Temporal Patterning and Magnitude of Covariate Risk for Suicidal Thought and Behavior-related Emergency Department Use Across the Perinatal Window: An Oregon Population-Level Analysis

by

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DISSERTATION ABSTRACT

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Title: Temporal Patterning and Magnitude of Covariate Risk for Suicidal Thought and Behavior-related Emergency Department Use Across the Perinatal Window: An Oregon Population-Level Analysis

Introduction: Suicide is a leading cause of maternal death in the United States (U.S.). Concerningly, U.S. suicide deaths during pregnancy and the first full year postpartum — also known as the perinatal window – are increasing. Symptoms of suicide risk, including suicidal thoughts and behaviors (STBs), are also increasing within the perinatal window. However, perinatal suicide screening guidelines are nonexistent due to insufficient evidence. There are significant empirical gaps around identifying which perinatal individuals are at risk for STBs, and anticipating when that risk is most likely to emerge. The current study addressed these gaps by leveraging administrative healthcare data to characterize the magnitude and timing of initial and recurrent STB-flagged emergency department (ED) utilization.

Aims: The current study had three domains of inquiry including: (1) Population Prevalence, (2) Covariate Hazard, and (3) Risk Timing. Aim 1 identified patterns of STB-flagged ED visits and visit recurrence within a population of perinatal individuals giving birth between 2020-2024. Aim 2 examined differential contributions of individual level risk factors within Access and Health Vulnerability domains, including acute care utilization recency, evaluating differential associations with the magnitude of the hazard for initial and recurrent events. Aim 3

leveraged composite vulnerability risk profiles to evaluate whether, how, and to what degree risk profiles influenced the timing of the hazard over prenatal and postpartum periods.

Method: The study was a retrospective population-level cohort study of linked administrative all-payer claims data for perinatal individuals with a live birth observed between 2020-2024. The unit of analysis was the perinatal window (N = 185,431 perinatal windows representing 155,713 perinatal individuals) spanning 280 days before delivery until 365 days after delivery. Data were derived from inpatient, delivery, and emergency department (ED) discharge records. Access Vulnerability (e.g., Age, Race, Insurance Status) were derived from delivery records. Health Vulnerability risk factors (e.g., Psychiatric problems, Substance Use Disorder) and theoretically driven vulnerability profiles were derived from ICD-9 and ICD-10 codes present at historical pre-2020 and perinatal healthcare events. Descriptives and inferential models evaluated the association between STB-associated risk flags and vulnerability profiles with the outcome of interest, either an initial or recurrent STB-flagged ED visit. Inferential methods consisted of piecewise exponential additive mixed models (PAMMs) associating individual level risk factors and vulnerability profiles with the magnitude of hazard for an initial or recurrent STB-flagged ED visit. First-derivative analysis was run on log-hazard curves to identify windows of elevated risk for perinatal STBs using a representative perinatal profile, and for baseline log-hazard curves representing vulnerability profiles.

Results: A small but clinically meaningful proportion of perinatal windows (0.51%) included at least one STB-flagged ED visit, with recurrence observed in approximately 16% of these windows at a median of 34 days between events. STB-flagged visits were more common postpartum than prenatally. The Combined Vulnerability profile accounted for approximately 80% of all STB-flagged visits despite comprising only 40% of the sample. Within the Access

Vulnerability domain, Black and American Indian/Alaska Native racial identity and public or other insurance status were associated with greater hazard, while older maternal age and Hispanic/Latino ethnicity were protective. A history of certain Health Vulnerability risk factors — specifically psychiatric problems or STBs — associated with greater initial and recurrent event risk. Health Vulnerability risk factors including STBs at delivery, psychiatric problems, SUD, and IPV significantly associated with greater hazard when observed at perinatal ED or delivery events. Recency of prior acute care utilization showed a graded association with both the initial and recurrent event hazard, showing the greatest magnitude of association for more recent acute care utilization (i.e. last seven days) and remaining significant when prior acute care utilization took place 90 days prior. The Combined Vulnerability profile was the only profile exhibiting significant nonlinear temporal patterning, with accelerating hazard from delivery through 9.2-9.7 weeks postpartum for both initial and recurrent event hazard.

Conclusion: Study findings indicate that perinatal STB-related ED utilization is temporally patterned and concentrated among individuals with co-occurring sociodemographic and clinical vulnerability. The findings also support surveilling clinical health history, perinatal ED visits, and delivery events for individual level Health Vulnerability risk factors (i.e., STB history, psychiatric history and comorbidity, substance use disorders, and intimate partner violence) to identify who may be at greater risk for perinatal STB observance. The results provide a preliminary evidentiary basis for STB screening as early as pregnancy onset, and between delivery and 9.7 weeks and throughout postpartum for higher risk individuals. Finally, the results suggest that recency of acute care utilization may serve as a clinical indicator of near-term STB risk and subsequent STB screening.

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DEDICATION

I dedicate this project to all women who have struggled with the will to live. This project is just the beginning.

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CHAPTER I

INTRODUCTION

Despite a global decline in maternal mortality rates (WHO, 2025) there has been a paradoxical increase observed in the United States (U.S.) during pregnancy and the first postpartum year (Declercq & Zephyrin, 2025). The U.S. maternal mortality rate is double that observed in peer high-income countries (O'Neil et al., 2021) and maternal mental health conditions are a leading cause of preventable maternal deaths (Gimbel et al., 2024). Among maternal mental health-related causes of death, suicide is the most common, accounting for at least 63% of deaths during pregnancy (Trost et al., 2021) and at least 20% of deaths during the postpartum period (Lindahl et al., 2005). The true rates of suicide deaths during pregnancy and the postpartum period are likely even higher, as maternal deaths by suicide appear to be significantly underestimated (Palladino et al., 2011; Horon & Cheng, 2011; Wallace et al., 2016). In addition, the prevalence of non-fatal suicidal thoughts and behaviors (STBs) — considered as precipitants of later suicide attempts and death — are also increasing among perinatal individuals in the U.S. (Admon et al., 2020). These trends contribute to acknowledgement of perinatal suicide as a current unmet public health need in the U.S. (Kobylski et al., 2023). Despite these concerning trends, there remain significant gaps in understanding around who is at greatest risk for perinatal STB emergence, and when during the perinatal window that risk is likely to emerge. This presents a critical need to investigate these gaps to inform prevention and intervention efforts to mitigate worsening perinatal suicide trends in the U.S.

The perinatal window is vulnerable to the onset and re-emergence of STBs (Gelaye, Kajeepeta, & Williams, 2016; LeCounte et al., 2026) with two sources of risk for STB emergence theorized in this study – developmental and activating. *Developmental risk* arises

from the sensitivity of the developmental transition, particularly from the profound changes in maternal physiology and functioning occurring at developmental inflection points such as pregnancy, delivery, and postpartum. Some examples of these changes include hormonal shifts (Schwartz & Villa, 2025), changes in emotion regulation (Takács et al., 2025; Sejer, Miskowiak, & Bjertrup, 2026), and maternal brain plasticity (Paternina-Die et al., 2024). These changes take place for most perinatal individuals and may introduce instability in maternal regulatory processes at critical time windows. *Activating risk* arises from the emergence or re-activation of pre-existing and contextual risk factors, such as a history of depression, or substance use disorder relapse, both of which are among a cohort of risk factors associated with STBs. What sets activating risk apart from developmental risk is that activating risk factors are not necessarily linked to developmental inflection points and may emerge across the perinatal window at any time, representing individual or group-level differences in STB emergence.

To date, perinatal STB research has examined *activating* risk factors in association with perinatal STBs — such as health and socio-contextual risk factors — but has stopped short of linking the full gamut of risk factors with developmental risk timing. Health related vulnerability factors include prior psychiatric problems, substance use disorders, intimate partner violence, chronic health problems, and non-suicidal self-injury (NSSI) (Peinado-Molina et al., 2025; Legazpi et al., 2022; Zivin et al., 2024; Bright, Doody, & Tuohy, 2022). Socio-contextual vulnerabilities related to perinatal STBs include racial/ethnic identity, rurality, low socioeconomic status, and low social support (Peinado-Molina et al., 2025). When these pre-existing or new-onset activating risk factors co-occur with perinatal-specific physiological strain and emotional-affective changes at developmental inflection points, the accumulation of stressors can overwhelm even the most emotionally resilient individuals (Alves, Cecatti, &

Souza, 2021). This combination may increase situational pressure for STBs at key points in time. However, this theoretical association between activating risk factors and developmental risk timing for STB emergence within the perinatal period has not yet been made in the literature.

This theoretical association is supported by linking leading theories of suicide risk with the transactional model of stress and coping (Lazarus & Folkman, 1984) — and extending this framing to the perinatal transition. Leading suicide theories such as the Integrated Motivational-Volitional (IMV) Model (O'Connor & Kirtley, 2018), the Three-Step Theory of Suicide (3ST) (Klonsky and May, 2015) and the Fluid Vulnerability Theory (Rudd, 2006) provide ideation-to-action frameworks illustrating symptom progression to suicide. These frameworks posit that suicidal behavior emerges from proximal socioemotional triggers, with some variation in attribution of risk from environmental, contextual, and historical risk factors. For example, 3ST does not overtly name contextual risk factors, while IMV and fluid-vulnerability frameworks do. Despite this variation, a theoretically derived throughline can be applied to the perinatal window in the way that distal risk factors may contextualize proximal risk for STBs, contributing to the development of socio-emotional precipitants.

Specifically, the perinatal transition may represent a prolonged environmental-contextual situation during which perinatal stressors arise and repeat, leading to the negative re-appraisals and emotional responses defined by the transactional model of stress and coping (Lazarus & Folkman, 1984). These negative reappraisals and emotional responses in response to repeated stressors — such as the physical discomfort of pregnancy, infant crying, or spousal conflict — may represent the proximal socio-emotional triggers represented in IMV and Fluid Vulnerability Theory, which in turn precipitate the progression from maladaptive cognitions and emotional distress to suicidal thoughts and behaviors (Kuehn et al., 2022). The key extension of theory here

is in the conceptualization of the perinatal window as time-bound, meaning that it may be possible to anticipate shared windows of STB vulnerability based on interactions between risk factors and developmental transition points across the perinatal window.

However, to investigate this association between STB risk factors and perinatal STB timing, perinatal information across the full perinatal window is needed — from conception, delivery, and up to a year postpartum. Perinatal STB research to date has been limited to cross-sectional snapshots, or longitudinal interval-based research capturing windows within either the prenatal or postpartum transition, but few, if any, have been able to capture risk across the full perinatal transition. This includes not just STB risk in and of itself, but also how, whether, and when associated risk factors (e.g., psychiatric problems, intimate partner violence) associate with STB emergence over the perinatal window. Further, traditional sample sizes within clinical research are unlikely to fully capture the prevalence of perinatal STBs given their relative scarcity and the lack of uniformity in screening efforts across care settings. Larger scale efforts to surveil STBs at the national level have addressed this challenge by using administrative healthcare data — such as discharge records from inpatient, delivery, or ED settings.

Emerging evidence supports the use of large-scale administrative health data to improve the accuracy and prediction of STB events (Hensley et al., 2025; Wang et al., 2024). For example, the Centers for Disease Control and Prevention (CDC) recently funded a STB surveillance programs within ED environments in ten states, including Oregon (CDC, 2026). In fact, suicide risk events in the U.S. are increasingly being monitored within emergency departments (EDs), as EDs often serve as the first point of contact for suicide-related behavior (Ceniti, Heinecke & McInerney, 2020). While population level STB surveillance efforts do not differentiate suicide risk in the general population level versus for perinatal individuals

specifically, administrative healthcare data can be parsed further to surveil STB-related acute care utilization among perinatal individuals.

ED utilization during the perinatal window is not uncommon; thus, there is opportunity to surveil perinatal STB prevalence, timing, and risk factors via STB-related ED visits during the perinatal window. Several population level studies have found that approximately 1 in 3 women utilize the ED during pregnancy (Declercq et al., 2024; Matenchuk et al., 2023). Among ED visits during pregnancy, 6.2% are estimated to occur for mental health-related reasons (Tyson, Kelleher & Chavez, 2022). Considering that STB onset during pregnancy and postpartum is considered a psychiatric emergency (Rodriguez-Cabezas & Clark, 2018), it is possible that acute healthcare utilization data from ED or inpatient settings may establish population level STB estimates across pregnancy and postpartum. In fact, acute care utilization data observed during the perinatal window has been used to estimate state-level prevalence of suicidal ideation and self-harm (Florida; LeCounte et al., 2026) and suicidal behavior (California: Goldman-Mellor et al., 2025). However, neither study evaluated both suicidal ideation and behaviors across the full perinatal window — introducing a critical window of opportunity to examine the full spectrum of STB symptom emergence across the perinatal window.

The first major empirical gap in the perinatal literature that this study addresses is the dearth of U.S.-based research leveraging acute healthcare utilization data to contextualize population level STB onset, emergence, and risk trajectories across the perinatal period. Empirical research associating perinatal ED utilization with STBs specifically have largely been conducted outside of the U.S. (e.g., Grigoriadis et al., 2017; Barker et al. 2024a; Barker et al. 2024b). Only a handful of U.S.-based studies have offered preliminary, cross-sectional prevalence estimates of perinatal STBs using administrative health data (Delker et al., 2023;

Mehta et al., 2016; LeCounte et al., 2026). Preliminary U.S. based assessments of the incidence and risk factors for perinatal suicide are extraordinarily sparse, with only one recently published study utilizing ED and delivery records to characterize risk for postpartum suicide in California (Goldman-Mellor et al., 2025). Goldman-Mellor and colleagues' study is among the first to link perinatal healthcare utilization records with STB outcomes, with several key differences in scope: their analytical approach examined whether, but not when, risk is elevated across the perinatal window, for an initial outcome event only, and in the context of a limited set of covariate risk factors. The present study expands this work by examining a broader array of STB-related covariate risk factors and distinguishing effects on the magnitude and temporal patterning of risk over time for both initial and recurrent STB-flagged ED events.

A second empirical gap concerns the association between STB-related risk factors and the degree to which risk factors associate with acute perinatal STB events. Surveilling the prevalence and timing of co-occurring risk factors associated with STB-related acute care events, such as ED visits for other psychiatric or physical health problems, may establish a clearer picture of which risk factors drive STB-related care seeking. ED care utilization during the perinatal period is associated with severe maternal morbidity, including psychiatric outcomes (Declercq et al., 2024). Very limited evidence exists linking health-related vulnerability factors observed at acute care incidents with STB-related outcomes. Of the limited evidence, Goldman-Mellor and colleagues found clinical risk factors such as prenatal ED visits for suicide attempts or psychiatric reasons, as well as psychiatric diagnoses observed at delivery, were associated with perinatal suicide attempts (2025). In addition, those who utilize the ED for STB-related reasons tend to have more access vulnerability characteristics such as younger age, non-Hispanic Black or Hispanic race and ethnicity, and Medicaid/Medicare or "Other" insurance status

(LeCounte et al., 2026). Overall, there is limited research evaluating how clinical health risk factors and sociodemographic risk factors may differentially or jointly contribute to the incidence or magnitude of acute perinatal STB risk.

In conceptualizing the perinatal transition as a sensitive developmental period, a third empirical gap emerges with the need to better characterize risk for suicide within the relatively time-bound window of the perinatal transition. A major gap in understanding exists around STB occurrence during the perinatal period and the temporal dynamics of STB symptom risk. In other words, little is understood about the timing of STB onset, prevalence, or persistence during the prenatal and postpartum periods. Emerging evidence suggests that STBs may follow time-related patterns, with different risk profiles emerging during pregnancy versus postpartum (Kaliush et al., 2024; Xiao et al., 2023). More specifically, suicidal ideation may be more prevalent during the prenatal window (Xiao et al., 2022; Xiao et al., 2023), while higher levels of suicidal behaviors, including attempts, are observed postpartum (Lommerse et al., 2019; Grigoriadis et al., 2017). While these findings offer snapshots of STB risk broadly across the perinatal window, there is currently no comprehensive understanding of when risk might be highest at a more granular level (e.g., per trimester, monthly) across the entire perinatal window from conception to one year postpartum.

A fourth empirical gap emerges regarding acute care utilization recency in association with perinatal STB risk. Suicide research broadly (i.e., research with any sample and demographic group) also shows a recency effect where prior incidents of care predict later suicidal behavior. For example, in non-perinatal samples, analyses of health record data show that prior ED utilization in the past year is associated with death by suicide (Neuroth et al., 2026), with greater suicide risk associated with more proximal healthcare utilization (i.e., the last

seven days, or the last 30 days) (Ahmedani et al., 2019). A singular perinatal study to date has found significant associations between greater prenatal ED utilization and postpartum suicide attempts but did not evaluate ED recency as a risk factor (Goldman-Mellor et al., 2025). Perinatal evidence from Canada has found temporal patterning in perinatal ED utilization, though not necessarily in association with STB risk. Canadian studies show that 1 in 20 women utilize the ED during the first six weeks after delivery (Clark et al., 2010), and up to 1 in 12 use the ED during the first 90 days after delivery (Batra et al., 2017). ED utilization is also associated with greater risk of non-fatal self-harm or death by suicide within one year for those with a psychiatric ED visit postpartum (Barker et al., 2024a). Corollary research associating perinatal ED utilization visit recency with STB risk is lacking within U.S. contexts, yet this research is urgently needed due to mounting evidence for visit recency effect associations and suicide risk within non-perinatal populations.

Taken together, there are four empirical gaps within the perinatal STB literature. The first is a comprehensive understanding of population level risk for STBs leveraging the specificity of acute healthcare claims data, determining the incidence of a relatively rare, but extremely critical, event. Second, prominent gaps exist when determining which STB-related risk factors are the strongest drivers of STB-related care seeking across the full perinatal window. Third, there are critical temporal gaps in the evidence for when risk is greatest for STB-associated acute healthcare events at more granular windows within pregnancy and postpartum, or how risk timing may be affected by Access and Health related vulnerability factors. Given the different developmental inflection points throughout the perinatal window, it is highly possible that STB-related risk is nonlinear — with increases and decreases associated with the compounding stressors within that transition in time. Finally, there is a fourth gap regarding the estimation and

evaluation of overall perinatal ED utilization, and acute care utilization visit recency, as a potential risk indicator of greater risk for subsequent perinatal STB risk emergence.

Evaluating both the magnitude and timing of a potentially nonlinear temporal phenomenon requires a flexible analytical method which is uniquely addressed by the novel application of Piecewise Exponential Additive Mixed Models (PAMMs). PAMMs provide a flexible approach to modelling risk over time (i.e., survival analysis) due to its underlying generalized additive model (GAM) architecture, which "transforms a survival task to a Poisson regression task" (Piller et al., 2026). PAMMs are unique in their ability to relax multiple assumptions that constrain alternative survival modelling options. For example, PAMMs can accommodate time-varying covariates, the interaction of groups with the hazard shape over time (i.e., specifying different baseline hazard curves), modelling recurrent event data, and accounting for dependencies within the data (Bender & Scheipl, 2018; Bender et al., 2018).

This translates to a greater capability to address complex research questions within the same survival analytic model. PAMM applications in clinical health research continue to grow, with recent methods papers explaining their value and application in survival modelling, including recurrent event analysis (Ramjith et al., 2022). For instance, PAMMs have successfully been used in research domains such as critical inpatient care (Hartl et al., 2022), and perinatal epidemiology — specifically estimating stillbirth risk across the gestational window (Bone et al., 2023). However, to date, they have not yet been applied to either perinatal mental health research or STB research — in part due to their novelty and potential learning curve. The current study leverages this flexible methodological option to simultaneously accommodate the complexity of the study research questions, providing an example for future perinatal STB studies to do the same.

A distinct advantage of PAMMs is their ability to accommodate both time-invariant risk factors as well as time-dependent covariates of STB risk. The current study utilized both types of covariate risk factors, including time-invariant sociodemographic and historical clinical health risk factors, and time-dependent clinical health risk factors observed perinatally. Individual level time-invariant risk factors at the sociodemographic level were grouped beneath an umbrella term used for the current study — the *Access Vulnerability Domain.* The Access Vulnerability domain included risk factors operating as structural and sociodemographic barriers to care such as public insurance and minoritized racial or ethnic identity. These are variables that tend to remain constant or relatively constant across the perinatal period, functioning as time-invariant risk factors. Further, these are risk factors that may impact STB risk through multiple avenues — including accessibility to appropriate healthcare.

To account for clinical risk factors, the *Health Vulnerability Domain* included both historic (time-invariant) and dynamic (time-dependent) clinical vulnerability risk factors associated with perinatal STB risk. The Health Vulnerability domain served as an umbrella term for individual level risk factors associated with greater perinatal STB risk — specifically, STB history, non-suicidal self-injury (NSSI), psychiatric problems, substance-use disorders, intimate-partner violence, and chronic health risk factor domains, as well as recency of acute care utilization. The Health Vulnerability risk factors observed prior to 2020 represented historic risk factors and operated as time-invariant predictors of risk. Health Vulnerability — Perinatal were risk factors observed within perinatal windows that were time-dependent, meaning their value could change over time.

This project also utilized composite vulnerability profiles derived from individual level risk factors within the Access and Health Vulnerability domains. These composite vulnerability

profiles were used to distinguish differential effects on the magnitude and timing for initial and recurrent perinatal STB-flagged ED visits. These vulnerability profiles were landmarked at prenatal and postpartum windows, providing insight into how historical vulnerability information informs prenatal STB risk, and how historical, prenatal, and delivery risk information informs postpartum STB risk. The current study also leveraged these vulnerability profiles to map risk timing — determining whether and how hazard timelines for initial and recurrent STB risk increase or decrease in association with different vulnerability profiles. In doing so, this study identified potentially distinct and overlapping risk pathways associated with perinatal STB-flagged ED occurrences, which may offer actionable insight into which perinatal individuals are most likely to be affected, and when that risk is likely to emerge.

1.1 Present Study

The present study aimed to fill key empirical gaps related to the prevalence, covariate risk and temporal patterning of STB-related ED visits during pregnancy and up to one year postpartum. Specifically, the study aimed to identify population-level prevalence of STB-related ED visit and visit recurrence during the perinatal period in a population cohort of individuals with a live birth between 2020 and 2024 in Oregon. Further, this study examined how key risk factors influence the magnitude and temporal patterning of perinatal STB-related acute care utilization. This study leveraged descriptive analyses and complex survival models (i.e., piecewise exponential additive mixed models; PAMMs) across three levels of inquiry: (1) Population Prevalence, (2) Covariate Hazard, and (3) Risk Timing from which three study aims were derived.

The first aim established prevalence estimates for initial and recurrent STB-flagged ED visits overall. The first aim also compared prevalence of initial and recurrent STB-flagged ED

visits among perinatal windows with Access Vulnerability characteristics and Health Vulnerability characteristics observed at incidents of care occurring before 2020 and during perinatal windows. The Access Vulnerability domain consisted of age, race/ethnicity, and insurance type observed at delivery. The Health Vulnerability domain consisted of non-ED related STBs, non-suicidal self-injury (NSSI), psychiatric problems (PSYCH), substance use disorders (SUDs), intimate partner violence (IPV), and chronic health problems (CH) observed at inpatient, delivery, and ED events. The second study aim assessed the strength and direction of the association between individual risk factors encompassed by Access and Health Vulnerability domains — including recency of acute care utilization — and instantaneous hazard of an initial and recurrent STB-flagged ED visits across the perinatal window. Finally, the third aim evaluated whether different profiles of risk identified at prenatal or postpartum windows significantly influenced risk timing for an initial or recurrent STB-flagged ED visit, identifying whether and when risk for a STB-flagged ED visit changed over time.

1.1.2 Summary of Study Aims & Hypotheses

Aim 1. Characterize the overall prevalence, frequency, and recurrence of STB-flagged ED visits during pregnancy and the first postpartum year. In addition, characterize and compare risk domains (Access Vulnerability and Health Vulnerability) associated with prenatal and postpartum ED visits to establish a comprehensive picture of perinatal individuals presenting for STB-related ED visits.

Hypotheses 1A. A minority of birthing individuals will utilize ED services for suicidal thoughts or behaviors during pregnancy and postpartum, with frequency levels non-uniformly stratified across pregnancy (0-40 weeks) and postpartum (0-52 weeks after delivery).

Hypotheses 1B. The average number of days between initial STB-related ED visit and recurrent ED visits will fall between 30 days and one year.

Hypothesis 1C. STB-flagged ED visits will be more common during the postpartum period compared to during pregnancy.

Hypotheses 1D. Perinatal windows characterized by one or both vulnerability domains (Access Vulnerability or Health Vulnerability) will have a greater proportion of STB-related ED visits and recurrent visits, and a greater proportion of overall ED utilization than those without any vulnerabilities.

Aim 2. Evaluate the extent to which Access Vulnerability and Health Vulnerability risk characteristics observed at pre-2020 care events and during perinatal windows are associated with greater hazard of a first and recurrent ED visits for STBs during pregnancy and the first postpartum year.

Hypothesis 2A: Perinatal windows where Access Vulnerability factors are present (i.e., non-white racial identity or Hispanic ethnicity, public insurance status) will exhibit higher instantaneous hazard of a first or recurrent STB-related ED visit during pregnancy and postpartum compared to those without Access Vulnerability factors.

Hypothesis 2B: Perinatal windows where Health Vulnerability factors are present (i.e., non-ED STB, NSSI, PSYCH, SUD or CH problems) will have a greater instantaneous hazard of an initial or recurrent STB-related ED visit compared to those without Health Vulnerability factors.

Hypothesis 2C: The proximity of recent acute care utilization will associate with greater hazard of an initial or recurrent STB-flagged ED visit specifically when the prior event is observed within the last 30 days, and with decaying effects observed. Specifically, more distal

events (observed at 91+ days prior) will have a non-significant influence on the instantaneous hazard estimate.

Aim 3. Identify temporal windows with significantly greater hazard for an initial or recurrent STB-flagged ED visit across the perinatal window and compare hazard timing between perinatal windows characterized by different vulnerability factors (i.e., No flags, Access Vulnerability only, Health Vulnerability only, and Combined vulnerability risk profiles).

***Hypothesis 3A*:** Perinatal windows with overlapping Access Vulnerability and Health Vulnerability domains ("Combined Vulnerability") will demonstrate the highest instantaneous hazard of an initial or recurrent STB-related ED visits compared to other vulnerability profiles.

Hypothesis 3B: Hazard curves for an initial STB-flagged ED visit will show two elevated periods of significant increase in the log-hazard: an early peak within the first six weeks after delivery and a later increase between approximately nine and twelve months postpartum for those with pre-existing risk factors. The magnitude of postpartum log-hazard increase will be most pronounced among perinatal windows with any vulnerability factors (Access Vulnerability, Health Vulnerability, or Combined vulnerability risk profiles).

Hypothesis 3C: Hazard curves for a recurrent STB-flagged ED visit will show fewer significant increases in the log-hazard consistent with overall greater risk following an initial event, but will show greater overall magnitude of risk across the perinatal window, with magnitude of risk greater for more the combined vulnerability profile.

CHAPTER II

LITERATURE REVIEW

The following chapter synthesizes prior research on perinatal suicidal thoughts and behaviors with particular emphasis on risk and risk timing, and acute care utilization across the perinatal window. Suicidal thoughts and behaviors (STBs) consist of passive and active suicidal ideation, planning and preparatory behaviors, and suicide attempts (Nock et al., 2008). In this review, STBs is a comprehensive term encompassing both suicidal ideation and behaviors, with certain components of the review differentiating STB symptomatology to provide appropriate context or background.

To provide a comprehensive review of relevant literature, this chapter is delineated into sub-sections providing essential context supporting the research aims. Section 2.1 evaluates the applicability of leading suicide theories to the perinatal context. This section grounds the larger study within a theoretically and developmentally coherent framework and summarizes the rationale for observing and estimating population-level perinatal STBs through individuals presenting to acute care settings. Section 2.2 summarizes current evidence for perinatal STB prevalence and associations with healthcare utilization. Section 2.3 introduces Access and Health Vulnerability constructs and reviews how these component risk factors associate with perinatal STBs and STB-flagged ED visits. Section 2.4 synthesizes evidence on timelines of perinatal STB risk, summarizes current understanding of perinatal acute care seeking and visit recurrence, and briefly reviews standard guidelines for perinatal mental health screening timelines, highlighting areas of mismatch between STB timing and conventional care timelines. Finally, Section 2.5 summarizes clinical and empirical gaps identified throughout the review in relation to perinatal STB risk and timing.

2.1 Theoretical Associations between Suicide Risk and Acute Care Seeking

Grounding perinatal STB research within existing suicide theoretical frameworks requires an extension of theory to meet the unique demands of the context. Explanatory frameworks of leading suicide theories are meant to apply to life broadly, as opposed to the unique developmental stressors within the perinatal context specific to birthing women. For example, Reid and colleagues reviewed ideation-to-action frameworks such as the Interpersonal Theory of Suicide, Integrated Motivational-Volitional Model, and the Three-Step Theory of Suicide to highlight this perinatal-specific gap, and used these deficits to introduce the value of a grounded theory drawing from perinatal women's lived experiences to better understand perinatal suicidality (Reid et al., 2022). Invoked theories also differ based on which aspect of suicidality is under investigation. Recent work evaluating acute STB presentations applied temporally oriented theories such as Fluid Vulnerability Theory to evaluate perinatal STBs, acknowledging the dynamism of perinatal STB endorsement (Kaliush, 2024). Other work has turned toward qualitative methods and has derived domain-relevant precursors for perinatal STB onset such as specific cognitions and contextual factors about motherhood (De Backer et al., 2024; Biggs et al., 2023). Taken together, leading suicide theories may fall short in applications to the perinatal context, requiring some level of theoretical extension to fully meet the contextual demands of the transition.

The perinatal period may be conceptualized as a time-bound developmental transition associated with elevated STB risk. Other age- and life-related transitions outside of the perinatal window are also associated with greater risk for STBs, including adolescence (Hua et al., 2023), menopause (Hendriks et al., 2025), and older adulthood for men 75+ (Garnett et al., 2025). These transitions share features such as rapid physiological change, identity restructuring, and shifting

social roles, all of which may increase vulnerability to STBs. Recent work posits a similar "stress recalibration" window for the perinatal window (Howland, 2023). This "stress recalibration" window may be a product of the compounding changes in hormone levels (Schiller, Meltzer-Brody & Rubinow, 2015), brain development and plasticity (Servin-Barthet et al., 2025), shifts in physical function (Moya et al., 2014), and "reconstruction" of identity and meaning (Şahin, Şahin & Sezgin, 2026) experienced by birthing individuals. In the case of adolescence and menopause, these transition-associated STB risks are effectively time-bound — limited in duration by some degree of physiological and identity stabilization. To an extent, the same temporal risk logic can be applied to the perinatal transition, whereby significant physiological and contextual changes compound within a specific time window, temporarily heightening risk for STBs.

Within this window of prolonged elevated risk for STB emergence, acute STB risk may emerge from higher susceptibility to socio-emotional thoughts and feelings triggered by maternal identity and role changes. Through the lens of the transactional model of stress and coping, the chronic accumulation of perinatal-related repeated stressors can overwhelm normative coping efforts and lead to more negative appraisals over time (Lazarus & Folkman, 1984), giving rise to acute cognitive STB triggers. Negative appraisals may lead to maladaptive cognitions, and the kind of painful socio-emotional triggers that precipitate STBs. Leading suicide theories (i.e., IMV, 3ST, and Fluid Vulnerability) all align in their assumption of acute socio-emotional triggers serving as proximal precursors to STBs. However, these models differ in their attribution of which thoughts and feelings serve as STB triggers, ranging from defeat/humiliation, and entrapment within the IMV framework, to pain, hopelessness, and connectedness within the 3ST framework. Within the perinatal context, these socio-emotional proximal triggers for STBs may

take on a uniquely perinatal tone, related to the overall transition and closely linked to the temporal dynamics of the developmental window. However, no such extension of theory has been applied to the perinatal window to date.

There is emerging evidence for perinatal-specific cognitive experiences associated with increased STB risk, some of which extend the constructs identified in leading suicide theories. Certain cognitions emerging among women and regarding motherhood align with established theories. These include cognitions such as hopelessness and perceived burdensomeness (Lubas-Grzyb et al., 2026), feelings of failure (Weiss et al., 2022), qualitative themes labeled *Trauma and Adversities* and *Entrapment and Despair* (De Backer et al., 2024), as well as shame-related beliefs about defectiveness and unworthiness of love and belonging (Biggs et al., 2023). However, these studies also unearth perinatal specific cognitions associated with STB risk for which leading suicide theories may not account. For example, qualitative research with perinatal women who attempted suicide in the UK revealed a theme of *Disillusionment with Motherhood* representing sub-themes including "Physical and mental challenges of pregnancy and birth", invalidation of identity and self-sacrifice in the context of motherhood, and experiencing a less powerful feeling of maternal love than expected (De Backer et al., 2024). These findings suggest there may be maladaptive cognitive thought patterns specific to the challenges of the perinatal transition that give rise to acute or more severe STBs. This suggests that it may be useful to extend suicide risk frameworks to account for developmentally informed socio-emotional and cognitive triggers.

Further, there may also be transition points within the perinatal window where STB risk is heightened. In non-perinatal samples, stressful life events increase risk for suicidal ideation and behaviors (Howarth et al., 2020), particularly stressful events that occur within the last 12

months (Milton et al., 2020). Perinatal research has associated certain perinatal stressors (i.e., partner, traumatic, financial, and emotional) with postpartum depression outcomes (Lederberg Stone et al., 2015), but no known work to this point has evaluated time-related developmental stressors with either psychiatric or STB-related outcomes. While transitions within the perinatal period may be considered normative components of the perinatal progression (e.g., morning sickness, postpartum healing), they carry with them physical and emotional stressors. Through this association, perinatal temporal inflection points may lead to maladaptive cognitions that progress to STBs.

Stressors may compound during early prenatal and early postpartum windows specifically, which heighten acute risk for STBs within those windows. Stressful transition points may present within the first 6 weeks of pregnancy between conception, awareness of pregnancy, and the first prenatal evaluation recommended at 6-10 weeks gestation (Peahl et al., 2023). Depending on maternal health status, the stress of the transition point may extend throughout the first trimester or longer for those with "morning sickness", especially those with severe morning sickness, which is linked with long-term mental health disorders and suicidal behaviors (Na et al., 2025). The third trimester may also present as a stressful transition point compared to prior trimesters (Redondo et al., 2025) given maternal identity development (Ionio et al., 2021) or physical discomfort and concerns about the impending delivery process. Early postpartum has a significant compounding of transition-related stressors, such as caregiving demands for a newborn including breastfeeding, sleep deprivation, and physical recovery from the birthing process (Madray et al., 2022). Additional transitional stressors may emerge between ten days to 6 weeks postpartum when infant crying is at its peak (Vermillet et al., 2022), and when many women return to work (Tucker et al., 2010; Van Niel et al., 2020). Additional inflection points

during postpartum may relate to other contextual and health related risk factors, which will be reviewed in more depth in section 2.3.

In summary, the perinatal window represents a distinct developmental transition during which both sustained vulnerability and acute stressors may contribute to STB emergence. The myriads of developmental and role changes inherent within the transition may give rise to patterns of perinatal-specific maladaptive cognitions and socio-emotional triggers that may transition to STBs over time. Qualitative studies suggest perinatal-specific socio-emotional STB precursors such as *Disillusionment with Motherhood* and doubts about being a good mother can arise and precede STB emergence (De Backer et al., 2024; Biggs et al., 2023), extending ideation-to-action frameworks by providing developmentally informed cognitive precursors. Further, developmentally salient time periods within the perinatal transition may also present as inflection points for STB emergence, specifically during early pregnancy, the third trimester, and early-mid postpartum. This background provides theoretical grounding for perinatal-specific STB-onset, as well as a temporal framework for developmental inflection points at which perinatal STBs may be most likely to emerge.

2.2 Perinatal STB Prevalence and Associations with Acute Care Utilization

Different data sources and measurement approaches are used to track perinatal STBs; such non-uniform approaches make estimating population-level perinatal STBs difficult. Historically, researchers have relied on death records and maternal mortality reviews to estimate causes of maternal mortality. These records and reviews consistently identify suicide as a leading cause of death for pregnant and postpartum women from pregnancy through 42 days after

delivery[1] (Azad et al., 2026). However, there is a strong likelihood that perinatal deaths by suicide are underestimated due to challenges in reporting. For example, checkboxes on death certificates indicating a pregnancy-associated death were added across states between 2003-2018 in the U.S. (Hoyert & Miniño, 2020). This presents a concerning reality that pregnancy-associated deaths were not reliably differentiated in national death records until 2018, suggesting a history of systemic underreporting of deaths associated with the perinatal window — suicide deaths included. Despite this record-keeping change, significant concerns remain about the misclassification of cause of maternal death and inaccuracies in identifying pregnancy-associated cases (Rossen et al., 2020; Park et al., 2025; Joseph et al., 2024). This translates to a history and present reality of underreported pregnancy-associated deaths from suicide that may not be easily remedied through death record evaluation.

Death record estimations of maternal suicide are also historically insufficient in determining the prevalence of STB symptomatology prior to death during windows when prevention efforts could occur. In other words, even when the cause of death by suicide is appropriately indicated for a maternal death, STB-related precursors — including acute healthcare utilization — is unknown, as this history is traditionally not associated with death records. Timely screening and prevention efforts require indications of risk prior to the pregnancy-associated death, requiring alternative data sources to map STB emergence and associated risk factors. Perinatal STB risk may be more reliably estimated by observing emergent suicidal thoughts and behaviors captured in other data sources, such as administrative or electronic health records, or larger datasets linking death records with perinatal healthcare data

[1] Azad and colleagues (2026) found that violent deaths (deaths by homicide or suicide) were the second most frequent cause of maternal death. Among the "violent deaths" category, 32% were attributed to death by suicide. Data were from the National Vital Statistics System.

(Meurk et al., 2021). The latter approach deriving prevalence from multiple data sources shows promise for estimating population level STB risk burden beyond the limitations of death records.

Perinatal research has moved towards capturing prevalence estimates of suicidal thoughts and behaviors to better estimate suicide risk beyond death record categorization. A comprehensive meta-analysis provided specific estimates differentiating perinatal STB symptom components, finding a prevalence of 7.2% for suicidal ideation, 7.8% for suicidal plan, and 1% for suicide attempt (Karaçam et al., 2024). Across these studies, perinatal suicidal ideation tends to be more prevalent than behaviors, such as attempts, though both symptom domains are associated with later suicide risk more broadly (Ribeiro et al., 2016). While non-perinatal suicide research hypothesizes disparate risk pathways for suicide ideation compared to suicide behavior (Klonsky & May, 2014), there is also value in estimating overall STB burden within the perinatal window as a foundational step before parsing distinct risk pathways. Thus, evaluating the prevalence of both symptom types encompassed beneath the STB umbrella is helpful to fully characterize suicide risk symptomatology within the perinatal context.

Recent studies have leveraged administrative healthcare records, often sourced across multiple care settings, to estimate perinatal STB prevalence. These studies identified that only a small subset of perinatal individuals (between 0.13 – 0.6%) had STBs noted within their healthcare records (Admon et al., 2021; Goldman-Mellor et al., 2025). Definitions of STB outcomes varied across studies, ranging from more inclusive definitions of suicidal ideation and intentional self-harm (Admon et al., 2021) and suicide ideation and suicide attempts (Delker et al., 2023), to narrower definitions of suicidal behaviors, such as nonfatal suicide attempt (Goldman-Mellor et al. 2025), and nonfatal suicidal behaviors (LeCounte et al., 2026). Several studies effectively mapped yearly patterns in STB prevalence at the population level, finding

growing trends over time (e.g., Admon et al., 2021; Delker et al., 2023). However, these studies did not estimate more granular distinctions of STB risk timing across the perinatal transition. In other words, these studies did not differentiate when risk might emerge across the perinatal window, and which risk factors are associated with more granular time windows of emergence. Based on these gaps, a clear empirical opportunity emerges to leverage large-scale claims data to differentiate more granular estimates of risk across the perinatal window.

The prevalence of STB-related acute care utilization presents a clinical intervention point and key opportunity for population-level surveillance of emergent STB risk. Perinatal STBs are considered a psychiatric emergency (Rodriguez-Cabezas & Clark, 2018) that may lead to interactions with acute care settings. STB prevalence may thus be estimated *in situ* within acute care settings when derived from the ICD codes associated with that visit. Given that 1 in 3 women having an ED visit during the perinatal window for any reason (Declercq et al., 2024; Matenchuk et al., 2023), there appears to be ample opportunity to utilize ED visits as a STB surveillance opportunity. Current research estimates only a minority of perinatal ED visits are for mental-health related reasons (6.2%; Tyson, Kelleher & Chavez, 2022), with very limited data evaluating perinatal ED-associated STBs in any form (Goldman-Mellor et al., 2025; Lewkowitz et al., 2019; LeCounte et al., 2026). However, to date, there are no conclusive prevalence estimates of ED visits for STBs (including suicidal thoughts and behaviors) across all of pregnancy or postpartum at the population level. This presents a feasible opportunity to estimate this prevalence rate using perinatal ED utilization data.

The association between perinatal ED utilization and perinatal STB emergence is important to understand given the established association between acute care utilization preceding suicide in non-perinatal samples. Greater levels of acute care utilization prior to

suicide are a documented phenomenon in non-perinatal suicide research, with some degree of recency effects also established (Neuroth et al., 2026; Ahmedani et al., 2019; Cerel et al., 2015). Ahmedani and colleagues (2019) evaluated specific time intervals of risk between prior healthcare utilization (ED, outpatient specialty, and primary care) and death by suicide for those who died by suicide and matched controls across eight U.S. healthcare systems between 2000-2013. They found that those who died by suicide used healthcare more frequently at 16.7 visits on average per year, and that half had a healthcare visit within the last 30 days before death. Specifically, they found that one-third of those who died by suicide had a healthcare visit in the 7-days before their suicide death, and nearly all (>90%) had a healthcare visit within the last 365 days. Neuroth and colleagues (2026) established similar findings specific to the ED setting, finding that one-third of those who died by suicide in North Carolina between 2019-2020 had past year ED use, and 21.6% of that one-third subsample were frequent ED users (used the ED ≥4 times). Further, those who frequently used the ED were less likely to survive within 30 days of their most recent non-fatal ED visit compared to infrequent users. This indicates that greater levels of healthcare utilization, and proximity to recency of prior care, differentiate those at greater risk for suicide within non-perinatal samples.

This pattern between healthcare utilization and utilization recency is less well understood, and largely undocumented, for perinatal individuals. The strongest available evidence for healthcare utilization is provided by Goldman-Mellor and colleagues' (2025) population level study, finding significantly greater risk of a postpartum suicide attempt when individuals had 1 or more ED visits during pregnancy — with the greatest magnitude of risk observed for 3 or more ED visits. This finding aligns with the non-perinatal literature linking greater levels of ED utilization with suicide risk (Neuroth et al., 2026). However, Goldman-Mellor and colleagues'

study did not examine ED utilization recency, or recency of healthcare utilization overall – meaning that no study to date currently estimates this association for perinatal samples. In addition, there are virtually no replication studies or associated research lending support, or building upon, Goldman-Mellor's perinatal-specific findings. For example, the closest corollary evidence links greater ED utilization during pregnancy with severe maternal morbidity (including psychiatric problems) at birth, though not STBs specifically (Declercq et al., 2024). Other research similarly does not disentangle STB-related risk, though a link between acute care utilization in the month prior to death (from multiple causes, including suicide) was found for perinatal individuals (Mehta et al., 2016). This illustrates a critical research gap unique to the perinatal window, where it is currently unknown whether or how acute care utilization recency associates with STB risk broadly, or during critical perinatal inflection points.

