Original Research Article

Head Injuries and the Gender Gap in Anxiety and Depression Symptoms

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Abstract

Objectives: Using 2017-2022 Midlife in the United States Biomarker Project data, this study explores the contribution of head injuries to the gender gap in depression and anxiety symptoms.
Methods: Linear regression models were used to estimate generation-specific gender differences symptoms. The contribution of head injuries to these differences was explored. In addition, sources of potential confounding were examined.
Results: Among women, a lifetime head injury is associated with a large increase in symptoms, and within Generation X the association is stronger. There is no association among men. Almost a third of Generation X women report a serious lifetime head injury. The contributions of accidents and sports injuries have increased between cohorts. The association between head injuries and symptoms is robust to numerous potential confounders, including other bodily injuries and trait anxiety.
Conclusion: Head injuries contribute to the gender gap in depression and especially anxiety.

Keywords

depression, injuries, social factors, anxiety, cohorts

The gender difference in anxiety and depression symptoms is well-known but not entirely understood. Women report more depression and anxiety symptoms than men, as well as higher rates of mood and anxiety disorders (Altemus et al., 2014; Sandhu et al., 2025). The gap begins around adolescence and persists over most of the life course (Sinkewicz et al., 2022). The difference has changed over time in magnitude but not in direction. It remains remarkably robust over different eras and even nations and cultures (Seedat et al., 2009). Furthermore, the difference is not limited to the US. In a meta-analysis encompassing 90 countries, the sex ratio in major depression was approximately 2:1 overall (Salk et al., 2017). A variety of explanations for the gap have been offered, including a disproportionate burden of stress among women, discrimination and diminished economic opportunities, and the emotional costs of caring (Simon, 2020). Research has pointed to more proximate risk factors, including sex differences in neurotransmitters (Covassin et al., 2016). Yet all these explanations remain incomplete, and given a seemingly robust gap, the literature has shifted in an even more reductive direction, citing sex differences in the brain as a potential root cause and, at least by implication, minimizing the role of acquired risk or the social environment.

This study adopts a population-level approach to an already well-established risk factor. It explores the contributions of head injuries to gender differences in depression and anxiety symptoms, focusing on the intersection of gender and generation. Depression and anxiety are often considered internalizing disorders, in reference to how symptoms are directed inward (as opposed to externalizing symptoms, such as impulsivity) (American Psychiatric Association, 2013). The contributions of head injuries to internalizing symptoms of this sort are well-known (Dehbozorgi et al., 2024). It is known that head injuries have a much stronger relationship with symptoms among women than men. But apart from understanding the basic epidemiology of these relationships, research has generally not considered the role of head injuries in understanding sex differences in depression and anxiety. The potential contribution of head injuries is large, but it is unclear whether head injuries contribute beyond the other vulnerabilities that increase women's risk of symptoms and injuries.

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Background

Brain injuries contribute to a variety of health problems, especially neuropsychiatric disorders. The prevalence of major depression among traumatic brain injury patients is as high as 61% and generally no less than one-in-five (Jorge et al., 2004). Although the mechanisms behind this relationship are not well understood, brain injuries are implicated in a wide-variety of neural and cognitive effects, including neuro-inflammation, social and cognitive impairment, hormonal changes, and neurotransmitter dysfunctions (e.g., Frank et al., 2022; Jahan & Tanev, 2023). The consequences of traumatic brain injuries vary in their impact, though their neuropsychiatric effects are often enduring. An elevated risk of major depression, for instance, can persist for decades following a head injury (Dehbozorgi et al., 2024; Koponen et al., 2002). In addition, the impact of brain injuries on psychiatric symptoms does not appear limited to traumatic brain injuries or to other severe head injuries. A persistently elevated risk is apparent even in "mild" brain injuries, the sort of injuries that might not occasion help-seeking among the injured (Sandhu et al., 2025).

In addition, brain injuries are generally more consequential for women than men (Colantonio et al., 2010; Sandhu et al., 2025). Following a brain injury, women experience more symptoms across a range of outcomes, including anxiety, depression, irritability, impaired concentration, insomnia, and fatigue (Farace & Alves, 2000), virtually all of which are already more common among women than men (Simon, 2020). Although the precise mechanisms for this gender difference in the consequences of head injuries are not understood, one possibility is impaired repair of the blood-brain barrier, which prolongs brain inflammation and may lead to greater accumulation of excitatory neurotransmitters, which can in turn damage neurons and produce depression (Jullienne et al., 2018). These pathways to internalizing symptoms are not limited to head injuries. Women are also more vulnerable after neurological events, with quality of life consistently lower for women than men following a stroke (Reeves et al., 2008). One reason for the lingering uncertainty regarding the mechanisms for women's elevated vulnerability is the historical exclusion of women from brain injury studies, including studies of internalizing symptoms (Gupte et al., 2019).

