Psychiatry Research 347 (2025) 116391

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Absence of nonfatal suicidal behavior preceding suicide death reveals differences in clinical risks

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ARTICLE INFO

Keywords:
Suicide mortality
Suicidal behavior
Electronic health records

ABSTRACT

Nonfatal suicidal behavior is the most robust predictor of suicide death. However, only ~10 % of those who survive an attempt go on to die by suicide. Moreover, ~50 % of suicide deaths occur in the absence of prior known attempts, suggesting risks other than nonfatal suicide attempt need to be identified to help prevent suicide mortality. We studied data from 4,000 population-ascertained suicide deaths and 26,191 population controls to improve understanding of suicide deaths without prior nonfatal attempts. This study included 2,253 suicide deaths and 3,375 controls with evidence of nonfatal suicidal ideation or behaviors (SUI_SI/SB and CTL_SI/SB) from diagnostic codes and natural language processing of electronic health records notes. Characteristics of these groups were compared to 1,669 suicides with no prior nonfatal SI/SB (SUI_None) and 22,816 controls with no lifetime suicidality (CTL_None). The SUI_None and CTL_None groups had fewer overall diagnoses and were older than SUI_SI/SB and CTL_SI/SB. Mental health diagnoses were far less common in both the SUI_None and CTL_None groups; mental health problems were far less associated with suicide death than with presence of SI/SB. Physical health diagnoses were conversely more often associated with risk of suicide death than with presence of SI/SB. Pending replication, results indicate highly significant clinical differences among suicide deaths with versus without prior nonfatal SI/SB, and suggest that, for a substantial number of individuals at risk for suicide mortality, history of SI/SB does not serve as an effective clinical marker of risk.

1. Introduction

The suicide death rate continues to rise precipitously in the U.S. (Curtin et al., 2023) Progress has been made in identifying risks leading to suicide attempts, (Barak-Corren et al., 2020; Lalovic et al., 2022; Sudol and Mann, 2017) but knowledge of risks specific to the outcome of suicide death remain largely elusive. (Belsher et al., 2019; Franklin et al., 2017) At this time, nonfatal suicide attempt remains the strongest predictor of later suicide death, (Berrouiguet et al., 2018; Geulayov et al., 2019; Vuagnat et al., 2019) but few individuals who make suicide attempts go on to die by suicide. Estimates range from only 2.5 % (three-year follow-up period) (Liu et al., 2020) to 3.9 % (five-year follow-up period) (Carroll et al., 2014) to 7 % (nine-year follow-up period). (Owens et al., 2002)

The need to study risks specific to suicide mortality is therefore imperative. As an outcome, suicide death is distinct in many ways from

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https://doi.org/10.1016/j.psychres.2025.116391
Received 17 May 2024; Received in revised form 17 December 2024; Accepted 5 February 2025
Available online 24 February 2025

suicide attempt. While suicide attempt is more than twice as likely in females than in males, (Bachmann, 2018) suicide death is close to four times more frequent in men compared to women in the U.S. and many other countries. (Lovero et al., 2023; Ritchie et al.) Recent results are also beginning to reveal genetic factors specific to risk of suicide death independent of genetic risks associated with psychopathology and/or suicide attempt. (Docherty et al., 2023; Mullins et al., 2022; Docherty et al., 2020) However, suicide deaths are comprised of two roughly equally sized subgroups: those who have evidence of nonfatal attempts, who may be more similar to living individuals with suicidality, and those with no prior nonfatal attempts.

Better understanding of clinical aspects of these subgroups will likely advance understanding of risks leading to suicide mortality. Co-occurring psychopathology has been broadly implicated in risk of nonfatal suicidal outcomes, (Chesney et al., 2014) and is often assumed to be a ubiquitous risk factor also for suicide death. However, evidence indicates that 80 %-90 % of individuals with psychiatric diagnoses will *not* go on to die by suicide, (Nordentoft et al., 2011; Inskip et al., 1998) suggesting that psychiatric risk is unlikely to be a sufficient condition for risk of suicide death. While predictive models of suicide attempt and suicide death within populations of individuals with psychiatric diagnoses are reaching acceptable rates of risk prediction, (Fredriksen et al., 2022; Simon et al., 2018) studies within non-clinic samples reveal a more complex risk landscape that strongly implicates aspects of physical health and other risks in addition to psychiatric diagnoes. (Stone et al., 2018; Stene-Larsen and Reneflot, 2019; Cavanagh et al., 2023) Recent work has further highlighted the multidimensional and transdiagnostic nature of risk of suicide death with modifiable risk factors found across disparate clinical and environmental domains including physical illness and sociodemographic and environmental factors. (Favril et al., 2023) In a latent class analysis of suicide death in the National Violent Death Reporting System, the largest risk cluster exhibited physical health conditions with low prior nonfatal suicidality and little evidence of psychiatric risk. (Xiao et al., 2024) It is unknown the degree to which the difference in clinical risks represent underlying biological differences versus societal and care delivery issues (e.g., undiagnosed mental health conditions due to insufficient mental health screening, lack of access to mental health services, and/or lack of care-seeking behavior).

Our study compared the characteristics of suicide deaths with and without evidence of prior nonfatal suicidality through comprehensive characterization of the large, population-ascertained sample of individuals who died by suicide in the Utah Suicide Mortality Risk Study (USMRS), stratifying by presence versus absence of prior suicidal ideation and/or nonfatal suicidal behavior (SI/SB) documented in the healthcare system. Because SI/SB is not well captured with diagnoses in the electronic health records (EHR), we supplemented case and control ascertainment using data from Natural Language Processing (NLP) of free text health care notes.