While the association between perinatal ED utilization and perinatal STBs is largely unknown, there is evidence of a preliminary association between ED utilization patterns and adverse psychiatric outcomes — suggesting opportunities for STB surveillance. Canadian healthcare data provide insight into perinatal ED utilization and visit recurrence, finding that 1 in 10 postpartum psychiatric ED visits were followed by a repeat ED visit within 30 days, and 1 in 100 women present to the ED for psychiatric reasons within the first year postpartum (Barker et al., 2024b). There may be a degree of shared risk between the likelihood of a psychiatric ED visit and the likelihood of STB-related acute care. For example, there is evidence that prenatal psychiatric-related ED visits confer greater risk for postpartum suicide attempts (Goldman-Mellor et al., 2025). This same pattern may hold for psychiatric-related ED visit recurrence and STB risk, with a Canadian study finding that 4.3% of those presenting with a preliminary postpartum psychiatric ED visit presented again for non-fatal self-harm, and 0.15% died by

suicide within one year (Barker et al., 2024a). While psychiatric-related symptoms have implications for STB emergence, the emphasis on psychiatric ED presentation presents an opportunity to expand the lens of analysis to surveil prevalence and timing of STB-flagged visits in particular.

Repeated utilization of ED services prior to suicide is a documented phenomenon in non-perinatal samples, but is largely unknown within the perinatal window. In the non-perinatal literature, recurring ED utilization is a recognized risk factor for later suicidal behavior (Olfson et al., 2021). An Icelandic population study found that ED visits occur twice as often for those who later die by suicide, with increasing number of ED visits associated with greater risk for suicide (Kvaran et al., 2015). This elevated risk persists even when recurring ED visits prior to suicide are for non-suicide specific causes (e.g., mental health or substance use disorder; Kvaran et al., 2015). Specific recency windows for ED recurrence risk prior to STB-related ED presentation has also been observed in non-perinatal samples, with one Spanish study finding that most STB-related recurring visits took place within 6 months after the index ED visit (Suárez-Pinilla et al., 2020). Currently, ED visit recurrence patterns and links to STB risk are only minimally established in perinatal samples (e.g., Goldman-Mellor et al., 2025; Barker et al., 2024b discussed above). Despite this progress, there is a significant lack of established evidence estimating perinatal STB-related ED recurrence, and the risk factors that may precipitate STB-related recurrence.

Together, this review presents a clear need to more clearly define perinatal STB prevalence within acute care settings. The body of work leveraging administrative healthcare data is nascent despite preliminary evidence that the richness of such data can support more specific population level estimates for STB prevalence. Further, current work leveraging such

data has not developed to the point of establishing time-related acuity of STB symptomatology within the perinatal window. The furthest extent of current temporal delineation of STBs is separating by pregnancy and postpartum epochs, effectively smoothing more granular windows of risk that may exist prenatally or during postpartum. This introduces the opportunity to leverage administrative healthcare data in the form of ED, inpatient, and delivery records to estimate more granular windows of STB-related risk during the perinatal window. This approach would allow for definitive estimates of STB-flagged ED visits, including STB-flagged ED visit recurrence across the full perinatal window. This approach would also allow for the evaluation of ED utilization and acute healthcare utilization recency, which are risk indicators known to associate with STBs in non-perinatal samples and not fully replicated in perinatal samples.

2.3 Access Vulnerability and Health Vulnerability Factors Associated with Perinatal STB Risk

Perinatal suicide research has identified a variety of health and contextual factors related to risk for STB onset or emergence. However, integrated evaluations of both sociodemographic and clinical health risk factors are frequently the byproduct of review papers rather than the work of comprehensive empirical studies. For example, review papers have flagged the risk factors linked with perinatal STB risk broadly: socioeconomic and sociodemographic factors, lack of social support, domestic violence, history of STBs or psychiatric disorders, psychiatric comorbidity, comorbid substance use, affective risk factors, medical conditions, and aversive life events (Orsolini et al., 2016; Chin et al., 2022; Arditi-Arbel et al., 2023). While these studies present a consolidated array of risk factors, few studies to date have empirically tested these associations with perinatal STB risk.

The singular most comprehensive study to date by Goldman-Mellor and colleagues did evaluate differential contributions of sociodemographic risk factors (i.e. age, race/ethnicity, insurance type, urbanicity) and clinical health risk factors (i.e., perinatal psychiatric comorbidity, comorbid substance use disorder, chronic health conditions, and number of ED visits) with perinatal STB risk (Goldman-Mellor et al., 2025). This study found significant associations between sociodemographic and perinatal clinical health risk factors and postpartum STB risk. However, the study was limited methodologically and temporally, as it collapsed the postpartum interval into a single risk period, excluding any modelling of risk timing and covariate contributions to risk timing, and did not estimate prenatal STB risk. This study represents the most comprehensive effort to date in predicting population-level perinatal STBs. However, significant empirical gaps remain in the inclusiveness of both sociodemographic and clinical health covariate risk factors and the modelling of risk timing that, to date, no studies have yet to address.

Further, when clinical heath risk factors are evaluated in relation to perinatal STB emergence, few studies account for the effects of both historical clinical risk factors and proximal clinical risk factors. There is temporal relevance in accounting for both historical and proximal clinical health risk factors, as historical risk factors can inform baseline STB risk levels at pregnancy onset, while proximal clinical health risk factors can contribute to more dynamic anticipation of STB risk within the perinatal window. Consistent associations have been found between historical clinical health risk factors such as a history of STBs and a history of psychiatric problems (primarily depression and anxiety) (Orsolini et al., 2016; Arditi-Arbel et al., 2023). Clinical health comorbidities (i.e., occurring within or proximal to the perinatal window or pregnancy-associated death) include psychiatric problems, substance use, chronic health

problems (Goldman-Mellor et al., 2025), intimate partner problems (Zivin et al., 2024), sleep disorders or disturbed sleep, and PTSD and traumatic events (Arditi-Arbel et al., 2023). To date, no studies have definitively evaluated both historical and perinatal clinical health risk factors simultaneously, which precludes a better understanding of how historical and proximal risk factors may contribute to STB onset and timeline of emergence.

Clinical health risk factors may also introduce greater likelihood of ED utilization during the perinatal window, with greater ED use also associated with STB risk in non-perinatal samples. From prior research, maternal psychiatric problems (e.g., severe mental illness, depression and anxiety symptoms), physical health (e.g., chronic illness), substance use disorders (e.g., alcohol, THC, or opioids) and intimate partner violence (IPV) are risk factors for perinatal ED visits in and of themselves (e.g., Beckerleg & Hudgins, 2022; Niedzwiecki et al., 2018; Davidov et al., 2023; Billings & Raven, 2013). This means that perinatal individuals with these clinical health risk factors may be prone to greater ED utilization overall, not just in association with STB presentation. However, this may confer specific vulnerability for STB-related ED visits during prenatal or postpartum time windows. While preliminary evidence links greater ED utilization with greater risk for STBs (non-perinatal: Neuroth et al., 2026; Kvaran et al., 2015; perinatal: Goldman-Mellor et al., 2025), there is incomplete evidence regarding the timing of ED utilization and perinatal STB emergence. In other words, STB-affiliated clinical health risk covariates may increase ED utilization, which is a known risk indicator for later STB risk — with little understood about how or whether the recency and timing of ED utilization associates with greater risk for perinatal STB. This presents an opportunity to evaluate how STB-related clinical risk factors associate with the prevalence of perinatal STBs, and whether there is an association between ED-related risk timing and greater risk for STB emergence.

The following section synthesizes current evidence for critical STB-related covariates that may present alongside perinatal STBs, and/or confer greater risk for STB-related acute healthcare utilization. These risk factors are separated into two domains indicating their respective risk pathways, specifically *Access Vulnerability* and *Health Vulnerability.* Health Vulnerability refers to either historical or perinatally observed clinical health risk factors associated with perinatal STB risk. Access Vulnerability refers to more stable sociodemographic STB-related risk factors indicative of impaired healthcare access. For the current study, the Health Vulnerability domain consisted of the individual covariates most strongly associated with perinatal STBs, including Non-Suicidal Self-Injury (NSSI) and STB history, psychiatric problems (PSYCH), substance use disorders (SUD), intimate partner violence (IPV), and chronic health problems. The Access Vulnerability domain consisted of socio-contextual risk factors such as age, race and ethnicity, and insurance type that have been previously associated with perinatal STB risk. The following sections review each domain, describing key components and their relevance to perinatal STBs and acute care utilization. The sections provide an empirical foundation supporting the value of accounting for multiple risk domains when estimating perinatal STB risk (Bright, Doody & Tuohy, 2022).

2.3.1 Health Vulnerability

The following review extends prior work by illustrating how each component clinical health risk factor contributes to perinatal STB risk overall. Further, this review evaluates each risk factor in association with known contributions to risk timing for perinatal STBs, and synthesizes evidence related to perinatal acute healthcare utilization. Each clinical health risk factor within the Health Vulnerability domain has been associated with STB risk in non-perinatal suicide literature, and for the most part, in perinatal literature as well. In instances when

perinatal-specific research is limited or lacking in adequate specificity, non-perinatal suicide literature will be synthesized to describe associations with STBs, providing a preliminary foundation for what may be observed within perinatal contexts. This comprehensive review of Health Vulnerability risk factors establishes a preliminary timeline and comprehensive symptom map for the perinatal window that is largely undefined.

STB History and NSSI. Several of the strongest predictors of STBs include having a documented history of STBs, and though less well recognized, active non-suicidal self-injury (NSSI). Individual level STB histories can range from passive or active ideation, planning and preparatory behaviors, or attempts occurring prior to observation, and have been consistently associated with later STB outcomes (Ribeiro et al, 2016). NSSI is defined as self-destructive behaviors to one's own body through various methods (e.g., cutting, burning, etc.) that take place without the intention to die (Klonsky, Victor & Saffer, 2014). Prevalence of STBs and NSSI differ, with greater prevalence of suicidal ideation (26.5%) than NSSI (4.7%) found in a large longitudinal twin study in Australia (Maciejewski et al., 2014). When evaluated in clinical and non-clinical samples, both NSSI and STB history are strongly associated with risk for later STBs, specifically suicide attempts (Klonsky, May & Glenn, 2013). NSSI may also serve as a signifier of individuals at greater risk for STBs, as individuals reporting NSSI are more likely to also report having suicide ideation (Maciejewski et al., 2014). Further, high-risk individuals exhibiting NSSI reported temporary reductions in suicidal ideation **f**ollowing NSSI, indicating a potential association between NSSI as a regulatory mechanism for individuals prone to other types of STBs (Herzog et al., 2022).

Perinatal research associating STB history with perinatal STBs is comparably richer than evidence for perinatal NSSI and STB outcomes. Having a previous history of either suicidal

ideation or suicide attempt has been associated with greater risk for perinatal STBs including death by suicide across multiple studies (Lysell et al., 2018; Orsolini et al., 2016; Modini et al., 2021, Makarious et al., 2026, Gelabert et al., 2024). The association appears strongest when individuals have a history of previous suicidal behavior, with one study finding 38-fold greater odds of perinatal suicide attempts for those with a history of prior suicide attempts (Gelabert et al., 2024). Prevalence estimates for perinatal NSSI are scarcer, particularly as studies tend to fold NSSI within other suicide related indicators to comprise a "self-harm" umbrella term (e.g., Lysell et al., 2018). Using this self-harm framing, one comprehensive review of 39 studies established self-harm prevalence estimates during pregnancy (0-2.39%) and postpartum (0-2.41%), though with greater self-harm estimates within higher risk samples, such as those with severe mental illness (Ayre et al., 2021; Taylor et al., 2016). Another study mapped temporal risk for self-harm, finding lower risk during pregnancy, but greater risk postpartum, with postpartum self-harm risk peaking at 6-12 months after delivery (Hope et al., 2022). However, neither NSSI-related study differentiated perinatal self-harm as non-self-injurious or injury with suicidal intent, which limits further interpretation. This means accurate assessments of how NSSI alone associates with perinatal STBs is not fully understood.

Proximity of NSSI symptomatology and STB history with perinatal STB risk is not well established, particularly within the U.S. Preliminary research has utilized administrative healthcare data to extract non-differentiated self-harm (including NSSI and suicidal self-injury) from healthcare visits within the perinatal window. One such study used UK electronic health record data to establish proximity effects for historical self-harm (combining NSSI and STB outcomes), finding greater risk for perinatal self-harm when prior self-harm occurred within the last two years (Taylor et al., 2016). Another UK based study established more granular recency

effects, finding that a majority of perinatal individuals dying by suicide had a nonrecent history of self-harm (48%), while a quarter had self-harmed within the last 3 months before death (24%) (Khalifeh et al., 2016). This work indicates that prior history of NSSI and STB-related self-harm is strongly associated with perinatal STB outcomes, yet there is significant opacity when estimating temporal effects of historical versus perinatal NSSI and risk for STB outcomes. Contributions to this opacity relate to the way studies conflate NSSI and STBs within broader "self-harm" constructs, in combination with a major lack of work systematically differentiating recency effects of NSSI and STB history in relation to STB risk. This suggests the need to disentangle NSSI from broader self-harm categories in order to fully understand how and when NSSI associates with greater perinatal STB risk and when that risk may emerge.

Psychiatric Problems. Psychiatric problems represent some of the most robust predictors of STB risk across populations. There is a richer evidence base between psychiatric problems and STB outcomes within non-perinatal samples. There is an eight-fold greater risk for suicide among those with a mental disorder (San Too et al., 2019), with an estimated 87.3% of deaths by suicide involving those with a psychiatric disorder diagnosis (Arsenault-Lapierre, Kim & Turecki, 2004). A recurring cluster of psychiatric disorders are linked with STB risk, including psychotic disorders, schizophrenia, mood disorders, bipolar disorder, personality disorders, substance use disorders, and anxiety disorders (San Too et al., 2019; Moitra et al., 2021). Further, those conditions have often been reviewed together in large cohort studies to identify and differentiate contributions of risk across disorders (San Too et al., 2019). One systematic review of 407 reviews extracted key conditions associated with the highest suicide risk, specifically identifying Borderline Personality Disorder, Anorexia Nervosa, Depression, and Bipolar Disorder (Chesney, Goodwin & Fazel, 2014). An additional set of diagnoses, often

independently associated with suicide risk, includes trauma disorders such as PTSD, which is a stronger risk factor for suicide among women (Fox et al., 2021), and sleep disorders, though to a weaker extent (Harris et al., 2020). This evidence supports the value of an inclusive approach to accounting for multiple types of psychiatric diagnoses when aiming to estimate effects on STB risk.

Within the perinatal context, there is similar evidence for the heightened risk of STBs due to psychiatric conditions, though with more evidence for some disorders over others. A significant number of studies associate depression with perinatal STB risk (Yu et al., 2024; Chin et al., 2022), with additional, though lesser evidence, associating STB risk with anxiety disorders, bipolar disorder, schizophrenia, personality disorders, and adjustment/PTSD (Goldman-Mellor et al., 2025; Chin et al., 2022; Lysell et al., 2018). Growing evidence also supports sleep disorders as a contributing risk factor (Arditi-Arbel et al., 2023). Having a history of psychiatric disorders is also associated with perinatal STB risk (Orsolini et al., 2016; Despotis et al., 2025). However, a history of psychiatric disorders is not consistently accounted for in evaluations of perinatal STB risk. Further, despite strong associations with STB risk more broadly, eating disorders are "poorly recognized" and largely neglected in perinatal care (Bye et al., 2020). This translates to virtually no perinatal studies including eating disorders within psychiatric risk categories when evaluating perinatal STB risk. This suggests the importance of including more neglected psychiatric conditions – such as eating disorders and a history of psychiatric disorders – when estimating effects of psychiatric problems on the risk for perinatal STBs.

Evidence for the association between psychiatric risk factors and temporal risk for STBs during distinct perinatal time windows is sparse, though broad estimates show elevated risk

during postpartum in comparison to the prenatal window. Temporal comparisons between the prenatal and postpartum windows show greater risk for psychiatric disorders (i.e., mood and anxiety disorders, psychotic disorders) and perinatal suicide during postpartum compared to the prenatal window (Mota et al., 2019). Differential associations between self-injury, psychiatric disorder, and perinatal timing have also been found, with evidence for a stronger association between personality disorders and prenatal self-harm, and psychotic disorders and postpartum self-harm (Ayre et al., 202). Other large cohort or longitudinal studies are limited in their conclusions around psychiatric problems and their contribution to prenatal STB risk timing, as many focus on the postpartum window only (e.g., Lysell et al., 2018; Goldman-Mellor et al, 2025, Mota et al., 2019). Thus, preliminary evidence establishes some level of contribution of psychiatric problems towards perinatal STB risk timing, with discordant estimates of prenatal and postpartum windows, and virtually no estimates across the full perinatal window.

No studies to date have established temporal granularity of perinatal ED utilization for STBs, but psychiatric ED utilization may provide indirect evidence for when risk might emerge. Postpartum women with an underlying mental health disorder are more likely to utilize the ED within 30 days after delivery compared to those without a psychiatric disorder, indicating heightened levels of acute care utilization in the immediate postpartum (Pluym et al., 2020). The thirty-day observation window extends to ED recurrence, with over 1 in 10 postpartum psychiatric ED visits followed by an additional visit within 30 days (Barker et al., 2024b). Barker and colleagues (2024b) also found that having an initial psychiatric related ED visit within 90 days postpartum was consistently associated with ED visit recurrence. Psychiatric ED utilization has STB implications whereby among those presenting to the ED for a postpartum psychiatric problem, approximately 4.3% had a non-fatal self-harm incident while 0.15% died by suicide

within one year (Barker et al., 2024a). Together, these findings suggest there is temporal patterning within acute care utilization for perinatal psychiatric problems. There may be a similar degree of temporal patterning in perinatal STB-flagged ED utilization, but no research to date has examined this association.

Substance Use Disorders. Substance use serves as a risk factor for suicide whereby people with substance use disorders are at 5.62 times higher risk for suicide (Athey et al., 2024). Substance use also serves as a cause of death whereby a substantial fraction (between 5-7%) of fatal drug overdoses observed in 2020 were considered intentional (Han, 2022). This pattern extends to perinatal populations where substance use is a significant cause of unintentional and intentional perinatal deaths, accounting for 11.4% of all pregnancy-associated deaths (Margerison et al., 2022). Concerningly, the rate of drug-related perinatal deaths grew by nearly 200% between 2010-2019 according to an evaluation of U.S. death records (Margerison et al., 2022). According to the same death record analysis, drug-related perinatal deaths were double the rate of perinatal deaths attributed to suicide (5.4% of pregnancy-associated deaths; Margerison et al., 2022). Disentangling unintentional versus intentional death by substance related poisoning or overdose is a difficult process, with some estimates indicating higher levels of suicide embedded within overdose attempts than may be reported (Oquendo & Volkow, 2018). Concerningly, rates of nonfatal overdoses within the perinatal window are nearly 60 times more common than fatal overdoses, indicating far more instances of fatal overdose attempts than death records alone indicate (Goldman-Mellor et al., 2025b).

While pregnancy appears to be relatively protective against substance use and misuse, the postpartum window is particularly vulnerable to substance use relapse, a precursor to overdose risk. Pregnancy may serve as a motivator for ceasing substance use, with many successfully

withdrawing or abstaining from substances during pregnancy for non-opiate substances (Forray et al., 2015). This protectiveness extends to the immediate postpartum when individuals with opioid use disorder maintain a strong desire to abstain from opioid use (Rankin et al., 2022). However, without sufficient support, relapse risk increases over time (Rankin et al., 2022). Specifically, relapse risk increases mid-to-late postpartum, with average relapse occurring within 109 – 138 days (approximately 3 and 4.5 months) for cigarettes, alcohol, and cannabis, within 287 days (9.6 months) for cocaine (Forray & Foster, 2015), and the year after birth for opioids (Schiff et al., 2018). This indicates temporal patterning in the risk timing for SUD abstinence and relapse within the perinatal window, with greatest risk postpartum.

Relapse risk translates to risk for intentional or unintentional overdose particularly within the first year postpartum. Broadly, risk for substance-related overdoses is greatest during the first year postpartum (Frankeberger et al., 2023) and increases during the late postpartum period (Smid et al., 2019). The first six months postpartum represents a critical relapse window for mothers with OUD specifically (Rankin et al., 2022), which precedes the peak period for opioid overdoses (either intentional or unintentional) at 7-12 months postpartum (Schiff et al., 2018; Nielsen et al., 2020). In cases when overdose behavior was determined to be intentional, mothers diagnosed with Opioid Use Disorder (OUD) during pregnancy were three times more likely to attempt suicide by opioid poisoning within the first year postpartum (Yoon et al., 2024). Overall, the risk for substance use relapses increases during the first six months postpartum, and intentional or unintentional drug overdose rates are greatest 7-12 months postpartum. This suggests that SUD relapse and overdose risk may have its own temporal inflection points, presenting opportunities for anticipating and surveilling potential STB emergence during windows of elevated risk for SUD relapse or overdose.

Acute care healthcare utilization is heightened for perinatal individuals with substance-related conditions, which may present temporal inflection points during which perinatal STB risk can be observed. In one retrospective study of pregnancy-related ED visits, a substantial minority were cross-coded for substance use/mental health disorders (11.9%), indicating there is substantial acute care seeking for perinatal individuals with SUD comorbidity (Spitz et al., 2025). There is also preliminary evidence that perinatal individuals with substance use disorders (specifically Opioid Use Disorder) and Medicaid insurance are more likely to seek emergency care than women without (Landis et al., 2023). Specifically, perinatal individuals with a substance-related diagnosis were more likely to have 1 or more ED visits or 3 or more days of inpatient care than perinatal women without a substance use disorder (Courchesne-Krak et al., 2022). Despite the heightened level of acute care utilization, perinatal individuals with substance use disorders are less likely to receive thorough treatment and adequate follow-up care within ED settings (Spitz et al., 2025). Perinatal individuals with substance use disorders may be more likely to seek ED care, which presents additional opportunities in acute healthcare settings to also detect comorbid STB risk.

Intimate Partner Violence. Intimate partner violence (IPV) consists of a pattern of harmful behaviors within romantic relationships and may include verbal, emotional, physical and sexual abuse, as well as isolation, deprivation, and coercive control (Basile, Smith & Friar, 2025). Although IPV may be considered a socio-contextual risk factor, it is categorized here as a Health Vulnerability component due to its direct physical and psychological consequences. In fact, homicidal violence is a leading cause of maternal deaths (Azad et al., 2026) and perinatal women experiencing IPV are 3 times more likely to die than perinatal women who do not experience IPV (Pastor-Moreno et al., 2020). IPV is both a cause of maternal death due to

homicide, as well as a significant risk factor for STBs as IPV is significantly associated with greater risk for both suicidal ideation and attempts among women (Alimoradi et al., 2026; Akinyemi et al., 2023). IPV risk is also heightened during the perinatal window. Pregnancy is consistently identified as a period of elevated risk (Steele-Baser et al., 2024) and as many as 20% of pregnant people experiencing some form of IPV (Drexler, Quist-Nelson, & Weil, 2022). More specifically, a synthesis of 86 studies found that the mid-to-late stages of pregnancy represent a critical period for IPV escalation, though high prevalence persists throughout the entire perinatal period (Mojahed et al., 2021).

IPV increases the risk for maternal suicidal ideation and suicidal behavior during pregnancy and postpartum (Halim et al., 2018). In one study of Brazilian women, IPV was found to exacerbate risk for suicidal thoughts threefold during postpartum (Tabb et al., 2018). IPV also increases the risk for suicidal behavior, with one study showing that intimate partner conflict was involved in more than half of suicide deaths among women during pregnancy (Palladino et al., 2011). In the U.S., IPV is a major co-occurring factor in perinatal suicide deaths, with IPV-involved relationships indicated in nearly half (47.3%) of suicide deaths occurring during pregnancy, as well as in nearly half (44.5%) of suicide deaths occurring postpartum (defined as 43 days to 1 year after birth) (Modest et al., 2022). IPV is a significant co-occurring risk factor implicated in suicide deaths during pregnancy and mid-late postpartum (43 days-1 year after birth). Taken together, the perinatal period is high-risk for IPV onset or exacerbation, with IPV implicated as a significant risk factor for perinatal STB emergence.

Despite the strong association between perinatal IPV and maternal mortality rates, literature establishing rates of perinatal IPV in acute care settings is alarmingly absent. While a comprehensive scoping review of 22 studies found that women experiencing IPV were more

likely to be admitted to EDs for self-harm or suicide attempts (Torrioni et al., 2025), prevalence estimates for such usage, particularly within the perinatal window, are scarce. IPV-related risk codes were indicated in only 0.06% of pregnant individuals in a 2016 nationwide sample of ED utilization (Murugan et al., 2021), while 0.84% of pregnancy-associated ED visits were for violent injury in a population level sample in California from 2010-2018 (Cruz et al., 2024). This illustrates lower levels of IPV codes identified at perinatal ED visits than perinatal prevalence estimates would suggest. Given that IPV is known to exacerbate during the perinatal window and is strongly associated with perinatal STB emergence and suicide deaths, remedying this observational gap is of critical importance to STB prevention efforts.

While women experiencing IPV are utilizing acute care at greater levels (Hoelle et al., 2015), there are significant reporting and clinical practice challenges complicating accurate detection perinatal IPV. One clinical care dimension is the lack of IPV screening implementation across levels of care, with a 2016-2019 evaluation of Pregnancy Assessment Monitoring system data finding that many perinatal individuals experiencing IPV were not screened for IPV at any point during pregnancy (26.9% unscreened) or postpartum (48.3% unscreened; Kozhimannil et al., 2023). An additional dimension may be that women experiencing IPV are less likely to utilize maternal health services, reducing opportunities to screen or seek help (Jackson et al., 2024). It is also possible perinatal women experiencing IPV state other primary complaints when seeking ED care, as was observed in non-perinatal IPV victims, who presented more for obstetrics and gynecology-related visits (Hoelle et al., 2015). Given its significant association with perinatal STB emergence, it is critically important to attempt more reliable estimates of IPV-related ED utilization and utilization timing.

Chronic Health Problems. Chronic medical conditions have been consistently associated with increased suicide risk in non-perinatal populations, specifically chronic pain, heart disease, chronic obstructive pulmonary disease, stroke, cancer, congestive heart failure, and asthma (Ahmedani et al., 2017). However, there is wide variation in which chronic health conditions are accounted for, with some studies evaluating 19 physical health conditions (Ahmedani et al., 2017) and others as many as 31 medical conditions in relation to suicide risk (Østergaard et al., 2024). A large population level study in Denmark found that of nine categories of medical conditions (i.e., circulatory, endocrine, pulmonary/allergy, gastrointestinal, urogenital, musculoskeletal, hematological, cancer, neurological), eight were statistically associated with greater suicide risk – specifically finding the strongest association for gastrointestinal conditions, cancer, and hematological conditions (Østergaard et al., 2024). Further, when physical health conditions are evaluated alongside mental health conditions, there was no interaction between medical conditions and mental disorders with suicide risk, indicating additive and/or distinct pathways between physical health problems and suicide (Østergaard et al., 2024).

While chronic health conditions are associated with STB risk more broadly, there are significant empirical gaps linking perinatal chronic health problems with STB outcomes. Chronic health problems among perinatal individuals is a worsening phenomenon. Approximately 91.8 per 1000 delivery hospitalizations involving mothers with at least one chronic condition in 2013-2014, with the greatest prevalence increases observed for chronic respiratory diseases, chronic hypertension, and diabetes (Admon et al., 2017). Scarce recent work has identified heart diseases, migraines, lupus, and epilepsy as the leading medical/physical health conditions associated with adverse maternal mental health outcomes (i.e., postpartum depression, psychosis,

other mental illnesses; Abu-Zaid et al, 2023). Very little is known about chronic health conditions and perinatal STB risk. Among seven studies identified in a systematic review by Arditi-Arbel and colleagues (2023), only chronic health conditions such as HIV, sexually transmitted infections (STIs) and headaches/migraines were associated with perinatal STB risk. It is possible the emphasis on HIV and STIs as opposed to other chronic health conditions across studies is likely due in part to elevated local prevalence, and prevention efforts aimed at mitigating the transmission of disease from mother to infant.

Preliminary evidence indicates that chronic health conditions are associated with greater risk for perinatal acute care utilization. Among the few studies associating chronic health problems with perinatal acute care utilization, one population level study in Canada found that perinatal individuals with 1 or more chronic health conditions were more likely to utilize the ED and have an inpatient hospitalization compared to those without a chronic condition (Brown et al., 2026). This relatively greater acute care utilization for those with chronic health problems presents an opportunity for enhanced STB surveillance, and temporal risk mapping, yet the dearth of clinical research presents challenges in estimating prevalence of such care seeking.

In addition, classification challenges arise when attempting to differentiate the influence of chronic health problems given the precedence of severe maternal morbidity research. Severe maternal morbidity (SMM) is a risk index defined by the CDC comprised of 21 health complications that may arise at delivery or postpartum (e.g. aneurysm, eclampsia, etc.; CDC, 2024). SMM conditions are physiological health conditions which, given their acuity, tend to take precedence in perinatal literature when investigating adverse maternal health outcomes. Specifically in relation to investigations of acute care utilization, there is evidence that acute care utilization is more likely for those who end up having SMM outcomes (Declercq et al., 2024).

SMM outcomes in turn render it more likely that individuals will utilize acute care for mental health problems (Blackman et al., 2024). Further, there is evidence that SMM is also associated with greater risk for STBs (Delker et al., 2023). Despite these associations, no known studies to date have comprehensively differentiated the influence of SMM and chronic health problems in relation to perinatal STB risk.

2.3.2 Access Vulnerability

Access Vulnerability refers to sociodemographic and structural factors that may influence perinatal STB risk through disparities in healthcare access and utilization. The U.S. system is unique and requires a closer interrogative lens given the privatized healthcare system and widening gaps in healthcare inequality unique to the U.S (Dickman, Himmelstein & Woolhandler, 2017). Broad deficits in perinatal care exist from "maternity care deserts" (Sonenberg & Mason, 2023) where over 35% of U.S. counties do not have maternity care access, and 56% of rural counties have no access to maternity care at all (Stoneburner et al., 2026). Impaired perinatal care access is also greater for those with Medicaid (e.g. publicly funded insurance for low-income individuals), who are more likely to (1) have fewer perinatal care visits, (2) initiate prenatal care late, or (3) have no prenatal visits at all (McElfish et al., 2025A). These perinatal care access deficits are pronounced for individuals who are Black, American Indian/Alaska Native and Native Hawaiian and Pacific Islander (McElfish et al., 2025A; McElfish et al., 2025B). These care deficits translate to unmet need and adverse outcomes in perinatal mental health due to both social and structural reasons unique to the U.S. context (Taiwo et al., 2024; Dossett et al., 2024).

These same Access Vulnerability characteristics also increase risk for perinatal STBs. Certain identity characteristics are more strongly associated with greater risk for perinatal STBs

than others, specifically younger age (Gelabert et al., 2024; Kim et al., 2015), and Black, Hispanic/Latina, Asian, and AI/AN identity (Margerison et al., 2024; Tabb et al., 2020; Salihu et al., 2022; Delker et al. 2023). Risk is particularly pronounced for women who identify as Black or AI/AN, who have the highest prevalence of pregnancy-associated deaths due to suicide compared to all other racial or ethnic identity statuses (Margerison et al., 2022; Salihu et al., 2022). In addition, certain contextual factors such as Medicaid or public insurance status (Kim et al., 2015), and rural or urban residence also significantly associate with perinatal STB risk (Delker et al., 2023). Within this context, perinatal STB risk may be especially elevated for those with intersecting contextual risk factors, such as having both a minoritized racial identity status and Medicaid insurance (Tabb et al., 2025). These Access Vulnerability risk factors are fairly stable and unchanging across the perinatal window, yet it is unclear how these sociodemographic factors relate to STB risk across the full perinatal window. Further empirical testing can determine whether and when these risk factors associate with perinatal STB risk timing.

These Access Vulnerability factors and associated deficits in outpatient perinatal care may translate to greater utilization of acute care utilization overall, and for STBs specifically. Those with Access Vulnerability characteristics are predisposed to greater ED utilization across the perinatal window, particularly for minority race individuals (e.g., Black and Hispanic patients) and those with Medicaid insurance (Zarrin et al., 2023; Malik et al., 2017). Individuals with these identities and insurance statuses have less access to preventive healthcare and perinatal care for structural and systemic reasons, leading to greater utilization of acute care services when problems reach a level of acuity that lower levels of care might have flagged and intervened on earlier. For mental-health related ED utilization, there is some evidence linking greater levels of ED utilization postpartum for women younger than 30 and those on Medicaid

insurance (Batchelor et al., 2023), as well as for individuals identifying as Black, though less so for Hispanic and Asian individuals (Karvonen et al., 2022). For STB-specific ED utilization within 30-days postpartum, Access Vulnerability characteristics such as public insurance and identifying as Black or Asian were significantly associated with greater risk among women with pre-existing mental health disorders (Pluym et al., 2021).

Despite preliminary evidence of heightened ED utilization for perinatal individuals with minority racial/ethnic identities and public health insurance, there is a scarcity of research associating these characteristics with STB-flagged utilization specifically. This reveals a critical need to further define how contextual risk factors for STB-related ED utilization operate across the entire perinatal window within a U.S. context. Together, Health and Access Vulnerability domains highlight the importance of considering both proximal clinical risk factors and broader structural determinants when estimating perinatal STB risk. Integrating these domains may provide a more comprehensive understanding of when and for whom STBs are most likely to emerge within the perinatal period

To better understand the crisis of maternal suicide in the U.S. context, interrogating data representative of the broader country may provide critical insights into perinatal healthcare utilization for STB reasons. Oregon is a geographically large state of 4.2 million people. While Oregon has limited racial/ethnic diversity (75.1% non-Hispanic White) it has much more geographic and socioeconomic diversity (Health Resources and Services Administration [HRSA], 2024). For example, Oregon's poverty level (1.4%) is higher than the national average, and racial/ethnic minority populations have higher poverty rates than non-Hispanic White (HRSA, 2024). Oregon is also unique in its passage of legislation incentivizing healthcare accountability metrics (e.g., House Bill 3100; House Bill 2310; Madamala et al., 2024), and

codifying suicide prevention measures for ED healthcare settings (House Bill 3090 [2017]/ORS 441.053). For example, HB 3090 required all hospital EDs to adopt the same 16 planning requirements guiding ED discharge for behavioral health concerns, including suicide-risk assessment (OHA, 2021). HB 3090 achieved an average policy implementation rate of 84% across all 16 discharge planning requirements, though implementation levels varied by requirement (OHA, 2021). The required behavioral health assessment policy was implemented across 97% of EDs, while suicide risk assessment policies were implemented at 93% of hospitals (OHA, 2021). Thus, Oregon is a helpful case study whereby ED-specific data for behavioral health, including STBs, is required to be tracked and reported by law – suggesting Oregon may provide more complete STB-related ED utilization prevalence estimates. This provides a particularly useful context for estimating perinatal-specific STB-flagged ED utilization compared to other states where ED-level STB screening policies are not legally mandated.

2.4 Perinatal STB Risk Timelines

The perinatal window can be considered a time-bound transition spanning from conception to one year after delivery, consistent with the Centers for Disease Control (CDC's) Pregnancy Mortality Surveillance System definition. According to the CDC, death is considered "pregnancy related" if it occurs either during pregnancy or within one year after delivery (CDC, 2025). There is value to estimating STB prevalence throughout the entire perinatal time window overall. For instance, such an estimation allows for a complete picture of how common perinatal STBs are overall. However, there is significant degree of temporal granularity lost when broadly estimating STB prevalence for the full perinatal window. There is a growing body of evidence differentiating risk within more temporally-defined windows. The following section synthesizes this evidence for perinatal STB timelines and peak risk windows. Laying this foundation

establishes a useful framework for evidence-based hypotheses estimating when during the perinatal window STB risk, and acute care utilization, may be greatest.

2.4.1 Perinatal STB Risk Timelines and Peak Risk Windows

When comparing findings across studies, there are differing estimates for which period of the perinatal window has the greatest risk for STBs. Xiao and colleagues (2022) reviewed 71 studies published prior to 2020 and found slightly higher prevalence of suicidal ideation during prenatal (10%) compared to postpartum (7%). However, in a more recent meta-analysis, Karaçam and colleagues (2023) evaluated 38 studies between April 2021-April 2023 and found higher estimates of both ideation and behavior during the postpartum period compared to pregnancy. Specifically, Karaçam and colleagues estimated ideation at 6.1% prenatally vs 9.2% postpartum, and suicide attempts at 0.5% during pregnancy and 0.7% postpartum.[2] Of note, Karaçam and colleagues specifically targeted studies conducted during the COVID-19 pandemic while Xiao and colleagues appeared to explicitly exclude COVID-19 related effects (e.g., only analyzing studies prior to August 2020). Differences in estimates between studies may be partially attributed to the negative impact of the COVID-19 pandemic on perinatal mental health (Wall & Dempsey, 2023). The comparison of these comprehensive meta-analyses indicates uncertainty around when suicide ideation is greatest. Conversely, there is converging evidence that suicidal behavior is more frequently observed postpartum. However, suicidal behavior estimates tend to vary across studies when defining the STB outcome under analysis, and the

[2] Karaçam and colleagues reported postpartum suicidal behavior prevalence as high as 23.4% pooled from findings across six studies where "suicidal behavior" was reported as the outcome. However, there was substantial heterogeneity across studies ($I^2 = 99\%$) and significant outliers within several studies, indicating the 23.4% estimate may not accurately represent postpartum suicidal behaviors. Thus this estimate was excluded as evidence for postpartum prevalence of suicidal behaviors.

temporal framing of the study (e.g., Goldman-Mellor, 2025; LeCounte et al., 2026; Lewkowitz et al., 2019; Molina et al., 2025).

There are empirical differences in perinatal STB risk observations which constrain accuracy in estimating when exactly STB risk is greatest. These different estimates can be attributed to a range of reasons, including how STBs were measured or defined, the length or temporal granularity of the observation window, and the sample type or country within which analyses were conducted. This introduces a critical need to summarize current evidence for STB prevalence during pregnancy and postpartum. As studies use different STB outcomes as their primary outcome variable, the STB term is deconstructed into ideation and behaviors to better summarize current research evidence based on timing. This temporary deconstruction allows for more detailed summaries of risk peaks, which can inform broader hypotheses regarding temporal risk for perinatal STBs.

Empirical studies outside of meta-analytic work have found greater levels of suicide ideation during pregnancy compared to postpartum. International studies in China (N=1089) and Romania (N = 258) found that suicide ideation was more common during pregnancy (prevalence = 12.1-13.9%) compared to 4-8 weeks postpartum (prevalence = 6.3-7.8%; Xiao et al., 2023; Enătescu et al., 2021). However, these studies assess postpartum outcomes only within the first 4-8 weeks, limiting conclusions about later postpartum risk. Among the scarce few U.S. studies comparing pregnancy vs. postpartum levels of suicidal ideation, one study (N = 223) found that rates of self-injurious thoughts were similar between pregnancy and postpartum (Molina et al., 2025). Other U.S. based studies have providing broader estimates of suicide ideation prevalence over time, without differentiating prevalence during prenatal vs. postpartum windows (e.g., Bodnar-Deren et al., 2016; Admon et al., 2021). Thus, there is preliminary international evidence

for elevated ideation levels during the prenatal period, but scant U.S. based evidence differentiating ideation levels between pregnancy and postpartum.

Cross-sectional studies indicate suicide ideation can occur at any time during pregnancy, with some evidence for elevated risk during the first and third trimester. Suicide ideation can begin as early as the first trimester, with one study in Spain reporting a prevalence of 2.6% in early pregnancy (Legazpi et al., 2021), with new onset ideation beginning as late as the third trimester for a third of participants in another study (Xiao et al., 2023). Within the U.S. context, analyses of a large sample of pregnant women from the National Survey on Drug Use and Health from 2009-2018 found that STBs were more prevalent during the first trimester of pregnancy (4.4%) compared to the second or third trimesters (2.9%), though ideation was encompassed within a STB construct inclusive of planning and attempts (Kitsantas et al., 2020). In comparison, another study (conducted in China) estimated a higher level of ideation (6.71% of pregnant women) during the third trimester (Zhang et al., 2022) in comparison to values observed by Kitsantas and colleagues (2020). These different estimates lend further support to the need for additional research to more clearly define risk peaks for STB symptoms within a U.S. context.

Evidence also suggests multiple potential peaks in suicidal ideation during the postpartum period — indicating a nonlinear risk trajectory over time. A longitudinal Australian study (N=1507) found self-harm ideation was most frequently reported during the first 12 months postpartum compared to pregnancy or other non-perinatal timepoints (Giallo et al., 2018). More specificity in timing was provided by a U.K. study, where suicidal ideation was more prevalent at four weeks postpartum (16.3%) than at 18 weeks (7.3%), indicating a decrease in prevalence throughout the postpartum window (Howard et al., 2011). However, there was new

onset ideation for a subset of mothers at 4 weeks, and another group who experienced new onset ideation at 18 weeks postpartum, suggesting that an earlier positive screen may not detect all participants at risk for later experience of ideation. This latter peak at 18 weeks is mirrored in a cohort of U.S. based mothers with a history of childhood maltreatment (n = 116), who experienced peak SI prevalence at 4 months postpartum, with persistent SI prevalence indicated in 25% of the sample between 4-18 months postpartum (Muzik et al., 2016). Taken together, it is possible there are multiple waves of peak risk for suicidal ideation during postpartum, but patterns may vary based on study sample location and timeframe.

Suicidal behaviors, such as creating a plan, preparatory behaviors, and attempts, remain less well characterized than ideation within perinatal populations. Broad prevalence estimates have been established for perinatal deaths by suicide, with greater rates observed during the later postpartum period. However, granular temporal estimates of perinatal suicidal behaviors are sparse, and even rarer still in U.S. contexts. Current deficits in clear estimation of suicidal behaviors may be partially attributed to measurement choices, with study outcomes combining ideation with behavior (Kitsantas et al., 2021). For example, one comprehensive systematic review found that only three out of fifty-nine studies sufficiently differentiated suicidal ideation from behavior (Reid et al., 2022). However, this coding difference does not fully address temporal gaps in understanding for when STB symptoms — including behaviors — are likely to emerge within the perinatal window.

When evaluated temporally, there appears to be differential risk for death by suicide across the perinatal window, which supports that there may be temporal patterning in STB symptoms. Death by suicide is more likely to occur during the postpartum period with between two-thirds and three-quarters of perinatal deaths by suicide occurring between 6 weeks and 1

year postpartum (Lommerse et al., 2019). There is further differentiation in the risk timing across the postpartum period as well. An analysis of the U.S. National Violent Death Reporting System (NVDRS) data yielded 1150 perinatal deaths with 39.6% occurring during pregnancy, and 60.3% occurring postpartum (17.7% within 42 days after pregnancy; 42.7% within 43-365 days after pregnancy; Zivin et al., 2024). The latter postpartum period appears to carry the greatest risk, as reflected in a Canadian study where the final quarter of the postpartum window (9-12 months postpartum) had the greatest occurrence of suicide deaths (Grigoriadis et al., 2017). Taken together, there are differing estimates for exactly when postpartum suicide risk is highest, identifying the need to clarify temporal risk windows with more granularity.

Empirical studies estimating suicidal behaviors beyond death by suicide (e.g. attempts, preparatory behaviors) are incredibly sparse, with different results on whether or when risk is greatest. A large-scale population study of hospital discharge records from 2006-2019 found consistently higher levels of postpartum hospitalizations for intentional self-harm compared to prenatal rates, though additional temporal distinctions were not provided (LeCounte et al., 2026). Similar work with large scale population data reinforces the postpartum precedence for suicidal behavior, including attempts (Goldman-Mellor, 2025; Lewkowitz et al., 2019). Very few studies offer further specificity in postpartum suicidal behavior risk. For example, one U.S. based longitudinal study ($N = 223$) found greater odds of self-injurious behaviors at 7 months postpartum compared to the third trimester of pregnancy (Molina et al., 2025). However, the latter study was only able to compare risk between the third trimester and 7 months postpartum, and delineation from risk at other postpartum timepoints was not possible. This work indicates elevated risk for suicidal behavior postpartum within U.S. based samples, but major gaps persist in defining when exactly risk is greatest during postpartum.