Social scientists, meanwhile, have their own uncertainties regarding the explanation for gender differences in internalizing symptoms. Women have higher rates of anxiety and mood disorders than men (Salk et al., 2017). Similar differences are apparent in dimensional and symptom-based measures of anxiety and depression, where women report more symptoms or more intense symptoms (Rosenfield & Mouzon, 2013; Simon, 2014). In general, social scientists know a great deal about what contributes to internalizing symptoms, as well as the relationship between those risk factors and gender. Yet no risk factor appears to explain the sex difference in internalizing symptoms entirely. The elevated risk of internalizing symptoms among women partly reflects psychological risk factors, such as more empathy, greater rumination, and more negative emotionality (Martel, 2013). Women also have much higher levels of role-related stress (Simon, 2020).

Yet even with a comprehensive understanding of stress in women and men, much of the gender difference remains unexplained. Some studies have been successful in explaining certain gaps or the gender gap in some segments of the population. Social scientists are sometimes able to explain, for instance, why parents are less happy than non-parents (Glass et al., 2016). But they have generally struggled to explain the gender difference in anxiety and depression in total, and there are few mechanisms that are consistently more harmful for women than men, frustrating attempts at a comprehensive account. Stress, for instance, often has a stronger relationship with depression and anxiety among women, though the difference is not consistent and, in fact, men sometimes report more distress than women following certain stressors (Simon, 2020). Women may report more distress following stressful events among those in their social network, but for other kinds of stressors the gender difference is less clear, if it is apparent at all. The net effect of these differences is to suppress the role of stress in explaining gender differences, leaving a large portion of the gap unexplained even when scientists succeed in illuminating what causes depression or anxiety (e.g., Platt et al., 2016). Reviewing the biological and environmental determinants of the gender gap, research has reached a general conclusion: sex hormones might help to explain some of the gap, but experiences or events that change hormones, such as pregnancy, do not consistently explain the gap in internalizing symptoms, and a more likely explanation is one that rests on how the environment, including stress, provokes enduring biological vulnerabilities, not limited to hormones (Farhane-Medina et al., 2022; Kessler, 2003). Recent research has moved to uncover biological risks correlated with the environment.

Gender and Brain Injuries

Women with brain injuries report more depression than men with brain injuries, though the prevalence of brain injuries is greater among men and has shifted over cohorts. The incidence of severe traumatic brain injuries increased from 2001 to 2010 (Centers for Disease Control and Prevention, 2015). Severe brain injuries are not rare. In US state-specific analyses, the lifetime prevalence of brain injuries that were sufficient to lead to loss of consciousness is one in five adults (Corrigan et al., 2018). Among men the prevalence rises to just over one in four, but nationally representative surveys of older civilian men point to a much higher prevalence. In a sample of older civilian adults (51+), the lifetime prevalence of head/neck injuries was 58% and, for at least one traumatic

brain injury, 45% (Kornblith et al., 2020). Recent studies of a head injury in the past year point to a high incidence as well, though they reveal somewhat different patterns, suggesting a changing environment. More women than men report a traumatic brain injury in the last 12 months, at 3.6% relative to 3.0% (Waltzman et al., 2025).

Men and women receive their injuries in different ways, but the origins of head injuries have shifted over time in ways that have likely increased women's risk. Women are more likely than men to receive their head injuries from assaults and domestic violence, whereas men are more likely to receive their injuries through motor vehicle accidents (Gupte et al., 2019). Women's participation in sports, especially those with high concussion rates, has increased over time and even within specific sports women suffer more concussions than men (Covassin et al., 2016). Although men are more likely to be involved with motor vehicle accidents than women, women suffer more severe health consequences in accidents (González & Labeaga, 2025). Similarly, men generally take more risks than women, but the gender difference in risk-taking shrank over the second half of the 20th century (Byrnes et al., 1999). More recent evidence links chronic illness to falls and, in turn, more head injuries. Women generally take more medications than men, and the number of medications sharply increases the risk of falls, both because medications reflect underlying morbidity and because some medications increase the risk of a fall through side effects (Cho et al., 2021).

Overall, the role of brain injuries in depression and anxiety is uncertain given the potential role of confounding. The environmental origins of head injuries compound this problem. Chronic illness, serious accidents, and risk-taking are all associated with higher levels of internalizing symptoms, but they are also associated with head injuries (Cobb-Clark et al., 2022). In addition, trait anxiety is associated with an increased risk of falls and accidents, but trait anxiety also predicts state anxiety (Hallford et al., 2016). Similarly, stress is associated with an increased risk of accidents and injuries, but it is also associated with internalizing symptoms (Taylor & Dorn, 2006).