2. Methods

2.1. Sample

This study used data from a subset of 4000 suicide deaths who died between 1996 and 2022 from the Utah Suicide Mortality Risk Study (USMRS) sample with available EHR diagnoses and clinical notes in the University of Utah Health Sciences Center (UUHSC) system, one of two large health care providers in Utah. The USMRS resource has been described in detail elsewhere. (Docherty et al., 2020) Briefly, suicide determination was made by the centralized Utah State Office of the Medical Examiner (OME) following detailed investigation of the scene and circumstances of the death. Because Utah has a single central OME, all deaths in this study were evaluated by the same office/processes, providing a consistent approach to suicide determination, an advantage over states with decentralized systems. Deaths were securely linked to health data within the Utah Population Database (UPDB,) (University of Utah Health and University of Utah Huntsman Cancer Institute, 2024) by UPDB staff. The UPDB is a state-wide database that contains over 27 million data records on over 11 million individuals, including demographic information and two decades of health records data. Data linking and NLP processing was done by UPDB staff who serve as honest data brokers outside of the research team whose task is to link and de-identify information. (Choi et al., 2015) Identifiers were subsequently stripped, rare diagnoses and demographic groups were aggregated, and NLP results were collapsed into ratings of positive/negative suicidality before data were given to the research team to protect privacy and confidentiality. For each suicide death, records from ten living individuals in the Utah population with the same sex and birth year were matched using at-risk sampling to minimize possible sampling biases. (Mansournia et al., 2013) Only health records up to the time of matching to the index suicide death were studied, and 39 controls who died by suicide after matching were removed from the control group for this study. Because controls were matched using only sex and birth year, and because we limited the study to those with clinical notes in the UUHSC system for NLP processing, not all linked to health records resulting in 26,152 matched controls. Control data were similarly processed, aggregated, and stripped of identifiers prior to analysis by the research team. This study was approved by Institutional Review Boards from the University of Utah and the Utah Department of Health and Human Services.

2.2. Diagnostic data

Suicides and controls were defined as having nonfatal suicidality in part from diagnostic data through ICD-9 or ICD-10 diagnoses. (Centers for Disease Control and Prevention, National Center for Health Statistics, 2024a; Centers for Disease Control and Prevention, National Center for Health Statistics, 2024b) The codes designating suicidal ideation or behavior (SI/SB) are listed in Supplemental Table S1. For suicide deaths, diagnoses that occurred within one week prior to death were excluded by our honest data brokers to eliminate health-related diagnoses that were a consequence of the final fatal suicide event (e.g., death-related cardiac arrest, respiratory failure, etc.) rather than erroneously misinterpreting this documentation of death-related events as reflecting prior health conditions associated with suicide risk. We acknowledge this conservative approach may miss some pre-existing health conditions with true associations to risk. For this analysis, ideation and behavior were combined into a single variable to be as conservative as possible in eliminating suicidality from the case and control groups assumed to have no SI/SB. Our data permissions require us to collapse diagnoses and determination of suicidality from NLP to consider the number of diagnostic events but not the timing of events, so we did not study time-to-event of prior suicidality to later suicide death.

2.3. NLP from health care notes

The NLP was based on the criteria for suicidal behavior and ideation in the Columbia Suicide Severity Scale CSSRS, (Posner et al., 2011) a questionnaire widely used in clinical practice and by agencies such as the FDA to assess the presence of SI/SB. The NLP is a rule-based algorithm detecting free text terms indicating current and lifetime suicidal behaviors and ideation. A version of this algorithm was validated in two large health care systems in the US and UK. (Cusick et al., 2022) The algorithm identifies both affirmative and negative mentions, and assigns a positive score if there is at least one affirmative mention. We manually validated the NLP in our Utah health records system on a pilot sample of notes from Utah suicide deaths and controls, finding a precision of 0.936 and an F1 score of 0.967 (see Supplemental tables S2-S7 for details). As with the diagnostic data, suicidal ideation and behavior from the NLP were combined.

Table 1
Tests of independent effects of age, sex, and number of diagnostic codes between suicide deaths and population controls with and without prior nonfatal suicide ideation or behavior (SI/SB), where SI/SB was determined from both diagnostic codes and NLP of EHR notes.

Characteristic	CTL_None (22,816)	CTL_SI/SB (3375)	All CTL (26,191)	SUI_None (1747)	SUI_SI/SB (2253)	All SUI (4000)	Effect of suicide death: OR (CI, p-value)	Effect of having SI/SB: OR (CI, p-value
Mean age (std dev)	47.01 (17.71)	40.31 (15.29)	46.14 (17.56)	47.73 (18.14)	41.77 (15.07)	44.35 (16.73_	0.988 (0.986–0.990, <0.0001))	0.961 (0.959–0.963, <0.0001)
Percent male[1]	73.30 %	69.96 %	72.86 %	80.53 %	63.31 %	70.76 %	1.05 (0.97–1.13, NS)	1.02 (0.95–1.10, NS)
Mean overall N PheCodes (std dev)[2]	47.27 (48.94)	96.59 (89.28)	53.65 (58.23)	51.81 (49.01)	95.74 (90.48)	76.75 (78.47)	1.123 (1.113–1.134, <0.0001)	1.324 (1.311–1.337, <0.0001)

[1] Coded male=1, female=0 for the logistic regression test.
[2] Raw N of codes is presented; for statistical testing, this variable was square root transformed because of skewness.

2.4. Group definition and analyses using diagnostic codes and NLP

A suicide death or control was defined as positive for prior nonfatal suicidality (SI/SB) from relevant ICD-9/ICD-10 codes and from the NLP screened across all types of health care notes if at least one note was positive for current or historical ideation or behavior (SI/SB). This definition resulted in inclusive groups for SUI_SI/SB and CTL_SI/SB, with SUI_None and CTL_None being exclusive of documented prior suicidality. Importantly, as with the diagnostic ICD data, NLP from notes within one week prior to suicide death were excluded to eliminate mentions associated with the fatal attempt.

