# A Four-Country Study of Strangulation-Related Alterations in Consciousness in Women Who Have Experienced Intimate Partner Violence: Co-Occurrence with Traumatic Brain Injuries and Measures of Psychological Distress

Shambhu Prasad Adhikari, Julia C Daugherty, Nathalia Quiroz Molinares, Naomi Maldonado-Rodriguez, Colin Wallace, Jonathan Smirl, Miguel Perez-García, Carlos José de los Reyes-Aragón, Natalia Hidalgo-Ruzzante, Paul van Donkelaar, et al.

**A Four Country Study of Strangulation-related Alterations in Consciousness in Women who have Experienced Intimate Partner Violence: Co-occurrence with Traumatic Brain Injuries and Measures of Psychological Distress**

Shambhu Prasad Adhikari[1], Julia C. Daugherty[2], Nathalia Quiroz Molinares[3], Naomi Maldonado-Rodriguez[1], Colin Wallace[4], Jonathan Smirl[5], Miguel Perez-García[6], Carlos José De los Reyes[7], Natalia Hidalgo-Ruzzante[6], Paul van Donkelaar[1], and Eve M. Valera[8*]

[1]School of Health and Exercise Sciences, University of British Columbia, Kelowna, British Columbia, Canada.

[2]Université Clermont Auvergne, CNRS, LAPSCO, Clermont-Ferrand, France.

[3]Department of Social Sciences / Universidad De la Costa, Colombia.

[4]Department of Kinesiology, Okanagan College, Kelowna, British Columbia, Canada.

[5]Faculty of Kinesiology, University of Calgary, Canada.

[6]Mind, Brain and Behavior Research Center, (CIMCYC), University of Granada, Spain

[7]Department of Humanities and Social Sciences, Universidad del Norte, Barranquilla, Colombia.

[8]Psychiatry, Harvard Medical School and Massachusetts General Hospital, Charlestown, Massachusetts, USA.

**Eve M Valera ([*]Corresponding Author)**

Department of Psychiatry, Harvard Medical School

Massachusetts General Hospital

149 13th Street

Charlestown, MA 02129, USA

Email: eve_valera@hms.harvard.edu

**Shambhu Prasad Adhikari (First author)**

School of Health and Exercise Sciences,

University of British Columbia, Okanagan Campus

ART360 (Arts Building)

1147 Research Rd.,

Kelowna, BC V1V 1V7, Canada

Email: shambhu.adhikri@ubc.ca

**Julia C. Daugherty**

Université Clermont Auvergne, CNRS, LAPSCO,

49 bd Francois Mitterrand, CS 60032,

63001 Clermont-Ferrand, France

Email: juliadaugherty1@gmail.com

**Nathalia Quiroz Molinares**

Department of Social Sciences

Universidad De la Costa, Colombia

Cl. 58 #55 - 66, Nte. Centro Historico,

Barranquilla, Atlántico, Colombia

Email: nathaliaq@uninorte.edu.co

**Naomi Maldonado-Rodriguez**

School of Health and Exercise Sciences,

University of British Columbia, Okanagan Campus

ART360 (Arts Building)

1147 Research Rd.,

Kelowna, BC V1V 1V7, Canada

Email: naomi.maldonadorodriguez@ubc.ca

**Colin Wallace**

Department of Kinesiology,

Okanagan College,

C245 (Science Building)

1000 KLO Road

Kelowna, British Columbia V1Y 4X8, Canada

Email: cwallace@okanagan.bc.ca

**Jonathan Smirl**

Faculty of Kinesiology,

Main Office KNB 135

376 Collegiate Blvd NW

University of Calgary

2500 University Drive, NW

Calgary, Alberta, Canada

Email: jonathan.smirl@ucalgary.ca

**Miguel Perez-García**

Mind, Brain and Behavior Research Center (CIMCYC)

University of Granada

Campus de Cartuja, s/n

18011 Granada, Spain

Email: mperezg@ugr.es

**Carlos José De los Reyes-Aragón**

Department of Psychology

Universidad del Norte,

Área metropolitana de, Kilómetro 5, Vía Puerto Colombia,

Barranquilla, Atlántico, Colombia

Email: cdelosreyes@uninorte.edu.co

**Natalia Hidalgo-Ruzzante**

The Mind, Brain and Behaviour Research Centre (CIMCYC), University of Granada, Spain

Department of Evolutionary and School Psychology, University of Granada, Spain

18011 Granada, Spain

Email: nhidalgo@ugr.es

**Paul van Donkelaar**

School of Health and Exercise Sciences,

University of British Columbia, Okanagan Campus

ART360 (Arts Building)

1147 Research Rd.,

Kelowna, BC V1V 1V7, Canada

Phone: +1 613-668-1008

Email: paul.vandonkelaar@ubc.ca

**Keywords:** anxiety; depression; intimate partner violence; post-traumatic stress; strangulation-related alteration in consciousness; traumatic brain injury

**Running title:** Co-occurrence of TBI and strangulation-related AIC

**Abstract**

At least one in three women experience intimate partner violence (IPV) in their lifetime. The most commonly sustained IPV-related brain injuries include strangulation-related alterations in consciousness (S-AICs) and traumatic brain injuries (TBIs). Moreover, survivors of IPV-related S-AICs and/or TBIs often demonstrate psychological distress such as depression, anxiety, and post-traumatic stress. However, the co-occurrence of S-AICs and TBIs, and whether such TBIs may be moderate to severe, has not been systematically examined, and most data have been collected from women in North America. The purpose of this study was to examine the co-occurrence of IPV-related S-AICs and TBIs across a range of geographical locations and to determine the extent to which these S-AICs are related to psychological distress. Women who had experienced physical IPV ($N$ = 213) were included in this secondary analysis of retrospectively collected data across four countries (Canada, USA, Spain, and Colombia). The Brain Injury Severity Assessment (BISA) was used to assess IPV-related BI across all sites. Because various questionnaires were employed to assess levels of depression, anxiety, and PTSD at each site, we created a standardized composite score by converting raw scores into *Z*-scores for analysis. Mann Whitney U tests and Chi square tests were conducted to examine differences between women with- versus without-experience of S-AICs and to discover if there was a relationship between the occurrence of S-AICs and TBIs. Analysis of variance, and analysis of covariance (to control for the potential confounding effects of age, education, and non IPV-related TBI) were used to compare levels of psychological distress in women who had or had not experienced S-AICs. Approximately 67% of women sustained at least one IPV-related BI (i.e., TBI and/or S-AIC). In a sub-sample of women who sustained at least one IPV-related BI, approximately 37% sustained both S-AICs and TBIs, 2% sustained only S-AICs (with no TBIs), and 61% sustained TBIs

exclusively (with no S-AICs). Furthermore, women who had sustained S-AICs (with or without a TBI) were more likely to have experienced a moderate to severe BI than those who had not sustained an S-AIC (BISA severity subscale: $U = 3939$, $p = 0.006$). Additionally, women who experienced S-AICs (with or without a TBI) reported higher levels of psychological distress compared to women who never experienced S-AICs, irrespective of whether they occurred once or multiple times. These data underscore the importance of assessing for S-AIC in women who have experienced IPV and when present, to also assess for TBIs and the presence of psychological distress. Unfortunately, there were methodological differences across sites precluding cross-site comparisons. Nonetheless, data were collected across four culturally and geographically diverse countries, and therefore highlight IPV-related BIs as a global issue which needs to be aggressively studied with policies established and then implemented to address findings.