Taken together, current evidence reveals substantial gaps in understanding when STB risk is greatest across the perinatal period, and more specifically, within the prenatal and postpartum windows. There is mixed evidence for whether ideation is more common during pregnancy compared to postpartum, with limited work indicating greatest risk during the first and third trimesters of pregnancy and during 4 weeks to 4 months postpartum. There is more coherent evidence indicating elevated risk postpartum for suicidal behaviors, with a collection of studies indicating greater levels of self-injurious behaviors or suicide from 6 weeks to 1 year postpartum, with potential peak in the latter postpartum period (e.g., 7 months onwards). This variation in both STB prevalence estimates and peak risk timing underscores the need to more clearly define STB risk peaks during pregnancy and postpartum and provide more granular temporal comparisons of risk.

2.4.2 Perinatal Healthcare Guidelines & Screening Timeline Mismatch

Despite increasing rates of maternal suicide and related STBs, there are currently no universal screening guidelines for suicidal thoughts and behaviors during the perinatal period. In fact, the United States Preventative Services Taskforce (USPSTF) currently concludes there is insufficient evidence to recommend routine screening for suicide risk in pregnant and postpartum populations (Jin, 2023). Professional opinions on the utility and efficacy of STB screenings vary, with no formal evaluation available on the potential risks or benefits of universal STB screenings in out-patient settings (USPSTF, 2023). Currently, screening for suicidal thoughts and behaviors in out-patient settings follows an indicated or selected screening process. This means that suicide screening must be indicated, either by patient disclosure or provider clinical judgement. Some researchers argue against universal screening in outpatient contexts due to limited predictive validity or potential unintended consequences (Bryan, Allen, Bryan, et al., 2023; Bryan, Allen, &

Hoge, 2023). In contrast, other researchers provide evidence supporting the feasibility and safety of universal suicide screenings more broadly (DeCou & Schumann, 2018), and in hospital and specialty care settings specifically (Goldstein Grumet & Boudreaux, 2023; Mann et al., 2021). While this debate is on-going, current perinatal care continues to proceed without any form of recommended suicide screening, unless indicated.

Existing perinatal mood screening guidelines are oriented toward postpartum depression detection and do not currently provide STB screening guidelines. Best practice perinatal mood screening guidelines are published by the American Academy of Obstetrics and Gynecology (ACOG) professional organization. The most recent iteration of ACOG guidelines recommend screening all perinatal individuals for depression and anxiety at the initial prenatal visit, later in pregnancy, and at postpartum visits (ACOG, 2023). Within this practice guideline, STB *symptom* screening is discussed as a component of standard mood screening questionnaires (e.g., Patient Health Questionnaire; Edinburgh Postnatal Depression Scale). However, standalone STB screening is not recommended. While perinatal depression is a risk factor for perinatal STBs (Yu et al., 2024), perinatal STBs can co-occur with subclinical depressive symptoms and may exist independently of depressive disorders (Despotis et al., 2025). This is an important distinction, as depression screens are not considered a sufficient proxy for STB screening (AMA, n.d.; Horowitz et al., 2023). This reveals a gap in guidance around STB screening, with current perinatal mood screening practices insufficient for STB detection.

To complicate the situation further, the timing of perinatal mood screening guidelines are incongruent with current evidence of the risk timing for perinatal deaths by suicide. Perinatal depression risk is considered to be greatest in the immediate postpartum period around 4-8 weeks after birth (Carlson et al., 2025; Horowitz et al., 2023). Interestingly, the 8-week upper bound is

currently outside of the standard 6-week postpartum check-up normalized in obstetric clinical care (Tully, Stuebe & Verbiest, 2017) — suggesting that recommended mood screening timelines and clinical practice may not align with perinatal depression risk either. In regard to STB risk specifically, preliminary evidence shows that maternal suicide peaks far later postpartum between 7-12 months postpartum for intentional or unintentional overdose deaths (Schiff et al., 2018; Nielsen et al., 2020), and 9-12 months postpartum for suicide deaths more broadly (Grigoriadis et al., 2017). This suggests discordant timelines of risk where the timing of perinatal mood screening does not extend to meet windows of elevated STB risk. As a result, it is highly likely that perinatal individuals at risk for STBs may not be identified within existing screening windows. These findings suggest that increases in perinatal STBs and growing awareness of STB timing may be outpacing the development of evidence-based screening guidelines.

Concerningly, the absence of STB screening guidance is pervasive across professional clinical care organizations. Based on a comprehensive review of perinatal screening guidelines across professional care organizations including obstetric, pediatric, primary care, midwifery, psychiatry, and psychology, it was found that only ACOG and pediatric care (American Academy of Pediatrics; AAP) professional organizations provide clinical guidance for responding to STBs endorsed on perinatal depression screens (Mendes et al., *forthcoming*). In addition, AAP's screening timeline extends further than ACOG's — recommending perinatal mood screening at well-child visits up to six months after delivery (Hagan, Shaw & Duncan, 2017; Earls et al., 2019). Unfortunately, the AAP screening recommendations are not uniformly implemented across pediatric care settings, translating to many perinatal individuals going unscreened at well-child visits (Lamere & Golova, 2022; Coker et al., 2024). This absence of

STB screening guidance is itself an implicit guideline that may contribute to the uncertainty around when and whether to screen perinatal women for STBs at all. This is particularly true in the absence of guidance provided around recognizing the STB risk factors that may precipitate perinatal STB risk. Thus, the absence of clinical care guidelines creates a problematic knowledge gap around STB risk pathways and timing that limits perinatal STB mitigation efforts.

The prior section outlined problematic gaps in perinatal mood screening guidelines, which omit STB screening guidance altogether. Although perinatal STBs and depressive symptoms share some risk processes, they also involve distinct mechanisms and risk timelines. Specifically, the mood screening guidelines recommended by professional care organizations are temporally out of sync with peak risk for perinatal suicide — which is most frequently observed 7-12 months postpartum. Even when screening guidelines extend further into the postpartum window (i.e., AAP), these screening recommendations are largely not implemented, leading to many perinatal women going unscreened after six weeks postpartum. Together, this presents a concerning reality for perinatal women who may experience emergent or recurring STB symptoms. The current infrastructure for perinatal mental health surveillance is currently not designed to thoroughly detect or address perinatal STB risk.

2.5 Synthesis and Summary of Gaps in Perinatal STB Detection

The previous sections highlight four key empirical gaps in the literature on perinatal STBs. First, limited research has applied established suicide risk frameworks within perinatal samples, with prior work engaging with leading theories such as IMV and Fluid Vulnerability to interrogate perinatal STBs (e.g. Reid et al., 2022; Kaliush et al., 2024). Existing research suggests that while these frameworks capture core mechanisms of risk, they may not fully account for the developmental and contextual specificity of the perinatal period. The

physiological, contextual, and identity-related changes inherent to the perinatal transition may introduce unique cognitive and emotional risk processes not fully captured by existing theories. These processes may be particularly salient during key developmental transitions (e.g., first trimester, immediate postpartum) which serve as inflection points for heightened STB risk, yet associations between critical perinatal transition points and STB emergence have not yet been made. Extending existing suicide theories to account for developmentally salient risk peaks within the perinatal context may improve temporal estimation of perinatal STB emergence from a meta perspective.

Secondly, current approaches to measuring perinatal suicide risk also remain limited. Historically, suicide risk has been assessed primarily through death records, which are limited by reporting and classification challenges. More recent work has expanded measurement to include perinatal suicidal thoughts and behaviors, revealing substantially higher levels of suicide symptomatology than suicide deaths alone capture. A more thorough estimation of perinatal STB risk is offered through administrative healthcare record data, for which there is emerging evidence that it serves as a rich data source to more precisely capture population level estimates (e.g., Goldman-Mellor et al., 2025). Administrative healthcare record data — specifically captured at delivery, inpatient, or emergency-department settings — provide a comprehensive level of specificity and temporal granularity in both prevalence, onset, timing, and critical covariates associating with perinatal STB risk. Thus, it is critical to leverage such data when formulating estimates for population level prevalence of perinatal STBs.

Third, a major gap in the literature concerns limited temporal granularity for when perinatal STBs are observed or can be anticipated. Existing studies typically estimate risk at broad levels (e.g., pregnancy vs postpartum, or discrete perinatal trimesters), obscuring more

precise windows of heightened vulnerability. Given that perinatal STBs are an emergent event, acute healthcare utilization embedded within administrative health record data provides a valuable opportunity to capture the timing of STB emergence. This level of granularity can clarify whether there is overlap between distinctive developmental transitions and heightened risk for perinatal STBs as observed within acute healthcare seeking. These data also capture variability in acute care-seeking, whereby differential utilization patterns may serve as an indicator of greater risk for perinatal STBs. This is particularly valuable for evaluating acute healthcare utilization and visit recurrence, a STB risk factor not yet fully explored within the perinatal context. Leveraging these data to map STB timing and recurrence may help to identify critical periods of vulnerability that are not captured in existing research.

Fourth, although numerous STB-related risk factors have been identified in key review studies, their role in contributing to the magnitude and timing of perinatal STB risk remains poorly understood. Comprehensive studies evaluating both Access and Health Vulnerability-related risk are rare, contributing to a lack of understanding in how combined risk may jointly contribute to perinatal STB emergence. Prior research has flagged Health Vulnerability risk factors such as STB history and NSSI, psychiatric problems, substance use disorders, IPV, and chronic health problems as critical risk factors for perinatal STB onset. However, no work to date has compared the influence of historical vs. perinatal incidents of clinical health risk vulnerability, which may differentially inform STB risk estimates at critical points in the perinatal window. It is also unknown whether these risk factors have a time-varying influence on STBs throughout the perinatal period, potentially contributing to windows of elevated risk depending on risk profile. Finally, this knowledge gap extends to whether ED utilization, and the recency of acute healthcare utilization overall, may associate with perinatal STB risk perinatally.

These knowledge gaps make it difficult to anticipate covariate risk indictors of perinatal STB risk, which may impede clinical decision-making around STB screening.

Taken together, these gaps highlight the need for research that integrates population-level data, both sociodemographic and clinical health risk factors at historical and perinatal levels of observation, and temporal precision to better characterize perinatal STB risk. The present study addresses these gaps by leveraging administrative healthcare data to examine the timing of STB-related acute care encounters, patterns of visit recurrence, and the contribution of both Health and Access Vulnerability factors in relation to STB risk across the perinatal window.

CHAPTER III

METHOD

This chapter describes the method used to assess the prevalence, strength of association, and risk timing between STB-associated risk factors and risk profiles and the hazard of an initial or recurrent STB-flagged ED event. This study is a retrospective, population-level cohort analysis of linked administrative healthcare claims data from Oregon Health Authority (OHA). The cohort consisted of individuals with a live birth between 2020-2024, with the unit of analysis being the perinatal window. Individual level Health and Vulnerability risk factors, prior acute care utilization, and composite vulnerability risk profiles were derived from discharge records from delivery records, inpatient stays, and ED visits. Descriptive statistics provided the prevalence and distribution of initial and recurrent STB flagged ED visits and covariate risk factors across the perinatal window. Piecewise exponential additive mixed models (PAMMs) estimated the strength of association between individual level risk factors —including recency of prior acute care utilization — and both initial and recurrent STB-flagged ED events across the full perinatal window. A second set of PAMMs were fit at prenatal and postpartum landmarks and estimated differential risk by vulnerability profile for initial and recurrent events. Finally, first-derivative analysis of the PAMM log-hazard curves defined windows of increasing or decreasing risk for the population-averaged hazard and for hazards stratified by vulnerability profiles.

3.1 Research Design

This research study was a retrospective, population-based observational cohort study using linked administrative healthcare records. Population level claims data was utilized for this study as it provided the most comprehensive data on both the timing and co-occurrence of critical risk covariates with sufficiently large data to capture the true incidence rate of rare events

like STB-flagged ED visits. Claims data provided specificity in healthcare event dates and diagnoses (ICD-9 and ICD-10 codes) that are unlikely to be reported with absolute fidelity by patients. It also provided a longitudinal overview of risk utilization over time with the kind of thoroughness and specificity unlikely to be captured by studies with smaller sample sizes. Additionally, administrative claims data compiled by state health authorities provide a cost-efficient data source from which analysis of healthcare utilization, timing, and risk factors can be applied without undue burden to participants themselves.

For Aims 1 and 2 of the study, the unit of analysis was the perinatal window associated with a unique pregnancy event. The operational definition of the perinatal window is defined as the interval spanning approximately 280 days prior to delivery (estimated conception) through 365 days following the delivery event. Each perinatal window was anchored at the delivery event, with multiple pregnancies allowed per individual and treated as independent events (see section 3.4 for further details). This approach allowed risk to be modeled relative to a clinically meaningful and temporally consistent reference point while preserving temporal ordering across pregnancy and postpartum periods.

For Aim 3 analysis, the unit of analysis shifted from the full perinatal window to two landmark windows of risk — the prenatal and postpartum windows. Each window included its own observation window and risk set confined to that observation window. The prenatal landmark began at 280 days prior to delivery (approximately conception) and ended the day prior to delivery. The postpartum landmark included the delivery event and spanned to 365 days after delivery. Vulnerability profiles used in Aim 3 analyses were defined by event data observed prior to the landmark window onset. Separate models were run for each landmark window. This structure preserved the temporal precedence of vulnerability risk profiles, preventing

misclassification that would result from applying a vulnerability profile status derived from future events relative to observation start. This approach allowed risk to be differentiated by vulnerability profiles across clinically meaningful windows while preserving the temporal ordering of events and avoiding immortal time bias.

The administrative availability of the outcome event — a STB-flagged ED visit — constrained the study observation window to calendar years 2020-2024. As a result, some prenatal windows were left-truncated when conception predated the ED observation window. In addition, some postpartum windows were right-censored when follow-up extended beyond December 31, 2024. These features were addressed analytically through time-to-event modeling strategies described in Section 3.4. History level diagnoses observed at inpatient and delivery events prior to 2020 were retained and included as time-invariant historical risk covariates for each perinatal window. This approach provided a richer covariate set for analyses by including historical risk covariates observed prior to 2020 and time-dependent covariates occurring perinatally between 2020-2024.

3.2 Data Sources and Participants

Quantitative data was acquired through application process with Oregon Health Authority (OHA) and included administrative claims level information submitted by 60 hospitals across Oregon and compiled by OHA for reporting and monitoring purposes. The data consisted of proto-claims (administrative) healthcare records aggregated at discharge, translating to event-specific data including patient-level details such as patient demographics, dates of service, ICD code diagnoses, and procedure codes recorded for insurance billing purposes. OHA compiled these data into three separate datasets sourced from distinct healthcare settings (i.e., at delivery events, inpatient visits, and emergency departments). No new data was collected by researchers

for this project. While legally mandated behavioral health screening and indicated suicide assessment policies have been implemented across Oregon EDs at high levels (97% and 93% respectively; OHA 2021), there is likely a significant minority of STB-presenting cases that are not screened or assessed due to differences in implementation. This might lead to underrepresentation of STBs flagged in ED records. This may be particularly true for the year 2020 prior to uniform implementation of ED screening and assessment policies. Despite these potential limitations, the OHA-provided data can be considered comparable to a census-level snapshot of all available care records for delivering individuals within the study observation window.

3.2.1 Data Sources and Linkages

OHA provided three datasets spanning 2008-2024, including a delivery dataset, an inpatient dataset, and an ED dataset. A unique record ID linked within-person events across the three care settings. The study cohort was limited to those with a perinatal window observed in the delivery dataset between 2020-2024. The observation window was limited to 2020-2024 due to all ED data, including the outcome variable (STB-flagged ED visits), being available only from 2020 onwards due to administrative record availability. Thus, inpatient and delivery event records observed between 2008 to the end of 2019 were used to classify historical health vulnerability risk factors. Inpatient, delivery, and ED events observed perinatally between 2020-2024 were used to classify perinatal-specific health vulnerability characteristics. The final combined dataset included both historical and perinatal risk factors differentiated by care setting for live-delivering individuals between 2020-2024.

The consolidated dataset was organized by pregnancy ID (unique record id plus distinct delivery date) with a perinatal observation window spanning from 280 days prior to the delivery

event to 365 days after delivery (i.e., the perinatal window). This structuring allowed for more than one perinatal window, differentiated by unique pregnancy ID, within individuals. For those with overlapping perinatal windows (e.g. when a pregnancy began during the prior pregnancy's postpartum window), the new pregnancy/delivery event took precedence to preserve temporal ordering. These data management decisions ensured that healthcare events were appropriately associated with the index delivery in alignment with their temporal proximity.

3.2.2 Inclusion and Exclusion Criteria

Individuals were eligible for inclusion if they had at least one live birth recorded in Oregon between January 1, 2020 to December 31, 2024, were 18 years of age or older at the time of delivery, and had a birth date indicated in their claims data. The 2020-2024 observational time window was selected due to limitations in ED data availability (see Section 3.2.1). The exclusion of births by individuals below 18 (n =1,368) accounted for the removal of n = 8 STB-flagged ED events, or 0.67% of all STB-flagged ED events from the general population data. Individuals below 18 were excluded due to coding differences in some ICD risk flags for juvenile patients, and more established care guidelines for adult perinatal individuals which provided a clearer reference for interpreting results. A small subset of the sample (n = 7) had birthdates logged at delivery as the date of service (e.g., age calculating to 0). For this small subset, age was imputed using the sample median value given the negligible proportion of affected cases (<0.01%), in order to retain those records for analyses. No additional exclusions were applied.

3.2.3 Sample

After accounting for exclusion criteria, the final cohort consisted of 185,431 perinatal windows representing 155,713 birthing individuals with observed ages between 18-64 in Oregon. There was an average of 1.19 perinatal windows per birthing individual, indicating some

had more than one perinatal window observed between 2020-2024. Of the 185,431 perinatal windows, 69% were for first delivery events (*n* = 127,895 perinatal windows), 28% were second delivery events (*n* = 51,974 perinatal windows), and 3% were third or more delivery events (*n* = 5,562 perinatal windows). Among all perinatal windows, 119,943 had fully observed perinatal windows, while 29,107 were left-truncated (i.e., some level of prenatal window unobserved due to 2020 window start), and 36,381 were right censored (i.e., some level of postpartum window was unobserved due to 2024 administrative cut-off). This cohort represents the full population of adult hospital-based live births recorded by OHA across Oregon between 2020-2024.

3.2.4 Consent and Ethical Considerations

A full waiver of authorization (i.e., permission to proceed without securing individual consent) was granted by the UO IRB (STUDY00001937; approval 09/10/2025). A full waiver was granted on the basis of minimal risk to subjects, adequate protections for data safety and security were specified, and the inability to feasibly conduct the study otherwise. HIPAA identifiers present in the data included date of birth, dates of care, and patient zip-code. Privacy safeguards were established to maintain confidentiality of the data. Implemented safeguards included secure data transfer between OHA and the University of Oregon by encrypted file transfer, secure data storage on UO servers, and data access limited to only those specified on the IRB. Furthermore, data will be destroyed within a two-year period after study end.

3.3. Measures

For Aim 2 Covariate models, risk factors were structured according to three levels of temporal proximity to the outcome with important distinctions in variable coding scheme and results interpretation. *Time-invariant covariates* (e.g., history of psychiatric inpatient events) had their value fixed at baseline and carried forward as a constant throughout each interval. These

risk factors represented stable sources of risk that did not vary over time but represented historical risk external to the current perinatal window. *Time-dependent covariates* (TDCs) were risk flags that could occur more than once over the perinatal window, meaning its value could vary depending on the interval under observation. TDCs were coded as binary predictors of within-interval risk, which allowed individual level risk flags to turn on (coded as 1) during the intervals they were observed, and reset to off (coded as 0) for intervals when they were not observed. This coding scheme preserved the temporal acuity of each risk flag at specific weekly (or more granular for recurrent model) time intervals. Further, this modelled hazard as concurrent – meaning that the aHRs reflected the instantaneous hazard of a STB-flagged ED visit during any interval when that TDC was "on". Finally, there were *lagged recency covariates* capturing the decaying hazard of a recent acute healthcare utilization visit within mutually exclusive lookback windows. The recency covariates were lagged by one interval such that they were not included in the current interval of observation – providing temporal precedence of the look-back window. This recency variable was updated at each interval as time elapsed since the covariate occurred. Together, these three coding schemes providing within-model comparisons of the magnitude of association depending on the temporal proximity of the risk factor with the outcome.

This three-level coding scheme was applied to Aim 2 models specifically. Individual level predictors for both the Access and Health Vulnerability – History domains were structured as time-invariant covariates. Health Vulnerability – Perinatal risk factors observed at inpatient and ED events were time-dependent covariates (TDCs) coded as binary predictors of within-interval risk. Delivery flags were TDCs as their value changed within the perinatal window, transitioning from "0" during the prenatal window to "1" at delivery. Delivery flag values were

carried forward as "on" for the remainder of postpartum. Finally, the lagged recency covariate represented inpatient and ED acute healthcare utilization recency for any medical reason (including STBs) across set look-back windows aligned with theorized windows of recency risk. The full covariate models included all three levels of temporal risk factors.

Aim 3 models were simplified and consisted of a composite Vulnerability profile structured as a time-invariant baseline predictor of risk. The Vulnerability Profile variable consisted of four mutually exclusive risk profiles derived from individual level risk factors observed at two perinatal landmarks. The prenatal landmark window structured the vulnerability profile from time-invariant access and health vulnerability risk factors available prior to conception. The postpartum landmark window expanded the vulnerability profiles, defining them by additional risk factors observed prenatally and at delivery (but not postpartum). The differentiation of each vulnerability profile at the prenatal and postpartum landmarks preserved temporal precedence of each profile classification prior to the outcome event.

Outcome Measure. Across all analyses, the outcome variable was a STB-flagged ED visit. There was an initial event outcome, and a recurrent event outcome variable used for inferential models. STB-flagged ED visits were coded by ICD codes excluded from all other risk categories, meaning it was a mutually exclusive domain. However, this code could co-occur with alongside other ED risk flags indicating within the same event (e.g., concurrent events). The STB-flag was all-encompassing of STB symptomatology and included both suicidal ideation and behavior ICD codes. Further, this code was indicated only if observed within a perinatal window. STB-flagged ED visits outside of perinatal windows were not included in outcome counts.

3.3.1 Multidimensional Access and Health Vulnerability Risk Factors for Aim 2 Models

Access Vulnerability Domain (Time-Invariant). Demographic and healthcare-access related variables comprise the Access Vulnerability risk profile. These variables include age, race, ethnicity, and insurance status recorded at time of delivery.

Age. Age at time of delivery was included as a pre-calculated variable provided by OHA as a component of administrative claims records. Median imputed age variables were included for 7 records whose date of birth was miscoded at time of delivery as the date of care.

Race. Racial identity codes were provided by OHA and included 9 levels for race: 1) American Indian or Alaska Native, 2) Asian, 3) Black or African American, 4) Native Hawaiian or Pacific Islander, 5) White, 6) Patient Refused, 7) Unknown, and 8) Other. These categories were likely originally self-reported by individuals at the time of care and coded by care providers and administrators for reporting purposes. Levels 6 (Patient Refused) and 7 (Unknown) were collapsed into one category (Refused_Unknown) for analyses.

Ethnicity. Ethnic identity codes were provided by OHA and included 4 levels for ethnicity: 1) Hispanic or Latino, 2) Non-Hispanic or Latino, 3) Patient Refused, and 4) Unknown. Levels 3 (Patient Refused) and 4 (Unknown) were collapsed for analyses into a single category (Refused_Unknown) to simplify categorization.

Insurance Status. Primary payer at time of delivery was provided by OHA and categorized into five groups: Commercial, Medicaid, Medicare, Uninsured, and Other. For analyses, Medicaid and Medicare were collapsed into a singular group ("Public") representing any kind of age/disability related or financial need-based insurance coverage, leading to four payer groups. OHA consolidated the "Other" category from multiple potential payment options, including codes such as "Department of Defense", "Indian Health Service Tribe", or "HRSA program", and "worker's compensation". These component codes comprising the "Other"

category were not specified within the data, and the broad level "Other" code was utilized in its stead.

Health Vulnerability Domain. The Health Vulnerability domain represented a set of individual-level risk factors derived from ICD-9 and ICD-10 diagnostic codes present in the claims data capturing underlying psychiatric, medical, and psychosocial risk conditions associated with STB risk. Specifically, the Health Vulnerability domain included six binary indicators for Suicidal Thoughts and Behaviors (STBs), Non-Suicidal Self-Injury (NSSI), Psychiatric Problems (PSYCH), Substance Use Disorder (SUD), Intimate Partner Violence (IPV), and Chronic Health (CH). Health Vulnerability flags were further differentiated by timing of observation, with those occurring prior to 2020 carried forward as fixed Health Vulnerability History (Hx) risk factors. Flags observed during a perinatal window between 2020-2024 were categorized as Health Vulnerability- perinatal flags. These Health Vulnerability flags were further distinguished from one another based on event setting (i.e., at delivery, inpatient, or ED events) to indicate the acuity of the context at which that flag was observed (see Table 1 for risk categories by Health Vulnerability domain). This approach preserved the inherent structure of claims data in which diagnostic codes are only observable at discrete points of care and are inseparable from care setting. Full ICD code specifications for each flag category are provided in a supplementary codebook available upon request to the author.

Health Vulnerability History (Hx) – Time Invariant. Health Vulnerability History consisted of five diagnostic risk flags (STB, PSYCH, SUD, IPV, and CH) observed at delivery and inpatient events occurring prior to 2020. The history of ED risk flags were not available prior to 2020 due to administrative data availability constraints. Pre-2020 inpatient healthcare events were not associated with a pre-2020 delivery event, but were carried forward as fixed risk

factors for those with perinatal windows observed between 2020-2024. In addition, the NSSI risk flag was excluded from the Health Vulnerability – Hx category due to the absence of this risk flag in the ICD-9, rendering data unavailable between 2008-2015 for this risk category. A risk flag was coded as present (=1) when at least one qualifying event occurred within the respective care setting, and absent (=0) otherwise. For example, ever_inpt_psych = 1 indicates at least one pre-2020 inpatient event during which a psychiatric ICD code was indicated, while ever_delv_psych = 1 indicates a pre-2020 delivery event at which a psychiatric ICD code was observed. Each coded Health Vulnerability Hx risk flag was carried forward as a fixed covariate for each participant. This yielded 10 total Health Vulnerability History variables (five risk flag categories across 2 care settings).

Health Vulnerability (Perinatal) – Time Dependent Covariate. Health Vulnerability - Perinatal consisted of six diagnostic risk flags (non-ED STB, NSSI, PSYCH, SUD, IPV, and CH) observed at ED, delivery and inpatient events occurring within perinatal windows between 2020-2024. STB flagged ED visits were utilized as the outcome variable in inferential models, meaning that STB risk factors were included as covariates only if they occurred in non-ED care settings (i.e., inpatient or delivery). The perinatal risk flags were collated weekly (or slightly more granular for recurrent event analysis) across the 93 weeks of the perinatal window. A risk flag was coded as present (=1) when at least one qualifying event occurred within a weekly time interval per care setting, and absent (=0) during that interval otherwise. For example, ed_flag_psych was present (=1) at week 7 postpartum, but was 0 for all other weekly intervals, indicating that one or more qualifying ED events occurred in postpartum week 7 during which a psychiatric ICD code was observed. After each interval, the risk flag was "reset" rather than carried forward to subsequent intervals to capture acuity of risk from new events. Each of the six

risk flags were indicated across the three settings for each time interval, resulting in 17 Health Vulnerability (Perinatal) risk flags (6 risk flag categories across 3 care settings, excluding ED_flag_STB as outcome variable).

Table 1

Risk Flags and Care Settings Comprising Each Health Vulnerability Domain (History vs. Perinatal Specific)

Risk Flag	Health Vulnerability History (Hx)			Health Vulnerability (Perinatal)		
	ED	*Delv*	*Inpt.*	*ED*	*Delv*	*Inpt.*
Chronic Health (CH)	✗	✓	✓	✓	✓	✓
Intimate Partner Violence (IPV)	✗	✓	✓	✓	✓	✓
Non-Suicidal Self-Injury (NSSI)	✗	✗	✗	✓	✓	✓
Psychiatric Problems (PSYCH)	✗	✓	✓	✓	✓	✓
Suicidal Thoughts and Behaviors (STB)	✗	✓	✓	◆	✓	✓
Substance Use Disorder (SUD)	✗	✓	✓	✓	✓	✓

Note. ED = Emergency Department; Delv = Delivery; Inpt = Inpatient. Health Vulnerability History flags are drawn from pre-2020 events. ◆ represents the outcome variable of a STB-flagged ED visit.

3.3.2 Acute Healthcare Utilization – Recency Variable for Aim 2 Models

ED and Inpatient Utilization Recency – Time Dependent Covariate. To capture the decay of risk from recent inpatient or ED visits during perinatal windows, lookback windows were constructed to flag recency of risk across the past 90 days or greater. ED or inpatient events observed during perinatal windows between 2020-2024 were included in the lookback windows, while pre-2020 events were not. Lookback windows accounted for events up to but not including the current interval, maintaining temporal precedence of prior events compared to the current interval under observation. Recency was calculated for an ED or inpatient event regardless of which diagnostic risk flags were present. Five recency categories were constructed to indicate the recency of a visit, including “None”, “Within 7 days”, “8-30 days”, “31-90 days”, and “91+

days", specified in alignment with preliminary recency windows established in perinatal STB and ED utilization literature (see Chapter II section 2.4 for a thorough review of timelines). Recency categories were updated at each time interval based on the elapsed time since the observed ED or inpatient event occurred. For example, an ED visit observed "Within 7 days" at prenatal week 20 would gradually transition through each recency category, finally entering the "91+ days" category by prenatal week 34 and carried forward.

3.3.3 Composite Vulnerability Profiles for Aim 1 Descriptives and Aim 3 Analyses

Vulnerability Profiles – Aim 3 Prenatal and Postpartum Landmarks. A four-level factor variable consisting of mutually exclusive risk profiles was derived from individual level risk factors observed within specific landmark windows. This risk indicator was derived for this study and has not been validated here or elsewhere. The four levels of vulnerability were: 1) No Flags, 2) Access Vulnerability, 3) Health Vulnerability and 4) Combined Vulnerability. The Health Vulnerability profile combined both Health Vulnerability – Hx and Health Vulnerability – Perinatal flags due to scarcity of mutually exclusive Hx flags on their own within the landmarked framework. The Vulnerability Profile variable was derived twice – the first time from event-level information observed pre-2020 for Prenatal Landmark models, and the second time to include additional information observed prenatally and at delivery for Postpartum Landmark models. Across prenatal and postpartum landmark models, the Vulnerability Profile variable retained its four-level factor structure.

The Vulnerability Profile variable for landmark analysis was time-invariant and derived at the start of each "landmark" window to serve as a categorization of risk across that observation window. Access, Health, and Combined Vulnerability were defined the same way as in descriptive analyses (i.e., comprised of the same individual level predictors) with only the

timeframe of reference changing. While the Access flags were technically observed at delivery – a future event relative to conception – sociodemographic factors were considered time-invariant and not subject to the same immortal time bias concerns. The prenatal Access, Health and Combined Vulnerability profiles were derived from risk flags observed during pre-2020 inpatient and delivery events. The postpartum Health and Combined Vulnerability profiles were expanded to include all risk flags observed up to and including delivery, but excluding postpartum flags. This demarcation of Vulnerability Profiles by risk window protected Aim 3 models from immortal time bias by excluding future information from classification of risk groups at each landmark baseline.

3.4 Analytic Plan

3.4.1. Data Processing – Risk Factor Coding

The data were processed at the individual risk factor level, and at the composite vulnerability profile level to prepare for descriptive and inferential analyses. Individual level risk flags were derived from sociodemographic (e.g., race, ethnicity) and event level data, with event level data consolidated by ICD codes into health-related risk group clusters (e.g., STB, NSSI, PSYCH, SUD, IPV, and CH). These individual level risk factor categories were used to construct larger Access and Health Vulnerability risk profiles. Both individual level risk flags and vulnerability profiles were used in descriptive and inferential analyses.

ICD Codes within Individual Risk Flags. Individual level risk flags were constructed by translating event-level ICD codes into risk flags for each healthcare setting. Each event could have up to twenty designated ICD-9 or ICD-10 codes across each dataset, requiring condensing into the risk domains specified for this study. Specifically, the six risk domains under assessment were Suicidal Thoughts and Behaviors (STBs), Non Suicidal Self Injury (NSSI), Psychiatric

Problems (PSYCH), Substance Use Disorders (SUD), Intimate Partner Violence (IPV), and Chronic Health Problems (CH). A seventh domain was also created to handle remaining ICD codes that did not belong to other domains (coded as Medical/Other). These risk flags were not mutually exclusive in that multiple domains could co-occur within a single medical event; however, individual ICD codes were assigned to only one domain and were not shared across categories. A codebook of all ICD codes and their categorization for this project is available at "ICD Code Categories Codebook", with columns indicating ICD version (icd_ver), the ICD code (ICD_Code), diagnostic description, and category flag (Category) under which this ICD code was categorized for analyses.

The ICD codes comprising each risk domain were pre-specified, with evidence-based expansions applied to several risk domains greater inclusivity of STB-relevant ICD codes. ICD code clustering for chronic health problems, psychiatric problems, substance use disorders, and suicide attempts were inspired by Goldman-Mellor and colleagues' coding framework used in a study utilizing ED records to identify risk factors for suicide attempts during the perinatal window (2025). Specifically, the substance use disorder risk domain was inspired by Goldman-Mellor's approach but was expanded to include the full spectrum of substance use codes (i.e., F10-F19 in the ICD-10). The current project also expanded STB coding used by Goldman-Mellor, limited to suicide attempt risk domain, to a more comprehensive STB domain by adding ICD codes for suicide ideation (e.g., R45.851 / V62.84), non-specific suicide attempt (T14.91), and subsequent suicide/self-harm related encounters (D, S codes) excluded in Goldman-Mellor's original framework.

Similarly, the psychiatric risk category was expanded to include disorders relevant to either elevated risk for STBs or adverse outcomes within the perinatal window. The psychiatric

problems category was derived from the clustering framework established by Goldman-Mellor and colleagues (2025) who categorized ICD-9 and ICD-10 codes to capture psychiatric comorbidity of suicide attempts during the perinatal period. Their psychiatric comorbidity domain was inclusive of mood disorders, anxiety, depression, and bipolar disorder. However, Goldman and Mellor's coding framework did not include ICD codes for trauma disorders, eating disorders, sleep disorders, personality/affective disorders, non-psychotic mental disorders (e.g., F68 factitious disorder), or perinatal-specific psychiatric codes. Each excluded psychiatric domain was deemed highly relevant to elevated STB risk (e.g., eating disorders, personality/affective disorders) or to perinatal mental health more broadly (e.g. perinatal-onset depression or psychosis). To rectify this problem, the ICD 9 and 10 codes representing those excluded domains were integrated into the psychiatric problems category alongside the preliminary codes identified by Goldman-Mellor's coding scheme.

This study also strategically included additional ICD-10 codes relevant to the intimate partner violence (IPV) risk category. The IPV risk category was constructed with commonly used T and Z codes indicating spousal abuse extracted from prior work by Shum and Colleagues (2024) who identified commonly endorsed IPV codes such as "T74.1 Physical abuse, confirmed", or "T74.91 Unspecified adult maltreatment, confirmed". To comprehensively cover perinatal specific IPV risk, additional ICD "O" codes were also included, with "O" codes classifying diseases or conditions related to the perinatal period including specific codes representing perinatal IPV. For example, O9A43 representing "Sexual abuse complicating the puerperium" or O9A513 "Psychological abuse complicating pregnancy, third trimester." In this way, the IPV risk domain was derived from best practices but expanded to better fit IPV risk within the perinatal window.

Finally, the Chronic Health problems risk domain was also expanded to include additional chronic health problems associated with STB risk that may commonly present in women and perinatal individuals. Goldman-Mellor and colleagues (2025) utilized a comprehensive set of chronic health-related ICD codes defined in the suicide literature (e.g., Ahmedani et al., 2017) as decedents of suicide risk. Certain chronic health conditions that are associated with STB risk broadly and in women specifically were excluded from that master list, including diagnoses such as epilepsy (Abu-Zaid et al., 2023), thyroid disorders, irritable bowel disease and Crohn's disease, Multiple Sclerosis, Anemia, and Osteoporosis (Østergaard, Heide-Jørgensen & Plana-Ripoll, 2024) and a more inclusive set of ICD codes for HIV/AIDS (Arditi-Arbel et al., 2023). The Chronic Health problems risk category was expanded to include both the original chronic health problems defined by Goldman-Mellor as well as the additional chronic health problems associated with STB risk. This expanded chronic health problem classification was meant to capture the full gamut of health problems associated with STB risk, particularly those that may affect women (e.g., anemias, thyroid disorders) or emerge within the perinatal window.

3.4.2 Data Processing – Structuring Data by Time Intervals

Data preprocessing involved re-structuring the data into universal time grids covering the perinatal window using a piecewise exponential data (PED) format. Defining universal time windows is standard in time-to-event analyses in order to compare hazard between individuals or groups in relation to discrete time intervals. In this study, two universal time grids were used: one to model time-to-first-event hazard, and one to model the recurrent event hazard. The universal time grid was broadly structured as weekly for initial events analysis (93 intervals) with additional intervals added to the recurrent events dataset to capture recurrent event risk (140

time intervals). The time-to-first-event and recurrent events data were transformed from standard survival format (see Figure 1 for illustration) to a PED format (see Figure 2 for illustration) using the *pammtools* package (Bender & Scheipl, 2018). A PED format constructs data in long-form with each row representing an interval on the universal time grid. For initial event analysis, each pregnancy ID had 93 rows, each representing a week-long time interval from conception to 365 days after birth. The recurrent events data had more rows whereby each pregnancy ID had 140 intervals/rows, providing more temporal granularity. Aligning each dataset to the same universal time grid allows for comparing event hazard for everyone within universally shared time intervals.

Figure 1

Standard data structure for a survival analysis depicting singular rows per ID

```
## # A tibble: 6 × 10
##      id  days status charlson_score   age sex    transfusion complications
##   <int> <dbl>  <int>          <int> <int> <fct>  <fct>       <fct>
## 1     1   579      0              2    58 female yes         no
## 2     2  1192      0              2    52 male   no          yes
## 3     3   308      1              2    74 female yes         no
## 4     4    33      1              2    57 male   yes         yes
## 5     5   397      1              2    30 female yes         no
## 6     6  1219      0              2    66 female yes         no
## # ℹ 2 more variables: metastases <fct>, resection <fct>
```

Note. Standard survival data is person-event style data where each ID has its own row, with "days" indicating the duration of their observation window, and "status" indicating whether the outcome occurred or not. Example is from a stomach tumor dataset available within the *pammtools* package, with the data structure illustration lifted from https://adibender.github.io/pammtools/articles/data-transformation.html.

Figure 2

PED style data expanded long-wise with added intervals per record ID

```
##     id tstart tend interval    offset ped_status age  sex complications
## 1  132      0    1    (0,1] 0.0000000          0  78 male           yes
## 2  132      1    2    (1,2] 0.0000000          0  78 male           yes
## 3  132      2    3    (2,3] 0.0000000          0  78 male           yes
## 4  132      3    5    (3,5] 0.6931472          1  78 male           yes
## 5  141      0    1    (0,1] 0.0000000          0  79 male           yes
## 6  141      1    2    (1,2] 0.0000000          0  79 male           yes
## 7  141      2    3    (2,3] 0.0000000          0  79 male           yes
## 8  141      3    5    (3,5] 0.6931472          0  79 male           yes
## 9  141      5    6    (5,6] 0.0000000          0  79 male           yes
## 10 141      6    7    (6,7] 0.0000000          0  79 male           yes
## 11 141      7    8    (7,8] 0.0000000          0  79 male           yes
## 12 141      8   10   (8,10] 0.6931472          0  79 male           yes
## 13 141     10   11  (10,11] 0.0000000          0  79 male           yes
```

Note. PED style data elongates the dataset depending on the number of time intervals specified whereby each record ID has a row per interval until their observation window ends. The offset value represents the log of the duration during which the subject was under risk in that interval" (Bender et al., 2026). Example is from a stomach tumor dataset available within the *pammtools* package, with the data structure illustration lifted from https://adibender.github.io/pammtools/articles/data-transformation.html.

For the current study, two sets of universal time grids were constructed to capture both the weekly granularity of the perinatal window for initial events, and the additional granularity required to capture the timing of recurrent STB-flagged ED events. The time-to-first-event dataset was structured with weekly time intervals across the perinatal window (~93 intervals, 92 weeks + 1 day 365) with the delivery event initiating the first postpartum week, which translated to approximately ~15 million rows. The recurrent events time grid was expanded from the weekly grid (~93 intervals) to also include an additional 47 time intervals representing unique STB ED events (140 intervals total) that would otherwise have been collapsed within the same week, expanding to approximately 17.9 million rows. The added granularity of the recurrent events time grid created separate intervals for same-week STB-flagged ED visits instead of reduced to one event within the one weekly interval. In this interval format, the outcome variable and covariates were coded in terms of whether that flag occurred within that interval (e.g., 0/1). These risk flags were not cumulative (e.g., counting multiple flags if they occurred in the same week).

To maintain the specified interval structure, left truncated and right censored data were adjusted to enter and exit the dataset in alignment with the weekly interval grid. When prenatal windows predated ED data availability (prior to 2020), these windows were left-truncated, indicating that some of the prenatal window was technically "unobserved". Conversely, postpartum windows extending beyond December 31, 2024, were right-censored reflecting unobserved follow-up. To align different entry and exit points for left truncated and right censored data, entry and exit points were "snapped" to the universal time grids. Left truncated data were "snapped forward", while right censored data was "snapped back", meaning each record entered and exited at the first fully observed week/interval instead of the original date. In cases of overlapping perinatal windows resulting from closely spaced pregnancies, prenatal windows for the subsequent pregnancy took precedence, and any events occurring in the prior postpartum period were reassigned accordingly. This approach preserved temporal ordering while ensuring analytic alignment with observable data.

3.4.3 Statistical Methods

A two-pronged analytical approach utilizing descriptive and inferential methods was used to interrogate the three study aims. Aim 1 characterized the population in terms of delivery events, healthcare utilization patterns, risk flag frequencies, and vulnerability profile comparisons using descriptive statistics, correlation analyses, and Kaplan-Meier curve estimation. Flexible survival models in the form of piecewise exponential additive mixed models (PAMMs) were used for Aims 2 and 3 inferential analyses. For Aim 2, PAMMs were used to identify the magnitude of association between individual level risk factors and the hazard of a STB-flagged initial or recurrent ED visit using a model-building approach. Aim 3 applied a simplified modelling approach using PAMMs to distinguish temporal patterning in the hazard

across risk profiles at prenatal and postpartum landmarks. First-derivative analysis was applied on Aim 3 log-hazard curves to identify time windows when the hazard for an initial or recurrent event hazard was significantly increasing or decreasing. Recurrent event models utilized the Prentice, Williams & Peterson Calendar Time (PWP-CT) model framework (Prentice et al., 1981) described further below. The following sections describe the descriptive analyses, introduce the PAMM modeling framework, and detail the model specifications and building approach for time-to-first-event analysis and PWP-CT recurrent events analysis. All analyses were conducted in R version 4.4.0.