2.5. Other co-occurring conditions relating to mental health

Mental health diagnoses collapsed into interpretable groups using the hierarchical classification of diagnoses in the PheWAS catalog (Denny et al., 2010, Bush et al., 2016) (PheCode Map 1.2 ICD10-CM), as implemented in the PheWAS R package. (Carroll, 2014) We began with the 1866 detailed PheCodes, then retained 64 PheCodes associated with mental health, omitting those that substantially overlapped with diagnostic codes that defined the SI/SB groups in our study or that were overly general and difficult to interpret (Supplemental Table S8). Logistic regression was used wherein each PheCode was regressed first on all suicides vs. all controls (suicide death effect, independent of presence of SI/SB) and then in separate models on all with SI/SB vs. all without SI/SB (independent of suicide or control status) to determine the relative independent impacts of suicide death versus presence of SI/SB. All tests adjusted for covariates detailed below. Results are reported as odds ratios from the models. The results represent the estimated odds of the binary outcome (suicide death vs. control, or presence vs. absence of non-fatal suicidality) resulting from the predictor (presence of a mental or physical health PheCode), accounting for covariates (age, sex, and number of diagnostic codes). (Norton and Dowd, 2018) The adjusted significance threshold for the tests of the 64 mental health PheCodes was $0.05/(2 \times 64) = 3.91E\text{-}04$. A mapping of each of the PheCodes to its specific ICD-9 and ICD-10 codes for 36 of the 64 mental health PheCodes where either the effect of suicide death or the effect of presence of SI/SB met this significance threshold is given in Supplemental Table S9.

2.6. Additional analyses of PheCodes associated with physical health conditions

We studied 319 relatively common physical health PheCodes where each code had a prevalence of 5 % or greater in any one of the four study groups (CTL_None, CTL_SI/SB, SUI_None, SUI_SI/SB). As with the mental health analysis, each PheCode was regressed first on case/control status (suicide death effect) and then in separate models on presence of SI/SB, adjusting for covariates. The significance threshold was $0.05/(2 \times 319) = 7.84E\text{-}05$. Health conditions spanned multiple clinical areas.

2.7. Covariates for PheCode analyses

All analyses were adjusted for effects of age and sex. In addition, we observed significantly more diagnoses of both mental and physical health among SUI_SI/SB and CTL_SI/SB groups than the SUI_None and CTL_None groups. This effect introduces bias such that any co-occurring condition would systematically have more chance of being observed in the SUI_SI/SB and CTL_SI/SB groups (informative presence bias). (Goldstein et al., 2016, Williams, 2021) For tests of specific conditions, we therefore additionally adjusted for overall number of ICD diagnoses, applying a square root transformation because of skewness in the distribution of observed number of diagnoses.

2.8. Sensitivity tests

Additional sensitivity tests assessed for: nonlinear effects of age to assure that results particularly for later onset diagnoses were not altered by more complex age effects; age x sex interaction effects to assure that results were not driven by more complex interactions; and year of death time-period cohort effect (defined in 5-year increments: <1996–2002, 2003–2007, 2008–2012, 2013–2017, 2018–2022) to assure that results were not altered by shifting trends in diagnostic practices. The first grouping (1996–2002) included 1996 and 1997 because of sparse electronic health records data from those years. Within the suicide death groups, we tested for effects of violent method of death to assure that diagnostic effects were not substantively driven by associations with lethality. Violent method of death was defined as gun-related, hanging, cutting, or other violent trauma.

3. Results

3.1. Defining presence/absence of nonfatal suicidality

Diagnoses within the UUHSC system linked to 4000 Utah suicide deaths. Of these, 1669/4000=41.73 % had evidence of prior nonfatal suicidality (SI/SB) from ICD-9 or ICD-10 codes. In addition, these deaths had 262,289 UUHSC health care notes across all types of encounters that were annotated by the NLP. Adding positive nonfatal suicidality from NLP to the determination from ICD codes resulted in 2253/4000=56.33 % in the overall SUI_SI/SB group from all sources, an increase of 32 % over and above the determination from ICD codes alone. Disagreement between determination of positive SI/SB from ICD codes vs. notes were primarily due to instances where there was a positive mention in notes but no corresponding positive ICD code ($N = 584$). Of note, only 24/4000=0.6 % of suicides had an ICD diagnostic code for suicidality, but no positive designation from the NLP, either due to missing note data ($N = 16$) or false negative rating in the NLP ($N = 8$).

Similarly, ICD data and NLP data were used to define control groups with SI/SB (CTL-SI/SB) and without SI/SB (CTL-None). There were 26,191 controls with diagnostic data in the UUHSC system. Of these, 1686/26,191=6.44 % were positive for SI/SB using ICD-9 or ICD-10 diagnostic codes. For these 26,191 controls, a total of 1005,814 UUHSC notes across all types of encounters were annotated using the

Table 2
Results from logistic regressions of presence/absence of mental health PheCodes on case-control status (suicide death effect) and also on presence/absence of SI/SB (presence of SI/SB effect).