## INTRODUCTION

It is estimated at least 1 in 3 women globally experience intimate partner violence (IPV) in their lifetime.[1] Widely recognized as a devastating public health problem, IPV occurs across a range of ages, ethnicities, socioeconomic statuses, and education levels[2] yet, its effects are disproportionately felt by women of color - particularly Black and Indigenous women[3, 4] – and women of lower socioeconomic status.[5]

An unfortunate consequence of physical IPV is brain injury (BI), hereafter termed as 'IPV-related BI' (intimate partner violence-inflicted brain injury), either via blunt force trauma, namely traumatic brain injuries (TBIs), or inferred from strangulation-related alterations in consciousness (S-AICs).[2-4, 6-10] A scoping review[11] found that 28%[12] and 100%[13, 14] of women who had experienced IPV had also endured one or more BIs. The rates of strangulation [a distinct form of violence that is characterized by the external compression of the airway and blood vessels in the neck,[15]] irrespective of AIC, have been reported to be as high as 68% in women who have experienced partner violence.[8] Valera and Berenbaum[6] reported that 27% of women sustained at least one S-AIC and 12% sustained repetitive S-AICs in a sample of 99 women who had experienced physical IPV. Furthermore, many women reported both S-AICs and TBIs. However, the co-occurrence of S-AICs and TBIs has not been systematically examined. It has also never been examined whether women who experience S-AICs also experience higher rates of moderate to severe BIs relative to women who do not experience S-AICs.

Additionally, IPV and IPV-related BIs have been associated with a multitude of physical,[14] psychological,[16] neurological,[14, 17] cognitive,[14, 17] and emotional outcomes, most notably, anxiety, depression, and post-traumatic stress disorder (PTSD).[13, 16] A recent systematic review

of papers published between 1980 and 2020 across 10 countries[15] synthesized 30 empirical and peer-reviewed studies on non-fatal strangulation in IPV and sexual assault. The authors found a link between strangulation and psychological distress including depression and PTSD. Two recent studies[16, 18] based on samples in the US and Spain included in this report, found associations between S-AICs and psychopathology. In the data collected from the US, Valera and colleagues[16] demonstrated that women who experienced S-AICs had higher levels of anhedonic depression and PTSD symptomatology compared to those who had not experienced S-AICs. From Spain, Daugherty and colleagues[18] demonstrated an association between strangulation attempts and PTSD, depression, and anxiety. These findings are not surprising, as women not only report S-AICs but also report strangulation to be one of the most terrifying forms of abuse they experience.[19, 20]

In this report, our first objective is to examine the co-occurrence of S-AICs and TBIs across samples of women from four culturally and geographically diverse countries, namely Canada, the USA, Colombia, and Spain. Second, we aim to examine whether S-AICs are associated with other outcomes (e.g., mild BIs vs. moderate to severe BIs). Our final objective is to determine the degree to which S-AICs are associated with psychological distress (PTSD, depression, and anxiety) across cultures. Specifically, we predict a high co-occurrence of S-AICs with TBIs, as well as an increased rate for moderate to severe BIs for women who have experienced S-AIC relative to women who have not experienced S-AIC. Consistent with, and extending findings of the studies by Valera and colleagues[16] and Daugherty and colleagues,[18] we anticipate greater levels of psychological distress (i.e., depression, anxiety, PTSD symptoms) in women who have experienced S-AICs.

## METHODS

### *Design, Participants and Study Settings*

This is a secondary analysis of prospectively collected data across four countries – Canada, the USA, Spain, and Colombia. The data were originally collected as part of studies conducted by several of the co-authors (MPG, NQM, EV, and PvD), who were the lead investigators on the original studies. Common inclusion criteria across all studies is the enrollment of women who had experienced at least one instance of IPV in the past. Only women who experienced physical IPV (with or without sexual or psychological IPV) were included in the current analyses.

At the Canadian site,[14] women between the ages 18 and 50 years were recruited from a local women's shelter and other women-serving organizations. With an aim to enroll with a spectrum of previous TBIs, women were recruited irrespective of previously reported head trauma. However, they were excluded if they had a history of neurological disease/disorder (e.g., stroke, seizures). Demographic, psychopathological and BI-related assessments (all in English) were conducted on two separate consecutive days by a trained research assistant.

At the site in the USA,[6] women between the ages 18 and 55 years were recruited from two women's shelters, as well as through different educational and women supporting programs. Five additional women were also recruited who heard about the study from a friend. Two sessions of assessment (all in English) were conducted in succession or on different days (within one week of each other) by the principal investigator of the study and two trained female research assistants.

At the Spanish site,[18] women between the ages 18 and 67 years were recruited through various information centers for women (governmental or non-governmental), and through flyers and word

of mouth. The cross-culturally adapted Spanish-version of the Composite Abuse Scale-Short Form (CAS) was used to measure physical IPV (including strangulation) throughout the entire lifespan as well as in the past 12 months. As assessments were conducted in Spanish, women were required to speak fluent and proficient Spanish. The mental health questionnaires, the BISA, and CAS were administered in one session by a trained doctorate student in psychology.

At the Colombian site,[21] women between the ages 18 and 57 years were recruited from different non-governmental organizations (e.g., shelters) and through flyers. Women who reported neurological or psychiatric problems were excluded. All assessments were conducted in Spanish (the local language) by a trained assessor.

At all sites, women were informed about the study either directly from the organization, the PI of the study, or through flyers and word of mouth. Women were able to stop their participation at any moment. They were also informed about their anonymity and that responses would not be analyzed individually, but rather at a group-level. At the USA site, as the PI was a volunteer at the shelter, this helped with establishing rapport with the women participating in the study. Additionally, at the Spanish site, the majority of women received information about the study from a support center where the women were receiving psychological treatment.

Demographic data, including age and education, were also collected. Approval to conduct each study was received from the local research ethics boards and all participants provided written informed consent prior to participation in the study. Further details are available in the previously published articles.[6, 14, 21, 22]

***Assessment of strangulation-related AICs and IPV-related TBIs***

The Brain Injury Severity Assessment (BISA) tool[6] was used (consistent with numerous previous studies),[6, 13, 14, 17, 18, 21, 23, 24] to assess IPV-related BI. The BISA tool was designed specifically to identify the types (i.e., TBIs, S-AICs) and severities of brain injuries sustained from IPV. It is a semi-structured interview containing a series of questions about AICs, including loss of consciousness, dizziness, memory loss, feeling stunned or disoriented, or seeing stars or spots following potential traumas to the brain. The first half of the BISA focuses on BIs sustained from a partner and the second half focuses on all other types (e.g., accident-related) of acquired BIs. The BISA tool does not include any questions to specifically distinguish TBI from strangulation-related AIC. Rather the questions about AICs (i.e., loss of consciousness, dizziness, memory loss, feeling stunned or disoriented, or seeing stars or spots) were asked, and once an AIC was endorsed the woman was asked what event caused the AIC. A blunt force trauma would indicate a TBI, whereas a strangulation ("choking" something pressing against the neck) were considered a strangulation related AIC.

The BISA provides a summary score ranging from 0 to 8, as well as sub-scores related to the frequency (0-4 scale), recency (0-3 scale), and severity (0-1 scale) of the IPV-related BIs (see **Table 1** for further details). The frequency score provides an estimate of the number of previous BIs, the recency score probes the time since the most recent event resulting in a BI, and the severity score indicates whether a moderate-to-severe brain injury was ever sustained.