This study seeks to uncover the contributions of head injuries to the gender gap in internalizing symptoms, indicated by depression and anxiety. It does so by first estimating generation-specific gender differences in symptoms, followed by a detailed investigation of the relationship between injuries and symptoms adjusting for multiple forms of confounding.

Data and Methods

Data for this study are drawn from Midlife in the United States (MIDUS), Third Wave, Biomarker Project, 2017–2022 (Ryff et al., 2023). The MIDUS Biomarker Project is one element of a family of surveys. The data included in this project consists of 747 respondents. The total includes the main respondents, who participated in a larger longitudinal project, as well as new set of respondents, drawn from Milwaukee. The response rate exceeded 70% for both components. The main sample contains a twin and sibling subsample (N = 286). In some analyses, the twin/sibling sample is used to control for unobserved influences using family fixed-effects models, which eliminate influences shared by siblings (Allison 2005). The Biomarker Project data are particularly useful for the present study given the project's assessment of depression and anxiety symptoms combined with its emphasis on behavioral and environmental factors related to morbidity.

Variables

Internalizing Symptoms. Respondents were asked a series of questions on depression and anxiety symptoms, occasionally referred to together as internalizing symptoms, though separated here into *depression symptoms* and *anxiety symptoms*, consistent with the instrument's design and psychometric properties (Watson et al., 1995). Respondents were asked, "how much have you felt or experienced things this way during the past week including today," with response categories ranging from not at all (one) to extremely (five). For depression symptoms respondents were asked how often they felt sad, discouraged, worthless, depressed, like a failure, blamed themselves for a lot of things, inferior to others, like crying, disappointed in myself, hopeless, sluggish or tired, and pessimistic about the future. For anxiety symptoms, respondents were asked how often they felt afraid, had diarrhea, nervous, uneasy, had a lump in their throat, had an upset stomach, felt keyed up or on edge, unable to relax, nauseous, tense or high-strung, and their muscles were tense or sore. For each scale, the values were summed (and mean substitution was used for cases where there was a missing value).

Some models include adjustments for *trait anxiety*, which was assessed using the Spielberger Trait Anxiety Inventory (Spielberger et al., 1983). Although some of the questions resemble state anxiety symptoms, the inventory was framed as how "you *generally* feel" and the instrument includes dispositions, such as "I am inclined to take things hard." Values on the twenty-item summary scale range from 20 to 75.

Head Injuries. Respondents were asked, "Have you ever had a head injury?" If so, they were then asked about the specific type of injury (e.g., concussion) and how the injury occurred (e.g., motor vehicle accident). They were asked about the number of head injuries they received, though most who reported any head injury reported no more than one, leading to the creation of an *any lifetime head injury* variable. Some analyses explore whether certain injuries are more damaging

than others, though most models employ an any head injury indicator.

Generations. Generations are defined according to birth year. The *Silent Generation* are those born between 1928 and 1945; *Baby Boomers* are those born between 1946 and 1964; *Generation X* are those born between 1965 and 1977 (the last year a survey participant was born).

Potential Confounding Variables. Several variables were introduced to address potential confounding between head injuries and internalizing symptoms. Abuse was measured over two dimensions, using a self-administered questionnaire (Bernstein & Fink, 1998; Paivio & Cramer, 2004). *Physical abuse* was measured using five questions about childhood trauma, with response categories ranging from never true (1) to very often true (5): "I got hit so hard by someone in my family that I had to see a doctor or go to the hospital," "people in my family hit me so hard that it left me with bruises or marks," "I was punished with a belt, a board, a cord, or some other hard object," "I believe that I was physically abused," and "I got hit or beaten so badly that it was noticed by someone like a teacher, neighbor, or doctor." *Sexual abuse* was asked in the same context using five questions: "Someone tried to touch me in a sexual way, or tried to make me touch them," "Someone threatened to hurt me or tell lies about me unless I did something sexual with them," "Someone tried to make me do sexual things or watch sexual things," "Someone molested me," and "I believe that I was sexually abused." The items were summed, creating scales ranging from 5 to 25 for both physical and sexual abuse.

Other Injuries and Accidents. Respondents were asked about falls and accidents. Respondents were asked how many times they had fallen in the last year. They were asked if, as an adult, they had ever broken a bone from a fall. Finally, they were asked if they were ever injured in a motor vehicle accident. These variables were included in models that address confounding, with each coded as zero or one.

Chronic Medical Conditions and Stress Hormones. Chronic physical illnesses are associated with more falls and more psychological symptoms. Two variables were used to address medical conditions. Respondents were asked about a series of conditions diagnosed by a physician. A variable was created corresponding to the total number. In addition, interviewers collected urine samples from respondents, from which cortisol levels were measured using liquid chromatography-tandem mass spectrometry (and adjusting for creatinine levels). Cortisol is routinely used as a measure of stress exposure, albeit one whose levels are affected by other medical conditions, one reason to control for medical conditions in the models that include cortisol too (Hellhammer et al., 2009).

