harm outcomes were reduced in magnitude but remained statistically significant (Table 3). Cutting injury patients also had elevated odds for prior deliberate self-harm. Increased risk of self-harm was seen among patients with poisoning by non-drug substances (RR=1.63, 95% CI = 1.12, 2.37) and among those with suffocation injuries (RR = 1.30, 95% CI = 1.03, 1.64). Unintentional fall patients were at *reduced* likelihood of both prior and subsequent self-harm visits when compared with the general reference patient group.

## DISCUSSION

This is the first study, to our knowledge, that uses longitudinal population-based emergency department data to examine associations between different subtypes of unintentional injury and deliberate self-harm among adolescents. We found that adolescents with drug-poisoning injuries consistently demonstrated the highest risk for self-harm, both prospectively and retrospectively, although there were also significant positive associations between several other types of unintentional injury – including non-drug poisoning, cutting/piercing, and suffocation – and self-harm. We also found that fall patients were at lower risk of self-harm. We conclude that all subcategories of unintentional injury patients included in this study appear to be at excess risk of self-harm, with the exception of fall patients.

Various factors may explain why adolescents who seek ED care for ostensibly accidental poisoning, cutting/piercing, and suffocation injuries experience elevated risk of self-harm ED visits. First, underlying vulnerability factors may predispose adolescents to both unintentional injury and self-harm behavior. Such factors include poor executive functioning, impulsivity, and psychopathology,<sup>17-19</sup> lack of parental supervision and low familial socioeconomic status,<sup>17,22</sup> and involvement with risk-taking peers.<sup>17,23</sup> Second, the strong association we observed specifically between visiting the ED for accidental drug overdose and for self-harm may arise from access to over-the-counter or prescription drugs.<sup>24,25</sup> Our findings thus reinforce the importance of restricting access to such drugs and educating adolescents about the risks of abusing drugs, especially among those with histories of mental health problems.<sup>26,27</sup> It is possible that clinicians would be more likely to interpret a new injury as involving self-harm if the patient has a history of prior drug overdose. Third, unintentional injury may also influence adolescents' risk of subsequent self-harm through direct causal pathways. Serious injuries can result in psychological trauma,<sup>28</sup> significant recovery periods during which the adolescent is isolated from peer-based social support networks,<sup>29</sup> and depression symptoms stemming from adjustment to a new disability, systemic inflammation pathways, or other injury-related effects.<sup>30,31</sup> These processes may, over time, give rise to psychological disorder, suicidal thoughts and self-harm behavior. Future research is needed to separate out the independent contributions of these various processes to the observed associations between unintentional injury and self-harm.

The magnitude of our estimates differed according to specification of the reference group (strike-injury patients vs. all other patients). When using strike-injured patients as the reference group, the relative risks for self-harm visits among drug-poisoning adolescents were substantially larger, and unintentional suffocation and cutting/piercing injury patients had significantly elevated risk. When using all other patients as the reference group, however, the signal was more mixed. The likeliest explanation for these differences is that the general reference group included a substantial number of patients who sought care in 2010 for self-harm and/or mental health problems, who therefore would be expected to experience higher-than-average likelihood of prior or subsequent self-harm. Whether adolescent strike-injury patients, or the general population of adolescent ED patients, should be viewed as the most relevant comparison group may depend on each clinician's specific clinical context and the composition of the patient pool.

Prior research reports that unintentional injury in youth is an independent risk factor for subsequent self-harm.<sup>14,15</sup> Our results temper and clarify this conclusion, by indicating that certain subtypes of unintentional injury – drug poisoning, other kinds of poisoning, and suffocation and cutting patients – convey the majority of this excess risk. From a clinical perspective, emergency department providers should incorporate this information when diagnosing, treating, and referring injured adolescent patients; moreover, interventions aimed at early identification and mental health risk reduction among adolescents should consider specifically targeting those with a documented history of unintentional overdose, cutting, and suffocation injuries. In addition, future research should incorporate independent assessments of injured adolescent patients' self-harm intent, to further elucidate the extent to which diagnostic misclassification may be responsible for the associations we observed here. Future research should also attempt to identify the causal relationships underlying the associations between unintentional injuries and self-harm (e.g., shared propensity for impulsivity). In doing so, there would be an opportunity for the development of targeted clinical assessment and treatment of these causal factors, further improving clinical interventions. For example, adolescents presenting with unintentional poisoning and suffocation injuries could be flagged for suicide risk screening and potential referral to outpatient mental health services.<sup>32</sup>

This study had several limitations. First, diagnostic coding in administrative healthcare datasets is known to contain inaccuracies, and classification of injury intent is particularly difficult;<sup>33,34</sup> therefore, misclassification of intent among the injured adolescent patients in our data is likely present. Because the administrative dataset did not contain detailed information from clinician notes, we were unable to perform a validation study confirming whether the diagnostic codes truly matched the clinical description of the visits. Similarly, because codes E950–958 do not distinguish between events involving self-inflicted injury with intent to die and those involving no lethal intent (i.e., non-suicidal self-injury), we could not distinguish between these types of injury events in our outcome definition. This study also created mutually exclusive patient groups to which adolescents were assigned based on their index injury type. Some adolescents may have received diagnoses for multiple injuries during their index visit and/or visited the ED multiple times for injuries during the study period; we think it unlikely, however, that alternative groupings would substantively change our findings. We also lacked the ability to longitudinally track adolescents whose ED records did not contain a unique identifier (approximately 30%).<sup>14</sup> Lastly, there may be unobserved confounders that we could not control for in our administrative dataset.