Based on the fact that there is typically very little further recovery a year or more after a BI[25, 26], participants for whom the most recent BI occurred a year or more ago were given a recency score of 0. Therefore, any incident occurring past one year was collapsed into a single score. Moreover, given that recall accuracy diminishes with the passage of time from the injury, this approach prevents making assumptions about precision. Finally, the prevailing method for identifying brain

injury in research and clinical contexts involves relying on an individual's recall of exposure to potentially brain-damaging events, despite its imperfections.[27, 28]

The severity score is based on the definition for mild traumatic brain injury provided by the American Congress of Rehabilitation Medicine (1993) – in particular, injuries resulting in LOC less than or equal to 30 minutes or post-traumatic amnesia (PTA) less than or equal to 24 hours were defined as mild BI (severity score: 0); whereas injuries resulting in LOC greater than 30 minutes and PTA greater than 24 hours were defined as moderate-severe BI (severity score: 1). In the presence of other alterations in consciousness (e.g., confusion, dizziness), the injury was always considered to be mild. Mild-BI was only determined if the aforementioned symptoms resulted from a plausible biomechanical force or act that could result in brain damage (e.g., hit to the head or strangulation). For further information on the BISA, please refer to Valera and Berenbaum.[6]

Although the BISA tool has not yet been formally tested for reliability and validity, it has been shown to capture the effects of IPV-related BI on resting state brain activation,[13] white matter diffusions,[23] brain morphology,[18] cognitive-motor function,[17] and brain injury symptoms.[14] Thus, the literature suggests that it is sensitive enough to previous brain injury to be a robust and reliable subjective measure and allow us to make strong inferences about the effects on brain function and structure. The BISA score has been shown to be predictive of a range of negative outcomes among women who have experienced IPV.[6, 13, 14, 17, 18, 21, 23, 24]

For use in local language (at Spanish and Colombian sites), the BISA was cross-culturally adapted by conducting a forward translation and backtranslation following International Test Commission guidelines. Translators and assessors were fluent and/or native speakers in both English and Spanish.

***Assessment of depression, anxiety and PTSD***

Various questionnaires were used to assess depression, anxiety, and PTSD at each site. At the Canadian site, depression, anxiety, and PTSD were measured using the Beck's Depression Inventory (BDI),[29] Beck's Anxiety Inventory (BAI),[30] and the Clinician-Administered PTSD scale (CAPS),[31] respectively. At the site in the USA, depression and anxiety were measured using the Mood and Anxiety Symptom Questionnaire-Short Form (MASQ),[32] and PTSD was measured using the CAPS.[31] At the sites in Spain and Colombia, the GAD-7 questionnaire,[33] the Patient Health Questionnaire depression subscale (PHQ-9),[34] and the PTSD Checklist for DSM-5 (PCL-5)[35] were used to measure depression, anxiety, and PTSD respectively.

While different measures were used to examine symptom severity for different types of psychopathology, the scales used for each psychopathology are highly correlated, demonstrating convergent validity. The PCL and CAPS scales are considered gold-standard measures for the assessment of PTSD.[36] Both scales were based on the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders[35, 37] and they are both intended to measure the severity of PTSD symptoms. There is also evidence that PTSD symptoms measured using the PCL highly correlate with the CAPS scores, across all CAPS sub-scales.[38] Similarly, the BAI and GAD-7 both measure anxiety and show adequate convergent validity ($r$ = 0.72).[33] The BAI is also significantly correlated with the MASQ with a medium effect size ($\eta^2$, Eta squared: 0.062).[39] The MASQ is also significantly correlated with the BDI, showing a large effect size ($\eta^2$= 0.192).[39] Finally, the two measures for depression (BDI and PHQ-9) are also highly correlated ($r$ = 0.77) and are essentially interchangeable.[40] Brief descriptions of each of these questionnaires are also available in the previously published articles.[6, 14, 21, 22]

Because these different questionnaires were used to assess depression, anxiety, and PTSD at each site, we created a standardized composite score for each site by converting raw scores into *Z*-scores. Converting a raw score into *Z*-score is a valid method of normalization and is widely employed, including in the World Health Organization's child growth standard index.[41-43] *Z*-scores were calculated by subtracting the site mean from the subject's value and then dividing by the standard deviation (*SD*) of that variable. After normalizing the values at each site, all data shared a common scale with a 0 mean and *SD* of 1,[42] allowing us to combine the *Z*-scores of the four different sites/datasets for subsequent analysis.[42, 43]

***Datasets for analysis***

Although we had initially hoped to compare data across sites, because our recruitment methods varied at each site, this was not possible (i.e., scientifically valid). That said, the fact that we had such different recruitment methods is a strength of the study in other ways as it increases the generalizability of these data to a wide range of women experiencing IPV. Unfortunately, because of methodological limitations (e.g., differences in how and where women were recruited across the sites), we were not able to compare across sites, but these data clearly indicate that these issues are important to address on a global level. Instead, we analyzed the combined data from the four sites for a total *N* of 213: Canada, *n* = 42; USA, *n* = 87; Spain, *n* = 42; Colombia, *n* = 42.

Due to changes in the personnel collecting the data at the Canadian site, the strangulation vs TBI specific information stopped being collected in detail after the first 18 participants. Therefore, for 18 of the Canadian women, we had detailed information on TBIs and S-AICs. However, for the other 22 women, we only acquired information regarding the experience of S-AIC (yes or no response) with or without TBIs (i.e., we did not know how many of them experienced only S-AIC,

only TBIs or both AIC and TBIs). This latter group of women therefore were excluded from analyses that required that information. As such, the co-occurrence of TBIs and S-AICs was determined from the sub-sample of 120 women for whom the BIs were broken down into TBIs and S-AICs (Canada $n$ = 18, USA $n$ = 64, Spain $n$ = 19, Colombia $n$ = 19). However, we had information regarding the experience of S-AIC (yes or no response) with or without TBIs on the full sample (213 women). Therefore, we considered the full sample to determine whether there is an effect of S-AIC (independent of the presence or absence of TBIs) on psychological distress. We did not compare psychological distress between TBIs and S-AICs groups.

***Statistical Analysis***

Descriptive statistics were conducted to analyze the demographic and clinical characteristics of the cohort. The Kolmogorov-Smirnov (K-S) test was used to examine the distribution of the data. For our first objective, descriptive statistics were used to assess the co-occurrence of sustaining S-AICs and TBIs. Chi square and Mann Whitney U tests were conducted for the second objective, which was to examine differences in TBI severities among women with versus without S-AICs. For our final objective, the outcome variables were normally distributed (K-S test, $P > 0.05$), and also met the assumptions of homogeneity (Levene's test, $p > 0.05$). As such, an analysis of variance (ANOVA) was used to compare levels of psychological distress in women who had or had not experienced S-AICs.[16] Analysis of covariance (ANCOVA) was used to control for the potential confounding effects of age, education, non IPV-related TBIs, and moderate-severe TBI. Effect size ($\eta^2$, Eta squared) was calculated to determine whether the effects were small (0.01), medium (0.06), or large (0.14).[44, 45] Significance was set at $p < 0.05$. All statistical analyses were performed using SPSS Statistics version 29.0 (IBM Corp, Armonk, NY).

## RESULTS

A sample of 213 women ages 18 to 67 years was included in this study. **Table 2** outlines the demographic and clinical characteristics of the cohort. There were no significant differences in age ($p$ = 0.59) nor education ($p$ = 0.83) for the two subgroups (with or without S-AICs) nor across the three groups (TBIs only or S-AICs only or TBIs + AICs). In the full sample ($N$ = 213), 32.86% women ($n$ = 70) experienced 1 to 5 previous BIs, 86.85% (n = 185) women had experienced a mild BI, and 66.67% (n = 142) women experienced the most recent IPV incident more than 52 weeks prior to the evaluation. Descriptive findings regarding the frequency, recency, and severity in various groups are shown in **Table 2**.