Research Questions and Empirical Strategy

This study addresses four questions: (1) what is the relationship between head injuries and internalizing symptoms, (2) do head injuries partly explain the gender gap in symptoms, (3) do head injuries have a stronger relationship with symptoms within certain generations, and (4) how sensitive is the relationship between head injuries and symptoms to confounding?

This study proceeds by presenting descriptive statistics before presenting two types of regression models. The first is linear regression models that progressively introduce variables to uncover the role of head injuries in gender differences in internalizing symptoms. In all these models, the gender difference is estimated by generation. The second type uses a Kitagawa-Oaxaca-Blinder decomposition to precisely assess the contributions of head injuries to the gender difference in anxiety and depression symptoms (Jann, 2008). This technique separates the gender difference in anxiety and depression to differences in the levels of a variable (an endowment effect) and differences in the relationship between that variable and the outcome (a coefficient effect). Head injuries are the focal variable in these analyses, and the gender difference is estimated for each generation separately. In both types of models, conventional tests of significance are used, starting at $p < .05$. All models were estimated using STATA.

Results

The results begin with descriptive statistics, arrayed by gender and generation. Table 1 indicates that, apart from the Silent Generation, head injuries are more common among men than women and have increased between generations. However, neither the gender difference (within each generation) nor the generation differences themselves are significant at conventional levels. Although not significantly greater, Generation X has the highest prevalence of head injuries, at .305 among women and .380 among men. Women tend to report their first head injuries at a slightly later age. Among the Silent Generation, the average age of the first injury is 39 for women and 38 for men. Among men the average age of first injury has declined precipitously, from 38 to 15 (difference significant at $p < .01$). Both depression and anxiety symptoms have increased between generations for women, and the gender difference is particularly large for anxiety symptoms, increasing from 15.600 to 18.683 (difference significant at $p < .01$).

Table 2 presents descriptive statistics for the type and source of the lifetime head injury. For women, an increasing proportion of head injuries are concussions (though the absolute number of concussions in the sample is small). Among Generation X women, about 40% of injuries are concussions relative to 44% for men (the results in the table are presented as proportions). The distribution of source

Table 1. Summary Statistics by Gender, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Female	Male
	Mean [SE or SD]	Mean [SE or SD]
Any head injury		
Silent Generation	0.289 [.068]	0.225 [.067]
Baby Boomer	0.270 [.030]	0.313 [.032]
Generation X	0.305 [.039]	0.380 [.058]
Age of first injury (5–85)		
Silent Generation	39.000 [32.995]	38.125 [32.708]
Baby Boomer	28.000 [23.275]	22.227 [21.455]
Generation X	25.881 [15.896]	15.346 [12.934]**
Depression symptoms (12–58)		
Silent Generation	17.000 [4.936]	17.225 [3.613]
Baby Boomer	18.892 [6.983]	17.780 [5.869]
Generation X	20.476 [8.394]	19.732 [6.627]
Anxiety symptoms (11–47)		
Silent Generation	15.600 [4.229]	15.945 [3.329]
Baby Boomer	17.027 [8.394]	15.777 [4.268]**
Generation X	18.683 [6.234]	16.656 [4.886]*
Physical abuse (5–24)	7.053 [3.276]	6.778 [2.556]
Sexual abuse (5–25)	7.370 [4.623]	5.975 [2.881]***
Number of falls in the past year (0–20)	0.908 [1.612]	0.951 [1.946]
Any motor vehicle accident	0.345 [.023]	0.308 [.026]
Any broken bone	0.539 [.025]	0.609 [.027]
Number of chronic conditions (0–19)	4.876 [3.117]	4.354 [2.812]*
Urine cortisol levels (ug/g) (.14–75.58)	10.599 10.1556]	9.324 [7.130]
Trait anxiety (20–75)	34.412 [8.965]	33.118 [8.303]*

N = 412 for women, 325 for men, 85 for the Silent Generation, 440 for Baby Boomers, and 212 for Generation X.
*$p < .05$; **$p < .01$; ***$p < .001$ (for test of significant gender difference within rows).

differences is significantly different between men and women (at $p < .01$). A smaller number of head injuries are characterized as cuts and bruises. Very few injuries are head fractures. At the same time, between generations fewer head injuries are the result of assault. Among women, the proportion reflecting a sports injury has increased. Among men the single largest contributor is sports injuries, though among both men and women a large fraction of injuries is due to assorted "other" causes.

