Exploring a Phenotype of Accelerated Aging in Midlife to Older Adult Women Survivors of Intimate Partner Violence

by

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Dedication

This dissertation is dedicated to survivors of violence, whose strength and resilience are reminders of hope. This work goes out especially to survivors, staff, and volunteers at Transition House in Cambridge, Massachusetts.

This work is also dedicated to Kelsey Palmer, my dear friend who articulated to me well before I was ever involved in the epidemiology of aging that "Aging is a privilege." Kelsey lost her life to cancer at age 29; her years were far too few, but her legacy is a reminder of the blessing of getting up there in years and doing it in style.

"But suddenly, there it is, right in front of you,
bright and vivid,
quietly waiting,
just as you imagined it would be."
- Shaun Tan, *The Red Tree*

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Abstract

Millions of women live with a history of intimate partner violence (IPV), having experienced physical, emotional, or sexual abuse from a current or former intimate partner. IPV confers unique health challenges to survivors, which can persist in the form of hypervigilance, chronic inflammation, and lingering physical and mental health conditions. Over time, survivors of intimate partner violence may exhibit an accelerated aging phenotype characterized by premature age-related disease development.

IPV is a significant and often chronic stressor and is explored in this dissertation as a contributor to the biological aging process by comparing the prevalence and trajectories of aging-related health outcomes between women who have and have not experienced violence from an intimate partner. This dissertation focuses on three outcomes: trajectories of the purported anti-aging hormone dehydroepiandrosterone-sulfate (DHEA-S), longitudinal changes in self-reported physical function, and mental health outcomes stratified by head injury status in IPV survivors. Each outcome influences health and quality of life: endocrine function can have serious implications for women's health through menopause, and low levels of DHEA-S may increase risk of cardiovascular disease and mortality; physical function is related to well-being and the ability to carry out meaningful activities and life roles; and head injuries, common and potentially harmful for mental health, may interact with the emotional and physiologic toll of IPV to lead to worse mental health outcomes.

Employing group-based trajectory modeling, mediation, mixed models, and retrospective chart review, this dissertation aims to make a meaningful contribution to the literature about the health effects of IPV in midlife and older adult women. Aim 1 modeled notable annual declines in DHEA-S after the final menstrual period (FMP) for the population but found levels and slope of DHEA-S were similar between women with and without a history of IPV. Aim 2 analyses indicate steeper decreases in longitudinal physical function scores for survivors as compared to their peers without a history of IPV, declines that are especially pronounced for survivors of sexual IPV. As physical function changes often occur in midlife, even before the menopausal

transition, physical function represents a modifiable condition that may be addressable in survivors. Aim 3 uses medical records to quantify mental health correlates of head injury, whether direct trauma or strangulation, in midlife to older women survivors of IPV. Survivors with a head injury from any source had higher odds of experiencing anxiety and post-traumatic stress disorder (PTSD), but not depression, while women with an IPV-related head injury had higher odds of PTSD. As head injuries and mental health conditions alike have been associated with faster biological aging but are treatable, these findings suggest a driver of aging and a point of intervention to support survivor health.

Endocrine health, physical function, and neurocognitive health are each critical to health and well-being for survivors; a threat to any of these systems, let alone multiple, can be devastating. When these impacts intersect with aging, survivors may face additional health challenges. Our bodies tell our stories, and whether intimate partner violence is one footnote or a chapter of that narrative, a survivor's health often reflects that experience. Even if IPV may have an outsized impact on health, survivors are much more than their histories; this work reiterates the charge to researchers and clinicians to better understand IPV-related population health effects and to support survivor health.

Chapter 1 A Framework for Understanding Intimate Partner Violence and Its Health Effects in Midlife to Older Adult Women

1.1 Shedding Light on the Epidemiology of IPV in Women

When intimate partner violence (IPV) is depicted, three elements are typically common: 1. The victim is a young, white woman., 2. She has a black eye., 3. She sits or stands in shadows. While there are many ways in which this portrayal represents only a segment of survivors[1] of IPV, there are several ways that this does reflect the reality of many experiences of IPV. *Women* are at higher risk of experiencing IPV and IPV-related consequences than men and are often *injured* in IPV, with the most common form of injurious assault being a hit or punch to the head, an injury that can lead to a black eye. Critically, intimate partner violence often happens in the proverbial dark, in circumstances that can be hard to notice and harder to truly confront. Though estimates of the true prevalence of IPV vary, one thing is certain: Too many people, let alone women, have lived with and will live with IPV, and many still feel the consequences even if the abuse subsides. This dissertation aims to shed light on the health challenges that may be associated with IPV in order for these challenges to be addressed.

Though IPV is exceedingly prevalent, violence often plays out far from the public eye. If there is hope for addressing IPV, which I believe there is, survivors' lived experiences must be acknowledged and brought to the forefront of scientific inquiry. While the stereotype of an IPV victim is a young woman in the shadows, survivors are much more heterogeneous in age, racial identity, and disability status than often depicted, and importantly, they live lives so much fuller than their abuse. This dissertation may serve as a small contribution towards making the health sequelae of IPV more tangible, urgent, and addressable.

[1] This dissertation uses the term "survivor" to refer to a person who has experienced intimate partner violence. This language moves away from terms like "victim" towards the empowerment of persisting through abuse. This language emerged from preferences of the survivor community.

1.1.1 Defining IPV and IPV Types

Intimate partner violence (IPV) is a pattern of harm committed by a current or former spouse or intimate partner that can have both short- and long-term health effects (Breiding et al., 2014). IPV is a common yet pernicious experience for many women[2] and has documented associations with a range of poor health outcomes. IPV takes on many forms, the most common being physical, psychological, and sexual violence. **Physical intimate partner violence** may include violent behaviors, like hitting, kicking, beating, threatening to use or using a weapon, that can lead to physical injury (Leemis et al., 2022). **Psychological intimate partner violence**, also called verbal or emotional abuse, encompasses yelling, threatening, or demeaning a partner, and also includes behavior intended to humiliate, isolate, or coercively control a partner. Emotional abuse is typically reported more frequently than physical abuse and may be more persistent or long-lasting than physical abuse. Previous research has also suggested that emotional abuse is particularly harmful to mental health (Jewkes, 2010; Pathak et al., 2019). **Sexual intimate partner violence** includes coerced sexual activity in the absence of consent (Bagwell-Gray et al., 2015). Like other forms of IPV, sexual violence is often meant to assert dominance over or control an intimate partner. Shown in Table 1-1, data from the National Intimate Partner and Sexual Violence Survey (NISVS), conducted in 2016-2017, indicate that, among women, emotional or psychological violence is the most common form of lifetime IPV (49.4%), followed by physical violence (42.0%) and sexual violence (19.6%) (Leemis et al., 2022). These figures translate to millions of women being affected by IPV in the United States each year and millions more affected across a lifetime. Women are more likely than men to experience IPV, be injured through IPV, and report an 'IPV-related impact', considered to be an experience of posttraumatic stress, police involvement, or disruption to work or education after IPV (Corrigan et al., 2003; Kwako et al., 2011; Leemis et al., 2022).

[2] The research for this dissertation focuses on cis-gender women. Existing research indicates that trans and non-binary populations may experience IPV and sexual violence at even higher rates than cis-gender women, making these populations especially important to include in research (Peitzmeier et al., 2020). Several researchers, including at the University of Michigan, are leaders in this field.

Table 1-1. Lifetime and Prior-Year Prevalence of US Women Affected by Several Types of Intimate Partner Violence

Type of Violence	Percentage of US women affected (Lifetime)	Number of US women affected (Lifetime)	Percentage of US women affected (Prior-year)	Number of US women affected (Prior-year)
Any physical or sexual violence	47.3%	59 million	7.3%	9 million
- **Physical violence**	42.0%	52 million	4.5%	5.6 million
- **Contact sexual violence**	19.6%	24.5 million	3.2%	4 million
- **Stalking**	13.5%	16.9 million	2.5%	3 million
Psychological violence	49.4%	61.7 million	6.7%	8.4 million

1.1.2 Capturing the Burden of IPV

Anyone with a current or past intimate partner is at risk for intimate partner violence, but not everyone has the same risk, which varies by geographical and cultural factors, as well as personal factors like race and ethnicity, education, and disability status. Globally, estimates of the burden of IPV varies by region, possibly due to cultural expectations of gender and relationships, normalcy of violence, and access to lethal weapons. While burden is often measured by the prevalence or incidence of IPV within a given group, time in a relationship with violence is another way to conceptualize IPV burden. A 2021 article quantified the expected number of years lived with IPV for women ages 15 to 49 in 151 countries (Gomez-Casillas et al., 2021). Overall, researchers found that women survivors in this age group would spend 4.1 years, on average, in a relationship with IPV, though estimates varied by region, ranging from 1.7 years to 6.0 years. Women survivors in the Americas, which includes Mexico, the United States, Canada, and countries in Central America, are expected to experience, on average, 2.6 years of IPV between ages 15 to 49. These are mind-boggling numbers: IPV is affecting millions of women across *years*, whether continuously or intermittently. If similar estimates were conducted in the latter part of midlife and older adulthood, it is likely that women would spend fewer years, on average, experiencing IPV over this time, but the enduring toll of living in a violent relationship for years can erode health even after the violence is over. Young adulthood and midlife, the years covered in this study, are often considered to be a person's "prime", the time of life when they are building their education and skill set, eligible to protect the nation through military service, or contributing to social safety nets, tax revenues, or raising the next generation of citizens. But these roles in young adulthood, however capitalistic and patriotic they may be,

are not the most important reason to ensure this group can live fewer years with IPV: Young adulthood and midlife can be both enjoyable *and* the prime time to set up better health in later adulthood. When IPV steals years of a person's life, the effects on an individual and societal level can be devastating, leading to worse health in later life.

In this vein, IPV can be incredibly costly, not just from a health perspective but literally from a financial perspective. Women who had a documented experience of violence in the United Health Clinical Research Database had higher medical costs and more visits as compared to their peers without a documented experience of violence (Kishton et al., 2022). Another analysis estimated costs for women and men affected by intimate partner violence, finding that women may expect costs, on average, of $103,767 across a lifetime, while costs for men were significantly lower, though still meaningful, at $23,414 (Peterson et al., 2018). On a societal scope, the combination of medical costs, lowered productivity, criminal justice encounters, and property loss totals over $3.5 trillion in 2014 dollars, a figure that is certainly even higher more than ten years later (Peterson et al., 2018). The human cost alone should be adequate drivers of solutions for IPV, but the staggering financial costs of IPV warrant solutions for advocates and policymakers.

1.1.3 Understanding IPV in Midlife and Older Adult Female Populations: Considering Past & Emergent Abuse

While most exposures to IPV in women occur well before menopause and women ages 18-24 are at highest risk of IPV, women still experience intimate partner violence in older ages, belying the harmful narrative that older adults can "age out" of abuse (Black, 2011; Temple, 2018). A narrative review from Pathak et al. (2019) gathered studies reporting the prevalence of recent exposure to IPV for women in midlife and older ages from across the globe; estimates of prevalence of current or recent abuse spanned 2.0% to 28.5%, indicating that women in midlife and older adulthood are still at risk for IPV and merit screening and care.

There are also special considerations for women in different age groups. A chapter published in *Essential Health Care Services Addressing Intimate Partner Violence* notes that IPV challenges differ by age group (National Academies of Sciences, 2024). For survivors in midlife, considerations may include postpartum challenges, anxiety and depression, substance use, and injuries to the head and neck (Bacchus et al., 2018; National Academies of Sciences, 2024; V. Wu et al., 2010). For older adult women, anxiety and depression remain considerations,

but physical injuries are less common and postpartum challenges are no longer a focus (Cook et al., 2011; National Academies of Sciences, 2024). Next, there are several factors that often emerge in midlife that have been associated with an increased risk of experiencing violence; these factors, including frailty, having a disability, and major life changes like retirement, menopause, children moving out of the home, or changes in health status, may be milestones for clinicians to inquire about relationship safety (Buchbinder & Winterstein, 2003; dos Santos Gomes et al., 2018; Hightower et al., 2008; Montminy, 2005; Pathak et al., 2019; Strezova et al., 2017). These experiences are also important because they often carry additional psychological weight, whether through confronting the end of reproductive capacity during menopause or restructuring daily routines when a child moves away. If these life shifts also coincide with an increased risk of IPV, the violence may compound the distress already experienced from these changes.

Additionally, past trauma exposure, including a history of physical and psychological abuse in earlier adulthood or even abuse in childhood, increases a person's likelihood of experiencing IPV as an older adult (Policastro & Finn, 2017). This linkage of abuse exposures reflects Ben-Shlomo and Kuh's conception (2002) of the 'chains of risk model,' echoed by Glymour and Manly (2008), where a person is "at risk of risk" because of a harmful earlier exposure. Being abused in childhood or even witnessing abuse in childhood can normalize this behavior. This may make a person more tolerant of abusive conduct and thus more likely to stay in an violent relationship later in life or not recognize the abuse as harmful and unacceptable (Bensley et al., 2003; Whitfield et al., 2003). This 'chains of risk' model is also relevant when considering survivors' lived circumstances on a day-to-day basis. Survivors often encounter financial difficulties, as their abusive partners may restrict access to finances as another form of control (Acierno et al., 2010). Survivors may be also more likely to have depressive symptoms or use alcohol or tobacco as coping mechanisms, all of which can negatively affect a person's health (Bacchus et al., 2018; Breiding et al., 2008; Devries et al., 2014; Jun et al., 2008; Øverup et al., 2015). When their risk factors for poor health accumulate over time, survivors may be at increased probability of lower perceived physical health, mental health, and activity limitations (Sanz-Barbero et al., 2019). Knowing that these vulnerabilities may in turn be associated with a greater risk for IPV furthers the importance of articulating the experiences of female older adult survivors.

1.1.3.1 Distinguishing IPV from Elder Abuse and Sexual Abuse

Unfortunately, intimate partner violence is not the only type of violence that is prevalent among older adults, including older women. **Elder abuse** is also common, with a national survey from the mid 2010s estimating that at least one in ten older adults has experienced some kind of abuse, whether an act of neglect or physical, emotional, or sexual mistreatment, by another person (Rosay & Mulford, 2017). A later survey reported that the prevalence of elder abuse increased during the SARS-CoV-2 global pandemic (Chang & Levy, 2021). The World Health Organization defines elder abuse as "a single or repeated act, or lack of appropriate action, occurring within any relationship where there is an expectation of trust, which causes harm or distress to an older person" (*Abuse of Older People*, 2022). Elder abuse can occur in the context of an intimate relationship, but it can also be perpetrated by caretakers, family members, acquaintances, or strangers (Desmarais & Reeves, 2007; Temple, 2018). Importantly, women may experience both IPV and elder abuse, whether concurrently or separately. The current dissertation focuses on abuse by an intimate partner but acknowledges that this type of abuse may overlap with elder abuse. Similarly, sexual violence, or sexual acts carried out in the absence of consent or with a person who is unable to consent, is a common experience for women, including older adult women (Basile & Saltzman, 2002). Sexual violence can occur in the context of an intimate partnership but can also be perpetrated by a person other than a current or past intimate partner. Neither elder abuse nor the latter form of sexual violence is explicitly included in this dissertation, meaning that the health effects only from violence perpetrated by an intimate partner can be measured. This is important to note for two reasons: first, because sexual violence perpetrated by an intimate partner may have distinct and/or overlapping sequelae compared to sexual violence perpetrated by an acquaintance or stranger or compared to elder abuse; second, women in this dissertation's study populations have undoubtedly experienced sexual violence perpetrated by non-intimate partners and potentially some have experienced elder abuse. In this way, women included in this dissertation may be categorized as not having a history of IPV but may have experienced elder abuse or sexual violence; however, women who are categorized as unexposed to IPV but have a history of another kind of abuse may be experiencing poor health effects due to that abuse. While disentangling these effects are beyond the scope of this dissertation, continued research into effects of elder abuse and sexual abuse are merited and run parallel to this dissertation.

1.1.3.2 The Aging of the Population

Projections of demographic trends in the United States indicate that the population of adults 65 years of age or older is rapidly increasing, with the number of older adults having increased by 34% between 2012 and 2022, while the population under 65 increased by 2% in the same time span (Administration for Community Living, 2021). In the years ahead, there will be both a larger number of older adult women in the US and also a higher proportion of older adult women in the population. Given that first exposure to IPV happens before age 25 in over 70% of survivors, there will be an influx of women entering midlife with a history of IPV, many of whom have lived with a history of IPV for decades (Leemis et al., 2022). In other words, both the number of women aging with the history of IPV and the number of years spent living with a history of IPV are substantial. Furthermore, older adult women are still at risk for intimate partner violence, especially if they have a history of abuse or are part of certain sociodemographic groups (e.g. immigrants, victims of abuse in childhood, communities with less access to education) which have been associated with an inequitably higher risk of violence (Sanz-Barbero et al., 2019). This growing tide of older adults with a history of IPV *and* at risk for IPV necessitates further research to understand and address the unique health challenges that older adult women may face related to IPV.

1.1.4 Assessing Long-term Impacts: Considering Weathering from IPV and Intersectionality with Social Identity

Examining the effect of violence in a longitudinal cohort of women in midlife, who may be years past an initial exposure of IPV, can capture health effects from IPV that may emerge after many years. This is important too because, as more time passes since the experience of IPV, women may be less likely to seek healthcare for conditions related to IPV (Campbell, 2002). Thus, capturing IPV experiences in a research setting like a cohort study is useful to understand the longitudinal health outcomes associated with IPV that may not be otherwise captured in a clinical setting where, unless the person is presenting for IPV, assessing IPV exposure history may not be a high priority.

Risk for IPV differs by several sociodemographic and economic factors, including race/ethnicity, educational attainment, income and employment status, and history of abuse (Campbell, 2002; Sanz-Barbero et al., 2019). In the most recent NISVS that gathered data between 2016-2017, women who were Black, American Indian/Alaska Native (AI/AN), or

multiracial reported higher lifetime prevalence of IPV compared to non-Hispanic white women (Leemis et al., 2022). Violence is of course not the only hardship that non-white women are more likely to experience than white women; non-white women face heightened risk of chronic health conditions because of greater exposure to stressors like racism, ableism, and financial strain (Geronimus, 2000; Kaestner et al., 2009; Lindsey, 2022; Pearson, 2008). There may also be interactive effects between these factors, which are unduly experienced by non-white groups, and IPV, thus worsening health consequences. While violence is often thought of on an individual scale, there are societal, political, and cultural factors that are violent toward women and can influence how they experience IPV; in other words, forces beyond the individual, whether capitalism, racism, or sexism, can perpetuate violence by conferring socially patterned disadvantages. Violent institutions have been in this country since before its founding, and as a minoritized group, women often face discrimination and dismissal relegating them to second-class citizenship, whether it is rejecting their stories of harassment or assault (e.g. backlash against the #MeToo movement) or normalizing a culture that enables male dominance. For women from minority racial groups or disadvantaged socioeconomic group, there is an additionally high cost of coping with everyday stressors, which may worsen health effects of violence. Understanding how educational attainment, financial stability, housing access, neighborhood investment, and the like are socially patterned is essential for understanding the more subtle but very real violence and discrimination waged on minority groups and how these factors both influence health and can be associated with intimate partner violence.

The importance of articulating the burden of IPV, whether in population prevalence, financial costs, lost productivity, or years lived with IPV, is not just that many women have a history of IPV but that IPV can enact a significant toll on health over time. Importantly, while people of any age may experience violence, more than 98% of female survivors in the United States were first exposed to IPV before age 45 (Leemis et al., 2022). This means, given that nearly half of women have experienced a form of intimate partner violence over their lifetime, **a significant proportion of women in the US will enter midlife with a history of IPV**. For some, the experience of IPV will be years in the past while for others, IPV will have been experienced regularly and will have escalated over time, remaining as a driver of health outcomes in the midlife period (Bonomi et al., 2007). For women, the midlife stage is a vulnerable time for health outcomes due to the rapid psychological and physiologic changes

related to the menopausal transition (Sowers et al., 2000). Thus, having experiences of IPV prior to or during this time may have detrimental ramifications for women's health into midlife and older adulthood. While there is existing research in women in midlife who have experienced IPV, there is much more to understand in midlife to older adult survivors, particularly regarding whether IPV contributes to an accelerated aging phenotype. In other words, does the experience of violence exert a strong enough bearing on health to be seen in the physiology of survivors? Do these outcomes result in worse health in survivors than their peers without abuse? That said, "accelerated aging" is a trendy and provocative but often vague term; rather than attempting to characterize an overall phenotype of accelerated aging, this dissertation will explore the prevalence and, when possible, age of onset of three health conditions that are related to aging and compare outcomes between survivors and women without a history of IPV.

IPV can have deleterious consequences for many dimensions of health, including physical health and mental health, which are intimately tied to morbidity and mortality. For women in midlife and older ages, IPV is a particularly important exposure to consider for two reasons: 1. Health effects of violence can continue to emerge long after an initial experience of IPV, and 2. While younger women are more likely to experience abuse, IPV still occurs in older adult women. In this way, examining the health effects of IPV in a cohort of midlife-to-older adult women is a pressing need and may illuminate another driver of poor health in midlife and older adulthood.

1.2 Health Effects of IPV: Known Consequences and Identified Gaps + Conceptual Model

Intimate partner violence is a pernicious driver of population health and has been implicated in a wide breadth of physical and mental health outcomes. These outcomes may contribute to an "accelerated aging" model, wherein women in midlife or older adulthood who have a history of IPV may experience, in greater numbers and at earlier ages, health conditions that are common among their *older* peers *without* a history of IPV, a manifestation of biological age outpacing chronological age. That said, accelerated aging is difficult to quantify because of the range of factors that contribute to aging and because there is no agreed-upon and widely used standard for measuring biological aging (Margolick & Ferrucci, 2015). There have been efforts to quantify accelerated aging through measurements of telomere length or DNA methylation clocks, but these methods remain costly and challenging to implement on a broad scale. Considering several aspects of aging together – measures of function, like physical function or

cognitive performance, along with levels and slopes of aging related biomarkers – can be indications of a faster aging process if these measurements indicate onset of domain-specific disability at earlier ages or domain-specific scores that are outside of the typical range for a particular age. Furthermore, if IPV and its correlates are drivers of a higher prevalence in survivors of adverse health conditions associated with poorer health over time, there may be additional evidence that IPV can hasten the aging process.

Characterizing an accelerated aging phenomenon in vulnerable groups is important because health in older adulthood is set up in midlife. Put simply, factors in midlife have a strong bearing on what health looks like ten or twenty years later. If women with a history of IPV do indeed reflect more rapid aging than their peers, survivors are at risk for poorer health in earlier ages, which has serious implications for quality of life and health. The next sections describe commonly reported health effects of IPV and the present gaps in the literature.

1.2.1 Health Effects of Intimate Partner Violence

The physical health effects of IPV are perhaps the most widely documented consequences of IPV. Prior literature has characterized specific injuries and health conditions in survivors, some of which are a direct result of IPV and others which may be a result of the cumulative stress of experiencing IPV. Injuries that are a direct result of IPV include broken bones; lacerations or tears in soft or connective tissue like skin, ligaments, and tendons; and traumatic brain injuries (Coker et al., 2000; Leemis et al., 2022). Specific physical health conditions can include chronic pain, changes in sensory function (e.g. vision and hearing), hypertension, cardiovascular disease, stomach ulcers, irritable bowel syndrome (IBS), and reduced immune function, which may lead to greater likelihood of chronic conditions in the long-term (Chandan et al., 2020; Coker et al., 2000; Constantino et al., 2000; Kwako et al., 2011; Leserman et al., 1998; Perona et al., 2005; Thurston et al., 2022; Wuest et al., 2008). IPV can also lead to changes in neurologic function including decreased neuronal repair and smaller hippocampal volume, which are especially important to consider in light of survivors' risk for strangulation and traumatic brain injury (Bergin et al., 2022; Kwako et al., 2011).

Intimate partner violence has also been associated with harmful consequences for reproductive health, including greater risk for urinary tract infections (UTIs), sexually transmitted infections (STIs), including Human Immunodeficiency Virus (HIV), or unwanted pregnancy (Raphael et al., 2022; Sharman et al., 2019; Stubbs & Szoeke, 2022; Sullivan, 2019).

Survivors of IPV also report more frequent pelvic pain and worse symptoms of menopause than those who have not experienced IPV (Coker et al., 2000; Ferreira et al., 2025; Gibson et al., 2019; Raphael et al., 2022; Stubbs & Szoeke, 2022). In studies of menopausal symptoms in survivors, different types of violence were associated with the worsening of different menopausal symptoms; both emotional and physical IPV were linked with night sweats, but only emotional IPV was associated with difficulty sleeping. Sexual IPV was associated with worse vaginal symptoms, including dryness and irritation, which are already common in postmenopausal women (Gibson et al., 2019).

Chronic inflammation is a physiological effect of violence and a potential culprit for the chronic health effects that survivors often face (Chrousos, 2000). Being in a relationship with an abusive individual can lead to near-constant activation of a person's threat-reaction system, including the hypothalamic-pituitary-adrenal (HPA) axis, further described in Chapter 2. If a person is unable to rest and restore away from an activating threat, the chronic cascade of stress hormones lead can to inflammation, increasing the risk for chronic conditions (Geronimus, 2023). Inflammatory markers may be inversely associated with levels of DHEA-S, a theoretical basis for Chapter 2, and elevated levels of these markers are also positively associated with worse pain tolerance and potentially poorer physical function, a possible driver for the hypothesized relationship explored in Chapter 3 (Brinkley et al., 2009; Prall & Muehlenbein, 2018).

Furthermore, increased inflammation has been associated with worse symptoms of depression, anxiety, and PTSD, which could be exacerbated by a head injury sustained by a survivor. Studies show markedly worse mental health outcomes for women who have experienced IPV compared to women who have never experienced IPV. IPV survivors, both those who have experienced physical IPV and psychological IPV together and those who experienced psychological IPV alone, had greater incidence of posttraumatic stress disorder (PTSD), suicidal ideation (SI), and worse symptoms of depression and anxiety (Coker et al., 2000; Pico-Alfonso et al., 2006). In recent years, there has been greater appreciation for the role that head and neck trauma can play in a survivor's mental and physical health, and as such, mental health conditions are explored as the outcome of head injuries in survivors in Chapter 4 of this dissertation (Esopenko et al., 2024).

1.2.2 Gaps in the Literature

While there is an extensive and growing body of research on health effects of IPV, more research in older adult female populations is needed to support older adult survivors. Older adulthood comes with its own set of challenges for women, whether declines in reproductive hormones, cognitive performance, or a greater risk of Alzheimer's Disease (Grummisch et al., 2023; Karlamangla et al., 2017; Levine et al., 2021; Rajan et al., 2021); for survivors of IPV, these challenges in older adulthood may be even harder because of past or present IPV. Endocrine and functional changes stemming from IPV are of interest in addressing health concerns of survivors, but fewer papers have characterized challenges in endocrine function and physical function more broadly in a cohort of midlife to older adult women, particularly in women moving through the menopausal transition. This dissertation will contribute to the literature by using data from a prospective cohort of women who were premenopausal at the initiation of the study and have since progressed through menopause. SWAN is responsible for much of the seminal work on hormonal trajectories in women, including those for DHEA-S, but trajectories of DHEA-S have not been mapped when all participants are post-menopausal, which helps to characterize changes before and after the final menstrual period (Crawford et al., 2009; Lasley et al., 2011). While there has been some literature comparing DHEA-S levels for women who have and have not experienced partner violence, no studies have mapped trajectories over decades while moving from pre-menopausal to post-menopausal in all women. Trajectories of DHEA-S matter because reduced DHEA-S levels have been associated with poorer health and increased mortality (Shufelt et al., 2010). Investigating whether IPV influences DHEA-S levels offers insight into another potential mechanism of the often poorer health of IPV survivors.

The Women's Health Initiative (WHI) team undertook an analysis of self-reported physical function trajectories in post-menopausal women, finding that survivors of IPV had levels of physical function comparable to their peers twenty years older but that similar declines in function occurred between women with and without a history of IPV. Analyses of physical function trajectories in Chapter 3 account for menopausal stage while also examining changes in function across a longer time period and by type of IPV. This chapter adds to the literature by demonstrating that effects of IPV may be long-lasting and that type of IPV may influence health outcomes. Together, Chapters 2 and 3 help to capture the physiological complexity of this point in the life course. Both IPV and menopause can bring expected and unexpected challenges in a

woman's life, including changes in physical function, alterations in roles, identity, and life circumstances. Understanding the interaction between IPV and the changes that come with menopause is vital for supporting the health of survivors, especially as they move through midlife into early older adulthood.

Additionally, a growing body of literature focuses on head injuries in survivors of intimate partner violence, but more epidemiological data examining the potential effects of head injury in survivors, whether from IPV or another source, is needed (Corrigan et al., 2003; Esopenko et al., 2024; Kwako et al., 2011). This dissertation adds to the literature by gathering data on head injury in survivors from 640 medical records from a large teaching hospital in Michigan. The medical records abstraction links injuries from head trauma and strangulation with odds of mental health outcomes like anxiety, depression, and PTSD, providing insight into whether an IPV survivor with a head injury may have higher odds of a mental health condition.

Figure 1-1 shows a simplified conceptual model for the relationship between structural, community, interpersonal, and individual factors and IPV, as well as the hypothesized relationships between IPV, physiologic factors, functional changes, IPV sequelae, and an accelerated aging phenotype.

1.3 Specific Aims and Hypotheses

1.3.1 Overarching Question

Do women who experienced intimate partner violence exhibit hallmarks of an accelerated aging phenotype, characterized by decreased levels of DHEA-S, steeper declines in physical function, and higher prevalence of mental health conditions after a head injury? Do these longitudinal changes or prevalence of conditions vary by type of IPV?

1.3.2 Aim 1 – Intimate Partner Violence & Trajectories of Dehydroepiandrosterone-sulfate

Levels of the hormone dehydroepiandrosterone (DHEA) and its sulfated form dehydroepiandrosterone-sulfate (DHEA-S) may change in response to stressful events, including intimate partner violence (Pico-Alfonso et al., 2004). DHEA-S supports a wide range of bodily functions, including the maintenance of skeletal health, cognition, mood, and cardiovascular health; abnormal levels of DHEA and DHEA-S, especially levels that are too low, have been associated with poorer outcomes and function in these domains (Cappola et al., 2009; Jiménez et al., 2013; Murialdo et al., 2000; Rutkowski et al., 2014; Thijs et al., 2003; T. T. Wu et al., 2017).

Thus, while DHEA and DHEA-S begin to naturally decrease in circulation after early adulthood, maintaining adequate levels of DHEA and DHEA-S may support overall health and wellbeing. While both hormones appear to have bioactivity in the body, DHEA-S is a much more abundant hormone than DHEA and frequently serves as a general proxy for levels of DHEA, given its longer (i.e. more stable) half-life and its rapid and frequent transformation from DHEA into DHEA-S by the enzyme sulfuryl transferase (Placzek, 2017).

As DHEA-S is linked to both physical and psychological health, levels and production of DHEA-S may be affected on numerous fronts by a stressor like IPV. In this way, women with a history of IPV may reflect a distinct trajectory of DHEA-S, both in initial levels of the hormone and also in the slope of DHEA-S over time. If survivors' trajectories of DHEA-S have a lower intercept or faster decline, this work can help tie together experiences of violence and their effects on the endocrine system across and after menopause. Clinically, this work offers opportunities to monitor and address aspects of endocrine function in survivors, given the apparent link between DHEA-S levels and many aspects of health. Thus, it is plausible that DHEA-S trajectories are a signal of overall health and a manifestation of the experiences of IPV.

Group-based trajectory modeling (GBTM) and linear mixed models are used to chart longitudinal changes in levels, slope, and variability of the hormone DHEA-S in 428 women from two sites of the SWAN cohort. This aim examines whether women who had ever experienced IPV are more likely to be categorized into a particular DHEA-S trajectory group.

Hypothesis 1: In all trajectory groups, levels of DHEA-S will decline across menopause and continue declining after the final menstrual period.

Hypothesis 2A: Women who report an experience of **IPV in their lifetime** will be more likely to have lower levels of DHEA-S at baseline than women who did not report IPV in their lifetime.

Hypothesis 2B: Women who report an experience of **IPV in their lifetime** will be more likely to be in the DHEA-S trajectory group with the lowest starting level and consistently low level of DHEA-S.

Hypothesis 3: Women who report **lifetime IPV** will be more likely to have greater declines in DHEA-S slope through menopause than women who did not report lifetime IPV.