PheCode	Grouping	Odds ratio: suicide death (p-value)	Odds ratio: presence SI/SB (p-value)
Depression	Affective	**2.56 (8.32E-85)**	**8.45 (<*E*-350)**
Bipolar	Affective	**2.21 (3.31E-42)**	**8.32 (1.47E-283)**
Major Depressive Disorder	Affective	**1.86 (3.34E-35)**	**11.07 (<*E*-350)**
Dysthymic disorders	Affective	**1.56 (3.50E-11)**	**3.50 (6.96E-81)**
Other mood disorders	Affective	**1.44 (4.76E-08)**	**7.44 (2.26E-193)**
Somatoform disorder	Anxiety/stress	**2.38 (9.54E-14)**	**2.43 (1.96E-12)**
Anxiety-related states & conditions	Anxiety/stress	**2.20 (7.03E-35)**	**14.88 (8.18E-304)**
Posttraumatic stress disorder	Anxiety/stress	**2.09 (5.29E-24)**	**6.78 (9.40E-132)**
Anxiety disorder	Anxiety/stress	**2.03 (1.78E-52)**	**4.01 (1.13E-265)**
Agoraphobia, social phobia, panic disorder	Anxiety/stress	**1.70 (3.76E-16)**	**4.57 (1.50E-122)**
Obsessive-compulsive disorders	Anxiety/stress	**1.50 (8.77E-05)**	**5.48 (2.11E-53)**
Generalized anxiety disorder	Anxiety/stress	**1.43 (4.08E-10)**	**5.01 (2.34E-203)**
Eating disorders	Anxiety/stress	1.62 (0.015)	**4.56 (3.27E-11)**
Acute reaction to stress	Anxiety/stress	1.31 (0.0069)	**2.13 (4.20E-15)**
Adjustment reaction	Anxiety/stress	1.28 (0.0027)	**3.43 (1.77E-54)**
Personality disorders (excluding antisocial PD and borderline PD)	PD	**2.61 (2.72E-28)**	**10.61 (5.20E-109)**
Antisocial PD & borderline PD	PD	**2.42 (8.66E-23)**	**11.10 (2.29E-101**
Conduct disorders	Impulsive	1.98 (0.072)	**5.56 (6.02E-65)**
Attention deficit hyperactivity disorder	Impulsive	1.97 (0.0067)	**3.18 (2.59E-81)**
Developmental delays & disorders	Developmental	1.08 (0.301)	**2.69 (7.70E-56)**
Delirium	Psychotic	**2.37 (1.10E-18)**	**2.75 (8.77E-23)**
Alteration of consciousness	Psychotic	**2.18 (2.55E-30)**	**2.42 (9.57E-39)**
Paranoid disorders	Psychotic	**2.08 (5.77E-13)**	**8.90 (4.87E-73)**
Psychosis	Psychotic	**1.98 (1.77E-23)**	**6.18 (5.65E-142)**
Schizophrenia	Psychotic	**1.90 (9.66E-15)**	**10.37 (1.15E-134)**
Altered mental status	Psychotic	**1.86 (2.88E-17)**	**2.43 (2.19E-35)**
Hallucinations	Psychotic	1.46 (0.0014)	**7.24 (3.89E-48)**
Substance addiction & disorders	SUD	**3.00 (1.95E-113)**	**5.18 (2.51E-308)**
Alcoholism	SUD	**2.77 (6.01E-94)**	**4.16 (1.96E-197)**
Alcohol-related disorders	SUD	**2.75 (4.06E-68)**	**5.23 (2.13E-170)**
Adverse events of opiates & narcotics in therapeutic use	SUD	**2.10 (2.54E-24)**	**2.02 (7.75E-23)**
Tobacco use disorder	SUD	**2.05 (6.96E-67)**	**2.10 (6.97E-85)**

Notes. Odds ratios were derived from logistic regressions (Norton and Dowd, 2018). Each binary presence/absence PheCode was regressed on case-control status (suicide death effect) and then on presence/absence of SI/SB (presence SI/SB effect), adjusting for age, sex, and transformed overall number of PheCodes. Tests that were significant after adjustment for multiple testing are shown in bold type.

NLP. Adding positive controls for SI/SB using the NLP to the determination using ICD codes resulted in 3375/26,191=12.89 %, approximately doubling the positive rate over the determination from ICD codes alone. Disagreement in positive SI/SB determination was again predominantly driven by positive mentions in notes without corresponding ICD diagnoses positive for SI/SB ($N = 1689$). Instances where ICD was positive but the NLP was not positive occurred in 30 controls, with 22 of these due to false negative NLP results.

Table 1 shows basic descriptive characteristics of Utah suicide deaths and controls with SI/SB and without SI/SB. Significant differences of age and number of PheCodes were found between suicides and controls (independent of presence of SI/SB), and between all with SI/SB vs. all without SI/SB (independent of case status). All covariates were retained for subsequent analyses including effects of sex due to expected residual effects of sex on diagnoses associated with mental health.

3.2. Diagnostic comparisons of mental health conditions

Of the 64 PheCodes included, 32 were significant using the adjusted threshold of 3.915E-04 for either the effect of suicide death or the presence vs. absence of SI/SB effects (Table 2, Fig. 1). Of the 32 other mental health PheCodes without significant effects, 27 were relatively rare in our study sample, with <5 % prevalence across all four of the comparison groups (SUI_SI/SB, SUI_None, CTL_SI/SB, and CTL_None).

Across the 32 significant mental health PheCodes, presence of mental health diagnoses was much more strongly associated with presence/absence of SI/SB than with suicide death (Table 2). Indeed, on average, presence of SI/SB on psychiatric diagnoses had odds ratios over three times greater than the odds ratios for suicide death (Table 2 and Fig. 1). The difference in the associations of SI/SB vs. suicide death was smallest for substance use disorders, and greatest for developmental disorders, conduct disorder, and ADHD.

Supplemental Figure 1 shows the prevalence of PheCodes within each subgroup (CTL_None, CTL_SI/SB, SUI_None, SUI_SI/SB) adjusted for effects of age, sex, and transformed overall number of diagnoses, further illustrating the differences in associations of suicide death vs. associations of presence of SI/SB. The figure shows SUI_SI/SB is generally more similar to CTL_SI/SB than to SUI_None, with exceptions for tobacco use disorder and adverse effects of opioids.

3.3. Characteristics involving other physical health conditions

Of the 319 physical health PheCodes, 133 were significantly associated with either suicide death or presence of SI/SB. Among these, 82 PheCodes showed significant effects only in the protective direction (odds ratio < 1) for either suicide death or presence of SI/SB (Supplemental Table S10). While these PheCodes are of interest and include many common physical health conditions, they will be the focus of future studies, as this analysis is focused on aspects leading to suicide risk. The results presented in Table 3 and Fig. 2 therefore reflect 51 PheCodes with significant positive (risk) effects associated with either suicide death or presence of SI/SB. Of note, certain other common physical conditions (dementias, for example), did not show significant risk or protective associations and are therefore not included either in Table 3 or in table S10.