Descriptive Analyses. Descriptives for Aim 1 included frequencies and proportions of the outcome variable (STB-flagged ED visits) stratified by prenatal and postpartum periods, as well as a calculation for average time elapsed between recurrent STB-flagged ED events. Inpatient, ED, and delivery event individual level risk flag prevalence were reported at both historical (inpatient and delivery; 2008-2020) and concurrent perinatal (2020-2024) time windows. Prevalence of perinatal windows with either Access Vulnerability only, Health Vulnerability only, Combined Vulnerability, or No Risk flags were calculated and frequencies of STB-flagged ED visits within each risk profile were illustrated. Tetrachoric correlations were run to account for binary data and examined relationships between individual level risk flags STB ED outcomes. A Kaplan-Meier survival curve was generated to model a baseline survival curve for risk for a first STB-flagged ED visit, providing a simplified illustration of whether variation in risk timing across the perinatal window is evident.

Complex Survival Models. Piece-wise exponential Additive Mixed Models (PAMMs) models were used to predict the hazard of (1) an initial STB-flagged ED visit and (2) recurrent STB-flagged ED visit for Aim 2 and Aim 3 models. PAMMs offer a flexible, semi-parametric

approach to modelling complex time to event data, including recurrent events analysis. PAMMs are exceptionally flexible compared to traditional survival models (e.g., Cox Proportional Hazard or Royston- Parmar) as PAMMs relax assumptions of proportional hazards, can model non-monotonic baseline hazard estimates, and allow for the inclusion of time-varying covariates. The *pammtools* (Bender & Scheipl, 2018) package in R was used to format the data into a piecewise exponential data (PED) format required for PAMM modeling. Basis functions and basis dimensions for the smooth terms were specified within the generalized additive modelling (GAM) architecture provided by the "mgcv" package in R (Wood, 2000). The degree of smoothing within PAMM models was estimated via restricted maximum likelihood (fREML) within the bam() architecture to accommodate large datasets. See section "justification for PAMM model selection" for further details on this modelling choice.

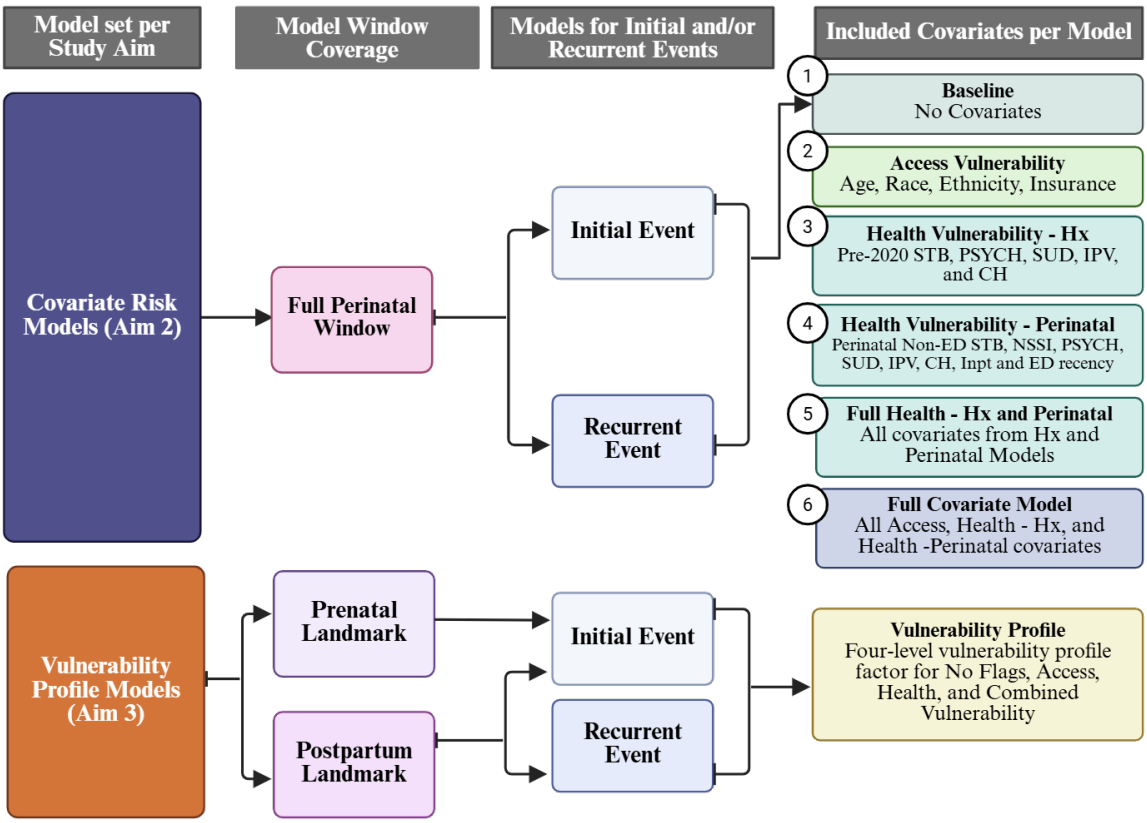
Covariate Models (Aim 2). A model-building approach was applied for Aim 2 when building Covariate Risk PAMMs. Covariate Risk models estimated the magnitude of effect of each individual risk flag (e.g., psychiatric ED flag, substance use delivery flag) on the hazard across the perinatal window. To assess contributions of independent risk factors within Covariate models, six hierarchical models were built and applied separately to the time-to-first event and recurrent-event outcomes. This translated to a total of 12 models that sequentially built to a full covariate risk model, six for the time-to-first event full covariate model, and six for the recurrent event full covariate model. Model building followed a domain-based hierarchical strategy in which complete sets of conceptually related covariates were introduced sequentially to evaluate their contribution to model fit (see Figure 3 for modelling schematic). The Covariate model building approach included a baseline model, an Access Vulnerability model, a Health Vulnerability History model, a Health Vulnerability perinatal model, a full Health Vulnerability

model (Hx and perinatal), and a full covariate model including all Access and Health Vulnerability risk factors. AIC and BIC values were calculated from each model to compare improvement of model fit with each subsequent model in the hierarchy.

Vulnerability Profile Models – Landmark Analysis (Aim 3). The Vulnerability Profile models were far simpler and included the factorized, mutually exclusive linear predictor of Vulnerability Profiles (i.e., No Flags, Access Vulnerability, Health Vulnerability, Combined Vulnerability), as well as a specifier allowing for different baseline hazard estimates per vulnerability profile (see Figure 3 for modelling schematic). Vulnerability Profile models were also distinguished by their landmark style structure with separate models run for the prenatal window and the postpartum window for initial and recurrent event models. Recurrent event models had an additional linear term to account for event strata (i.e., initial vs. recurrent). Recurrent event models were also intended to include a frailty term to account for individual level differences in multiple outcome events within perinatal windows. However, computational limits led to the exclusion of the frailty term. Thus, recurrent event model results provide a population level hazard estimate rather than one corrected for within-perinatal window dependencies.

Figure 3

Model building schematic for Covariate Risk Models (Aim 2) and Vulnerability Profile Models (Aim 3)



Note. Figure 3 depicts the model building schematic for Covariate Risk models for Aim 2 Analysis, and the simplified Vulnerability Profile models for Aim 3 analyses. Covariate Risk models were modelled across the entire perinatal window for both initial and recurrent events. Each initial and recurrent event model set consisted of a series of six progressively more complex models, illustrated in the column "Included Covariates per Model." Conversely, simplified Vulnerability profile models were separated by perinatal window landmarks for the prenatal and postpartum windows. The four-level Vulnerability profile was the singular predictor, apart from the enumerator differentiating "first" events from "recurrent" events within recurrent event models. The prenatal landmark model for recurrent events was not feasible due to scarcity of observed outcome events, and was excluded from the schematic.

Additional PAMM Specifications. All Aim 2 and Aim 3 initial and recurrent event models used the same specification of the 'k' parameter within the GAM architecture underlying PAMMs. The 'k' parameter is a specifier of "wiggliness", or nonlinearity, allowed when estimating the line of best fit, with greater levels of k permitting more complex curve shapes. Each baseline model was evaluated at different levels of 'k' (e.g., 10, 15, 20) to determine the best fit for the 'k' parameter (the basis dimension) allowing for the maximum level of

complexity or “wiggliness” allowed in the smooth term. Baseline models were set with different values of ‘k’ and compared with k.check() to evaluate the K-index and compare estimated degrees of freedom. Across Covariate and Vulnerability profile models, time-to-first-event and the recurrent event models fit best when k = 15, or slightly above the default of k=10. The k parameter was set at 15 for all subsequent models.

Where the models diverged was in the specifications of the basis functions within the time-to-first-event and recurrent event models. PAMMs within the mgcv modelling architecture require the specification of a basis function, or the mathematical function underlying the smooth term. For Covariate risk time-to-first-event models, P-splines were specified (bs = “ps”) which were selected for efficiency in regularly spaced data points (e.g., weekly intervals). For Covariate risk recurrent events, thin plate regression splines (bs = “tp”) were specified, which is more adaptive to an irregular distribution of data inherent to the 140 intervals within the recurrent events models. Vulnerability Profile models were standardized across initial event and recurrent event models using the bs = “tp” basis function to allow for simpler cross-model profile comparison.

The models also diverged in terms of how time was structured for recurrent events analysis within the PWP-CT framework. The PWP framework stratifies the baseline hazard between those with a first event, compared to those with more than one event. To reduce dimensionality, the levels of recurrence were collapsed into “first” and “recurrent” to estimate baseline hazard between the two groups (e.g., s(tend, by = enum_strata)). Collapsing the recurrence strata into two also maintained stable estimates at each level given the smaller observation numbers at higher recurrence numbers. The calendar time framework assesses risk from a starting point in time, in this case, an estimated 280 days prior to delivery date

representing the start of the prenatal window. When outcome events occur within the timeline effectively ending the current risk interval, a new risk interval continues forward from the prior events occurrence date rather than resetting the entire risk interval back to 0. In this way, recurrent event risk is mapped on the perinatal timeline.

Model Checks. Post-hoc model checks included several levels of evaluation to determine goodness of fit and confirm model specifications. Model summaries were reviewed to evaluate standard errors and confirm stability of coefficients, as well as to detect any convergence issues. Variables with large standard errors (exceeding 2) were flagged for review, with those far exceeding 10 excluded from subsequent models as the 95% confidence intervals were rendered too wide for interpretation, indicating that the model was unable to reliably estimate that covariate's effects consistent with complex or quasi-complete separation (Heinze & Schemper, 2002). Estimated degrees of freedom (edf) values were reviewed to confirm adequate specification of basis dimensions for smooth terms. AIC and BIC comparisons were made to compare goodness of fit between successive models in the model-building approach, with a difference of 10% used to differentiate a significantly improved fit. Model residual diagnostic checks with the *'gratia'* package were unable to be run due to the sample size and computational complexity of the analysis. K-index testing, edf review, and model summary examination served as the functional equivalent of residual diagnostics.

First-Derivative Analysis of Log-Hazard Curves. To extract hazard slope "peaks" and translate into windows of risk, first-derivative analysis of each log-hazard curve was conducted on the best fitting model using the gratia package in r (Simpson, 2024). Taking the first-derivative of a log-hazard curve is a mathematical approach to assess when a slope is significantly increasing or decreasing, and extracting the "peak" point at which the change is the

greatest. This approach is a post-hoc method of identifying and extracting intervals of significant slope change along a smooth curve once a model has been run. This approach was selected because it provides confidence intervals around the derivative that are corrected for multiple comparisons across the full span of the curve (i.e. simultaneous confidence intervals). When contiguous windows of slope change had confidence intervals excluding 0, determinations on the significance of the slope change could be made, indicating whether the hazard was significantly increasing or decreasing.

Inference Criteria and Effect Size. Standard inference criteria such as null hypothesis significance testing and a priori power calculations were not solely relied on in line with comparable population-level data studies opting for alternative inference criteria (e.g., Richmond-Rakerd et al., 2026). Instead, inference criteria for the detection of significant findings were defined by model comparisons (AIC/BIC), hazard ratio confidence intervals (95%), and model output comparisons with comparable literature. Lower AIC/BIC values indicated a better fitting model broadly, with differences of 10 units or more considered meaningfully significant (Raftery, 1995; Kass & Raftery, 1995). For this study, BIC value differences were prioritized as they represented the correct model fit for observed data and applied a stronger penalty for model complexity (Burnham & Anderson, 2004; Chakrabarti & Ghosh, 2011).

In determining the significance of individual risk factors, hazard ratio (HR) 95% confidence intervals that excluded 1 were interpreted as meaningful associations, with those above 1 indicating a risk factor, and those below 1 indicating a protective factor. Corresponding p-values (i.e., $p < 0.05$) were considered complementary evidence but were not solely relied on to distinguish statistical significance. Lastly, discussions of effect magnitude were interpreted contextually against prior literature on perinatal acute healthcare utilization for STBs rather than

against a fixed threshold as encouraged by recent research on effect sizes (Riesthuis, 2024). For example, we compared the effect size of psychiatric flags at delivery associating with STB-flagged ED visits to risk observed in other population-level studies (e.g., Goldman-Mellor et al., 2025), to evaluate how the magnitude observed in this study compares to magnitudes observed in other studies.

3.4.4 Missing Data

Prior to analyses, each predictor was evaluated for data completion yielding minimal missing data. Additionally, the delivery dataset included several records (n = 7) where the maternal age was 0 due to erroneous hospital coding. For these missing records, median sample age was imputed for the records where age is missing. This imputation ensured that these cases were not dropped in models where age was a covariate. Finally, OHA disclosed that approximately 6,000 – 10,000 inpatient discharge records were missing from calendar year 2013. However, variables derived from pre-2020 discharge records were consolidated as binary indicators of each risk factor over 12 years, minimizing the potential impact of missing data from one year.

3.5 Methods Justification

In comparison to other survival modelling approaches, PAMMs provided superior flexibility for modelling complex survival analyses. There are other survival modelling options which are computationally less burdensome than PAMMs such as Kaplan-Meier estimator (used here for descriptive modelling), semi-parametric Cox Proportional Hazard (Cox PH models) and extended Cox models, parametric models (e.g., exponential, Weibull), and Royston-Parmar flexible parametric survival models. However, each carries a set of constraints that rendered them a poor fit for the current study. In contrast to alternative model options, PAMMs flexibly

estimate a baseline hazard curve, allowing it to form freely without a specified or pre-determined shape. The underlying generalized additive modelling architecture ("GAM" models") upon which PAMMs function allows for the specification of the number of splines used to estimate the log-hazard, which provides flexibility in how "wiggly" the hazard curve is allowed to be. PAMMs also allow for smooth terms of continuous predictors, such as time. The proportional hazard assumption is also relaxed, and time varying covariates are easily integrated with *pammtools* in interval style analysis. To accommodate both time-to-first-event and recurrent events analysis, potential violation of proportional hazard assumption, presumed non-monotonic hazard curve, and time-varying covariates, PAMMs were the only modelling approach flexible enough to account for all features. Thus, PAMMs were selected for superiority over comparable survival modelling options to address the study questions at hand.

3.6 Transparency and Open Science

This study was pre-registered on Open Science Forum (preregistration 10.17605/OSF.IO/ACH7X). There were several deviations from the pre-registered study plan worthy of mention. The first was the exclusion of the Access Vulnerability variable indicating rural or urban zip code location in Oregon. Zip codes at time of delivery were categorized into rural or urban designations based on OHA guidelines for rurality status. However, a sizeable proportion of the sample contained out of state home zip codes at time of delivery which could not be mapped to Oregon rurality status. As missing rurality status would lead to dropped cases in analyses, rurality was not included as a covariate in final models in order to retain the full sample size.

A second deviation from the pre-registered plan was the need to exclude the planned frailty component from both sets of PAMM models. A frailty component accounts for

dependencies within cases, such as within a perinatal window, or events within an individual like multiple pregnancy events. A frailty component within PAMMs (i.e., s(preg_id, bs = "re")) would have allowed a random smooth to be calculated for each perinatal window, accounting for different baseline hazard between individuals not accounted for by other covariates in the model. However, due to the size of the expanded PED dataset (between 17-20 million rows), the frailty component was computationally impossible. Attempts to run models with this component crashed despite generous RAM budgets at 256 GB. Given this computational constraint, the frailty component was excluded from both the time-to-first-event and recurrent events models.

Several tools are also included in this project's online pre-registration to aid replication efforts. These tools include the pre-registered plan, as well as the ICD codebook in excel format specifying which ICD-9 and 10 codes comprise each risk domain (i.e., CH, IPV, NSSI, PSYCH, STB, SUD). However, the de-identified data is not available on the registered project site due to sharing constraints agreed upon with Oregon Health Authority. Requests for this data can be made through Oregon Health Authority for identical data files. To aid data request efforts, the request form submitted to OHA detailing which variables and datasets were requested is also available for download.

CHAPTER IV

RESULTS

4.1. Prevalence (Aim 1)

The following section summarizes Aim 1 results characterizing the overall prevalence, frequency, and recurrence of emergency department (ED) visits flagged for suicidal thoughts and behaviors (STBs) during pregnancy and the first postpartum year. The following section also characterizes the cohort by prevalence of individual level risk factors and composite risk profiles (i.e. Access and Health Vulnerability) observed across care settings within the full perinatal window. Descriptive analyses established a comprehensive picture of the 2020-2024 birthing individuals cohort, including differences in the prevalence of covariate risk for those with and without perinatal STB-related ED visits.

There were a total of 185,431 perinatal windows observed between 2020-2024 (see Table 2 for sample demographics). The average age at delivery was 30 (SD = 5.6, range = 18-64). The majority of perinatal windows were racially White (69% of perinatal windows) and non-Hispanic/Latino identity (77.5%). Other racial identities were represented by “Other” at 14.9% of perinatal windows, followed by Asian at 5.7%, Refused/Unknown at 4.4%, Black or African American at 3.4%, American Indian/Alaska Native (AI/AN) at 1.5%, and Native Hawaiian/Pacific Islander at 1.2%. Hispanic/Latino ethnic identity was indicated for 17.8% of perinatal windows, while 4.7% had ethnicity status unknown. In addition, a majority of perinatal windows had Commercial insurance indicated (53.8%) while Public insurance followed close behind at 43.0% of perinatal windows. Other insurance status (2.4%) and Uninsured (0.9%) represented far smaller proportions of perinatal windows.

Among the 185,431 perinatal windows, most represented one perinatal window (82.1%). This indicates that most of the sample consisted of a singular perinatal window per individual. However, there were multiple perinatal windows for some individuals, indicating more than one delivery observed between 2020-2024. Approximately 17% of perinatal windows were for a second perinatal window, while 1.1% were for a third perinatal window, with just 0.04% representing a fourth or more perinatal window. This translated to an overall delivery rate of 1.19 perinatal windows per individual.

Table 2

Cohort Demographic Characteristics for Perinatal Windows Observed Between 2020-2024

Characteristic		N (%) or Summary
Total perinatal windows		185,431
Age at delivery	Mean (SD)	30.0 (5.6)
	Range	18–64
Perinatal windows per individual between 2020-2024	1	127,895 (82.1%)
	2	25,987 (16.7%)
	3+	1,762 (1.1%)
	4+	69 (0.04%)
Race	American Indian/Alaska Native	2,740 (1.5%)
	Asian	10,495 (5.7%)
	Black or African American	6,239 (3.4%)
	Native Hawaiian/Pacific Islander	2,250 (1.2%)
	Other	27,572 (14.9%)
	Refused/Unknown	8,215 (4.4%)

Characteristic		N (%) or Summary
	White	127,920 (69.0%)
Ethnicity	Hispanic/Latino	32,995 (17.8%)
	Non-Hispanic/Latino	143,653 (77.5%)
	Refused/Unknown	8,783 (4.7%)
Insurance status	Commercial	99,719 (53.8%)
	Other	4,443 (2.4%)
	Public	79,655 (43.0%)
	Uninsured	1,614 (0.9%)

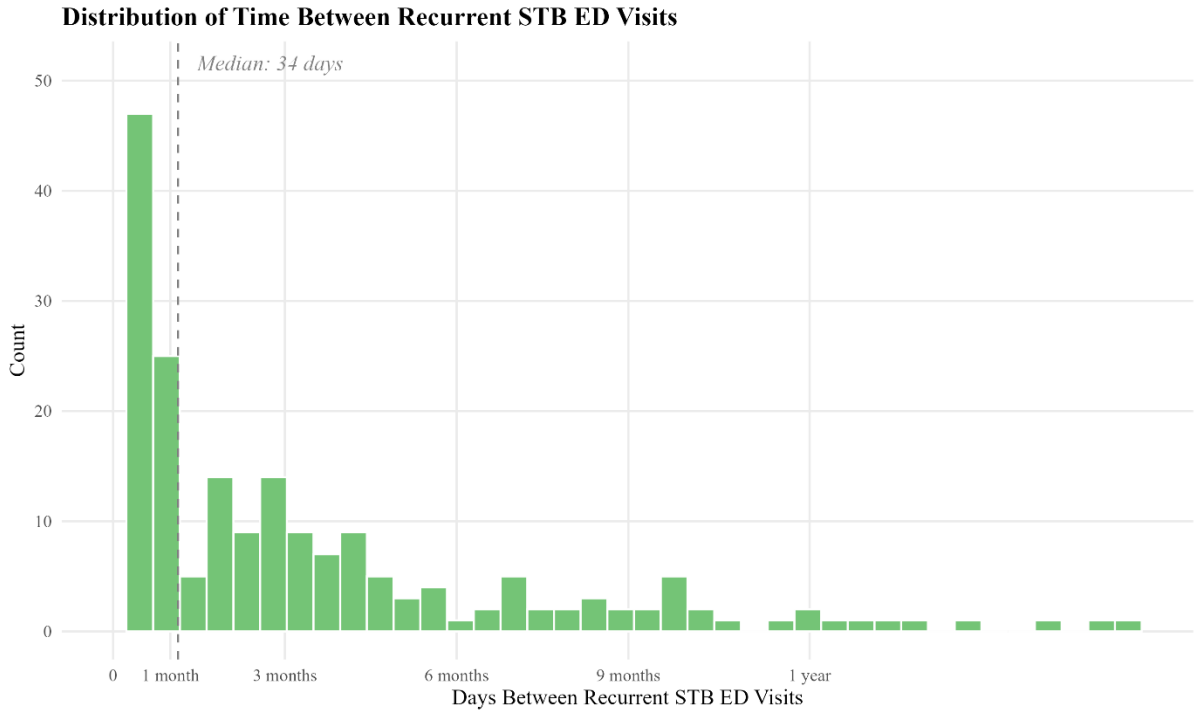
A small but clinically meaningful minority of perinatal windows had an initial STB-flagged ED visit (0.51%), while approximately one in six perinatal windows with an initial event had a recurrent STB-flagged ED visit within the same perinatal window. There were 1,191 total STB-flagged ED visits distributed across 951 perinatal windows (0.51% of perinatal windows). Out of the 951 perinatal windows, a singular STB flagged ED visit occurred for most (84.2%; n = 801), indicating that most perinatal STB-flagged ED visits were a one-time event. A recurrent STB-flagged ED visit was observed for 15.8%, or n = 150, out of the total 951 perinatal windows. The latter finding indicates that for a meaningful subset, an initial STB-flagged ED event was followed by a recurrent event within the same perinatal window. This finding is among the first to characterize STB-related ED recurrence at the population level, establishing a meaningful level of recurrence within the same perinatal window.

Recurrence analysis revealed a median of 34 days between an initial and recurrent STB-flagged ED visit, indicating that half of all recurrent visits occurred within a little over a month of the index event (see Figure 4). This demonstrates that when recurrence took place, it was

likely to happen within a proximal time-frame within the perinatal window. However, the remaining 50% of recurring STB-flagged ED were stratified across the perinatal window, with most concentrated within the first 6 months following an initial event. An important caveat is that recurring events were only accounted for when they took place within the perinatal window. This limited a true recurrence estimate for those with initial events emerging late in the postpartum window where a subsequent non-perinatal recurrent event would be unaccounted for. Despite the limitations in window of observation, these findings suggest recurrent events take place in a sensitive window following an initial event, while others emerge at later, less proximal perinatal timepoints.

Figure 4

Distribution of time between recurrent STB ED visit



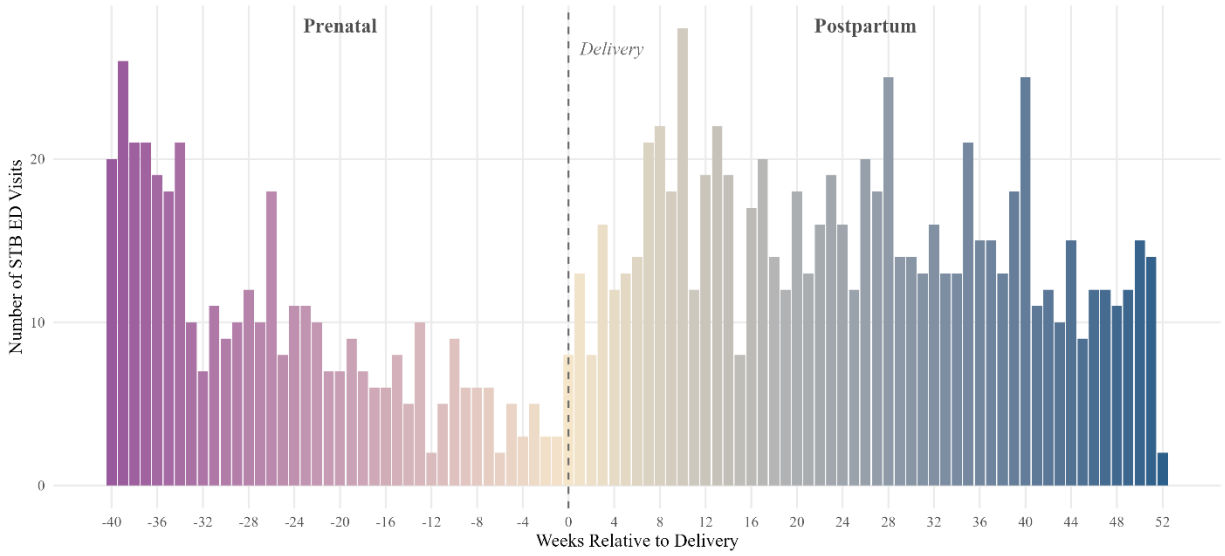
Note. Bin width is 14 days, with each bar representing events occurring within a 14-day window. There were n = 5 recurring events that took place on the same calendar day as the index event, representing 2.1% of overall recurrent visits.

There were substantially more STB-flagged ED visits during postpartum (67%; n = 798) compared to pregnancy (33%; n = 393), with temporal patterning observed in the concentration of flags within pregnancy and postpartum windows (see Figure 5). Visual inspection of the distribution of STB-flagged ED visits revealed a prenatal global maximum during early pregnancy (~1-2 weeks gestation), with a relative decline in frequency throughout the remainder of the prenatal window. There were exceptions to the uniformity of the prenatal decrease with a frequency spike at prenatal week 14 (~3.5 months gestation) and several local spikes right before and after ~7 months gestation. This illustrates a greater concentration of prenatal STB-flagged ED utilization during the first trimester of pregnancy, with demonstrably lower levels throughout the remainder of pregnancy.

There was more consistent elevation in the frequency of STB-flagged ED visits postpartum compared to the prenatal window. Across the postpartum distribution (see Figure 5), there was a global maximum around 10 weeks postpartum (2.5 months postpartum) when the greatest number of STB-flagged ED visits occurred. There were also two local maxima around 28 and 40 weeks postpartum (e.g., 7 months and 10 months postpartum), indicating subsequent intervals where frequencies of STB-flagged ED visits were higher. Overall, the distribution reflected a sustained temporal pattern of postpartum STB-flagged ED utilization at greater magnitude than the prenatal window, with potential inflection points at distinct time points.

Figure 5

Weekly distribution of STB-flagged ED visits across the prenatal and postpartum periods



Note. Bin width is 7 days representing weekly intervals during pregnancy and postpartum. Weeks on the x-axis are labeled relative to delivery, with prenatal weeks indicated as -40-0, and postpartum weeks spanning 0 – 52 following delivery.

Descriptives for Vulnerability Profile group membership showed that a relative majority of perinatal windows met criteria for the Combined Vulnerability profile. These categories (No Flags, Access Vulnerability, Health Vulnerability (Hx and Perinatal), and Combined Vulnerability (Access & Health Vulnerability) were defined by categorizing individuals by their risk flags, or lack thereof, observed historically and across the entire perinatal window at either delivery, inpatient, or ED events (see Table 3). These proportions are descriptive distributions and not adjusted risk estimates. Of the total population of perinatal windows (*N*=185,431), there were 77,210 (41.6%) that met criteria for the Combined Vulnerability profile, followed by Health Vulnerability (Hx and Perinatal) at 45,195 (24.4%), then Access Vulnerability with 32,560 (17.6%), and those without any vulnerability flags (i.e., No Flags) at 30,466 perinatal windows (16.4%). These proportions align with the number of risk components comprising each category whereby the profiles derived from a broader range of risk factors (i.e., Combined Vulnerability, Health Vulnerability) were larger than groups comprised of fewer risk variables.

However, the Combined Vulnerability risk profile (i.e., both Access and Health Vulnerability flags) had the greatest concentration of STB-flagged ED visits (n = 959; 80.5%) despite representing only 41.6% of perinatal windows (see Table 3). The remaining proportion of STB-flagged ED visits were stratified in order of magnitude across Health Vulnerability (15.5%), Access Vulnerability (2.9%) and the No flags profile (1%). This indicates that perinatal windows with both structural-access related and clinical-health vulnerabilities had the greatest proportion of STB-flagged ED visits. This finding supports Hypothesis 1D and suggests that STBs are more concentrated when Access and Health vulnerability co-occur.

Table 3

Vulnerability Profile Frequency Summaries and STB-flagged ED Visit Counts per Profile Across the Perinatal Window

		STB Flags		
Vulnerability Profile	Perinatal windows (N)	Total Flags (*n*)	Prenatal Flags (*n*)	Postpartum Flags (*n*)
1. No Flags	30,466	12	8	4
2. Access Vulnerability	32,560	35	30	5
3. Health Vulnerability (Hx & Perinatal)	45,195	185	48	137
4. Combined Vulnerability	77,210	959	307	652
Totals (n)	185,431	1,191	393	798

Note. Access Vulnerability includes all those with public insurance, and/or non-white and Hispanic racial/ethnic identity. Health Vulnerability combines Hx and Perinatal events, including perinatal windows with one or more flags at pre-2020 or perinatal delivery, inpatient, or ED events. Combined Vulnerability includes those with both an Access Vulnerability and a Health Vulnerability flag.

ED utilization also differed for those with a STB-flagged ED visit, and those without. The perinatal windows with a STB-flagged ED visit had a median of 4 ED visits for any reason, while perinatal windows without a STB-flagged visit had a median of 0. The median was reported rather than the mean to account for skew in the maximum number of visits (i.e., max of n = 92 visits for perinatal windows with a STB visit; max of n = 54 for perinatal windows

without a STB visit). Rates of perinatal ED utilization for any reason differed between vulnerability groups, and between the perinatal windows that had a STB-flagged ED visit compared to those that didn't. Overall, one-third of all perinatal windows (34%; n = 62,965) had an ED visit for any reason, with a mean of 0.71 ED visits per perinatal window (SD = 1.61). ED utilization by vulnerability group differed where the Combined Vulnerability profile had the greatest percentage of perinatal windows with an ED visit, followed by Health Vulnerability, Access Vulnerability and No Flags groups (see Table 4).

Table 4

Proportion of Perinatal Windows with Perinatal ED Visits for Any Reason within the Sample and Across Vulnerability Profiles

Vulnerability Profile	Perinatal Windows (*N*)	Perinatal Windows with all cause ED visit *n* (%)
1. No Flags	30,466	2,566 (8.4%)
2. Access Vulnerability	32,560	4,632 (14.2%)
3. Health Vulnerability	45,195	14,353 (31.8%)
4. Combined Vulnerability	77,210	41,414 (53.6%)
Total	185,431	62,965 (34%)

Note. Table 4 depicts the number of all-cause perinatal ED visits occurring for any reason, inclusive of STB-flagged ED visits, stratified by vulnerability profile.

The majority of STB flags, and specific STB-related risk factors such as NSSI and IPV, were observed within perinatal ED settings compared to inpatient or delivery events. The frequencies and proportions of each Health Vulnerability flag were visualized across healthcare settings and pre-2020 historical and perinatal time windows (see Table 5). The majority of Health Vulnerability risk flags were observed during perinatal windows as opposed to historical events pre-2020, with most flags concentrated at delivery events. This aligns with expectations given that each perinatal window had a delivery event with covariate risk factors flagged, though having an ED or inpatient record varied. While the majority of Heath Vulnerability risk flags

were observed at delivery, this was not the case for STB, NSSI, or IPV flags, which were predominantly observed at perinatal ED visits. This suggests that perinatal STB flags – and certain STB risk precursors such as NSSI and IPV – are more likely to be observed within an ED acute care setting.

Table 5

Health Vulnerability Risk Flags Observed by Historical Context and Data Source

ICD Domain	Context	Data Source	N flags	N Perinatal Windows	% perinatal windows/full cohort
Psychiatric Problems	*History (pre-2020)*	Inpatient	2,947	2,947	1.59
		Delivery	8,585	8,585	4.63
	Perinatal (2020-2024)	Delivery	37,128	37,128	20.02
		Emergency	9,821	6,467	3.49
		Inpatient	1,680	1,447	0.78
Suicidal Thoughts and Behaviors	*History (pre-2020)*	Inpatient	1,224	1224	0.66
		Delivery	25	25	0.01
	Perinatal (2020-2024)	Delivery	78	78	0.04
		Emergency	**1,191**	**951**	**0.51**
		Inpatient	169	153	0.08
Non-Suicidal Self-Injury	*History (pre-2020)*	Inpatient	0	0	0
		Delivery	0	0	0
	Perinatal (2020-2024)	Delivery	<10*	<10*	0
		Emergency	**10**	**10**	**0.01**
		Inpatient	0	0	0
Substance Use Disorder	*History (pre-2020)*	Inpatient	2,414	2,414	1.3
		Delivery	5,380	5,380	2.9
	Perinatal (2020-2024)	Delivery	14,711	14,711	7.93
		Emergency	15,382	8,207	4.43
		Inpatient	1,162	947	0.51
Chronic Health Problems	*History (pre-2020)*	Inpatient	5,282	5,282	2.85
		Delivery	21,710	21,710	11.71
	Perinatal (2020-2024)	Delivery	87,097	87,097	46.97
		Emergency	75,705	42,890	23.13
		Inpatient	3,314	2,878	1.55
Intimate Partner Violence	*History (pre-2020)*	Inpatient	169	169	0.09
		Delivery	222	222	0.12
	Perinatal (2020-2024)	Delivery	149	149	0.08
		Emergency	**488**	**438**	**0.24**

Inpatient	21	20	0.01

Note. Table 5 illustrates the Health Vulnerability flags distribution across care settings and time windows, with the risk flags observed more in emergency settings highlighted in yellow and bolded for emphasis. Frequencies with numbers less than 10 were indicated by a <10* to adhere with small number reporting guidelines (i.e., not reporting numbers lower than 10). The final column represents a percentage of perinatal windows with the observed flag out of the total cohort of perinatal windows (N = 185,431).

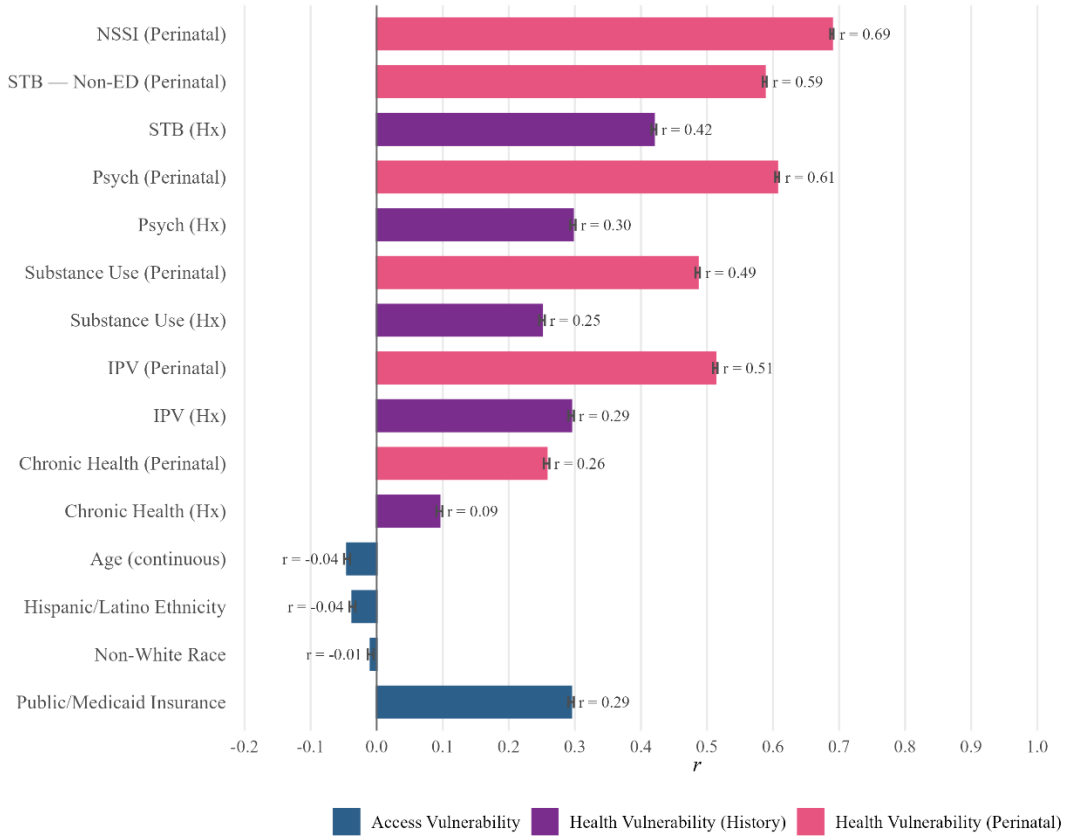
To further examine associations between Access Vulnerability and Health Vulnerability risk flags, tetrachoric (for binary risk flags) and point-biserial correlations (for age) were run to assess the strength of association between risk flags and STB-flagged ED visits. Health Vulnerability risk factors observed during the perinatal period showed the strongest correlation with STB-flagged ED visits (see Figure 6). Specifically, NSSI, PSYCH, non-ED STB, and IPV risk flags observed during the perinatal window had *r*s >= .50. SUD observed during the perinatal window, a history of either STBs, PSYCH or IPV, and public insurance (Access Vulnerability) *r*s ranged from.30-.49, indicating moderately strong positive correlations with STB-flagged ED visits. Smaller effects were observed for a history of substance use disorder and chronic health problems (historically and perinatally) with *r*s ranging from .10 - .29. Negligible correlations (*r*<.10) were observed for access vulnerability variables like non-white race, Hispanic/Latino ethnicity, and age.

When comparing the strength of associations between STB-flagged ED events with Health Vulnerability flags observed historically vs. during the perinatal window, flags observed during the perinatal window demonstrated consistently stronger bivariate associations with perinatal STB-flagged ED visits. This indicated that proximal perinatal-associated risk flags associated more strongly with risk outcomes than most historical Health Vulnerability factors. One exception to this pattern is a history of STB flags observed at pre-2020 inpatient or delivery events (*r* = .42), which was associated with STB-flagged ED visits at levels comparable to

perinatal SUD (r = .49), but less than perinatal STBs, PSYCH, or NSSI. Taken together, both a history of STBs and Health Vulnerability risk flags observed during the perinatal window were moderately to strongly associated with STB-flagged ED visits.

Figure 6

Access and Health Vulnerability flag correlations with STB-flagged ED Visits



Note. All predictors were evaluated as binary risk factors with the exception of age. Tetrachoric correlations evaluated the association between the binary outcome and binary risk flags (e.g., Psych (perinatal)). A point-biserial correlation evaluated the association between the binary outcome and age, a continuous risk factor. NSSI – History (Hx) comprised of flag counts at inpatient and delivery events was excluded due to n = 0 for 2008-2020 events.

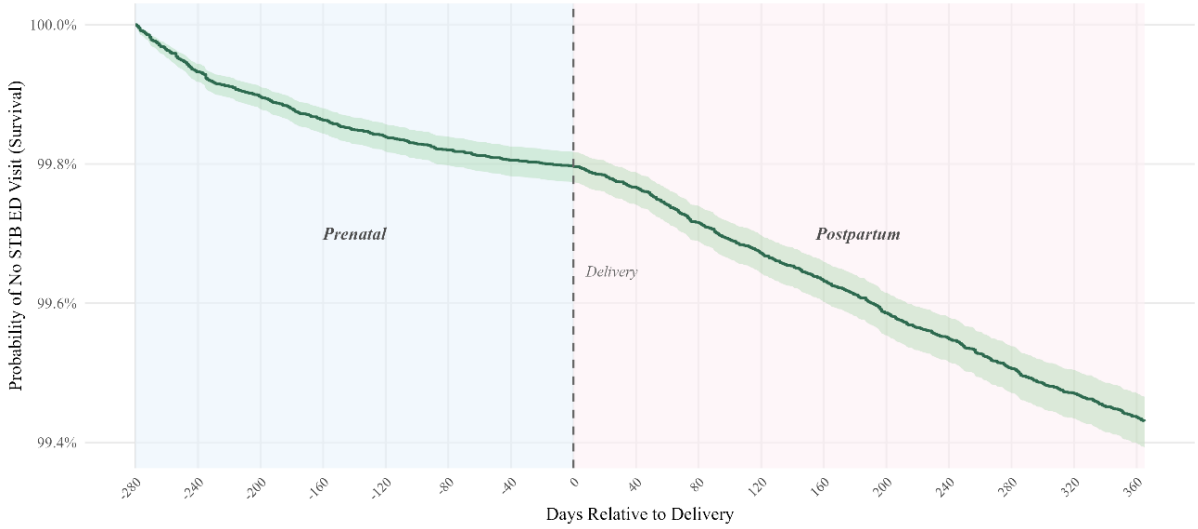
To establish a baseline level of STB-flagged ED visit prevalence within the population, a Kaplan-Meier survival curve analysis was used to examine the cumulative probability of remaining free from an initial STB-flagged ED visit across the perinatal window (−280 to 365 days relative to delivery, or conception to one year after delivery). Survival curves start at 1.0

representing 100% probability of no STB event, and the curve decreases as the outcome event takes place whereby steeper slope changes indicate when the probability of that event is greater.

The survival curve showed two periods of accelerated decline at early prenatal and later postpartum windows, providing preliminary evidence of two-time intervals of change in the probability of a STB-flagged ED visit (see Figure 7). The first slope acceleration occurred during the early prenatal window (ranging from 280 to 200 days before delivery, or conception to 11.4 weeks/2.9 months gestation) demonstrating elevated risk of a STB-flagged ED visit during this time. A secondary slope acceleration was observed after delivery, with a consistent decline beginning around delivery and continuing throughout day 365, with a relatively steeper slope than the decline observed during the prenatal window. These findings provide preliminary evidence for two-time intervals of change in the probability of a STB-flagged ED visit, the first during the early prenatal window and the second following delivery across the postpartum year.

Figure 7

Survival curve illustrating two windows of elevated risk for initial STB-flagged ED visit probability



Note. Survival curves illustrate the probability of a perinatal window having no observed STB-flagged ED visit across time. When a STB-flagged ED visit is observed within a perinatal

window, that perinatal window's observation window ends and the window is excluded from the remaining population under observation moving forward. The remaining curve illustrates the probability of "surviving" the risk of having a STB-flagged ED visit for those still under observation, decreasing over time as more events are observed at discrete time points.

K-M curves are a useful tool for illustrating population level survival, but are constrained by the limitations in accounting for recurrent events, either historical or time-varying risk covariates, or more granular temporal risk windows (e.g., hazard illustration). This curve provides an effective foundation for Aim 2 and Aim 3 results, which leverage more flexible survival models to provide specificity on significant risk factors and time windows for STB-flagged ED visits.