1.3.3 Aim 2 – Intimate Partner Violence and Associations with Physical Function

Aim 2 seeks to understand whether midlife and older adult women who experienced lifetime IPV are at increased risk of poor physical function or experience more rapid declines in physical function as compared to women with no experience of IPV. Analyses will also consider type of IPV as having distinct associations with changes in function across time. The proposed work in this aim makes an important contribution to understanding how physical function may change across and beyond menopause in women who have and have not experienced IPV, as few papers have examined this in a cohort of older adult women. An analysis conducted in the Women's Health Initiative found that women who had experienced physical interpersonal violence reflected the physical function status of their cohortmates two decades older (Cannell et al., 2015). Moreover, psychological violence can also have long-term effects on function, as evidenced by participants who experienced psychological violence and reported decreased function even a year later (Sanz-Barbero et al., 2019). Looking at function through the menopausal transition is essential, as menopause-associated changes in metabolism, bone health, and muscle strength are often reflected in changes in function and activity through the menopausal transition, changes which may be even more pronounced in women with a history of IPV. As physical function has been associated with decreased ability to live independently and greater risk of developing diabetes, heart attacks, osteoporosis, frailty, and early mortality, understanding whether IPV contributes to poorer function is important for supporting survivor health (Karvonen-Gutierrez, 2015; Pope et al., 2001).

Hypothesis 1: Women who reported a **lifetime experience of IPV** will have lower baseline scores of physical function, as measured by the SF-36, than SWAN women who did not report lifetime experiences of IPV.

Hypothesis 2: Women who reported a **lifetime experience of IPV** will have greater declines across study visits in scores of physical function, as measured by the SF-36, than SWAN women who did not report lifetime experiences of IPV.

Hypothesis 3: Women who reported **lifetime physical IPV** will have steeper declines in physical function than women who experienced lifetime sexual or psychological IPV.

Hypothesis 4: **Bodily pain, depressive symptoms, and financial strain** will partially mediate any association between IPV and physical function scores.

1.3.4 Aim 3 – Head Injuries and Mental Health Sequelae in Survivors of IPV

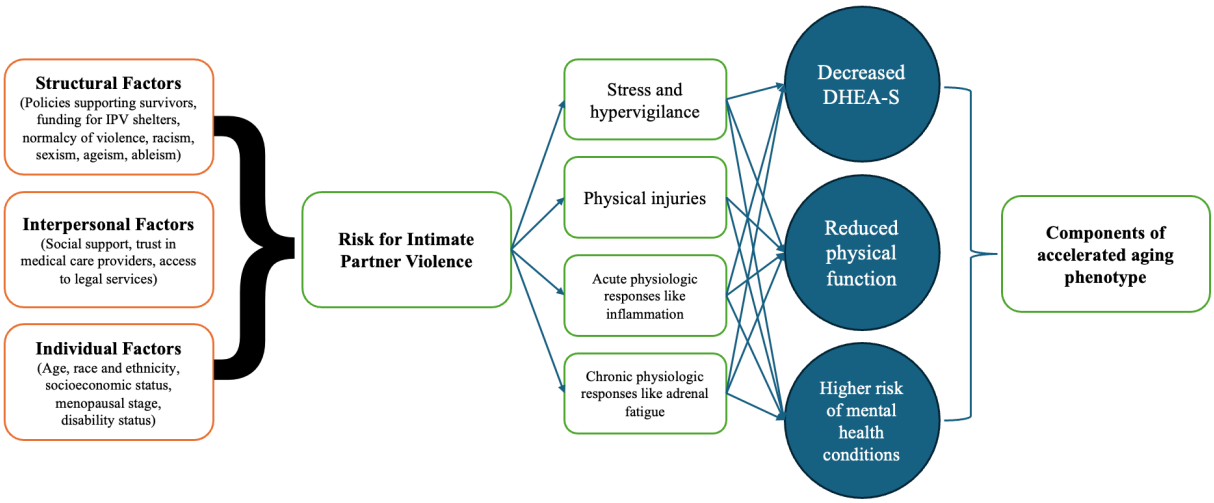
Head injuries, whether through direct trauma to the head or strangulation, are a common occurrence in the course of intimate partner violence and have been associated with poorer health for survivors (Esopenko, et al., 2024). However, few papers have examined the phenomena of head injury, both from IPV and other origins (e.g. falls, motor vehicle crashes), in midlife and older adult survivors of partner violence while also examining mental health outcomes like anxiety, depression, and posttraumatic stress disorder (PTSD).

Aim 3 explores the relationship between these mental health outcomes and head injuries of IPV and non-IPV sources in a cohort of IPV survivors using electronic health record (EHR) data from Michigan Medicine. This aim compares prevalence of depression, anxiety, and PTSD in women with documented IPV and explores head injury, both from IPV and from sources other than IPV, as a contributor to the mental health condition burden in survivors of IPV.

> *Hypothesis 1:* Women whose medical records documented **IPV** + an **IPV-related head injury** will be more likely to have a mental health condition (depression, anxiety, or PTSD) compared to women without a head injury, and compared to women with a head injury from another source.
> *Hypothesis 2:* Women whose medical records documented **strangulation in the context of IPV** will be more likely to have a mental health condition (depression, anxiety, or PTSD) than women without strangulation.

Together, these aims represent the foundation for work exploring a hypothesis of accelerated aging in women who have experienced IPV. The first two aims utilize the strength of the SWAN cohort study, while the third aim leverages the rich medical record data of Michigan Medicine patients. Together, this dissertation aims to add to collective knowledge on possible health effects of IPV, especially as they relate to the health of midlife-to-older adult women, and build the evidence base for the continued importance of studying the health effects of IPV, even years after initial exposure.

Figure 1-1. Conceptual Model for Dissertation



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Chapter 2 Relationship of Intimate Partner Violence and Dehydroepiandrosterone-Sulfate Trajectories in a Cohort of Midlife and Older Adult Women

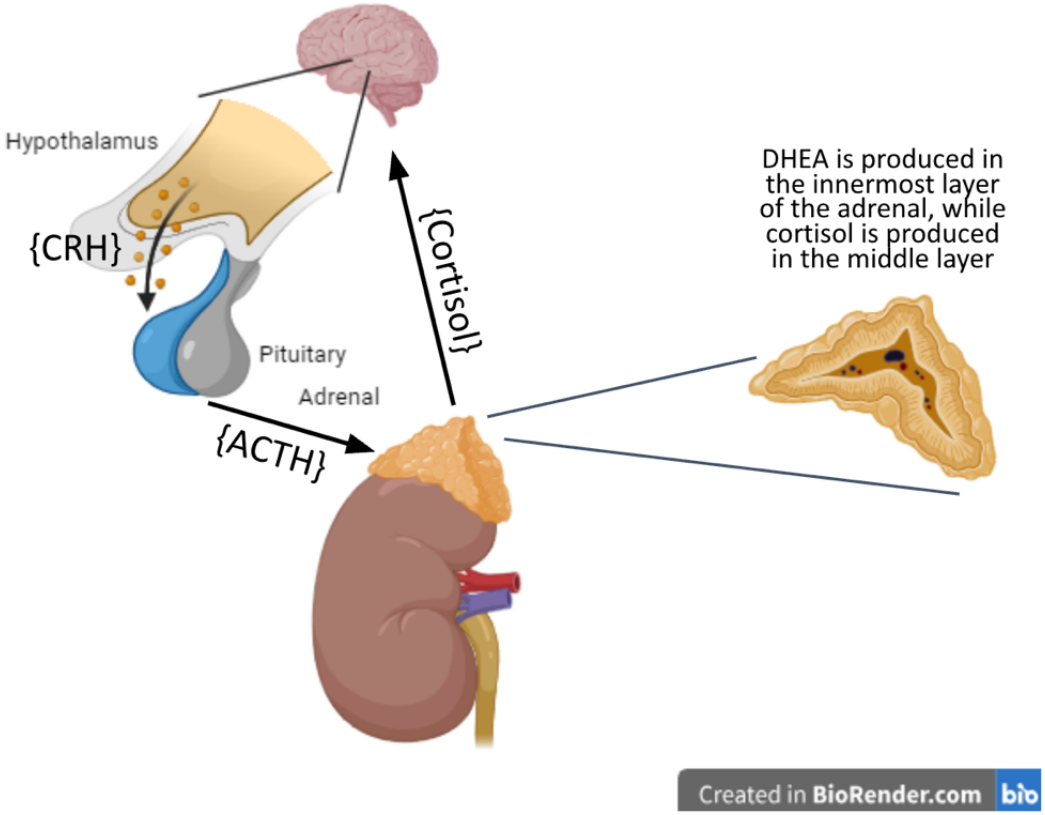
Intimate partner violence (IPV) is violence committed by a current or former spouse, dating partner, or sexual partner (Leemis et al., 2022). Experiences of IPV can take many forms, including physical violence, psychological coercion, verbal abuse, financial abuse, and/or sexual violence. IPV is the most common form of violence against women globally, with approximately one in three women experiencing IPV in their lifetime (García-Moreno, 2013). IPV is a risk factor for adverse health consequences, including physical injury, mental health challenges, and chronic conditions for survivors (J. C. Campbell, 2002; Ellsberg et al., 2008; Goldberg et al., 2021). IPV is rarely a one-time experience; many women report multiple episodes of violence and/or multiple forms of IPV throughout a violent partnership (Ferraro & Johnson, 1983; Pagelow, 1981). Verbal abuse or psychological coercion are consequential in and of themselves, and often escalate to more overt forms of violence like physical abuse or sexual violence, though intimate partnerships can also include physical or sexual violence without psychological abuse (Hacıaliefendioğlu et al., 2020; Leemis et al., 2022).

2.1 Background

IPV, whether a one-time or repeated experience, can be a chronic stressor for survivors. The deleterious health effects of chronic stress have been well-documented (Geronimus et al., 2006; Guilliams & Edwards, 2010; McEwen, 1998; McEwen & Wingfield, 2003) and include hypertension (Spruill, 2010), cardiovascular events (Muller et al., 1989), inflammation (Chrousos, 2000), diabetes (Merabet et al., 2022), and depression (Slavich & Irwin, 2014) and anxiety (Bystritsky & Kronemyer, 2014). Even with a growing body of literature detailing the harmful effects of IPV, more research is needed to characterize dimensions like endocrine health in a population of older adults. This paper examines trajectories of the hormone dehydroepiandrosterone-sulfate (DHEA-S) through and beyond the menopausal transition, while exploring whether IPV influences DHEA-S levels and slope.

Chronic stress enacts a physiologic toll on the body through numerous pathways, including the hypothalamic-pituitary-adrenal (HPA) axis, which is designed to respond to threats or challenges and, once the stressor has passed, return the system to baseline to maintain homeostasis (Figure 2-1). A stressor, whether real or anticipated, contemporary or recalled, triggers the brain's fear response, governed by the amygdala, and begins a cascade of hormones and physiologic responses to signal the paraventricular neurons, located in the hypothalamus, to secrete corticotropin-releasing hormone (CRH) (Chrousos, 2000). Through the hypophysial portal system network of capillaries linking the hypothalamus and the pituitary, CRH signals the corticotropic cells of the anterior pituitary gland to release adrenocorticotrophic hormone (ACTH), which travels through the bloodstream to the adrenal glands, promoting the release of glucocorticoids, including cortisol, from the adrenal gland's *zona fasciculata* (Rainnie & Ressler, 2009; Sturgeon, 2018).

Figure 2-1. Hypothalamus-Pituitary-Adrenal Axis



The release of adrenal glucocorticoids, including epinephrine and norepinephrine, into the bloodstream initiates physiologic responses throughout the body to manage the stressor, known as the 'fight or flight' response (Chrousos, 2000). These physiologic responses, known as

adaptive functions, include dilation of blood vessels, slowed digestion, waste elimination, and glucose release from glycogen stored in the liver and skeletal muscles. These activities allow for the prioritization of energy towards essential actions needed to fight or flee (Herman et al., 2016; McCarty, 2016). When in this state of heightened arousal, the body's heart rate, respiration, and muscle contractility increase, and a person may feel more alert, reactive, and tolerant of pain. Although this response is advantageous in the short term, chronic activation of the stress-response system drains energetic resources and can lead to dysregulation of the HPA axis. Manifestations of HPA dysregulation include the hyposecretion of glucocorticoids and "adrenal insufficiency," or, on the other end of the spectrum, a hypersensitive stress response (Herman et al., 2016). Individuals who have experienced chronic stress may also have phenotypic responses like posttraumatic stress disorder (PTSD) and other chronic conditions (Kendall-Tackett, 2009).

The General Adaptation Syndrome (GAS) model of stress responses posits that if a stressor is chronic, the body enters the Exhaustion Stage following the Alarm and Resistance stages (T. S. Campbell et al., 2020; Selye, 1946, 1950). The Exhaustion Stage is characterized by a significant loss of the body's homeostasis, leading to fatigue, mental health challenges, a weakened immune system, and depleted energy reserves. Thus, an individual in the Exhaustion Stage is vulnerable to poor health outcomes due to ongoing physiologic toll of the stress response and may be unable to mount adequate stress responses to new threats.

For a survivor of IPV, a current or former intimate partner is a tangible threat to their well-being. In many cases, the threat is present and clear. For example, survivors may be unable to leave an abusive situation because of disability, children and/or pets, or financial dependence, among myriad other reasons. Survivors in these circumstances may encounter violent acts from an abusive partner regularly, leading to a state of near-constant fear and hypervigilance (Fávero et al., 2025; Golding, 1999). However, as stressors can be real or anticipated, and contemporary or recalled, a partner does not have to be actively present and/or hurting a person to initiate a stress response; the *threat or recall* of IPV alone can lead to a cascade of endocrine responses and can be physiologically detrimental. These experiences, both real or anticipated, and contemporary or remembered, can result in a long-term state of stress. In the absence of the regulating role of the parasympathetic nervous system, chronic stress has been associated with higher blood pressure and higher inflammation, both of which are linked to higher incidence of chronic disease (Geronimus, 2023).

Endocrine Responses to Stress – Cortisol and the General Adaptation Syndrome

The release of cortisol as part of the HPA axis response is one of the body's important physiologic reactions to stress. Cortisol has been frequently studied as an outcome of stressful experiences, though research has produced mixed findings on whether IPV is associated with increased or decreased cortisol levels, which are reviewed in the following sections. However, these contradictory findings may be explained by participants being in distinct stages of the GAS. Thus, the research findings that follow include, when available, the study's assessment of cortisol relative to IPV, a proxy for GAS phase.

In some studies, participants who had experienced IPV proximal to cortisol assessment may have been in the Resistance Phase, indicated by experiencing more recent (i.e. approximately within the past year) IPV. A small study in Cameroon demonstrated that women who had experienced IPV within the past year had higher waking salivary cortisol levels than non-exposed counterparts, though the effect was moderated in part by self-esteem (Wadji et al., 2021). Another study found that higher PTSD symptomatology in survivors living in a shelter was associated with higher waking cortisol responses (Johnson et al., 2008). Griffin et al. (2005) found the opposite, demonstrating that IPV survivors with PTSD had lower morning cortisol levels; however, the timing of the IPV relative to the study was not accounted for, so these women may have experienced more distal IPV than the other studies. Another study found that IPV survivors with severe anxiety and depression symptoms had heightened cortisol responses after a stressful test, indicating that these women still had the energetic reserve to respond to novel stressors, at least in the short term (Cerda-De la O et al., 2022).

In some studies, repeated exposure to IPV and IPV severity are associated with lower cortisol levels, indicated by a dulled cortisol awakening response (CAR), the surge in cortisol from the adrenals approximately 30-60 minutes after a person wakes in the morning (Fries et al., 2009; Johnson et al., 2008; Pinto et al., 2016; Seedat et al., 2003). A reduced or blunted CAR indicates that the HPA axis can no longer respond robustly to produce cortisol as a person is waking, a feature characteristic of the Exhaustion Phase of the GAS. (As noted above, one study found that women with more recent abuse had higher CARs, thus offering two potential explanations for effect modification of DHEA-S levels by IPV recency.) This idea that survivors may have a reduced adrenal response and thus be in the Exhaustion Phase after experiencing chronic IPV is supported by work in another study, finding that women with both IPV and

depressive symptoms, also a characteristic of the Exhaustion Phase, had lower cortisol than women with a profile of IPV and no depressive symptoms (Blasco-Ros et al., 2014).

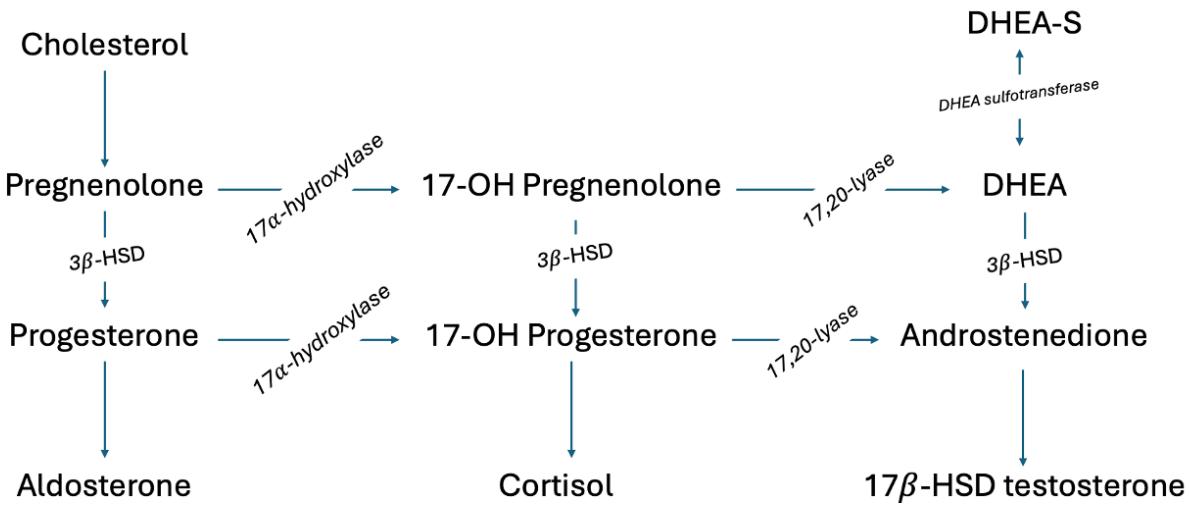
In short, there may be effect modification by GAS stage. For example, if the IPV is relatively recent or has been shorter in duration, a survivor may be navigating the Resistance Phase, with adrenals in overdrive, heart rate elevated, and senses sharpened to respond to threats. Conversely, if the IPV has been longer in duration or is less recent, a survivor may be in the Exhaustion Phase and thus have blunted production of stress hormones and a lowered immune response, while also facing increased risk of chronic disease through chronic hypertension or inflammation.

This body of findings indicates that the timing of IPV relative to cortisol assessment, the perception of IPV by a survivor, and the severity and duration of IPV likely shape cortisol responses, offering a potential model for how levels of other stress hormones may respond to IPV.

Endocrine response to stress – DHEA + DHEA-S

Another important biomarker of stress is dehydroepiandrosterone (DHEA), a 19-carbon steroid converted from 17-OH pregnenolone by the enzyme 17α-hydroxylase/17,20-lyase and the more abundant, sulfated form, DHEA-S (Figure 2-2) (Brown et al., 2006; Maninger et al., 2009; Soucy & Luu-The, 2000). DHEA is synthesized in the *zona reticularis*, the innermost layer of the adrenal gland, and also is produced by gonads (Turcu et al., 2014). DHEA-S generally peaks by age 30 and gradually decreases through the life course, declining at a rate of about 2% per year, though this rate may increase for men in older adulthood (Goodarzi et al., 2015; Tannenbaum et al., 2004; Vermeulen, 1995). While declines of DHEA-S are normal across the lifecourse, markedly lower levels of DHEA-S have been associated with cardiovascular disease mortality and all-cause mortality (Shufelt et al. 2010).

Figure 2-2. Synthesis pathways of DHEA and DHEA-S



Enzymes are italicized. Figure modified from Sumida et al. (2012)

DHEA has been available as a supplement with purported anti-aging properties for nearly 50 years, though the effects of exogenous administration for conditions other than dyspareunia have yet to be established (Torbarti, 2023). Beyond being a precursor to testosterone and estradiol, DHEA can affect neuronal function by affecting ion channels and downregulating action potentials (McEwen, 1991); DHEA negatively modulates γ-amino butyric acid (GABA) receptors and positively modulates N-methyl-D-aspartate (NMDA) receptors. Through these actions, DHEA may be involved in regulating depressive symptoms, as animal models indicate that administration of DHEA has antidepressive properties, and there is some evidence that DHEA levels are lower in people with depression (Genud et al., 2009; Herbert, 1998). The same effects of exogenous administration are cautiously supported in humans, as results from a small meta-analysis indicate a reduction in depressive symptoms, though the authors caution about the quality of the evidence being "very low" (Peixoto et al., 2020). Other studies have indicated little to no benefit of exogenous administration of DHEA-S for sexual function, weight, cholesterol levels, blood glucose levels, or bone mineral density (Elraiyah et al., 2014).

Previous research in studies of workers and otherwise healthy caregivers has suggested that DHEA-S levels are lower in chronically stressed individuals (Jeckel et al., 2010; Lennartsson et al., 2013). Short-term studies have also found decreases in DHEA and DHEA-S

when participants have encountered stressful situations, though a cross-sectional study of Korean nurses found that emergency room nurses, shown in this study to have high job-related stress, had higher levels of DHEA-S than other nurses (Cho et al., 2019; Gomez-Merino et al., 2003; Izawa et al., 2012). DHEA-S has been included as a marker of allostatic load, indicating its salience in the stress response (McCrory et al., 2023). While DHEA and cortisol are both released by the adrenals in response to stress, far more studies have examined cortisol in relation to IPV, while only a few studies have examined the relationship between IPV and DHEA-S (Blasco-Ros et al., 2014; Pico-Alfonso et al., 2004). A meta-analysis examining DHEA-S levels in patients with PTSD after other traumatic experiences like combat, childhood abuse, and other trauma, found that participants with a trauma history had higher DHEA-S levels regardless of whether they had symptoms of PTSD (van Zuiden et al., 2017).

As DHEA-S is linked to both stress and health outcomes, women with a history of IPV may reflect a distinct pattern of DHEA-S, both in initial levels of the hormone and also in the slope of DHEA-S over time. If survivors' trajectories of DHEA-S reflect common characteristics in level or slope, this may suggest that disruptions to the endocrine system may be a key pathway linking IPV to poor health outcomes. Thus, the goals of this paper include: 1) to characterize the trajectories of DHEA-S over the period of the midlife and early older adulthood among a community-based cohort of women; 2) to explore the relationship between IPV and DHEA-S levels and slope during the time spanning menopause into early older adulthood; and 3) to assess whether participants cluster into trajectory groups with similar intercepts and slopes of DHEA-S, groups that may differ by IPV status.

2.2 Methods

Study Population

The Study of Women's Health Across the Nation (SWAN) is a multi-ethnic, multi-site community-based cohort study of women followed through the menopausal transition and into late adulthood (Sowers et al., 2000). The study cohort began in 1996-1997 with 3,302 participants across seven sites in the United States. Since baseline, SWAN has completed 17 follow-up visits with participants, and biospecimens were obtained in the majority of these visits. Two of the sites, Michigan and Pittsburgh, collected self-reported lifetime exposure to intimate partner violence at the follow-up visit 17, conducted in 2022-2023. There were 1,006 women

who participated at the Michigan and Pittsburgh SWAN sites at baseline, and 520 women (51.7% of the original sample of Michigan and Pittsburgh participants) participated at V17.

The final analytic sample included 428 women (42.5% of the original sample of Michigan and Pittsburgh participants). Of the women who had participated at the Michigan and Pittsburgh sites at V17, 59 did not complete the IPV questionnaire. Reasons for non-participation included concerns for privacy, not interested, and non-response. In total, 434 participants completed the entire form, and 27 completed the form but had missing items, resulting in a total of 461 participants with at least one response to the questionnaire. Four women did not answer the lifetime IPV questions and thus were not included. Of these remaining 457 women, 29 women did not have an adequate number of DHEA-S measurements (three or more) to construct a trajectory, resulting in an analytic sample of 428 women.

Measuring the Exposure: Intimate Partner Violence

Data on experiences of partner violence, harassment, sexual violence, and assault were collected through a self-administered questionnaire at SWAN Visit 17, the Extended-Hit Insulted Threatened Scream questionnaire (E-HITS) (Appendix, Iverson et al., 2015). Five items in the questionnaire asked about past year and lifetime experiences of IPV. These responses were used to generate an E-HITS score for the past year and the lifetime. The E-HITS score has been used previously in the literature to assess cumulative experiences of partner violence (Goldstein et al., 2023). E-HITS scores ranged from 5 (indicating no experience of IPV) to 25 (indicating frequent experience of each type of violence); women who reported scores of 7 or more were considered to have experienced IPV.

Measuring the Outcome: DHEA-S

At each in-person study visit between baseline and Visit 17, women could consent to a blood draw, which included measuring the level of DHEA-S level in serum. The assay and measurement of DHEA-S has been previously described (Crawford et al., 2009). In brief, for study visits from baseline to Visit 10, the laboratory used Bayer Diagnostics' ACS-180 automated analyzer with chemiluminescent technology and a competitive assay. From V12 onward, a calibrated Centaur machine was used. DHEA-S results are reported in micrograms/deciliter, and in mixed model analyses, the log-transformed form of DHEA-S was used.

Participants had up to 15 measures of DHEA-S across more than 20 years, with the longest participant span being 27 years (1996-2023). The analytic sample included 5,558 measures from 428 women. Women had an average of 13 samples. Over 80% of the sample had 12 or more measures of DHEA-S, and about 36% of participants had measurements at each of the 15 study visits where DHEA-S was collected.

Measuring Covariates

Age was calculated as date of visit minus date of birth and rounded to the nearest tenth of a year. Race and ethnicity were self-reported at baseline, and women in this sample were either Black/African American or White/Caucasian, as the sample drew from the Michigan and Pittsburgh sites, which enrolled only Black and White women. Educational attainment was assessed at baseline as "Less than high school," "Finished high school," "Some college," "College graduate," or "More than college," and categories were collapsed into "High school or less," "Some college," and "College or more" for analysis. Body mass index (BMI) was calculated from weight (kg), measured using a balance beam scale, divided by height, measured using a stadiometer, in meters squared; BMI at V17 is used as a covariate, though for 15 participants, BMI at V17 was missing and was thus imputed from the most recently available study visit.

At V17, the SF-36 Physical Function questionnaire was administered to assess self-reported limitations in a number of daily activities (Ware et al., 1993). The Childhood Trauma Questionnaire (CTQ) was administered at follow-up visit 15 (Bernstein et al., 2003). Analyses used two dimensions of trauma before age 18 from the CTQ – sexual abuse and physical abuse. The CTQ assesses five different dimensions of trauma before the age of 18. Smoking status at baseline and V17 was dichotomized as current versus former/never. Perceived stress at baseline was measured by the Cohen Perceived Stress Scale, resulting in scores from 4 to 18, with higher scores indicating higher stress (Cohen et al., 1983). Physical disability status was measured with a score below 50 on the SF-36 Physical Function scale at baseline (Ware et al., 1993). Financial strain at V17 was assessed by asking women how difficult it is to pay for basic necessities; women could respond "very", "somewhat", or "not at all". The "very" and "somewhat" responses were grouped for analyses to reflect women who had any financial strain vs. none.

Primary Time Variable: Age at Final Menstrual Period

Age at the final menstrual period (FMP) was used in analyses as the primary time variable of interest. At each SWAN visit, women were asked about bleeding patterns, hormone therapy use, and any gynecological surgeries; this information was used to categorize women into a menopausal stage at each visit. These stages were: premenopausal, early peri-menopausal, late peri-menopausal, natural postmenopausal, postmenopausal by bilateral Salpingo oophorectomy (BSO), pregnant/breastfeeding, unknown due to hormone therapy use, or unknown due to hysterectomy. Natural menopause was defined as the cessation of bleeding for twelve consecutive months, without hormone therapy for at least three months and without the surgical removal of both ovaries. The age at which a woman's final menstrual period occurred is designated as a woman's age at FMP. For these women with natural menopause, their FMP is "observed." For this group, the first study visit after their documented FMP date is assigned as time 0, or FMP=0.

The rest of the group has an imputed age at FMP, which may be imputed for several reasons: too many missed study visits to determine an FMP, hormone therapy (HT) use that masks bleeding related to HT versus menstruation, or surgical removal of the uterus that also obscures bleeding patterns. To impute the age at FMP for a woman without an observed FMP, ten imputed FMP dates and ages were randomly generated between two endpoints: the left endpoint marked the last known contact with SWAN that included observed bleeding without HT or within the three-month washout period after HT while the right endpoint was set at age 60 for women with missing data or whose bleeding was obscured by HT or hysterectomy (Little & Rubin, 2002). The ten imputed ages were averaged to arrive at a specific imputed FMP age. For women with an imputed FMP age, the first study visit they would have potentially attended after that date was designated as FMP=0.

Statistical Analyses

Descriptive statistics were generated for all variables included in analyses using means and standard deviations (SD) for continuous variables and frequencies and percentages for categorical variables. For bivariate analyses, the sample was categorized by E-HITS scores; for both lifetime and past-year violence, participants were categorized into those with E-HITS scores ≥7 ("Experienced IPV") and with E-HITS score of 5 or 6. Comparisons of women by E-HITS scores were performed using Pearson's Chi-square tests and Fisher's exact tests for categorical

variables and t-tests and Wilcoxon-Mann-Whitney tests for continuous variables. SAS software [Version 9.4] was used for analyses (SAS Institute, Inc., Cary, NC).

Linear Mixed Model

Given the longitudinal nature of the data and associated correlations of repeated measures for a given participant, linear mixed models were employed using PROC GLIMMIX in SAS. This approach is robust to handling the uneven spacing of visit variables and can incorporate participants with missing measures, with the assumption that measures are missing at random. In linear mixed models, DHEA-S levels were log-transformed as residuals from log-transformed DHEA-S were independent and normally distributed; results from mixed models are presented with log-DHEA-S.

To determine whether the inclusion of random slopes improved the fit of the model, unadjusted models with and without random slopes were compared by AIC. The model with random intercept and random slopes had an AIC of 4351.91. The model with a random intercept only and no random slopes had an AIC of 4859.84. As the smaller AIC indicates improved fit, and the model provides additional information from the random intercept and slopes, the model that includes the random intercept and slopes was chosen. The inclusion of the random intercept is critical for better model fit, as the random intercept accounts for each person's initial point of DHEA-S at the beginning of the study. The inclusion of a random intercept also would reduce residual variability. Random slopes allow each woman's change in DHEA-S over time to vary by the individual. Within-woman variability appears to lessen after the final menstrual period, possibly reflecting ovarian and adrenal aging and regression to lower hormonal output in the population relative to the final menstrual period. Because there is not constant variance between time points, correlation structures with heterogeneous variance structures were tested. The unstructured correlation matrix, which already supports heterogeneous variance as a feature, had the lowest AIC. Though not the most parsimonious model, it still fit better than the heterogeneous autoregressive or compound symmetry structures.

Because DHEA-S levels across the menopausal transition are likely driven more by menopausal timing than by age, the data corresponding to study visits are anchored based upon the timing from the final menstrual period (FMP). Study visits prior to the FMP=0 visit were assigned a negative number, and study visits after the FMP were labeled with positive numbers. Women with observed and imputed FMPs were included in analyses. A sensitivity analysis was

conducted including only women with an observed FMP, and results were not significantly different from the full sample.

The years around the final menstrual period appear to be an inflection point for DHEA-S, and other hormones like estradiol and FSH distinctly change around the FMP, lending additional credence that the slope of DHEA-S, as a hormone of ovarian and adrenal origin, may shift around the FMP (Burger et al., 2002). To account for the non-linearity in DHEA-S over time, knots at FMP=-2, 0 and 2 were explored, with the models that included a knot at FMP=0 and a knot at FMP=2 indicating similar fits to the data in terms of AIC. The model with a knot at FMP=0 reflects similar physiology to models of other hormones that change around the FMP and thus was chosen as the final form of the model.

For fixed effects covariate selection, likelihood ratio testing and theory on the relationship under study guided model selection, and the tested covariates were: race, education, age, smoking status, perceived stress at baseline, disability status at baseline, financial strain at V17, BMI at V17 (centered on group average), childhood sexual abuse, childhood physical abuse, and an interaction term between race and IPV.

Group-Based Trajectory Modeling

Group-based Trajectory Modeling (GBTM) is a statistical approach to understanding how a measure of interest changes across time and how individuals cluster within a group, lending insight into whether certain characteristics are similar within and distinct between trajectory groups (Nagin et al., 2018; Sweeten, 2014). GBTM assumes there are unobserved, heterogeneous characteristics in each cluster that drive the trajectory groupings. These trajectories are probabilistic rather than deterministic, and each woman has a probability of being assigned to each trajectory group. The group assignments that emerge for each participant from GBTM reflect the group's assignment with the highest probability of belonging. Thus, within each trajectory group, there will be participants with a high likelihood of belonging to the group, up to 100%, and there are people with a lower likelihood of belonging to the group. Generally, 70% is used as a threshold of acceptable fit of belonging to the group.