Out of 213 women, 66.67% ($n$ = 142) sustained partner-related BIs (i.e., TBIs and/or S-AICs). Of the 142 women who experienced BIs (Canada $n$ = 40, USA $n$ = 64, Spain $n$ =19, Colombia $n$ = 19), the data of 120 women (Canada $n$ = 18, USA $n$ = 64, Spain $n$ = 19, Colombia $n$ = 19) were broken down into whether the BIs were S-AICs only or TBIs only or both. In this sub-sample, the results for our first objective demonstrate that approximately 37% ($n$ = 44) sustained both S-AICs as well as TBIs, approximately 61% ($n$ = 74) sustained TBIs only, and approximately 2% ($n$ = 2) sustained only S-AICs.

With regard to our second objective, we found that women who had sustained S-AICs ($n$ = 60) were more likely to have experienced TBI-related LOC exceeding 30 minutes and/or TBI-related PTA surpassing 24 hours (i.e., a moderate to severe brain injury) compared to women who had never experienced S-AICs ($n$ = 82) (BISA severity subscale: n = 142, $U$ = 2060, $p$ = 0.02). Incidentally, approximately one third of women ($n$ = 68) also experienced non IPV-related TBIs in

the past, with a larger percentage being in the group of women who experienced S-AICs ($\chi^2$ = 8.35, *df* = 1, *p* = 0.004).

With respect to our third objective regarding psychological distress, ANOVAs run on the full sample (*N* = 213) revealed that women who had experienced S-AICs had higher scores on PTSD and depression symptomatology compared to women who had never experienced S-AICs (see **Table 3**), with a small to medium effect size ($\eta^2$ = 0.02 to 0.04). The ANCOVAs further demonstrated that the relationship between PTSD and experience of S-AIC remained significant even after controlling for the potential confounding effects of age, education, non IPV-related TBIs, and moderate-to-severe TBI (see **Table 4**). The association between depression and experience of S-AIC was not statistically significant after controlling for potential confounding factors; however, the effect size ($\eta^2$ = 0.02, small-to-medium) did not change. We did not find any significant relationships between anxiety and the experience of S-AIC (see **Tables 3 and 4**). The Z-scores for PTSD, depression, and anxiety are plotted as a function of group (i.e., women who had vs. had not experienced S-AIC) and presented in **Figure 1**. Z-scores were significantly different between the groups for PTSD (*p* = 0.0069) and depression (*p* = 0.0485) but not for anxiety (*p* = 0.6855). PTSD, depression, and anxiety scores have also been plotted against the frequency and recency scores following one-way ANOVA and are presented in **Figure 2**. The Z-scores for PTSD, depression, and anxiety showed significant differences between the highest versus lowest scores in frequency as well as recency. In other words, PTSD, depression, and anxiety scores were higher when frequency for BI was higher or more recent.

## DISCUSSION

This is the first study to systematically examine the co-occurrence of S-AICs and IPV-related TBI. Data were combined from four culturally and geographically diverse countries to increase generalizability and to expand our knowledge in this area beyond what is known almost exclusively in North America. Across our sample of 213 women, approximately 67% (142 women) sustained either a TBI and/or a S-AIC. In a subset of those women (120 women) for whom we had details regarding the type of BI (TBI or S-AIC), we found that approximately 37% of women experienced both S-AICs and IPV-related TBIs. When distinguishing between the different types of potential BI, results indicate that 61% percent sustained a partner-related TBI only while only two women sustained an S-AIC without TBI. This last finding is critical, as it indicates that if a woman has been strangled by her partner, there is a reasonable likelihood that she has also acquired a partner-related TBI. Nonetheless, as S-AIC and TBI frequently co-occur, it is difficult to disentangle their relative contributions to symptom presentation. However, results from our second objective demonstrated that women with S-AICs were more likely to sustain a moderate to severe BI than those who had not experienced S-AIC. Thus, strangulation with AIC may serve as a red flag for co-occurring TBI, and practitioners should consider screening for BI caused by traumatic hits to the head if strangulation has been detected.

The results of our third objective demonstrated higher levels of psychological distress (PTSD and depression) for women sustaining S-AIC relative to women who did not sustain S-AIC. Specifically, women who sustained S-AICs reported higher levels of PTSD and depression compared to women who had never sustained an S-AIC. The association with PTSD could not be accounted for by age, education, non IPV-related TBIs nor moderate to severe TBI. However, the association with depression was strongly influenced by education to the degree that the effect was no longer statistically significant. Nonetheless, the effect size suggested that there could be a

potentially meaningful association that we were underpowered to detect. These data are not only consistent with results from the individual studies using the USA[16] and Spain[18] cohorts, but further extend their findings by providing a larger sample and including data from two additional countries, namely Canada and Colombia.

In addition, the findings of our third objective also fall in line with the results of a recent review,[15] and other existing literatures,[46-49] which found higher levels of depression and PTSD symptomology, as well as suicide ideation and nightmares, among strangulation survivors. Beyond the physical trauma, strangulation is often used as a coercive control tactic.[50-52] Indeed, a singular incident of strangulation can be enough to instill paralyzing fear in women, further strengthening the perpetrator's power and reinforcing the victim's compliance and isolation.[53] Thus, it is unsurprising that several studies, including this one, have shown women who experience strangulation also exhibit many symptoms consistent with depression, and PTSD.[8, 46-49, 51, 52, 54]

Using an international sample, the current study has demonstrated that IPV-related TBIs and their negative associations are broad, across several culturally diverse locations. In particular, our data was heterogeneous in that it was: 1) collected across four culturally diverse countries; and 2) from women who had a wide range of previous BIs (0 to >16), and post injury durations (incidents had occurred within the past 13 weeks to more than a year ago). Additionally, our study demonstrated a relationship between the PTSD and S-AIC, even after controlling for the potential confounding effects of age, education, non IPV-related TBIs and moderate-to-severe TBIs. However, the present study did not find any association between the experience of strangulation and anxiety, which is in contrast with the findings of previous work.[16, 18] This variation may stem from methodological differences among studies (e.g. how BI is defined), variations between research

sites (e.g. recruitment strategies), as well as the diverse cultural interpretations and definitions of anxiety and its dimensions.[55] This highlights the necessity for further research to better understand the complex relationship between psychopathology and non-fatal strangulation.

**Limitations of the study**

We did not consistently collect data on various dimensions of identity [e.g., ethnicity, gender, sexual orientation, socioeconomic status, citizenship status, etc.[56]]. Canada, the USA, Spain, and Colombia are diverse, culturally heterogenous countries with populations that are made up of many, ethnicities, languages, and religions. That we observed S-AICs and IPV-related TBIs across these complex sociodemographic and sociopolitical contexts underscore the need for intersectional approaches that consider the social location of an individual in the design and implementation of resources for women who have experienced IPV. An intersectional approach exploring the impact of various dimensions of identity (e.g., ethnicity, socioeconomic status, citizenship status, etc.) could allow for a more nuanced analysis of S-AICs and IPV-related TBIs and inform the design of effective and culturally-sensitive resources and supports. Unfortunately, because of methodological limitations (e.g., differences in how and where women were recruited across the sites), we were not able to compare across sites, but these data clearly indicate that these issues are important to address on a global level.