4.2. Covariate Hazard Estimates for Initial and Recurrent Events (Aim 2)

Aim 2 of the current study examined how individual level predictors observed historically and within the perinatal window contributed to the magnitude of risk across the perinatal window. A series of piecewise exponential additive mixed models (PAMMs) were run to estimate the magnitude and direction of association between individual risk factors within the Access and Health Vulnerability domains — including recency of an inpatient/ED visit — with the hazard of an initial and recurrent STB-flagged ED visit. A model building approach was used, consisting of sequentially adding risk domains to a baseline model and comparing fit to identify the risk domain(s) that fit the data best. The full covariate model was used to estimate the independent contribution of risk factors within each vulnerability domain with the hazard of an initial or recurrent STB-flagged ED visit (expressed as adjusted hazard ratios; aHR). These aHRs provide the magnitude of effects on the instantaneous hazard of a STB-flagged ED event at any point across the perinatal window. However, it is important to note that Aim 2 risk factors

were added as linear predictors, and effects on the temporal patterning of the hazard curve itself were not directly modelled here.

4.2.1 Vulnerability Risk Factors Contributing to First Event Hazard

The first series of PAMMs utilized the model building approach to estimate the hazard of an initial STB-flagged ED visit across the perinatal window. The step-wise model building comparison revealed that Perinatal Health Vulnerability factors contributed most to model fit, and the full covariate model was the best fit for time-to-first-event models based on AIC/BIC model comparisons (see Table 6).

Table 6

Model Comparisons Showing Lowest AIC and BIC Values and Best Fit for Time-to-first Event Full Covariate Model

Time-to-first-event Model		
Model Level	AIC	BIC
Baseline	20199.27	20398.19
Access Vulnerability	19483.66	19857.34
Health Vulnerability (Hx)	19793.86	20123.84
Health Vulnerability (Perinatal)	18050.35	18569.01
Full Health Vulnerability	17938.67	18589.32
Full Covariate Model	17653.61	18481.41

Note. Lower AIC/BIC values indicate better model fit to the data.

Magnitude of Effects for Access Vulnerability Risk Factors. Significant associations were observed between certain racial identities – such as American Indian/Alaskan Native and Black individuals – and the greater hazard of an initial STB flagged ED visit. Category groups were compared in reference to the "White" racial identity status given its majority representation in the population. Significant effects indicated a difference in magnitude of effect compared to those with a White racial identity. Compared to this reference group, American Indian/Alaskan Native individuals had 82% higher hazard (aHR = 1.82, 95% CI: 1.32–2.51, $p < 0.001$) while Black individuals had 49% higher hazard (aHR = 1.49, 95% CI: 1.16–1.92, $p = 0.002$) of an

initial STB-flagged ED visit. This indicates that certain minority racial identities are associated with greater risk of an initial event within Oregon, but not all, with non-significant effects observed for Asian, Hawaiian/Pacific Islander, and "other" racial statuses.

In reference to perinatal windows with Commercial insurance status, both public and other insurance statuses were associated with greater instantaneous risk of an initial STB flagged ED visit. Specifically, public insurance status (representing either Medicaid or Medicare) was associated with 112% greater hazard compared to commercial insurance (aHR = 2.12, 95% CI: 1.79-2.51, p <0.001). The Other insurance status also significantly associated with greater instantaneous risk of initial STB-flagged ED visit at 68% higher hazard (aHR =1.68, 95% CI: 1.04-2.73, p=.034). The significance of public insurance status matched hypotheses while the significant effect of Other insurance status was an unexpected result. Together, these findings suggest that non-Commercial insurance status observed at delivery is associated with greater instantaneous hazard of an initial STB-flagged ED visit.

Conversely, older maternal age and Hispanic/Latino ethnicity were protective, significantly associating with lower risk of the outcome across the perinatal window. Each additional year of maternal age (7% lower hazard; aHR = 0.93, 95% CI: 0.92-0.94, p<0.001) and Hispanic/Latino ethnic identity (27% lower hazard; aHR = 0.73, 95% CI: 0.58-0.92, p=0.009) were both associated with lower hazard of an initial STB-flagged ED visit. While the association between greater maternal age and lower outcome hazard aligned with hypotheses, the significantly protective effect of Hispanic/Latino ethnic identity was unexpected and contrary to what was hypothesized. This result is further expanded upon in the discussion section.

Protective effects were also observed for delivery year. Compared to the reference group (i.e., delivery year 2020) delivery years of 2021 and 2022 were protective, with 24% lower

hazard for each year (2021: aHR = 0.76, 95% CI 0.62-0.92, p = .006; 2022: aHR = 0.76, 95% CI: 0.62 – 0.93, p = .008). Of note, 2020 was the height of the Covid-19 pandemic, with implications of this finding discussed further in the final chapter.

Magnitude of Effects for Time-Invariant Health Vulnerability Risk Factors. Of the time-invariant historical health vulnerability factors, only psychiatric and STB risk factors observed at delivery or inpatient events (pre-2020) significantly associated with greater hazard of a perinatal STB ED. Having a psychiatric flag observed at a pre-2020 delivery event contributed 42% higher hazard (aHR = 1.42, 95% CI: 1.12-1.81, p=.004), while a psychiatric flag observed at a pre-2020 inpatient event contributed 121% higher hazard (aHR = 2.21, 95% CI: 1.55-3.17, p<.001). Similarly, an inpatient history with an observed STB flag contributed 113% higher hazard (HR = 2.13, 95% CI: 1.48-3.05, p<.001). IPV, substance use, and chronic health risk flags observed at pre-2020 inpatient or delivery events had no significant effects. This suggests certain historical risk factors observed prior to the current perinatal window serve as indicators of elevated risk for an initial STB-flagged ED visit – specifically psychiatric flags and STB flags. Of note, STB flags observed at pre-2020 delivery events were removed from models due to inflated standard errors, thus estimates are not available for this predictor.

Magnitude of Effects for Health Vulnerability TDCs by Healthcare Context. Nearly all Health Vulnerability TDC flags observed at an ED visit during the perinatal window were significantly associated with greater concurrent hazard of a STB-flagged ED visit. The significant associations were observed for psychiatric, NSSI, SUD, and IPV flags occurring at a perinatal ED event – indicating that whenever such a flag occurred, there was a significantly greater hazard for an initial STB-flagged ED visit within the same interval. Specifically, psychiatric flags associated with 7,715% higher hazard (aHR = 78.15, 95% CI: 58.58-104.26,

p<.001) followed by an NSSI flag at 300% higher hazard (aHR = 4.00, 95% CI: 1.32-12.16, *p*=.014), IPV at 219% higher hazard (aHR = 3.19, 95% CI: 1.46-7.00, *p*=.004), and substance use at 48% greater hazard (aHR = 1.48, 95% CI: 1.05-2.08, *p*=.026). The exceptionally large aHRs for psychiatric ED flags suggest that, despite mutually exclusive coding schemes for STBs and psychiatric problems, there may be partial confounding of the covariate with the outcome itself. Taken together, this suggests that psychiatric, NSSI, SUD, and IPV risk flags are each associated with greater concurrent hazard of a STB-flagged ED visit, with potential confounding effects for psychiatric flags due to co-occurrence with the outcome.

Further, a perinatal ED visit with a chronic health flag was the exception to other risk flags due to relatively protective effects, translating to 42% *lower* hazard (aHR = 0.58, 95% CI: 0.42-0.80, *p*<.001).

For TDC risk factors observed at perinatal inpatient events, IPV and psychiatric risk flags were significantly associated with greater hazard of a perinatal STB-flagged ED visit. An IPV flag indicated that when a perinatal inpatient visit was observed, it was associated with a 1,484% higher hazard of a perinatal STB-related ED visit within the same interval of observation (aHR = 15.84, 95% CI: 1.22-204.95, *p*<.001). Similarly, when a psychiatric flag was observed within an interval, it was associated with an 842% higher hazard of an initial STB-flagged ED visit occurring within the same interval (aHR = 9.42, 95% CI: 2.38-37.24, *p*=.001). This suggests both inpatient IPV and psychiatric risk flags were associated with concurrent risk for a STB-flagged ED visit within the perinatal window. One caveat to note is the wide confidence interval for both findings, indicating less certainty for the perinatal inpatient IPV and psychiatric flag effects. While the inpatient STB flag also associated with greater hazard of the outcome (189% greater

hazard), the nonsignificant *p*-value combined with the confidence interval including 1 indicated this association was not statistically meaningful.

At delivery, STB, psychiatric, and substance use risk flags were significantly associated with greater hazard of an initial STB-flagged ED-visit. Delivery flags were activated at the delivery event and carried forward through postpartum, meaning that delivery flags contributed to the hazard estimate at each interval across the postpartum period. Thus, a STB flag at delivery was associated with 351% greater hazard of a STB flagged ED visit postpartum (aHR = 4.51, 95% CI: 2.06-9.88, $p<.001$), while a psychiatric flag was associated with 137% greater hazard (aHR = 2.37, 95% CI: 2.00-2.80, $p<.001$), and a SUD flag was associated with 58% greater hazard (aHR = 1.58, 95% CI: 1.30-1.92, $p<.001$). IPV and chronic health risk flags observed at delivery were not significantly associated with the outcome. This suggests that delivery-observed risk flags – specifically STBs, psychiatric flags, and SUD – are meaningful indicators of greater risk for a postpartum initial STB-flagged ED visit.

Magnitude of Effects for ED and Inpatient Utilization Recency. There was a gradient pattern observed for the lagged ED recency TDC variable and the hazard of an initial STB-flagged ED visit, with greatest magnitude observed for more recent look-back windows. The greatest magnitude in hazard was observed when an ED visit (for any medical reason, including STBs) took place in the last seven days, which associated with 456% greater hazard (aHR = 5.56, 95% CI: 4.15-7.43, $p <.001$). In fact, all recency windows were significantly associated with greater instantaneous hazard. The magnitude of aHRs decreased over time following the past 7-days recency window – ranging from 386% greater hazard for ED events occurring 8-30 days prior to the current interval (aHR = 4.86, 95% CI: 3.88-6.07, $p <.001$), 262% greater hazards for events 31-90 days prior (aHR = 3.62, 95% CI: 2.93-4.46, $p <.001$), and 110% greater

hazard for events occurring 91+ days prior (aHR = 2.10, 95% CI: 1.75-2.52, p<.001). This pattern suggests there may be a post-crisis sensitivity window following recent ED utilization for any reason. Further, these effects remain significant even when the prior event occurred 91 or more days prior, suggesting that the full latency window may not have been fully mapped with the defined lookback windows.

There was a similar gradient pattern observed for the magnitude of aHRs for each recency strata of the lagged inpatient recency variable and the significant association with the hazard of an initial STB-flagged ED visit. The greatest hazard magnitude was observed for more recent look-back windows, specifically for an inpatient visit (for any medical reason, including STBs) occurring within the last seven days at 350% greater hazard (aHR = 4.50, 95% CI: 2.08-9.74, p <.001). The magnitude of the aHR's decayed over time and was observed at 212% greater magnitude for inpatient events occurring 8-30 days prior to the current interval (aHR = 3.12, 95% CI: 1.68-5.80, p <.001), 106% greater hazard for an inpatient visit 31-90 days prior (aHR = 2.06, 95% CI: 1.20-3.53, p = .009), and 72% greater hazard for an inpatient visit taking place 91+ days before the current interval (aHR = 1.72, 95% CI: 1.23-2.41, p=.001). This gradient pattern mirrored the pattern observed in ED recency flags, though the inpatient recency confidence intervals were relatively larger due to fewer observed events compared to perinatal ED visits. This pattern suggests a similar post-crisis sensitivity window following inpatient care utilization for any reason, with a potentially broader latency window beyond the 90 days mapped for the current study.

Summary of Covariate Effects for Time-to-First Event Model. The full covariate model revealed that certain Access Vulnerability indicators and select Health Vulnerability – history risk factors were strong stable predictors of greater hazard of an initial event over time.

Among the Access risk factors, only AI/AN and Black racial identity and public or "other" insurance status significantly associated with greater aHRs, while additional year of maternal age and Hispanic/Latino ethnicity were protective – contributing to lower aHRs of the outcome. Within the Oregon context, this indicates maternal individuals with certain minority racial identities and public/other insurance status may be at greatest instantaneous risk for an initial STB-flagged ED event across the perinatal window. When accounting for health vulnerability history (pre-2020), only PSYCH flags at delivery and STB and PSYCH flags at inpatient events associated with greater aHRs. This suggests tracking historical risk factors – specifically STB and PSYCH flags – offers meaningful predictive insight for perinatal STB-flagged ED presentation.

The full covariate model also provided the significance of certain Health Vulnerability – Perinatal risk factors – with significant concurrent risk associated with ED flags, and significant postpartum stable risk associated with delivery flags. However, the reliability of effects for perinatal Health Vulnerability risk factors varied – with reliable estimates observed for most ED and delivery risk flags, but less so for inpatient flags, which were more sparse and had wider CIs. This suggests that the ED and delivery contexts are a rich source of STB-related risk indicators and offer reliable estimates of instantaneous risk for an initial STB-flagged ED visit. This is true for certain risk factors over others – specifically, PSYCH, SUD, and IPV within perinatal ED settings, and STB, PSYCH and SUD risk flags observed at delivery. This suggests that PSYCH, SUD, and IPV flags observed during perinatal ED visits are strong indicators of concurrent risk for a STB-flagged ED visit within that interval, and may represent acute points of care in reference to perinatal STB risk. Within the delivery context, these results suggest that STB,

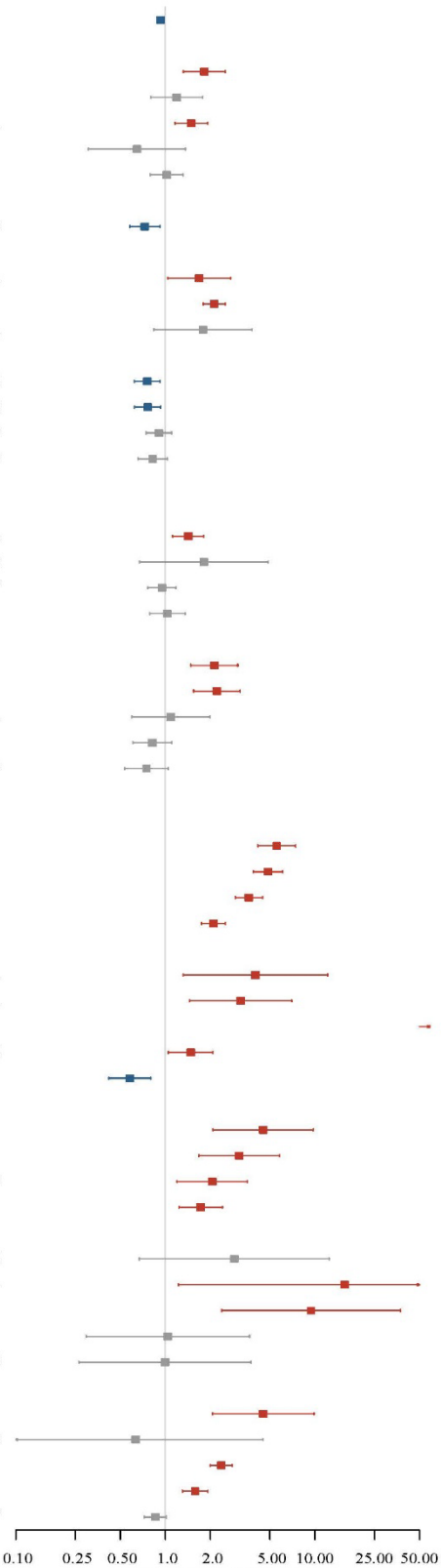
PSYCH, and SUD flags observed at delivery are meaningful indicators of elevated postpartum risk for a STB-flagged ED visit.

Finally, all estimates for recency effects of ED and inpatient care utilization were significant and relatively reliably estimated for recency effects spanning the last 7 days to 91+ days. These results provide the first known effort to estimate decay effects associated with perinatal acute care utilization in association with risk for a STB-flagged ED visit. The findings suggest that the temporal proximity of acute care utilization at inpatient or ED contexts may be a valuable indicator of perinatal STB emergence across the perinatal window. While prior acute care utilization is unlikely to precipitate STBs themselves, this may serve as a proxy indicator of overall distress and may provide contextual insight for the imminence of perinatal acute care utilization for STBs.

Figure 8

Time-to-first-event full covariate model output

Access Vulnerability		
Age (at delivery)	0.93 (0.92–0.94)	<0.001
Race (ref: White)		
AI/AN	1.82 (1.32–2.51)	<0.001
Asian	1.19 (0.80–1.77)	0.391
Black	1.49 (1.16–1.92)	0.002
Hwn/PI	0.65 (0.31–1.36)	0.251
Other	1.02 (0.79–1.31)	0.881
Ethnicity (ref: Non–Hispanic)		
Hispanic/Latino	0.73 (0.58–0.92)	0.009
Insurance (ref: Commercial)		
Other	1.68 (1.04–2.73)	0.034
Public	2.12 (1.79–2.51)	<0.001
Uninsured	1.79 (0.84–3.80)	0.132
Delivery Cohort Year (ref: 2020)		
2021	0.76 (0.62–0.92)	0.006
2022	0.76 (0.62–0.93)	0.008
2023	0.90 (0.74–1.10)	0.319
2024	0.82 (0.66–1.03)	0.090
Health Vulnerability — Time–Invariant		
Delivery History (pre–2020)		
Psych	1.42 (1.12–1.81)	0.004
IPV	1.81 (0.67–4.88)	0.240
Chronic Health	0.95 (0.77–1.18)	0.637
Substance Use	1.03 (0.78–1.36)	0.823
Inpatient History (pre–2020)		
STB	2.13 (1.48–3.05)	<0.001
Psych	2.21 (1.55–3.17)	<0.001
IPV	1.09 (0.60–1.99)	0.784
Chronic Health	0.82 (0.61–1.10)	0.191
Substance Use	0.75 (0.54–1.05)	0.089
Health Vulnerability — Time–Varying		
ED Recency (ref: None)		
Within 7 Days	5.56 (4.15–7.43)	<0.001
8–30 Days	4.86 (3.88–6.07)	<0.001
31–90 Days	3.62 (2.93–4.46)	<0.001
91+ Days	2.10 (1.75–2.52)	<0.001
ED Flags		
NSSI	4.00 (1.32–12.16)	0.014
IPV	3.19 (1.46–7.00)	0.004
Psych	78.15 (58.58–104.26)	<0.001
Substance Use	1.48 (1.05–2.08)	0.026
Chronic Health	0.58 (0.42–0.80)	<0.001
Inpatient Recency (ref: None)		
Within 7 Days	4.50 (2.08–9.74)	<0.001
8–30 Days	3.12 (1.68–5.80)	<0.001
31–90 Days	2.06 (1.20–3.53)	0.009
91+ Days	1.72 (1.23–2.41)	0.001
Inpatient Flags		
STB	2.89 (0.67–12.46)	0.155
IPV	15.84 (1.22–204.95)	0.034
Psych	9.42 (2.38–37.24)	0.001
Substance Use	1.04 (0.30–3.66)	0.951
Chronic Health	1.00 (0.27–3.74)	0.996
Delivery Flags		
STB	4.51 (2.06–9.88)	<0.001
IPV	0.63 (0.09–4.52)	0.649
Psych	2.37 (2.00–2.80)	<0.001
Substance Use	1.58 (1.30–1.92)	<0.001
Chronic Health	0.86 (0.72–1.02)	0.077



Red = significant risk (p<0.05) | Blue = significant protective | Grey = not significar

4.2.2 Vulnerability Risk Factors Contributing to Recurrent Event Hazard

The second series of PAMMs utilized the model building approach to estimate the hazard of a recurrent STB-flagged ED visit across the perinatal window. Compared to the time-to-first-events model, the recurrent events models allowed for more than one outcome event to exist per individual, with STB-flagged ED events differentiated by an enumerating variable – e.g., "first event" or "recurrent". The recurrent events model building approach was the same as the approach to the first event models.

Given the time-to-first-event (reported in section 4.2.1) and recurrent events models consisted of the same predictor sets and differed by outcome variable only, the following results summaries will emphasize the differences between model sets. This comparison allows for the differentiation of the predictors more strongly associated with the hazard of a recurrent STB-flagged ED visit, after having had an initial visit. Based on model comparisons, the full covariate model including both access and health vulnerability predictors was the best fitting model (see Table 7). The following results are reported from the full-covariate model (see Figure 9).

Table 7

Model Comparisons Showing Lowest AIC and BIC Values and Best Fit for Recurrent Events Full Covariate Model

Recurrent Events Models		
Model Level	AIC	BIC
Baseline	23547.44	23877.21
Access Vulnerability	22955.35	23459.01
Health Vulnerability (Hx)	23188.14	23649.7
Health Vulnerability (TV)	22031.78	22664.14
Full Health Vulnerability	21899.74	22663.43
Full Covariate Model	21629.5	22574.1

Note. Lower AIC/BIC scores indicate better model fit to the data.

Access Vulnerability and Recurrent Event Hazard. Access Vulnerability risk characteristics in the recurrent events full covariate model largely replicated the results observed

in time-to-first-event models. American Indian/Alaska Native racial identity (reference: White), other insurance status, and public insurance status (reference: Commercial insurance) were significantly associated with the outcome variable in alignment with time-to-first-event models, with small differences in effect sizes (see Figure 9). Similarly, older maternal age, Hispanic/Latino ethnicity, and delivery year of 2021 and 2022 (reference: 2020) were protective and associated with lower hazard of a recurrent event. However, there were also differences in significance between model sets. Unlike the time-to-first-event full covariate model, Black racial identity was no longer significantly associated with recurrent events outcomes. Further, delivery year in 2024 was protective within the recurrent events model, when it was non-significant in the time-to-first-event model – suggesting that deliveries in 2024 had a lower hazard of a recurrent event following an initial event compared to deliveries in 2020. These findings suggest that the same stable sociodemographic risk indicators for an initial event are significant indicators of risk for a recurrent event, with potential decrease in recurrence hazard for deliveries in 2024.

Time-Invariant Health Vulnerability Risk Factors and Recurrent Event Hazard. Historical Health Vulnerability risk factors were also similar across full covariate models, with key differences in magnitude of historical psychiatric inpatient visits and protectiveness of historical chronic health flags at delivery. Significant associations were observed between pre-2020 psychiatric risk flags at delivery and inpatient visits, and STB flags at pre-2020 inpatient visits, which replicated the results observed in time-to-first-event full covariate model. However, the magnitude of the pre-2020 psychiatric inpatient flag (aHR = 2.23, 95% CI: 1.66-2.99, $p<.001$) was a stronger predictor than STB inpatient flag (aHR = 1.48, 95% CI: 1.10-1.99, $p=.010$) within the recurrent events full covariate model. This finding differed from time-to-first-event models where STB and psychiatric risk flags were comparable in hazard magnitude. This

suggest that a history of PSYCH flags at inpatient events may provide more meaningful insight for perinatal event recurrence risk than a history of inpatient STB flags. In addition, chronic health flags observed at pre-2020 delivery events were protective within recurrent events models (aHR = 0.77, 95% CI: 0.63-0.94, *p*=.010), whereas in time-to-first-event models, this variable was non-significant. This difference suggests that chronic health problems observed at historical delivery events may represent a different cohort altogether, or indicate something about additional contact with the healthcare system for chronically ill individuals which is further discussed in the final chapter.

Health Vulnerability TDCs by Healthcare Context and Recurrent Event Hazard. Among the perinatal Health Vulnerability variables, there were fewer significant effects and smaller magnitude of effect hazard compared to the time-to-first-event full covariate model. Within perinatal ED settings, only IPV and PSYCH risk factors associated with concurrent risk for a recurrent STB-flagged ED visit, while NSSI, SUD, and CH flags did not. In fact, ED-flagged IPV and PSYCH risk factors were significant in both initial and recurrent event models, though the PSYCH risk flag magnitude was relatively smaller in the recurrent events model (468% higher concurrent hazard compared to 7,715% higher concurrent hazard). NSSI, SUD, and CH flags were non-significant in the recurrent events model, while they were significant in the time-to-first-event model (though CH was protective). The salience of ED-flagged PSYCH and IPV risk factors across full covariate models suggests they may be particularly meaningful indicators of concurrent risk for both an initial or recurrent STB-flagged ED visit within the perinatal window.

Within the recurrent events full covariate model, only the PSYCH flag observed at perinatal inpatient events was significant — remaining at the same magnitude of risk between

model sets (recurrent events: aHR = 9.44, 95% CI: 1.90-46.96, p=.006). This finding suggests that within intervals where an inpatient PSYCH flag was observed, the concurrent hazard of an initial or recurrent STB-flagged ED event is similarly high (842% initial - 844% recurrent). Across both models, the CIs for the PSYCH risk flag remained wide, with a broader interval observed for the recurrent events model. This suggests that PSYCH flags observed at perinatal inpatient visits do associate with greater instantaneous concurrent hazard of a recurrent STB-flagged ED visit, but are less reliably estimated. While inpatient PSYCH flags may provide preliminary insight into risk for recurrence specifically, their relative scarcity, combined with scarcity of recurrent events themselves, likely contribute to the uncertainty of their concurrent predictive value overall.

Finally, STB, PSYCH, and SUD flags — activated at delivery and carried forward as constant postpartum risk indicators — were significantly associated with the outcomes in both the time-to-first event and recurrent events models. PSYCH and SUD flags showed comparable hazard magnitudes across the two models (PSYCH: 123-137% greater hazard; SUD: 57-58% greater hazard), though the recurrent events model had a smaller magnitude for STBs flagged at delivery. This difference suggested a relatively stronger association between STBs flagged at delivery and initial event risk (351% greater hazard) compared to associations with recurrent event risk (181% greater hazard). Together, this suggests that STB, PSYCH, and SUD flags observed at delivery events meaningfully differentiate which perinatal windows are at greater risk for either an initial or recurrent postpartum STB-flagged ED event.

ED and Inpatient Utilization Recency and Recurrent Event Hazard. ED perinatal recency flags had similar gradient patterns in hazard across time-to-first-event and recurrent event models, whereby the hazard was greatest for more proximal ED. All ED recency flags

were significantly associated with greater hazard for a recurrent event, specifically when an ED visit occurred within the last 7 days (1,144% higher hazard) followed by an ED visit within the last 8-30 days (618% greater hazard), within the last 31-90 days (315% greater hazard), or at 91 days or more (117% greater hazard). The ED recency hazard gradient was greater in magnitude for recurrent event outcomes as opposed to initial event outcomes. Given that the recurring event must take place within an ED setting, there may be some overlap between the recency of a STB-flagged ED visit specifically vs an ED visit for any reason, as initial and recurring events may occur in close proximity to one another. While it is clear proximal ED utilization is associated with greater magnitude of both initial and recurrent events, there is less clarity for whether this effect is due to STB-flagged events specifically, or ED utilization more broadly.

There was also a gradient pattern observed for the magnitude of effects for the recency of a perinatal inpatient visit for any reason and the greater hazard of a recurrent outcome, with a between-model difference for the last 7 days category. While there were significant effects observed for inpatient utilization and recurrent events within the last 8-30 days (193% greater hazard), 31-90 days (146% greater hazard), and 91+ days (88% greater hazard), no significant association was observed for inpatient recency within the last 7 days. Notably, an inpatient visit within the last seven days was significantly associated with an *initial event* at the greatest order of magnitude (350% greater hazard) compared to other inpatient recency indicators. While other recency categories were comparable in magnitude between initial and recurrent event models, the observed non-significance of inpatient events within the last 7 days is profound. While further analysis is needed, there is the possibility that inpatient visits may represent a competing risk such that ED visits cannot simultaneously take place during an inpatient stay. However, both inpatient events and the outcome variables were coded based on discharge dates – suggesting

that temporal ordering between events is preserved between intervals. Therefore, the perinatal inpatient stay might represent a stabilizing event whereby immediate risk is attenuated within 7 days. Further research is needed to disentangle whether this effect is a competing risk, or whether it represents a more protective post-hospitalization effect.

Summary of Covariate Effects for Recurrent Event Model. Taken together, there was a similar pattern in which covariates were associated with greater hazard of either an initial or recurrent event, with several important differences. This was largely the case across time-invariant Access Vulnerability risk factors. The same Access Vulnerability risk factors were associated with greater hazard of an initial or recurrent event – suggesting that those identifying as AI/AN with either public or "other" insurance status are at greater risk for either type of event. The loss of a significant association between Black racial identity and recurrent event risk does not in itself suggest that Black perinatal individuals are at lower risk for recurrence. Instead, this finding suggests a critical need for further evaluation and perhaps comparison with death records to determine if these individuals remained in the risk set after an initial STB-flagged ED visit.

There was also a similar pattern in the same Health Vulnerability – Hx and Health Vulnerability – Perinatal risk flags associating with greater hazard of both an initial and recurrent event. Historical risk factors such as PSYCH (at delivery or inpatient) and STB flags (at inpatient) observed at pre-2020 events were significantly associated with a greater hazard for both an initial or recurrent event, suggesting these risk factors serve as stable predictors of perinatal STB-flagged ED utilization. Further, time-dependent indicators of risk emerging perinatally – specifically related to ED-flagged IPV and PSYCH and inpatient flagged PSYCH – represented important indicators of concurrent risk for either an initial or STB-flagged ED visit. Notably, STB, PSYCH, and SUD flags observed at delivery events were also consistently

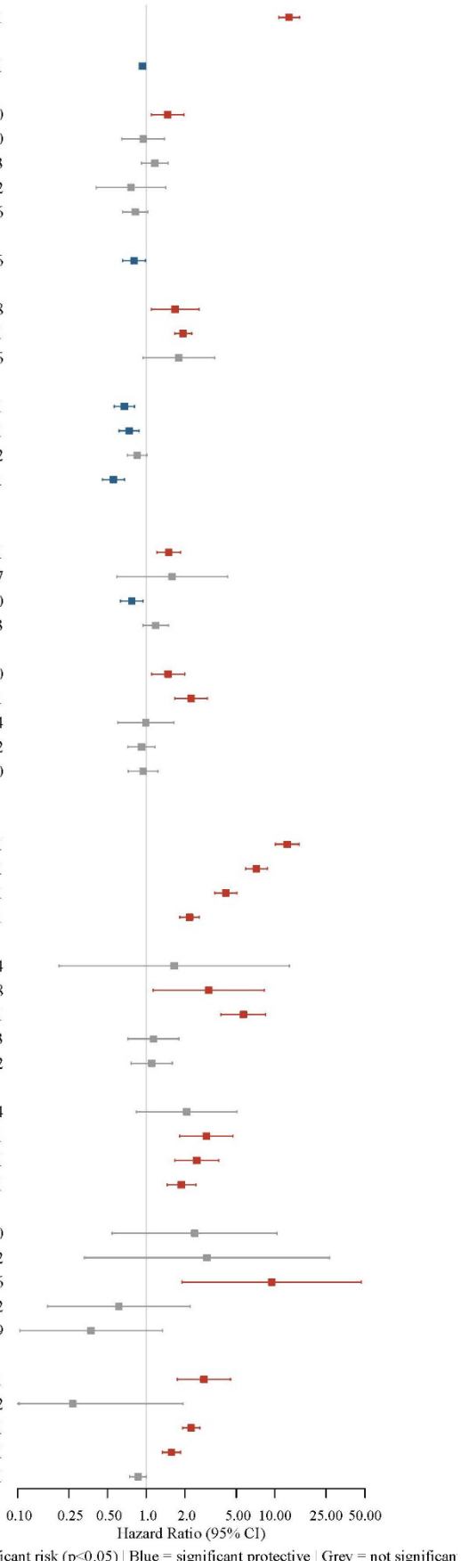
significant across models – suggesting these risk factors represent a reliable indicator of postpartum risk for both an initial or recurrent STB event. Together, these findings indicate that perinatal windows at risk for initial or recurrent STB-flagged ED events can largely be identified by the same Access and Health Vulnerability risk factors.

Finally, recency effects for inpatient and ED visits for any reason were significant across initial and recurrent event models. With the exception of a recent inpatient visit within the last 7 days for recurrent event models, a gradient patten was observed across recency look-back windows with closer temporal proximity to the current interval associated with the greatest hazard of an initial or recurrent event. This broadly suggests that the recency of acute care utilization at ED or inpatient care settings may serve as an indicator of imminent initial or recurrent STB-flagged ED utilization. Further, it appears the full latency effects were not fully captured by the current study's look-back windows. Significant aHR's were observed for events occurring at the furthest look-back window — 91+ days — indicating the full decay effects of prior acute care utilization can be more granularly differentiated beyond 90 days than the current study did.

Figure 9

Recurrent events model output

Event Stratum (ref: First)		
Recurrent (vs. First)	12.87 (10.68–15.50)	<0.001
Access Vulnerability		
Age (at delivery)	0.94 (0.93–0.95)	<0.001
Race (ref: White)		
AI/AN	1.47 (1.10–1.96)	0.010
Asian	0.95 (0.65–1.39)	0.780
Black	1.17 (0.92–1.48)	0.203
Hwn/PI	0.76 (0.41–1.42)	0.392
Other	0.82 (0.66–1.03)	0.086
Ethnicity (ref: Non–Hispanic)		
Hispanic/Latino	0.80 (0.65–0.99)	0.036
Insurance (ref: Commercial)		
Other	1.68 (1.09–2.57)	0.018
Public	1.93 (1.66–2.25)	<0.001
Uninsured	1.79 (0.94–3.40)	0.076
Delivery Cohort Year (ref: 2020)		
2021	0.68 (0.56–0.81)	<0.001
2022	0.74 (0.62–0.88)	<0.001
2023	0.85 (0.71–1.01)	0.062
2024	0.56 (0.45–0.68)	<0.001
Health Vulnerability — Time–Invariant		
Delivery History (pre–2020)		
Psych	1.50 (1.21–1.85)	<0.001
IPV	1.59 (0.59–4.27)	0.357
Chronic Health	0.77 (0.63–0.94)	0.010
Substance Use	1.19 (0.94–1.49)	0.143
Inpatient History (pre–2020)		
STB	1.48 (1.10–1.99)	0.010
Psych	2.23 (1.66–2.99)	<0.001
IPV	0.99 (0.60–1.64)	0.974
Chronic Health	0.92 (0.72–1.17)	0.492
Substance Use	0.95 (0.72–1.23)	0.680
Health Vulnerability — Time–Varying		
ED Recency (ref: None)		
Within 7 Days	12.44 (10.03–15.42)	<0.001
8–30 Days	7.18 (5.91–8.73)	<0.001
31–90 Days	4.16 (3.42–5.05)	<0.001
91+ Days	2.17 (1.82–2.58)	<0.001
ED Flags		
NSSI	1.65 (0.21–12.91)	0.634
IPV	3.06 (1.13–8.27)	0.028
Psych	5.68 (3.81–8.47)	<0.001
Substance Use	1.14 (0.72–1.79)	0.583
Chronic Health	1.10 (0.76–1.59)	0.602
Inpatient Recency (ref: None)		
Within 7 Days	2.06 (0.84–5.05)	0.114
8–30 Days	2.93 (1.82–4.73)	<0.001
31–90 Days	2.46 (1.66–3.65)	<0.001
91+ Days	1.88 (1.45–2.42)	<0.001
Inpatient Flags		
STB	2.38 (0.54–10.41)	0.250
IPV	2.96 (0.33–26.57)	0.332
Psych	9.44 (1.90–46.96)	0.006
Substance Use	0.61 (0.17–2.20)	0.452
Chronic Health	0.37 (0.10–1.33)	0.129
Delivery Flags		
STB	2.81 (1.74–4.51)	<0.001
IPV	0.27 (0.04–1.93)	0.192
Psych	2.23 (1.92–2.60)	<0.001
Substance Use	1.57 (1.33–1.85)	<0.001
Chronic Health	0.86 (0.74–1.00)	0.051



4.3 Temporal Patterns in Hazard of Initial and Recurrent Events (Aim 3)

Aim 3 evaluated temporal patterns in the baseline hazard curve for an initial or recurrent STB-flagged ED event at two levels of analysis: 1) for the average perinatal window, and 2) for different Vulnerability profiles. This analysis establishes when and for whom the log-hazard was increasing, providing insight into whether there are differential timelines of elevated hazard for a STB-flagged ED visit within the perinatal population as a whole or within certain vulnerability groups only. The predicted estimates for a representative "average" perinatal individual were extracted from the Aim 2 full covariate model to illustrate the baseline hazard curve for initial and recurrent events. To compare whether the timing of the baseline hazard differed depending on risk profile, simplified Vulnerability profile models were run and predicted estimates were extracted to compare differences in magnitude and timing of effects of the baseline hazard for each vulnerability profile.

For both the representative profile (extracted from the Aim 2 full covariate model) and the vulnerability profile outputs (extracted from Aim 3 Vulnerability profile models), first-derivative analyses were conducted on the log-hazard smooths where the derivative value indicated the rate of change in the log-hazard at a given point in time. Significantly positive derivative values indicate the hazard is accelerating and events are occurring at a faster rate, while a significantly negative derivative value indicates that the hazard is slowing down and events are occurring at a slower rate. Applying first-derivative analyses on the log-hazard smooths provided insight for when the baseline hazard was elevated for initial and recurrent events for a representative perinatal individual, and for each vulnerability profile.

4.3.1 Temporal Pattern of Baseline Hazard Curve for Representative Perinatal Window

Baseline hazard curves from the full covariate models established in Aim 2 analyses were visualized for time-to-first-event and recurrent event models based on the hazard estimates of an

average perinatal window (see Figure 10). Population-averaged hazard curves were estimated by setting each covariate to its sample-level value: continuous variables to the sample mean (e.g., age ≈ 30), categorical variables to the modal reference category (e.g., White, non-Hispanic, commercial insurance), and all binary risk flags in the full covariate model to their sample prevalence (e.g., chronic health at delivery = 0.27, psychiatric problems at delivery = 0.11). Baseline hazard curves were displayed on a log-transformed axis for readability. Hazard curves are mapped from data-driven estimates, and their intercept on the y-axis varies depending on the data – unlike set intercepts for KM survival curves. Significant increases or decreases in a log-hazard smooth are detected in reference to itself rather than a set hazard curve reference. This provides a predicted hazard trajectory for the average participant in the cohort where each risk factor contributes to the "representative" hazard estimate in proportion to its prevalence in the population. This approach establishes the temporal patterning of the baseline hazard for the average perinatal birthing individual in Oregon between 2020-2024.

The baseline hazard curve extracted from the time-to-first-event full covariate model showed a non-monotonic temporal trajectory (see Figure 10), with a global peak in predicted hazard during early pregnancy prior to the third trimester, and a local peak in predicted hazard starting before delivery and lasting until early-mid postpartum. Further examination of the baseline hazard curve revealed two critical time intervals where the first derivative of the log-hazard smooth[3] was statistically significant. The log-hazard was significantly decreasing from gestational day 7 through day 207 (early first trimester through late second trimester; derivative

[3] "Log-hazard smooth" refers to the baseline hazard smooth on the log-hazard scale, which is the scale used to compute derivatives. Derivative results are reported in reference to the "log-hazard curve", which is simply the technically precise language to describe the more conceptual baseline hazard curve.

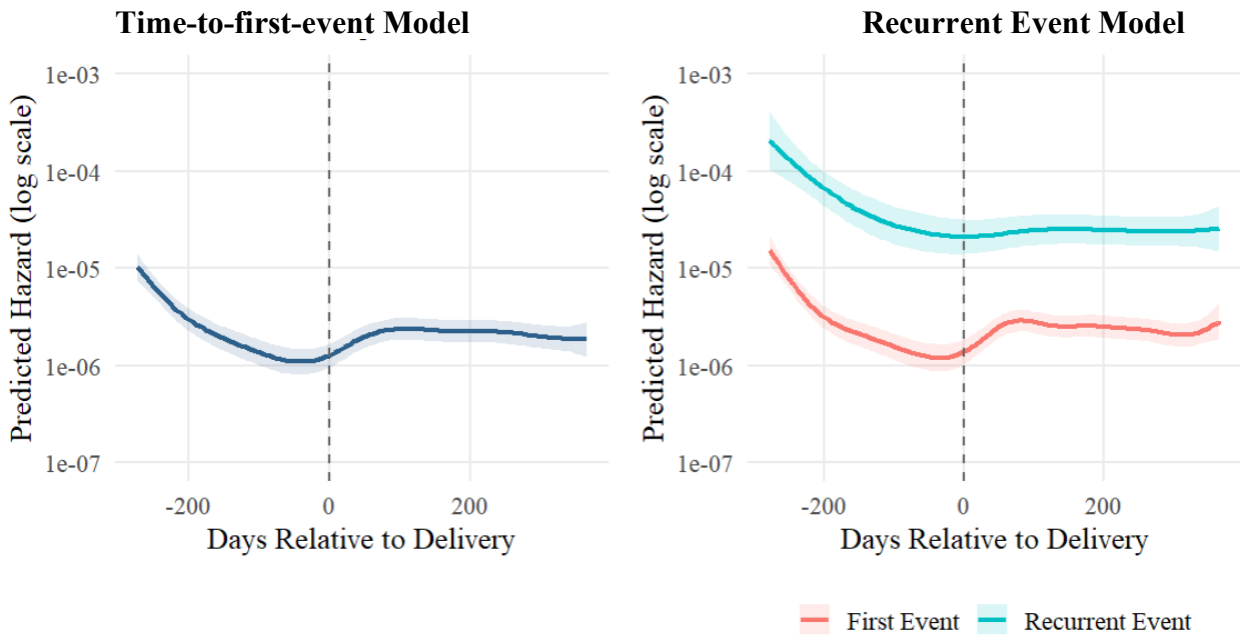
= -0.020, 95% CI: -0.030, -0.011) and significantly increasing from prenatal day 265 (15 days prior to delivery) to postpartum day 69 (~2.3 months after delivery), with the steepest rate of increase at postpartum day 23 (~3 weeks after birth; derivative = 0.009; 95% CI: 0.005, 0.013). These results show two things: first, the prenatal intercept was the highest relative point on the curve, indicating the greatest instantaneous hazard was observed from day 0 to day 7. Second, there was a second increase in the log-hazard starting 15 days before delivery and lasting until 2.3 months after birth – suggesting a window of relative increase in instantaneous hazard of a first STB-flagged ED event for those who hadn't yet experienced an event.

The recurrent events model (PWP-CT) simultaneously estimates separate baseline hazard curves for the first-event and recurrent-event strata. Baseline hazard curves for initial and recurrent events are estimated jointly, and the first-event curve derived here is not identical to the first-event curve reported above. Differences between initial event curves reflect the influence of modeling both initial and recurrent events within the same model. First-derivative analysis of the extracted hazard curves revealed two time intervals of significant change in the time-to-first-event stratum, but only one significant interval for the recurrent events stratum. The time-to-first event stratum log-hazard from the recurrent events model was significantly decreasing from gestational day 2 through day 119 (early first trimester through mid-second trimester; derivative = -0.025, 95% CI: -0.036, -0.014) and significantly increasing from prenatal day 275 (5 days prior to delivery) to postpartum day 60 (2 months after delivery), with the steepest rate of increase observed at postpartum day 27 (~4 weeks after birth; derivative = 0.013; 95% CI: 0.001, 0.014). Conversely, the recurrent events log-hazard was significantly decreasing from prenatal day 2 (approximately conception) to prenatal day 184 (~6 months gestation), with the steepest rate of decrease at day 2 (derivative = -0.016; 95% CI: -0.026, -0.005). These results indicate the

baseline hazard curve for recurrent STB related ED events is greater in overall magnitude than the time-to-first event curves. However, the recurrent event log-hazard slope is consistently decreasing from its peak around conception, which differs from the secondary significant increase observed in time-to-first event log-hazard curves.