Additionally, Bayesian information criteria (BIC) and group size supported model selection. Models with lower BIC were preferred, and a threshold of 5% was used as the minimum acceptable group size. Once group membership probabilities were assigned to each participant, participants were assigned to the group based on the highest likelihood of

membership. Through PROC TRAJ in SAS, two-, three-, and four-group models were explored for these data.

Ordinal logistic regression was used to predict group membership based on IPV history and the same covariate adjustment set as the linear mixed model. A sensitivity analysis removing participants with a <70% probability of being assigned to a group was performed.

2.3 Results

Table 2-1 includes descriptive characteristics of the analytic cohort. At baseline, the average age was 45.5 (standard deviation, 2.6) years old, and the mean BMI was 28.3 (6.5) kg/m^2. By V17, participants were an average of 71.1 (2.7) years old and had an average BMI of 30.7 (6.8). Over half of the sample (59.0%) was White. Three-fourths of women had some college education or more. Just under a quarter of participants at V17 (103, 24.1%) reported any difficulty (some or a lot) paying for basic necessities. Nearly one-half of the sample (48.9%, N=177) reported any form of childhood trauma; of the five types of childhood trauma measured, physical abuse was most common, reported by 25.1% of the sample. About one in five participants experienced three or more kinds of childhood trauma.

Women in the analytic sample were more likely than those not included to have a college or more education, to be white, to have never smoked at baseline, and to have no reported trauma in childhood. There were no statistically significant differences in reported physical disability status, BMI, or age at baseline.

Over half of women in the analytic sample (50.5%, n=212) had an E-HITS score of 7 or more, indicating that they had an experience of IPV in their lifetime. There were seven women whose past-year E-HITS scores were seven or above but their lifetime scores did not indicate any violence. Because lifetime violence includes past-year violence, these women were categorized as having had lifetime IPV. The overall sample had an average E-HITS score of 8.13 (SD=4.18, range: 5-25) and the group categorized as having experienced IPV had an average E-HITS score of 10.98 (SD=4.24, range: 7-25). Just over ten percent of women (n=46) reported experiencing IPV in the past year, and this group had an average past year E-HITS score of 8.33 (SD=1.58, range: 7-13).

All types of IPV (physical, sexual, and psychological) were reported by the cohort. Reported by 29.2% and 29.7% of the sample respectively, physical and psychological lifetime IPV were more common than sexual IPV, reported by 18.2% of the cohort. Experiencing

multiple forms of IPV was a relatively common experience; of the 174 women who reported some form of lifetime IPV and answered all of the IPV questions, 107 (60.8%) reported experiencing multiple forms of IPV.

In the year prior to the V17 survey, 46 women (10.8%) reported an experience of IPV. Psychological IPV was the most common experience of IPV in the year prior, reported by 4.4% of the sample. Sexual IPV was reported by 10 women, while physical IPV was reported by four women. Of the women who reported at least one form of IPV, nine reported experiencing multiple forms of IPV.

Women who had experienced lifetime IPV were slightly younger and more likely to be Black than women who did not experience IPV. However, there were not statistically significant differences in baseline BMI, perceived stress, or educational attainment among women who did and did not experience lifetime IPV.

Table 2-1. Descriptive Statistics for Analytic Sample

		Lifetime IPV		
	Overall (N = 428)	**No (n = 212)**	**Yes (n = 216)**	
Variable	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	***p*-value[a]**
Age (baseline, years)	45.5 (2.7)	45.7 (2.8)	45.2 (2.5)	<0.05
Age (V17, years)	71.1 (2.7)	71.4 (2.9)	70.9 (2.5)	0.061
Body mass index (V17, kg/m^2)	30.7 (6.8)	29.8 (6.3)	31.5 (7.2)	<0.05
Perceived stress, baseline	8.2 (3.1)	8.0 (3.1)	8.3 (3.1)	0.246
	N (%)	**N (%)**	**N (%)**	***p*-value[b]**
Race/ethnicity				<0.001
White	254 (59.3)	152 (68.9)	108 (50.0)	
Black	174 (40.7)	71 (31.1)	108 (50.0)	
Site				<0.001
Michigan	200 (46.7)	85 (37.3)	121 (56.0)	
Pittsburgh	228 (53.3)	133 (62.7)	95 (44.0)	
Education level				0.619
High school or less	93 (22.0)	42 (20.2)	51 (23.7)	
Some college	159 (37.6)	78 (37.5)	81 (37.7)	
College degree or post-college	171 (40.4)	88 (42.3)	83 (38.6)	

Difficult to pay for basic necessities				<0.001
Very/Somewhat	101 (23.9)	32 (15.3)	69 (32.2)	
Not at all	322 (76.1)	177 (84.7)	145 (67.8)	
Any childhood trauma (CTQ)[c]				<0.001
Yes	176 (49.0)	69 (39.2)	111 (60.7)	
Childhood sexual abuse				<0.001
Yes	71 (19.6)	19 (10.4)	52 (29.1)	
Childhood physical abuse				<0.001
Yes	91 (25.0)	27 (14.8)	64 (35.4)	
Smoking, baseline				<0.01
Never	259 (60.7)	141 (66.8)	118 (54.6)	
Past, but not current	111 (26.0)	54 (25.6)	57 (26.4)	
Current	57 (13.3)	16 (7.6)	41 (19.0)	

[a]: T-test; [b]: Chi-square test, except where otherwise noted; [c]: Childhood Trauma Questionnaire (Bernstein et al., 2003)
SD = standard deviation

The analytic sample had a mean (SD) DHEA-S level at the visit immediately following the FMP of 122.53 (75.79) ug/dL (Table 2-2). Figure 3 depicts average DHEA-S levels by visit relative to the FMP. In the study population, DHEA-S levels and variability remain relatively stable in the visits leading up to the FMP. Similar trends can be seen between groups in terms of decline over time, though the group without a history of IPV appears has slightly higher DHEA-S means and typically larger variability (Table 2-3). In 19 of the 26 time points measured, the group without IPV has higher mean levels of DHEA-S, albeit only slightly higher at most time points.

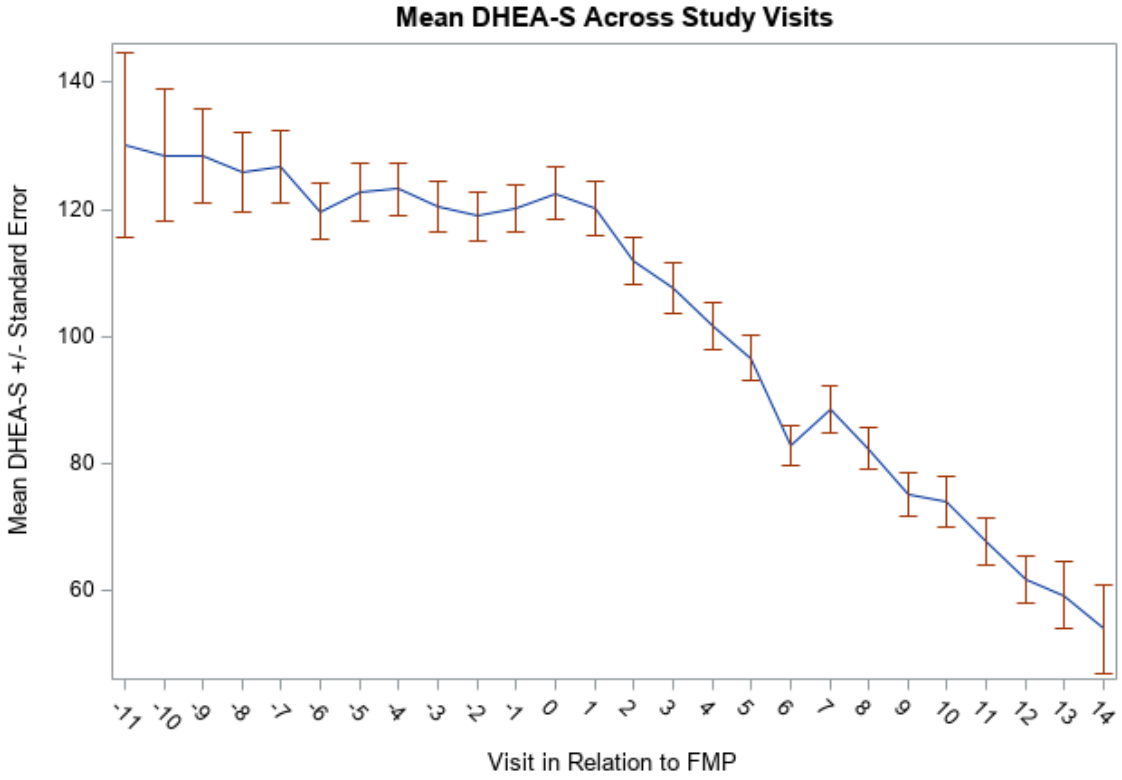
Table 2-2. Average DHEA-S levels and SDs over time, in relation to FMP

Visit	N	Mean (SD)	Minimum	Maximum
-11	32	130.3 (85.2)	33.2	395.7
-10	72	130.2 (91.4)	22.7	543.1
-9	111	129.3 (79.8)	2.2	557.3
-8	145	126.1 (76.6)	1.6	442.7
-7	205	127.3 (81.3)	1.1	442.9
-6	252	119.8 (69.4)	1.0	411.7
-5	303	123.4 (80.0)	5.1	410.6
-4	330	123.5 (77.3)	7.8	453.6
-3	351	120.4 (77.0)	4.8	536.9
-2	361	119.3 (74.3)	13.9	603.6
-1	366	120.5 (71.1)	11.4	560.8
0	349	122.7 (75.8)	8.2	444.9
1	358	120.3 (78.9)	8.3	489.4
2	329	112.1 (67.8)	6.6	465.0
3	281	107.5 (66.5)	10.9	383.3
4	265	101.8 (60.1)	9.2	367.8
5	256	96.8 (56.7)	2.4	301.6
6	246	82.9 (49.5)	7.1	325.5
7	192	88.5 (50.8)	5.4	292.3
8	211	82.3 (48.8)	2.3	300.6
9	143	74.9 (40.9)	5.3	199.8
10	145	74.0 (48.4)	11.3	266.3
11	99	67.9 (36.7)	13.8	185.6
12	83	61.6 (33.2)	12.5	171.4
13	52	59.2 (38.2)	7.3	245.3
14	21	53.9 (32.4)	18.2	137.2

Table 2-3. Average DHEA-S levels and SDs over time, in relation to FMP, by IPV status

History of IPV					No History of IPV			
N	Mean (SD)	Minimum	Maximum	**Visit**	N	Mean (SD)	Minimum	Maximum
15	129.5 (81.7)	33.2	329.3	**-11**	17	131.0 (90.7)	44.9	395.7
35	123.7 (73.9)	33.7	364.6	**-10**	37	136.3 (106.0)	22.7	543.1
55	136.8 (85.2)	34.6	557.3	**-9**	56	121.9 (74.2)	2.2	385.9
73	117.7 (67.0)	11.4	442.7	**-8**	72	134.7 (84.9)	1.6	423.4
108	127.6 (78.7)	7.5	436.0	**-7**	97	126.9 (84.5)	1.1	442.9
129	116.5 (70.7)	11.4	411.7	**-6**	123	123.3 (68.1)	1.0	336.1
153	115.3 (75.9)	5.1	408.9	**-5**	150	131.6 (83.4)	24.3	410.6
169	114.9 (64.8)	7.8	372.7	**-4**	161	132.6 (87.8)	19.0	453.6
180	114.8 (66.5)	8.9	412.3	**-3**	171	126.2 (86.5)	4.8	536.9
183	113.6 (65.3)	13.9	339.8	**-2**	178	125.2 (82.4)	18.7	603.6
180	115.5 (61.0)	11.4	336.8	**-1**	186	125.3 (79.6)	17.2	560.8
171	114.3 (65.3)	8.2	374.4	**0**	178	130.8 (84.1)	9.4	444.9
182	112.8 (72.5)	11.5	445.7	**1**	176	128.1 (84.5)	8.3	489.4
163	106.8 (59.5)	6.6	369.1	**2**	166	117.3 (74.9)	7.1	465.0
134	107.4 (66.3)	16.4	383.3	**3**	147	107.5 (67.0)	10.9	370.0
132	94.3 (54.2)	9.2	307.2	**4**	133	109.3 (64.7)	11.2	367.8
127	90.6 (48.9)	12.7	254.0	**5**	129	102.8 (63.0)	2.4	301.6
120	83.4 (48.0)	12.1	249.9	**6**	126	82.4 (51.1)	7.1	325.5
91	81.0 (41.8)	17.1	218.8	**7**	101	95.3 (57.1)	5.4	292.3
110	83.3 (48.7)	2.3	229.3	**8**	101	81.3 (49.2)	16.7	300.6
69	75.5 (43.5)	5.3	199.2	**9**	74	74.4 (38.7)	17.9	199.8
76	72.4 (49.3)	11.3	266.3	**10**	69	75.7 (47.7)	12.1	229.9
44	65.2 (34.2)	13.8	154.4	**11**	55	70.0 (38.8)	21.2	185.6
42	60.1 (29.2)	12.5	143.8	**12**	41	63.2 (37.2)	21.9	171.4
23	56.0 (23.7)	14.7	94.8	**13**	29	61.8 (47.0)	7.3	245.3
11	44.7 (19.8)	20.1	77.0	**14**	10	64.0 (41.0)	18.2	137.2

Figure 2-3. Population mean trend of DHEA-S across study visits anchored to the FMP



In the model of time and log-DHEA-S with a knot at the FMP, the slope of log-DHEA-S shows a non-significant decrease of 0.3% per visit before the FMP, a statistically non-significant change, and after the FMP, log-DHEA-S significantly declines at 3.8% per visit (Figure 2-3). Without the knot included, log-DHEA-S declines approximately 2.3% per year across the entire time period. Women who experienced any IPV during their lifetime had slightly higher starting levels of log-DHEA-S than women without IPV exposure, though an interaction term between IPV and the time variables indicated trends over time were not modified by IPV exposure and thus were not included for the sake of a more parsimonious model. However, the interaction between race and IPV is important to consider; while Black women without a history of IPV had slightly higher starting levels of DHEA-S than white women without a history of IPV, Black women survivors had the lowest starting levels of DHEA-S.

As shown in Table 2-4, in models adjusted for lifetime IPV exposure, race and ethnicity, BMI, education, financial strain, BMI, and childhood sexual and physical abuse, there remained a statistically significant decline in log-DHEA-S after the FMP, and the magnitude of the decline was similar to unadjusted models. None of the included covariates, including IPV, were significantly associated with log-DHEA-S with a *p*-value of less than 0.05, but the IPV covariate,

which would indicate the effect of IPV for white women given the interaction term in the model, was marginally significant at p=0.0792.

There were no statistically significant associations between any of the IPV subtypes considering either lifetime or past year and log-DHEA-S. Those who reported physical IPV had higher levels of DHEA-S compared to women without an IPV history, while those who reported sexual IPV had lower levels, though all associations were not statistically significant.

Table 2-4. Unadjusted and adjusted linear mixed models of IPV and log-DHEA-S

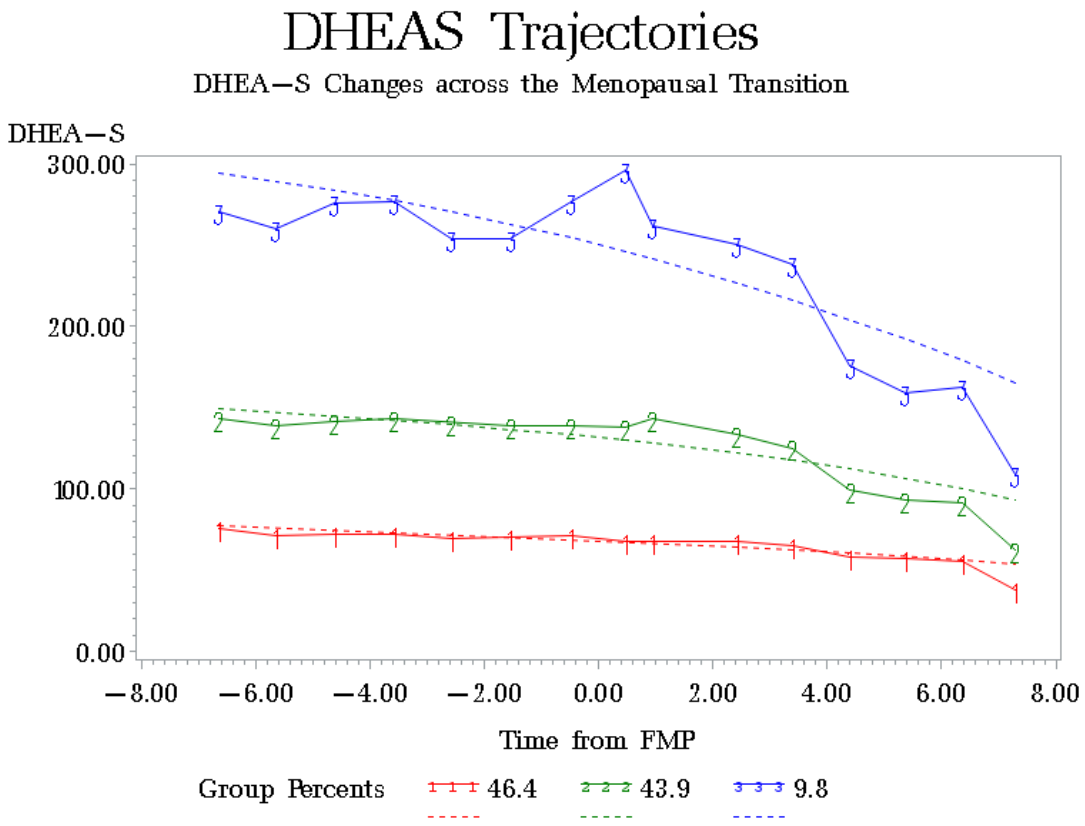
	Model 0	**Model 1**	**Model 2**	**Model 3**
	Beta (95% CI)	**Beta (95% CI)**	**Beta (95% CI)**	**Beta (95% CI)**
Intercept	4.607 (4.548, 4.666)	4.628 (4.551, 4.704)	4.610 (4.494, 4.727)	4.596 (4.471, 4.720)*
Slope up to FMP=0	0.0002 (-0.006, 0.006)	0.0002 (-0.006, 0.006)	-0.002 (-0.006, 0.007)	-0.003 (-0.009, 0.004)
Slope after FMP=0	-0.042 (-0.051, -0.033)*	-0.042 (-0.051, -0.033)*	-0.041 (-0.051, -0.031)*	-0.039 (-0.049, -0.029)*
Lifetime IPV		-0.041 (-0.139, 0.057)	0.100 (-0.031, 0.231)	0.129 (-0.015, 0.274)^
Race/ethnicity				
- **White**			Ref	Ref
- **Black**			0.102 (-0.057, 0.260)	0.137 (-0.035, 0.309)
Race*IPV			-0.287 (-0.493, -0.080)*	-0.307 (-0.531, -0.083)
Body Mass Index (kg/m^2, V17), centered on group average			-0.006 (-0.014, 0.001)^	-0.006 (-0.014, 0.095)
Education				
- **High school or less**			-0.048 (-0.184,)	-0.051 (-0.202, 0.096)
- **Some college**			Ref	Ref
- **College graduate or post-grad**			-0.030 (-0.144, 0.084)	-0.021 (-0.142, 0.100)
Financial strain (V17)				
- **None**				Ref
- **Some or a lot**				-0.060 (-0.194, 0.074)
Childhood Sexual Abuse				0.072 (-0.074, 0.218)
Childhood Physical Abuse				-0.081 (-0.215, 0.054)

*: p<0.05 ^: 0.05<p<0.10
Model 0: Time only
Model 1: Unadjusted
Model 2: Adjusted for body mass index, race/ethnicity, education
Model 3: Adjusted for variables in model 2, plus childhood sexual abuse and childhood physical abuse
Ref: Reference group

PROC TRAJ was used for group-based trajectory modeling, and a three-group model was selected based on AIC and group size (Figure 2-4). The three groups were: a low and steady group (46.4% of the sample), a medium group with decline (43.9%), and a higher group with greater variability and decline over time (9.8%). When operationalizing trajectory group

membership as the outcome in adjusted ordinal logistic regression models, there was no statistically significant difference between IPV exposure and trajectory group membership (p=0.31), though women with IPV were non-significantly less prevalent in the trajectory group with the highest DHEA-S levels. The highest trajectory group's lifetime IPV prevalence was 35.7%, and about half of the women – 50.3% for Group 2 and 49.3% for Group 1 – in each of the other groups had a history of lifetime IPV. A sensitivity analysis including only women with 70% or higher probability of being in their assigned group resulted in similar findings. There was no trend when examining specific types of IPV in relation to DHEA-S trajectory group.

Figure 2-4. Group-based Trajectory Models for three-group model



2.4 Discussion

DHEA-S production changes with age, and some research indicates that levels of DHEA-S respond to stress; thus, it is plausible that levels of DHEA-S may serve as a marker of accelerated aging. Intimate partner violence is a highly prevalent experience in women, and IPV can lead to a chronic stress response, increasing a survivor's risk for chronic disease and early

mortality. If DHEA-S levels appear to respond to IPV as a source of stress, DHEA-S may serve as another physiologic link between IPV and poorer health. This could also provide evidence to support interventions that maintain or increase endogenous levels of DHEA and DHEA-S. The General Adaptation Syndrome and the weathering hypothesis provide physiologic and social patterns for how IPV may take a toll on the health of survivors. This is the first paper to our knowledge to examine the longitudinal relationship between repeated measures of DHEA-S, a biomarker of aging and stress, in relation to intimate partner violence in a cohort of midlife to older adult women over twenty years.

With over half of the women in the sample having experienced lifetime IPV, lifetime prevalence of IPV in this sample is slightly higher than national estimates of the prevalence of IPV for women in the United States, which is 47.3% (Leemis et al., 2022). Past-year trends of IPV were higher in this sample (10.6% in SWAN vs. 7.3% in the United States), which is notable given that SWAN women are older adults, and incidence of IPV typically declines with age (Leemis et al., 2022). Furthermore, the Michigan site had the highest prevalence of past-year physical IPV at baseline (7.4% vs. all other sites, which ranged from 1.4% to 3.9%).

Women in the sample experienced an *overall* decline in DHEA-S over the course of the study, spanning pre- or early peri-menopause through post-menopause, though this does not refute prior work in SWAN showing an increase around the FMP (Crawford et al., 2009). This prior work in SWAN demonstrates that around 85% of women experienced an increase, however slight, in DHEA-S levels around the FMP. A possible explanation of this phenomenon is that the adrenal glands increase production of DHEA as the ovary slows production through menopause. In this study, around the FMP, DHEA-S slopes had marked accelerations in decline on the population level, perhaps indicating that the ovary's production of DHEA-S is rapidly ceasing, and adrenal production does not fully compensate for the ovarian loss. In the present study sample, 86% of women had an increase in DHEA-S in the years ahead of the final menstrual period, though the increase was very small in some women (e.g. <5 ug/dL) and the clinical significance of such an increase is likely negligible.

Although we observed a decline in DHEA-S across the menopausal transition, in unadjusted and adjusted models, women who had experienced lifetime IPV had non-significant lower levels of DHEA-S compared to those without lifetime IPV. An interaction term between

lifetime IPV and the post-FMP slope was tested. *P*-values were not significant ($p>0.50$), and this term was not included in the models.

Additionally, when models predicting DHEA-S levels in relation to a specific type of IPV (physical, sexual, or psychological) there was no statistically significant association between a more specific type of IPV and levels of DHEA-S, though the associations moved in different directions depending on type of IPV. If this trend were seen in other cohorts, this may suggest that there are different physiologic stress response profiles to different types of IPV. It also raises the question of how multiple types of IPV may interact to affect a person's physiology. It is critical to reiterate that experiencing only one form of IPV can lead to deleterious health effects, and there may be an interactive effect with multiple forms of IPV, resulting in greater effects on health. Future work in larger samples may examine potential interaction between types of IPV.

Participants who were exposed to childhood trauma were statistically significantly more likely to report lifetime IPV compared to participants who reported no childhood trauma. Specifically, the prevalence of childhood physical abuse and sexual abuse was statistically significantly higher among those with lifetime IPV as compared to those without IPV exposure. Traumatic exposures before the age of 18 may affect physiological development, including the adrenal's production of DHEA-S. Childhood trauma was prevalent in the sample, with nearly half of women reporting a form of childhood trauma, meaning that a high number of participants' histories of abuse may have led to altered adrenal function prior to the start of this study's data collection. In this set of covariates though, neither sexual nor physical abuse in childhood was associated with decreased production of DHEA-S. Future research could examine whether DHEA-S patterning across the lifecourse is altered in survivors of childhood trauma.

The current work is novel in its use of many time points of DHEA-S over time, namely up to 27 years. One previous study of older women and men used two time points of DHEA-S to observe changes across older adulthood in a period spanning ten to fourteen years. The Rancho Bernardo study's findings align with the present study in affirming that most older adults have an overall decline between DHEA-S levels in midlife and later life, though the present study had up to 15 time points for participants, allowing for more nuanced looks into how DHEA-S changes over time in older adult women (Tannenbaum et al., 2004). In the Rancho Bernardo study, Tannenbaum et al. also used multiple approaches to measure change, including a percent change between the two time points of DHEA-S measurement. They found that 28% of women had at

least a 10% increase from the first measurement to the second, compared to only 5% of men. This points to the possibility that women have more variation in DHEA-S in older adulthood due to the menopausal transition, a finding supported by our results and extended by the additional measurements of DHEA-S, which span premenopause/early perimenopause and extend well into postmenopause.

Findings from the present study also support previous work that, overall, DHEA-S declines approximately 2% per year (Crawford et al., 2009; Tannenbaum et al., 2004). However, in women, declines before and after the FMP are notably distinct; in these data, the average change is not statistically significantly different from zero before the FMP, but after the FMP, DHEA-S declines approximately 4% per year in the population. The pre-FMP annual change of close to 0% may belie larger variation in pre-FMP levels (i.e. an increase related to increased adrenal production) that is obscured by calculating an annual change over the course of the entirety of the pre-FMP period.

Findings from a study in Sweden indicated that participants who experienced work-related stress had lower levels of DHEA-S than their non-stressed counterparts (Lennartsson et al., 2013). However, the study sample was small (N=81) and the study included working age women and men, a group that may have displayed greater variation in DHEA-S levels as a group, enabling the detection of true distinctions; as this present study includes older adult women, there may be less variation in the population, especially after the FMP, which may obscure differences in DHEA-S levels between those with and without a history of IPV.

Perhaps supporting these findings that DHEA-S does not necessarily change in response to intensely stressful situations, Rasmusson and colleagues found that DHEA-S levels were not significantly different between women with and without PTSD, which can be an outcome of exposure to interpersonal trauma like intimate partner violence (Rasmusson et al., 2006). While this study was small with a sample size of 19 women, there was a difference in allopregnanelone levels and allopregnanelone/DHEA ratio in women with PTSD. The group with a higher allopregnanelone/DHEA ratio had a lower recurrence of PTSD symptoms, suggesting a separate question that can be explored in future research of whether the ratios of other hormones with DHEA may have a greater physiologic effect than DHEA or DHEA-S levels alone.

We did not see an association between experiencing IPV and having marked shifts in DHEA-S levels or slope for the group as a whole. There may be several explanations for this.

First, IPV may not be a specific enough driver of DHEA-S levels to see a signal. Indeed, the only two variables included in our models that had a statistically significant association with DHEA-S levels was the slope after the FMP and the interaction term between race and IPV. To cite the chains of risk model of lifecourse epidemiology, survivors of IPV often live with other stressors, past and present, and race is another factor that is highly associated with risk for poorer health because of social and structural discrimination (Ben-Shlomo & Kuh, 2002). Furthermore, it is possible that the accumulation of lifecourse stressors contributes to nearly equalizing DHEA-S levels for survivors and those without an experience of IPV in the population by the midlife, which continue to decline until reaching similarly low levels in the eighth decade of life. Second, the size of the analytic sample is not huge, a larger sample size may have provided more confidence in whether marginally significant associations, like a marginally significant greater decline in DHEA-S over time for White survivors versus White participants without an IPV history, were true effects. To extend the discussion of race and ethnicity, Black survivors had a significantly lower starting level of DHEA-S compared to White survivors and compared to White and Black women without a history of IPV. This may indicate that the accrual of stressors over the lifespan, which for Black women may include quotidian microaggressions to overt displays of hostility, may decrease levels of DHEA-S in Black survivors specifically. This relationship merits further investigation in a larger cohort of women.

DHEA-S and cortisol are both synthesized in the adrenal glands and modulated by stress, so cortisol may serve as a comparison point for DHEA-S. The fact that studies have found mixed results for IPV and cortisol, mirroring mixed findings for IPV and DHEA-S, support the idea that the relationship between IPV and the physiologic stress response, particularly for the HPA axis, is not simple and may be strongly influenced by the presence of PTSD symptoms (Griffin et al., 2005; Lauc et al., 2004; Lemieux & Coe, 1995; Neylan et al., 2005; Rasmusson et al., 2006; Wessa et al., 2006). Timing of IPV in relation to the adrenal hormone measurement, duration of IPV, and self-perception of IPV may alter a person's physiologic response, leading to a more individualized response rather than a clear population-level response. It is clear that IPV leads to detrimental health effects; while IPV undoubtedly affects the endocrine system, this paper does not provide strong evidence that IPV is a driver of DHEA-S-specific changes but does point to questions for further investigation.

In fully adjusted models, there was no association between IPV and DHEA-S levels and slope. Future research in a larger cohort may examine timing in relation to DHEA-S levels. Unfortunately, it is difficult to pinpoint, beyond the year prior to the V17 questionnaire, when an experience of IPV may have occurred and thus whether the IPV may have been linked with the DHEA-S levels. It is possible that women who experienced more recent IPV demonstrate an increase in DHEA-S because a more recent major stressor may call upon the adrenal stress response reserves, resulting in lower DHEA-S levels. Because of having a relatively small number of women who reported *current* experiences of violence over the course of the study and because there are only a few time points where IPV experiences were collected, the sample had only a small number of women whose DHEA-S levels could be measured in relation to concurrent violence and this relationship was not studied due to lack of power. It is possible that women who experienced recent violence had mounted a physiologic response and were capable of producing an adrenal reaction of DHEA-S to the stress. However, it's also possible, within the framework of the General Adaptation System, that women who had experienced violence for a long time and were experiencing more violence were incapable of mounting a physiologic stress response sufficient for a DHEA-S increase or had a dulled physiologic stress response. We also did not collect information related to PTSD, the symptoms of which may play a role in adrenal responses. Future studies that measure PTSD symptoms should account for this important experience, which can occur after IPV.

Hormones remain critical to health throughout the lifecourse, through menopause and beyond. DHEA-S patterns *after menopause* have not been well characterized in the literature, an important gap that this research addresses by tracking DHEA-S nearly ten years after the final menstrual period. Further research can examine variability in DHEA-S levels between groups with and without IPV to explore whether women with a history of IPV have a reduced production capacity for DHEA-S. Furthermore, the characterization of the influence of a psychosocial and physical stressor like IPV on DHEA-S trajectories may add to the understanding of IPV as a chronic stressor and driver of health outcomes, though potentially through pathways other than DHEA-S.

This aim's strength comes from the importance of its findings and its methodologic approach. First, this aim builds upon previous work in SWAN that has characterized DHEA-S trajectories by incorporating measurements from additional study visits (Crawford et al., 2009;

Lasley et al., 2002). Importantly, this work establishes trajectories of DHEA-S after all remaining participants have moved into post-menopause. Given the relevance of menopausal timing with levels of DHEA-S, trends in DHEA-S seen in this work might lend greater insight into ovarian and/or adrenal aging. A further strength of the work is the application of linear mixed models to account for within-woman correlated, longitudinal data and the use of group-based trajectory modeling to investigate clusters of DHEA-S patterns around the FMP. Importantly, this work examines another aspect of the deleterious health effects of IPV over time. Though this research does not clearly indicate that IPV drives changes in DHEA-S, it is possible that there is unobserved heterogeneity in patterning of different IPV experiences based on timing relative to DHEA-S measurement, IPV type, and IPV duration. Future research with a larger sample may investigate whether these factors indeed influence DHEA-S levels.

A limitation of this analysis is that participants with fewer than three measures of DHEA-S over time are excluded. The participants included in analyses were more highly educated and more likely to be white, non-smokers, and to have not reported childhood trauma, all indications that the study sample may be healthier than the SWAN group as a whole. This is critical to consider, as these characteristics also may be associated with a lower risk of IPV and perhaps higher levels of DHEA-S than the SWAN cohort as a whole. Future analyses should consider the incorporation of inverse probability weighting to statistically account for this discrepancy between the later sample and the original cohort.

Furthermore, there is potential misclassification of women into the non-IPV group when they have experienced IPV. Reporting IPV, even on a paper questionnaire, can come with stigma or with a desire to not be associated with IPV. Differential misclassification of women into the non-IPV group may obscure some of the true effect of this relationship, meaning that these estimates are likely conservative.