In contrast to the mental health conditions, these PheCode results showed on average larger odds ratios associated with suicide death than with presence of SI/SB (Fig. 2). For 27 of the 51 PheCodes, there was a significant association with suicide death but no significant association with presence of SI/SB. An additional 10 of the PheCodes showed significant but smaller associations with SI/SB than with suicide death, and five PheCodes had approximately equivalent effects. Results also included three conditions with opposing significant results: positive

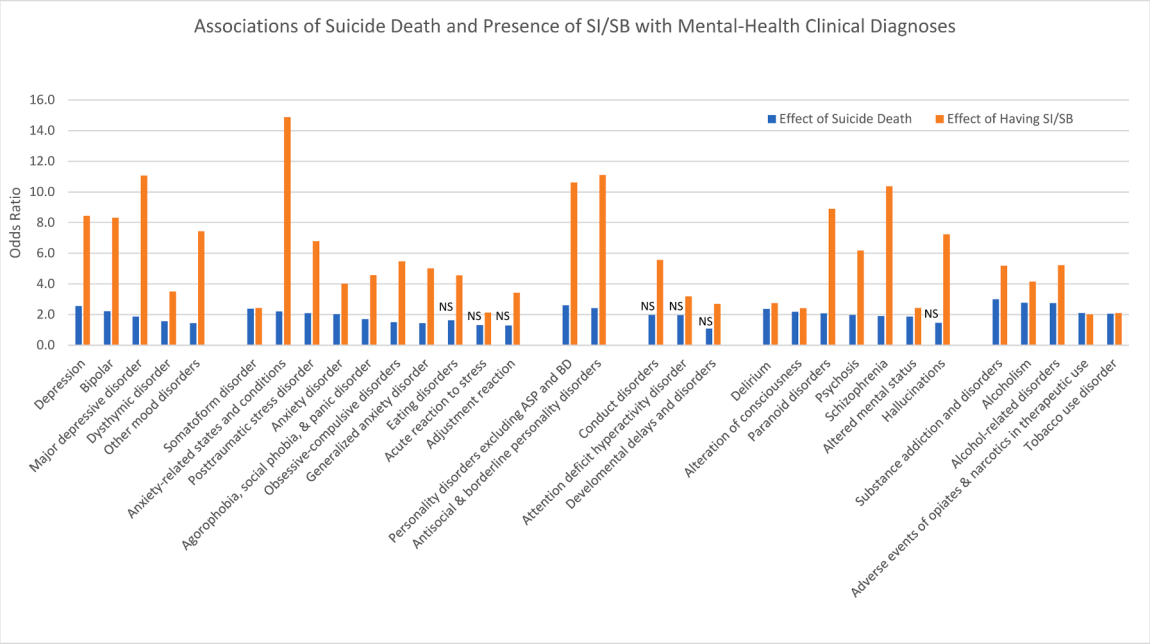


Fig. 1. Results from logistic regressions of presence/absence of mental health PheCodes on case-control status (blue: suicide death effect) and also on presence/absence of SI/SB (red: have SI/SB effect).
Note. Odds ratios were derived from logistic regressions.(Norton and Dowd, 2018) Each binary presence/absence PheCode was regressed on case-control status (blue: suicide death effect) and on presence/absence of SI/SB (red: have SI/SB effect), adjusting for age, sex, and transformed overall number of PheCodes.

(risk) associations with suicide death and protective associations (odds ratio < 1) with presence of SI/SB. Only six of the physical health PheCodes showed stronger associations with SI/SB than suicide death.

3.4. Sensitivity tests of non-linear age effects and age by sex interactions

Main analyses used a primary, parsimonious, simple model with adjustment only for age, sex, and transformed overall N of diagnoses. For the results in Tables 2 and 3, we additionally applied sensitivity tests for nonlinear effects of age, for age by sex interactions, and for time period cohort effects. Inclusion of these additional covariates did not alter significance status of main effects, and the prevalence (adjusted for covariates) of mental health-associated PheCodes changed only modestly, resulting in average changes of 0.005, 0.004, 0.003, and 0.001 for CTL_None, CTL_SI/SB, SUI_None, and SUI_SI/SB, respectively (Supplemental Table S11). Results were similar for PheCodes associated with physical conditions, again not altering overall main effects, and resulting in only modest changes in prevalence (0.008, 0.007, 0.005, and 0.003, for CTL_None, CTL_SI/SB, SUI_None, and SUI_SI/SB, respectively; Supplemental Table S12).

3.5. Violent vs. non-violent method of suicide death

Sensitivity tests of violent suicide death (adjusting for age, sex, and transformed N of diagnoses) were limited to the 2 suicide death groups. The effect of violent death on prevalence of mental health PheCodes across the four groups was not significant adjusting for multiple testing, with a few exceptions, including significantly decreased prevalence of Depression, Anxiety-related conditions, Substance addiction and disorders, and Opioid adverse events (Supplemental Table S13). These observed changes were independent of occurrence of SI/SB and did not affect overall substantive results. No physical health PheCodes had significant effects of violent death after adjusting for multiple testing.

4. Discussion

This study provides characterization of a large sample ($N = 4000$) of suicide deaths with evidence of prior nonfatal suicidal ideation or behavior (SI/SB) versus those with no prior evidence of SI/SB, comparing to data from 26,152 matched controls with and without SI/SB. Evidence of nonfatal suicidal ideation or behaviors (SUI_SI/SB and CTL_SI/SB) came from sources including diagnostic codes supplemented by information from NLP applied to notes in the EHR. Defining groups for presence/absence of SI/SB using both diagnoses and the NLP resulted in more accurate determination; the NLP increased the SUI_SI/SB group size by about 35 %, and the CTL_SI/SB group size by about 50 %. The performance of this NLP suggests the importance of not relying solely on the ICD diagnostic system to identify those with positive suicidality. Importantly, the defined groups without SI/SB (SUI_None and CTL_None) were less likely to have false negative instances of undetected SI/SB than if SI/SB determination had only been based on ICD diagnostic codes.

Demographic comparisons of the four resulting groups showed that the SUI_SI/SB and CTL_SI/SB groups both were significantly younger at death (or matching age) than SUI_None and CTL_None ($p < 0.0001$), and both had significantly more diagnoses across all PheCodes ($p < 0.0001$), replicating previous results. (Ahmedani et al., 2019) We adjusted subsequent tests for this significant systematic difference in diagnoses following recommendations as described elsewhere. (Carroll, 2014, Norton and Dowd, 2018)

Tests of clinical diagnoses used PheCodes from the PheWAS hierarchical classification system, (Posner et al., 2011, Cusick et al., 2022) allowing us to collapse similar codes into interpretable groups. Thirty-two mental health related PheCodes were highly significantly increased in both the suicide and control groups with SI/SB. The association between presence of SI/SB and psychiatric diagnoses was on average over three times greater than the association with suicide death. Prevalence of PheCodes were strikingly similar across SUI_SI/SB and CTL_SI/SB for most psychiatric diagnoses; presence of SI/SB appears to be much more substantially associated with psychopathology than with suicide death. Sensitivity tests of non-linear effects of age, interactions, a time-period cohort effect, and violent method of death did not substantively alter these results.