Figure 10

Baseline hazard curve comparison between time-to-first-event and recurrent event models



Note. Population-averaged hazard curves were estimated by setting each covariate to its sample-level value: continuous variables to the sample mean (e.g., age ≈ 30), categorical variables to the modal reference category (e.g., White, non-Hispanic, commercial insurance), and binary risk flags to their sample prevalence (e.g., chronic health at delivery = 0.27, psychiatric problems at delivery = 0.11). This approach yields a predicted hazard trajectory for the average participant in the 2020–2024 Oregon birthing cohort, where each risk factor contributes to the hazard estimate in proportion to its prevalence in the population.

4.3.2 Comparing Temporal Patterns of Hazard Curves across Vulnerability Profiles

A mutually exclusive indicator of Vulnerability was created and differentiated by prenatal and postpartum landmarks to preserve temporal precedence of covariate risk factors within vulnerability models. This meant re-configuring Vulnerability profiles based on covariate risk variables available prior to the onset of each landmark onset. This resulted in a four-level

vulnerability profile (No Flags, Access Vulnerability, Health Vulnerability, and Combined Vulnerability) with different risk flag composition within each profile depending on the landmark window of analysis, and initial or recurrent event analysis. Table 8 illustrates the difference in Vulnerability profile group composition and STB events per profile across prenatal and postpartum landmarks, and between initial and recurrent event landmarks. To protect against immortal time bias, prenatal vulnerability profiles were constructed from risk flags observed prior to the landmark of 280 days before delivery. Postpartum vulnerability profiles were updated at the delivery landmark and included risk factors observed prior to 280 days pre-delivery, as well as flags observed prenatally and at delivery. This resulted in a more balanced distribution of vulnerability profile membership within postpartum landmark profiles (see Table 8). Given the scarcity of recurrent events observed prenatally, prenatal recurrent events and flags are excluded from the table and from vulnerability profile models.

Table 8

Vulnerability Profile Membership per Prenatal and Postpartum Landmark Analysis

Landmark	Vulnerability Profile	Perinatal Windows (N)	STB Events	STBs Per Perinatal Window
Prenatal – Initial Event	No Flags	69,804	42	0.06%
	Access Vulnerability	82,572	174	0.21%
	Health Vulnerability	9,380	7	0.07%
	Combined Vulnerability	22,262	111	0.50%
Postpartum – Initial Event	No Flags	34,052	24	0.07%
	Access Vulnerability	33,921	52	0.15%
	Health Vulnerability	45,684	84	0.18%
	Combined Vulnerability	71,439	456	0.64%
Postpartum – Recurrent	No Flags	34,207	24	0.07%
	Access Vulnerability	34,318	57	0.17%
	Health Vulnerability	45,576	91	0.20%
	Combined Vulnerability	71,321	477	0.67%

Landmark-specific Vulnerability profiles were used as predictors within simplified PAMMs to detect differential hazard trajectories by risk group over time. Vulnerability Profile models excluded all individual level predictors explored in Aim 2, and instead included the Vulnerability Profile factor-level predictor. Within each model, the baseline hazard curve was stratified by Vulnerability profile, which allowed each profile's curve to have its own distinct shape over time in alignment with that profile's respective risk level. Within the recurrent event model, an additional linear term was added to differentiate "first" vs "recurrent" events. The recurrent event model was run for the postpartum window only due to sparsity of prenatal recurrent STB-flagged ED events.

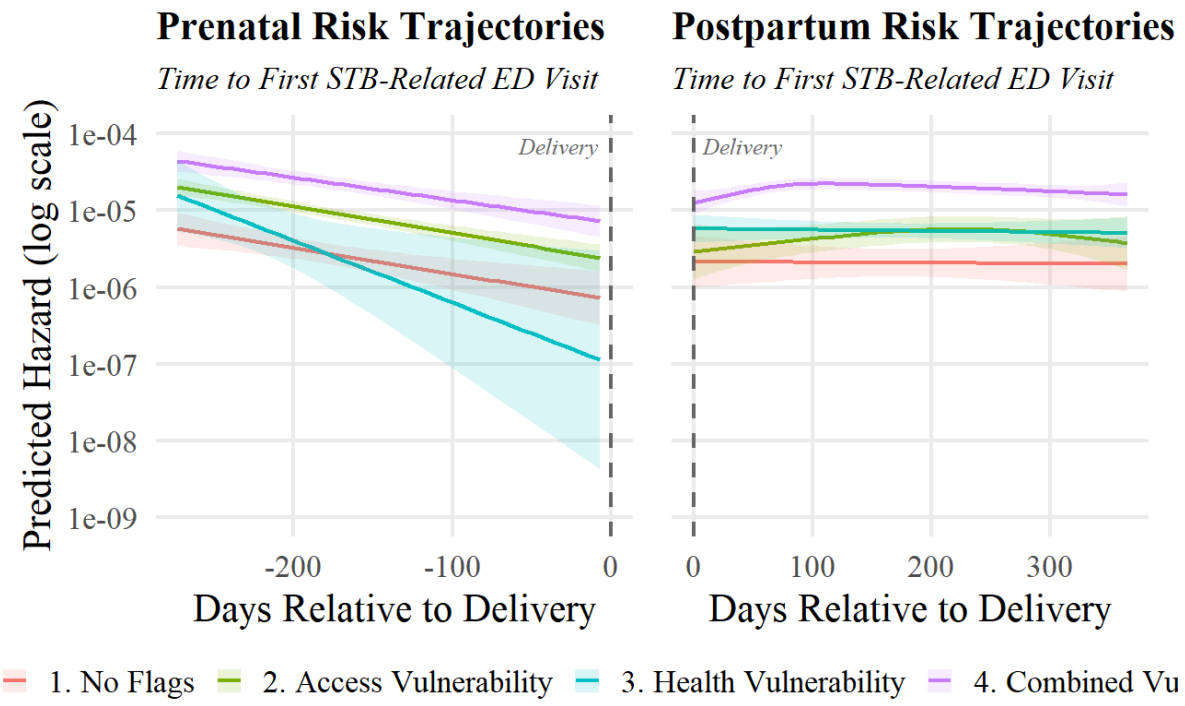
4.3.3 Vulnerability Profiles and Differential Contributions to Initial and Recurrent Hazard Estimates

Magnitude and Temporal Differences in the Hazard by Vulnerability Profile. Together, the Vulnerability Profile model outputs (Table 9) and respective hazard curve visualizations (Figures 11-12) provide insight into which risk profiles were at greatest instantaneous risk for a STB-flagged ED visit, and when. Profile-level hazard estimates were visualized on a log-transformed axis for readability (see Figure 11 for time to first event models and Figure 12 for the recurrent event model). These curves provide a visual comparison of which hazard curves have meaningful differences in their shape over time. Model outputs in Table 9 provide two layers of information – the magnitude of profile effects on the hazard curve, and evidence for whether each risk profile meaningfully affected the baseline hazard shape (i.e., the smooth) over time. Significant effects of each profile on the magnitude of each baseline hazard curve are based on the magnitude of the adjusted hazard ratios, the 95% confidence intervals excluding 1, and the p-value measuring $<.05$. Meaningful effects on the shape of the hazard

curve are assessed by the value of the estimated degree of freedom (edf) and the p-value of <.05. The edf value indicates the "wiggliness" in the curve, with values >1 indicating non-linearity, and higher values indicating greater levels of non-linearity in the curve. The associated p-value indicates whether the vulnerability profile significantly contributed to the "wiggliness" of the log-hazard shape.

Figure 11

Temporal hazard trajectories for an initial STB-flagged ED visit stratified by vulnerability profile and modeled by prenatal and postpartum time windows

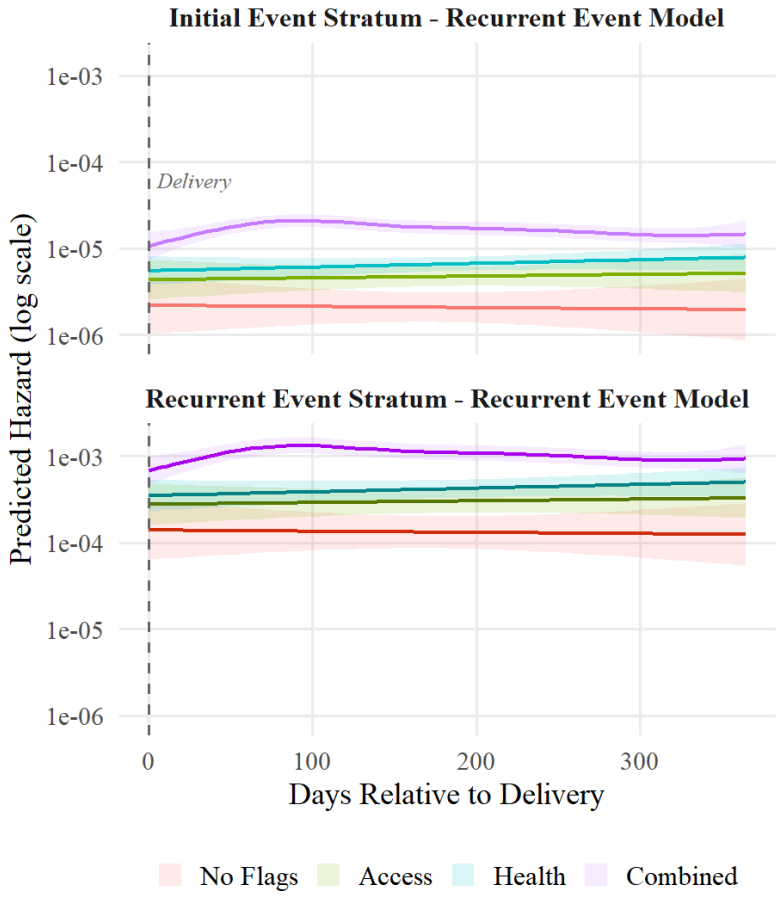


Note. The plots for Prenatal Risk Trajectories and Postpartum Risk Trajectories can be read left to right. Results from time-to-first-event Vulnerability Profile PAMMs show linear effects for all profiles prenatally, and nonlinear effects for only Combined and Access Vulnerability profiles postpartum. The left panel shows hazard trajectories across the prenatal window, while the right panel shows hazard trajectories across postpartum. Each panel represents a separate model representing a prenatal or postpartum window, while both are estimating the outcome of time-to-first STB-flagged ED event. The prenatal and postpartum models were run separately to protect against immortal time bias. Prenatal vulnerability profiles were constructed from risk flags

observed prior to the landmark of 280 days before delivery. Postpartum vulnerability profiles were updated to include risk factors observed prior to 280 days pre-delivery, prenatally and at delivery. Caution should be applied in interpreting the prenatal Health Vulnerability profile smooth due to the sparse number of windows with a STB flag observed (n = 7).

Figure 12

Temporal hazard trajectories for a STB-flagged ED visit postpartum with trajectories stratified by vulnerability profiles and event order strata



Note. Results from the simplified Vulnerability Profile model estimating the hazard of a STB-flagged ED visit by vulnerability profile and stratified by outcome event type (i.e., initial event or recurrent event). This model utilized data formatted in a Prentice-Williams-Peterson – Continuous Time recurrent events format and retained both initial and recurrent events for analysis. Both the top and bottom panels show hazard estimates for the postpartum window only due to sparse recurrent events observed during the prenatal window. Postpartum vulnerability profile construction included risk factors observed prior to 280 days pre-delivery, prenatally and at delivery.

Across all models, nearly all vulnerability profiles were consistently associated with greater magnitude of prenatal and postpartum hazard for an instantaneous STB-flagged ED visit (see Table 9). When compared against the reference profile "No Flags", each Vulnerability profile had a significant effect on the hazard of curve – meaning that each profile contributed to an increase in the hazard curve along the y-axis (i.e., increase in hazard magnitude). This effect was observed across time-to-first event models (both prenatal and postpartum windows) and the recurrent event models (postpartum modelled only). The exception to this pattern was the Health Vulnerability profile in the time-to-first event prenatal model, which had a non-significant effect. This non-significant effect was likely the result of scarce numbers of STB-flagged ED visits observed for this prenatal vulnerability profile (n = 7 observed STB outcome events). This shows that the Vulnerability profiles categorized at prenatal and delivery landmarks offer meaningful associations with detecting who is at greatest risk for an instantaneous STB-flagged ED visit across the perinatal window.

Prenatally, the Access Vulnerability and Combined Vulnerability profiles had a significant effect on the magnitude of the hazard, indicating that risk factors observed prior to the prenatal window were informative in identifying whom is at greater instantaneous risk for an initial STB-flagged ED visit. Those profiled by Combined Vulnerability risk factors observed prior to the prenatal window had the greatest magnitude of instantaneous risk compared to Access Vulnerability. Further, the smooths for No Flags, Access, and Combined Vulnerability were statistically significant (p<.05), with all edf values <=1 – indicating only significant linear, rather than nonlinear, effects on the hazard curve. When measured prior to the prenatal window, these risk profiles provide only linear associations with the hazard over time – illustrating a significant decline in each log-hazard smooth from an early prenatal intercept to the end of the

prenatal window. Together, this indicates that while the Access and Combined Vulnerability profiles measured prenatally are useful for detecting those with the greatest instantaneous hazard of an initial STB-flagged ED visit, they do not provide additional information regarding profile-level variability in risk timing across the prenatal window.

Across the postpartum window, each Vulnerability profile significantly contributed to the greater magnitude of hazard for an initial or recurrent STB-flagged ED visit, but only the Combined Vulnerability profile had significant nonlinear effects on the trajectory over time (see Table 9). Within the postpartum initial and recurrent event models, the adjusted hazard ratios of the Combined Vulnerability profile were consistently the greatest. This indicates that while each mutually exclusive vulnerability profile was a helpful risk indicator, the Combined Vulnerability profile was most informative for identifying whom is at greatest instantaneous risk of a STB-flagged ED visit postpartum. The Combined Vulnerability profile was also the only profile to have a significant nonlinear effect on the hazard curve, with edf > 1 and a significant p-value. This translates to the Combined Vulnerability profile being the only risk profile to significantly affect the shape of the hazard over time, informing when across the postpartum window the hazard is greatest. The significance of this effect was definitively observed for the hazard of a *recurrent* STB-flagged ED visit postpartum. However, the p-value was above the $p<.05$ threshold ($p = 0.055$) within the initial event model, indicating that the effect on the initial event hazard curve was not statistically significant. Thus, the Combined Vulnerability profile offers meaningful insight into when and for whom the risk for a recurrent (and possibly initial) STB-flagged ED visit is greatest.

Table 9

Simplified Vulnerability Profile PAMM Outputs Showing Each Profile's Effect on the Magnitude and Shape of Each Profile's Baseline Hazard Curve

		Magnitude		Shape (smooth)	
Model	**Vulnerability Profile**	aHR (95% CI)	*p*	edf	*p*
First event — prenatal	1. No Flags	Reference	—	1.00	< .001
	2. Access Vulnerability	3.44 (2.33, 5.09)	< .001	1.00	< .001
	3. Health Vulnerability	0.65 (0.15, 2.76)	0.561	1.00	0.012
	4. Combined Vulnerability	8.82 (5.87, 13.24)	< .001	1.00	< .001
First event — postpartum	1. No Flags	Reference	—	1.00	0.927
	2. Access Vulnerability	2.17 (1.33, 3.54)	0.002	1.94	0.354
	3. Health Vulnerability	2.61 (1.65, 4.12)	< .001	1.00	0.733
	4. Combined Vulnerability	9.09 (6.01, 13.74)	< .001	3.36	0.055
Recurrent — postpartum	1. No Flags	Reference	—	1.00	0.867
	2. Access Vulnerability	2.29 (1.45, 3.64)	< .001	1.00	0.707
	3. Health Vulnerability	3.19 (2.08, 4.89)	< .001	1.00	0.265
	4. Combined Vulnerability	7.93 (5.33, 11.81)	< .001	4.26	0.009

Note. Table 9 shows the results of simplified Vulnerability Profile models. Three separate models were run with factor-level vulnerability profile variable, each anchored by a prenatal or delivery landmark. The "Magnitude" column captures the magnitude of effects on the instantaneous hazard of a STB-flagged ED visit. The "Shape" column depicts the association of each vulnerability profile with the *shape* of the hazard curve. Edf values greater than 1 indicate nonlinearity, while edf values = 1 indicate linear effects. The *p*-value within the Shape column indicates whether the Vulnerability profile was *significantly* associated with the shape of the hazard curve. When the edf >1 and the p-value is <.05, this indicates that the vulnerability profile significantly contributed to the nonlinear shape of the hazard curve.

First-Derivative Analysis Detecting Significant Windows of Log-Hazard Increase.

First-derivative analysis was conducted on postpartum log-hazard curves to derive windows of significant increase or decrease in each hazard curve, indicating windows when the risk is rising

(see Table 10). First-derivative analysis was not conducted on prenatal hazard curves given their linearity, as first-derivative analyses would not provide meaningful insight in changes in the shape over time. This analysis identified one postpartum window of significant increase observed in both the postpartum initial and postpartum recurrent event models. Specifically, the log-hazard increased between delivery and 9.2 - 9.7 weeks postpartum when postpartum windows were characterized by the Combined Vulnerability risk profile. This suggests there is a similar postpartum risk window between delivery and approximately 2.2 months after delivery during which initial or recurrent event occurrences are accelerating for higher risk perinatal windows. Following this increase in the log-hazard, the Combined Vulnerability profile baseline hazard curve plateaued– indicating that the hazard remained elevated but stable across postpartum, rather than increasing or decreasing over time. First-derivative analysis did not detect additional intervals of significant change in the log-hazard either prenatally or postpartum for other vulnerability profiles.

The linearity of comparative hazard curves contributed to the lack of significant log-hazard changes detected. For example, while prenatal hazard curves were observed to decrease linearly across vulnerability profiles (e.g., hazard curves are decreasing; see Figure 11), first-derivative analyses provide meaningful insight on nonlinear changes in the log-hazard over time. Remaining differences in log-hazard smooths across profiles are reduced to linear differences in magnitude as opposed to nonlinear differences in shape over time.

Table 10

First-derivative Analysis of Vulnerability Profile Log-hazard Curves Depicting Significant Windows of Change

Postpartum Model	Profile	Direction	Start	End	Steepest Point	Derivative	95% CI
First Event - Postpartum	Combined Vulnerability	Significant Increase	0	9.7	0	0.01	0, 0.02
Recurrent Event - Postpartum	Combined Vulnerability	Significant Increase	0	9.2	0	0.01	0, 0.02

Note. The table shows windows of significant increase (in weeks) in the first-derivative of the log-hazard curves for the Combined Vulnerability profiles. These effects were observed within the postpartum first-event model and the recurrent event stratum of the recurrent events model. The estimated degrees of freedom (edf) were >1 for both profiles and model outputs showed the 95% CI did not include 0, indicating significant non-linear effects on the hazard curve. The hazard curves for other profiles within all other models had edf <=1 and had non-significant results from first-derivative analyses.

CHAPTER V

DISCUSSION

This study addressed multiple empirical and clinical gaps by examining whether and when individual risk factors and risk timing converge into population-level patterns of acute healthcare utilization for STBs within the developmentally sensitive perinatal transition. Aim 1 results identified patterns of STB-flagged ED visits and visit recurrence within the population of Oregon perinatal individuals giving birth between 2020-2024. Aim 2 examined differential contributions of individual level risk factors within Access and Health Vulnerability domains, including acute care utilization recency, finding differential associations with the magnitude of the hazard for initial and recurrent events. Aim 3 leveraged composite vulnerability risk profiles to evaluate whether, how, and to what degree risk profiles influenced the timing of the hazard over prenatal and postpartum periods. These findings have significant implications for the anticipation of STB-related ED utilization across the perinatal window, specifically in identifying whom, and when, risk may be likely to emerge. By situating this study within the time-bound perinatal window, the study findings reduce ambiguity around when perinatal STB screenings and prevention efforts may be indicated, and who may be most likely to benefit from such efforts.

The following chapter is organized into three sections mirroring the study aims: prevalence of STB-flagged ED visits and the vulnerability profiles within which they aggregate (5.1), the covariate contributions to hazard magnitude (5.2), and the timing of peak risk for initial and recurrent events across vulnerability profiles at prenatal and postpartum periods (5.3). The chapter closes with a synthesis of implications, limitations, and future directions.

5.1 Prevalence of Perinatal STBs and Covariate Risk Factors

The first aim of this study descriptively illustrated the prevalence and temporal distribution of STB-flagged ED visits and associated covariates across the perinatal window at the population level. These disparate threads — prevalence, distribution, timing, and covariate risk profiles — are rarely interrogated as components of the same risk ecosystem that may give rise to a high-risk outcome such as a perinatal STB-flagged ED visit. The prevalence aim of this study combined these associated threads and descriptively illustrated what current event distribution looks like at the population level, when recurrence typically occurs, and for whom in the population STB-flagged ED visits are most likely to converge. The findings from this descriptive aim established temporal benchmarks not previously observed or illustrated in the perinatal literature while also illustrating the vulnerability profiles for whom STB-flagged ED visits are most likely to be observed.

Firstly, this study found consistency in the prevalence of initial STB-flagged ED visits in comparison to other research, but notable differences in the distribution of STB-flagged ED visits. Within the current study, 513 per 100,000 perinatal windows included at least one STB-flagged ED visit. This represents a small but clinically meaningful proportion of perinatal windows (0.51%). This aligns with estimates from a population-level study that found 600 STB-related events per 100,000 individuals (N = 595,237; Admon et al., 2021). However, there was temporal variation in the distribution of *when* STB-flagged ED visits were observed. STB flagged events increased within the first six weeks of pregnancy and rose again approximately six weeks postpartum. In other words, the distribution of events was not constant across the perinatal window.

Although STB flags increased at distinct intervals both during and after pregnancy, STB-flagged ED visits were far more common during postpartum compared to during pregnancy. This

aligns with multiple studies finding the same pattern of higher STB prevalence at postpartum vs. during pregnancy (Molina et al., 2025; LeCounte et al., 2026; Goldman-Mellor, 2025; Lewkowitz et al., 2019). At the meta-level, this reinforces prior research indicating potential escalations in acute STB presentation are more likely to occur postpartum compared to the prenatal window.

An additional layer of temporal significance was in establishing the median refractory period for recurrent STB-flagged ED visits. Twenty percent of initial STB events were followed by one or more recurring STB-flagged ED events during the perinatal window. For those with recurrent visits, there was a median of 34 days between the index STB-flagged ED visit and the second STB-flagged ED visit. However, 50% of recurring events occurred up to a year or more after the index event, indicating prolonged recurrence latency for half of individuals. This study hypothesized a recurrence window between 30 days and 1 year after the index event, estimated from several Canadian and one U.S. based study establishing timelines of perinatal acute healthcare utilization (Barker et al., 2024a; Barker et al. 2024b; Pluym et al., 2020). This study is the first known work to establish population level recurrence rates for perinatal STB-flagged ED visits and to identify the ~1 month refractory period (at the median) between index and recurring events within a U.S. based perinatal sample.

Approximately 80% of STB-flagged ED visits (80.5%) occurred within perinatal windows of individuals who experienced both Access Vulnerability and Health Vulnerability factors (i.e., the “Combined” risk profile); this preponderance of STB-flagged ED visits was despite the Combined group representing roughly 40% of the overall sample. Although it was clear that STB-flagged ED visits were most common within the Combined risk group, it is important to emphasize that the vast majority of individuals in the Combined group did not

experience a STB-flagged ED event. This descriptive finding validated the need to examine individual level vulnerability risk factors in addition to broader risk profiles to determine which specific factors contribute to the magnitude of STB-flagged ED visits.

This study's descriptive findings around ED utilization broadly reinforce the importance of considering perinatal acute healthcare utilization (i.e., for any reason, including but not limited to STBs) as a predictive indicator of later STB-related care utilization. This is not to say that ED or inpatient care utilization increases STB risk itself, but rather, that acute care utilization is a behavioral indicator of distress and relief seeking that may be associated with STB risk. More specifically, the current study found that approximately 1 in 3 index pregnancies (34%) involved ED utilization for any reason during the perinatal window. This aligns exactly with prior work's estimation of ED utilization throughout the perinatal window (Declercq et al., 2024; Matenchuk et al., 2023). The current study also found that overall ED utilization was greater for perinatal windows with a STB-flagged ED visit, observing a median of 4 ED visits for any reason compared to a median of 0 for those without a STB-flagged ED visit. While non-perinatal suicide research has found that greater levels of ED utilization for any reason is an independent risk factor for later suicide risk (Neuroth et al., 2026; Kvaran et al., 2015), the current study did not associate ED utilization levels with suicide outcomes specifically, which limits full proof of concept within perinatal populations. Rather, this finding suggests that within perinatal populations, greater levels of acute care utilization serve as a prescient indicator for further screening and referrals for further care.

5.2 Covariate Contributions to the Magnitude of Perinatal STB Hazard

Although the presence of individual level risk factors represented by Access and Health Vulnerability domains were individually associated with higher STB risk, inferential models

revealed the greatest magnitude of risk was observed within the "Combined" risk profile for both initial and recurrent STB-flagged ED events. Prior review studies (e.g., Arditi-Arbel, 2023; Karaçam et al., 2023) and empirical research (e.g., Goldman-Mellor et al., 2025; Zivin et al., 2024) have evaluated certain characteristics within the Access and Health Vulnerability profiles as linear predictors of perinatal STBs, yet the present study is among the first to examine how the combination of both domains of risk contributes to perinatal STB risk magnitude. At a broad level, this verifies the mutual contribution of both Access and Health related risk factors to perinatal STBs. At a more discrete level, it highlights the value of simultaneously accounting for both structural and clinical risk pathways when estimating STB risk. For example, individual level demographic and insurance related indicators can serve as proxies of greater structural barriers to accessing and receiving timely, affirming, high-quality healthcare — translating to greater STB risk from an Access related pathway. Thus, accounting for risk from both structural and clinical sources is critically important when estimating perinatal STB risk.

Subsections 5.2.1 and 5.2.2 discuss outputs from full covariate models for initial and recurrent events. The hazard ratios extracted from these more granular models quantify the *magnitude* by which each risk factor raises or lowers the instantaneous hazard at every point across the perinatal window. The following discussion describes which Access and Health related vulnerability factors significantly contributed to proportional shifts in the hazard level. It is important to frame the following findings in relation to their influence on overall magnitude of hazard as opposed to changes in temporal pattern of risk, which was modeled differently and addressed in the discussion of Aim 3 findings.

5.2.1 Components of Access Vulnerability Significantly Associated with Perinatal STBs

Components of the Access Vulnerability profile were significant risk factors for perinatal STBs and can serve as indicators for who may be at greater risk for perinatal STB risk. Specifically, AI/AN and Black racial identities had greater instantaneous risk for an initial STB-flagged ED visits in comparison to non-Hispanic, White racial identity reference group. AI/AN racial identity was significantly associated with greater risk for both an initial and recurrent event – indicating this identity is associated with the highest level of risk outcome. Other racial identities were not significantly associated with either outcome (i.e., Asian, Hawaiian/Pacific Islander, "other" identity) in reference to the non-Hispanic, White identity. This non-significant results may be a population artifact due to smaller proportions of perinatal individuals with those identities in Oregon. Further research with populations that are more representative of those identities is needed to thoroughly test the association.

Across initial and recurrent event models, public insurance status (as well as "other" insurance status) were also associated with greater risk for perinatal STBs in comparison to commercial insurance. This finding is particularly relevant as a significant proportion of perinatal windows had public insurance status at 43.0%, indicating that this risk factor alone introduces vulnerability for close to half of perinatal windows in Oregon. While "other" insurance status represented only 2.4% of perinatal windows, it suggests that alternative care coverage options may associate with similar vulnerability to perinatal STBs. However, this study did not assess mechanistic associations between insurance status and risk for STB care utilization, and the exact direct or indirect nature of this relationship is not known. Taken together, this finding suggests that public and other sources of insurance status are meaningful indicators of differentiating who may be at greater risk for perinatal STBs.

These individual level risk factors within the Access Vulnerability domain reinforce findings from perinatal and suicide literature, finding that AI/AN and Black racial identities and public insurance status associate with perinatal STB risk (Margerison et al., 2022; Salihu et al., 2022; Tabb et al., 2025; Kim et al., 2015). The current study's findings add to this literature in several ways. Firstly, Aim 2 of the current study found that these effects were significant across the full perinatal window rather than within specific perinatal snapshots alone. Further, the modelling approach assessed for instantaneous hazard – meaning that these sociodemographic indicators are stable indicators of both initial and recurrent STB-flagged ED visits at any point in time across the perinatal window. Together, these significant identity and insurance related risk factors suggest extra care should be taken for perinatal individuals characterized by these identities and insurance statuses, specifically when considering STB related risk emergence.

Contrary to hypotheses, there were several Access Vulnerability risk factors associated with unexpected protectiveness against instantaneous risk for perinatal STBs. The Aim 2 full covariate model showed that the hazard estimate significantly decreased for each year of additional maternal age, and for those identifying as Hispanic/Latino. The protectiveness of older age aligns with literature indicating younger delivering individuals (e.g., below 30) are typically at greater risk for STBs (Gelabert et al., 2024; Kim et al., 2015). There is also preliminary evidence that Hispanic/Latina identity and acculturation status is associated with lower levels of perinatal mental health problems like depression or anxiety, suggesting the phenomenon of the "immigrant paradox" may serve as a protective buffer for perinatal women identifying as Hispanic/Latina who are less acculturated to U.S. culture (Petruzzi et al., 2025; Alhasanat & Giurgescu, 2017). However, caution is recommended in generalizing the statistical "protectiveness" of Hispanic/Latino identity observed for other dimensions of perinatal mental

health as indicative of lower risk for STBs specifically. Despite the current study's significant results, this is not sufficient evidence alone to support this conclusion. It is certainly possible a true protective effect has been observed such that relative to the White-identifying reference group, Hispanic/Latino perinatal individuals are less at risk for perinatal STBs. If Hispanic/Latino identity is indeed protective, this raises an important future research direction in identifying the sources of resilience, coping, and support for these perinatal individuals.

There were also macro-level "protective" effects observed for delivery year, whereby deliveries occurring in certain years had lower hazard rates for a STB-flagged ED visits when compared to the reference year of 2020. Specifically, 2021 and 2022 had lower hazards for initial STB events compared to 2020, and 2021, 2022, and 2024 had lower hazards for recurrent STB events compared to 2020. The reference year (2020) may represent a higher risk reference point given the peak of the COVID-19 pandemic, which disrupted in-person healthcare access and provision and is associated with adverse perinatal mental and physical health outcomes (Chmielewska et al., 2021). The disruption in care from the pandemic may have translated to greater risk for acute healthcare seeking due to lack of availability of in-person preventative care, or due to co-morbid COVID-19 presentation. Future sensitivity analysis examining associations between year, patterns of STB-related acute healthcare utilization, and historical/policy-related contextual factors may clarify whether year-level variation reflects true differences in perinatal STB risk or shifts in the care delivery environment.

5.2.2 Components of Health Vulnerability Significantly Associated with Perinatal STBs

Aim 2 full covariate models illustrated that most component risk factors within the Health Vulnerability category (i.e., NSSI, non-ED STBs, PSYCH, SUDs, and IPV) were associated with greater hazard of an initial or recurrent STB-flagged ED visit. These findings

align with prior perinatal research associating these individual risk factors with perinatal STBs specifically (Orsolini et al., 2016; Chin et al., 2022; Arditi-Arbel et al., 2023). However, the current study's finding extends prior work in several ways. For one, this study showed the value of specific historical Health Vulnerability risk factors in estimating perinatal STB risk. It also identified the magnitude of effects for a larger group of perinatal-observed Health Vulnerability risk factors than what has been tested in prior work, differentiating which factors contributed the most to risk estimates across the full perinatal window. Further, the results found that the magnitude of effects for Health Vulnerability risk factors varied by care setting, with consistently significant associations observed for ED and delivery events. And finally, these results were modelled for both initial and recurrent events – illustrating associations between covariate Health Vulnerability risk factors and recurrent STB-flagged ED visits for the first time. Together, these results suggest that evaluating the history of certain risk flags and monitoring their presentation at perinatal ED visits and at delivery can inform who may be at greater risk for perinatal STBs.

Psychiatric Problems and Non-ED STB Risk. Across all individual level Health Vulnerability risk factors, Psychiatric and non-ED STB Health Vulnerability flags were the most consistently associated with perinatal STB-flagged ED visits when observed historically and within the perinatal window. This suggests that monitoring perinatal individuals for a history of psychiatric or STB-related care utilization before pregnancy may meaningfully differentiate those at greater risk for perinatal STBs. It also presents the value of monitoring acute care settings and the delivery event as meaningful surveillance points for psychiatric and STB related risk flags within the perinatal window. Prior perinatal research has flagged recent or historical STBs and psychiatric disorders as indicators of greater risk for perinatal STBs (e.g., Barker et al., 2024a; Goldman-Mellor et al, 2025). This study extended these findings by identifying the

contribution of both historical and time-dependent psychiatric and STB-related risk surveillance and identifying which healthcare settings are the richest sources for monitoring both. However, some caution is suggested in presuming that perinatal psychiatric flags observed at ED visits are the single greatest driver of initial event risk at over 7,000% greater hazard. Since ED variables were modelled concurrently with the outcome, the size of the aHR suggests there is likely some degree of overlap between psychiatric and STB flags at ED settings. Despite this limitation, these findings suggest that both historical and perinatal flags for psychiatric and non-ED STB risk are meaningful indicators of perinatal STB emergence.

Substance Use Disorders (SUDs). Substance Use Disorders (SUDs) flags were significantly associated with greater risk for both initial and recurrent events, but only when observed perinatally. This indicates that historical SUD flags observed at pre-2020 inpatient or delivery events were not meaningful indicators of who is at greater risk for perinatal STBs. However, SUD flags observed at perinatal ED or delivery events were significantly associated with both initial and recurrent event risk. For the SUD flags at perinatal ED settings, this finding suggests that for the intervals a SUD flag was observed, the hazard of the outcome was significantly greater. Given the concurrent modelling of ED flags, this indicates that SUD ED flags are a significant indicator of concurrent risk for a STB flag. For delivery SUD flags, which were carried forward as predictors across postpartum, this indicates that delivery flagged SUD is a stable indicator of postpartum STB-flagged ED visits.

Further, SUD flags were fairly prevalent at perinatal ED (4.43% of perinatal windows) and perinatal delivery events (7.93% of perinatal windows) compared to other risk flags. This indicates that SUD flags are relatively widespread risk factor at the population level, frequently observed within ED and delivery settings, and are associated with greater instantaneous risk for

perinatal STBs – though at comparatively lesser magnitude than psychiatric or non-ED STB risk flags discussed above. The heightened prevalence of SUDs observed at perinatal ED settings aligns with evidence that acute care is more frequently utilized by perinatal individuals with SUDs (Courchesne-Krak et al., 2022). However, delivery care settings had the greatest frequency of SUD flags – suggesting delivery is a useful opportunity for surveilling active SUDs as an indicator of postpartum risk. As SUDs and intentional overdose are critical drivers of perinatal suicidal behaviors and overall suicide risk (Goldman-Mellor et al., 2025b), this study's findings indicate that perinatal ED and delivery settings provide an ideal setting for STB screening, surveillance, and intervention for perinatal individuals.

Intimate Partner Violence (IPV). Unexpectedly, IPV flags were infrequently indicated across care settings, and reliable estimates were observed for IPV flags at perinatal ED visits only. Aim 2 model outputs showed that IPV flags observed at ED settings were significantly associated with concurrent risk for both an initial or recurrent STB flagged ED visit. This indicates that historical IPV observation was not a useful indicator of who may be at greater perinatal STB risk, while perinatal ED-observed IPV flags were significantly likely to occur in the same interval as STB-flagged ED visits. In other words, perinatal intervals with an IPV flagged ED visit were significantly associated with greater hazard of a within-interval ED visit flagged for STBs. The singular significant outcome may be an artifact of the scarcity of IPV indication across care settings. This study observed n = 1048 flags across 998 perinatal windows (0.54% frequency). Of these flags, n = 488, or 46.6% of flags, were observed at perinatal ED visits.

Concerningly, the IPV flag indication and model outcomes may represent more problematic gaps in disclosure, evaluation, and medical record keeping. Similarly low

proportions of IPV codes have been observed at perinatal ED events in population studies, finding just 0.06% of ED-presenting pregnant individuals (Murugan et al., 2021) and 0.84% of pregnancy associated ED visits (Cruz et al., 2024) had an IPV flag coded. In combination with the current study's results, this might suggest that perinatal IPV is an infrequent phenomenon. However, these estimates are substantially lower than the 20% of individuals estimated to experience some form of IPV during pregnancy (Drexler, Quist-Nelson, & Weil, 2022). It is possible these observed rates are lower than the real rates in part due to an interplay between patient lack of disclosure and lack of appropriate screening practices within acute care settings (Kozhimannil et al., 2023). This problem may also be the result of coding practices. Even when IPV disclosures are made to healthcare providers, providers may not document the disclosures within medical records (Spangaro et al, 2021). Given that IPV is one of the strongest risk factors for perinatal suicide risk (Modest et al., 2022; Palladino et al., 2011), it is critically important that a multi-pronged effort is put forward across research and clinical settings to remedy this deficit in screening and disclosure. Potential solutions include providing safe environments for IPV disclosure (e.g., establishing care and asking directly; Spangaro et al., 2016) and routinizing screening and clinical documentation of IPV disclosures.

Non-Suicidal Self-Injury (NSSI). Notably, Non-Suicidal Self Injury (NSSI) Health Vulnerability risk variable was indicated so infrequently across all care settings that accurate estimates were difficult to determine. NSSI (indicated by a singular ICD code – R45.88) was observed within perinatal ED settings and at perinatal delivery events only, with just 10 or fewer flags each. The ED observation level was sufficient to estimate a significant concurrent effect for greater risk for an initial event outcome. As expected, this estimate also has a large CI — indicating substantial uncertainty for this estimate. In addition, NSSI was not observed at

historical care settings. This is largely an artifact of the introduction of the NSSI ICD code's effective date, which was established in 2021, after the pre-2020 history window cut-off in the ICD-10 (Centers for Disease Control and Prevention, 2021). This dearth of NSSI codes observed across care settings is concerning, and the current study's frequencies are far below those observed elsewhere. A UK-based study found that a near majority of perinatal individuals dying by suicide had a nonrecent history of self-harm (48%), while a quarter had self-harmed within the last 3 months before death (24%) (Khalifeh et al., 2016). This study's findings can definitively conclude little regarding the association between NSSI and perinatal STBs. Instead, this finding highlights a critical need to identify gaps in the detection, screening, and ICD-coding pipeline for perinatal NSSI. For example, using additional ICD codes (i.e., Z91.52 – Personal History of Non-suicidal Self-Injury) might capture prevalence of NSSI at more representative levels.

Chronic Health Problems. Contrary to hypotheses, chronic health problems observed in certain contexts and varying proximity to the index delivery were found to be protective against STB-flagged ED visits. Chronic health problems flagged at perinatal ED visits, or at pre-2020 delivery events, were associated with lower hazards of both an initial STB-flagged ED visit and a recurrent STB-flagged ED visit. These protective effects indicate that the chronic health risk category is inversely associated with instantaneous hazard magnitude for perinatal STBs. The chronic health risk flag category was specifically structured to encompass established risk factors for perinatal STBs (e.g., HIV, migraines; Arditi-Arbel et al., 2023), as well as physical health problems associated with maternal mental health problems more broadly (e.g., lupus, epilepsy; Abu-Zaid et al, 2023). The current study's findings indicate that ED utilization for chronic health problems, or chronic health problems identified at delivery, are unlikely to be strong markers of

acute healthcare utilization for perinatal STBs. Future research may be able to disentangle whether certain chronic health conditions confer genuine "protectiveness", or whether this "protectiveness" is a by-product of more frequent encounters with the healthcare system — perhaps due to more consistent care provision from healthcare providers (Chatterjee et al., 2008) or from more frequent chronic-health related ED utilization (Cunningham et al., 2017).

5.2.3 Recency Effects of Prior Acute Care Utilization on STB-flagged ED Hazard Timing

Aim 2 full covariate model results also established recency effects of prior acute healthcare utilization for any reason and greater risk for either an initial or recurrent STB-flagged ED visit. Recency variables served as indicators of risk decay over time, where models accounted for the proximity of a prior ED or inpatient event for any reason when estimating the hazard at each consecutive interval across the perinatal window. Recency effects were classified into recency windows, spanning from within 7 days, to 8-30 days, 31-90 days, and 91+ days. Inferential models revealed a gradient effect whereby more proximal ED or inpatient visits had the strongest association with the instantaneous hazard of a STB-flagged ED visit with greater hazards observed for more recent ED or inpatient events. This association was the strongest for recurrence risk of a STB-flagged ED visit, perhaps artificially inflated due to the inherent prerequisite of an initial STB-flagged ED visit preceding a recurrent visit. This suggests that recent ED or inpatient utilization for any reason may serve as a temporal indicator of elevated near-term risk for initial or recurrent STB-flagged ED visits, with risk increasing according to the recency of the prior event.

This study is the first known to formally model decay effects of recent acute care utilization across distinct time windows over the full perinatal transition. The current study addressed this gap through a relatively proximal time frame (between 7 days and 91+ days),

demonstrating a clear gradient of risk attenuation over time. The more recently a prior event took place, the greater the hazard of an initial or recurrent event – with the greatest hazard observed for ED utilization in the last 7 days, followed by 8-30 days, with significant effects observed at even the most distal time window (91+ days). This finding suggests that proximity of acute care utilization is an important indicator that signals elevated risk for STB emergence across the full perinatal window, even when adjusted for a comprehensive set of Access and Health Vulnerability covariates. At the clinical level, this suggests that accounting for recency of perinatal acute care utilization between the last 7 days and 91+ days may serve as an important indicator of who may be at greater instantaneous risk for a STB-flagged ED visit.

This finding aligns with preliminary recency windows found in select studies, but contributes more granular evidence for specific lookback windows across the entire perinatal window. Among those who died by suicide, non-perinatal suicide evidence shows greater odds when there is an ED or inpatient visit in the last 3 months (O'Neill, Graham & Ennis, 2019), or within the last month for pregnancy-associated death, including suicide (Mehta et al., 2016). Further, frequent ED users are more likely to die by suicide within 30 days of their last nonfatal ED visit (Neuroth et al., 2026). While this prior evidence supports greater risk of suicide death specifically as opposed to STBs more broadly, the current study's finding reinforces the importance of accounting for proximity of prior acute care utilization when estimating STB risk. This suggests that recency of acute care utilization for any reason may be an important indicator influencing determinations of perinatal STB screening, with further research needed to establish the full duration of latency effects conferred by recent care utilization.

5.3 Timing and Risk Peaks for Perinatal STBs

Aim 3 vulnerability profile models — differentially modelled at prenatal and postpartum landmark events —revealed significant nonlinear temporal associations with the baseline hazard curve for the "Combined Vulnerability" profile across postpartum only. The magnitude of association between vulnerability profiles and the hazard curve itself was significant across models, indicating that each vulnerability profile significantly contributed to the *magnitude* of the slope. This means that Access, Health, and Combined Vulnerability risk profiles were each significantly associated with where the hazard curve sat on the y-axis in reference to the "No Flags" profile. However, only Combined Vulnerability (both Access and Health Vulnerability flags) significantly contributed to the nonlinear shape of the hazard curve. Further, this significant effect was only observed in postpartum models and not the prenatal model. This difference between prenatal and postpartum models may partially be attributed to fewer outcome events and covariate flags used in prenatal landmark models, reducing the estimate to a linear curve due to insufficient information. Despite this difference, this finding indicates that perinatal windows characterized by the Combined Vulnerability profile had windows of increasing risk for both initial and recurrent STB-flagged ED visits when the most health information was available.