It is possible that women who had experienced more severe IPV, or even had experienced childhood abuse, which has been shown to be associated with IPV, were more likely to be lost to follow-up over the course of the study and thus not be included in analyses. Unfortunately, questions about lifetime experience of IPV or childhood abuse were not collected until later study visits, precluding comparative analyses of women who left the study before Visit 12, whenever lifetime IPV experiences were assessed. However, a question about past-year physical violence was included in the baseline questionnaire, so it is possible to determine whether

women who were exposed to physical violence at baseline were more likely to be lost to follow up over time. In the Michigan and Pittsburgh samples, 5.3% of women reported past-year physical IPV at baseline; of the group of participants who were included in this sample, 4.2% had reported past-year physical IPV at baseline, indicating a decline in participation, though not statistically significant, in women with prior exposure to physical IPV. In the case of differential loss-to-follow-up of women with a history of IPV experience, results from the present study may underestimate the difference in DHEA-S levels between those with and without a history of IPV. Future longitudinal studies examining DHEA-S over time may apply retention weights to account for differential loss-to-follow-up.

Even with these limitations, this aim can add to the characterization of an accelerated aging phenotype by describing trajectories of DHEA-S and their correlates, particularly as IPV may play a role in affecting production of DHEA-S across the lifecourse. As low DHEA-S may be considered an indicator of chronic stress and linked to several age-related conditions, it is important to understand possible drivers of lower DHEA-S that translates into poor health and accelerated aging.

This work does not indisputably indicate that IPV confers an overall change to a woman's DHEA-S levels and slope over time, but the sample is relatively small and reflects loss to follow up between baseline and Visit 17. If these are true null findings, DHEA-S may not be a specific enough measure to reflect IPV-related changes. However, research indicates that DHEA-S is associated with health outcomes, including mortality, so maintaining adequate DHEA-S levels may be beneficial for health into older adulthood. Critically too, addressing intimate partner violence remains one of the most pressing public health concerns of our time. The work to gather evidence to support screening for intimate partner violence, offer healing for survivors, and implement effective prevention measures continues.

2.5 References

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Chapter 3 Lifetime History of Self-Reported Intimate Partner Violence and Longitudinal Physical Function in a Cohort of Older Adult Women in the United States

Intimate partner violence (IPV) is a common and often devastating experience for many individuals, particularly women, in the United States. National estimates suggest that more than 40% of US women are affected by IPV in their lifetimes, and survivors of IPV may face health challenges following violence, including mental health conditions, acute injury and chronic pain, cardiovascular disease, and limitations in physical function (Bonomi et al., 2006; Campbell, 2002; Coker et al., 2000; Leemis et al., 2022; Thurston et al., 2022). Documenting the harms of IPV on an individual and population health scale is critical to mobilizing resources to not only support the health of IPV survivors but also to prevent IPV from occurring in the first place. Previous studies into the health effects of IPV have been limited by small sample sizes, convenience samples, lack of a control group, or incomplete information on sociodemographic and environmental factors, which play a critical role in IPV risk and subsequent health outcomes. This investigation of the physical function-related correlates of intimate partner violence in midlife to older adult women uses data from a community-based, multi-ethnic cohort of participants who were enrolled in midlife nearly 30 years ago. Analyses also incorporate the rich longitudinal phenotyping of the cohort, elucidating the social and environmental aspects of SWAN participants' lives that may contribute to health effects that emerge in the wake of IPV (Johnson et al., 2022; Ogbe et al., 2020).

3.1 Background

Adequate physical function is one of the most important contributors to quality of life and health; maintaining physical function with aging is a beneficial goal in and of itself, allowing people to carry out their life roles and responsibilities and support their quality of life. Sufficient self-reported physical function is also an important signal of health, demonstrating predictive value for decreased mortality and lower risk of adverse health outcomes, such as cardiovascular disease, falls, and dementia (Goldman et al., 2014; Hu et al., 2022; Lange-Maia et al., 2020;

Schaefer et al., 2025; Zhou et al., 2022). Regardless of age, challenges to physical function may develop gradually, in the case of a health condition like arthritis or diabetes, or suddenly, in the case of an injury like a fracture or fall. For women specifically, adequate physical function is especially important to maintain, as older adult women have longer life expectancy but are also at greater risk for disability than older adult men, translating to more years lived in poorer health if function is not maintained (Courtney-Long et al., 2015). Given the high prevalence of IPV history in women, it is crucial to consider IPV as a driver of some physical function limitations in midlife and older adult women.

In the schema of the International Classification of Functioning, Disability and Health (ICF), disability encompasses "impairments, activity limitations and participation restrictions" (WHO, 2002, p. 2), while physical function has been described as a person's capacity to carry out tasks like activities of daily living, typically by linking simple movements to more complex movements (Painter et al., 1999). Disability and challenges in physical function are common in older adulthood, with Medicare data indicating that in 2020, disability affected approximately one in three US older adults (2020 Medicare Current Beneficiary Survey Annual Chartbook and Slides, 2020). Deficits in physical function are important to understand because they often precede morbidity, are a predictor of mortality, and may be malleable during the midlife (Karvonen-Gutierrez, 2015; Karvonen-Gutierrez & Strotmeyer, 2020).

The menopausal transition has been associated with greater declines in functional status, and women are at higher risk than men of having certain health conditions associated with function – chronic pain, for example – which may have implications for overall quality of life and be more common in women who have experienced partner violence (Casale et al., 2020; Fillingim et al, 2009). IPV survivors are a population vulnerable to poor health, whether through increased stress, injuries, inflammation, mental health challenges, or chronic disease; IPV alone or in conjunction with these additional consequences may exacerbate poor physical function, which can lead to decreased quality of life and increased medical costs. Poor physical function may be a marker of accelerated aging in survivors of partner violence, and there is no point in the life course when violence is a negligible experience for a person's daily functioning; violence in childhood, the midlife, and older adulthood alike, can have lifelong repercussions for health (Fadeeva et al., 2025). If evidence suggests that survivors are indeed at greater risk for physical function challenges, further interventions to support the physical function of survivors are

merited, along with greater support to prevent violence. Thus, further illuminating the role of intimate partner violence in physical function limitations in women may provide additional evidence of a driver of function in older adulthood for women. Women in older adulthood are physically resilient; still, those with a history of IPV may reflect faster declines in physical function than their peers without IPV.

There has been limited research on the impact of IPV on changes in function during the midlife, let alone the menopausal transition. However, data from the Women's Health Initiative (WHI), a study of *post-menopausal* women started in the early 1990s provides cross-sectional and longitudinal findings about violence and physical function in older adult women (Cannell et al., 2015). Eleven percent of the WHI study population (n = 17,435 women) reported exposure to interpersonal violence[1] in the year prior to their baseline interview. Women who experienced abuse in the year prior to their baseline visit were more likely to report poorer baseline physical function as measured by the physical function scale of the Rand 36-Item Health Survey. Additionally, physical function scores were inversely associated with age, including in those who reported IPV, and women who had experienced physical and psychological interpersonal violence had physical function scores that reflected the function of women 20 years older (Cannell et al., 2015). Since all women were post-menopausal in this study, there was no assessment of changes in function by stage of menopause, and it is important to note that physical function changes occur before the menopausal transition is finished. These results, while valuable, do not capture the dynamic nature of physical function across menopause.

Another study of postmenopausal women assessed prevalence of physical and emotional abuse and compared SF-36 Physical Function scores between women exposed and unexposed to abuse (Mouton, 2003). In a cross-sectional survey of over 1,000 postmenopausal women who were enrolling in a trial of women's health in San Antonio, TX, over a quarter reported exposure to physical abuse in their lifetimes, and about half reported exposure to verbal abuse in their lifetimes. The group who had experienced physical abuse had SF-36 Physical Function scores that were 4.91 points lower than those who had not experienced physical abuse, though this figure was not statistically significantly lower. Those who had experienced emotional abuse had physical function scores that were 6.91 points lower than those without emotional abuse, a margin that was statistically significant. However, this group reported higher past-year violence than the figures seen in the SWAN cohort. In the Texas cohort, approximately 5% of women

reported past-year physical abuse, and 23% reported past-year verbal abuse. The differences in prevalence may reflect different phrasing of the questions ascertaining abuse status and methods of ascertainment, with the Texas cohort being verbally interviewed and the SWAN cohort reporting violence primarily via written questionnaire.

A study of women across different age cohorts, the Australian Longitudinal Study on Women's Health (ALSWH), compared trajectories of physical function over 16 years of study between women who had and had not experienced intimate partner violence (Loxton et al., 2017). Analyses included three birth cohorts within ALSWH, born in 1921-1926, 1946-1951, and 1973-1978. The authors found that women with any history of IPV had consistently lower scores of physical function than their peers without a history of IPV. The gap between scores for women with and without an IPV history grew with increased age, indicating that deficits in function persist and may even be amplified into older adulthood. However, analyses of the middle age cohort did not account for menopausal stage, but this study is notable for the years of data captured and the longitudinal insight from the cohort.

The present study is the first to analyze IPV as a driver of longitudinal changes in physical function in a time period that includes menopause, a critical part of understanding how lifetime experiences of IPV affect physical function outcomes from midlife into older adulthood. These analyses use the self-reported SF-36 Physical Function scale as a measure of impairment in two forms: 1) categorical, with ranges reflecting those previously used in SWAN by Ylitalo et al. (2013) (≤50 signaling significant impairment, 51-85 signaling moderate impairment, and 86-100 signaling no impairment), and 2) continuous measure, with a delta of 3 points or more indicating a clinically significant change in physical function (Maruish et al., 2011; Ogura et al, 2022). Menopause-associated changes in metabolism, bone health, and muscle strength are often reflected in changes in physical function through the menopausal transition; for women with a history of IPV or women who are experiencing IPV during menopause, these changes may be even more pronounced. This work aims to quantify this important phenomenon in women from two sites of SWAN.

To our knowledge, no studies have examined longitudinal changes in physical function through, in addition to after, menopause in survivors of intimate partner violence. Thus, this study considers the long-term physical function of survivors of IPV, documenting a critical

aspect of health in survivors which is closely linked to not only quality of life but also overall health.

3.2 Methods

The Study of Women's Health Across the Nation recruited 3,302 women to enroll in a longitudinal cohort, with study visits beginning with a baseline visit (V0) between 1996 and 1997. SWAN recruited a multi-ethnic community-based sample from seven study sites, though the present study uses data from Michigan and Pittsburgh, the two sites which administered the IPV questionnaire at V17. Study visits were conducted annually for the first ten years of the study and have been conducted approximately biennially since, for a total of 18 study visits, with the most recent visit (V17) finishing data collection in 2023. Study methods have been described previously (Sowers et al., 2000).

At baseline, 1,006 women participated from the Michigan and Pittsburgh sites, and at V17, 520 women (51.7% of the original cohort) participated from these two sites. Of this group, 461 women (45.8% of the original cohort and 88.7% of women who participated in V17) were included in analyses. Inclusion criteria were: 1) having SF-36 physical function scores at V17 plus at least two other visits and 2) having responded to the question about lifetime IPV history at V17. Women could refuse participation in the physical function questionnaire or IPV questionnaire for any reason.

Exposure: Intimate Partner Violence

Experiences of lifetime and past-year intimate partner violence were assessed at Visit 17 at the Michigan and Pittsburgh sites via the Extended-Hit Insulted Threatened Scream (E-HITS) questionnaire, a validated measure of IPV history (Iverson et al., 2015; Sherin et al., 1998) and is included as an Appendix to this dissertation. The E-HITS questionnaire assesses experiences of physical, psychological, and sexual violence. The self-reported frequency of each type of violence ("Never", "Rarely", "Sometimes", "Often", and "Frequently") is assigned a score from 1-5, respectively, and is assessed within each time frame, lifetime and past-year. Scores are summed to an overall E-HITS score for each time frame, ranging from 5-25, with higher scores indicating more frequent experiences of violence and/or more kinds of violence over each time frame.

Outcome: Physical Function Scores, SF-36 PF Scale

Physical functioning, as measured through the SF-36 Physical Function Scale, was measured at nine study visits for this analysis (Ware et al., 1993). The scale asks participants to rate their degree of difficulty completing everyday tasks, including carrying groceries, completing moderate physical activity, climbing stairs, and walking. Participants can indicate they are "limited a lot", "limited a little", or "not limited at all." Raw scores were transformed into a score from 0-100, with higher scores indicating fewer perceived limitations. Transformed scores were also trichotomized into three categories: no limitations (scores of 100-86), some limitations (85-51), and significant limitations (50 or below), in keeping with prior work within SWAN. Both continuous and categorical forms of this variable are used in analyses.

For each study visit, participants were categorized as having no physical function limitations, some physical function limitations, or significant physical function limitations based on their SF-36 Physical Function scale score. For analyses comparing the odds of significant impairment versus some or none, the "some" and "none" groups were combined. We also created a "lifetime impairment" variable to indicate whether women had significant impairment at any visit during the study; this variable was coded as '1' if women had an SF-36 score of 50 or below at any SWAN study visit.

Covariates

Covariates were collected at study baseline and/or at visits 4, 6, 8, 10, 12, 13, 15, and 17 through clinical interviews or questionnaires. Race was collected at the baseline SWAN study visit, and for the Michigan and Pittsburgh sites, all women were African American/Black or Caucasian/White. Age at V17 was measured in years. Relationship status was self-reported at V17 as married, single, divorced, widowed, or separated; the latter four categories were combined as "non-partnered", creating a dichotomous variable indicating partnered vs. non-partnered; non-partnered was the reference group. Educational attainment was assessed at baseline and categorized into high school degree or less, some college, or college degree or more; some college was the reference group. Smoking status was based on V17 self-reported current smoking status; participants were categorized as current smokers or past/never smokers; past/never was the reference group. Alcohol consumption at V17 was based on the self-reported average number of drinks per week. Participants were classified as none-to-light (<1 drink per week), medium (1-4 drinks per week), or heavy (5-6 times per week or one or more drinks per day); none-to-light was the reference group. Depressive symptoms at V17 were based on the

CES-D scale, and women who scored 16 or more were classified as having high depressive symptoms; CES-D scores <16 made up the reference group. Self-reported financial strain, assessed by the degree of difficulty paying for basic necessities, was reported at V17 as "not very difficult", "somewhat difficult", or "very difficult." As the "very difficult" category had a small number of participants, the "somewhat" and "very difficult" categories were combined, representing a group of women experiencing any financial strain; the group without financial strain was the reference group. Financial strain was collected at the same study visits that coincided with PF measurements, namely baseline, V4, V6, V8, V10, V12, V13, V15, and V17. If women indicated they had any financial strain at more than half of these visits, they were coded as experiencing "prolonged strain."

Several covariates were also considered as mediators and/or effect modifiers. Prior-month pain, modeled as both a mediator and a modifier, was assessed at Visits 15 and 17. Participant-reported pain was scored from 0 to 6. Pain scores 4-6 were classified as "moderate to severe", while pain scores of 0-3 were "none to mild" and served as the reference group. Physical and sexual abuse in childhood was included as a modifier and was assessed in two ways: first, through two questions asked at V12, and second, via the Childhood Trauma Questionnaire (CTQ), administered at V15. The two questions asked at V12 were: "As a child, were you ever beaten, physically attacked, or physically abused?" and "As a child, were you ever sexually attacked, raped, or sexually abused?" Participants could respond with "Yes", "No", or "Don't know." A "Yes" response to the former question resulted in an indication of physical child abuse, while a "Yes" response to the latter resulted in an indication of sexual child abuse. The CTQ is scored by summing the scores from five statements for each construct of child abuse, with 1 indicating the statement is "Never true" and 5 indicating the statement is "Very often true." The questionnaire and scores have been previously validated in community populations (Bernstein et al., 2003). Scores of 8 for the physical and sexual abuse categories resulted in a positive screen for that type of abuse. Though across multiple assessments of child abuse, "no" answers are more likely to be consistent (Wielaard et al., 2018), reports of child abuse are more likely to be underreported rather than falsely reported (McKinney et al., 2009). Thus, if a participant reported experiencing physical or sexual abuse at one time point (V12 or V15), the participant was categorized as experiencing child abuse.

Statistical Analyses

To generate descriptive statistics, means and standard deviations for continuous variables and percentages for categorical variables were calculated. Continuous variables were compared by lifetime IPV status with independent t-tests, and categorical variables were compared with Chi-Square tests. Bivariate analyses were conducted to compare the means and frequencies of the covariates by lifetime IPV status. Analyses were conducted primarily in SAS [Version 9.4] (SAS Institute, Inc., Cary, NC), and the mediation analyses and several figures were completed in R, using the *mediation*, *ggalluvial*, and *ggplot* packages [R version 5.0] (Wickham et al., 2019).

Logistic regression was used to predict significant impairment (vs. some or none) at V17 based on lifetime IPV history, adjusting for covariates. Incremental adjustment by covariate groups is shown in Figure 1. Because childhood physical and/or sexual abuse status may be an effect modifier for the relationship between IPV and physical function, results are also presented stratified by childhood abuse status. In addition to using lifetime IPV as the exposure of interest, these analyses were also run with each type of IPV (physical, psychological, or sexual) as the predictor. Finally, to visualize population movement between physical function categories between study visits, alluvial plots were constructed.

Figure 3-1. Adjustment Sets for Each Model

Model #	**Included Variables**
Model 0	Unadjusted
Model 1	Race, Age at V17, Marital Status
Model 2	Education, Current Smoking at V17, Alcohol Consumption at V17 + Variables in Model 1
Model 3	Financial Strain, Depressive Symptoms + Model 2

Four separate linear regression models were fit to predict V17 continuous physical function scores based on lifetime IPV status, adjusting for different sets of covariates, which are also reflected in Figure 1. Linear regression analyses are also presented stratified by childhood physical and/or sexual abuse status. For analyses assessing the effect of a lifetime experience of a particular type of IPV (physical, psychological, or sexual), the same methodology is used, though with each type of IPV as a predictor.

A linear mixed model was used to model physical function scores over time, with any lifetime IPV and each type of IPV as the exposures of interest. For this model, time was modeled in years since the screener interview, given that the number of years between visits could vary significantly between women. For each study visit the participant completed, the difference in days between screener and the study visit was calculated. To convert this variable to years, each difference was divided by 365.25 to yield the number of years since screener.

The linear mixed model also included the same covariates listed in Figure 3-1, with the addition of an interaction term between time and IPV, to quantify the additional change in physical function over time that may occur in participants with a history of IPV. Akaike's Information Criterion (AIC) scores and a likelihood ratio chi-square test to compare models with and without a random intercept and random slope were compared to guide model selection. To choose the appropriate covariance structure, the model determined to have the best fit was run with varying covariance structures, and the most parsimonious covariance structure with lowest AIC was chosen. Women missing covariates included in the model are excluded from analyses and assumed to be missing at random, given that they are participating in V17. Figure 3-2 includes the equation used in the mixed model.

Figure 3-2. Equation for linear mixed model

$$Physical\ Function\ Score_{ij} = \beta_0 + \beta_1 Lifetime\ IPV_i + \beta_2 Years\ since\ screener_{ij} + \beta_3(Lifetime\ IPV_i * Years\ since\ screener_{ij}) + \beta_4 Age\ at\ V17_i + \beta_5 Race_i + \beta_6 Education_i + \beta_7 Menopausal\ Stage_i + \beta_8 Marital\ Status_i + \beta_9 Smoking_i + \beta_{10} Alcohol\ Use_i + \beta_{11} High\ Depressive\ Symptoms_i + \beta_{12} Financial\ strain_i + b_{0i} + b_{1i} Years\ since\ screener_{ij} + \varepsilon_{ij}$$

The mediation package in R was used to conduct mediation analyses of several variables at V15 that were plausible mediators of the relationship between IPV and physical function at V17, as they could conceivably be effects of partner violence, likely occurred after initiation of violence, and lead to changes in physical function. Tested variables included pain at baseline, depressive symptoms at V15, pain at V15, and prolonged strain; each variable was tested as a mediator in independent models.

For each mediation analysis, following methodology from Imai et al. (2010) as described in Sales (2017), we first tested the relationship between the potential mediator and intimate partner violence. Next, we set up a model predicting physical function scores at V17 as a function of an interaction between intimate partner violence and the mediator. Finally, we combine these two models with the package to test the statistical significance of each mediator, generating estimates of the direct and indirect effects and the proportion of the relationship mediated by the tested variable. Models used in mediation were adjusted for the same covariates described above.

3.3 Results

At baseline, women were an average age of 45.5 (SD=2.6) years old, and at V17, an average of almost 26 years later, were an average of 71.2 (2.8) years old (Table 3-1). The analytic sample was 41.9% Black, and slightly more than half of the cohort (52.3%) was from the Pittsburgh site. Forty-nine percent were partnered. Just over 23% of the cohort completed high school or less, 38.1% completed some college, and 38.6% completed a college degree or more. About a quarter of the sample reported at V17 that paying for basic necessities was "somewhat" or "very" difficult. A similar percentage (26.3%) experienced prolonged strain over the course of the study visits.

At V17, 7.2% of women were current smokers, and 11.8% were classified as heavy drinkers. At V17, 12.6% of the sample exhibited high levels of depressive symptoms. At baseline, 27.0% of the sample had moderate to severe pain in the month prior; later at V15, 30.5% of the sample had moderate to severe prior-month pain, and at V17, 34.3% of the sample had moderate to severe pain. A third of the sample disclosed experiences of physical and/or sexual abuse in childhood.

As shown in Table 3-1, many demographic factors differed by experience of lifetime IPV. Women with a history of IPV tended to be slightly younger at both time points, and women with a history of IPV were more likely to be Black, be from the Michigan site, be unpartnered, have financial strain at V17, have prolonged financial strain, have experienced physical and/or sexual abuse in childhood, be current smokers at V17, have high depressive symptoms, and have pain in the month prior to baseline, V15, and V17 alike.

Multiple kinds of IPV were often reported with individual participants. Figure 3-3 displays the relative prevalence of each type of lifetime IPV, as well as their overlap. For lifetime

IPV, more than half of women with a history of IPV experienced multiple types of IPV. Additionally, physical IPV and psychological IPV were reported by the same number of women, though not always in the same women, and sexual IPV was the least common type of IPV. For past-year exposure to IPV at V17, the most common form was psychological, followed by sexual and physical IPV (Figure 3-4). No one in the sample experienced past-year physical IPV in isolation, and several women reported overlap between sexual and psychological IPV.

Figure 3-3. Venn diagram of lifetime IPV types in analytic sample

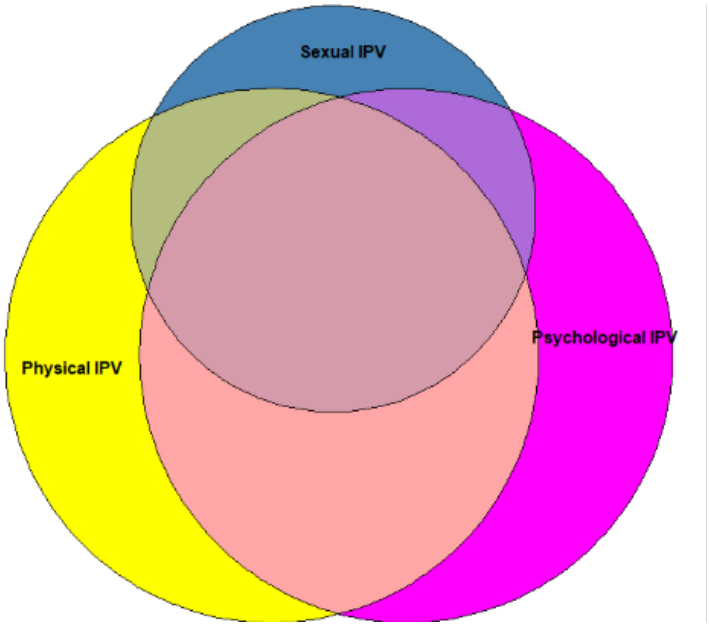


Figure 3-4. Venn diagram of past-year IPV types in analytic sample

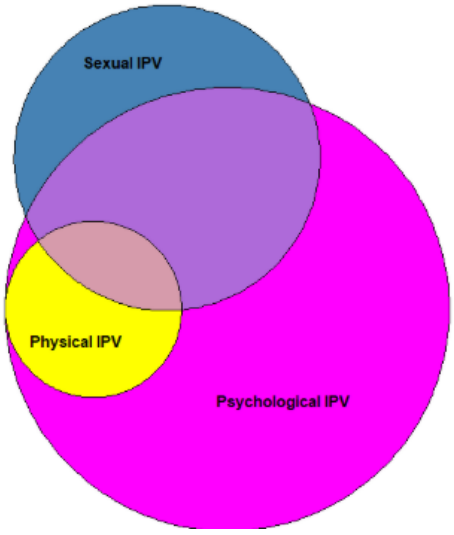


Table 3-1. Descriptive statistics of analytic sample, overall and stratified by lifetime IPV status

		Lifetime IPV		
	Overall (N = 461)	**No (N = 239)**	**Yes (N = 222)**	
Variable	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**p-value[a]**
Age (baseline, years)	45.5 (2.6)	45.8 (2.8)	45.1 (2.4)	<0.05
Age (V17, years)	71.2 (2.8)	71.5 (2.5)	70.9 (2.5)	<0.05
Body mass index (baseline, kg/m^2)	28.2 (6.5)	28.0 (6.6)	28.7 (6.4)	0.38
Body mass index (V17, kg/m^2)	30.9 (7.1)	30.5 (7.0)	31.4 (7.2)	0.16
Depressive symptom scores, V15	7.1 (7.5)	5.7 (6.2)	8.7 (8.5)	<0.001
	N (%)	**N (%)**	**N (%)**	**p-value[b]**
Physical Function Impairment, V17				<0.01
Yes	105 (22.9)	42 (17.7)	63 (28.6)	
Race/ethnicity				<0.001
White	268 (58.1)	158 (66.1)	110 (49.5)	
Black	193 (41.9)	71 (33.9)	112 (50.5)	
Site				<0.001
Michigan	220 (47.7)	96 (40.2)	124 (55.9)	
Pittsburgh	241 (52.3)	143 (59.8)	98 (44.1)	
Marital Status				<0.001
Partnered	222 (49.0)	148 (62.7%)	74 (34.1%)	
Non-partnered	231 (51.0)	88 (37.3%)	143 (65.9%)	
Education level				0.71
High school or less	106 (23.4)	52 (22.3)	54 (24.4)	
Some college	173 (38.1)	87 (37.3)	86 (38.9)	
College degree or post-college	175 (38.6)	94 (40.3)	81 (36.7)	
Difficult to pay for basic necessities				<0.001
Very/Somewhat	113 (24.8)	41 (17.4)	72 (32.9)	
Not at all	342 (75.2)	195 (82.6)	147 (67.1)	
Prolonged financial strain				<0.001
Yes	121 (26.3)	43 (18.0)	78 (35.1)	
Physical and/or sexual abuse in childhood				<0.001
Yes	148 (33.8)	51 (22.4)	97 (46.2)	
Smoking, V17				<0.05
Never or past	424 (92.8)	226 (95.4)	198 (90.0)	

Current	33 (7.2)	11 (4.6)	22 (10.0)	
Alcohol intake (V17)				0.33
None-to-light	341 (74.6)	175 (73.8)	166 (75.5)	
Moderate	62 (13.6)	37 (15.6)	25 (11.4)	
Heavy	54 (11.8)	25 (10.6)	29 (13.2)	
Depressive symptoms (V17, CES-D ≥ 16)				<0.01
Yes	58 (12.6)	19 (8.0)	39 (17.6)	
Pain in prior month (V15)				<0.05
None/mild	296 (69.5%)	167 (74.9)	129 (63.6)	
Moderate to severe	130 (30.5%)	56 (25.1)	74 (36.5)	
Pain in prior month (V17)				<0.01
None/mild	301 (65.7%)	171 (72.9)	130 (59.1)	
Moderate to severe	157 (34.3%)	67 (28.2)	90 (40.9)	

Across study visits, women with a lifetime history of IPV (Figure 3-5) have a higher proportion of any impairment than women without a lifetime history of IPV (Figure 3-6). For women with a lifetime history of IPV, there are proportionally more women moving from categories reflecting less impairment (none or some) to categories reflecting more impairment (some or significant) between visits, indicating a higher burden of functional impairment in women with a lifetime history of IPV. Of those with lifetime IPV, 56.3% (101/222) women reported significant impairment during at least one study visit, compared to 42.3% (125/239) women without a history of IPV, translating into 33% greater odds of having significant impairment at any time point during the study. However, the odds of significant impairment by IPV group varied by visit. Women with an IPV history were more likely to have significant impairment at Visit 6, Visit 15, and Visit 17. At Visits 8, 10, 12, and 13, women with an IPV history were more likely to have significant impairment, though not by a statistically significant margin.

Figure 3-5. Alluvial plots of physical function impairment category across visits for those with lifetime IPV

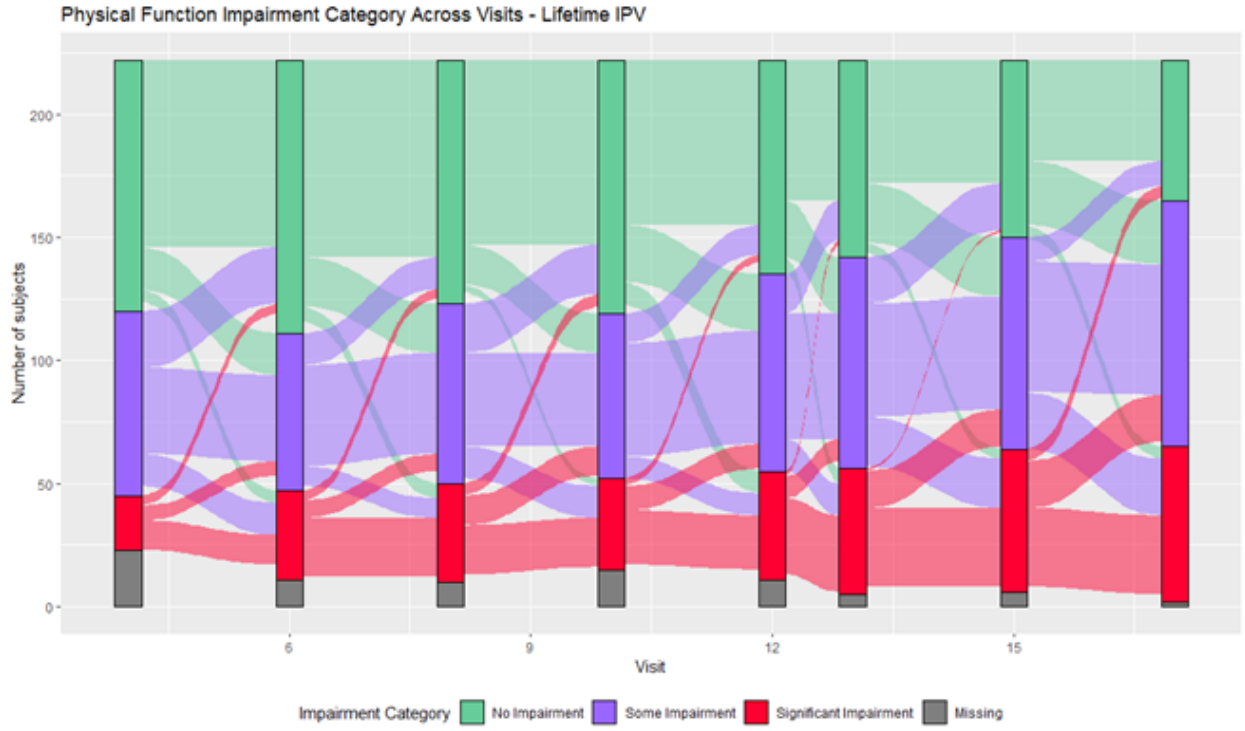
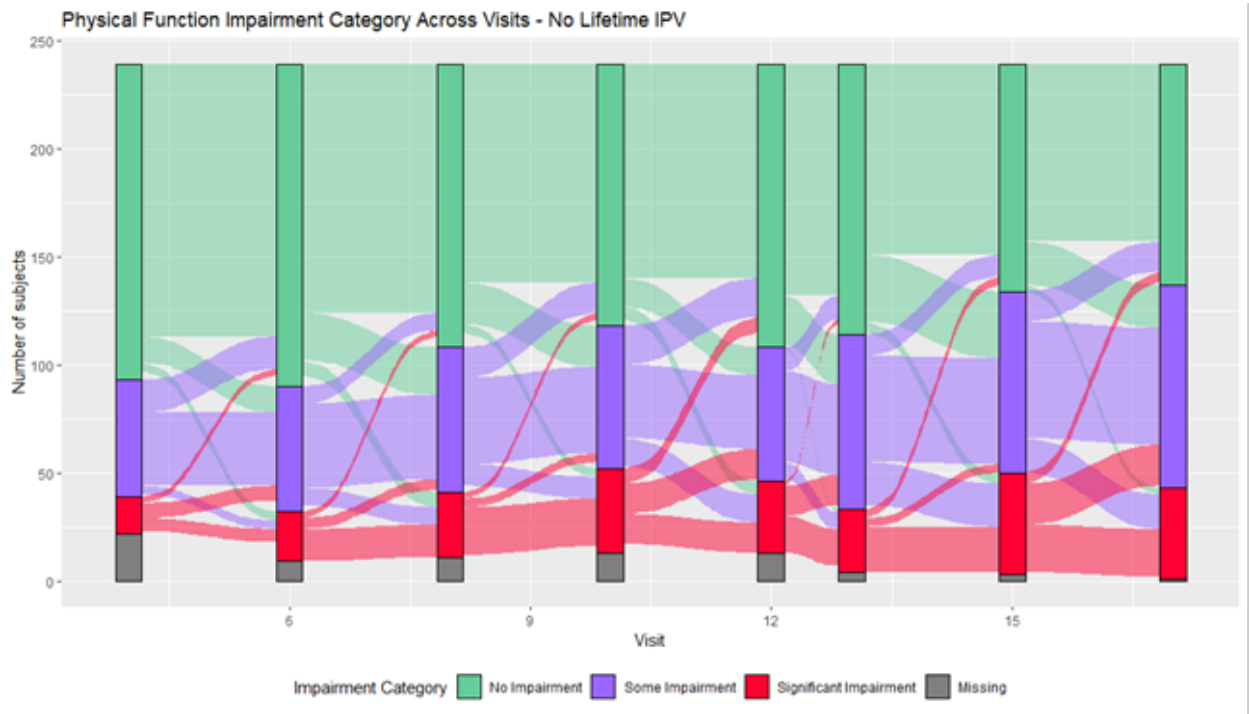


Figure 3-6. Alluvial plots of physical function impairment category across visits for those without lifetime IPV



In logistic regression analyses predicting significant impairment at V17, unadjusted analyses indicated women who had reported lifetime IPV were more likely to have had significant impairment at V17 than women who did not report lifetime IPV (OR=1.76, 95% CI 1.22, 2.55). Women who had experienced physical, psychological, or sexual IPV also had increased odds of experiencing impairment at V17. However, when incorporating covariates, differences in function between IPV groups were tempered, particularly when adding financial strain and high depressive symptoms to the model. After full adjustment, only sexual IPV remained marginally significant for functional impairment at V17. Table 3-2 displays these results.