Our study also had several notable strengths. The data are population-based, and the study was conducted in California, where E-coding has been mandatory for 20 years. Additional advantages include our ability to track patients longitudinally as they made visits to any ED in California, follow-up periods of several years, and statistical controls for patients' prior ED utilization patterns.

Results from this study have the potential to improve clinical practice by highlighting a population of adolescent patients – those with unintentional drug and non-drug poisoning overdose, cutting, and suffocation injuries – who exhibit elevated risk of self-harm, but whose need for mental health services might otherwise go unrecognized. Future studies



should examine the mechanisms underlying these associations to inform the development of effective clinical and public health interventions.

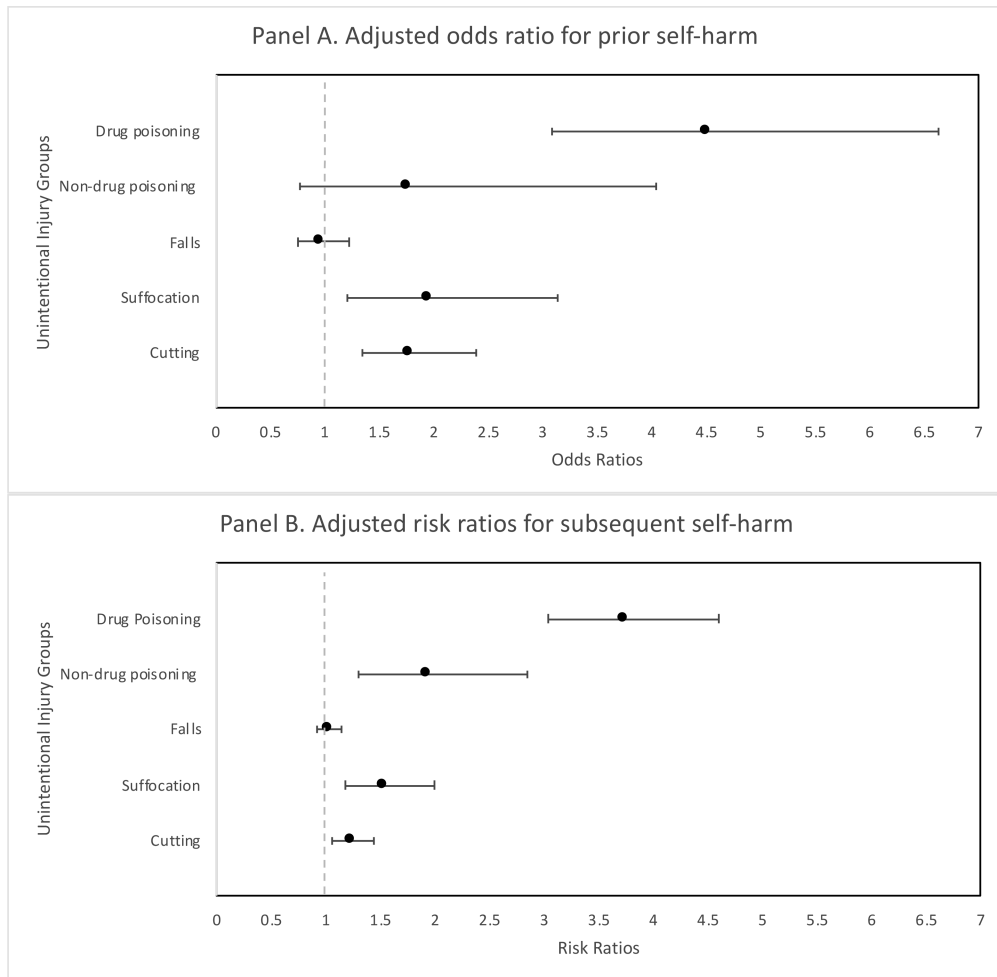
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**Figure 1.** Associations between unintentional injury groups and prior ED visits for self-harm (Panel A) as well as subsequent ED visits for self-harm (Panel B).

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Characteristics assessed at index visit according to patient status, among 490,071 adolescents receiving emergency department care in California during 2010.

Table 1.