Table 3 presents the first of the regression results. The linear regression model estimates generation-specific gender differences in depression and anxiety symptoms (denoted using a multiplicative interaction), beginning with depression followed by anxiety. Gender differences in depression symptoms (Model 1) are relatively muted and not significant, though among Baby Boomers the gender difference is close to significant ($b = 1.112$, $p = .082$), as is the overall gender difference not separated by generation (not shown, $b = .856$, $p = .088$). Gender differences in anxiety (Model 3) are much more pronounced. Among both Baby Boomers and Generation X, women report more anxiety symptoms than men. Among Generation X, the difference is 2.027. For depression and anxiety, the second set of models (Models 2 and 4) introduce gender-specific coefficients for head injuries. Among women, head injuries have a large relationship with both depression and anxiety symptoms, but no significant relationship (and a negative coefficient) among men. The inclusion of any head injury reduces the previously significant gender gap in anxiety symptoms to statistical insignificance among Baby Boomers and Generation X (and reduces the insignificant gender differences in depression even further).

As a more formal test of the contributions of head injuries to the gender gap in symptoms, Table 4 presents a Kitagawa-Oaxaca-Blinder decomposition (Jann, 2008). Decompositions are presented for both anxiety and depression and for each generation. Panel A presents the expected symptom score for men and women, based on the underlying regression model, along with the estimated difference. Panel B presents the decomposition of the difference, divided into two parts: an endowment and coefficient effect. The contributions of gender differences in the prevalence of head injuries (the endowment effect) are never greater than the contributions of the gender difference in the relationship between head injuries and symptoms (the coefficient effect). At least among Generation X, the coefficient difference is

Table 2. Type and Source of Head Injury by Gender and Generation, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Female	Male
	Proportions	Proportions
Type of injury		
Concussion		
Silent Generation	0.077	0.333
Baby Boomer	0.361	0.537
Generation X	0.395	0.444
Cut or bruise		
Silent Generation	0.462	0.111
Baby Boomer	0.328	0.164
Generation X	0.140	0.222
Fracture		
Silent Generation	0.077	0.000
Baby Boomer	0.016	0.015
Generation X	0.023	0.000
Other		
Silent Generation	0.385	0.556
Baby Boomer	0.295	0.284
Generation X	0.442	0.333
Source of Injury		
Assault		
Silent Generation	0.077	0.111
Baby Boomer	0.033	0.015
Generation X	0.023	0.037
Accident		
Silent Generation	0.154	0.111
Baby Boomer	0.311	0.224
Generation X	0.233	0.111
Fall		
Silent Generation	0.538	0.111
Baby Boomer	0.328	0.224
Generation X	0.256	0.148
Sports of play		
Silent Generation	0.077	0.556
Baby Boomer	0.098	0.239
Generation X	0.163	0.370
Other		
Silent Generation	0.154	0.111
Baby Boomer	0.230	0.299
Generation X	0.326	0.333

Note. N = 412 for women and 325 for men. Proportions sum to one within generation.
Source of injury is significantly different between men and women at p = .007 (using a chi-square test). Type of injury is not significantly different between sexes, p = .091.

sufficient on its own to reduce the gender difference in anxiety by more than 80% (Model 6). Specifically, the gender difference is 2.027 and the coefficient difference contributes 1.673, whereas the endowment effect contributes only .075 (for a total of 1.748 of the 2.027). A similar pattern pertains to the gender difference in depression among Baby Boomers (Model 2). The gender difference is 1.112 and the coefficient effect explains 84% of the difference (.931/1.112), whereas the endowment effect explains only 3% (.037/1.112).

All these models are minimally specified (the decomposition focuses only on head injuries). But the relationship between head injuries and internalizing symptoms is likely confounded by a variety of environmental exposures, which may be particularly relevant for women. The remaining tables explore this possibility. Table 5 begins with depression symptoms, while Table 6 presents anxiety symptoms. In each case, the sequence of models is the same and the results are similar. Model 1 estimates, among women, generational differences in the relationship between head injuries and symptoms. This, in effect, tests whether generations report different consequences for anxiety and depression because they report different types of head injuries (which would be obscured in an any head injury coefficient). It is possible that recent generations report milder injuries than earlier generations, resulting in less impact on depression and anxiety. Model 1 suggests this is not the case and, indeed, suggests the opposite. The relationship between head injuries and symptoms, if anything, increases between generations for both depression (Table 5) and anxiety (Table 6). The second model introduces the first of a series of potential confounders, starting with physical and sexual abuse. These models return to estimating generation-specific gender differences. Recall that the baseline unadjusted coefficient (Table 3) is 2.701 for depression symptoms (Model 2) and 2.374 for anxiety symptoms (Model 4). Including both measures of abuse, sexual and physical, reduces the any head injury coefficient, though it remains significant. The number of falls is positively associated with depression, though does little to explain the influence of head injuries, nor do other types of injuries (Model 3). Other chronic physical conditions increase depression and anxiety but do little to change the head injuries coefficient (Model 4). The use of family fixed-effects, in Model 5, does not reduce the coefficient and, in fact, yields a somewhat larger one. In the case of depression, the coefficient is not significant by conventional standards (p = .088), but in the case of anxiety the coefficient remains significant.