Table 3-2. Logistic regression for impairment at any time point by IPV type

	Model 0 OR (95% CI)	**Model 1 OR (95% CI)**	**Model 2 OR (95% CI)**	**Model 3 OR (95% CI)**
Lifetime IPV	1.76 (1.22, 2.55)* Missing = 0	1.53 (1.03, 2.27)* Missing = 15	1.49 (0.99, 2.24)^ Missing = 16	1.29 (0.84, 1.98) Missing = 47
Sexual IPV	2.25 (1.35, 3.73)* Missing = 0	2.07 (1.22, 3.52)* Missing = 15	2.18 (1.27, 3.75)* Missing = 16	1.69 (0.95, 2.99)^ Missing = 16
Physical IPV	1.93 (1.28, 2.91)* Missing = 0	1.58 (1.02, 2.43)* Missing = 15	1.51 (0.97, 2.35)^ Missing = 16	1.27 (0.79, 2.04) Missing = 16
Psychological IPV	1.85 (1.22, 2.78)* Missing = 0	1.60 (1.04, 2.47)* Missing = 15	1.55 (1.00, 2.42)^ Missing = 16	1.33 (0.83, 2.12) Missing = 16

*- $p<0.05$; ^-$p=0.051$-0.10
Model 0 – Unadjusted
Model 1 – Race/ethnicity, age at V17, and relationship status (partnered vs. no partner)
Model 2 – Adding education, smoking at V17, and alcohol consumption at V17
Model 3 – Adding financial strain and high depressive symptoms, both at V17

At individual study visits, women with an IPV history were more likely to have significant impairment at Visit 6, Visit 15, and Visit 17. At Visits 8, 10, 12, and 13, women with an IPV history were more likely to have significant impairment, though not by a statistically significant margin. However, when incorporating covariates, differences in function between IPV groups were tempered. In fully adjusted models, when adjusting for financial strain and depressive symptoms, there were higher odds of impairment in the IPV group, though not by a statistically significant margin.

For the linear mixed model, AIC and likelihood ratio testing indicated the model with the random intercept and random slope had the best fit ($p<0.05$). When testing covariance matrix type, the unstructured and heterogeneous Toeplitz had the same AIC and BIC, though because the heterogeneous Toeplitz structure is more parsimonious, this structure was chosen. Appendix Table 3-5 in this chapter's appendix includes the average number of years between the screener and study visit for the sample. The fully adjusted linear mixed model indicated both that physical function scores trended downward with additional years since study baseline and that women with a history of IPV had greater losses in physical function scores over time than women without an IPV history (Table 3-3). With all covariates held constant, women with a history of IPV have a 42% greater decline per year in physical function scores, though this number was marginally significant ($p<0.10$). This translates into a widening gap in physical function between women with and without a history of IPV over time. In this particular set of covariates, high depressive symptoms, alcohol consumption, and financial strain had a statistically significant bearing on physical function scores.

For linear mixed models with the types of IPV as main predictors, each model indicated a similar annual decline in function, between -0.45 and -0.49 points annually, but sexual IPV appeared to result in the largest decline across time for survivors (Table 3-4). Rates of functional decline in survivors of sexual IPV are declining more than twice as fast as their peers without a history of sexual IPV. These declines translate into clinically meaningful declines in function within a matter of years, widening the gap between women with and without histories of IPV.

Few of the explored mediation analyses yielded statistically significant results. Results from mediation analyses are shown in this chapter's Appendix 3-2. Results indicate a marginally significant partial mediation effect from pain at baseline in the relationship between lifetime IPV (any kind) and physical function. Additionally, depression at V15 appeared to partially mediate the relationship between sexual IPV and physical function.

Table 3-3. Linear mixed model results

Variable	Model 0	Model 1	Model 2	Model 3
Intercept	84.86	87.77	84.75	87.67
IPV	-2.00	-0.45	-0.89	1.66
Years	-0.44*	-0.44*	-0.44*	-0.44*
IPV*Years	-0.31*	-0.30*	-0.33^	-0.32^
Black race		-3.83*	-3.11	-1.66
Menopausal stage				
- Perimenopausal			-0.55	-0.27
- Postmenopausal			-2.18	-1.83
Education				
- High school or less			-2.84	-2.49
- College graduate or more			4.66*	2.58
Alcohol consumption				
- Moderate to heavy drinking			6.32*	6.44*
High depressive symptoms				-7.94*
Financial strain				-13.67*

* - $p<0.05$ ^ - $p<0.1$

Table 3-4. Linear mixed models, comparing types of IPV

Variable	**Any Kind of IPV**	**Physical IPV**	**Psychological IPV**	**Sexual IPV**
Intercept	87.67	88.05	88.32	88.43
IPV	1.66	1.28	0.46	2.68
Years	-0.44*	-0.47*	-0.49*	-0.45*
IPV*Years	-0.32^	-0.46*	-0.36*	-0.86*
Black race	-1.66	-1.50*	-1.64	-1.93
Menopausal stage				
- Perimenopausal	-0.27	-0.34	-0.28	-0.55
- Postmenopausal	-1.83	-1.92	-2.36	-2.11
Education				
- High school or less	-2.49	-2.30	-2.36	-3.06
- College graduate or more	2.58	2.58	2.55	2.79
Alcohol consumption				
- Moderate to heavy drinking	6.44*	6.23*	6.23*	5.81*
High depressive symptoms	-7.94*	-7.41	-7.56*	-7.42*
Financial strain	-13.67*	-13.59*	-13.61*	-13.18*

* - $p<0.05$ ^ - $p<0.1$

Figure 3-7. Physical Function Trends between Women with and without a History of IPV

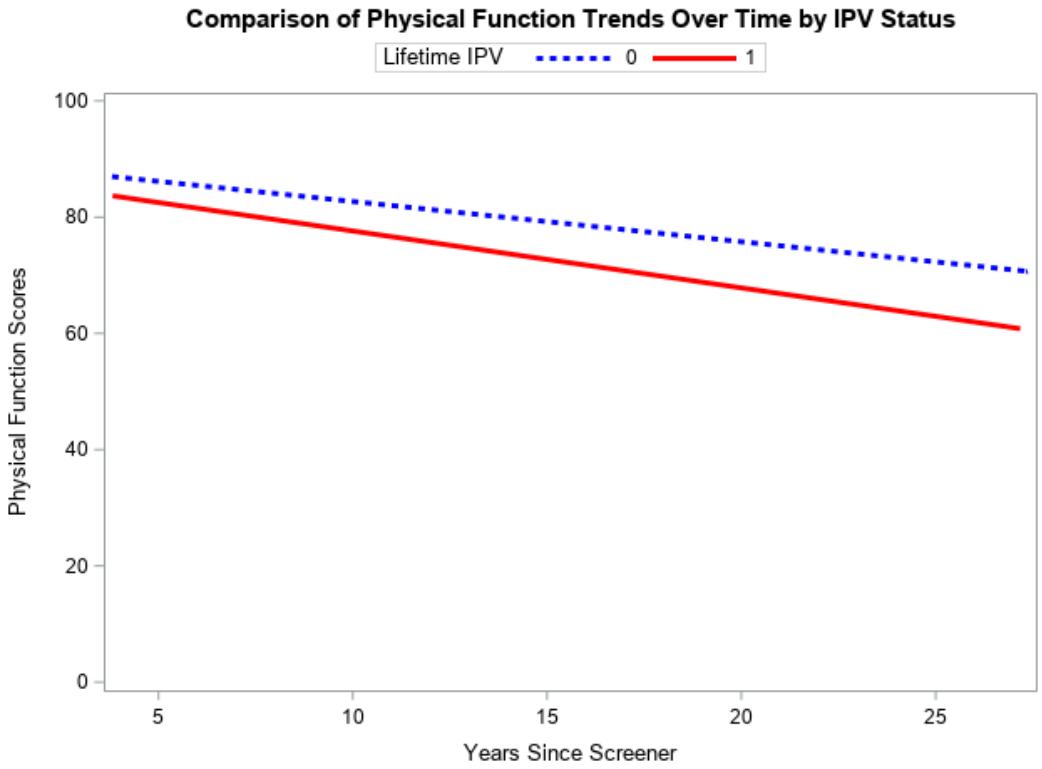
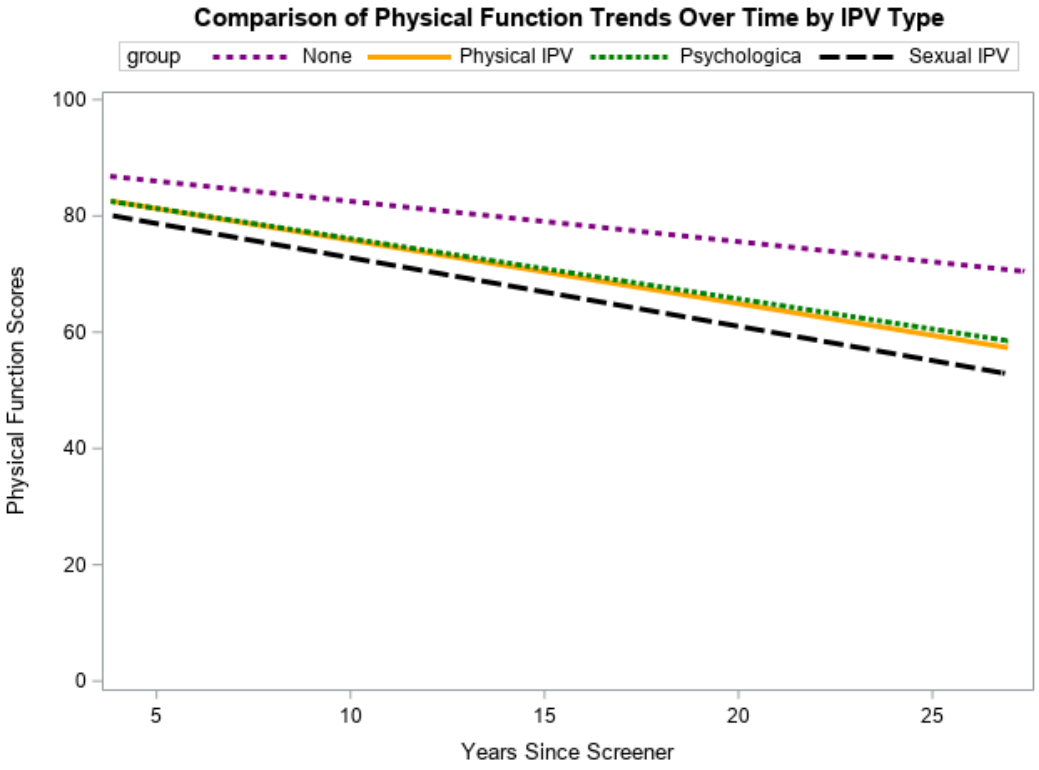


Figure 3-8. Comparison of Physical Function Trends between Women with Different IPV Types



3.4 Discussion

This is the first paper to examine IPV status as a potential driver of longitudinal changes in physical function for midlife and older adult women accounting for menopausal status. These results indicate that, in a sample of Black and White SWAN women, participants with an IPV history are more likely to faster declines in physical function relative to their peers without a history of IPV, declines that, over time, widen the gap of physical function between women with and without a history of violence. When examining differences in function attributable to particular types of IPV, each individual type was shown to be harmful for physical function, as women with a history of physical, psychological, or sexual abuse had, across time, faster accelerations of decline in physical function than women without a history of that kind of IPV, emphasizing that no type of IPV is benign to physical function. Sexual IPV was associated with the fastest rate of decline in physical function scores, accelerating declines in function by more than a factor of two.

For psychological abuse in particular, this finding echoes previous research that this type of abuse, which involves behaviors like belittling or humiliating language, coercion, and intimidation, can indeed be associated with long-term (i.e. more than a year) effects on physical function; in one study, women over the age of 50 who had experienced psychological violence, even in the absence of physical violence, had increased odds of reporting that their daily activities were impeded for more than a year (Sanz-Barbero et al., 2019). Results of the current study indicate that even psychological violence can have persistent effects that accelerate function potentially years after an experience of abuse. The effects of psychological abuse may be through pathways other than physical injury perpetrated by a partner, but its effects can be just as consequential.

Even if declines among certain groups with IPV were faster, women with IPV did not have significantly lower scores of function at each time point than women without IPV. Specifically, while physical function deficits were lower in survivors at V4, there was a trend of scores becoming more similar around V10. This was the visit when most of the SWAN cohort was post-menopausal, and so women without a history of IPV may have a “catching up” of poorer function compared to their peers with IPV, who were seeing more pronounced deficits in function five to six years earlier.

For logistic models predicting significant impairment at V17, Models 0, 1, and 2 resulted in statistically significantly higher odds of impairment for survivors of lifetime IPV and each type of IPV. However, when adjusting for depressive symptoms and financial strain, odds of impairment were not significantly higher in survivors of physical IPV or psychological IPV, suggesting that more proximal risks for functional challenges like financial stress and depressive symptoms are associated with a notable effect on function and might exert a stronger influence on function than IPV, which is likely a more distal exposure. Model 2, which does not adjust for financial strain and high depressive symptoms, is comparable to a cross-sectional assessment from the International Mobility in Aging Study (IAMS), where participants who had experienced physical violence at any point in their lives were 78% more likely to have a limitation in physical function later in life (Guedes et al., 2016); however, these analyses did not adjust for current financial strain, and depressive symptoms were incorporated as a mediator. Additionally, while some analyses were stratified by sex, these results were adjusted for sex, obscuring any differences.

Results from the linear mixed model are notable; while an additional penalty per year of a few tenths of a point for IPV survivors is small on an annual basis, this translates into significant deficits in function over just a few years and should be considered an important finding. A relatively small change, even 3-5 points, in SF-36 scores can translate into a clinically significant difference in function. If survivors may be seeing these changes in function across midlife, such changes can lead to poorer quality of life for IPV survivors earlier than their peers without a history of violence, making physical function deficits another notable potential consequence of IPV. Results from Loxton et al. (2017) indicate there is also the possibility that concurrent violence enacts additional deficits in function, though the number of women who had experienced concurrent violence was too small to test this hypothesis with any statistical confidence.

There are few other research articles to which our results are directly comparable; Cannell et al. (2015) used the same measure of function, but all women were post-menopausal at the time of functional and IPV assessment. This work noted a similar trend of women with and without IPV having comparable slopes in function across time (i.e. essentially parallel trends) though IPV survivors had a lower intercept. This paper also examined significant impairment but had a higher cut-off point of 80 points to mark impairment. Thus, while our results are not

directly comparable, both papers point to the importance of factors earlier in life that influence function, which may be relevant for function in midlife and older adulthood. The ALSWH results from the middle age cohort represent a similar, though slightly younger age group, with sixteen years of total follow-up (Loxton et al., 2017). Results indicate that women with a history of IPV have lower physical function and potentially greater declines, though results were not adjusted for potential confounding factors. Our results also showed lower levels of function in women who had reported IPV, though these results were tempered by adjustment for factors like financial strain and depressive symptoms.

These results also emphasize that women are not experiencing IPV divorced from other risk factors. Other risk factors for detriments in physical function, like financial strain and depressive symptoms, indeed contributed to lower physical function scores and often co-occur with IPV. In the linear mixed model for lifetime IPV, current high depressive symptoms conferred more than a seven-point disadvantage, holding all other covariates constant. Furthermore, women without financial strain had physical function scores that were more than 13 points higher on average at baseline. Interestingly, women with moderate to high alcohol consumption had *higher* function scores at baseline; while investigating this further is beyond the scope of the paper, it is possible that reverse causation is at play, and women with poorer function were less apt to drink than their peers with better function. Other research has demonstrated that women who have experienced IPV are more likely to use alcohol (Devries et al., 2014; Øverup et al., 2015), have financial instability (Lin et al., 2023), and live with depressive symptoms (Watson & Bitsika, 2025). As these risk factors often co-occur, women who have experienced IPV may be more likely to be living not only with one of these risk factors for lower function, but with multiple risk factors for lower function. This collective effect can be a driver of poor function, a phenomenon that merits further characterization, as it is another example of how a person's physical and social environment and circumstances collectively influence health.

Several of these commonly co-occurring risk factors were explored as mediators, though analyses revealed few associations of statistical significance. Baseline pain had a marginally significant, partial mediation effect on the relationship between lifetime IPV and physical function. The presence of depressive symptoms at V15 as a potential mediator between sexual IPV and physical function represents a potential pathway to explain the greater declines in

physical function in survivors of IPV. These results are worth exploring further in future analyses.

Financial coercion often accompanies other forms of violence but is not assessed in commonly used measures of violence (Johnson et al., 2022). While we cannot determine whether women in this sample have experienced financial coercion because SWAN does not ask about financial coercion, it is possible that some of the financial strain that women report was linked with experiences of partner violence, either predating the violence and making the participant more vulnerable to abuse or being precipitated in connection to the violence. The exploration of prolonged strain as a mediator was out of recognition that financial strain may be an insidious and longer-lasting form of violence (Postmus et al., 2020), though mediation analyses did not indicate prolonged strain had a pronounced mediative role. Future research into intimate partner violence should consider financial coercion as a significant part of violence and as a potential driver of health effects. Furthermore, the role that pain might play in the link between IPV and physical function merits further exploration. Baseline pain was explored as a mediator, suggesting marginally significant mediation effects. Furthermore, women with moderate to severe pain at baseline had a higher prevalence of impairment at V17 compared to women with mild or no pain at baseline, suggesting that pain or the effects of pain may persist across many years.

There are several strengths to this work. First, the data come from two sites of a well-characterized cohort of women in SWAN who have been followed for over twenty years. Second, the SF-36 Physical Function scale is a validated measure of physical function used in many research articles that assess function, including several referenced in this paper. Furthermore, while this measure is self-reported and reflects a respondent's perception rather than objective function, the perception of function, which may be influenced by life experiences like IPV, can be an important part of a person's physical function. In other words, whether the objective function of survivors of IPV is meaningfully different from women without a history of IPV, differences in subjective function may indicate that IPV changes perception of function. Future research can incorporate and compare self-report and objective measures to further explore the role of IPV in changing perception of function. A final strength of the analysis is the incorporation of mediation analyses to explore the mechanisms of the IPV to physical function relationship. Multiple mediators from time points between baseline and V17 were explored as

potential mechanistic explanations for any association between IPV and physical function. Further research in larger samples may yield greater insight with improved statistical power.

There are several limitations to these results. First, the SWAN cohort has experienced loss-to-follow-up over its nearly thirty years. The percentage of women at the Michigan and Pittsburgh sites who reported physical IPV within the year prior to the baseline survey is comparable to the percentage of women in this analytic sample who reported physical IPV at baseline (4.2%), indicating that there was not statistically significant differential loss-to-follow-up; however, it is possible that women with a *lifetime* history of IPV, rather than simply physical IPV in the year prior to baseline, were more likely to be lost to follow-up over time than women without a lifetime history of IPV. Since SWAN did not collect experiences of lifetime IPV prior to V12, any loss-to-follow-up prior to this study visit cannot be assessed by lifetime IPV status. These results may be affected by a form of survivor bias wherein the women in this cohort with a history of IPV may be heathier than women with a history of IPV who were lost-to-follow-up of the course of the study; in other words, the group lost-to-follow-up prior to V17 may have had more of the risk factors that cluster with IPV, meaning the group in these analyses is not representative of women in SWAN who started at baseline and who had a lifetime history of IPV. Prior to V12, there was no assessment of lifetime IPV in the SWAN cohort, so it is not possible to determine whether women with a lifetime history of IPV were more likely to be lost to follow up between baseline and V12. Future analyses should consider the use of analytic weights to analytically account for differential loss to follow up over the course of longitudinal follow-up.

The use of a self-reported IPV measure is another limitation to these analyses. Though nearly all measures of IPV are self-reported, it is likely that some participants had experienced IPV but chose not to report the IPV via the E-HITS questionnaire. This phenomenon would mean the group purportedly free of IPV would include women with a history of IPV and potentially poorer function, thus making the effect size smaller than the true effect. Given the already notable effect of IPV on physical function across time, the potential for larger effect sizes should highlight this topic as one of interest for researchers and clinicians.

Another limitation of the questionnaire is that, aside from women who reported past-year IPV, we do not have information on IPV timing. Incorporating timing of IPV into future analyses could help to illuminate whether there is an amelioration effect by time on the IPV-function

relationship or whether effects of IPV on physical function are persistent in older adult women. It is most likely that many of the women who experienced violence in the population experienced violence in their teens or 20s, which, for this sample, would be prior to the initiation of the SWAN cohort when they were in their 40s or early 50s (Leemis et al., 2022). Given that the group with IPV has increasingly lower scores of physical function throughout the study, these results suggest that effects on physical function may be persistent into older adulthood. That said, future research can improve the precision of the effects of IPV on function by incorporating information on timing of IPV.

Perhaps one of the hardest dimensions of IPV research to account for is the distinction between intimate partner violence and sexual violence perpetrated by a person or persons other than an intimate partner. Sexual violence and intimate partner violence can overlap – sexual IPV is a form of sexual violence – but sexual violence can be perpetrated by a person other than an intimate partner. This paper is not studying the effect of sexual violence specifically on physical function but the demonstrated effect no doubt captures some of, though not all, of the effect of sexual violence on physical function, as some of the group with IPV has experienced and reported sexual violence, but some of the group classified as not having experienced IPV, which may be true, has experienced sexual violence. Sexual violence may have a different or similar effect on function that these analyses cannot disentangle. Further research should remain mindful of this distinction and apply appropriate measures to quantify the effects.

Observational analyses almost always include the possibility for unmeasured confounding, as the exposure is not randomly assigned. While efforts have been made to account for factors that are associated with both IPV and physical function, it is possible that there are other factors that were not measured or which we did not account for.

Reverse causation is often a potential explanation for cross-sectional results, though even for cross-sectional logistic regression, the potential of this as an explanation for results is limited given the inherent temporality in the assessment of IPV, which most likely preceded the first assessment of physical function. The survey also asked about experiences of self-reported physical function in the previous seven days. It is possible that poor physical function within the week prior to the interview led to an experience of violence, but capturing IPV that was precipitated by recent functional challenges is highly unlikely in this population and would not occurring on a population level; furthermore, it is much more plausible that experiences of

violence reported occurred earlier in life and that effects shown in these analyses have been influenced, however distally, by experiences of intimate partner violence.

Older adult women with a history of violence may be more likely than women without a history of violence to experience deficits in physical function, though not necessarily significant impairment. Results from adjusted analyses also point to the importance of the survivor's environment and circumstances that also contribute to health. Anticipating changes in physical function may be especially important for IPV survivors, as many women are aging with a history of intimate partner violence. In other words, there is a potentially significant dovetailing of the physiological changes in function from menopause with changes in function stemming from IPV. This confluence of age-related and violence-related drivers of functional changes is vital to characterize, as this phenomenon may point to tailored approaches to maintain or improve the physical functioning of survivors.

Older adult women are resilient, and physical function can be recovered. A history of intimate partner violence is not modifiable, but physical function is. Critically though, survivors face structural barriers to better health, with many lacking the financial resources, social support, or healthcare access that could enable functional recovery from intimate partner violence. Future research investigations and policies should implement meaningful supports for recovery for survivors and ways to prevent violence before it occurs.

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3.6 Chapter 3 Appendix Tables

Table 3-5. Appendix Table - Average Time in Years between Screener and Study Visit

Visit	Average time, in years (SD)	Minimum – Maximum
Visit 4	4.13 (0.16)	3.80 – 4.73
Visit 6	6.18 (0.22)	5.82 – 7.42
Visit 8	8.16 (0.25)	7.70 – 9.36
Visit 10	10.12 (0.25)	9.68 – 11.35
Visit 12	13.66 (0.41)	12.53 – 14.69
Visit 13	15.50 (0.38)	14.43 – 16.99
Visit 15	19.20 (0.47)	17.88 – 20.53
Visit 17	25.74 (0.54)	24.27 – 27.37

Table 3-6. Appendix Table - Mediation Results

Exposure	Mediator	Estimate (95% CI) of Indirect Effect	Estimate (95% CI) of Direct Effect	Estimate (95% CI) of Proportion Mediated
Lifetime IPV	Pain at Baseline	-1.02 (-2.39, 0.08)^	-5.34 (-10.43, 0.02)^	0.15 (-0.02, 0.87)^
Physical IPV	Pain at Baseline	-0.98 (-2.60, 0.31)	-3.30 (-9.27, 2.37)	0.19 (-1.36, 2.24)
Psychological IPV	Pain at Baseline	-1.21 (-2.89, 0.07)^	-3.40 (-9.02, 2.37)	0.22 (-0.82, 2.08)
Sexual IPV	Pain at Baseline	-1.17 (-3.05, 0.22)	-5.51 (-12.32, 1.02)	0.15 (-0.09, 1.24)
Lifetime IPV	Depression at V15	-0.39 (-1.39, 0.26)	-6.94 (-12.15, -1.77)*	0.05 (-0.04, 0.24)
Physical IPV	Depression at V15	-0.97 (-2.46, 0.00)^	-3.95 (-9.62, 2.03)	0.16 (-0.58, 0.13)
Psychological IPV	Depression at V15	-0.65 (-1.93, 0.26)	-5.12 (-10.54, 0.52)^	0.10 (-0.10, 0.50)
Sexual IPV	Depression at V15	-1.50 (-3.75, -0.15)^	-6.35 (-13.34, 0.31)^	0.18 (0.01, 0.95)*
Lifetime IPV	Pain at V15	-0.34 (-1.70, 1.02)	-5.85 (-11.04, -0.72)*	0.04 (-0.25, 0.38)
Physical IPV	Pain at V15	0.41 (-1.08, 2.04)	-4.77 (-10.52, 0.63)^	-0.05 (-1.65, 1.52)
Psychological IPV	Pain at V15	-0.76 (-2.32, 0.42)	-4.46 (-9.83, 1.43)	0.12 (-0.47, 0.96)
Sexual IPV	Pain at V15	0.48 (-1.29, 2.18)	-7.47 (-14.51, -0.83)*	-0.06 (-0.80, 0.29)
Lifetime IPV	Prolonged Strain	-0.60 (-1.91, 0.46)	-7.17 (-12.48, -1.82)*	0.07 (-0.09, 0.34)
Physical IPV	Prolonged Strain	-0.82 (-2.47, 0.58)	-7.20 (-12.27, -1.82)*	0.13 (-0.56, 0.85)
Psychological IPV	Prolonged Strain	-0.34 (-1.34, 0.23)	-3.73 (-9.78, 1.99)	0.06 (-0.52, 0.98)
Sexual IPV	Prolonged Strain	-0.59 (-1.97, 1.26)	-5.75 (-12.48, 1.26)	0.07 (-0.40, 0.74)

*- $p<0.05$; ^-$p=0.051$-0.10

Note: Physical Function Scores (Continuous) is the outcome for each model, and models are adjusted for the full set of covariates.

Chapter 4 Associations between Head Injuries and Mental Health Conditions in Midlife to Older Adult Female Survivors of Partner Violence: A Retrospective Chart Review

Physical injuries are a common outcome for women experiencing intimate partner violence (IPV), and estimates from the National Intimate Partner and Sexual Violence Survey (NISVS) indicate over 40% of US women have experienced physical violence, contact sexual violence, or stalking from a current or former intimate partner in their lifetime (Leemis et al., 2022). Of this group, nearly three out of four reported experiencing a physical injury from their partner, a statistic that points to not only the immense scale of physical partner violence, but also that, more often than not, women experiencing partner violence will encounter injurious physical abuse. Partner-inflicted brain injuries, a designation that includes traumatic brain injuries through direct trauma to the head or neck, whiplash injuries from shaking or shoving, and acquired brain injuries via strangulation, are common manifestations of the injurious events sustained by survivors of intimate partner violence (Nemeth et al., 2025).

While intimate partner violence may be a common cause of brain injuries for survivors, women who are experiencing IPV are still at risk for head injuries from other sources like falls, occupational injuries, or motor vehicle crashes, summarily described as "non-IPV-related head injuries." When a person has a history of head injury while also being a survivor of IPV, the confluence of the physical trauma of a brain injury and the psychosocial trauma of intimate partner violence may lead to worse mental health outcomes like depression, anxiety, and posttraumatic stress disorder (PTSD) than either of these factors alone; however, few previous studies have compared mental health outcomes from IPV-related head injuries, including strangulation, with non-IPV-related head injuries (Corrigan et al., 2003).

Survivors of IPV may be especially vulnerable to worse outcomes after a TBI if they are unable to access timely medical care. It is vital to assess and treat a TBI as soon as possible after occurrence, as recurrent TBI before the healing of an initial TBI increases risk of poorer long-term health outcomes (Kwako et al., 2011; Wetjen et al., 2010). If survivors are not seeking care for TBI, regardless of the source, it is possible that there is a notable and treatable burden of TBI

in a vulnerable population already subject to poor health. However, little previous research has compared the prevalence of three major mental health conditions – anxiety, depression, and post-traumatic stress disorder (PTSD) – in midlife and older adult IPV survivors to understand whether IPV-related head injuries incur a unique risk for mental health, above and beyond a head injury from another source. This retrospective investigation of medical records of female midlife to older adult IPV survivors who are primary care patients at Michigan Medicine aims to explore the potential mental health harms of experiencing IPV-related versus non-IPV-related head injuries in survivors.

4.1 Background

Defining Injuries in the Context of Intimate Partner Violence

An injury is a harm, damage, or impairment to the body taking one of two forms, either an acute, external transfer of energy exceeding a physiologic threshold or the lack of a vital element, such as air or warmth (Runyan & Baker, 2009). IPV puts a person at risk for both of these types of injuries: People experiencing abuse are vulnerable to direct trauma to the head via a mechanical or kinetic transfer of energy by hitting, punching, or kicking, and they may also experience asphyxiation, or a lack of oxygen, through strangulation. However, patients are often not screened for brain injury due to stigma or patients and care providers not recognizing the signs of IPV-related head injuries and strangulation (McGrath et al., 2023). Thus, brain injuries are a condition of concern in survivors of IPV and may be more common in women than men (Campbell et al., 2022; Esopenko et al., 2024; Muelleman et al., 1996; Valera et al., 2021).

Sheridan and Nash (2007) undertook one of the first investigations detailing the breadth of injuries in survivors of IPV and reported that being hit or punched in the head was the most common mechanism and location of injury reported. While this mechanism was most common, the authors noted that strangulation to the neck, blocking the vasculature carrying oxygen to and carbon dioxide from the brain, is "underassessed and underappreciated by healthcare professionals" (Sheridan & Nash, 2007, p. 283). Additional research with IPV survivors has echoed findings from Sheridan and Nash, suggesting that the location of injuries in survivors is most likely to be the head, face, or neck, and that the most common mechanism of the injury is direct trauma or strangulation (Berrios & Grady, 1991).