Tests of physical health PheCodes resulted in a markedly different

Table 3
Results from logistic regressions of presence/absence of physical health PheCodes on case-control status (suicide death effect) and also on presence/absence of SI/SB (presence of SI/SB effect).

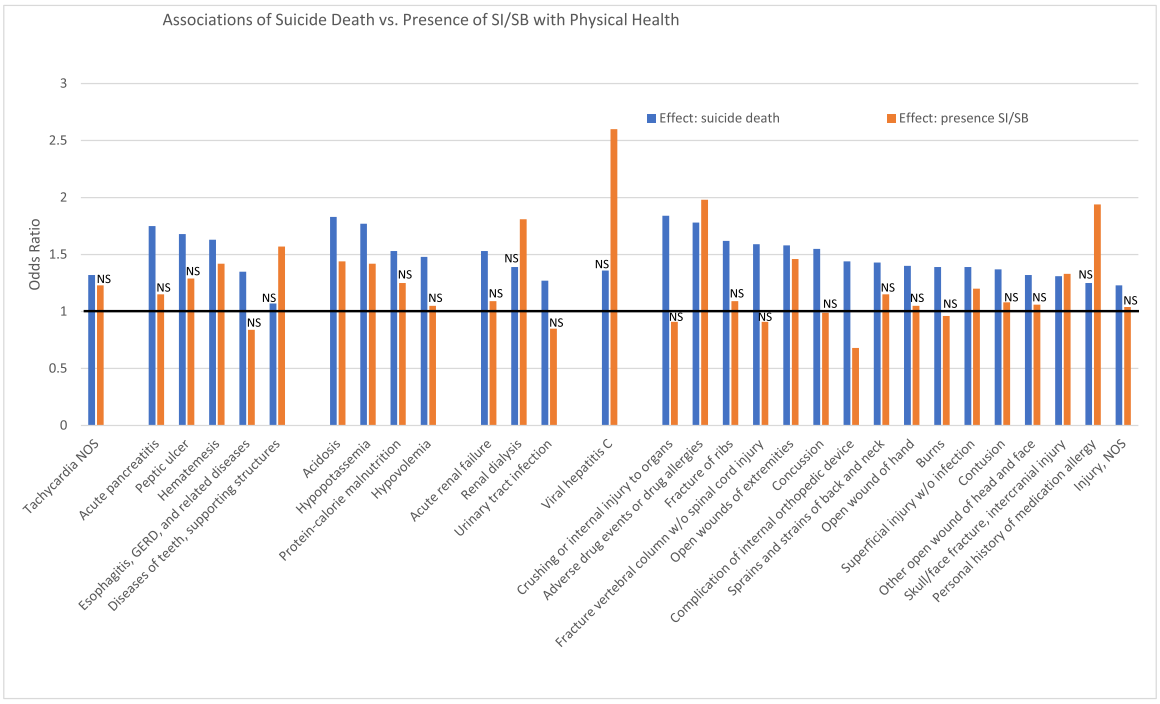
PheCode	Grouping	Effect: suicide death (p-value)	Effect: presence SI/SB (p-value)
Tachycardia NOS	Circulatory	**1.32 (1.11E-05)**	1.23 (2.20E-04)
Acute pancreatitis	Digestive	**1.75 (2.35E-08)**	1.15 (0.161)
Peptic ulcer	Digestive	**1.68 (6.72E-10)**	1.29 (0.0022)
Hematemesis	Digestive	**1.63 (4.29E-05)**	1.42 (0.0027)
Esophagitis, GERD, and related diseases	Digestive	**1.35 (7.36E-05)**	0.84 (0.0087)
Diseases of teeth and supporting structures	Digestive	1.07 (0.437)	**1.57 (2.15E-08)**
Acidosis	Endocrine	**1.83 (8.59E-16)**	**1.44 (4.69E-07)**
Hypopotassemia	Endocrine	**1.77 (2.48E-20)**	**1.42 (2.41E-09)**
Protein-calorie malnutrition	Endocrine	**1.53 (7.01E-07)**	1.25 (0.0070)
Hypovolemia	Endocrine	**1.48 (3.23E-14)**	1.05 (0.257)
Acute renal failure	Genitourinary	**1.53 (1.25E-08)**	1.09 (0.257)
Renal dialysis	Genitourinary	1.39 (0.0033)	**1.81 (2.52E-09)**
Urinary tract infection	Genitourinary	**1.27 (2.39E-05)**	0.85 (0.0015)
Viral hepatitis C	Infectious	1.36 (0.0047)	**2.60 (2.33E-19)**
Crushing or internal injury to organs	Injuries	**1.84 (4.19E-11)**	0.91 (0.238)
Adverse drug events or drug allergies	Injuries	**1.78 (2.66E-20)**	**1.98 (1.37E-31)**
Fracture of ribs	Injuries	**1.62 (3.01E-08)**	1.09 (0.291)
Fracture of vertebral column w/o spinal cord injury	Injuries	**1.59 (5.14E-06)**	0.91 (0.277)
Open wounds of extremities	Injuries	**1.58 (1.39E-17)**	**1.46 (3.19E-14)**
Concussion	Injuries	**1.55 (1.99E-10)**	0.99 (0.807)
Complication of internal orthopedic device	Injuries	**1.44 (2.62E-05)**	**0.68 (2.99E-06)**
Sprains and strains of back and neck	Injuries	**1.43 (1.72E-14)**	1.15 (0.00104)
Open wound of hand	Injuries	**1.40 (2.32E-06)**	1.05 (0.498)
Burns	Injuries	**1.39 (4.76E-05)**	0.96 (0.596)
Superficial injury w/o infection	Injuries	**1.39 (1.36E-11)**	**1.20 (3.86E-05)**
Contusion	Injuries	**1.37 (1.88E-13)**	1.08 (0.0456)
Open wound of head and face	Injuries	**1.32 (1.27E-07)**	1.06 (0.211)
Skull and face fracture and other intercranial injury	Injuries	**1.31 (2.22E-05)**	**1.33 (9.39E-05)**
Personal history of medication allergy	Injuries	1.25 (0.0184)	**1.94 (1.18E-13)**
Injury, NOS	Injuries	**1.23 (2.36E-06)**	1.04 (0.366)
Other and unspecified disc disorder	Musculoskeletal	**1.60 (3.88E-08)**	0.77 (0.0015)
Degeneration of intervertebral disc	Musculoskeletal	**1.32 (6.00E-07)**	**0.79 (1.15E-05)**
Spondylosis w/o myelopathy	Musculoskeletal	**1.29 (2.70E-05)**	**0.76 (7.89E-07)**
Displacement of intervertebral disc	Musculoskeletal	**1.28 (4.76E-05)**	0.81 (2.63E-04)
Chronic pain syndrome	Neurologic	**2.13 (5.09E-12)**	**1.66 (6.23E-06)**
Convulsions	Neurologic	**1.71 (1.86E-16)**	**1.36 (6.82E-07)**
Encephalopathy	Neurologic	**1.59 (1.16E-06)**	**1.67 (2.59E-08)**
Unspecified disorders of nervous system	Neurologic	**1.58 (9.20E-06)**	**1.53 (2.71E-05)**
Coma	Neurologic	**1.56 (8.14e-05)**	**2.18 (5.78E-12)**
Insomnia	Neurologic	**1.44 (1.64E-12)**	**2.53 (1.92E-88)**
Chronic pain conditions	Neurologic	**1.43 (3.27E-10)**	**1.50 (2.26E-15)**
Abnormal involuntary movements	Neurologic	**1.40 (1.44E-05)**	**1.44 (8.44E-07)**
Migraine	Neurologic	**1.35 (1.49E-06)**	1.21 (8.22E-04)
Other sleep disorders	Neurologic	0.84 (0.0363)	**1.42 (1.52E-06)**
Pneumonitis due to inhalation of food or vomit	Respiratory	**2.63 (5.14E-25)**	**2.18 (2.10E-15)**
Respiratory failure	Respiratory	**2.09 (3.50E-23)**	1.28 (6.11E-04)
Chronic airway obstruction	Respiratory	**1.62 (9.79E-08)**	1.11 (0.259)
Asphyxia and hypoxemia	Respiratory	**1.32 (4.77E-05)**	0.99 (0.767)
Rhabdomyolysis	Symptoms	**2.50 (3.10E-13)**	**2.82 (3.51E-14)**
Syncope and collapse	Symptoms	**1.28 (2.21E-05)**	1.10 (0.0699)
Cervicalgia	Symptoms	**1.28 (3.15E-06)**	0.96 (0.322)