The inclusion of trait anxiety in the MIDUS survey allows for an especially robust test of potential confounding, at least for anxiety symptoms (Table 6, Model 6). Trait anxiety is associated with more injuries and is strongly associated with anxiety symptoms, though even its inclusion in the model does not eliminate the relationship between head injuries and anxiety symptoms. The female head injuries coefficient from this model is only slightly smaller than the coefficient from a model that controls for physical and sexual abuse (Model 2).

The relationship between head injuries and physical and sexual abuse deserves special attention. Among the potential confounders explored here, abuse plays a relatively important role. The relationship between abuse and head injuries has, however, declined between generations and its potential role

Table 3. Regression of Depression and Anxiety Symptoms on Gender, Generation, and Any Head Injury, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Depression	Depression	Anxiety	Anxiety
	Model 1	Model 2	Model 3	Model 4
Generation (vs. Silent)				
Baby Boomer	0.555	0.621	−0.168	−0.146
	(1.154)	(1.147)	(0.870)	(0.862)
Generation X	2.507	2.623*	0.711	0.750
	(1.325)	(1.319)	(0.998)	(0.991)
Silent Generation	−0.225	−1.173	−0.345	−1.088
× female	(1.456)	(1.470)	(1.097)	(1.104)
Baby Boomer	1.112	0.149	1.251**	0.531
× female	(0.639)	(0.709)	(0.482)	(0.532)
Generation X	0.744	−0.364	2.027**	1.207
× female	(0.975)	(1.037)	(0.735)	(0.779)
Any head injury		−0.747		−0.252
× male		(0.796)		(0.598)
Any head injury		2.701***		2.374***
× female		(0.726)		(0.546)
Constant	17.225***	17.393***	15.945***	16.002***
R^2	0.03	0.05	0.04	0.07
N	737	737	737	737

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (standard errors in parentheses).

as a confounder has decreased. Among women in the Silent Generation, both types of abuse are positively correlated with head injuries, at .362 ($p = .01$) for physical abuse and .304 ($p = .04$) for sexual abuse (results not shown). Among women in Generation X, however, these correlations drop to .147 ($p = .08$) and .046 ($p = .59$). By contrast, the correlations among other confounders, like the number of falls and chronic conditions, have remained relatively flat between generations.

Table 7 presents the final set of confounding tests, this time limited to women. The distributions of types and sources of head injuries differ somewhat between men and women (though only the distribution of sources differs significantly) (see Table 2). In particular, men report

Table 4. Kitagawa-Oaxaca-Blinder Decomposition of Gender Gap in Depression and Anxiety Symptoms as a Function of Head Injuries, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Depression			Anxiety		
	Silent Generation	Baby Boomer	Generation X	Silent Generation	Baby Boomer	Generation X
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
A. Expected symptom score						
Women	17.000***	18.892***	20.476***	15.600***	17.027***	18.683***
	(0.744)	(0.466)	(0.709)	(0.637)	(0.356)	(0.527)
Men	17.225***	17.780***	19.732***	15.945***	15.777***	16.656***
	(0.578)	(0.402)	(0.792)	(0.533)	(0.292)	(0.584)
Difference	−0.225	1.112	0.744	−0.345	1.251**	2.027**
	(0.943)	(0.615)	(1.063)	(0.831)	(0.461)	(0.786)
B. Decomposition						
Endowment	−0.083	0.037	0.017	−0.050	−0.004	0.075
	(0.152)	(0.053)	(0.124)	(0.111)	(0.028)	(0.114)
Coefficient	0.608	0.931*	1.594	0.669	0.508	1.673*
	(0.512)	(0.434)	(0.878)	(0.465)	(0.322)	(0.671)
N	85	440	212	85	440	212

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (standard errors in parentheses).