Traumatic Brain Injuries

Traumatic brain injuries, or an acute application of an external force to the head or neck leading to a rapid acceleration and deceleration of the brain, coupled with short-term symptoms, can also result in long-term disability (Haag et al., 2022; Menon et al., 2010). Short-term effects may include dizziness, headaches, brain fog, memory loss, and photophobia, and long-term effects can include cognitive impairment, dementia, and PTSD (Daneshvar et al., 2011; June et al., 2020). Traumatic injuries can lead to brain damage through the initial transfer of energy, leading to axonal stretch and perforation, leading to axonal death and a neuroinflammatory response (Feghali & Wright, 1997; Rodney et al., 2018). Microglia, an immune cell of the central nervous system, are activated in the inflammatory response, removing dead cells and acting as surveillance to trigger a greater release of cytokines, if needed (Zhao et al., 2025). The inflammatory response aids the brain in healing from the injury but also represents an especially vulnerable period where glucose metabolism is suppressed and an additional injury before resolution of the first injury's symptoms is especially dangerous (Bergsneider et al., 2000); for a person living in an actively violent environment, another insult to the head, face, or neck, can exacerbate symptoms, prolong healing, and potentially put the person at risk for worse health outcomes, including death (Kwako et al., 2011). Head trauma can also lead to cortical contusions, or microhemorrhages in the brain. Progression of contusions happens in a segment of TBI patients, potentially resulting in disability or death, but can be monitored with imaging and treatment (Adatia et al., 2021). Timely care and recovery may be less accessible for survivors, making them vulnerable to worse outcomes from brain injuries, which may include mental health conditions.

Previous research with survivor populations has revealed a significant burden of head injuries involving direct trauma. One of the earliest studies of this phenomenon in women found that 35% of respondents in the study of women survivors had reported a head injury (Monahan & O'Leary, 1999). Later studies collected larger samples, and some added control groups. The message was the same: A large proportion of survivors experience head trauma over the course of their abuse, ranging from about 30% to over 90% (Kwako et al., 2011; Nemeth et al., 2025; Rowe et al., 2021; Thompson et al., 2006; Valera et al., 2022; Valera & Berenbaum, 2003). Several studies have also found that head trauma and strangulation often co-occur in injurious events; a recent study of 47 service-seeking survivors found that over 80% of the group

experienced head trauma, and nearly half experienced strangulation in the same injurious event (Nemeth et al., 2025).

Strangulation and Acquired Brain Injuries

Strangulation occurs when a perpetrator uses their hands or a ligature to decrease or stop the flow of blood to and from a victim's brain via the carotid arteries and jugular veins, respectively. Estimates of the prevalence of strangulation among survivors of IPV have risen over time, with a 1991 study reporting about a quarter of survivors presenting to an emergency department had experienced strangulation and later studies reporting estimates as high as 68% (Berrios & Grady, 1991; Wilbur et al., 2001). Whether this rising prevalence is due to more accurate detection of strangulation, greater likelihood of strangled survivors presenting for care, or higher perpetration due to increased depiction of strangulation and other forms of violence in widely accessible pornography merits further research (Shor & Liu, 2025).

Abuse by strangulation can cause not only physical harm and the erosion of a survivor's mental health due to the intense display of coercive control that is strangulation, but it is also a well-established warning sign for the escalation of violence (Glass et al., 2008; Myhill & Hohl, 2019). Non-fatal strangulation had occurred in nearly half of intimate partnerships *before* a partner was murdered or attempted to be killed by their abusive partner (Glass et al., 2008). Put even more starkly, HOPE International calls strangulation a "last warning shot", underscoring its importance as a predictor of homicide.

Even when a strangulation does not result in death, there can be an "acquired brain injury" (ABI), wherein the brain is deprived of oxygen, and carbon dioxide and intracranial pressure build to life-threatening levels. In a typical timeline of strangulation, a survivor could have pressure applied to the vasculature of the neck and lose consciousness in less than ten seconds. Within 15 seconds, both an anoxic seizure and loss of bladder control occur, and within 30 seconds, a person can lose bowel control. If pressure to the neck continues after a minute or more, death can occur (Carter et al., 2024). Unfortunately, a survivor may not remember whether she lost consciousness and often cannot report how long she was strangled. Time strangled can be an indicator of severity which may support providers in assessing the most pressing health needs for a survivor in the aftermath of a strangulation attack.

Strangulation can also be especially insidious because visible injuries, if they appear at all, may not present in the immediate aftermath of a strangulation episode, sometimes taking

hours to manifest (Donaldson et al., 2023; Messing et al., 2018); thus, even when survivors present to the ER, if the strangulation is not disclosed, a provider may have no visual cue to ask about it. If a survivor is not ready to disclose experiences of strangulation, they may miss out on critical imaging than could diagnosis a fatal condition like a carotid artery dissection or intracranial hemorrhage (Bergin et al., 2022).

Additionally, surviving multiple strangulation attempts can be associated with poorer health, with a study of 101 people reporting that survivors with multiple attempts reported more frequent neck and throat injuries along with higher prevalence of psychological and neurological disorders (D. J. Smith et al., 2001). In addition to earlier studies reporting that a high percentage of service-seeking survivors have encountered strangulation, later studies have also suggested strangulation is common in IPV survivors. In a review of forensic nursing records in a Canadian province, 60% of patients had experienced strangulation, and as an indication of the seriousness of strangulation, this group had 2.24 times the risk of displaying symptoms of a brain injury (Adhikari et al., 2024). Even when women experience strangulation, it is not always reported, but even when it is reported, it is not always documented. In a study of survivors who presented to the ER, all of whom had strangulation, only one in four charts documented this aspect of the abuse, suggesting a broad underreporting of strangulation in medical records (Bergin et al., 2022).

Not All Risk is Created Equal: Considering Health Disparities in IPV- Related Head Injuries

Though prevalence of TBI and strangulation vary, given how often head injuries and IPV may co-occur, women in certain racial and ethnic groups may be at greater risk for IPV-related TBI, as they are at increased risk of experiencing intimate partner violence (S. G. Smith et al., 2017). In the most recent National Intimate Partner and Sexual Violence Survey, women who were Black, American Indian or Alaska Native (AI/AN), or multiracial reported higher lifetime prevalence of IPV compared to white women. Though empirical research is limited, given the correlation between IPV and head injury, it is possible that there is a higher burden of head injury and strangulation among populations with higher prevalence of IPV. One study that examined this relationship found that AI/AN people had 15% higher odds than other racial groups of experiencing a TBI in the context of IPV (Linton, 2015). The same study found that women had 35% increased odds of experiencing an IPV-related TBI compared to men,

indicating notable vulnerability for AI/AN women. Furthermore, data from Arizona indicate that both Black and Native American people represent a larger proportion of TBI victims than their population proportion in the state, suggesting that these trends may play out in other contexts, underscoring that Black, AI/AN, and multiracial women at greater risk of an IPV-related TBI (Rowe et al., 2021).

There is also evidence that citizenship status, relationship status, and disability can have bearing on risk for an IPV-related head injury. In one early study of the correlates of partner violence victimization, IPV survivors were more likely to have been born outside of the United States and to have been divorced than age-matched controls (Brismar et al., 1987). Women with a disability may be more likely to experience physical violence and to be in situations with less agency to access healthcare (Breiding & Armour, 2015). Like many survivors of IPV, those with disability who present to an emergency room or a clinician with injuries sustained from IPV are often not asked about whether they are in a safe partnership. People with disabilities may be more likely to have their intimate partner accompanying them to clinical care, ostensibly as a support system, and almost certainly do not feel comfortable reporting their experiences of violence in front of their partner (Breiding & Armour, 2015). Additionally, quick fixes like screening the patient in private may not provide adequate space for a person to share their experience and get access to resources that may be sustainably supportive. In short, women, particularly those who are from a non-white racial group, those who do not hold citizenship through birth or naturalization, and those living with disability are especially susceptible to IPV. There is reason to think too that those same groups may have worse health outcomes when experiencing a head injury and may be less likely to be recognized as having a head injury.

IPV, TBI, and Mental Health Outcomes

There is evidence that IPV is associated with depression, anxiety, posttraumatic stress disorder (PTSD), and suicidal ideation (Bacchus et al., 2018; Bonomi et al., 2006; Chandan et al., 2020; Devries et al., 2013; Dillon et al., 2013; Mittal et al., 2018; Pico-Alfonso et al., 2006; Toccalino et al., 2023). Furthermore, there is some evidence that the presence of mental health conditions can increase a person's risk for IPV, highlighting the complexity of the IPV-mental health relationship (Iverson et al., 2022). Recent research has investigated head injuries as one additional mechanism that itself can contribute to inflammation, offering an addition explanation for some of the greater rates of mental health disparities seen in survivors.

Namely, if the inflammatory response in the wake of a head injury is prolonged, the associated cytokine activity, commonly measured through elevated levels of interleukin-6 (IL-6) and C-reactive protein (CRP), may be implicated in greater symptoms of depression and anxiety (Enokida et al., 2024; Felger & Lotrich, 2013). Neuroinflammation is one possible explanation for an increased risk of mental health conditions in survivors with a history of a brain injury. An inflammatory response after injury is essential for recovery, but a longer-term inflammatory response can exacerbate mental health symptoms. In a review article incorporating findings from 18 articles, Rodney and colleagues (2018) found that higher levels of tumor necrosis factor alpha, interleukin (IL)-6, IL-1, IL-8, and IL-10 were associated with worse functional outcomes after a TBI. One study included in their review suggested worse depressive symptoms may be related to this combination of inflammatory markers, but the authors noted that more research into mental health outcomes after brain injury are merited. In the same vein, decreased levels of brain-derived neurotropic factor (BDNF), a protein whose production is decreased after a head injury, have been associated with increased vulnerability to PTSD, marking this as another potential explanatory biomarker in the head injury-mental health symptom pathway (Giesler et al., 2024; Mojtabavi et al., 2020).

Objectives and Hypotheses

Previous research into documenting head and strangulation injuries of survivors of IPV have been limited by small sample sizes and have not focused on older adult women, thus making it difficult to gain insight into the correlates of violence in this population. The current study addresses these limitations by conducting a retrospective chart review in a large sample of women who are primary care patients from a large hospital system in the Midwest, Michigan Medicine. Notably, the tools allow for an extensive look into a patient's medical history, and as Michigan Medicine is a teaching hospital, notes on conditions, symptoms, and care are typically well documented. The objective of this research is to lend further insight into a common injury in an understudied population of survivors. Additionally, this study details lessons learned that may be helpful for practitioners who may encounter survivors with a head injury. The goals of this study are to calculate rates of head injury and strangulation in a population of women with documented IPV, describe common symptoms associated with injury, and quantify whether women with a head injury have increased risk of mental health conditions including depression, anxiety, and PTSD.

Hypothesis #1: In cross-sectional analyses of medical records, women IPV survivors in midlife and older adulthood with a documented head injury of any kind will be more likely to have a mental health condition (depression, anxiety, and PTSD) compared to IPV survivors without a documented head injury and compared to survivors with a head injury from another source.

Hypothesis #2: Women whose medical records documented strangulation in the context of IPV will be more likely to have a mental health condition (depression, anxiety, or PTSD) than women without strangulation.

4.2 Methods

Two tools available from the Michigan Medicine Data Office were used for this work: DataDirect and EMERSE. DataDirect is a cohort-building tool wherein approved users can specify parameters for patients in the Michigan Medicine Electronic Health Records (EHR) system. Cohorts can be constructed based on demographic factors like age, race, ethnicity, birth year, vital status, diagnosed health conditions, or test results. Patients can also be selected based on the department (e.g. Emergency Medicine, Obstetrics & Gynecology) where they sought care. DataDirect can provide basic demographics for the created cohort as well as export patient lists to the Electronic Medical Record Search Engine (EMERSE). EMERSE allows approved users to access patient notes, allowing for a more qualitative view into a patient's experience (Hanauer et al., 2015). When a patient population has been built, users enter one or more search terms to be identified in the EHR system. EMERSE also allows for searching negation of terms (e.g. patient does *not* have history of intimate partner violence), "fuzzy" searching if a word's spelling is close but not exact to the search term (e.g. 'strangel' instead of 'strangle'), and proximity searches where, if a search term includes multiple words, other words can be in between the search terms and still be flagged for review (e.g. 'violence from her partner' would be flagged in a proximity search for 'partner violence'. This study was approved by the Institutional Review Board at Michigan Medicine.

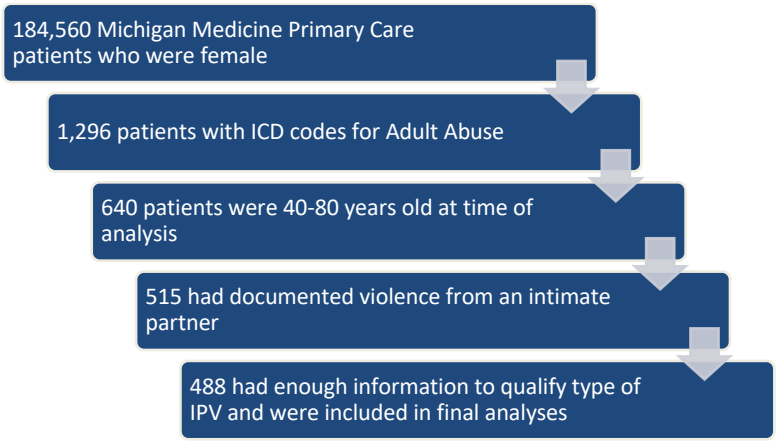
In EMERSE, I set up a filter for female patients who were between 40 and 80 years of age at the time of the search. This stipulation meant that the records most recently collected in the Michigan Medicine system would capture patients in midlife to older adulthood. Forty years old was chosen as the low end of the range, as 40 is typically considered the beginning of midlife. Eighty years old was chosen as the ceiling because the life expectancy for women is

around 80 years old. Patients living beyond 80 may be exceptional in ways that are not captured in the data that go above and beyond our question of interest. Additionally, the line between intimate partner violence and elder abuse can become more blurred around this time, so excluding patients over 80 focused the cohort on women who would be more likely to differentiate between IPV and elder abuse.

In search criteria, patients could be any race and could be alive or deceased at the time of the search. I filtered for medical encounters after January 1, 2014 until July 24, 2025, when these cohorts were being built. On July 24, 2025, there were 1,712,525 female patients in EMERSE, and 184,560 female Primary Care patients ages 18-80 in Michigan Medicine. Figure 4-1 displays a flow chart of the application of selection criteria to patients.

Of the nearly 200,000 women who were primary care patients, only 1,296 (0.7%) of the group had an ICD code for IPV. This number likely represents a vast underestimate of the true presence of IPV in the population, the implications of which are discussed later in this paper. The group of 1,296 was further narrowed by applying the age filter for 40-80 years old at the time of the cohort building (July 24, 2025), resulting in a group of 640 patients. This group was transferred to EMERSE and medical records abstraction began. In this group, 125 patients did not have documented IPV; of this group, 72 women had experienced abuse from someone other than an intimate partner, 42 did not have evident documentation of IPV in their record, and 11 had some evidence of violence, but not enough to definitively classify the patient as a survivor of IPV. In the group of 515 women with definitive IPV, 488 had enough information to classify the type of IPV experienced, and these women were included in the final cohort.

Figure 4-1. Flow Chart of Patients Included in Analyses



There were several demographic variables collected from the medical record. These included race, ethnicity, birth year, marital status, vital status, and current age. In a securely stored file, the medical record number (MRN) was maintained to differentiate participants, but when abstraction was complete, a version of the spreadsheet without MRN was created and used for analyses to better protect patient confidentiality. Patient names were visible in EMERSE but were not recorded in the spreadsheet.

IPV information, including type of IPV and age at which IPV was experienced, was collected from the medical record, aided by the EMERSE tool, which highlighted specified search terms of "assault*", "abusive", "sexual abuse", "physical abuse", "verbal abuse", "IPV", "intimate partner violence", "domestic violence", "DV". The source of IPV disclosure, whether screening tool or directly to a clinician, was also abstracted. In a free text field, health or social effects from the IPV were noted as consequences of IPV.

Abstracting the Exposure – Head Injuries and Symptoms

Head injuries were identified through ICD-9 and ICD-10 codes (850.0-.5, 850.9 and 506.0, respectively) and through search terms used in EMERSE ("head injury", "traumatic brain injury", "TBI", "head trauma", "concussion", "chok*", "strangl*", and "strangulation"). The search function allowed for words to be in a different order than the search term, and for other words to be between the words of interest while still resulting in a positive search term identification (e.g. "Injury to the head"). Head injuries in this population were coded in two steps to first, identify any head injury and second, to identify IPV-related head injuries.

First, a patient was coded as having a head injury if the medical record described trauma to the head or face that plausibly exceeded a physiologic threshold which could lead to a brain injury. Strangulation was also coded as a head injury due to its consequence of reducing blood flow to the brain and its potential for leading to hemorrhaging or stroke. Examples of coded head injuries in the medical record included: patients falling on ice and hitting their head, patients being punched in the head, patients being hit in the head with a household object like a hair dryer, patients being injured in a motor vehicle crash (MVC), or being strangled by another person's hands. There were several records in which a head injury was noted but lacked details about mechanism and subsequent symptoms; these cases were coded was "Indicated" to classify this group into possible but not definitive head injury. This group included 16 women, who were

ultimately included in the "Yes" group due to the higher likelihood of having sustained a head injury of some kind.

Second, the origin of the head injury was classified into IPV-related or non-IPV-related. The origin of the head injuries was typically self-reported by the patient and documented in the medical record; in some instances, the injury was witnessed by others. However, self-report and witness-report, especially of the origin of an injury in women with a documented head injury, may be unreliable in survivors of IPV if the head injury was due to violence. In the majority of records with a head injury, it was evident what the origin was based on self-report; however, instances of contact in which the intent of the injury was unclear (e.g. a fall with a head strike occurring after potentially incidental contact with an intimate partner) were coded as "Indicated." Furthermore, when the provider noted suspicion of IPV ("suspected but not coded for"), I coded that as "Indicated". In the group of 488 women included in analyses, there were two head injuries for which IPV was indicated as the origin. These women were ultimately included in the "IPV-head injury" group because it is more likely that the origin of a TBI in women with known histories of IPV will be misclassified as "non-IPV-related" than misclassified as "IPV-related."

Furthermore, many records, though not all, included symptoms from the head injury. Symptoms abstracted from the record when present included loss of consciousness, headache, dizziness, photophobia, nausea, vision problems, memory loss, mental fog or difficulty thinking, irritability, sleep disruption, and persistent post-concussion symptoms. Symptoms were not collected in the record consistently enough to be covariates in analyses, but frequency of symptoms was reported in this chapter's Appendix. The frequency of these symptoms thus represents the lowest estimates of symptom frequency in this group.

EMERSE was used to find mentions of depression, anxiety, and PTSD with the following search terms: "depress*", "anxiety", and "PTSD". Participants were coded as having depression or anxiety if their medical record reflected a positive diagnosis of the condition, medication use for the condition, or at least three visits with moderate to severe symptoms for the condition on a screening tool in the medical record. PTSD was categorized only by a documented diagnosis in the medical record, as screening tools for PTSD were not widely used in the Michigan Medicine records. As a post hoc search term, documentation of suicidal ideation or attempt was captured through the search terms "suicid*", "suicid* attempt", "suicidal ideation" and "SI."

Statistical Analyses

Descriptives statistics were generated by constructing frequency tables for the following variables of interest: IPV type [physical, psychological, and/or sexual], race, ethnicity, age as of July 24, 2025, year of birth [1945-1949, 1950-1959, 1960-1969, 1970-1979, 1980-1985], marital status [partnered or unpartnered], vital status, and documented history of physical, emotional, or sexual child abuse. To consider the interactive effects of different types of IPV, women experiencing two or more types of IPV were considered to have "Multiple forms of IPV", a designation added in descriptive tables.

The main frequency table was stratified by presence of head injury of any origin. Chi-square tests were used to determine whether one group had a statistically significant difference in frequency of the variable of interest by head injury compared to the other group. *P*-values for the Chi-square test are included in the results table. Fisher's exact test was used in comparisons with cell sizes of ten or fewer participants. One variable, age, was a continuous variable and thus, the mean and standard deviation was generated, and a Student's t-test was used to test whether the mean age differed by head injury status.

Descriptive statistics of interest were further stratified by head injury type, with IPV-related head injuries being distinguished from non-IPV head injuries. Comparisons of variables in women with head injuries aimed to quantify differences in the group with IPV-specific head injury as compared to non-IPV head injury; descriptive statistics were compared between IPV-related head injuries and non-IPV head injuries directly, without a head injury-free category.

Information on strangulation was also abstracted from the medical record. Descriptive statistics based on strangulation status were calculated and reported, with Chi-square tests and Fisher's exact test deployed to assess between-group differences in prevalence.

Logistic models predicting odds of anxiety, depression, and PTSD based on head injury experience were run, while adjusting for available covariates. Model 1 was adjusted for birth year and race, and Model 2 adjusted for covariates in Model 1 plus partner status and history of child abuse. The first set of models used the two-level head injury variable, with exposure categories for any kind of head injury and no head injury. The second set of models were restricted to those with a head injury and differentiated between IPV-related head injuries and non-IPV-related head injuries, using non-IPV-related head injuries as the reference group. The

third set of models predicted odds of mental health conditions based on presence of strangulation in the medical record.

4.3 Results

Table 4-1 shows characteristics of the 488 women included in the sample, as well as characteristics of the group with and without a recorded head injury, whether from IPV or another source. In the group overall, 51.2% reported experiencing multiple forms of violence, which the combination of physical and psychological violence being the most common (38.7%). About one in four survivors reported physical abuse only (27.7%), while one in five reported psychological abuse only. (Of note, those with psychological abuse only who fall into the head injury category would have had a documented head injury from a source other than IPV.) A small percentage, only 7 women (1.4%), experienced sexual abuse only. Fourteen (2.9%) and eleven (2.3%) women experienced physical and sexual abuse or sexual and psychological abuse, respectively. Thirty-six women (7.4%) reported all three forms of violence. A majority of women (62.5%) were White, about a quarter (23.4%) were Black, and 6.1% were Asian. Eight percent of women identified as another racial group; while these were combined for the sake of adequate cell sizes for analyses, the "Other" group comes from several unique backgrounds that, while considered statistically monolithic, should not be considered as such when interpreting results. Five women were American Indian/Alaska Native, one woman was Middle Eastern/North African (MENA), thirty women were categorized as "Other", and three women had an unknown racial identity or refused to answer the question. Most women in the sample were non-Hispanic (91.0%), while 7% were Hispanic. Ten women (2.0%) did not know their ethnicity or refused to respond. Forty-one percent of women were partnered, meaning they were either married or had a significant other. Forty-nine percent of women were single, divorced, widowed, or legally separated, while the remaining ten percent categorized their relationship status as "Other" or the status was listed as Unknown.

As women were ages 40-80 in the summer of 2025, all women were born in or between 1945 and 1985, though younger decades had a greater proportion of women represented in the cohort. Fifteen women were born in the 1940s, 74 in the 1950s, and 146 in the 1960s; the most frequently represented decade was the 1970s, with 30.7% of the cohort being born between 1970 and 1979. Just over 100 women were born in the 1980s; as the full decade was not represented in eligible women, there were more women per year in the 1980s than any other decade. Most of

the cohort were noted to be living, with only 6.4% of the cohort having died between intake into Michigan Medicine and the time of this records review. Cancer was the most common cause of death noted. At least a quarter of the sample reported experiencing abuse in childhood.

Just under half of the group had a documented head injury (n=227, 46.5%), and in this group, women were twice as likely to report a head injury of IPV-related origin. In the group overall, 31.6% had a head injury from IPV, while 15.0% had a non-IPV-related head injury. In the group with physical IPV, 76 women (20.7%) reported strangulation. Of the group with strangulation, 49% reported also having experienced direct trauma to the head, indicating potential injuries from strangulation and head trauma.

Mental health conditions were highly prevalent in the group overall, with more than 80% of the group having anxiety and over 85% of the group having depression. Diagnoses of PTSD were present in 120 women, or 24.6% of the sample. Over half of the cohort had expressed suicidal ideation or attempted suicide.

Chi-square tests indicated significant between-group differences, with Black women being more likely to have a documented head injury than the other racial groups. (Relationships between race and head injury type are visualized in Figure 4-2.) There were no statistically significant differences in head injury prevalence by ethnicity, vital status, or history of child abuse, though each of these tests involved small cell sizes, making these estimates unstable.

Table 4-1. Sample Characteristics (n=488), by Head Injury Status

Variable	Total (n=488)	Reported Head Injury of *Any Kind* (n=227, 46.5%)	No Reported Head Injury (n=261, 53.3%)	*P*-value
IPV Exposure				-
Physical abuse only	135 (27.7%)	93 (41.0%)	42 (16.2%)	
Psychological abuse only	96 (19.7%)	8 (3.5%)	88 (33.5%)	
Sexual abuse only	7 (1.4%)	3 (1.3%)	4 (1.5%)	
Physical + Psychological	189 (38.7%)	93 (41.0%)	96 (36.9%)	
Physical + Sexual	14 (2.9%)	11 (4.8%)	3 (1.2%)	
Sexual + Psychological	11 (2.3%)	1 (0.4%)	10 (3.8%)	
Physical + Psychological + Sexual	36 (7.4%)	18 (7.9%)	18 (6.9%)	
More than one type of IPV				0.22
Two or more types	250 (51.2%)	123 (54.2%)	127 (48.7%)	
Race*				**<0.05***
Asian (3)	30 (6.1%)	10 (4.4%)	20 (7.7%)	
Black (2)	114 (23.4%)	66 (29.1%)	48 (18.4%)	
Other (9)	39 (8.0%)	17 (7.5%)	22 (8.5%)	
White (1)	305 (62.5%)	134 (58.8%)	171 (65.8%)	
Ethnicity				0.38#
Hispanic	34 (7.0%)	13 (5.7%)	21 (8.1%)	
Non-Hispanic	444 (91.0%)	211 (93.0%)	233 (89.3%)	

Refused or Unknown	10 (2.0%)	3 (1.3%)	7 (2.7%)	
Marital Status				0.08^
Partnered	200 (41.0%)	83 (36.6%)	117 (44.8%)	
Not partnered	288 (59.0%)	144 (63.4%)	144 (55.1%)	
Age	55.2 (10.1)	54.6 (10.1)	55.8 (10.2)	0.21
Decade of birth				**<0.05***
1945-1949	15 (3.1%)	8 (3.5%)	7 (2.7%)	
1950-1959	74 (15.2%)	31 (13.7%)	43 (16.5%)	
1960-1969	146 (29.9%)	65 (28.6%)	81 (31.0%)	
1970-1979	150 (30.7%)	70 (30.8%)	80 (30.7%)	
1980-1985	103 (21.1%)	53 (23.3%)	50 (19.2%)	
Vital Status				0.69
Alive	457 (93.6%)	211 (93.0%)	246 (94.3%)	
Child Abuse				0.16
Yes	120 (24.6%)	63 (27.8%)	57 (21.8%)	
Anxiety				**<0.01***
Yes	397 (81.4%)	197 (86.8%)	200 (76.6%)	
Depression				0.59
Yes	418 (85.7%)	197 (86.8%)	221 (84.7%)	
PTSD				**<0.01***
Yes	120 (24.6%)	74 (32.6%)	46 (17.6%)	
Suicide Ideation or Attempt				0.15
Yes	240 (49.2%)	120 (52.9%)	120 (46.0%)	

Actual Marital Status: Divorced=69; Legally Separated=17; Married=197; Significant Other=9; Single=159; Unknown or Other=50; Widowed=14

[#]-Fisher's Exact test used for comparisons that included cells with fewer than ten participants

* - $p<0.05$ ^ - $0.051 \leq p < 0.10$

Table 4-2 focuses on women with any kind of head injury and compares variables of interest between survivors with an IPV-related head injury and with a non-IPV head injury. Women with an IPV-related head injury were more likely to be Black and marginally more likely to be classified as non-partnered. Women with a head injury ascribed to another source were more likely to be White, older, and to have had a history of child abuse. Women with an IPV-related head injury were more likely to have PTSD, and women with a non-IPV-related head injury were more likely to have anxiety.

Descriptive statistics for patients with a history of physical IPV stratified by documented strangulation are presented in Table 4-3. Because strangulation injuries unrelated to physical violence are rare, these results were limited to women with a documented history of physical IPV. One in five women had documented strangulation by an intimate partner in her chart. Women who were strangled were more likely to be Black and marginally more likely to be unpartnered. (Figure 4-3 shows proportion of racial identity within reported head injury type.) Anxiety and PTSD were more common in the group with strangulation compared to the group of women who experienced physical IPV without strangulation.