Within the prenatal time-to-first event model, all four hazard curves (including Combined Vulnerability) were observed to uniformly decrease from conception to delivery– indicating a decrease in the hazard for an initial STB-flagged ED visit over time. This pattern may associate with research indicating the perinatal window may be "protective" against STBs, finding comparatively lower prevalence of perinatal STBs from non-perinatal windows (Loree et al., 2025; LeCounte et al., 2026; Lysell et al., 2018). The time-to-first event evidence preliminarily supports this for the prenatal window, finding a decrease in the hazard for all risk profiles from a global peak around conception. This pattern may also be an artifact of data availability, given

that profile categorization was derived from pre-2020 events data, and there were fewer observed events prenatally. Despite this caveat, these findings suggest two interpretations and one implication for clinical practice. The first interpretation is that the prenatal window is indeed protective against perinatal STBs. The second interpretation is that current healthcare scaffolding for perinatal individuals during second and third trimesters may indeed be prophylactic against prenatal STB emergence. The implication for clinical care is that for all perinatal individuals, STB-related screening may be the most useful during the earliest trimester – or as soon as pregnancy is noted.

The lack of nonlinear hazard shapes for No Flags, Access, and Health Vulnerability profiles in postpartum plots suggests that these risk categories do not provide additional information about *when* initial or recurrent risk increases or decreases. Postpartum hazard curve plots showed that these same curves started at a higher y-intercept compared to their prenatal counterpart — indicating greater magnitude of risk to start for the postpartum landmark. However, these curves remained stable horizontal lines for most of the postpartum period, neither increasing nor decreasing. This suggests that for each risk category outside of Combined Vulnerability, that level of risk was sustained over time, without sufficient information to inform whether the hazard increased or decreased at any point.

First-derivative analysis of the vulnerability profile hazard curves revealed a significant increase in the log-hazard curve for initial and recurrent events from delivery to 2.2. months postpartum for the Combined Vulnerability profile only. This indicates that those with both sociodemographic and clinical health vulnerability risk factors had an increased risk for either an initial or recurrent STB-flagged ED visit in the immediate postpartum. Following the increase, risk curves plateaued, which indicated sustained levels of risk for STB-flagged ED visits

throughout the remainder of postpartum. This finding partially supported the hypothesized risk peak within the first six weeks postpartum for initial events —though the current study extended this timeline to 2.2 months postpartum (i.e., 9.2 - 9.7 weeks). This suggests for higher risk individuals, there is value in continued monitoring and indicated STB screening for perinatal individuals beyond the standard six-week check-up.

However, these results did not support the second hypothesized risk peak occurring from 9-12 months postpartum, which was informed by Canadian perinatal death statistics (Grigoriadis et al, 2017). Instead, the hazard curves were observed to plateau and neither increase nor decrease over time. This pattern might also suggest sustained risk for STB-related ED utilization holding steady throughout postpartum. This sustained risk over time may have implications for suicide deaths emerging in the latter postpartum period (Azad et al., 2026; Grigoriadis et al, 2017). While the current study does not link with mortality data, and associations with death by suicide cannot be definitively made, this finding suggests at the very least that STB-flagged ED visit hazard curves do not significantly decrease throughout postpartum for any perinatal individual. Taken together, this finding indicates that relative to the prenatal window, risk for a STB-flagged ED visit is greater and sustained across time without significant changes in increases or decreases in risk for most perinatal windows.

This finding also supports the theorized sensitivity of the perinatal window, with differential risk observed at specific developmental transition points. The uniform decrease in risk for STB-flagged ED visits around conception may reflect an early prenatal peak in STB-flagged ED utilization from the potential stressful transition between conception, awareness of pregnancy, and the first prenatal evaluation recommended at 6-10 weeks gestation (Peahl et al., 2023). Conversely, it may also reflect a uniform drop in risk in alignment with the comparative

"protectiveness" of the perinatal window (Loree et al., 2025; LeCounte et al., 2026; Lysell et al., 2018). The risk increase observed between delivery and roughly ten weeks postpartum for Combined Vulnerability individuals also aligns with developmental transition points. Specifically, delivery and early postpartum period consist of a compounded set of internal and external risk factors related to the delivery process and stress around the transition (Redondo et al., 2025), maternal identity development (Ionio et al., 2021), heightened physiological and caregiving demands (Madray et al., 2022) or early return to work expectations, particularly for lower-income women (Tucker et al., 2010; Van Niel et al., 2020). This framing introduces the potential for prolonged shifts in baseline STB risk (e.g., Fluid Vulnerability theory), whereby baseline risk temporally shifts in alignment with developmental inflection points.

5.4 General Discussion

This study has significant clinical implications for whether and when STB screening should be conducted across the perinatal window. This study found heightened ED utilization for STBs at distinct junctures within the perinatal window for those with greater complexity of risk factors. This suggests that those with a pattern of pre-2020 or perinatal acute care utilization for STB-related risk factors or for any reason, may be at greater imminent risk for perinatal STB presentation. Further, this risk was not uniform across the perinatal period, with significant increases in hazard curves indicating that the late third trimester throughout postpartum may have elevated risk for STB-flagged ED presentation. Currently, leading care guidelines do not recommend universal screening for STBs during the perinatal window due to insufficient evidence, unless screening is indicated either through symptom disclosure or clinical judgement (USPSTF, 2016; ACOG, 2023). This study suggests there may be an evidentiary basis for perinatal STB screening prior to the late third trimester, and perhaps more routinely throughout

postpartum for those with STB-related or acute care utilization risk factors, and particularly within preventative care settings such that STB-related acute care utilization can be deterred.

This study also suggests that recent acute care utilization may be an indicator for perinatal STB screening. Study results indicated that those at greater risk for STB-flagged ED visits were more likely to be frequent ED utilizers, and that temporal proximity of prior utilization was associated with greater magnitude of hazard STB-flagged ED utilization. Recent and/or frequent acute care utilization for any reason in perinatal individuals should signal greater need to administer validated STB risk assessments, and to refer these higher risk patients for mental health care. However, this suggestion is not meant to replace further scrutiny on presenting problems for perinatal patients such that their concerns are dismissed as mental health related only. In fact, perinatal individuals frequently utilizing the ED should be validated for their health seeking behaviors, specifically when presenting for diagnoses or concerns clinically associated with STB risk (e.g., psychiatric, IPV, SUD, or NSSI related concerns) as their utilization is associated with greater imminent risk for STBs. Frequent perinatal acute care utilization can be reframed to a strengths-based perspective, where those seeking acute care are demonstrating life-affirming behaviors. This reframe may strengthen provider efforts to transition high-risk clients to more stable sources of mental health care and mitigates future acute care utilization.

Finally, this study's findings suggest a broader developmentally informed framework for understanding STB risk across important transitions in women's health. This study demonstrated that perinatal STB-related ED visit risk follows a distinct temporal trajectory across the perinatal window, with increases in risk at developmentally sensitive inflection points for higher risk profiles. This suggests that within certain time-bound transitions in women's health, there may

be a broader temporal architecture in STB-related acute care seeking. Similarly, transitions affecting biological females that involve physiological, socio-emotional, and identity-related dimensions beyond the perinatal period may associate with heightened STB-related ED utilization along temporally distinct trajectories at the population level. These transitions may include macrolevel developmental periods such as puberty (Ho, Gifuni & Gotlib, 2022) and menopause (Hendriks et al., 2025) and micro-transitional states such as menstruation (Ross et al., 2024). While these are "normative" developmental transitions, risk for STB-related acute care utilization may arise for those with vulnerability factors that increase susceptibility at developmental inflection points.

This framing also augments current ideation to action suicide frameworks by applying a feminist lens, such that gender-specific transition windows should be considered when making determinations of STB risk and risk screening. Existing ideation to action frameworks conceptualize risk factors and risk timing as dynamic processes that precipitate suicidal thoughts and behaviors — specifically, mapping the transition between pre-ideation risk factors, to suicidal cognitions and suicidal behavior. This study suggests an additional contextual layer relevant to larger scale developmental transitions across the lifespan such that predictable sensitive developmental windows may carry commonly shared inflection points that give rise to STB risk for vulnerable individuals. This framing conceptualizes these developmental inflection points as a type of prolonged, precipitating stressful event similar to those described in IMV and Fluid Vulnerability suicide theories, and maps them to distinct developmental windows. These transition points provide a future-facing temporal architecture for anticipating emergent STB risk and can serve as effective life-span level indicators for suicide screening.

5.4.1 Strengths & Limitations

Though this study found a series of clinically meaningful findings, there are study limitations that should be considered. A preliminary set of limitations relate to the timing and context of available data. Due to administrative reasons, there was a lack of ED records prior to 2020, which likely would have provided a rich source of information on perinatal healthcare utilization and a broader view of patterns in perinatal care utilization over time. Available data was also limited to only acute care and delivery event discharge records. Data were not available for outpatient care settings. This is unfortunate because outpatient care records likely provide further evidence of STB disclosure at routine perinatal care visits, such as obstetric or even pediatric well-child visits.

In addition, while discharge records are a rich source of population-level prevalence indication, it is also susceptible to systemic challenges in reporting and record-keeping which may impact appropriate screening, capture, and reporting of ICD codes, thus caution is recommended on inferring STB and covariate risk prevalence are the true risk levels within the perinatal population. More specifically, these data are also not representative of true levels of population level STBs outside of acute care and delivery settings, as there is likely a substantial proportion who do not disclose or seek help for STB symptoms within the perinatal window due to concerns of escalations in care or unanticipated reactions to their disclosure. Finally, while this study does provide population level prevalence estimates, these findings' relevance to individuals living in states other than Oregon may be limited, considering broad between-state differences in demographic characteristics, socioeconomic diversity, historical context, and healthcare policy and infrastructure.

This study was also limited in how variables were categorized and how risk profiles were derived. STB outcomes were coded by collapsing suicidal thoughts and suicidal behaviors into a

singular STB outcome, which may artificially reduce variability in STB symptomatology and obscure different patterns in timing estimates for discrete suicide-related outcomes. In addition, Access and Health Vulnerability profiles were derived from theoretically meaningful distinctions between the presence or absence of sociodemographic and health-related vulnerability factors. Vulnerability profile development may have benefitted from more methodologically rigorous, data-driven approaches such as latent class analysis or a combination of dimensionality reduction and grouping approaches to synthesize statistically meaningful, data-driven vulnerability profiles as opposed to groupings that are based on theoretical distinctions alone.

This study also has several important strengths. This study was the first known work to apply PAMMs within the STB and perinatal risk literature. This work establishes a precedent for applying complex, but flexible, survival analytic approaches to model nonlinear hazard curves over time – particularly within the perinatal context. Further, this study had more than sufficient statistical power at the population level as the data included all delivering individuals within the state of Oregon from 2008-2024, strengthening estimates overall. This study is also among the first within the suicide and perinatal suicide literature to examine STB risk over time within the framing of a longitudinal sensitive developmental transition point in women's health. It is also unique in applying complex survival analysis to estimating risk hazards, an approach that accommodated time-varying covariates and non-monotonic hazard curves allowing for a more dynamic representation of risk over time. This study also uniquely contributed temporal specificity when estimating exactly when during the perinatal period STB-flagged ED visits are at greatest risk of occurrence, providing data-driven insight on patterns of acute STB risk. Further, this study bridged a critical gap in understanding the risk conferred by recency of acute care utilization within the perinatal period, highlighting an important risk factor that may inform

intervention efforts. Together, these distinctive strengths coalesce in their contribution of bridging critical temporal and empirical gaps in perinatal suicide literature, and contributing timely evidence that may influence current guidelines in perinatal mental healthcare provision.

The strengths and limitations of this study inform several pathways for future research in perinatal suicide literature. Future research may leverage multi-source healthcare data including outpatient care records to determine within which care settings STB screening and disclosure is taking place and disentangle the acute care burden of perinatal STB management. This approach may also more thoroughly map the timing of STB emergence across the perinatal window by including more incidents of care than major events alone. This approach may also provide more accurate prevalence estimates of critical STB risk factors such as IPV and NSSI, which currently appear underreported in acute and delivery care records. In addition, future research may leverage data driven approaches to develop vulnerability profiles by reducing unnecessary dimensionality and identifying the strongest contributing factors and associated covariates driving perinatal STB risk timing. Further, algorithms derived from machine learning models may help indicate when to administer STB screening by drawing from risk factors derived from medical record data and acute care utilization recency (e.g., Walsh, Ribeiro & Franklin, 2017), creating dynamic indicators for screening that may guide the timeliness of STB screening and care provision.

In conclusion, this study closes critical knowledge gaps in the prevalence and risk timing of STBs across the perinatal window. This study applied suicide and developmental risk frameworks to the context of the perinatal window, extending prior work by evaluating temporal risk for STB-flagged ED utilization across perinatal inflection points. By leveraging multi-source administrative healthcare discharge records anchored across the perinatal window, this study

elucidated distinctions in the magnitude and timing of risk for STB presentation in acute care settings, particularly for those with pre-existing clinical or structural risk factors. Results from this study fill several gaps in understanding around when risk emerges at the level of acute healthcare utilization for STBs, for whom this risk is elevated, and introduces the value of tracking healthcare utilization as an indicator of perinatal STB screening. This study suggests that perinatal STB risk trajectories are not a monolith, and higher risk individuals seeking acute care deserve validation and support in their efforts to seek relief amidst a transitionary window that is incredibly challenging for them.

REFERENCES

Abu-Zaid, A., Gari, A., Alsharif, S. A., Alshahrani, M. S., Khadawardi, K., Ahmed, A. M., Baradwan, A., Bukhari, I. A., Alyousef, A., Alharbi, F. S., Saleh, S. A. K., Adly, H. M., Abuzaid, M., & Baradwan, S. (2023). Exploring the impact of chronic medical conditions on maternal mental health: A National Inpatient Sample analysis. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *289*, 42–47. https://doi.org/10.1016/j.ejogrb.2023.08.011

Admon, L. K., Dalton, V. K., Kolenic, G. E., Ettner, S. L., Tilea, A., Haffajee, R. L., Brownlee, R. M., Zochowski, M. K., Tabb, K. M., Muzik, M., & Zivin, K. (2021). Trends in Suicidality 1 Year Before and After Birth Among Commercially Insured Childbearing Individuals in the United States, 2006-2017. *JAMA Psychiatry*, *78*(2), 171–176. https://doi.org/10.1001/jamapsychiatry.2020.3550

Ahmedani, B. K., Peterson, E. L., Hu, Y., Rossom, R. C., Lynch, F., Lu, C. Y., Waitzfelder, B. E., Owen-Smith, A. A., Hubley, S., Prabhakar, D., Williams, L. K., Zeld, N., Mutter, E., Beck, A., Tolsma, D., & Simon, G. E. (2017). Major Physical Health Conditions and Risk of Suicide. *American Journal of Preventive Medicine*, *53*(3), 308–315. https://doi.org/10.1016/j.amepre.2017.04.001

Ahmedani, B. K., Westphal, J., Autio, K., Elsiss, F., Peterson, E. L., Beck, A., Waitzfelder, B. E., Rossom, R. C., Owen-Smith, A. A., Lynch, F., Lu, C. Y., Frank, C., Prabhakar, D., Braciszewski, J. M., Miller-Matero, L. R., Yeh, H.-H., Hu, Y., Doshi, R., Waring, S. C., & Simon, G. E. (2019). Variation in patterns of health care before suicide: A population case-control study. *Preventive Medicine*, *127*, 105796. https://doi.org/10.1016/j.ypmed.2019.105796

Akinyemi, O., Nasef, K. E., Aaron, S., Martins, C., Utomi, A., Alqurashi, L., Adeola, O., Oduwole, O., Ajogbasile, O., Lipscombe, C., Nwosu, U., & Ogundare, T. (2023). Intimate Partner Violence: An Independent Predictor of Emergency Department Visits for Attempted Suicides and Self-inflicted Injuries among American women. *HPHR*, *62*. https://www.jstor.org/stable/48826563

Alhasanat, D., & Giurgescu, C. (2017). Acculturation and Postpartum Depressive Symptoms among Hispanic Women in the United States: Systematic Review. *MCN: The American Journal of Maternal/Child Nursing*, *42*(1), 21. https://doi.org/10.1097/NMC.0000000000000298

Alimoradi, Z., Arabloo, J., Jandaghian-Bidgoli, M., Alizadeh, S., Griffiths, M. D., Gorji, H. A., Abdi, F., & Shalbafan, M. (2026). The association between intimate partner violence and suicide ideation and attempts among women: A systematic review and meta-analysis. *Journal of Affective Disorders*, *394*, 120511. https://doi.org/10.1016/j.jad.2025.120511

Alves, A. C., Cecatti, J. G., & Souza, R. T. (2021). Resilience and Stress during Pregnancy: A Comprehensive Multidimensional Approach in Maternal and Perinatal Health. *The Scientific World Journal*, *2021*(1), 9512854. https://doi.org/10.1155/2021/9512854

American College of Obstetricians and Gynecologists (ACOG). (2023). Screening and Diagnosis of Mental Health Conditions During Pregnancy and Postpartum: ACOG Clinical Practice

Guideline No. 4. *Obstetrics and Gynecology*, *141*(6), 1232–1261. https://doi.org/10.1097/AOG.0000000000005200

American Medical Association (AMA). (n.d.). *Suicide prevention how-to guide*. https://www.ama-assn.org/system/files/bhi-suicide-prevention-how-to-guide.pdf

Arditi-Arbel, B., Hamdan, S., Winterman, M., & Gvion, Y. (2023). Suicidal ideation and behavior among perinatal women and their association with sleep disturbances, medical conditions, and known risk factors. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.987673

Arsenault-Lapierre, G., Kim, C., & Turecki, G. (2004). Psychiatric diagnoses in 3275 suicides: A meta-analysis. *BMC Psychiatry*, *4*(1), 37. https://doi.org/10.1186/1471-244X-4-37

Athey, A., Shaff, J., Kahn, G., Brodie, K., Ryan, T. C., Sawyer, H., DeVinney, A., Nestadt, P. S., & Wilcox, H. C. (2024). Association of substance use with suicide mortality: An updated systematic review and meta-analysis. *Drug and Alcohol Dependence Reports*, *14*, 100310. https://doi.org/10.1016/j.dadr.2024.100310

Ayre, K., Bittar, A., Dutta, R., & Howard, L. (2021). Suicide and self-harm in women with mental disorders during pregnancy and the year after birth. *European Psychiatry*, *64*(Suppl 1), S173. https://doi.org/10.1192/j.eurpsy.2021.459

Ayre, K., Liu, X., Howard, L. M., Dutta, R., & Munk-Olsen, T. (2023). Self-harm in pregnancy and the postnatal year: Prevalence and risk factors. *Psychological Medicine*, *53*(7), 2895–2903. https://doi.org/10.1017/S0033291721004876

(A). Barker, L. C., Brown, H. K., Bronskill, S. E., Fung, K., Kurdyak, P., Zaheer, J., & Vigod, S. N. (2024). Non-fatal self-harm and suicide following postpartum psychiatric emergency department visits: A population-based retrospective cohort study. *Psychiatry Research*, *335*, 115856. https://doi.org/10.1016/j.psychres.2024.115856

(B). Barker, L. C., Fung, K., Zaheer, J., Brown, H. K., Bronskill, S. E., Kurdyak, P., & Vigod, S. N. (2024). Risk of Repeat Psychiatric Emergency Department Visits in the Postpartum Period: A Population-Based Retrospective Cohort Study. *Annals of Emergency Medicine*, *83*(4), 360–372. https://doi.org/10.1016/j.annemergmed.2023.11.002

Basile, K. C., Smith, S. G., & Friar, N. W. (2026). Defining Intimate Partner Violence. In C. Mitchell, E. Miller, B. McCaw, & K. A. Alexander (Eds.), *Intimate Partner Violence: A Health-Based Perspective* (p. 0). Oxford University Press. https://doi.org/10.1093/oso/9780197758991.003.0001

Batchelor, J. L., Townsel, C. D., Jiang, L., Leplatte-Ogini, D., Caldwell, M., Giuliani, E., & Marsh, E. E. (2023). Disparities in Emergency Department Utilization Among Women with Postpartum Mood Disorders (2006–2016). *Maternal and Child Health Journal*, *27*(1), 158–167. https://doi.org/10.1007/s10995-022-03544-w

Batra, P., Fridman, M., Leng, M., & Gregory, K. D. (2017). Emergency Department Care in the Postpartum Period: California Births, 2009-2011. *Obstetrics and Gynecology*, *130*(5), 1073–1081. https://doi.org/10.1097/AOG.0000000000002269

Beckerleg, W., & Hudgins, J. (2022). Substance Use-related Emergency Department Visits and Resource Utilization. *Western Journal of Emergency Medicine*, *23*(2), 166–173. https://doi.org/10.5811/westjem.2022.1.53834

Bender, A., Groll, A., & Scheipl, F. (2018). A generalized additive model approach to time-to-event analysis. *Statistical Modelling*, *18*(3–4), 299–321. https://doi.org/10.1177/1471082X17748083

Bender, A., Scheipl, F., Piller, J., & Kopper, P. (2026). *pammtools: Piece-wise exponential additive mixed modeling tools* (Version 0.8.1) [R package]. https://adibender.github.io/pammtools/

Bender, A., & Scheipl, F. (2018, June 4). *pammtools: Piece-wise exponential Additive Mixed Modeling tools*. arXiv.Org. https://arxiv.org/abs/1806.01042v1

Biggs, L. J., Jephcott, B., Vanderwiel, K., Melgaard, I., Bott, S., Paderes, M., Borninkhof, J., & Birks, M. (2023). Pathways, Contexts, and Voices of Shame and Compassion: A Grounded Theory of the Evolution of Perinatal Suicidality. *Qualitative Health Research*, *33*(6), 521–530. https://doi.org/10.1177/10497323231164278

Billings, J., & Raven, M. C. (2013). Dispelling An Urban Legend: Frequent Emergency Department Users Have Substantial Burden Of Disease. *Health Affairs*, *32*(12), 2099–2108. https://doi.org/10.1377/hlthaff.2012.1276

Blackman, A., Ukah, U. V., Platt, R. W., Meng, X., Shapiro, G. D., Malhamé, I., Ray, J. G., Lisonkova, S., El-Chaâr, D., Auger, N., & Dayan, N. (2024). Severe Maternal Morbidity and Mental Health Hospitalizations or Emergency Department Visits. *JAMA Network Open*, *7*(4), e247983. https://doi.org/10.1001/jamanetworkopen.2024.7983

Bodnar-Deren, S., Klipstein, K., Fersh, M., Shemesh, E., & Howell, E. A. (2016). Suicidal Ideation During the Postpartum Period. *Journal of Women's Health*, *25*(12), 1219–1224. https://doi.org/10.1089/jwh.2015.5346

Bone, J. N., Joseph, K. S., John, S., & Lisonkova, S. (2023). A flexible approach to modelling stillbirths using the foetuses at risk approach. *Paediatric and Perinatal Epidemiology*, *37*(6), 547–554. https://doi.org/10.1111/ppe.12993

Bright, A.-M., Doody, O., & Tuohy, T. (2022). Women with perinatal suicidal ideation–A scoping review of the biopsychosocial risk factors to inform health service provision and research. *PLOS ONE*, *17*(9), e0274862. https://doi.org/10.1371/journal.pone.0274862

Brown, H. K., Fung, K., Cohen, E., Dennis, C.-L., Grandi, S. M., Rosella, L. C., Varner, C., Vigod, S. N., Wodchis, W. P., & Ray, J. G. (2026). Multiple Chronic Conditions Before Pregnancy and Risk of Adverse Maternal Health Outcomes: Population-Based Cohort Study. *BJOG: An International Journal of Obstetrics & Gynaecology*, *133*(1), 142–153. https://doi.org/10.1111/1471-0528.18347

Bryan, C. J., Allen, M. H., Bryan, A. O., Thomsen, C. J., Baker, J. C., & May, A. M. (2023). Does Suicide Risk Screening Improve the Identification of Primary Care Patients Who Will Attempt Suicide Versus Depression Screening Alone? *The Joint Commission*

Journal on Quality and Patient Safety, *49*(12), 680–688. https://doi.org/10.1016/j.jcjq.2023.08.008

Bryan, C. J., Allen, M. H., & Hoge, C. W. (2023). Weighing the Costs and Benefits of Universal Suicide Risk Screening in Primary Care: An Evidence-Based Approach. *Psychiatric Services*, *74*(1), 79–81. https://doi.org/10.1176/appi.ps.202100611

Burnham, K. P., & Anderson, D. R. (2004). Multimodel Inference: Understanding AIC and BIC in Model Selection. *Sociological Methods & Research*, *33*(2), 261–304. https://doi.org/10.1177/0049124104268644

Bye, A., Nath, S., Ryan, E. G., Bick, D., Easter, A., Howard, L. M., & Micali, N. (2020). Prevalence and clinical characterisation of pregnant women with eating disorders. *European Eating Disorders Review*, *28*(2), 141–155. https://doi.org/10.1002/erv.2719

Carlson, K., Mughal, S., Azhar, Y., & Siddiqui, W. (2025). Perinatal Depression. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK519070/

CDC. (2024, May 20). *Severe Maternal Morbidity*. Maternal Infant Health. https://www.cdc.gov/maternal-infant-health/php/severe-maternal-morbidity/index.html

CDC. (2025, December 17). *About the Data: Pregnancy Mortality Surveillance System*. Maternal Mortality Prevention. https://www.cdc.gov/maternal-mortality/php/pregnancy-mortality-surveillance-data/about.html

CDC. (2026, February 18). *About NSSP*. National Syndromic Surveillance Program (NSSP). https://www.cdc.gov/nssp/php/about/index.html

Ceniti, A. K., Heinecke, N., & McInerney, S. J. (2020). Examining suicide-related presentations to the emergency department. *General Hospital Psychiatry, Suicide and Medical Settings*, *63*, 152–157. https://doi.org/10.1016/j.genhosppsych.2018.09.006

Cerel, J., Singleton, M. D., Brown, M. M., Brown, S. V., Bush, H. M., & Brancado, C. J. (2015). Emergency Department Visits Prior to Suicide and Homicide. *Crisis*. (world). https://econtent.hogrefe.com/doi/10.1027/0227-5910/a000354

Chakrabarti, A., & Ghosh, J. K. (2011). AIC, BIC and Recent Advances in Model Selection. In P. S. Bandyopadhyay & M. R. Forster (Eds.), *Philosophy of Statistics* (Vol. 7, pp. 583–605). North-Holland. https://doi.org/10.1016/B978-0-444-51862-0.50018-6

Chatterjee, S., Kotelchuck, M., & Sambamoorthi, U. (2008). Prevalence of Chronic Illness in Pregnancy, Access to Care, and Health Care Costs: Implications for Interconception Care. *Women's Health Issues, Women's Health Issues*, *18*(6, Supplement), S107–S116. https://doi.org/10.1016/j.whi.2008.06.003

Chesney, E., Goodwin, G. M., & Fazel, S. (2014). Risks of all-cause and suicide mortality in mental disorders: A meta-review. *World Psychiatry*, *13*(2), 153–160. https://doi.org/10.1002/wps.20128

Chin, K., Wendt, A., Bennett, I. M., & Bhat, A. (2022). Suicide and Maternal Mortality. *Current Psychiatry Reports*, *24*(4), 239–275. https://doi.org/10.1007/s11920-022-01334-3

Chmielewska, B., Barratt, I., Townsend, R., Kalafat, E., Meulen, J. van der, Gurol-Urganci, I., O'Brien, P., Morris, E., Draycott, T., Thangaratinam, S., Doare, K. L., Ladhani, S., Dadelszen, P. von, Magee, L., & Khalil, A. (2021). Effects of the COVID-19 pandemic on maternal and perinatal outcomes: A systematic review and meta-analysis. *The Lancet Global Health*, *9*(6), e759–e772. https://doi.org/10.1016/S2214-109X(21)00079-6

Clark, S. L., Belfort, M. A., Dildy, G. A., Englebright, J., Meints, L., Meyers, J. A., Frye, D. K., & Perlin, J. A. (2010). Emergency department use during the postpartum period: Implications for current management of the puerperium. *American Journal of Obstetrics and Gynecology*, *203*(1), 38.e1-6. https://doi.org/10.1016/j.ajog.2010.02.033

Coker, T. R., Gottschlich, E. A., Burr, W. H., & Lipkin, P. H. (2024). Early Childhood Screening Practices and Barriers: A National Survey of Primary Care Pediatricians. *Pediatrics*, *154*(2), e2023065552. https://doi.org/10.1542/peds.2023-065552

Courchesne-Krak, N. S., Kepner, W., Rubano, A., & Marienfeld, C. (2022). Differences in outpatient, emergency, and inpatient use among pregnant women with a substance-related diagnosis. *American Journal of Obstetrics & Gynecology MFM*, *4*(2), 100559. https://doi.org/10.1016/j.ajogmf.2021.100559

Cruz, S. Sta., Margerison, C., Gemmill, A., Ha, S., Hurd, T., Jensen, J., & Goldman-Mellor, S. (2024). Trends and disparities in violence-related injury morbidity among pregnant and postpartum individuals. *Annals of Epidemiology*, *100*, 50–56. https://doi.org/10.1016/j.annepidem.2024.11.001

Cunningham, S. D., Magriples, U., Thomas, J. L., Kozhimannil, K. B., Herrera, C., Barrette, E., Shebl, F. M., & Ickovics, J. R. (2017). Association Between Maternal Comorbidities and Emergency Department Use Among a National Sample of Commercially Insured Pregnant Women. *Academic Emergency Medicine*, *24*(8), 940–947. https://doi.org/10.1111/acem.13215

Davidov, D. M., Gurka, K. K., Long, D. L., & Burrell, C. N. (2023). Comparison of Intimate Partner Violence and Correlates at Urgent Care Clinics and an Emergency Department in a Rural Population. *International Journal of Environmental Research and Public Health*, *20*(5), 4554. https://doi.org/10.3390/ijerph20054554

De Backer, K., Pali, A., Challacombe, F. L., Hildersley, R., Newburn, M., Silverio, S. A., Sandall, J., Howard, L. M., & Easter, A. (2024). Women's experiences of attempted suicide in the perinatal period (ASPEN-study) – a qualitative study. *BMC Psychiatry*, *24*(1), 255. https://doi.org/10.1186/s12888-024-05686-3

Declercq, E. R., Liu, C.-L., Cabral, H. J., Amutah-Onukagha, N., Diop, H., & Mehta, P. K. (2024). Emergency Care Use During Pregnancy and Severe Maternal Morbidity. *JAMA Network Open*, *7*(10), e2439939. https://doi.org/10.1001/jamanetworkopen.2024.39939

Declercq, E., & Zephyrin, L. C. (2025, July 29). *Maternal Mortality in the United States, 2025*. Commonwealthfund.Org. https://doi.org/10.26099/kdfd-fc19

DeCou, C. R., & Schumann, M. E. (2018). On the Iatrogenic Risk of Assessing Suicidality: A Meta-Analysis. *Suicide & Life-Threatening Behavior*, *48*(5), 531–543. https://doi.org/10.1111/sltb.12368

Delker, E., Marienfeld, C., Baer, R. J., Parry, B., Kiernan, E., Jelliffe-Pawlowski, L., Chambers, C., & Bandoli, G. (2023). Adverse Perinatal Outcomes and Postpartum Suicidal Behavior in California, 2013–2018. *Journal of Women's Health*, *32*(5), 608–615. https://doi.org/10.1089/jwh.2022.0255

Despotis, A., Harrison, S., Quigley, M. A., Alderdice, F., & Fellmeth, G. (2025). Suicidal ideation in the postpartum period: A population-based study of prevalence and risk factors using data from two national maternity surveys in England. *Journal of Affective Disorders*, *389*, 119707. https://doi.org/10.1016/j.jad.2025.119707

Dickman, S. L., Himmelstein, D. U., & Woolhandler, S. (2017). Inequality and the health-care system in the USA. *The Lancet*, *389*(10077), 1431–1441. https://doi.org/10.1016/S0140-6736(17)30398-7

Dossett, E. C., Stuebe, A., Dillion, T., & Tabb, K. M. (2024). Perinatal Mental Health: The Need For Broader Understanding And Policies That Meet The Challenges. *Health Affairs*, *43*(4), 462–469. https://doi.org/10.1377/hlthaff.2023.01455

Drexler, K. A., Quist-Nelson, J., & Weil, A. B. (2022). Intimate partner violence and trauma-informed care in pregnancy. *American Journal of Obstetrics & Gynecology MFM*, *4*(2), 100542. https://doi.org/10.1016/j.ajogmf.2021.100542

Earls, M. F., Yogman, M. W., Mattson, G., Rafferty, J., COMMITTEE ON PSYCHOSOCIAL ASPECTS OF CHILD AND FAMILY HEALTH, Baum, R., Gambon, T., Lavin, A., & Wissow, L. (2019). Incorporating Recognition and Management of Perinatal Depression Into Pediatric Practice. *Pediatrics*, *143*(1), e20183259. https://doi.org/10.1542/peds.2018-3259

Enătescu, I., Craina, M., Gluhovschi, A., Giurgi-Oncu, C., Hogea, L., Nussbaum, L. A., Bernad, E., Simu, M., Cosman, D., Iacob, D., Marinescu, I., & Enătescu, V. R. (2021). The role of personality dimensions and trait anxiety in increasing the likelihood of suicide ideation in women during the perinatal period. *Journal of Psychosomatic Obstetrics & Gynecology*, *42*(3), 242–252. https://doi.org/10.1080/0167482X.2020.1734790

Forray, A., & Foster, D. (2015). Substance Use in the Perinatal Period. *Current Psychiatry Reports*, *17*(11), 91. https://doi.org/10.1007/s11920-015-0626-5

Forray, A., Merry, B., Lin, H., Ruger, J. P., & Yonkers, K. A. (2015). Perinatal substance use: A prospective evaluation of abstinence and relapse. *Drug and Alcohol Dependence*, *150*, 147–155. https://doi.org/10.1016/j.drugalcdep.2015.02.027

Fox, V., Dalman, C., Dal, H., Hollander, A.-C., Kirkbride, J. B., & Pitman, A. (2021). Suicide risk in people with post-traumatic stress disorder: A cohort study of 3.1 million people in Sweden. *Journal of Affective Disorders*, *279*, 609–616. https://doi.org/10.1016/j.jad.2020.10.009

Frankeberger, J., Jarlenski, M., Krans, E. E., Coulter, R. W. S., & Mair, C. (2023). Opioid use disorder and overdose in the first year postpartum: A rapid scoping review and implications for future research. *Maternal and Child Health Journal*, *27*(7), 1140–1155. https://doi.org/10.1007/s10995-023-03614-7

Garnett, M. F., M.P.H., Zehner, A. M., & M.P.H. (2025, September 29). *Changes in Suicide Rates in the United States From 2022 to 2023*. https://doi.org/10.15620/cdc/174625

Gelabert, E., Plaza, A., Roca-Lecumberri, A., Bramante, A., Brenna, V., Garcia-Esteve, L., Lega, I., Subirà, S., Toscano, C., & Torres-Giménez, A. (2024). Suicide Attempts during Pregnancy and Postpartum: A Systematic Review and Meta-Analysis. *Maternal and Child Health Journal*, *28*(9), 1443–1453. https://doi.org/10.1007/s10995-024-03956-w

Gelaye, B., Kajeepeta, S., & Williams, M. A. (2016). Suicidal ideation in pregnancy: An epidemiologic review. *Archives of Women's Mental Health*, *19*(5), 741–751. https://doi.org/10.1007/s00737-016-0646-0

Giallo, R., Pilkington, P., Borschmann, R., Seymour, M., Dunning, M., & Brown, S. (2018). The prevalence and correlates of self-harm ideation trajectories in Australian women from pregnancy to 4-years postpartum. *Journal of Affective Disorders*, *229*, 152–158. https://doi.org/10.1016/j.jad.2017.12.064

Gimbel, L. A., Weingarten, S. J., Smid, M. C., & Hoffman, M. C. (2024). Maternal mental health as a major contributor to maternal mortality. *Seminars in Perinatology, Perinatal Mental Health: Research and Treatment in the 21st Century*, *48*(6), 151943. https://doi.org/10.1016/j.semperi.2024.151943

Goldman-Mellor, S., Jensen, J., Cruz, S. S., Olfson, M., Gemmill, A., Yan, Y., & Margerison, C. (2025). Trends in and characteristics of drug overdose morbidity among pregnant and postpartum individuals in California, 2010-2018. *American Journal of Epidemiology*, *194*(2), 379–388. https://doi.org/10.1093/aje/kwae177

Goldman-Mellor, S., Olfson, M., Gemmill, A., & Margerison, C. (2025). Incidence and Risk Factors for Suicide Attempt During Pregnancy and the Postpartum Period. *Journal of Clinical Psychiatry*, *86*(2), 24m15633. https://doi.org/10.4088/JCP.24m15633

Goldstein Grumet, J., & Boudreaux, E. D. (2023). Universal Suicide Screening Is Feasible and Necessary to Reduce Suicide. *Psychiatric Services (Washington, D.C.)*, *74*(1), 81–83. https://doi.org/10.1176/appi.ps.202100625

Grigoriadis, S., Wilton, A. S., Kurdyak, P. A., Rhodes, A. E., VonderPorten, E. H., Levitt, A., Cheung, A., & Vigod, S. N. (2017). Perinatal suicide in Ontario, Canada: A 15-year population-based study. *Canadian Medical Association Journal*, *189*(34), E1085–E1092. https://doi.org/10.1503/cmaj.170088

Hagan, J. F., Shaw, J. S., & Duncan, P. M. (2008). *Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents* (Third Edition). The American Academy of Pediatrics.

Halim, N., Beard, J., Mesic, A., Patel, A., Henderson, D., & Hibberd, P. (2018). Intimate partner violence during pregnancy and perinatal mental disorders in low and lower middle income countries: A systematic review of literature, 1990–2017. *Clinical Psychology Review, Gender and Mental Health*, *66*, 117–135. https://doi.org/10.1016/j.cpr.2017.11.004

Han, B., Compton, W. M., Einstein, E. B., Cotto, J., Hobin, J. A., Stein, J. B., & Volkow, N. D. (2022). Intentional Drug Overdose Deaths in the United States. *American Journal of Psychiatry*, *179*, 163–165. https://doi.org/10.1176/appi.ajp.2021.21060604

Harris, L. M., Huang, X., Linthicum, K. P., Bryen, C. P., & Ribeiro, J. D. (2020). Sleep disturbances as risk factors for suicidal thoughts and behaviours: A meta-analysis of longitudinal studies. *Scientific Reports*, *10*(1), 13888. https://doi.org/10.1038/s41598-020-70866-6

Hartl, W. H., Kopper, P., Bender, A., Scheipl, F., Day, A. G., Elke, G., & Küchenhoff, H. (2022). Protein intake and outcome of critically ill patients: Analysis of a large international database using piece-wise exponential additive mixed models. *Critical Care*, *26*(1), 7. https://doi.org/10.1186/s13054-021-03870-5

Health Resources and Services Administration (HRSA). (2024). *Oregon—2022—III.B. Overview of the State*. Hrs.Gov. https://mchb.tvisdata.hrsa.gov/Narratives/Overview/08657c19-0041-4a79-aea2-657ec67ce181

Heinze, G., & Schemper, M. (2002). A solution to the problem of separation in logistic regression. *Statistics in Medicine*, *21*(16), 2409–2419. https://doi.org/10.1002/sim.1047

Hendriks, O., McIntyre, J. C., Rose, A. K., Sambrook, L., Reisel, D., Crockett, C., Newson, L., & Saini, P. (2025). Menopause and suicide: A systematic review. *Women's Health*, *21*, 17455057251360517. https://doi.org/10.1177/17455057251360517

Hensley, S., Szewczyk, W., Casey, D., & Matheson, A. I. (2025). New Opportunities for Health and Resilience Measures for Suicide Prevention (NO HARMS): Protocol to investigate suicidal behaviours using linked multisystem administrative data. *BMJ Open*, *15*(9), e100665. https://doi.org/10.1136/bmjopen-2025-100665

Herzog, S., Choo, T.-H., Galfalvy, H., Mann, J. J., & Stanley, B. H. (2022). Effect of non-suicidal self-injury on suicidal ideation: Real-time monitoring study. *The British Journal of Psychiatry*, *221*(2), 485–487. https://doi.org/10.1192/bjp.2021.225

Ho, T. C., Gifuni, A. J., & Gotlib, I. H. (2022). Psychobiological risk factors for suicidal thoughts and behaviors in adolescence: A consideration of the role of puberty. *Molecular Psychiatry*, *27*(1), 606–623. https://doi.org/10.1038/s41380-021-01171-5

Hoelle, R. M., Elie, M.-C., Weeks, E., Hardt, N., Hou, W., Yan, H., & Carden, D. (2015). Evaluation of Healthcare Use Trends of High-Risk Female Intimate Partner Violence Victims. *Western Journal of Emergency Medicine*, *16*(1), 107–113. https://doi.org/10.5811/westjem.2014.12.22866

Hope, H., Pierce, M., Osam, C. S., Morgan, C., John, A., & Abel, K. M. (2022). Self-harm risk in pregnancy: Recurrent-event survival analysis using UK primary care data. *The British Journal of Psychiatry*, *221*(4), 621–627. https://doi.org/10.1192/bjp.2022.31

Horon, I. L., & Cheng, D. (2011). Effectiveness of Pregnancy Check Boxes on Death Certificates in Identifying Pregnancy-Associated Mortality. *Public Health Reports®*, *126*(2), 195–200. https://doi.org/10.1177/003335491112600210

Horowitz, J. A., & Goodman, J. (2004). A longitudinal study of maternal postpartum depression symptoms. *Research and Theory for Nursing Practice*, *18*(2–3), 149–163. https://doi.org/10.1891/rtnp.18.2.149.61285

Howard, L. M., Flach, C., Mehay, A., Sharp, D., & Tylee, A. (2011). The prevalence of suicidal ideation identified by the Edinburgh Postnatal Depression Scale in postpartum women in primary care: Findings from the RESPOND trial. *BMC Pregnancy and Childbirth*, *11*, 57. https://doi.org/10.1186/1471-2393-11-57

Howarth, E. J., O'Connor, D. B., Panagioti, M., Hodkinson, A., Wilding, S., & Johnson, J. (2020). Are stressful life events prospectively associated with increased suicidal ideation and behaviour? A systematic review and meta-analysis. *Journal of Affective Disorders*, *266*, 731–742. https://doi.org/10.1016/j.jad.2020.01.171

Howland, M. A. (2023). Recalibration of the stress response system over adult development: Is there a perinatal recalibration period? *Development and Psychopathology*, *35*(5), 2315–2337. https://doi.org/10.1017/S0954579423000998

Hoyert, D. L. (2021, April 1). *Maternal Mortality Rates in the United States, 2019*. https://doi.org/10.15620/cdc:103855

Hoyert, D. L., & Miniño, A. M. (2020). Maternal Mortality in the United States: Changes in Coding, Publication, and Data Release, 2018. *National Vital Statistics Reports: From the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System*, *69*(2), 1–18.