	Strike-injury reference patient group (n=34,598)	General reference patient group (n=434,228)	Drug poisoning patient group (n=1,426)	Non-drug poisoning patient group (n=668)	Fall patient group (n=39,591)	Suffocation patient group (n=2,479)	Cutting patient group (n=1,679)
Female sex, n (%)	10,229 (29.6%)	232,311 (53.5%)	790 (55.4%)	257 (38.5%)	14,468 (36.5%)	1,140 (46.0%)	3,898 (33.4%)
Age, mean (SD)	14.7 (2.7)	15.6 (2.9)	16.3 (2.3)	15.4 (2.8)	14.4 (2.9)	15.2 (3.0)	15.7 (2.9)
Race/ethnicity, n (%)							
White	13,653 (39.5%)	145,619 (33.5%)	602 (42.2%)	310 (46.4%)	15,565 (39.3%)	900 (36.2%)	4,640 (39.7%)
Black	4,152 (12.0%)	54,997 (12.7%)	137 (9.6%)	66 (9.9%)	3,780 (9.6%)	297 (12.0%)	1,241 (10.6%)
Hispanic	12,622 (36.5%)	185,320 (42.7%)	554 (38.9%)	227 (34.0%)	15,412 (38.9%)	1,011 (40.8%)	4,453 (38.1%)
Asian/PI	1,488 (4.3%)	17,186 (4.0%)	48 (3.4%)	17 (2.5%)	1,785 (4.5%)	106 (4.3%)	485 (4.2%)
Other	2,683 (7.7%)	31,106 (7.2%)	85 (6.1%)	48 (7.2%)	3,049 (7.7%)	165 (6.7%)	860 (7.4%)
Payer type, n (%)							
Private insurance	18,432 (53.3%)	178,862 (41.2%)	660 (46.3%)	255 (38.2%)	19,088 (48.2%)	1,051 (42.4%)	5,206 (44.6%)
Medicaid	11,883 (34.4%)	183,950 (42.4%)	532 (37.1%)	293 (43.9%)	15,034 (38.0%)	1,030 (41.6%)	4,044 (34.6%)
Self-pay	3,160 (9.1%)	56,710 (13.1%)	198 (13.9%)	85 (12.7%)	4,104 (10.4%)	269 (10.9%)	1,568 (13.4%)
Other	1,122 (3.2%)	14,681 (3.4%)	36 (2.5%)	34 (5.1%)	1,359 (3.4%)	128 (5.2%)	859 (7.4%)

**Table 2.**

Associations between unintentional injury patient group and both prior and subsequent ED visits for self-harm injury, with strike-injury patients as the referent group.

Patient group	Prior self-harm visit	Subsequent self-harm visit	Prior self-harm visit	Subsequent self-harm visit
	N (%)	N (%)	aOR (95% CI) <sup>a</sup>	aRR (95% CI) <sup>b</sup>
Strike-injury reference patients (n=34,598)	123 (0.4%)	517 (1.5%)	1.00	1.00
Drug poisoning patients (n=1,426)	39 (2.7%)	100 (7.0%)	<b>4.52 (3.08, 6.64)</b>	<b>3.74 (3.03, 4.60)</b>
Non-drug poisoning patients (n=668)	7 (1.1%)	25 (3.7%)	1.77 (0.77, 4.05)	<b>1.93 (1.30, 2.85)</b>
Fall patients (n=39,591)	150 (0.4%)	638 (1.6%)	0.96 (0.75, 1.23)	1.02 (0.92, 1.15)
Suffocation patients (n=2,479)	22 (0.9%)	67 (2.7%)	<b>1.95 (1.21, 3.14)</b>	<b>1.53 (1.18, 1.99)</b>
Cutting patients (n=11,679)	87 (0.7%)	221 (1.9%)	<b>1.79 (1.35, 2.39)</b>	<b>1.23 (1.05, 1.44)</b>

<sup>a</sup> Logistic regression model adjusted for age, sex, race/ethnicity, insurance type, and total number of ED visits made in the 4 years prior to 2010.

<sup>b</sup> Risk ratio model adjusted for age, sex, race/ethnicity, insurance type, total number of ED visits made in the 4 years prior to 2010, and history of any self-harm ED visit.

**Table 3.**

Associations between unintentional injury group and both prior and subsequent ED visits for self-harm injury, with all other ED patients as the referent group.

Patient group	Prior self-harm visit	Subsequent self-harm visit
	aOR (95% CI) <sup>a</sup>	aRR (95% CI) <sup>b</sup>
General reference patients (n=434,228)	1.00	1.00
Drug poisoning patients (n=1,426)	<b>3.50 (2.52, 4.86)</b>	<b>3.11 (2.58, 3.75)</b>
Non-drug poisoning patients (n=668)	1.40 (0.64, 3.06)	<b>1.63 (1.12, 2.37)</b>
Fall patients (n=39,591)	<b>0.72 (0.61, 0.86)</b>	<b>0.81 (0.75, 0.87)</b>
Suffocation patients (n=2,479)	1.49 (0.97, 2.29)	<b>1.30 (1.03, 1.64)</b>
Cutting patients (n=11,679)	<b>1.31 (1.05, 1.62)</b>	0.98 (0.86, 1.12)

<sup>a</sup>Logistic regression model adjusted for age, sex, race/ethnicity, insurance type, and total number of ED visits made in the 4 years prior to 2010.

<sup>b</sup>Risk ratio model adjusted for age, sex, race/ethnicity, insurance type, total number of ED visits made in the 4 years prior to 2010, and history of any self-harm ED visit.