Methodological heterogeneity between sites very likely affected our results. For instance, each site used a different clinical questionnaire to assess anxiety and depression. In addition, the BISA tool is limited by the self-reported and retrospective nature of its assessment. The BISA tool has not yet been validated, and this may lead to variations in administration. Nonetheless, at the time these data were collected, there were no other measures developed for the assessment of BIs in samples

of women across a range of countries. Furthermore, the BISA has been used successfully in a range of studies showing associations with cognitive and psychological functioning,[6] white matter fractional anisotropy,[23] brain morphology,[18] cognitive motor dysfunction,[16] and TBI symptoms.[14] Despite these potential limitations, the current study revealed that the BISA is able to elicit important information on both TBIs and S-AICs across cultures, which are consistently linked to psychological distress in survivors of IPV.

Furthermore, in theory, using medical records to validate responses regarding incidents of TBI or S-AIC could be useful. However, studies, for e.g., Valera and Berenbaum, 2003[6] have shown that women do not typically seek medical attention for these injuries (for a host of reasons including fear of or being prevented by the abuser). As such there would be no such medical documentation for many of most women, resulting in high rates of false negatives.

## CONCLUSION

Harnessing international data collected across four countries, this study provides important information regarding the co-occurrence of TBIs and S-AICs in women who have experienced physical IPV. More specifically, women experiencing S-AICs have a higher likelihood of sustaining an IPV-related TBI. Further, the present study found that women who experienced S-AICs had higher likelihoods of sustaining moderate to severe IPV-BIs as well as higher levels of PTSD and depression compared to women who had never experienced strangulation-related AICs. These findings underscore the urgency of conceptualizing IPV-related BIs as a global issue, and highlights the need to consider strangulation as an important risk factor for both TBIs and potentially moderate to severe TBIs. Additional studies are needed to better understand the

interaction between IPV, BIs, and mental health as both IPV and BI contribute to mental health issues observed in women who experience IPV.

**Acknowledgements**

We would like to show our deepest gratitude to all of the women who participated in this study. The authors also thank the staff working at various recruitment sites across four countries. The authors are thankful to the IBIA (International Brain Injury Association) for providing us platforms to present on the data included in this manuscript at the 2021 IBIA conference ("A cross-cultural assessment of brain injury in women who have experienced intimate partner violence") and 2023 IBIA conference ("Characterizing intimate partner violence-caused brain injury in relationship to strangulation and mental health comorbidities across four countries").

**Authors' Contribution**

**SPA**: Conceptualization, analysis, methodology, writing (original draft), writing (review and editing); **NMR, CW and JS**: Methodology, data collection, writing (review and editing); **MPG, CJDR and NHR**: Conceptualization, writing (review and editing); **PVD, EMV, JCD and NQM**: Conceptualization, methodology, supervision, data collection, writing (review and editing).

**Author Disclosure Statement**

No competing financial interests exist.

**Funding Information**

Dr. Valera would like to acknowledge current funding (R01 NS112694-01). This research was funded by National Research Service Award 1 F31 MH11763–01A2, from the National Institutes of Health, and by three grants from the University of Illinois, the Graduate College On-Campus Dissertation Research Grant, Women's Studies Funding for Feminist Scholarship, and the Graduate College Thesis Project Grant. This work was supported at the Canadian site by grants from the Department of Women and Gender Equality (GV18315-01), Canadian Institutes of Health Research (013902), Canadian Foundation for Innovation, and an anonymous donor (012153). NMR was supported by a Canada Graduate Scholarship – Master's award. The study at the Spanish site was funded by the I+D+I Operative Program FEDER project of the Andalusian Government in 2018 (B-CTS493-UGR18). JCD was funded by a predoctoral fellowship of the Ministry of Education and Professional Training in Spain as well as the postdoctoral Puente contract at the University of Granada (Spain). The study at Colombian site was supported by the Minciencias, (Grant number 727 from 2015).

**Transparency, Rigor, and Reproducibility Statement**

This is a secondary analysis of prospectively collected data across four countries – Canada, the USA, Spain, and Colombia. Neither the study nor the analysis plan was preregistered. The materials and methods are described in detail in the articles that are already published using these four datasets (one each from four countries).[6, 14, 21, 22] Participants selection, settings, measurements and procedures in those articles are described in a simpler and clearer form to

enhance the reproducibility of the studies. Trained assessors collected the data in the local language.

Those women survivors of IPV who met eligibility criteria were recruited at each site. Women between the ages of 18 and 67 years who had experienced at least one instance of IPV in the past were recruited from various women-serving organizations in the community. Only women who experienced physical IPV (with or without sexual/psychological IPV) and had complete data (BISA score, depression, anxiety and PTSD scores) were included in the current analysis. Women were excluded if they had a history of neurological disease/disorder (e.g., stroke, seizures) or reported current illicit substance abuse. This resulted to a total sample size of 213 (Canada= 42; USA= 87; Spain= 42; Colombia= 42). The data of 120 women (Canada= 18, USA= 64, Spain= 19, Colombia= 19) for whom there were complete datasets were broken down into whether they experienced traumatic brain injury or strangulation-related alteration in consciousness. Therefore, this sub-sample of 120 women was used to calculate the co-occurrence of traumatic brain injury and strangulation-related alteration in consciousness.

The statistical analysis conducted in this secondary analysis is consistent with the statistical method applied in the existing literature.[15, 18] Co-occurrence of traumatic brain injury and strangulation-related alteration in consciousness was calculated using descriptive statistics (number and percentage). Chi square test and Mann Whitney U tests were conducted to examine differences in traumatic brain injury severities among women with versus without strangulation-related alteration in consciousness. The analysis of variance was used to compare levels of psychological distress in women who had or had not experienced strangulation-related alteration in consciousness. Analysis of covariance was used to control for the potential confounding effects

of age, education and non IPV-related TBIs. Effect size (*r*) was calculated to determine whether the effects were small (0.1 to < 0.3), medium (0.3 to < 0.5), or large (0.5 to 1.0).[44, 45]

Approval to conduct each study was received from the local research ethics boards and all participants provided written informed consent prior to participation in the study. Funding sources, and acknowledgements are included. Data from each site are securely stored by the principal investigator of each study.[6, 14, 21, 22] Anonymized data is available upon request from the Canadian site. However, as such sharing was not required by the funding agencies and given the sensitivity of the data, this type of data sharing was not requested in the informed consent for the protocols used in the US, Spain, and Colombia. As such these data are not allowed to be shared freely.

**References**

1. WHO. Violence Against Women Prevalence Estimates, 2018. 2021 [Available from: https://apps.who.int/iris/bitstream/handle/10665/341604/WHO-SRH-21.6-eng.pdf, (last accessed: 10/-8/2023).

2. WHO. Understanding and Adressing Violence against Women 2012 [Available from: https://www.who.int/reproductivehealth/topics/violence/vaw_series/en/, (last accessed: 10/-8/2023).

3. Boyce J. Victimization of Aboriginal people in Canada, 2014: Statistics Canada; 2016 [Available from: http://www.niagaraknowledgeexchange.com/wp-content/uploads/sites/2/2016/07/Stats-Canada-June-28_2016-Victimization-of-Aboriginal-People-in-Canada_2014.pdf, (last accessed: 10/-8/2023).

4. Linton KF, Kim BJ. Traumatic brain injury as a result of violence in Native American and Black communities spanning from childhood to older adulthood. Brain Inj. 2014;28(8):1076-81. doi: 10.3109/02699052.2014.901558.

5. Abramsky T, Watts CH, Garcia-Moreno C, et al. What factors are associated with recent intimate partner violence? findings from the WHO multi-country study on women's health and domestic violence. BMC Public Health. 2011;11:109. doi: 10.1186/1471-2458-11-109.