Table 5. Regression of Depression Symptoms on Generation, Head Injuries, and Potential Confounding Variables, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Model 1	Model 2	Model 3	Model 4	Model 5
	Generation-specific effects	+ Physical and sexual abuse	+ falls, accidents, and broken bones	+ Chronic conditions and cortisol	+ Family-fixed effects
Generation (vs. Silent)					
Baby Boomer	1.726	0.350	0.726	1.311	
	(1.396)	(1.097)	(1.140)	(1.107)	
Generation X	2.673	2.326	2.547	4.213**	
	(1.472)	(1.261)	(1.309)	(1.287)	
Silent Generation	1.406				
× head injury	(2.378)				
Baby Boomer	2.122				
× head injury	(1.083)				
Generation X	3.965**				
× head injury	(1.322)				
Silent Generation		−1.315	−1.247	−0.826	
× female		(1.402)	(1.460)	(1.411)	
Baby Boomer		−0.073	0.253	−0.103	
× female		(0.679)	(0.704)	(0.682)	
Generation X		−0.959	−0.324	−0.724	
× female		(0.994)	(1.028)	(0.995)	
Head injury		−0.877	−0.772	−0.975	−0.517
× male		(0.759)	(0.797)	(0.763)	(1.750)
Head injury		1.877**	2.751***	1.729*	3.027
× female		(0.699)	(0.746)	(0.708)	(1.756)
Physical abuse		0.390***			
		(0.090)			
Sexual abuse		0.311***			
		(0.067)			
Number of falls			0.539***		
			(0.140)		
Motor vehicle accident			−0.785		
			(0.544)		
Broken bone			0.161		
			(0.498)		
Chronic conditions				0.653***	
				(0.083)	
Cortisol				−0.027	
				(0.027)	
Constant	16.594***	13.174***	16.979***	14.071***	18.339***
Family-fixed effects	No	No	No	No	Yes
R^2	0.05	0.14	0.07	0.13	0.03
N	412 (women)	737	737	737	737

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (standard errors in parentheses).

somewhat more concussions than do women, and the consequences of head injuries might differ by the type or source of injury. Table 7 presents models for depression and anxiety symptoms, with separate coefficients for both specific types of head injuries and different sources of injury (relative to no injury). The analysis is limited to women. The results generally support the idea that the relationship between head injuries and symptoms is not limited to concussions. For depression symptoms, a concussion and fracture have the largest relationships with symptoms (Model 1). For anxiety, a concussion is significantly related to symptoms, but so too is an injury characterized as a mere

Table 6. Regression of Anxiety Symptoms on Generation, Head Injuries, and Potential Confounding Variables, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Generation-specific effects	+ Physical and sexual abuse	+ falls, accidents, and broken bones	+ Chronic conditions and cortisol	+ Family-fixed effects	+ Trait anxiety
Generation (vs. Silent)						
Baby Boomer	1.593	−0.391	−0.051	0.477		−0.601
	(1.056)	(0.831)	(0.857)	(0.827)		(0.699)
Generation X	2.677*	0.488	0.709	2.119*		−0.191
	(1.113)	(0.955)	(0.984)	(0.962)		(0.805)
Silent Generation	2.185					
× head injury	(1.798)					
Baby Boomer	1.725*					
× head injury	(0.819)					
Generation X	3.401***					
× head injury	(1.000)					
Silent Generation		−1.211	−1.115	−0.859		−0.830
× female		(1.061)	(1.098)	(1.054)		(0.896)
Baby Boomer		0.418	0.607	0.284		0.510
× female		(0.514)	(0.529)	(0.510)		(0.432)
Generation X		0.840	1.227	0.916		1.290*
× female		(0.752)	(0.773)	(0.743)		(0.632)
Head injury		−0.353	−0.296	−0.442	0.680	0.416
× male		(0.575)	(0.599)	(0.570)	(1.014)	(0.486)
Head injury		1.806***	2.364***	1.564**	3.411**	1.648***
× female		(0.529)	(0.561)	(0.529)	(1.017)	(0.444)
Physical abuse		0.319***				
		(0.068)				
Sexual abuse		0.178***				
		(0.051)				
Number of falls			0.405***			
			(0.105)			
Motor vehicle accident			−0.447			
			(0.409)			
Broken bone			0.100			
			(0.375)			
Number of chronic conditions				0.533***		
				(0.062)		
Cortisol				0.000		
				(0.020)		
Trait anxiety						0.339***
						(0.017)
Constant	14.969***	13.026***	15.654***	13.027***	16.163***	5.053***
Fixed effects	No	No	No	No	Yes	No
R^2	0.07	0.14	0.09	0.15	0.09	0.39
N	412 (women)	737	737	737	737	737

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (standard errors in parentheses).

cut or bruise (Model 3). Of note, a head injury reflecting assault has the largest relationship with both depression (Model 2) and anxiety (Model 4) symptoms, but injuries in the other categories are significantly related to symptoms too.

Discussion

Social scientists have struggled to explain the gender gap in internalizing symptoms, even as they have recognized that a likely explanation for the gap implicates both environmental

Table 7. Regression of Depression and Anxiety on Head Injuries by Types and Source, Among Women, Midlife in the United States (MIDUS 3), Neuroscience Project, 2017–2022