1 Symptoms is a PheWas category including symptoms resulting from conditions across multiple clinical domains.
Notes. Odds ratios were derived from logistic regressions (Norton and Dowd, 2018). Each binary presence/absence PheCode was regressed on case-control status (suicide death effect) and then on presence/absence of SI/SB (presence SI/SB effect), adjusting for age, sex, and transformed overall number of PheCodes. Tests that were significant after adjustment for multiple testing are shown in bold type.

pattern, with significant effects associated with suicide death that were, on average, larger than effects associated with presence of SI/SB. These results replicate a large recent latent class study of suicide death. (Xiao et al., 2024) PheCodes with markedly higher suicide death associations than presence of SI/SB included those with challenging chronic pain and/or disability (spondylosis, degeneration or displacement of intervertebral discs, complications from an internal orthopedic device). In general, the conditions significant for suicide death were enriched for diagnoses associated with injuries and neurologic conditions associated with pain. While some of these may represent unreported suicide attempts (e.g., Open wounds of extremities, Adverse drug events or drug allergies), those with strong suicide death associations may have clinical relevance in the implication of pain as a risk factor leading to suicide mortality, even in the absence of documented SI/SB.

4.1. Limitations

The differences in clinical data specifically associated with mental health could result from less care-seeking behavior in the SUI_None group, which could stem from lack of access to mental health care services or social stigma, issues we are unable to measure in this study. We did attempt to minimize this possible effect by including data only from individuals with evidence of encounters with the health care system, and by adjusting all tests for the number of diagnostic codes in the records.