6. Valera EM, Berenbaum H. Brain injury in battered women. J Consult Clin Psychol. 2003;71(4):797-804. doi: 10.1037/0022-006x.71.4.797.

7. Malek AM, Higashida RT, Halbach VV, et al. Patient presentation, angiographic features, and treatment of strangulation-induced bilateral dissection of the cervical internal carotid artery. Report of three cases. J Neurosurg. 2000;92(3):481-7. doi: 10.3171/jns.2000.92.3.0481.

8. Wilbur L, Higley M, Hatfield J, et al. Survey results of women who have been strangled while in an abusive relationship. J Emerg Med. 2001;21(3):297-302. doi: 10.1016/s0736-4679(01)00398-5.

9. Haag HL, Jones D, Joseph T, et al. Battered and Brain Injured: Traumatic Brain Injury Among Women Survivors of Intimate Partner Violence-A Scoping Review. Trauma Violence Abuse. 2019:1524838019850623. doi: 10.1177/1524838019850623.

10. Hunnicutt G, Lundgren K, Murray C, et al. The intersection of intimate partner violence and traumatic brain injury: A call for interdisciplinary research. Journal of family violence. 2017;32:471-80. https://doi.org/10.1007/s10896-016-9854-7.

11. Campbell JK, Joseph A-LC, Rothman EF, et al. The Prevalence of Brain Injury Among Survivors and Perpetrators of Intimate Partner Violence and the Prevalence of Violence Victimization and Perpetration Among People With Brain Injury: a Scoping Review. Current Epidemiology Reports. 2022:1-26. https://doi.org/10.1007/s40471-022-00302-y.

12. Iverson KM, Dardis CM, Pogoda TK. Traumatic brain injury and PTSD symptoms as a consequence of intimate partner violence. Compr Psychiatry. 2017;74:80-7. doi: 10.1016/j.comppsych.2017.01.007.

13. Valera E, Kucyi A. Brain injury in women experiencing intimate partner-violence: neural mechanistic evidence of an "invisible" trauma. Brain Imaging Behav. 2017;11(6):1664-77. doi: 10.1007/s11682-016-9643-1.

14. Smirl JD, Jones KE, Copeland P, et al. Characterizing symptoms of traumatic brain injury in survivors of intimate partner violence. Brain Inj. 2019;33(12):1529-38. doi: 10.1080/02699052.2019.1658129.

15. Bichard H, Byrne C, Saville CWN, et al. The neuropsychological outcomes of non-fatal strangulation in domestic and sexual violence: A systematic review. Neuropsychol Rehabil. 2022;32(6):1164-92. doi: 10.1080/09602011.2020.1868537.

16. Valera EM, Daugherty JC, Scott OC, et al. Strangulation as an Acquired Brain Injury in Intimate-Partner Violence and Its Relationship to Cognitive and Psychological Functioning: A Preliminary Study. J Head Trauma Rehabil. 2022;37(1):15-23. doi: 10.1097/HTR.0000000000000755.

17. Maldonado-Rodriguez N, Crocker CV, Taylor E, et al. Characterization of Cognitive-Motor Function in Women Who Have Experienced Intimate Partner Violence-Related Brain Injury. J Neurotrauma. 2021;38(19):2723-30. doi: 10.1089/neu.2021.0042.

18. Daugherty JC, Verdejo-Román J, Pérez-García M, et al. Structural Brain Alterations in Female Survivors of Intimate Partner Violence. J Interpers Violence. 2022;37(7-8):Np4684-np717. doi: 10.1177/0886260520959621.

19. Pritchard AJ, Reckdenwald A, Nordham C. Nonfatal Strangulation as Part of Domestic Violence: A Review of Research. Trauma Violence Abuse. 2017;18(4):407-24. doi: 10.1177/1524838015622439.

20. Monahan K, Bannon S, Dams-O'Connor K. Nonfatal strangulation (NFS) and intimate partner violence: A brief overview. Journal of Family Violence. 2020:1-12. https://doi.org/10.1007/s10896-020-00208-7.

21. Quiroz Molinares N, Navarro Segura MC, de Los Reyes-Aragon CJ, et al. Intimate Partner Violence-Related Brain Injury Among Colombian Women. J Head Trauma Rehabil. 2022. doi: 10.1097/HTR.0000000000000793.

22. Daugherty JC, Pérez-García M, Hidalgo-Ruzzante N, et al. Perceived Executive Functioning among Female Survivors of Intimate Partner Violenc e. Journal of Aggression, Maltreatment & Trauma. 2021;30(1):25-42. https://doi.org/10.1080/10926771.2020.1783734.

23. Valera EM, Cao A, Pasternak O, et al. White Matter Correlates of Mild Traumatic Brain Injuries in Women Subjected to Intimate-Partner Violence: A Preliminary Study. J Neurotrauma. 2019;36(5):661-8. doi: 10.1089/neu.2018.5734.

24. Saadi A, Chibnik L, Valera E. Examining the Association Between Childhood Trauma, Brain Injury, and Neurobehavioral Symptoms Among Survivors of Intimate Partner Violence: A Cross-Sectional Analysis. J Head Trauma Rehabil. 2022;37(1):24-33. doi: 10.1097/HTR.0000000000000752.

25. Carroll L, Cassidy JD, Peloso P, et al. Prognosis for mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Journal of rehabilitation medicine. 2004;36(0):84-105. doi: 10.1080/16501960410023859

26. Losoi H, Silverberg ND, Wäljas M, et al. Recovery from mild traumatic brain injury in previously healthy adults. Journal of neurotrauma. 2016;33(8):766-76. doi: 10.1089/neu.2015.4070

27. Bogner J, Corrigan JD. Reliability and predictive validity of the Ohio State University TBI identification method with prisoners. J Head Trauma Rehabil. 2009;24(4):279-91. doi: 10.1097/HTR.0b013e3181a66356.

28. Corrigan JD, Bogner J. Initial reliability and validity of the Ohio State University TBI Identification Method. J Head Trauma Rehabil. 2007;22(6):318-29. doi: 10.1097/01.HTR.0000300227.67748.77.

29. Beck AT. Manual for the beck depression inventory-II. 1996.

30. Beck AT, Steer RA. Manual for the Beck Anxiety Inventory. San Antonio, TX: Psychological Corp. 1993.

31. Blake DD, Weathers FW, Nagy LM, et al. The development of a Clinician-Administered PTSD Scale. J Trauma Stress. 1995;8(1):75-90. doi: 10.1007/BF02105408.

32. Clark LA, Watson D. Tripartite model of anxiety and depression: psychometric evidence and taxonomic implications. J Abnorm Psychol. 1991;100(3):316-36. doi: 10.1037//0021-843x.100.3.316.

33. Spitzer RL, Kroenke K, Williams JB, et al. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med. 2006;166(10):1092-7. doi: 10.1001/archinte.166.10.1092.

34. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med. 2001;16(9):606-13. doi: 10.1046/j.1525-1497.2001.016009606.x.

35. Blevins CA, Weathers FW, Davis MT, et al. The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. J Trauma Stress. 2015;28(6):489-98. doi: 10.1002/jts.22059.

36. Resick PA, Straud CL, Wachen JS, et al. A comparison of the CAPS-5 and PCL-5 to assess PTSD in military and veteran treatment-seeking samples. Eur J Psychotraumatol. 2023;14(2):2222608. doi: 10.1080/20008066.2023.2222608.

37. APA. American Psychiatric Association (APA). Diagnostic and Statistical Manual of Mental Disorders. 4th ed. ed1994.

38. Ben-Zion Z, Zeevi Y, Keynan NJ, et al. Multi-domain potential biomarkers for post-traumatic stress disorder (PTSD) severity in recent trauma survivors. Transl Psychiatry. 2020;10(1):208. doi: 10.1038/s41398-020-00898-z.