	Depression	Depression	Anxiety	Anxiety
	Model 1	Model 2	Model 3	Model 4
Generation (vs. Silent)				
Baby Boomer	2.085	1.951	1.507	1.518
	(1.175)	(1.181)	(0.894)	(0.892)
Generation X	3.596**	3.374**	3.222***	3.091**
	(1.237)	(1.242)	(0.941)	(0.938)
Type of head injury (vs. no injury)				
Concussion	3.239**		2.663**	
	(1.210)		(0.921)	
Cut or bruise	2.584		3.856***	
	(1.337)		(1.018)	
Fracture	15.596***		4.588	
	(4.158)		(3.165)	
Other	1.356		0.799	
	(1.183)		(0.901)	
Source of head injury (vs. no injury)				
Assault		8.196*		8.345**
		(3.630)		(2.741)
Accident		1.771		2.035*
		(1.361)		(1.028)
Fall		1.642		1.828
		(1.245)		(0.940)
Sports or play		1.670		0.645
		(1.975)		(1.491)
Other		4.762***		3.429**
		(1.384)		(1.045)
Constant	16.086***	16.235***	14.836***	14.873***
R^2	0.07	0.06	0.08	0.09
N	412	412	412	412

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (standard errors in parentheses).

vulnerability and proximate biological risks. To date, head injuries have not featured prominently in the literature on depression and anxiety symptoms, even less so in the literature on population patterns in those symptoms. The present study demonstrates the importance of head injuries across gender and generations. Among women, depression and anxiety symptoms are strongly associated with head injuries. Head injuries are unrelated to internalizing symptoms among men, but among women they are associated with a substantial increase in both depression and anxiety symptoms. These relationships are robust to a wide variety of potential confounding variables. Virtually all the potential confounders tested here are positively associated with depression and anxiety but do little to alter the relationship between head injuries and symptoms. The differential vulnerability apparent in the consequences of head injuries is sufficient to reduce the gender difference in anxiety symptoms to statistical insignificance among Baby Boomers and Generation X.

The contributions of head injuries to depression and anxiety are premised on both their demonstrable impact on symptoms and their remarkably high prevalence among certain segments of the population. Even as head injuries are growing more common and more recognized by those who experience them, the impact of head injuries on internalizing symptoms has grown between generations. From the Silent Generation to Generation X, the relationship between head injuries and depression more than doubled and the relationship with anxiety increased by more than 50% (though in this sample the coefficients are not significantly different from each other by conventional standards). At the same time, the average age of the first lifetime injury decreased by a decade or more. The gender difference in the consequences of head injuries for internalizing symptoms is even more striking given the apparent severity of men's injuries. Among Generation X, the average age of the first head injury is 26 among women but only 15 among men. Head injuries are more consequential at younger ages, but the fact that women report injuries at older ages does little to suppress the head injury coefficient. At the same time, the prevalence of head injuries among men has increased between generations, growing from about 23% in the Silent Generation to 38% among Generation X. Relative to women, a greater share of men's injuries are concussions, implying greater severity. Yet the relationship between head injuries and internalizing symptoms among men is statistically insignificant across all the specifications presented here.

The role of head injuries in gender differences in internalizing symptoms might have been obscured in prior research because there are still many other risk factors that disadvantage women. This study aligns with others in demonstrating, for instance, the roles of abuse and chronic conditions in internalizing symptoms. Furthermore, the neglect of head injuries in research on anxiety and depression is not inconsistent with how head injuries are treated in clinical settings, especially when head injuries are presented in the context of polytrauma. For instance, head injuries are often ignored in studies of upper-body fractures, as well as when people with head injuries are excluded from studies concerned with traumas in other anatomical areas (Hardy et al., 2023). Even within families head injuries are often minimized or ignored, despite having consequences that are difficult for family members to avoid (Ridley, 1989). One reason the current study was able to uncover patterns not documented elsewhere is its use of a non-clinical sample and more broadly representative data. Many studies of traumatic brain injuries focus exclusively on men, a limitation noted in prior research but one the literature has been slow to correct (Colantonio, 2016).

Limitations

The current study is, however, limited in other ways. The sample is limited to respondents aged 43 and over. Head

injuries are increasingly common among adolescents and young adults. It is uncertain whether head injuries have the same consequences in more recent cohorts as earlier ones, but by extension the between-generation patterns documented here suggest that head injuries are common among younger cohorts too and they likely contribute to gender differences in internalizing symptoms. In addition, this study might have overlooked some of the psychological consequences of head injuries for men. The present study focused on internalizing symptoms, where women are especially disadvantaged, but the implications of head injuries for men might be stronger for the kinds of symptoms that men are more likely to express. Externalizing symptoms, for instance, are more common in men than women, and the gender expression hypothesis stipulates that risk factors might vary in their effects according to the psychological outcome under consideration (Simon, 2020). Head injuries do not appear, however, to have the same kinds of relationships with all externalizing symptoms. For instance, in these data (results not shown), head injuries were statistically unrelated to expressed anger (among both men and women). But the results of the present study do not preclude the possibility that head injuries are implicated in other gender gaps in mental health or functioning. Indeed, given the strong role of head injuries in an array of internalizing symptoms it is reasonable to expect that they are also implicated in other psychological outcomes.

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