

### Visit level suicidality/self-harm phenotyping in bipolar disorder

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#### Abstract

Patients suffering from bipolar disorder have an increased risk of attempting self-harm/suicide by numerous means. Although many suicidal patients are hospitalized for diagnosis and treatment, the vast majority of such visits are not documented with suicidality/self-harm diagnostic codes in administrative claims data, which makes studies related to this outcome difficult. In the Truven Health Analytics MarketScan® database, we observed in a cohort of 1.3M bipolar disorder patients that visits containing likely self-inflicted external injuries (suspicious injuries), are rarely accompanied by self-harm diagnostic codes. The fraction of visits with suspicious injuries in which suicidality/self-harm was also coded varies from 1.28-40%, depending on the injury code and state. Summary statistics are presented, along with preliminary machine learning approaches to imputing suicidality/self-harm at a visit level to support investigation of this phenotype in time-to-event studies.

#### Introduction

Bipolar Disorder (BD) is associated with excess mortality from suicide and high rates of attempted suicide<sup>1</sup>. Despite the fact that most patients who attempt suicide are treated in a hospital or emergency department setting<sup>2</sup>, the majority of suicidal behavior and self-harm is not explicitly coded in administrative claims billing data. The frequency of using ICD9CM diagnostic codes to report suicidal ideation and suicidal attempts in patients with depression was shown to be only 3% and 19% respectively in primary care organizations<sup>3</sup>. The low frequency of labeled self-harm visits relative to reality makes it challenging to develop a robust predictive model for suicidality as a visit-level outcome. Some published studies report code-based suicide-detecting algorithms with positive predictive value up to 85.0-98.9%<sup>4,5</sup>.

#### Methods and results

We used the Truven Health Analytics MarketScan® administrative claims database to analyze data on 1.3M inpatient and outpatient individuals with at least two diagnoses of bipolar or schizoaffective disorder during the observation period 2003-2015. To get a comprehensive picture of the events accompanying each visit, we constructed “meta-visits”, defined as a consecutive sequence of visits, which, for example, might include an ER visit, an outpatient visit, and a subsequent psychiatric hospitalization. The meta-visits contain more information than a single visit, thus, we expect the percentage of correctly reported cases of self-harm to be higher. We identified a set of ICD9 and ICD10 diagnostic and procedure codes “suspicious” for suicide/self-harm based on self-harm methods existing in current international classifications of diseases. We aimed to define what percentage of visits/meta-visits with suspicious codes were accompanied with a diagnosis of suicide/self-harm (ICD9CM E95[0-9]\*; ICD10CM X7[1-9]\*, X8[0-3]\*; SNOMED 59274003, 276853009, 418420002 and descendants). We observed that reporting rates for self-harm/suicide are higher for visits with suspicious injuries as compared to all others. Visits/meta-visits with suspicious codes had varying prevalence of self-harm diagnoses, depending on the injury type and state (1.28-33.7% for visits and 1.43-35% for meta-visits) (Figures 1, 2), which can be explained by existing differences in electronic health records policies between US geographical regions<sup>6</sup>. Only two states have more than 10% reporting of self-harm with suspicious injuries and many states have less than 6% reporting.

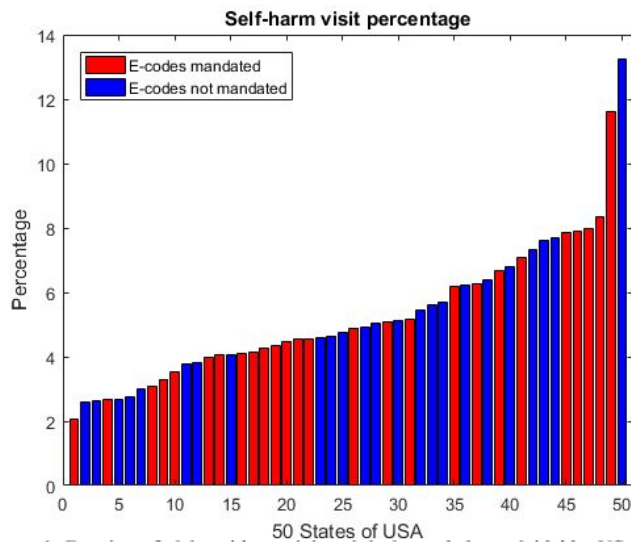


Figure 1: Fraction of visits with suspicious injuries coded as suicidal by US State. There is little evidence that state mandates to code injuries increase the capture of suicide/self-harm in administrative claims data.

We used the XGboost<sup>7</sup> machine learning approach to develop a classification model based on these data. Class ‘1’ was assigned to the visits that were documented as self-harm/suicide and class ‘0’ was assigned to the rest of the visits. Covariates characterizing visits included observations, conditions, procedures, drug ingredients, as well as two manually curated sets of covariates for injuries as well as BD clinical characteristics, comorbidities, and concomitant drug classes. As the data have unbalanced classes because of incorrect documentation, XGboost’s scale\_pos\_weight parameter was used to control the balance of class ‘1’ and class ‘0’ weights. We performed a sensitivity analysis to covariate type within a 10-fold cross-validation framework on a smaller subset of the data. The best models gave more than 90% area under curve (AUC) and more than 30% Matthews correlation coefficient (MCC). We found that observations and our hand-curated covariates contributed most to model performance with procedures having no benefits.

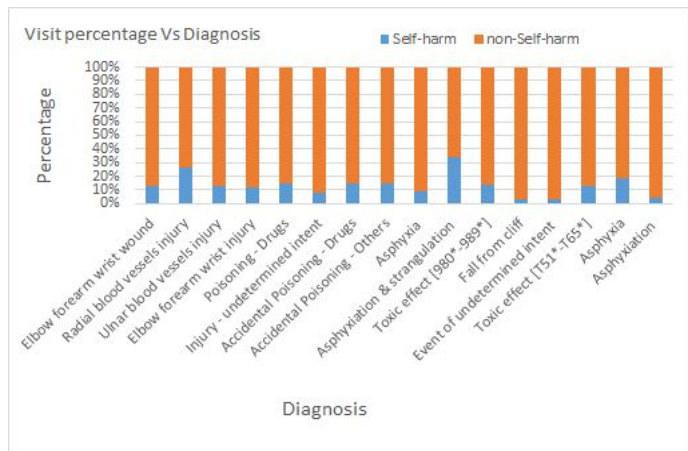


Figure 2. Percentage of visits with suspicious diagnosis codes that were documented as self-harm/suicide visits.

### Conclusion

The results of our study show that most bipolar patients hospitalized for attempted suicide/self-harm do not have associated billing codes for such, with significant regional biases in data collection, which could confound observational studies. Initial machine learning results suggest the lack of a harmonized vocabulary for procedures that covers CPT4, HCPCS, ICD9Proc and ICD10PCS codes prevents the utilization of important procedure information in predicting suicidality. Expert-curated collections of codes improve model performance. The notion of meta-visits, which coincides with Vocabulary Working Group efforts to create a visit\_era table, appear to increase the detection of suicidality. Further work remains to develop unbiased classifiers for visit-level suicidality.

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