39. Talkovsky AM, Norton PJ. The Mood and Anxiety Symptom Questionnaire across four ethnoracial groups in an undergraduate sample. Am J Orthopsychiatry. 2015;85(5):431-40. doi: 10.1037/ort0000095.

40. Kung S, Alarcon RD, Williams MD, et al. Comparing the Beck Depression Inventory-II (BDI-II) and Patient Health Questionnaire (PHQ-9) depression measures in an integrated mood disorders practice. J Affect Disord. 2013;145(3):341-3. doi: 10.1016/j.jad.2012.08.017.

41. World-Bank. World Bank (WB). KEI and KI Indexes (KAM). 2009. Available online: http://info.worldbank.org/etools/kam2/kam_page5.asp 2009, (Last accessed: 10/-8/2023).

42. Talukder B, W. Hipel K, W. vanLoon G. Developing composite indicators for agricultural sustainability assessment: Effect of normalization and aggregation techniques. Resources. 2017;6(4):66. https://doi.org/10.3390/resources6040066.

43. Andrade C. Z scores, standard scores, and composite test scores explained. Indian Journal of Psychological Medicine. 2021;43(6):555-7. doi: 10.1177/02537176211046525.

44. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. Front Psychol. 2013;4:863. doi: 10.3389/fpsyg.2013.00863.

45. Field A, editor. Discovering statistics using SPSS. 2nd ed. London: SAGE publications; 2005.

46. Funk M, Schuppel J. Strangulation injuries. Wmj. 2003;102(3):41-5.

47. Smith DJ, Jr., Mills T, Taliaferro EH. Frequency and relationship of reported symptomology in victims of intimate partner violence: the effect of multiple strangulation attacks. J Emerg Med. 2001;21(3):323-9. doi: 10.1016/s0736-4679(01)00402-4.

48. Joshi M, Thomas KA, Sorenson SB. "I didn't know I could turn colors": Health problems and health care experiences of women strangled by an intimate partner. Soc Work Health Care. 2012;51(9):798-814. doi: 10.1080/00981389.2012.692352.

49. Yen K, Vock P, Christe A, et al. Clinical forensic radiology in strangulation victims: forensic expertise based on magnetic resonance imaging (MRI) findings. Int J Legal Med. 2007;121(2):115-23. doi: 10.1007/s00414-006-0121-y.

50. Myhill A, Hohl K. The "Golden Thread": Coercive Control and Risk Assessment for Domestic Violence. J Interpers Violence. 2019;34(21-22):4477-97. doi: 10.1177/0886260516675464.

51. Nemeth JM, Bonomi AE, Lee MA, et al. Sexual infidelity as trigger for intimate partner violence. J Womens Health (Larchmt). 2012;21(9):942-9. doi: 10.1089/jwh.2011.3328.

52. Thomas KA, Joshi M, Sorenson SB. “Do you know what it feels like to drown?” Strangulation as coercive control in intimate relationships. Psychology of Women Quarterly. 2014;38(1):124-37. https://doi.org/10.1177/0361684313488.

53. Michael P. Johnson JML. The Differential Effects of Intimate Terrorism and Situational Couple Violence: Findings From the National Violence Against Women Survey. Journal of Family Issues. 2005;26(3):322-49. https://doi.org/10.1177/0192513X04270.

54. Vella SAM, Marianne M; Lambert, Jessica E, et al. "I Felt Close to Death": A Phenomenological Study of Female Strangulation Survivors of Intimate Terrorism. Journal of feminist family therapy. 2017;29(4):171-88. https://doi.org/10.1080/08952833.2017.1370572.

55. Koydemir S, Essau CA. Anxiety and anxiety disorders in young people: A cross-cultural perspective. Understanding uniqueness and diversity in child and adolescent mental health: Elsevier; 2018. p. 115-34. https://doi.org/10.1016/B978-0-12-815310-9.00005-8.

56. Bitzel A. Who are" We"? Examining identity using the Multiple Dimensions of Identity model. 2013. https://doi.org/10.1080/08952833.2017.1370572

**Table 1:** Scoring Brain Injury Severity Assessment (BISA) tool

| ***Subscales*** | ***Score*** | ***Description*** |
|---|---|---|
| | 0 | There have been no previously reported brain injuries |
| Frequency | 1 | There have been 1 to 5 previously reported brain injuries |
| | 2 | There have been 6 to 10 previously reported brain injuries |
| | 3 | There have been 11 to 15 previously reported brain injuries |
| | 4 | There have been 16 or more previously reported brain injuries |

| | | |
|---|---|---|
| Recency | 0 | The event occurred more than 52 weeks ago |
| | 1 | The event occurred between 27–52 weeks ago |
| | 2 | The event occurred between 14–26 weeks ago |
| | 3 | The event occurred within the past 13 weeks |
| Severity | 0 | The presence of exclusively mild brain injuries |
| | 1 | At least one episode involving loss of consciousness for over 30 minutes or a period of post-traumatic amnesia for over 24 hours had occurred (indicating presence of moderate-to-severe injuries) |

**Table 2:** Summary of demographic and clinical information of the women by full and sub-sample

| **Characteristics** | **Experience of S-AICs** [a] **(Full sample, N = 213)** | | **Co-occurrence of TBIs and S-AICs** [b] **(Sub-sample, n = 120)** | | |
|---|---|---|---|---|---|
| | ***Who experienced S-AICs (with or without TBIs) (n = 60)*** | ***Who had not experienced S-AICs (with or without TBIs) (n = 153)*** | ***Only TBIs (n = 74)*** | ***Only S-AICs (n = 2)*** | ***TBIs + S-AICs (n = 44)*** |
| Age (Y): Mean ± SD | 35.10 ± 9.91 | 34.56 ± 11.06 | 32.61 ± 9.36 | 31.0 ± 2.83 | 34.48 ± 9.70 |
| Education (# of Y): | | | | | |
| Mean ± SD | 13.09 ± 3.21 | 13.10 ± 4.60 | 12.55 ± 3.12 | 17.0 ± 0.0 | 12.93 ± 3.03 |
| Non IPV-related TBIs; n (%) | | | | | |
| Yes | 28 (46.7) | 40 (26.1) | 17 (22.97) | 0 (0.0) | 19 (43.18) |

| | | | | | |
|---|---|---|---|---|---|
| No | 32 (53.3) | 113 (73.9) | 57 (77.03) | 2 (100) | 25 (56.82) |
| **Number (percentage) of women according to the scores on the BISA-subscales** [c] | | | | | |
| Frequency score; n (%) | | | | | |
| 0 | 0 | 71(46.41) | 0 | 0 | 0 |
| 1 | 20 (33.33) | 50 (32.67) | 48 (64.86) | 2 (100) | 16 (36.36) |
| 2 | 12 (20.0) | 10 (6.54) | 9 (12.16) | 0 | 10 (22.73) |
| 3 | 2 (3.33) | 2 (1.31) | 1 (1.35) | 0 | 0 |
| 4 | 26 (43.34) | 20 (13.07) | 18 (24.33) | 0 | 18 (40.91) |
| Recency score; n (%) | | | | | |
| 0 | 26 (43.33) | 116 (75.81) | 37 (50) | 1 (50) | 18 (40.91) |
| 1 | 7 (11.67) | 11(7.19) | 9 (12.16) | 1 (50) | 4 (9.09) |
| 2 | 7 (11.67) | 7 (4.58) | 10 (13.51) | 0 | 6 (13.64) |
| 3 | 20 (33.33) | 19 (12.42) | 18 (24.33) | 0 | 16 (36.36) |
| Severity score; n (%) | | | | | |
| 0 | 46 (76.67) | 139 (90.85) | 68 (91.89) | 2 (100) | 34 (77.27) |
| 1 | 14 (23.33) | 14 (9.15) | 6 (8.11) | 0 | 10 (22.73) |