Table 4-2. Characteristics of Women with Head Injuries (n=227), by IPV and non-IPV Head Injury Status

Variable	Total (n=227 with head injury)	Reported IPV Head Injury (n=154, 67.8%)	Reported Non-IPV Head Injury (n=73, 32.2%)	*P*-value from χ^2 Test or Fisher exact test
IPV Exposure				
Physical abuse only	93 (41.0%)	75 (48.7%)	18 (24.7%)	
Psychological abuse only	8 (3.5%)	0 (0.0%)	8 (11.0%)	
Sexual abuse only	3 (1.3%)	0 (0.0%)	3 (4.1%)	
Physical + Psychological	93 (41.0%)	62 (40.3%)	31 (42.5%)	
Physical + Sexual	11 (4.8%)	8 (5.2%)	3 (4.1%)	
Sexual + Psychological	1 (0.4%)	0 (0.0%)	1 (1.4%)	
Physical + Psychological + Sexual	18 (7.9%)	9 (5.8%)	9 (12.3%)	
More than one type of IPV				0.20
Two or more types	123 (54.2%)	79 (51.3%)	44 (60.3%)	
Race*				0.06#^
Asian (3)	10 (4.4%)	7 (4.5%)	3 (4.1%)	
Black (2)	66 (29.1%)	53 (34.4%)	13 (17.8%)	
Other (9)	17 (7.5%)	10 (6.5%)	7 (9.6%)	
White (1)	134 (59.0%)	84 (54.5%)	50 (68.5%)	
Ethnicity				0.27#
Hispanic	13 (5.7%)	7 (4.5%)	6 (8.1%)	
Non-Hispanic	211 (93.0%)	144 (93.5%)	67 (91.8%)	
Refused or Unknown	3 (1.3%)	3 (1.9%)	0 (0.0%)	
Marital Status				0.99
Partnered	83 (36.6%)	56 (36.4%)	27 (37.0%)	
Not partnered	144 (63.4%)	98 (63.6%)	46 (63.0%)	
Age	54.6 (10.1)	53.4 (9.6)	57.1 (10.6)	**0.01***
Decade of birth				0.12#
1945-1949	8 (3.5%)	3 (1.9%)	5 (6.8%)	
1950-1959	31 (13.7%)	19 (12.3%)	12 (16.4%)	
1960-1969	65 (28.6%)	43 (27.9%)	22 (30.1%)	
1970-1979	70 (30.8%)	47 (30.5%)	23 (31.5%)	
1980-1985	53 (23.3%)	42 (27.3%)	11 (15.1%)	
Vital Status				0.99
Alive	211 (93.0%)	143 (92.9%)	68 (93.2%)	
Child Abuse				0.10^
Yes	63 (27.8%)	37 (24.0%)	26 (35.6%)	
Anxiety				0.63
Yes	197 (86.8%)	132 (85.7%)	65 (89.0%)	
Depression				**0.01***
Yes	197 (86.8%)	128 (83.1%)	69 (94.5%)	
PTSD				0.69
Yes	74 (32.6%)	52 (33.7%)	22 (30.1%)	
Suicide Ideation or Attempt				0.84#
Yes	120 (52.9%)	80 (51.9%)	40 (54.8%)	

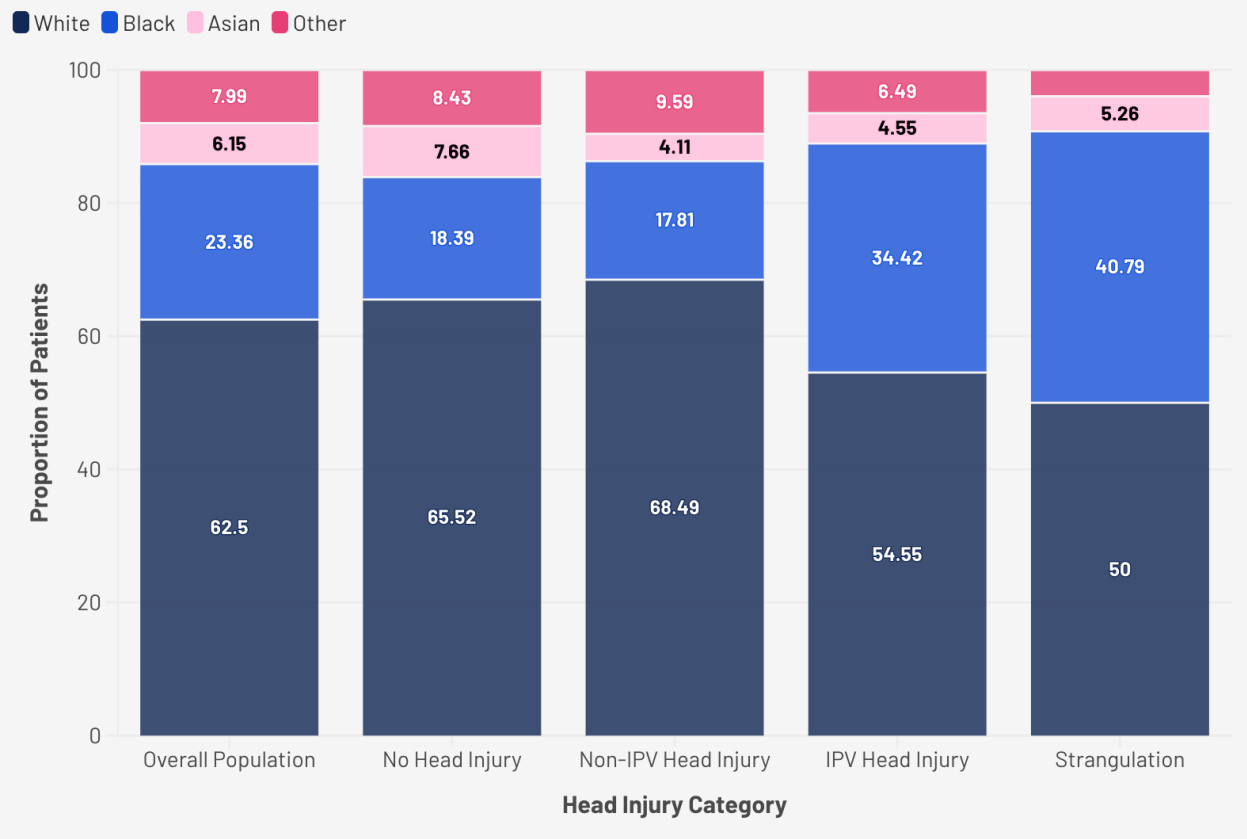
#-Fisher's Exact test used for comparisons that included cells with fewer than ten participants
* - $p<0.05$ ^ - $0.051 \leq p < 0.10$

Table 4-3. Characteristics of Physical IPV Survivors (n=386) by Strangulation Status

Variable	Total (n=368 with physical IPV)	Reported Strangulation (n=76, 20.7%)	No Reported Strangulation (n=292, 79.3%)	*P*-value from χ^2 Test or Fisher exact test
IPV Exposure				
Physical abuse only	135 (27.7%)	33 (40.8%)	102 (16.2%)	
Psychological abuse only	100 (20.5%)	13 (5.7%)	97 (33.5%)	
Sexual abuse only	9 (1.8%)	5 (2.2%)	7 (1.5%)	
Physical + Psychological	185 (37.9%)	89 (39.0%)	149 (36.9%)	
Physical + Sexual	12 (2.5%)	9 (3.9%)	10 (1.2%)	
Sexual + Psychological	11 (2.3%)	1 (0.4%)	11 (3.8%)	
Physical + Psychological + Sexual	36 (7.4%)	5 (7.9%)	31 (6.9%)	
Direct trauma to head				0.18
Yes	154 (41.8%)	37 (48.7%)	117 (40.1%)	
Race*				**<0.05***
Asian (3)	19 (5.2%)	4 (5.3%)	15 (5.1%)	
Black (2)	97 (26.4%)	31 (40.8%)	66 (22.6%)	
Other (9)	29 (7.9%)	3 (3.9%)	26 (8.9%)	
White (1)	223 (60.6%)	38 (50%)	185 (63.4%)	
Ethnicity				0.43[#]
Hispanic	28 (7.6%)	4 (5.3%)	24 (8.2%)	
Non-Hispanic	334 (90.8%)	70 (92.1%)	264 (90.4%)	
Refused or Unknown	6 (1.6%)	2 (2.6%)	4 (1.4%)	
Marital Status				0.10^
Partnered	134 (36.4%)	31 (40.8%)	103 (35.3%)	
Not partnered	234 (63.6%)	45 (59.2%)	189 (64.7%)	
Age	54.7 (10.1)	54.1 (9.2)	54.9 (10.4)	0.53
Decade of birth				0.35
1945-1949	15 (3.1%)	8 (3.5%)	7 (2.7%)	
1950-1959	74 (15.2%)	31 (13.6%)	43 (16.5%)	
1960-1969	146 (29.9%)	66 (28.9%)	80 (30.8%)	
1970-1979	150 (30.7%)	70 (30.7%)	80 (30.8%)	
1980-1985	103 (21.1%)	53 (23.2%)	50 (19.2%)	
Vital Status				0.51
Alive	457 (93.6%)	212 (93.0%)	245 (94.2%)	
Child Abuse				0.18
Yes	120 (24.6%)	64 (28.1%)	56 (21.5%)	
Anxiety				**<0.05***
Yes	397 (81.4%)	197 (86.4%)	200 (76.9%)	
Depression				0.76
Yes	418 (85.7%)	197 (86.4%)	221 (85.0%)	
PTSD				**<0.05***
Yes	120 (24.6%)	74 (32.5%)	46 (17.7%)	
Suicide Ideation or Attempt				**<0.05***
Yes	49 (10.0%)	30 (13.2%)	19 (7.3%)	

[#]-Fisher's Exact test used for comparisons that included cells with counts less than 5
* - $p<0.05$ ^ - $0.051 \leq p < 0.10$

Figure 4-2. Histogram of Head Injury Category by Race



Results from logistic models also indicated mixed effects by condition. Women with a history of a head injury had higher odds of anxiety and PTSD but not depression compared to those without a history of a head injury. In the model adjusted for race, age, relationship status, and child abuse, survivors with a head injury had 92% increased odds (95% CI: 1.18, 3.18) of anxiety and more than twice increased odds of PTSD (aOR = 2.13, 95% CI: 1.34, 3.43, Figure 4-3).

There appeared to be different effects by the type of head injury. In the model restricted to women with a head injury of any kind, women with a non-IPV-related head injury had consistently higher odds of depression compared to the IPV-related head injury group, even when controlling for age, race, marital status, and history of child abuse (aOR = 0.28, 95% CI: 0.08, 0.81, Figure 4-4). (As the non-IPV head injury group is the "control" group, point estimates and confidence intervals to the left of the null indicate higher odds of the condition in the group with a non-IPV-related head injury.) Odds of anxiety and PTSD were not significantly higher in

those with IPV-related head injury or non-IPV-related head injury (Anxiety aOR = 0.71, 95% CI: 0.27, 0.178; PTSD aOR = 1.59, 95% CI: 0.79, 3.29).

Women who had experienced strangulation in the context of IPV had 148% increased odds of anxiety in the fully adjusted model (95% CI: 1.12, 6.32), and odds of PTSD were also more than twice as high as their peers without strangulation (aOR=2.18, 95% CI: 1.22, 3.89). Strangulation appeared protective for depression, even when adjusted for other factors including age and race, though the application of the Firth Penalty for small cell sizes rendered this association not statistically significant (aOR=0.45, 95% CI: 0.23, 0.92, Figure 4-5).

Figure 4-3. Odds of Mental Health Conditions for Patients with Head Injuries

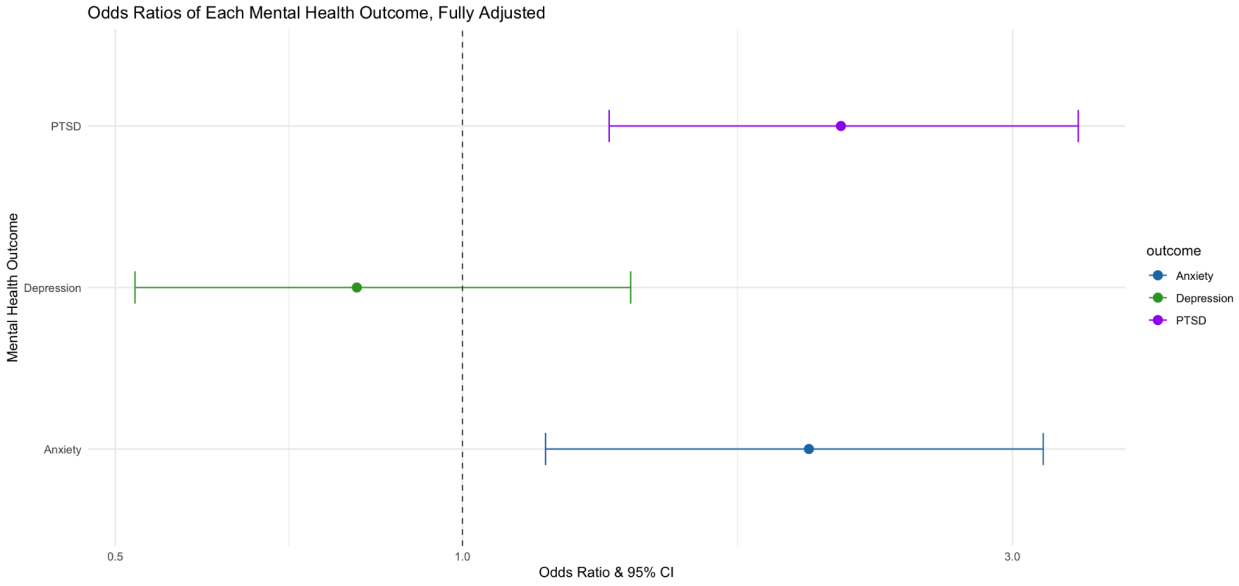


Figure 4-4. Odds of Mental Health Conditions for Patients with IPV-Related Head Injuries and Non-IPV-Related Head Injuries

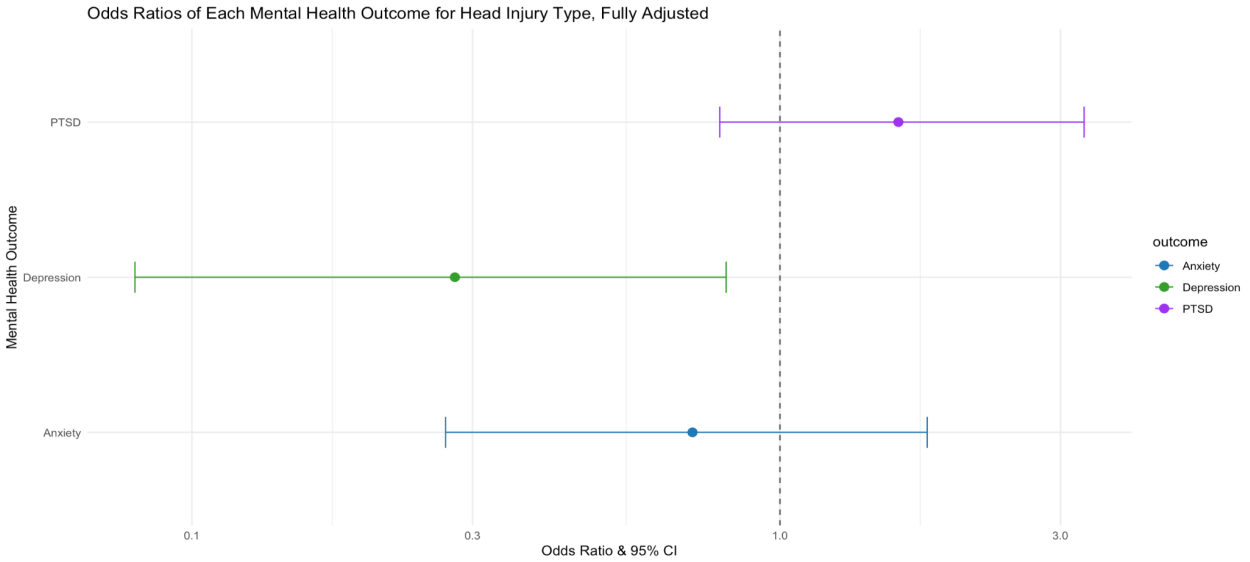
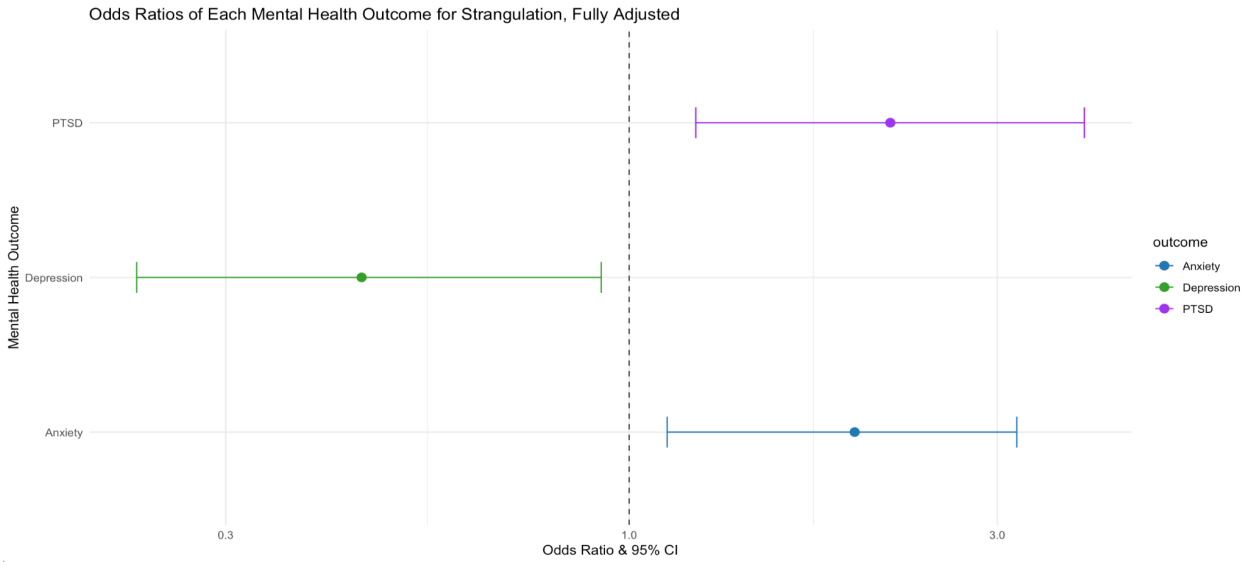


Figure 4-5. Odds of Mental Health Conditions for Patients with Strangulation



While this is not a qualitative study, over the course of abstraction, other effects of partner violence were noted, both as symptoms of head injuries and as consequences of violence generally. The prevalence of these may spark future research questions. Common terms were included “pain”, “fracture”, “PPO” meaning personal protective order (commonly known as a restraining order), “divorce”, broken teeth, jaw fracture, “depression”, and “PTSD”. Figure 4-7 at

the end of the chapter shows a word cloud, with larger words indicating more frequently noted terms in the records. This is far from exhaustive and reflects effects that the author chose to note but provides additional insight into what consequences of violence individuals may be encountering.

4.4 Discussion

This retrospective and cross-sectional chart review is one of the few studies of survivors of intimate partner violence that has explored IPV- *and* non-IPV-related head injuries as potential drivers of mental health conditions. Estimates of head injury and strangulation prevalence in this cohort are comparable to other studies of survivors. About 31% of this group of survivors had an IPV-related head injury, an estimate that falls well within the range of previous estimates in the literature (Campbell et al., 2022; Esopenko et al., 2024; Kwako et al., 2011; Thompson et al., 2006). The prevalence of strangulation in this group (15.6% in group overall, 20.7% in those who experienced physical IPV) was lower than an estimate from a study of 99 female IPV survivors, which found that 27% of women experienced strangulation in an IPV event and lower than studies which included estimates only from IPV-service-seeking survivors (Adhikari et al., 2024; Nemeth et al., 2025; Valera & Berenbaum, 2003). Racial disparities in prevalence of IPV-related head injury and strangulation differed, with Black women more likely than other racial groups to experience both direct head trauma and strangulation.

Head injuries were not associated with higher odds of depression in this cohort, a finding which may be partially driven by the high presence of depression in this cohort. That said, anxiety is also highly prevalent, and there was a signal for non-IPV-related head injury being associated with odds of anxiety. However, the group with a non-IPV-related head injury had a higher prevalence of depression than either an IPV-related head injury or no head injury. These results could suggest an additional contribution from the stress of a brain injury in the context of IPV, above and beyond the stress of a brain injury from another source. While this would need further research, it is possible that the fear sparked by an IPV-related brain injury, namely the implication that an abusive partner is signaling that they are capable of killing the other, heightens hypervigilance but not depressive symptoms.

Other studies examining the link between IPV-related head injury with loss of consciousness (LOC) have also found elevated odds of PTSD and somewhat inconsistent results

for anxiety and depression. In a study examining mental health outcomes after a brain injury with LOC, Black women in the ESSENCE cohort with a probable TBI had increased scores of PTSD but not depression (Cimino et al., 2019). This study's control group were all survivors, but this study includes head injuries with LOC, a more severe form of brain injury. Women in the present study experienced LOC but analyses included head trauma with and without LOC. It is possible that the restriction of analyses to women with a head injury with LOC would increase the strength of associations, potentially making more severe head injury display a stronger link with mental health conditions. In another study, results from a study of over 600 patients in the PREVENT Dementia cohort of participants in midlife indicated that a head injury with LOC was associated increased odds of PTSD but not with anxiety; the link between TBI with LOC and depression was marginally significant (Jenkins et al., 2025). However, the study includes both men and women and it is possible that there would be effect modification by sex or gender. Furthermore, their control group includes participants who had not experienced violence, which is a distinct control group from the current study where the control group was survivors without a head injury.

Strangulation was, surprisingly, inversely associated with depression in the first run of analyses, an association not seen for anxiety or PTSD. This finding was the opposite from a study of 99 women ages 18-54, which found that those who had been strangled had higher likelihood of depression and no association with anxiety (Valera et al., 2022). That said, this current finding in relation to depression may be due to statistical reasons, similar to what is described above for the non-finding of head injury and depression. Depression had the highest prevalence in the overall group, so it is possible that small cell sizes are having outsized influence on odds; indeed, only 16 out of 76 women with strangulation did not have depression. Since the majority of survivors in this study had depression, a protective result may be due to this small number of women without depression having a history of strangulation, thus having an outsized influence on results. A Firth correction was applied to the logistic model, and while the result still looked protective, the 95% confidence interval included the null (95% CI: 0.30, 1.09). A protective result could also reflect differences in reporting or ascertainment of strangulation, which may be harder to detect in a clinical setting and less likely to be reported to a clinician unless it is specifically asked about; however, given that anxiety and PTSD did not also display a similar protective effect, this possibility is less likely. Results related to strangulation do echo

findings from a study of 139 women in the Boston, MA area who had experienced physical IPV (Xu et al., 2025). Women who had experienced strangulation had higher symptoms of PTSD, as measured through the PTSD Checklist for the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition. However, these results were attenuated and non-significant when adjusted for confounders like age, education, and alcohol use. Since our adjustment set was limited, our results may have displayed similar attenuation if similar covariates were accounted for. All in all, these mixed findings underscore the complexity of mental health conditions and potential head injuries in IPV survivors.

This study reflects numerous strengths, including the synthesis of qualitative data from medical records from a large tertiary teaching hospital in Michigan, which reflects a multi-racial and ethnic population with well-documented care across many years. DataDirect and EMERSE eased the process of medical records abstraction, supporting the exploration of critical questions for survivor health by building cohorts with specific diagnoses and highlighting search terms of interest. Furthermore, access to medical records allowed for a larger sample size than many other previous studies and expanded eligible participants to include women who were not necessarily presenting for care for IPV. Having samples of IPV-service-seeking survivors is critical, as they represent an especially vulnerable group which has likely experienced serious or serial violence, and also, having samples that include women who are seeking care for other reasons but also disclose violence can incorporate a broader population of survivors that can further represent the broader swath of women experiencing IPV.

There are several limitations to consider for these analyses. There are, with certainty, many more women in the Michigan Medicine medical records system ages 40-80 who have a history of IPV. The 640 women in the original data pull are a vast undercount and may be fundamentally different than women have experienced IPV but who do not have this experience documented in their chart. There are many reasons, on both the provider and patient side, that IPV may not be documented. Even when aware of abuse, care providers may choose to not note the IPV in the medical record. Given that abusive behavior by partners is often driven by control over the survivor, abusive partners may have access to medical records and to messages between provider and patient. A provider may choose to not code for IPV if there is a risk of an abusive partner seeing that the patient is disclosing abuse and becoming violent because of it. However, providers may choose to hide records or notes from the patient portal to prevent other parties

from seeing the notes, and care providers should be better trained in how to block a chart from a patient record to prevent an abusive partner from accessing notes about violence.

Another reason patients may not have IPV documented in their chart is a lack of screening (King et al., 2025). Providers may not recognize signs of abuse and further, may not adequately recognize IPV-related traumatic brain injuries for several key reasons. First, screening tools that do exist for IPV-related TBI have not yet been widely deployed (Clarke et al., 2024; Dams-O'Connor et al., 2023). Second, providers may not have been adequately trained to recognize symptoms of a brain injury (Haag et al., 2019). Third, symptoms like having trouble thinking or speaking clearly or having a hard time with balance may mirror those of other conditions, like mental health conditions or substance use disorders. Finally, IPV survivors with a TBI may be perceived to be in need of other, more pressing care like a fracture or a mental health condition rather than a patient in need of treatment for a brain injury (Esopenko et al., 2024; St. Ivany & Schminkey, 2016). What further compounds this issue is that, because of the brain injury, IPV survivors with TBI may have cognitive challenges and not remember details of the abuse. As Dr. Jonathan Lifshitz described the aftermath of these head injuries, "The patient or the victim is the least reliable source because the element that they need to report reliably has been damaged" (Criado Perez, 2022).

Another reason IPV may not be documented is that, as medical encounters came from interactions with departments across the medical system, records did not have consistent methods of screening for or documenting intimate partner violence or head injuries. A more standard set of screening questions was introduced to the Michigan Medicine system in 2019 for physical, verbal, and sexual abuse, but these questions appeared to be only for encounters with certain departments (e.g. Family Medicine) and patients are not required to fill out the screening questionnaires before their appointment. Even if patients do fill out the screening questions, providers may have higher priorities within the limited window of time for an appointment and may not address violence directly with the patient, though a positive IPV screen should trigger follow-up from a nurse or social worker. With this in mind, comparisons of head injury prevalence between this study and others should only be made with caution, as other studies included specific methods for head injury assessment and symptom screening. In this cohort, it is likely that many women presenting with IPV-related injuries sustained a head injury but had more obvious trauma, like fractures or lacerations, to be addressed. In this way, estimates of the

prevalence of head injury and strangulation are likely an underestimate of the true prevalence of head injury and strangulation in this group.

Furthermore, there is likely misclassification of the IPV-related head injuries as non-IPV-related head injuries to avoid intervention from law enforcement or potential retaliation. There has been a suggestion in the literature that injuries to the head, neck, or face that were not witnessed by others may be of IPV etiology, though this may not be disclosed by the patient; on the other hand, injuries to upper or lower extremities likely will not have been of an IPV origin (Wu et al., 2010). The former is echoed in my chart review, as several women had initially reported a head injury as stemming from a non-IPV source and later admitted the injury had come from IPV. This reiterates how important trust-building is with a survivor for any clinician or social worker interacting with patients; while a head injury should be treated regardless of the source, understanding etiology can support risk of additional TBI and access to resources that may be needed for the survivor.

Stigma related to IPV and of having a brain injury may have led women to misrepresenting the source of their injury, a phenomenon which also may have resulted in the underassessment of IPV-related TBI in this cohort. To illustrate this point, during an IPV-TBI conference held in early November 2025, a survivor spoke of misrepresenting the source of a head injury; for a long time and even with friends and family, she told others she had had a bike crash rather than a violent attack from her partner (personal communication, November 6, 2025). She noted that IPV alone was a source of shame, and that the brain injury led to slowed cognition and shifts in her personality. She was embarrassed to have a head injury and to admit that her injury had changed her into a person she had trouble recognizing. Her experience is not unique. One of the misrepresentations in this cohort was a woman who presented to the ER for a "fall" but later told her provider she was abused by her partner. To apply this misclassification to our results, if this misrepresentation were more likely to happen in women with anxiety or PTSD due to greater fear of disclosing a brain injury, this would bias the estimates of the odds ratios towards the null, making IPV-related head injuries look less harmful for anxiety and PTSD than in reality.

There also may be uncertainty about the reliability of the mental health data collected in IPV survivors, particularly that the group with head injuries may be assessed more thoroughly for mental health conditions or may be more likely to consult a specialist like a psychiatrist, who

could offer a more thorough evaluation. That said, setting a high bar for classification of a positive mental health classification in abstraction (i.e. clear diagnosis in chart, taking medication for the condition) should help allay this uncertainty, especially as abstraction was done consistently regardless of head injury status. However, if mental health conditions were more likely to be documented in those with head injury, analyses may result in spurious findings, a possibility to consider and that could be addressed in future analyses with a non-IPV and non-head injury control group.

A further limitation is unmeasured confounding. In the medical records, there were a limited number of potential covariates that were consistently reported and thus could be easily abstracted. Future analyses should gather more information on factors like educational attainment, housing, insurance type, and social support. Despite the limitations of this work, this research also suggests an extension of existing injury epidemiology to IPV-related head injury.

4.5 Developing a Haddon Matrix for Partner-Inflicted Head Injuries

The Haddon Matrix is a tool used in injury epidemiology that elegantly brings together the three levels of prevention in public health and the epidemiologic triangle (Haddon Jr., 1980). The epidemiologic triangle, as conceptualized for injury prevention, considers the interplay of a host, an agent, and the environment, with each of these "points" of the triangle representing an opportunity for intervention. Each of those columns intersects with a row of prevention: primary, secondary, and tertiary. Solutions at the level of primary prevention aim to prevent IPV-related head injuries before they occur, while those at the level of secondary prevention aim to reduce the severity of energy transfer in an injurious event like an IPV-related head injury. The goal of tertiary prevention is to reduce further morbidity and long-term consequences in the wake of an IPV-related head injury. Each cell in a completed Haddon Matrix suggests a tool of injury prevention that could address the injury issue at hand.

In the available literature, the Haddon Matrix has not been applied to traumatic brain injury in the context of IPV and has rarely been applied to intimate partner violence prevention (Forum on Global Violence Prevention, 2013). The Haddon Matrix is difficult to apply to intentional injuries, as intervening on the "agent", or the perpetrator of an intentional injury, is inherently challenging – modifying the behavior of the agent involves shifting the psychology of a violent individual, which has likely been shaped by community and societal-level factors for years. Furthermore, intervening at the level of the "host", or the vulnerable person, is also

challenging because they may already be encountering so many other stressors that getting out of a violent situation may feel like a high threshold to cross. Additionally, survivors are likely already deploying coping mechanisms to deal with violence, and so even if the burden of prevention should not be on survivors, it is still valuable to conceptualize what can be modified at the host level. Additionally, the social environment is difficult to change on a large-scale, and the political and legal environment is inherently sclerotic; modifying either will take time and concerted effort. However, if anything is to be learned from the history of injury epidemiology, it is that tiny changes made over years of trial and error can shift risk for injury. IPV may seem like an intractable problem, but so did traffic safety in the 1970s and opioid deaths in the 2010s. Previous successes in injury epidemiology should provide hope that efforts to support the health of survivors is worthwhile.

The Haddon Matrix below is just one example of many potential iterations of this table which can suggest points of intervention to consider for preventing IPV-related head injuries, allaying their effects, or preventing mortality from these injuries. The intersecting levels of prevention and points of intervention each contain one or more suggestions for preventing IPV-related head injuries, ranging from an aggressor's recognition of their own triggers of violence (primary, agent) to ensuring domestic violence shelters include modifications for survivors with brain injuries to help navigate the environment and prevent falls that could further impair health (tertiary, policy + legal environment). None of these proposals are quick or easy fixes, nor could they all be tackled by one entity; the beauty of the Haddon Matrix is in brainstorming about points of intervention that can be accomplished by many different people and groups over time. The power of this matrix would also be enhanced by completing it in cooperation with stakeholders and, eventually, working with providers and advocates to implement, design, or assess interventions to prevent IPV-related head injury.

Figure 4-6. Haddon Matrix as Applied to IPV-Related Head Injury Prevention

	Host	Agent	Social Environment	Policy + Legal Environment
Primary prevention	• Recognition of coercive or violent behaviors • Education on the importance of avoiding head injury	• Self-awareness of triggers of violence • Sobriety from drugs and alcohol that may increase violent tendencies	• Normalizing healthy, non-violent relationships • Teaching conflict resolution • Not glorifying violence against women or minority groups	• Laws criminalizing abuse with additional penalties for causing a brain injury

Secondary prevention	• De-escalation tactics • Self-defense strategies to redirect violence directed at head and face	• Anger diversion to find outlets to express aggression	• Bystander training to intervene in case of escalating violence • Broader education on prevention of head injury	• Training law enforcement to protect a victim's head in case of violence
Tertiary prevention	• Pre-existing relationship with primary care provider • Completing baseline testing prior to any kind of injury to have a baseline for cognitive, physical, and mental health	• Group therapy targeted at abusive individuals with education on head injuries	• Making shelters accessible, especially for survivors with brain injury • Training advocates and clinicians to look for signs of brain injury	• Funding shelters to make environmental modifications for guests with brain injuries • Funding programs to screen and treat survivors with brain injuries • Broader EMS training to recognize IPV brain injuries in patients

4.6 Conclusions

Mental health sequelae associated with head injury in survivors are not straightforward, as it may be difficult to disentangle consequences from experiencing violence versus symptoms from a brain injury originating from another source. That said, while the research base continues to build, providers must recognize and treat the symptoms that survivors may be experiencing related to a head injury. Though the group included in analyses is likely not representative of survivors more broadly, it is still critical for providers to assess brain injury in women with a definitive or suspected history of IPV, a step which may not only identify those at risk for worse mental health outcomes but also help to avoid serious brain injuries like stroke or carotid artery dissection. Beyond physical and mental health though, there is the specific human cost to consider: The experience of being abused by an intimate partner can be extremely isolating, especially when a head injury is involved. After a brain injury, survivors often speak of needing to re-learn who they are. The experience of IPV can lead to a survivor questioning their judgment, their sense of control, and their sense of self-efficacy; these interrogations may be heightened after experiencing a brain injury. The value of this work is emphasizing that a head injury can be associated with conditions out of a survivor's control, and by documenting possible sequelae, this work is a reminder that the blame for these consequences lies squarely with the abuser. No one asks for a brain injury, yet many survivors are living with one. Furthermore, mental health conditions are treatable, and head injuries can be recovered from with time and care. Even if these consequences were not chosen, survivors, with the support of clinicians, advocates, and friends and family, can work towards healing.