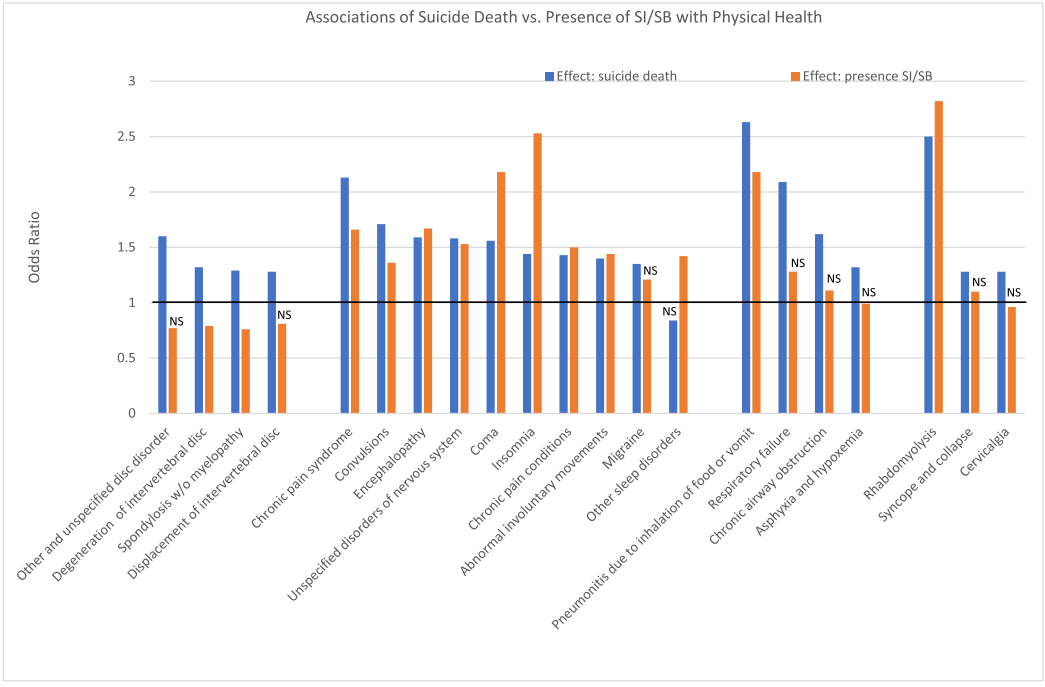


Fig. 2. Results from logistic regressions of presence/absence of physical health PheCodes on case-control status (blue: suicide death effect) and also on presence/absence of SI/SB (red: have SI/SB effect).
Note. Odds ratios were derived from logistic regressions.(Norton and Dowd, 2018) Each binary presence/absence PheCode was regressed on case-control status (blue: suicide death effect) and on presence/absence of SI/SB (red: have SI/SB effect), adjusting for age, sex, and transformed overall number of PheCodes. Odds ratios below 1.0 represent protective effects.

Additionally, our data resource requires that SI/SB is defined medically by the administrative data available in the EHR. Though we attempted to minimize this effect through our addition of SI/SB from NLP in EHR notes, some of those in the SUI_None and CTL _None groups were likely experiencing undocumented nonfatal SI/SB or by non-medically defined SI/SB. Importantly, our findings are limited to those individuals who are identified as dying by suicide, but may not be applicable to those whose suicide death is not able to be confidently identified based on current medical examiner processes. We note that while our data represent state-wide population ascertainment, results may not be generalizable to other populations.

Importantly, in our data, number of PheCodes is highly associated with number of clinical notes available for NLP, as notes and PheCodes are both consequences of clinical encounters. We observed a larger number of PheCodes, and also a larger number of notes for NLP among suicides compared to controls, suggesting that availability of

information (both diagnostic, and text for NLP) for determination of SI/SB was likely greater among suicide deaths than controls. Therefore, accuracy of determination of SI/SB may be decreased among controls as compared to suicide deaths. However, this effect would result in more undetected SI/SB within the CTL_None group, making this group more similar to the CTL_SI/SB and SUI_SI/SB groups, and conservatively diminishing the striking similarity in our results between SUI_None (presumably more accurately absent of SI/SB) and CTL_None (presumably with more undetected SI/SB).

4.2. Conclusions

This study uses a population-ascertained resource of suicide deaths and age-/birth year-matched control data to begin to address suicide mortality knowledge gaps. We augmented the definition of presence of SI/SB using both diagnoses and NLP of health notes to provide more inclusive groups with SI/SB and groups without SI/SB that are less likely to include false negatives. Results suggested powerful associations of presence of nonfatal SI/SB with psychopathology, with effects far overshadowing associations between psychopathology and suicide death. Results additionally implicated other physical conditions, particularly those associated with injury and pain, as potentially having specific relevance for risk of suicide death in the absence of documented prior nonfatal SI/SB. In addition to replication of these results, definitive tests for additional underlying biological vulnerabilities that could partially drive these observed clinical results will require further study. However, these results suggest that for a substantial number of individuals at risk for suicide mortality, SI/SB does not serve as an effective clinical marker of risk, with implications for traditionally applied screening efforts.

Declaration of generative AI and AI-assisted technologies in the writing process

No AI tools were used in the writing of this manuscript.

CRediT authorship contribution statement

Hilary Coon: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Andrey A. Shabalin:** Writing – review & editing, Software, Methodology, Formal analysis, Data curation. **Emily DiBlasi:** Writing – review & editing, Methodology, Formal analysis. **Eric T. Monson:** Writing – review & editing, Methodology, Data curation. **Seonggyun Han:** Writing – review & editing, Visualization, Investigation, Data curation. **Erin A. Kaufman:** Writing – review & editing, Visualization. **Danli Chen:** Methodology, Formal analysis, Data curation. **Brent Kious:** Writing – review & editing, Validation, Methodology, Investigation. **Nicolette Molina:** Validation, Methodology, Data curation. **Zhe Yu:** Validation, Data curation. **Michael J. Staley:** Writing – review & editing, Supervision, Investigation, Data curation. **David K. Crockett:** Writing – review & editing, Supervision, Project administration, Data curation. **Sarah M. Colbert:** Writing – review & editing, Validation. **Niamh Mullins:** Writing – review & editing, Validation, Supervision, Investigation, Funding acquisition, Conceptualization. **Amanda V. Bakian:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis. **Anna R. Docherty:** Writing – review & editing, Writing – original draft, Supervision, Methodology. **Brooks R. Keeshin:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

All authors of this study declare no competing financial or personal interests relevant to this work.

Acknowledgments

This work was supported by the National Institute of Health (HC, grant number R01MH122412, R01MH123489; AD, grant number R01MH123619; AVB, grant number R01ES032028); the American Foundation for Suicide Prevention (ED), the Brain & Behavior Research Foundation–NARSAD (ED, grant number 28132; AS grant number 28686); and the Clark Tanner Foundation (HC, AS, EM, AVB). Partial support for all datasets housed within the Utah Population Data Base is provided by the Huntsman Cancer Institute (HCI), http://www.huntsmancancer.org/, and the HCI Cancer Center Support grant, P30CA42014 from the National Cancer Institute. Research was supported by NCRR grant "Sharing statewide health data for genetic research" R01RR021746 with additional support from the Utah Department of Health and Human Services and the University of Utah. We thank University of Utah Health Data Science Services for data and analytics support, and the University of Utah Pedigree and Population Resource and the University of Utah Health Enterprise Data Warehouse for establishing the Master Subject Index between the Utah Population Database and the University of Utah Health Sciences Center. We thank Dr. Hunter Strohmeyer and Dr. Michael Pope for their assistance in manual validation of the NLP pipeline. We thank Drs. Marika Cusick, John Mann, and Jyotishman Pathak for their collaborative help in deploying the NLP pipeline and additional input on this study.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2025.116391.

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