Hua, L. L., Lee, J., Rahmandar, M. H., Sigel, E. J., COMMITTEE ON ADOLESCENCE, & COUNCIL ON INJURY, V., AND POISON PREVENTION. (2023). Suicide and Suicide Risk in Adolescents. *Pediatrics*, *153*(1), e2023064800. https://doi.org/10.1542/peds.2023-064800

Ionio, C., Smorti, M., Mascheroni, E., Ongaro, G., Cattaneo, E., Gemignani, A., Von Wunster, S., & Bonassi, L. (2021). What is the role played by pregnancy in the construction of a woman's identity and her association with her child-to-be? *Journal of Reproductive and Infant Psychology*, *39*(3), 250–262. https://doi.org/10.1080/02646838.2019.1695042

Jackson, K. T., Marshall, C., & Yates, J. (2024). Health-Related Maternal Decision-Making Among Perinatal Women in the Context of Intimate Partner Violence: A Scoping Review. *Trauma, Violence, & Abuse*, *25*(3), 1899–1910. https://doi.org/10.1177/15248380231198876

Jin, J. (2023). Screening for Depression and Suicide Risk in Adults. *JAMA*, *329*(23), 2102. https://doi.org/10.1001/jama.2023.9449

Joseph, K. S., Lisonkova, S., Boutin, A., Muraca, G. M., Razaz, N., John, S., Sabr, Y., Chan, W.-S., Mehrabadi, A., Brandt, J. S., Schisterman, E. F., & Ananth, C. V. (2024). Maternal mortality in the United States: Are the high and rising rates due to changes in obstetrical factors, maternal medical conditions, or maternal mortality surveillance? *American Journal of Obstetrics and Gynecology*, *230*(4), 440.e1-440.e13. https://doi.org/10.1016/j.ajog.2023.12.038

Kaliush, P. R. (2024). *Transdiagnostic Susceptibility for Self-Injurious Thoughts and Behaviors During the Perinatal Period: A Dynamic Systems Approach* [Ph.D., The University of Utah]. https://www.proquest.com/docview/3109560843/abstract/1B5784A58FAD4AC3PQ/1

Kaliush, P. R., Butner, J. E., Williams, P. G., Conradt, E., & Crowell, S. E. (2024). Dynamic Associations Among Sleep, Emotion Dysregulation, and Desire to Live in a Perinatal Sample. *Biopsychosocial Science and Medicine*, *86*(4), 272. https://doi.org/10.1097/PSY.0000000000001297

Karaçam, Z., Sarı, E., Yüksel, R., & Arslantaş, H. (2024). The prevalence of suicidal behavior and ideation during pregnancy and postpartum period, its variation in the COVID-19 pandemic, and the related factors: A systematic review and meta-analysis of observational studies. *European Journal of Psychiatry*, *38*(2). https://doi.org/10.1016/j.ejpsy.2023.100248

Karvonen, K. L., Baer, R. J., Blebu, B., Calthorpe, L., Fuchs, J. D., Jelliffe-Pawlowski, L., Karasek, D., McKenzie-Sampson, S., Oltman, S. P., Rand, L., Shannon, M. T., Washington, T. E., Woolridge, T., Rogers, E. E., & Pantell, M. S. (2022). Racial disparities in emergency mental healthcare utilization among birthing people with preterm infants. *American Journal of Obstetrics & Gynecology MFM*, *4*(2), 100546. https://doi.org/10.1016/j.ajogmf.2021.100546

Kass, R. E., & Raftery, A. E. (1995). Bayes Factors. *Journal of the American Statistical Association*, *90*(430), 773–795. https://doi.org/10.1080/01621459.1995.10476572

Khalifeh, H., Hunt, I. M., Appleby, L., & Howard, L. M. (2016). Suicide in perinatal and non-perinatal women in contact with psychiatric services: 15 year findings from a UK national inquiry. *The Lancet Psychiatry*, *3*(3), 233–242. https://doi.org/10.1016/S2215-0366(16)00003-1

Kim, J. J., La Porte, L. M., Saleh, M. P., Allweiss, S., Adams, M. G., Zhou, Y., & Silver, R. K. (2015). Suicide Risk Among Perinatal Women Who Report Thoughts of Self-Harm on Depression Screens. *Obstetrics & Gynecology*, *125*(4), 885. https://doi.org/10.1097/AOG.0000000000000718

Kitsantas, P., Aljoudi, S. M., Adams, A. R., & Booth, E. J. (2020). Prevalence and correlates of suicidal behaviors during pregnancy: Evidence from the National Survey on Drug Use and Health. *Archives of Women's Mental Health*, *ePub*(ePub), ePub. https://doi.org/10.1007/s00737-020-01089-x

Klonsky, E. D., & May, A. M. (2014). Differentiating Suicide Attempters from Suicide Ideators: A Critical Frontier for Suicidology Research. *Suicide and Life-Threatening Behavior*, *44*(1), 1–5. https://doi.org/10.1111/sltb.12068

Klonsky, E. D., & May, A. M. (2015). The Three-Step Theory (3ST): A New Theory of Suicide Rooted in the "Ideation-to-Action" Framework. *International Journal of Cognitive Therapy*, *8*(2), 114–129. https://doi.org/10.1521/ijct.2015.8.2.114

Klonsky, E. D., May, A. M., & Glenn, C. R. (2013). The relationship between nonsuicidal self-injury and attempted suicide: Converging evidence from four samples. *Journal of Abnormal Psychology*, *122*(1), 231–237. https://doi.org/10.1037/a0030278

Klonsky, E. D., Victor, S. E., & Saffer, B. Y. (2014). Nonsuicidal Self-Injury: What We Know, and What We Need to Know. *The Canadian Journal of Psychiatry*, *59*(11), 565–568. https://doi.org/10.1177/070674371405901101

Kobylski, L. A., Keller, J., Molock, S. D., & Le, H.-N. (2023). Preventing perinatal suicide: An unmet public health need. *The Lancet Public Health*, *8*(6), e402. https://doi.org/10.1016/S2468-2667(23)00092-0

Kozhimannil, K. B., Lewis, V. A., Interrante, J. D., Chastain, P. L., & Admon, L. (2023). Screening for and Experiences of Intimate Partner Violence in the United States Before, During, and After Pregnancy, 2016–2019. *American Journal of Public Health*, *113*(3), 297–305. https://doi.org/10.2105/AJPH.2022.307195

Kuehn, K. S., Dora, J., Harned, M. S., Foster, K. T., Song, F., Smith, M. R., & King, K. M. (2022). A meta-analysis on the affect regulation function of real-time self-injurious thoughts and behaviours. *Nature Human Behaviour*, *6*(7), 964–974. https://doi.org/10.1038/s41562-022-01340-8

Kvaran, R. B., Gunnarsdottir, O. S., Kristbjornsdottir, A., Valdimarsdottir, U. A., & Rafnsson, V. (2015). Number of visits to the emergency department and risk of suicide: A population-based case–control study. *BMC Public Health*, *15*(1), 227. https://doi.org/10.1186/s12889-015-1544-5

Lamere, K., & Golova, N. (2022). Screening for Postpartum Depression During Infant Well Child Visits: A Retrospective Chart Review. *Clinical Pediatrics*, *61*(10), 699–706. https://doi.org/10.1177/00099228221097272

Landis, R. K., Stein, B. D., Griffin, B. A., Saloner, B. K., Terplan, M., & Faherty, L. J. (2023). Disparities in Perinatal and Emergency Care Receipt Among Women With Perinatal Opioid Use Disorder in Medicaid, 2007 to 2012. *Journal of Addiction Medicine*, *17*(6), 654. https://doi.org/10.1097/ADM.0000000000001199

Lazarus, R. S., & Folkman, S. (1984). *Stress, Appraisal, and Coping*. Springer Publishing Company.

LeCounte, E. S., Salemi, J. L., Vamos, C. A., Flynn, H. A., & Kirby, R. S. (2026). Maternal Suicidal Behavior: Comparisons Between Pregnancy and Postpartum Periods and Nonpregnancy, 2006–2019. *Journal of Women's Health*, *35*(6), 574–584. https://doi.org/10.1177/15409996261423419

Legazpi, P. C. C., Rodríguez-Muñoz, M. F., Le, H.-N., Balbuena, C. S., Olivares, M. E., & Méndez, N. I. (2022). Suicidal ideation: Prevalence and risk factors during pregnancy. *Midwifery*, *106*, 103226. https://doi.org/10.1016/j.midw.2021.103226

Legazpi, P. C. C., Rodríguez-Muñoz, M. F., Olivares-Crespo, M. E., & Izquierdo-Méndez, N. (2022). Review of suicidal ideation during pregnancy: Risk factors, prevalence,

assessment instruments and consequences. *Psicologia: Reflexão e Crítica*, *35*(1), 13. https://doi.org/10.1186/s41155-022-00220-4

Lewkowitz, A. K., Rosenbloom, J. I., Keller, M., López, J. D., Macones, G. A., Olsen, M. A., & Cahill, A. G. (2019). Association Between Severe Maternal Morbidity and Psychiatric Illness Within 1 Year of Hospital Discharge After Delivery. *Obstetrics and Gynecology*, *134*(4), 695–707. https://doi.org/10.1097/AOG.0000000000003434

Li, Y.-S., Tsai, S.-J., Cheng, C.-M., Bai, Y.-M., Chen, T.-J., & Chen, M.-H. (2026). Utilization of psychiatric and emergency room service and prescriptions of psychotropic drugs during the 180 days prior to suicide. *Journal of Affective Disorders*, *397*, 120925. https://doi.org/10.1016/j.jad.2025.120925

Lindahl, V., Pearson, J. L., & Colpe, L. (2005). Prevalence of suicidality during pregnancy and the postpartum. *Archives of Women's Mental Health*, *8*(2), 77–87. https://doi.org/10.1007/s00737-005-0080-1

Lommerse, K., Knight, M., Nair, M., Deneux-Tharaux, C., & Van Den Akker, T. (2019). The impact of reclassifying suicides in pregnancy and in the postnatal period on maternal mortality ratios. *BJOG: An International Journal of Obstetrics & Gynaecology*, *126*(9), 1088–1092. https://doi.org/10.1111/1471-0528.15215

Loree, A. M., Hecht, L. M., Yeh, H.-H., Gavrilova, L., Furman, K., Westphal, J., Simon, G. E., Lynch, F. L., Beck, A., Owen-Smith, A., Rossom, R., Daida, Y. G., Lu, C. Y., Boggs, J. M., Frank, C., Waring, S., & Ahmedani, B. K. (2025). Factors associated with suicide mortality among reproductive age women: A case-control study. *Journal of Reproductive and Infant Psychology*, *43*(1), 215–226. https://doi.org/10.1080/02646838.2023.2223636

Lubas-Grzyb, A., Rode, D., Rode, M., & Marganski, A. J. (2026). Gender-Specific Correlates of Suicidal Behaviour: Insights from the Interpersonal Theory of Suicide. *Journal of Clinical Medicine*, *15*(4), 1335. https://doi.org/10.3390/jcm15041335

Lysell, H., Dahlin, M., Viktorin, A., Ljungberg, E., D'Onofrio, B. M., Dickman, P., & Runeson, B. (2018). Maternal suicide – Register based study of all suicides occurring after delivery in Sweden 1974–2009. *PLOS ONE*, *13*(1), e0190133. https://doi.org/10.1371/journal.pone.0190133

Maciejewski, D. F., Creemers, H., Lynskey, M. T., Madden, P. A. F., Heath, A. C., Statham, D. J., Martin, N. G., & Verweij, K. J. H. (2014). Different outcomes, same etiology? Shared genetic and environmental influences on non-suicidal self injury and suicidal ideation. *JAMA Psychiatry*, *71*(6), 699–705. https://doi.org/10.1001/jamapsychiatry.2014.89

Madamala, K., Beaudrault, S., Menza, T., & Biddlecom, C. (2024). Oregon's Approach To Demonstrating The Value Of A Modern Public Health System Through Accountability Metrics. *Health Affairs*, *43*(6), 864–872. https://doi.org/10.1377/hlthaff.2024.00012

Madray, C., Richardson, J., Hornsby, P., Grello, C., Drake, E., & Kellams, A. (2022). Exploring the Unmet Needs of Postpartum Mothers: A Qualitative Study. *The Journal of Perinatal Education*, *31*(2), 71–81. https://doi.org/10.1891/JPE-2021-00009

Makarious, L., Oei, J. L., Page, A., Hossain, S., Dronavalli, M., Uebel, H., Lee, E., Dickson, M., Burns, L., Bajuk, B., Eastwood, J., & Munasinghe, S. (2026). Maternal Deaths Due to Suicide, Accidental Poisoning and Undetermined Intent Within 5 Years Following Childbirth: A Population-Based Study. *BJOG: An International Journal of Obstetrics and Gynaecology*, *133*(8), 1581–1591. https://doi.org/10.1111/1471-0528.70212

Malik, S., Kothari, C., MacCallum, C., Liepman, M., Tareen, S., & Rhodes, K. V. (2017). Emergency Department Use in the Perinatal Period: An Opportunity for Early Intervention. *Annals of Emergency Medicine*, *70*(6), 835–839. https://doi.org/10.1016/j.annemergmed.2017.06.020

Margerison, C. E., Roberts, M. H., Gemmill, A., & Goldman-Mellor, S. (2022). Pregnancy-Associated Deaths Due to Drugs, Suicide, and Homicide in the United States, 2010–2019. *Obstetrics and Gynecology*, *139*(2), 172–180. https://doi.org/10.1097/AOG.0000000000004649

Margerison, C. E., Wang, X., Goldman-Mellor, S., Muzik, M., & Gemmill, A. (2024). Changes in Racial and Ethnic Inequities in Pregnancy-Associated Death in the United States During the COVID-19 Pandemic. *American Journal of Public Health*, *114*(7), 733–742. https://doi.org/10.2105/AJPH.2024.307651

Matenchuk, B. A., Rosychuk, R. J., Rowe, B. H., Metcalfe, A., Chari, R., Crawford, S., Jelinski, S., Serrano-Lomelin, J., & Ospina, M. B. (2023). Emergency Department Visits During Pregnancy. *Annals of Emergency Medicine*, *81*(2), 197–208. https://doi.org/10.1016/j.annemergmed.2022.06.021

(A) McElfish, P. A., Caldwell, A. R., Selig, J. P., Watson, D., Langner, J., Callaghan-Koru, J., Porter, A., Willis, D. E., Andersen, J. A., Hawley, N. L., Mendoza-Kabua, P., & Brown, C. C. (2025). Disparities in Prenatal Care Utilization in the United States. *Maternal and Child Health Journal*, *29*(12), 1670–1678. https://doi.org/10.1007/s10995-025-04150-2

B) McElfish, P. A., Caldwell, A., Watson, D., Langner, J., Callaghan-Koru, J., Porter, A., Willis, D. E., Andersen, J. A., Hawley, N. L., Selig, J. P., Forati, A., Alcala, M. R., White, L., Gomez-Pomar, E., & Brown, C. C. (2025). Sociodemographic factors associated with prenatal care utilization in Arkansas, United States. *Preventive Medicine Reports*, *51*, 102983. https://doi.org/10.1016/j.pmedr.2025.102983

Mehta, P. K., Bachhuber, M. A., Hoffman, R., & Srinivas, S. K. (2016). Deaths From Unintentional Injury, Homicide, and Suicide During or Within 1 Year of Pregnancy in Philadelphia. *American Journal of Public Health*, *106*(12), 2208–2210. https://doi.org/10.2105/AJPH.2016.303473

Meurk, C., Wittenhagen, L., Lucke, J., Barker, R., Roberts, S., Moss, K., Waterson, E., & Heffernan, E. (2021). Suicidal behaviours in the peripartum period: A systematic scoping review of data linkage studies. *Archives of Women's Mental Health*, *24*(4), 579–593. https://doi.org/10.1007/s00737-021-01102-x

Milton, A. C., Davenport, T. A., Iorfino, F., Flego, A., Burns, J. M., & Hickie, I. B. (2020). Suicidal Thoughts and Behaviors and Their Associations With Transitional Life Events

in Men and Women: Findings From an International Web-Based Sample. *JMIR Mental Health*, *7*(9), e18383. https://doi.org/10.2196/18383

Modest, A. M., Prater, L. C., & Joseph, N. T. (2022). Pregnancy-Associated Homicide and Suicide: An Analysis of the National Violent Death Reporting System, 2008-2019. *Obstetrics and Gynecology*, *140*(4), 565–573. https://doi.org/10.1097/AOG.0000000000004932

Modini, C., Leske, S., Roberts, S., Whelan, N., Chitakis, A., Crompton, D., & Ellwood, D. (2021). Maternal deaths by suicide in Queensland, Australia, 2004–2017: An analysis of maternal demographic, psychosocial and clinical characteristics. *Archives of Women's Mental Health*, *24*(6), 1019–1025. https://doi.org/10.1007/s00737-021-01107-6

Moitra, M., Santomauro, D., Degenhardt, L., Collins, P. Y., Whiteford, H., Vos, T., & Ferrari, A. (2021). Estimating the risk of suicide associated with mental disorders: A systematic review and meta-regression analysis. *Journal of Psychiatric Research*, *137*, 242–249. https://doi.org/10.1016/j.jpsychires.2021.02.053

Mojahed, A., Alaidarous, N., Kopp, M., Pogarell, A., Thiel, F., & Garthus-Niegel, S. (2021). Prevalence of Intimate Partner Violence Among Intimate Partners During the Perinatal Period: A Narrative Literature Review. *Frontiers in Psychiatry*, *12*. https://doi.org/10.3389/fpsyt.2021.601236

Mota, N. P., Chartier, M., Ekuma, O., Nie, Y., Hensel, J. M., MacWilliam, L., McDougall, C., Vigod, S., & Bolton, J. M. (2019). Mental Disorders and Suicide Attempts in the Pregnancy and Postpartum Periods Compared with Non-Pregnancy: A Population-Based Study. *The Canadian Journal of Psychiatry*, *64*(7), 482–491. https://doi.org/10.1177/0706743719838784

Moya, J., Phillips, L., Sanford, J., Wooton, M., Gregg, A., & Schuda, L. (2014). A review of physiological and behavioral changes during pregnancy and lactation: Potential exposure factors and data gaps. *Journal of Exposure Science & Environmental Epidemiology*, *24*(5), 449–458. https://doi.org/10.1038/jes.2013.92

Murugan, V., Holzer, K. J., Termos, M., & Vaughn, M. (2021). Intimate partner violence among pregnant women reporting to the emergency department: Findings from a nationwide sample. *BMJ Sexual & Reproductive Health*, *47*(3), e7–e7. https://doi.org/10.1136/bmjsrh-2020-200761

Na, X., Wang, X., Tan, D. S., Tan, Y., Yang, C., Zhang, J., Yang, Y., Ji, J. S., & Zhao, A. (2025). Long-term mental health disorders and suicidal behaviors linked to excessive vomiting during pregnancy: Evidence from the UK biobank. *Journal of Affective Disorders*, *388*, 119706. https://doi.org/10.1016/j.jad.2025.119706

Neuroth, L. M., Brathwaite, D., Waller, A. E., & Harmon, K. J. (2026). Past-Year Emergency Department Utilization Patterns Among Suicide Decedents: Characterizing At-Risk Patient Populations. *Annals of Emergency Medicine*. https://doi.org/10.1016/j.annemergmed.2026.01.025

Niedzwiecki, M. J., Sharma, P. J., Kanzaria, H. K., McConville, S., & Hsia, R. Y. (2018). Factors Associated With Emergency Department Use by Patients With and Without

Mental Health Diagnoses. *JAMA Network Open*, *1*(6), e183528. https://doi.org/10.1001/jamanetworkopen.2018.3528

Nielsen, T., Bernson, D., Terplan, M., Wakeman, S. E., Yule, A. M., Mehta, P. K., Bharel, M., Diop, H., Taveras, E. M., Wilens, T. E., & Schiff, D. M. (2020). Maternal and Infant Characteristics Associated with Maternal Opioid Overdose in the Year Following Delivery. *Addiction (Abingdon, England)*, *115*(2), 291–301. https://doi.org/10.1111/add.14825

Nock, M. K., Borges, G., Bromet, E. J., Alonso, J., Angermeyer, M., Beautrais, A., Bruffaerts, R., Chiu, W. T., de Girolamo, G., Gluzman, S., de Graaf, R., Gureje, O., Haro, J. M., Huang, Y., Karam, E., Kessler, R. C., Lepine, J. P., Levinson, D., Medina-Mora, M. E., … Williams, D. (2008). Cross-national prevalence and risk factors for suicidal ideation, plans and attempts. *The British Journal of Psychiatry: The Journal of Mental Science*, *192*(2), 98–105. https://doi.org/10.1192/bjp.bp.107.040113

O'Connor, R. C., & Kirtley, O. J. (2018). The integrated motivational–volitional model of suicidal behaviour. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1754), 20170268. https://doi.org/10.1098/rstb.2017.0268

Olfson, M., Gao, Y. N., Xie, M., Wiesel Cullen, S., & Marcus, S. C. (2021). Suicide Risk Among Adults With Mental Health Emergency Department Visits With and Without Suicidal Symptoms. *The Journal of Clinical Psychiatry*, *82*(6), 20m13833. https://doi.org/10.4088/JCP.20m13833

O'Neill, S., Graham, B., & Ennis, E. (2019). Emergency department and hospital care prior to suicide: A population based case control study. *Journal of Affective Disorders*, *249*, 366–370. https://doi.org/10.1016/j.jad.2019.02.052

Oquendo, M. A., & Volkow, N. D. (2018). Suicide: A Silent Contributor to Opioid-Overdose Deaths. *New England Journal of Medicine*, *378*(17), 1567–1569. https://doi.org/10.1056/NEJMp1801417

Oregon Health Authority (OHA). (2021). *HB 3090: Emergency department release survey of hospitals—2021 legislative report*. Oregon Health Authority. https://oregonalliancetopreventsuicide.org/wp-content/uploads/2021/12/HB-3090-Legislative-Report-Draft-Nov.-2021.pdf

Orsolini, L., Valchera, A., Vecchiotti, R., Tomasetti, C., Iasevoli, F., Fornaro, M., De Berardis, D., Perna, G., Pompili, M., & Bellantuono, C. (2016). Suicide during Perinatal Period: Epidemiology, Risk Factors, and Clinical Correlates. *Frontiers in Psychiatry*, *7*. https://doi.org/10.3389/fpsyt.2016.00138

Østergaard, S. D., Momen, N. C., Heide-Jørgensen, U., & Plana-Ripoll, O. (2024). Risk of Suicide Across Medical Conditions and the Role of Prior Mental Disorder. *JAMA Psychiatry*, *81*(12), 1198–1206. https://doi.org/10.1001/jamapsychiatry.2024.2561

Palladino, C. L., Singh, V., Campbell, J., Flynn, H., & Gold, K. (2011). Homicide and Suicide During the Perinatal Period: Findings from the National Violent Death Reporting System. *Obstetrics and Gynecology*, *118*(5), 1056–1063. https://doi.org/10.1097/AOG.0b013e31823294da

Park, R. Y., Bilinski, A., Parks, R. M., & Flaxman, S. (2025). Trends in Maternal, Fetal, and Infant Mortality in the US, 2000-2023. *JAMA Pediatrics*, *179*(7), 765–772. https://doi.org/10.1001/jamapediatrics.2025.0440

Pastor-Moreno, G., Ruiz-Pérez, I., Henares-Montiel, J., & Petrova, D. (2020). Intimate partner violence during pregnancy and risk of fetal and neonatal death: A meta-analysis with socioeconomic context indicators. *American Journal of Obstetrics and Gynecology*, *222*(2), 123-133.e5. https://doi.org/10.1016/j.ajog.2019.07.045

Peahl, A. F., Turrentine, M., Srinivas, S., King, T., & Zahn, C. M. (2023). Routine Prenatal Care. *Obstetrics and Gynecology Clinics*, *50*(3), 439–455. https://doi.org/10.1016/j.ogc.2023.03.002

Pediatrics, A. A. of. (n.d.). *Bright Futures Guidelines for Health Supervision of Infants, Children, and Adolescents*. Retrieved July 9, 2026, from https://publications.aap.org/aapbooks/monograph/478/Bright-Futures-Guidelines-for-Health-Supervision

Peinado-Molina, R. A., Ballesta-Castillejos, A., Martinez-Galiano, J. M., Cano-Ibáñez, N., Khan, K. S., & Martínez-Vazquez, S. (2025). Suicidal ideation during the perinatal period: An umbrella review of prevalence and risk factors. *Medicina de Familia. SEMERGEN*, *51*(7), 102567. https://doi.org/10.1016/j.semerg.2025.102567

Petruzzi, L., Yokananth, R., Rosenthal, M., Hudson, E., Harper, L., Valdez, C., & Burgermaster, M. (2025). Exploring the Immigrant Paradox: Nativity, Ethnicity, and Postpartum Mental Health Among Latinas in Central Texas. *Journal of Primary Care & Community Health*, *16*, 21501319251400706. https://doi.org/10.1177/21501319251400706

Piller, J., Orsini, L., Wiegrebe, S., Langbein, S. H., Burk, L., Zobolas, J., Studener, P., Goeswein, M., & Bender, A. (2026). Reduction techniques for survival analysis. *Lifetime Data Analysis*, *32*(2), 34. https://doi.org/10.1007/s10985-026-09714-0

Pluym, I. D., Holliman, K., Afshar, Y., Lee, C. C., Richards, M. C., Han, C. S., Krakow, D., & Rao, R. (2021). Emergency department use among postpartum women with mental health disorders. *American Journal of Obstetrics & Gynecology MFM*, *3*(1), 100269. https://doi.org/10.1016/j.ajogmf.2020.100269

PRENTICE, R. L., WILLIAMS, B. J., & PETERSON, A. V. (1981). On the regression analysis of multivariate failure time data. *Biometrika*, *68*(2), 373–379. https://doi.org/10.1093/biomet/68.2.373

Raftery, A. E. (1995). Bayesian Model Selection in Social Research. *Sociological Methodology*, *25*, 111–163. https://doi.org/10.2307/271063

Ramjith, J., Bender, A., Roes, K., & Jonker, M. (2022). Recurrent events analysis with piece-wise exponential additive mixed models. *Statistical Modelling*, *24*, 1471082X2211176. https://doi.org/10.1177/1471082X221117612

Rankin, L., Mendoza, N. S., & Grisham, L. (2023). Unpacking Perinatal Experiences with Opioid Use Disorder: Relapse Risk Implications. *Clinical Social Work Journal*, *51*(1), 34–45. https://doi.org/10.1007/s10615-022-00847-x

Redondo, M. M., Liebana-Presa, C., Pérez-Rivera, J., Martín-Vázquez, C., Calvo-Ayuso, N., & García-Fernández, R. (2025). Exploring Self-Perceived Stress and Anxiety Throughout Pregnancy: A Longitudinal Study. *Diseases*, *13*(4), 121. https://doi.org/10.3390/diseases13040121

Reid, H. E., Pratt, D., Edge, D., & Wittkowski, A. (2022). What makes a perinatal woman suicidal? A grounded theory study. *BMC Psychiatry*, *22*(1), 386. https://doi.org/10.1186/s12888-022-04015-w

Ribeiro, J. D., Franklin, J. C., Fox, K. R., Bentley, K. H., Kleiman, E. M., Chang, B. P., & Nock, M. K. (2016). Self-injurious thoughts and behaviors as risk factors for future suicide ideation, attempts, and death: A meta-analysis of longitudinal studies. *Psychological Medicine*, *46*(2), 225–236. https://doi.org/10.1017/S0033291715001804

Richmond-Rakerd, L. S., Milne, B. J., Houts, R. M., Davie, G., D'Souza, S., Goldman-Mellor, S., Khalifeh, L., Caspi, A., Moffitt, T. E., & Torvik, F. A. (2026). Mental health conditions are associated with increased risk of subsequent self-harm, assault and unintentional injuries in two nations. *Nature. Mental Health*, *4*(1), 102–111. https://doi.org/10.1038/s44220-025-00553-w

Riesthuis, P. (2024). Simulation-Based Power Analyses for the Smallest Effect Size of Interest: A Confidence-Interval Approach for Minimum-Effect and Equivalence Testing. *Advances in Methods and Practices in Psychological Science*, *7*(2), 25152459241240722. https://doi.org/10.1177/25152459241240722

RODRIGUEZ-CABEZAS, L., & CLARK, C. (2018). Psychiatric Emergencies in Pregnancy and Postpartum. *Clinical Obstetrics and Gynecology*, *61*(3), 615–627. https://doi.org/10.1097/GRF.0000000000000377

Ross, J. M., Barone, J. C., Tauseef, H., Schmalenberger, K. M., Nagpal, A., Crane, N. A., & Eisenlohr-Moul, T. A. (2024). Predicting Acute Changes in Suicidal Ideation and Planning: A Longitudinal Study of Symptom Mediators and the Role of the Menstrual Cycle in Female Psychiatric Outpatients With Suicidality. *The American Journal of Psychiatry*, *181*(1), 57–67. https://doi.org/10.1176/appi.ajp.20230303

Rossen, L. M., Womack, L. S., Hoyert, D. L., Anderson, R. N., & Uddin, S. F. G. (2020). The Impact of the Pregnancy Checkbox and Misclassification on Maternal Mortality Trends in the United States, 1999-2017. *Vital & Health Statistics Series 3, Analytical and Epidemiological Studies*, (44), 1–61.

Rudd, M. D. (2006). Fluid Vulnerability Theory: A Cognitive Approach to Understanding the Process of Acute and Chronic Suicide Risk. In *Cognition and suicide: Theory, research, and therapy* (pp. 355–368). American Psychological Association. https://doi.org/10.1037/11377-016

Şahin, A., Şahin, F., & Sezgin, L. (2026). Reconstruction of Identity and Meaning in the Postpartum Period: Women's Experiences of Social Vulnerability and Existential Transition—A Phenomenological Study. *Healthcare*, *14*(5), 693. https://doi.org/10.3390/healthcare14050693

Salihu, H. M., Dongarwar, D., Oduguwa, E., Atkinson, J. O., & Harris, T. B. (2022). Racial/Ethnic Disparity in Suicidal Ideation, Suicide Attempt and Non-suicidal Intentional Self-harm Among Pregnant Women in the United States. *Journal of Immigrant and Minority Health*, *24*(3), 588–596. https://doi.org/10.1007/s10903-021-01260-1

Schiff, D. M., Nielsen, T., Terplan, M., Hood, M., Bernson, D., Diop, H., Bharel, M., Wilens, T. E., LaRochelle, M., Walley, A. Y., & Land, T. (2018). Fatal and Nonfatal Overdose Among Pregnant and Postpartum Women in Massachusetts. *Obstetrics and Gynecology*, *132*(2), 466–474. https://doi.org/10.1097/AOG.0000000000002734

Schiller, C. E., Meltzer-Brody, S., & Rubinow, D. R. (2015). The role of reproductive hormones in postpartum depression. *CNS Spectrums*, *20*(1), 48–59. https://doi.org/10.1017/S1092852914000480

Schwartz, E., & Villa, J. K. (2025). Navigating the Postpartum Period: Hormonal Changes and Essential Care for Women. In *Postpartum Period for Mother and Newborn*. IntechOpen. https://doi.org/10.5772/intechopen.1008428

Sejer, C., Miskowiak, K. W., & Bjertrup, A. J. (2026). Emotional-cognitive differences during pregnancy: Adaptations for motherhood. *Infant Mental Health Journal*, *47*(1), e70046. https://doi.org/10.1002/imhj.70046

Servin-Barthet, C., Martínez-García, M., Paternina-Die, M., Marcos-Vidal, L., Martín de Blas, D., Soler, A., Khymenets, O., Casals, G., Prats Rodriguez, P., Pozo, O. J., Pretus, C., Carmona, S., & Vilarroya, O. (2025). Pregnancy entails a U-shaped trajectory in human brain structure linked to hormones and maternal attachment. *Nature Communications*, *16*(1). https://doi.org/10.1038/s41467-025-55830-0

Shum, M., Robertson, D., Ryus, C., & Tiyyagura, G. (2024). The Role of *International Classification of Diseases 10 Codes* in Intimate Partner Violence Surveillance: Examining the Sensitivity and Specificity of Current Practice. *Annals of Emergency Medicine*, *84*(2), 220–222. https://doi.org/10.1016/j.annemergmed.2024.03.019

Simpson, G. L. (2024). Gratia: An R package for exploring generalized additive models. *Journal of Open Source Software*, *9*(104), 6962. https://doi.org/10.21105/joss.06962

Smid, M. C., Stone, N., Baksh, L., Debbink, M. P., Einerson, B. D., Varner, M. W., Gordon, A. J., & Clark, E. A. (2019). Pregnancy-Associated Death in Utah: Contribution of Drug-Induced Deaths. *Obstetrics and Gynecology*, *133*(6), 1131–1140. https://doi.org/10.1097/AOG.0000000000003279

Sonenberg, A., & Mason, D. J. (2023). Maternity Care Deserts in the US. *JAMA Health Forum*, *4*(1), e225541. https://doi.org/10.1001/jamahealthforum.2022.5541

Spangaro, J., Koziol-McLain, J., Zwi, A., Rutherford, A., Frail, M.-A., & Ruane, J. (2016). Deciding to tell: Qualitative configurational analysis of decisions to disclose experience of intimate partner violence in antenatal care. *Social Science & Medicine*, *154*, 45–53. https://doi.org/10.1016/j.socscimed.2016.02.032

Spangaro, J., Rutherford, A., Koziol-McLain, J., Herring, S., & Zwi, A. B. (2021). “It’s not a yes or no question”: Disparities between women’s accounts of disclosing intimate partner violence and patient documentation in antenatal settings: A qualitative synthesis. *Psychology of Violence*, *11*(2), 155–163. https://doi.org/10.1037/vio0000367

Spitz, A. M., Deichen Hansen, M. E., Goldfarb, S. S., & Harman, J. S. (2025). Inequities and Missed Opportunities: A National Analysis of Emergency Department Visits for Pregnant Individuals with Mental Health and Substance Use Disorder. *Journal of Women’s Health*, *34*(7), 897–904. https://doi.org/10.1089/jwh.2024.0223

Steele-Baser, M. (2024). Intimate Partner Violence and Pregnancy and Infant Health Outcomes—Pregnancy Risk Assessment Monitoring System, Nine U.S. Jurisdictions, 2016–2022. *MMWR. Morbidity and Mortality Weekly Report*, *73*. https://doi.org/10.15585/mmwr.mm7348a1

Stone, S. L., Diop, H., Declercq, E., Cabral, H. J., Fox, M. P., & Wise, L. A. (2015). Stressful Events During Pregnancy and Postpartum Depressive Symptoms. *Journal of Women’s Health*, *24*(5), 384–393. https://doi.org/10.1089/jwh.2014.4857

Stoneburner, A., Lucas, R., F. Chestnut, J., Jones, E. E., & DeMaria, A. L. (2026). Nowhere to go: An overview of maternity care access across the U.S.. *Seminars in Perinatology, The New Normal: Post-Pandemic Perinatal Health Service Threats and Opportunities*, *50*(1), 152188. https://doi.org/10.1016/j.semperi.2025.152188

Suárez-Pinilla, P., Pérez-Herrera, M., Suárez-Pinilla, M., Medina-Blanco, R., López-García, E., Artal-Simón, J. Á., & de Santiago-Díaz, A. I. (2020). Recurrence of suicidal thoughts and behaviors during one year of follow-up: An exploratory study. *Psychiatry Research*, *288*, 112988. https://doi.org/10.1016/j.psychres.2020.112988

Tabb, K. M., Hsieh, W.-J., Gavin, A. R., Eigbike, M., Faisal-Cury, A., Hajaraih, S. K. M., Huang, W. D., Laurent, H., Carter, D., Nidey, N., Ryckman, K., & Zivin, K. (2020). Racial differences in immediate postpartum depression and suicidal ideation among women in a Midwestern delivery hospital. *Journal of Affective Disorders Reports*, *1*, 100008. https://doi.org/10.1016/j.jadr.2020.100008

Tabb, K. M., Huang, H., Valdovinos, M., Toor, R., Ostler, T., Vanderwater, E., Wang, Y., Menezes, P. R., & Faisal-Cury, A. (2018). Intimate Partner Violence Is Associated with Suicidality Among Low-Income Postpartum Women. *Journal of Women’s Health*, *27*(2), 171–178. https://doi.org/10.1089/jwh.2016.6077

Tabb, K. M., Pangori, A., Tilea, A., Sugg, G., Hall, S. V., Huang, H., Dalton, V., & Zivin, K. (2025). Perinatal outcomes among multiracial women compared to both Monoracial Majority and Minority groups in a Medicaid sample: 2017-2019. *Research Square*, rs.3.rs-6835988. https://doi.org/10.21203/rs.3.rs-6835988/v1

Taiwo, T. K., Goode, K., Niles, P. M., Stoll, K., Malhotra, N., & Vedam, S. (2024). Perinatal Mood and Anxiety Disorder and Reproductive Justice: Examining Unmet Needs for Mental Health and Social Services in a National Cohort. *Health Equity*, *8*(1), heq.2022.0207. https://doi.org/10.1089/heq.2022.0207

Takács, L., Putnam, S. P., Monk, C., Kaňková, Š., Ullmann, J., Abuaish, S., & Kreisinger, J. (2026). The course of women's emotions from early pregnancy to the postpartum period. *Journal of Reproductive and Infant Psychology*, *44*(2), 559–573. https://doi.org/10.1080/02646838.2025.2466622

Taylor, C. L., van Ravesteyn, L. M., van denBerg, M. P. L., Stewart, R. J., & Howard, L. M. (2016). The prevalence and correlates of self-harm in pregnant women with psychotic disorder and bipolar disorder. *Archives of Women's Mental Health*, *19*(5), 909–915. https://doi.org/10.1007/s00737-016-0636-2

Too, L. S., Spittal, M. J., Bugeja, L., Reifels, L., Butterworth, P., & Pirkis, J. (2019). The association between mental disorders and suicide: A systematic review and meta-analysis of record linkage studies. *Journal of Affective Disorders*, *259*, 302–313. https://doi.org/10.1016/j.jad.2019.08.054

Torrioni, P., Benfante, A., Bullaro, F., Cangelosi, M., & Zara, G. (2025). When Only Death Can Save Me! Understanding Suicidality in Women Victims of IPV Admitted to Emergency Departments: A Scoping Review. *Trauma, Violence, & Abuse*, 15248380251372151. https://doi.org/10.1177/15248380251372151

Trost, S. L., Beauregard, J. L., Smoots, A. N., Ko, J. Y., Haight, S. C., Moore Simas, T. A., Byatt, N., Madni, S. A., & Goodman, D. (2021). Preventing Pregnancy-Related Mental Health Deaths: Insights From 14 US Maternal Mortality Review Committees, 2008-17. *Health Affairs (Project Hope)*, *40*(10), 1551–1559. https://doi.org/10.1377/hlthaff.2021.00615

Tucker, J. N., Grzywacz, J. G., Leng, I., Clinch, C. R., & Arcury, T. A. (2010). Return to work, economic hardship, and women's postpartum health. *Women & Health*, *50*(7), 618–638. https://doi.org/10.1080/03630242.2010.522468

Tully, K. P., Stuebe, A. M., & Verbiest, S. B. (2017). The fourth trimester: A critical transition period with unmet maternal health needs. *American Journal of Obstetrics and Gynecology*, *217*(1), 37–41. https://doi.org/10.1016/j.ajog.2017.03.032

Tyson, D. P., Kelleher, K. J., & Chavez, L. J. (2022). Mental Health-related Utilization of Emergency Departments During Pregnancy in the U.S., 2016–2019. *Maternal and Child Health Journal*, *26*(10), 1953–1958. https://doi.org/10.1007/s10995-022-03487-2

US Preventive Services Task Force. (2023). Screening for Depression and Suicide Risk in Adults: US Preventive Services Task Force Recommendation Statement. *JAMA*, *329*(23), 2057–2067. https://doi.org/10.1001/jama.2023.9297

U.S. Preventative Services Task Force (USPSTF). (2016, January 26). *Archived: Screening for Depression in Adults | United States Preventive Services Taskforce*. https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/depression-in-adults-screening

Van Niel, M. S., Bhatia, R., Riano, N. S., de Faria, L., Catapano-Friedman, L., Ravven, S., Weissman, B., Nzodom, C., Alexander, A., Budde, K., & Mangurian, C. (2020). The Impact of Paid Maternity Leave on the Mental and Physical Health of Mothers and

Children: A Review of the Literature and Policy Implications. *Harvard Review of Psychiatry*, *28*(2), 113. https://doi.org/10.1097/HRP.0000000000000246

Vermillet, A.-Q., Tølbøll, K. B., Mizan, S. L., Skewes, J., & Parsons, C. (2022). Crying in the first 12 months of life: A systematic review and meta-analysis of cross-country parent-reported data and modeling of the "cry curve." *Child Development*, *93*(4), 1201–1222. https://doi.org/10.1111/cdev.13760

Wall, S., & Dempsey, M. (2023). The effect of COVID-19 lockdowns on women's perinatal mental health: A systematic review. *Women and Birth*, *36*(1), 47–55. https://doi.org/10.1016/j.wombi.2022.06.005

Wallace, M. E., Hoyert, D., Williams, C., & Mendola, P. (2016). Pregnancy-associated homicide and suicide in 37 US states with enhanced pregnancy surveillance. *American Journal of Obstetrics and Gynecology*, *215*(3), 364.e1-364.e10. https://doi.org/10.1016/j.ajog.2016.03.040

Walsh, C. G., Ribeiro, J. D., & Franklin, J. C. (2017). Predicting Risk of Suicide Attempts Over Time Through Machine Learning. *Clinical Psychological Science*, *5*(3), 457–469. https://doi.org/10.1177/2167702617691560

Wang, J., Kharrat, F. G. Z., Gariépy, G., Gagné, C., Pelletier, J.-F., Massamba, V. K., Lévesque, P., Mohammed, M., & Lesage, A. (2024). Predicting the Population Risk of Suicide Using Routinely Collected Health Administrative Data in Quebec, Canada: Model-Based Synthetic Estimation Study. *JMIR Public Health and Surveillance*, *10*, e52773. https://doi.org/10.2196/52773

Wood, S. (2000). *mgcv: Mixed GAM Computation Vehicle with Automatic Smoothness Estimation* (p. 1.9-4) [Dataset]. https://doi.org/10.32614/CRAN.package.mgcv

World Health Organization (WHO). (2025). *Trends in maternal mortality 2000 to 2023: Estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division*. https://www.who.int/publications/i/item/9789240108462

Xiao, M., Hu, Y., Huang, S., Wang, G., Zhao, J., & Lei, J. (2022). Prevalence of suicidal ideation in pregnancy and the postpartum: A systematic review and meta-analysis. *Journal of Affective Disorders*, *296*, 322–336. https://doi.org/10.1016/j.jad.2021.09.083

Xiao, M., Fu, B., Huang, S., Hu, Y., Tang, G., & Lei, J. (2023). Trajectories of perinatal suicidal ideation from early pregnancy to six weeks postpartum and their influencing factors: A prospective longitudinal study. *Psychiatry Research*, *328*, 115467. https://doi.org/10.1016/j.psychres.2023.115467

Yoon, J., Masoumirad, M., Bui, L. N., Richard, P., & Harvey, S. M. (2024). Prenatal opioid use as a predictor of postpartum suicide attempts among reproductive-age women enrolled in Oregon Medicaid. *BMC Women's Health*, *24*(1), 196. https://doi.org/10.1186/s12905-024-03019-w

Yu, H., Shen, Q., Bränn, E., Yang, Y., Oberg, A. S., Valdimarsdóttir, U. A., & Lu, D. (2024). Perinatal Depression and Risk of Suicidal Behavior. *JAMA Network Open*, *7*(1), e2350897. https://doi.org/10.1001/jamanetworkopen.2023.50897

Zarrin, H., Vargas-Torres, C., Janevic, T., Stern, T., & Lin, M. P. (2023). Patient Sociodemographics and Comorbidities and Birth Hospital Characteristics Associated With Postpartum Emergency Department Care. *JAMA Network Open*, *6*(3), e233927. https://doi.org/10.1001/jamanetworkopen.2023.3927

Zhang, L., Yang, Y., Li, M., Zhou, X., Zhang, K., Yin, X., & Liu, H. (2022). The prevalence of suicide ideation and predictive factors among pregnant women in the third trimester. *BMC Pregnancy and Childbirth*, *22*(1), 266. https://doi.org/10.1186/s12884-022-04590-6

Zivin, K., Zhong, C., Rodríguez-Putnam, A., Spring, E., Cai, Q., Miller, A., Johns, L., Kalesnikava, V. A., Courant, A., & Mezuk, B. (2024). Suicide Mortality During the Perinatal Period. *JAMA Network Open*, *7*(6), e2418887. https://doi.org/10.1001/jamanetworkopen.2024.18887