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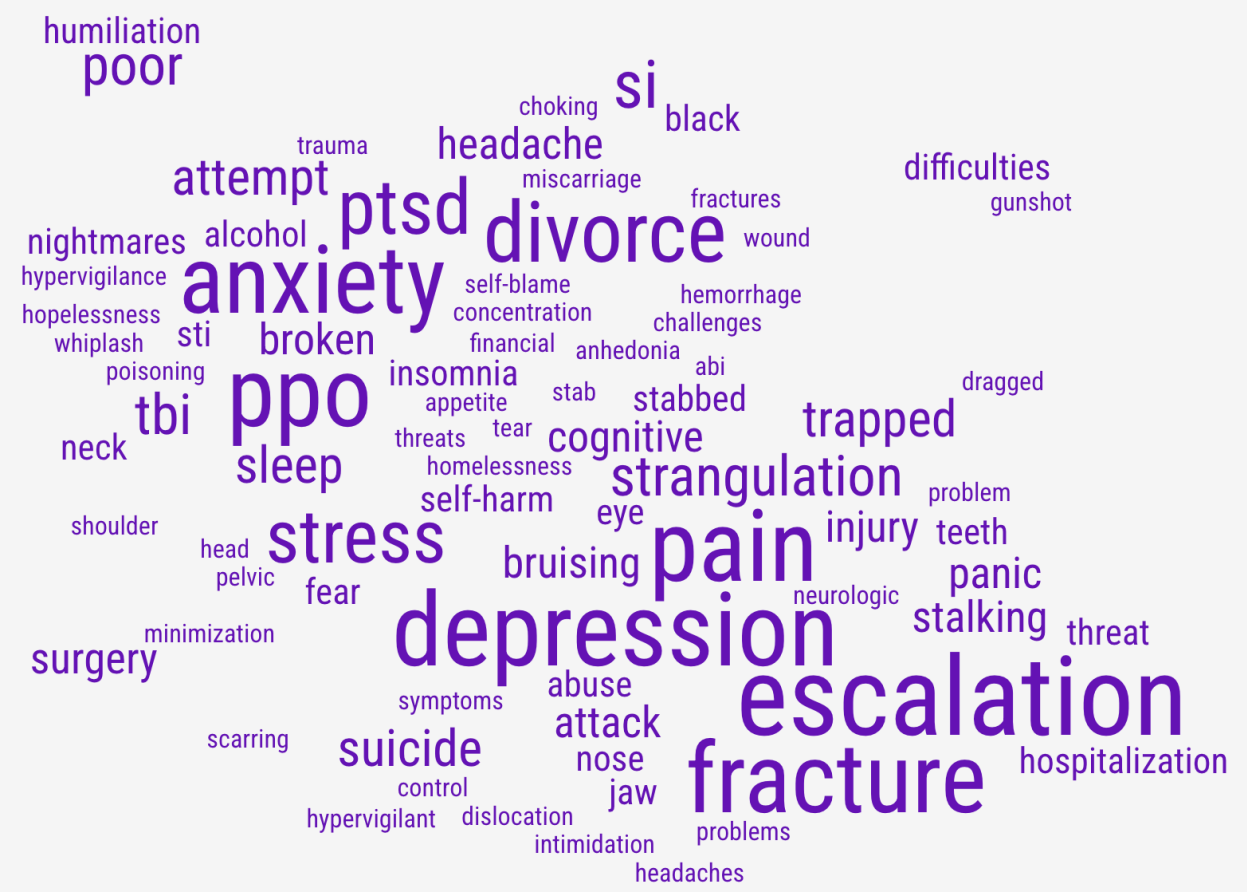
4.8 Chapter 4 Appendix Table and Figure

Table 4-4. Appendix Table – Head Injury Symptom Frequency Table

Symptom after Head Injury	Frequency of report
Headache	56
Loss of consciousness	31
Dizziness	26
Nausea	17
Vision problems	14
Persistent post-concussion symptoms	12
Mental fog or trouble thinking	10
Photophobia	9
Memory loss	6
Irritability	4
Sleep disruption	2

Figure 4-7. Appendix Figure - Word cloud of IPV-related Effects



Chapter 5 The Public Health Importance of Intimate Partner Violence

In late October of 2025, I attended an on-campus panel of experts on intimate partner violence. As the panel was hosted by three student groups with interest in public health, the first question posed to panelists boiled down to "Why is IPV a public health issue?" "Fantastic," I thought, "Chapter 5 is going to write itself." Imagine my surprise when a panelist responded, "I don't see it that way." My mild disappointment in this answer turned into a reminder – applying a public health lens to intimate partner violence is *vital* but every stakeholder brings their own perspective to addressing violence and supporting survivors. The panelist who said this had training in a separate field with its own theory and frameworks, which is important to bring to a comprehensive understanding of the drivers of IPV and their effects. To the credit of another panelist, the group discussed primary, secondary, and tertiary prevention of IPV, and those outside of public health, including the person who did not see IPV as a public health issue, echoed the value of these levels of prevention. I emerged from the panel with more than expert viewpoints percolating in my brain with this reminder: Any one field cannot tackle the drivers of violence alone, nor address the healing in survivors that needs to occur in the wake of violence. Public health must be part of the conversation. Put simply, intimate partner violence is a public health issue, and the findings from this dissertation will grow the evidence base that IPV is a harmful but preventable driver of physiologic, functional, and injurious outcomes.

5.1 Summary of Dissertation Results

5.1.1 Aim 1

DHEA-S is an adrenal and ovarian hormone that typically declines across a person's lifespan after peaking in a person's late twenties. There has been decades-long speculation about the role DHEA-S plays, whether the long-sought-after "fountain of youth" hormone with biological activity of its own or simply a precursor to testosterone and estradiol, two critical hormones across the lifespan. While this dissertation was not equipped to answer quite so lofty a question, this dissertation did chart trajectories of DHEA-S through and, to add to previous

SWAN work, *beyond* menopause. Results from this aim showed clinically meaningful declines in DHEA-S after the menopausal transition at an average decline of about 4% per study visit.

Tying in intimate partner violence, there had been some evidence that DHEA-S levels are responsive to acute and chronic stressors, a physiologic response theoretically supported by the General Adaptation Syndrome framework, wherein the body responds to a stressor with an alarm and resistance phase and a subsequent exhaustion phase. As DHEA-S is an adrenal hormone, it is very plausible that DHEA-S levels change in response to the activation of the hypothalamus-pituitary-adrenal axis, which can be chronically activated in women living through IPV.

When considering the association between IPV and DHEA-S, levels and slopes of the hormone in survivors were not significantly different than those in women without a history of partner violence. It may be that DHEA-S is not specific enough to IPV to show an obvious response, especially because IPV survivors may face so many stressors. Alternatively, it is possible that more recent IPV could have a greater effect on DHEA-S levels than having a more remote history, a future research direction for others interested in the link between stress and DHEA-S. Importantly too, Black survivors in the sample appeared to have significantly lower starting levels of DHEA-S, which may suggest an interactive effect between IPV and the stress of living as a Black woman in the United States, another potentially important avenue to explore in future research.

5.1.2 Aim 2

Given the high prevalence of injury and chronic stress in IPV survivors, deficits in physical function are a valuable outcome to explore. Few papers have quantified physical function trajectories in older adult women survivors, and this work is the first to my knowledge to investigate whether IPV contributes to declines in physical function through and beyond the menopausal transition. Results from these analyses suggested that women with a history of IPV experienced more rapid, though marginally significant, decreases in physical function compared to women without a history of IPV. This aim also incorporates type of IPV into analyses, showing that sexual IPV enacted a steeper toll on function compared to physical or psychological IPV, resulting in an acceleration in functional decline for survivors with this experience of violence. This aim also highlighted the influence of covariates like financial strain and high depressive symptoms, which often levied a more significant toll on physical function scores than

IPV alone. Such results are a reminder that risk factors often cluster together and may lead to worse health outcomes.

As physical function is a predictor of quality of life and living independently and has also been linked with cognitive health, understanding drivers of poor physical function, especially in older adult women, is vital on a population level. In pursuit of that goal, this aim's importance lies in exploring the association between IPV and function and in investigating which factors might mediate the given associations. While there were no measured factors that provided a substantial mediation effect, there was a signal that high depressive symptoms could play a role between sexual IPV and physical function deficits. As sexual IPV represented the most negative influence on function, depressive symptoms may be a modifiable risk factor for physical function in survivors of sexual IPV.

5.1.3 Aim 3

Mental health conditions like anxiety and depression can be common in both IPV survivors and those who have experienced a traumatic brain injury or strangulation, which are often grouped together as partner-inflicted brain injuries. Traumatic or acquired brain injuries lead to short-term symptoms and, in the case that a brain is re-injured before healing, can lead to long-term disability. The question of what happens when a person experiences both IPV and a head injury, particularly when a head injury may be from a source other than IPV, merits additional investigation in older adult women. This aim involved the abstraction of 640 medical records using tools to highlight terms of interest after identifying a cohort of 488 women ages 40-80 whose records included codes indicating IPV and were ultimately included in analyses.

Results indicated that survivors with any kind of head injury, including strangulation, had higher odds of anxiety and PTSD than survivors without a head injury. Analyses incorporating depression showed mixed results, with non-IPV-related head injuries being associated with higher odds of depression but strangulation being associated with lower odds of depression, though this result was tempered with a Firth penalty correct. While there may be statistical reasons or a reporting bias at play, the overall trends suggest an association between head injuries and PTSD, offering additional evidence that head injuries in survivors may be a mechanism for poorer mental health. These findings support training for clinicians to recognize and treat brain injuries, potentially alleviating some of the mental health burden in survivors.

Furthermore, older adult women are at greater risk for falls, which puts them at risk for non-IPV-related head injuries. Findings for non-IPV-related head injuries in older adult women with a history of violence are relevant for this group, including that this group have higher odds of depression. This aim contributes to a growing and important field linking head injuries in midlife to older adult female survivors with potential health effects while demonstrating feasibility of using medical records to build a large cohort.

5.2 **Importance for Public Health**

Together, these aims explore several understudied age-relevant aspects of survivor health, particularly in midlife and older adult women, a population that is often not the first to be thought of when considering IPV survivors. In addition to suggesting modifiable risk factors for clinicians, social workers, and advocates to consider, findings from this dissertation about the breadth of IPV and their consequences for older adults also have important implications for public health.

First, findings from across the aims of this dissertation underscore that **IPV is pervasive in women**. The SWAN cohort, as a community-based sample, had slightly higher though comparable numbers to national estimates of the prevalence of lifetime IPV, with just over half of women reporting some form of IPV. Furthermore, in both the SWAN cohort and the Michigan Medicine cohort, more than half of women who experienced IPV reported multiple types of IPV. The possibility of interactive effects of multiple types of violence is important to consider as a risk factor for poor health outcomes after IPV. Experiences of IPV are not static, and while it was common for women included in this dissertation to report a single type of IPV, the review of medical records in Aim 3 showed that psychological abuse can escalate to physical abuse, even in midlife, and results from Aim 2 indicate that psychological abuse is not benign for physical function, underscoring that various forms of violence can be consequential for health. Exploring how different types of violence may have distinct sequelae for health is an analytic choice that should be carried out when possible.

Second, as the US population ages, the public health importance of this dissertation in investigating drivers of accelerated aging grows. This research into IPV in midlife and older adult women occurs in the context of two demographic and health shifts happening in the United States and other industrialized nations. First, the United States is one of many countries undergoing a shift in population aging, wherein the birth rate has remained below the

replacement rate (i.e. the number of offspring needed to replace the previous generation), translating to a larger proportion of older adults in the population than seen previously (Hamilton et al., 2025). Another effect of this shift is a strain on care systems for older adults, who may find that quality, affordable care is harder to come by with fewer working age adults in the future. Second, humans are living longer; life expectancy in the US in 2023 was 81.1 years for women and 75.8 years for men, which nearly recovered SARS-CoV-2 pandemic-related losses in life expectancy (Murphy et al., 2024; Tejada-Vera et al., 2022). These trends are critical to consider in the context of IPV, as **survivors may be living longer with disability or harms brought about by IPV**. Research from this dissertation and research conducted in other studies suggests that outcomes like physical function deficits may be appearing at earlier ages than the non-survivor population. If this framework indeed extends to other conditions, IPV survivors are set up for poorer health over longer periods of time, potentially without quality care to allay harms or disability. This is an unacceptable outcome, as some of the health effects explored in this dissertation, whether physical function or mental health outcomes, are treatable.

With older adulthood often comes challenges associated with each of these aims. DHEA-S levels reach lower levels and may continue to decline for women into older adulthood; as lower DHEA-S levels have been associated with undesirable symptoms like vaginal dryness and dyspareunia, it may be important for survivors' quality of life to investigate this mechanism. However, the fact that DHEA-S was not found to show an obvious signal for survivors of IPV was evidence against the stated hypotheses that IPV may suppress DHEA-S production. That said, the null result does not disprove that closer proximity and longer time lived with the stressor could have a bearing on DHEA-S; for instance, IPV may initially depress levels, which can then rebound if a stressor is further away. This could not be investigated in these analyses, as the IPV measurement in SWAN did not capture information on timing of IPV aside from past-year violence. These results should also suggest that collecting more nuanced data on IPV timing and duration can support analyses that may indicate whether IPV timing plays an effect modifier role in hormonal levels. That said, **analyses indicated no meaningful interaction between IPV and DHEA-S *declines* over time, though there is evidence that IPV and race may a role in dictating baseline DHEA-S levels.** That said, while DHEA-S may be affected by IPV, **t**here may be other pathways influencing survivor health that are more worth exploring than DHEA-S.

One such pathway can be found in Aim 3, which joins the body of literature describing the notable prevalence of head injuries, including strangulation, in survivors. **Head injuries and strangulation are common and may be a driver of the mental health burden seen in IPV survivors.** Quantifying this phenomenon may support resource mobilization towards better treatment of head injuries in survivors and may also support head injury prevention in an aging population. Aim 3 also proposes one version of many potential Haddon Matrices that can help those working with survivors and their advocates to recognize and treat head injuries in this population of survivors.

In terms of Aim 2 and older adults, decreases in physical function are critical to investigate in survivors, as they are associated with limitations in independence and declines in quality of life. For women in particular, **longer lifespans often translate into more years lived with worse function and decreased quality of life, a period which may be even longer for an IPV survivor if accelerated aging indeed translates into poorer health at younger ages**. This is critical to address, as the results from the SWAN cohort suggest that **deficits in physical function may be present long after the violence has passed**, as most women in analyses did not endorse past-year violence. While violence still may have occurred in midlife or older adulthood, for many of these women, it is likely that their history of IPV was years prior to the period under study. If physical function may be a long-standing challenge for IPV survivors, more care and funding can be directed toward supporting physical function in older survivors, whether routing survivors to physical or occupational therapy or making environmental modifications more affordable.

As this dissertation asserts, older adult women may face particular challenges when confronting partner violence later in life. In many cases, the partner violence may have been long-standing; if an older adult woman is seeking services to support herself establish independence or to leave the relationship, she may have to disentangle financial accounts, housing, and healthcare that has been intertwined with her partner's and may have been under the partner's control (Weeks et al., 2021). Additionally, navigating the legal system can challenging for anyone but navigating paperwork, new legal terms, and a courthouse may be particularly hard for an older adult. Services specifically for older adult female survivors may be helpful for this vulnerable group, but little literature exists on effective interventions for this population. Weeks and colleagues (2021) conducted interviews with directors of programs in

Canada that provide services specifically to older adults. Findings indicated that intergenerational, regular support groups and emergency shelters with mobility accommodations for older adult women may be two of the most important measures to support older adult survivors. However, the administrators interviewed noted that funding and ageism both remain relevant challenges to continuing these programs. To the latter challenge, the authors described that some program administrators, even those working with IPV survivors, deemed the allocation of funds and support to older adults as being "redundant and a waste of scarce resources" (Weeks et al., 2021, p. 3022). It is a stark reminder of the presence of ageism, even in the thinking of those working with a vulnerable group, and implies a zero-sum mindset, where resources devoted to older adults could not benefit other survivors. However, resources tailored to older adult women will become *more* needed in the future, and in shelters specifically, older adult women who are well supported can act as further sources of support for younger women, making an investment in older adults worthwhile for all. That said, older adult women need specific supports to, for example, have their own space to discuss sexuality and religion, topics that may differ and require nuanced attention for older versus younger survivors (Weeks et al., 2021).

5.2.1 Changing Views on IPV: the Importance of Understanding Complexity of IPV

This work also details several of the harms that may occur after experiencing violence, which may suggest avenues of study for other researchers interested studying consequences of violence and working to prevent violence before it starts. To use the parlance of Bruce Link and Jo Phelan, violence is a "fundamental cause" of health disparities (Link & Phelan, 1995). As one form of violence, IPV influences an array of health conditions and is associated with generating risk of additional risks. This dissertation acknowledges that survivors are often living with other factors that might contribute to poor health, be it mental health conditions, financial strain, job and/or housing instability, addiction, or caregiving duties. This constellation of risk factors is a recognition that violence does not happen in a vacuum, and violence may be one of many stressors for a survivor.

As long as violence exists, those subject to violence will likely encounter worse health than those who do not, especially those whose social identities, including age and race, are marginalized (Farrell et al., 2022). Critically, even if the manifestations of violence are addressed and even "fixed", other effects of violence will emerge unless the mindset that generates violence is eradicated. For instance, partner violence can lead to traumatic brain injuries, which

lead to greater morbidity in survivors. Even if IPV-related traumatic brain injuries were eliminated, greater morbidity in survivors may persist through IPV-stress-induced cardiovascular health conditions. Even if cardiovascular health disparities were addressed for survivors, survivors may still face higher levels of anxiety, and so on and so forth. Fundamental cause theory functions like a perverse game of Whack-a-Mole, where the fundamental cause (e.g. violence) leads to a different health disparity that pops up just when it seemed the previous issue was solved. The solution is to dismantle the mechanisms inside the game entirely. Fundamental causes find a way to rear their ugly heads, and confronting the drivers of violence, even in small steps, can be a step toward supporting survivor health.

5.2.2 Considering Drivers of IPV: the Intersection of Power, Control, and Shame

Though much of this dissertation has focused on female survivors, I'd be hard-pressed to articulate a public health significance without addressing the perpetrators of violence, many of whom are male, though the gender of the perpetrator is less important than the fact that they're perpetrating violence.[3] In many cases, a perpetrator is re-enacting, whether consciously or not, violence they have witnessed or experienced. Perpetrators may have experienced violence in childhood at the hands of a parent or trusted figure, may have beheld the glorification of athletes tackling and body slamming each other to the roars of thousands, or witnessed the loss of friends or civilian lives in combat (Maldonado & Murphy, 2021; Travers et al., 2022). Exposure to trauma can lead a person to feel powerless; there may be rumination, a loss of sense of self and self-efficacy, or in some cases, PTSD. Early life trauma, whether witnessing or experiencing physical or sexual violence, can be associated with later perpetration of violence (Ardino, 2012). This is an extension of the chains of risk model mentioned in Chapter 1 and provides insight on addressing the fundamental cause of violence; in the chains of risk model, survivors of violence may be at risk of risk because their life circumstances may pose a greater risk of violence, but in the case of someone who has experienced violence, a person with early risk factors poses a risk to others. Being a perpetrator of harm is a health risk too (Sesar et al., 2018; Spencer et al.,

[3] To state the obvious, women and non-binary people are also capable of committing partner violence, and IPV happens in all kinds of relationships. Carmen Maria Machado's memoir *In the Dream House* is an account of her experience in a violent relationship with another woman. Machado writes compellingly about the dissonance between wanting to protect the fragility of visible queer relationships ("[Q]ueer folks *need* that good PR", p. 228) and the recognition that queerness does not protect from violence ("But haven't we been trying to say, this whole time, that we're just like you?", p. 228).

2024). This does not in any way excuse the violence or the dehumanization and desire for control that precipitate it, but this is a reminder that violence often stems from previous trauma, and that, because violence is a choice by a human being, it is preventable with interventions targeted at supporting potential perpetrators of violence.

Conceptualizing violence as a fundamental cause driven by experiences of earlier-life violence and by a desire for control has two implications. First, in keeping with fundamental cause theory, addressing the downstream effects of violence is a temporary though necessary fix, and violence will continue to lead to health disparities in aging populations unless the thinking that gives way to violence is shifted. Second, this is preventable. Entire dissertations have been devoted to exploring restrictive ideas of masculinity and femininity and how they affect modern romance, dating, and sex. In short, aggression and displays of dominance can be borne out of shame. Mental health struggles or not displaying sexual prowess have been wrongfully and harmfully associated with weakness or being a "beta"; this can lead to shame or feelings of worthlessness, which may lead a person to forcing control or power on an intimate partner (Gilligan, 2003; Lawrence & Taft, 2013).

People who have experienced trauma may look for other people to abuse, and intimate partners offer a ready target. Intimate relationships involve disclosure, closeness, and vulnerability and can be a place where a person feels like they can reclaim power and control. More comprehensive education and modeling on healthy expressions of power and teaching a balanced sense of control may be ways to address the violence that is present (Taft & Campbell, 2024). It also cannot go without saying that, more broadly, a common narrative in the United States currently is a polarized 'Us versus Them' zero-sum game, which can exacerbate existing sexism, racism, ableism, and ageism that may contribute to violence. Those who ascribe to this mindset may think, "I won't get mine if he's getting his," or, "If I'm not winning, I'm losing." Domination and expressing apathetic control are powerful social currencies and are just two manifestations of the thinking that pushed Donald Trump, a man found liable for sexually abusing E. Jean Carroll and accused of sexual violence by his ex-wife, back into the presidency for a second term (*Carroll v. Trump*, 2024). This sort of 'Us versus Them' thinking has always existed in some way, but whether it was decorum and lip service or a true belief that we could work toward a more equitable world, including addressing violence against women, years of progress is at great risk of being negated and, furthermore, being put at risk by the administration

of the aforementioned current president. Expressing gender and sexual diversity is under threat, funding for domestic violence shelters is being slashed, and even research into partner violence is at risk of being underfunded if not in alignment with the warped priorities of the current administration (Jones, 2025; McCarthy, 2025; National Network to End Domestic Violence, 2025). Many people with positions of political, legal, or social power have had credible accusations of abuse levied against them, making work to understand and prevent violence against women and marginalized groups all the more challenging but essential. However, there are some historic victories and some societal understandings that provide some hope that the narrative around violence against women provides some resistance to the previously mentioned forces.

Intimate partner violence and violence against women are hardly new phenomena; however, the interest in addressing partner violence with an eye towards population health is. In parallel with rising crime rates, the Civil Rights, and Women's Liberation movements, the 1960s and early 1970s brought a surge of interest in recognizing violence as a pervasive and harmful experience it is; in other words, intimate partner violence became viewed as a phenomenon of public concern rather than a private affair (Kimball et al., 2023). Because of its societal costs, both in terms of human health and strain on financial and legal systems, IPV could not be shoved back in the proverbial closet. Decades later, after further research into the prevalence of violence and a better understanding of the drivers, in 1994, the Violence Against Women Act (VAWA) was signed into law (Kemper & Sacco, 2019). Through grants to existing programs and the creation of new programs, VAWA's goal has been to strengthen violence prevention efforts and enforcement of laws related to violent crimes against women. Grants currently funded through VAWA include formula grant programs to enhance partnerships between governments, the legal system, and violence shelters; funding for sexual assault crisis centers and other service providers; and targeted programs specifically to prevent partner violence against special groups, like rural populations, campus populations, and Indigenous populations (Kemper & Sacco, 2019).

Additionally, younger generations have recognized that certain behaviors in relationships are unacceptable. As these generations have moved into older adulthood, there is a larger population of older adult women seeking services related to intimate partner violence. Qualitative interviews have noted that younger women in the midlife to older adult cohort may

be feel more comfortable advocating for services related to IPV than their older peers, which may increase demand for services for survivors in the future as those experiencing and recognizing IPV may continue to age (Weeks et al., 2021).

IPV has often been misunderstood or mischaracterized through the years, with a reductive view that considered violence to be physical abuse by a cis-gender male against his wife, a cis-gender female, who may be unfairly blamed for the abuse or told that she did something to deserve it. Thankfully, the societal understanding of IPV as: 1) a multi-faceted expression of control and power that encompasses emotional abuse, sexual abuse, and financial abuse, among other forms of abuse, and 2) fully the fault of the perpetrator rather than the survivor can better support survivors to recognize the harms they have experienced and move toward healing.

5.3 Charting a Path Forward

In addition to the public health implications of this work, there are several implications for clinicians and researchers who work with populations who may be experiencing partner violence. First, even with a trusted medical professional, patients often will not disclose violence until they are ready to do so. Consider IPV in differential diagnoses but do not pressure a patient to disclose IPV. Resources (local shelters, IPV hotlines) can be suggested but without coercion. In the medical records I reviewed, several providers noted they had patients whose potentially abusive partners were accompanying them to their visit; in these cases, providers set up further testing or assessments with a patient to prolong contact in case a patient would be ready to disclose IPV without her partner in the room. In one instance, the provider told the patient set up a follow-up visit, ostensibly for a Pap smear, when she could return to the office the following week. Presenting routine care that can be used as a diversion into another part of the medical clinic (e.g. additional scan, blood draw, or imaging) is a reasonable way to prolong contact with the patient if they may be close to disclosing abuse. While it may seem obvious, verbal screening for abuse should be completed while the patient is alone. The presence of a partner can sway a patient's responses, even if the partner is not actively abusive.

Clinicians, especially those in primary care, OB/GYN, and emergency medicine, will be encountering patients with IPV (Zieman et al., 2017). Given how common this experience is, these clinicians will be encountering patients with a remote history of IPV and some who are actively experiencing IPV. Signs of IPV are often subtle or non-specific, and in some cases,

survivors will obscure the causes of their injuries in order to protect themselves or children and pets from retaliation. Clinicians may ask patients more specific questions, but if a survivor is not ready to talk, the best a clinician can do is to offer a supportive and non-judgmental space. It may also be helpful for clinicians to describe how IPV plays out, as some patients may not recognize that their relationship dynamic signals violence. In several medical records review for Chapter 4, the provider noted that the patient responded that she did not realize she was in an abusive situation until the provider described trends in abusive relationships. The patient identified with the dynamics of psychological abuse and was able to access resources.

Mandated reporters and clinicians should understand their state's reporting requirements. While many cases of adult abuse not involving a vulnerable group do not need to be reported, cases involving a deadly weapon do. However, also in most cases, while the circumstances of the violence do need to be disclosed, identifying information about the patient or abuser does not have to be disclosed. There is evidence that a misunderstanding of reporting requirements can erroneously lead survivors and/or clinicians to believe personal details will be disclosed to authorities, a major disincentive for survivors who believe they would face retaliation from an intimate partner (Jordan & Pritchard, 2018). As one example, Michigan law (MCLS § 750.411) requires that those working in hospitals or pharmacies make a report to law enforcement of any injuries inflicted by a deadly weapon (e.g. knife or gun) when the injury is intentional, criminal, or could result in death (Hospitals, Pharmacies, Physicians; Duty to Report Injuries; Violation as Misdemeanor; Immunity; Limitations, 1931). However, the names of those involved does not need to be disclosed.

It would behoove anyone working in clinical settings, educational settings, or setting with vulnerable populations to be aware of local resources for IPV, whether a nearby shelter where a person could access a bed or a sexual assault and prevention center on a college campus. For those working directly with patients, facilitating a warm hand-off to a resource can maximize the chances of a survivor accessing healthcare, safe housing, and a supportive environment.

5.4 Future Directions

It is vital that work to understand the health of survivors continues. In SWAN, there will be further data collection of physical function measures, so the longitudinal trajectories of physical function can be extended to include older ages. Examining objective measures of physical function by IPV status would be a way to extend this work and incorporate further

measures of function collected through SWAN, including gait speed and stair climb. Furthermore, while self-reported physical function and objective function will typically correlate, there is an element of self-perception and self-efficacy involved in self-reported physical function measures. For women who have lived with long-term violence, it is possible that years of violence have eroded self-perception of function and self-efficacy; in this way, it is possible that women with IPV would have lower self-reported function without having significantly limited function. However, given the incidence of injury in this population, as well as the potential for living in a chronic state of stress and inflammation, it is possible that women do indeed have lower objective function compared to their peers.

Screening for intimate partner violence in women should not cease with reproductive capacity. The US Preventive Services Task Force's decision to screen for partner violence only in women of reproductive age was controversial because it left out IPV screening in older adults, who are living at the confluence of vulnerability to elder abuse, IPV, and age-related health conditions (US Preventive Services Task Force et al., 2018). Part of the justification was that there were not enough evidence-based interventions to prevent IPV if a screening was positive in an older adult. However, the evidence base cannot grow if research into this phenomenon is not incentivized. There are many groups across the world interested in supporting survivor health through the provision of services specifically for survivors. The continued growth of these groups, as well as evaluation of their successes and lessons learned can be a critical contribution to the evidence base to support the health of older adult survivors.

This dissertation focuses on cis-gender women, but as noted in Chapter 1, cis-women are far from the only group who experience violence. Existing data indicate that trans and non-binary people are at greater risk for IPV and may be less likely to present for care or services due to fear that their gender identities may be dismissed or that their trauma may be compounded (Peitzmeier et al., 2020). The work being done by trans and non-binary researchers and their allies to articulate the experiences of queer survivors is inspiring and vital. Additionally, sexual identity can be explored as a variable of interest, as cis-gender women encompass the entire spectrum of sexual identity. Many datasets, especially of older adults whose lived experiences may have discouraged anything other than heterosexual expressions of sexuality, compartmentalize sexuality into no more than a couple of categories. Questions similar to the

ones in this dissertation are important to consider in the queer community with the understanding that gender and sexual identity may interact with IPV to result in a distinct trajectory of function.

Finally, continuing the theme of considering social identity, it is important to consider how older adult women are treated in the medical system. Previous studies have supported the idea of a gender bias in medicine: women's pain and health complaints often get downplayed or dismissed entirely (Beyer, 2022). These dismissals may be even more pronounced in older adult female patients, especially if a provider has not been specifically trained in working with older adults, and in patients with other marginalized social identities (Eymard & Douglas, 2012; Farrell et al., 2022; Kydd & Fleming, 2015). Those working with survivors must understand how social identities, and furthermore the identity of being a survivor of intimate partner violence, influence health and how a person might show up in a healthcare setting. As noted, some healthcare experiences can prolong suffering experienced but survivors, but when providers have awareness of social identities and how trauma may impact healing, healthcare institutions can shift from impeding recovery to truly supporting healing.

5.5 Conclusions

Overall, this dissertation has several implications for public health, including additional evidence that women often experience multiple kinds of violence and that psychological abuse can be similarly harmful to health as other, often more obvious, forms of violence. This dissertation has also been conducted in a context where older adult health is more critical than ever – the population of older adults will continue to grow in the years ahead, and older adult female survivors are an especially vulnerable population that need support. This dissertation also posits that violence is a fundamental cause of health disparities in survivors and that continued research into reducing perpetration of violence and into supporting older adult women survivors is essential to addressing the health of older adult survivors, who may be vulnerable to worse health at earlier ages. While this dissertation examines only a few dimensions of accelerated aging, it adds evidence to the body of research articulating the harms of IPV. There is evidence that physical function declines more quickly in survivors, and the high prevalence of mental health conditions in survivors, especially those with head injuries, is a reminder that mental and physical health are deeply intertwined. In other words, mental health conditions, which may be exacerbated by head injuries, are very much potential drivers of accelerated aging in IPV survivors. The less clear-cut results of the dissertation (for example, no clear interaction between

DHEA-S levels and time in survivors and mixed effect of IPV and time by race on DHEA-S) bring up further questions to explore. To situate this dissertation in the wider body of literature of IPV's health effects, IPV can contribute to some aspects of accelerated aging, and it is exciting to be working in a time when these questions continue to emerge.

As this work is ongoing, the most important note with which I can end this dissertation is a resounding hope for the future. Epidemiology is a largely quantitative field, but when working with people, every data point represents some part of a person's lived experience. Experiences of IPV are reduced to a dichotomous 1 or 0 in analyses, but that '1' can hold so much weight for a survivor. Those working with survivors and with any vulnerable population keep going because there is hope for healing and hope for a better future. This healing is almost never linear, pretty, or quick, but it is possible. This work acknowledges some of the darkest experiences of a person's life but is fundamentally rooted in the hope that something can shift to make survivors' lives better. This shift may not be noticeable now or even in a couple years, but through research efforts like these, along with clinicians, social workers, therapists, and advocates across the global, the lives, health, and stories of survivors, just like the ones reflected in this dissertation, can improve.

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Appendix: Intimate Partner Violence Questionnaire

Below is part of the questionnaire administered at V17 to participants at the Michigan and Pittsburgh sites. The questionnaire's introductory text precedes the questionnaire. The questions included here were the ones used in analyses for Aims 1 and 2 of this dissertation, but there were additional questions related to harassment and sexual coercion included in the questionnaire that are not shown here, as they were not specific to intimate partner violence.

Introductory text:

We have some questions that we are asking you to complete on your own. If anything is unclear to you, please feel free to ask questions. Study representatives are available and happy to help you. Please take as much time as you need with each question. It is very important to us that you complete the entire questionnaire. Please find the most appropriate response to each question and circle the number for the answer you choose.

Please pay careful attention to the time frames of these questions, such as, since your last study visit, in the past month, in the last 2 weeks, etc.

Please remember that this information will remain confidential.
Thank you for your participation in this important study.

This questionnaire covers material that is sensitive and personal. Remember, confidentiality is assured. While we hope you are willing to answer all of the questions, if there are questions you would prefer not to answer, you are free to skip the question. Please find the most appropriate response to each question and circle the response for the answer you choose.

Part I.

Intro: *The next questions ask about experiences you may have had with your romantic or sexual partners, which might include spouses, boyfriends, girlfriends, people you have dated, or people you were seeing.*

During the past 12 months:

How often has a current or former partner…	Never	Rarely	Sometimes	Often	Frequently
1. Physically hurt you?	**1**	**2**	**3**	**4**	**5**
2. Insulted or talked down to you?	**1**	**2**	**3**	**4**	**5**
3. Threatened you with harm?	**1**	**2**	**3**	**4**	**5**
4. Screamed or cursed at you?	**1**	**2**	**3**	**4**	**5**
5. Forced you to have sexual activities?	**1**	**2**	**3**	**4**	**5**

During your lifetime:

How often has a current or former partner…	Never	Rarely	Sometimes	Often	Frequently
1. Physically hurt you?	**1**	**2**	**3**	**4**	**5**
2. Insulted or talked down to you?	**1**	**2**	**3**	**4**	**5**
3. Threatened you with harm?	**1**	**2**	**3**	**4**	**5**
4. Screamed or cursed at you?	**1**	**2**	**3**	**4**	**5**
5. Forced you to have sexual activities?	**1**	**2**	**3**	**4**	**5**