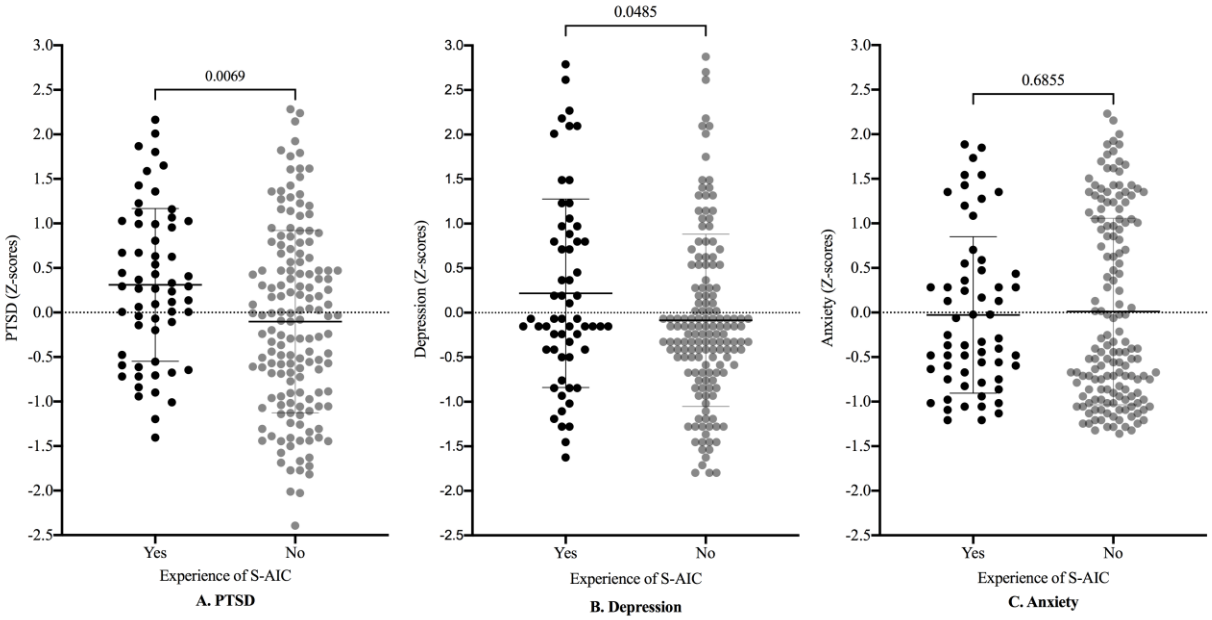
IPV: Intimate Partner Violence, TBIs: Traumatic Brain Injuries, S-AICs: Strangulation-related Alterations in Consciousness, Y: year; SD: Standard Deviation. [a]The Mann-Whitney U test was used to analyze differences between the women who had and had not experienced strangulation-related alterations in consciousness; [b]One way ANOVA was used to analyze differences across three groups; Significance level was set at $p < 0.05$; *n*: Number of women in a subgroup; *N*: Total number of women in the full sample. [c] Scoring of the Brain Injury Severity Assessment (BISA) tool in terms of frequency, recency and severity is presented on Table 1.

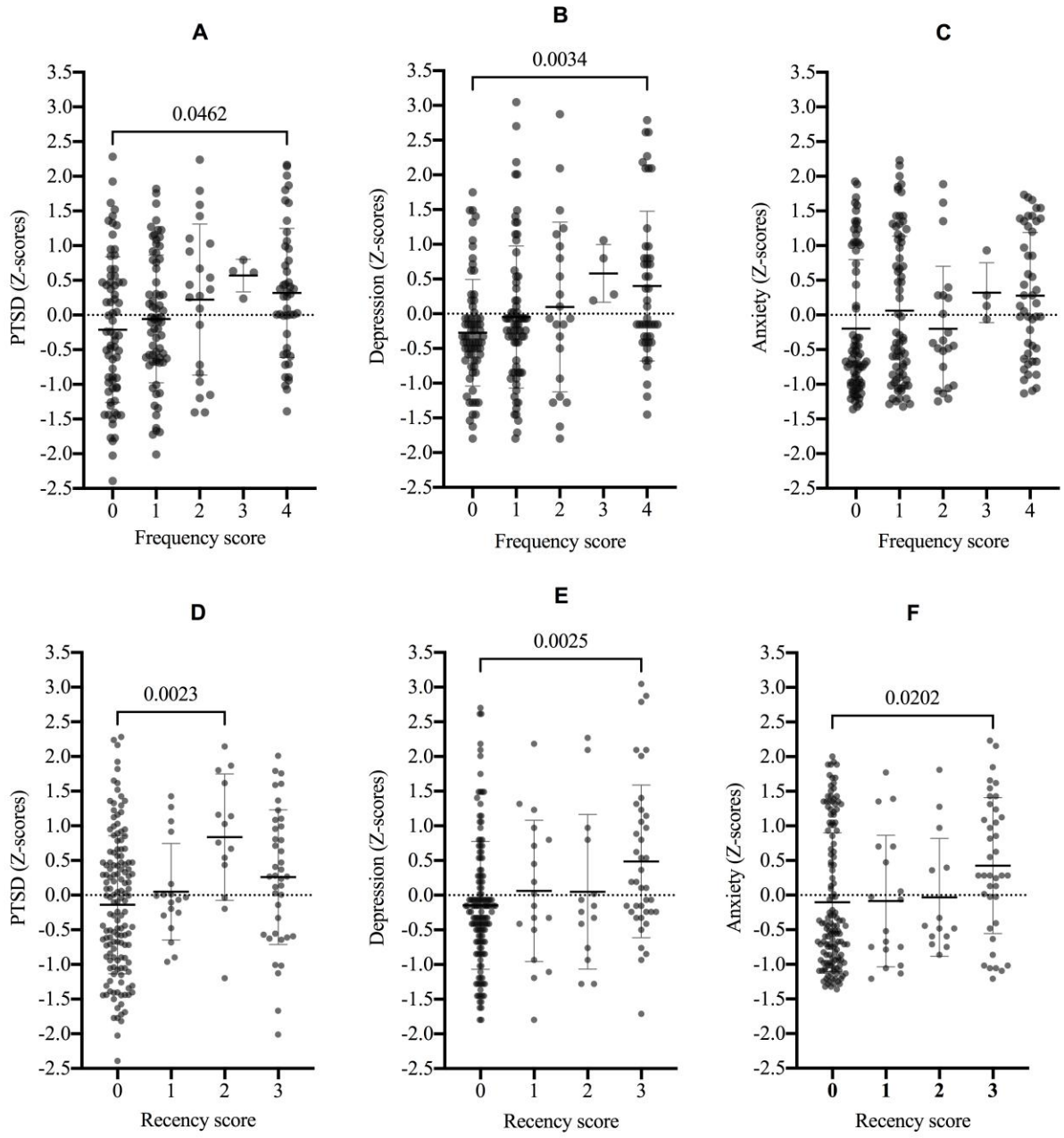
**Table 3**: Analysis of variance to compare mental health comorbidities for women who had versus had not experienced strangulation-related alteration in consciousness (*N* = 213)

| ***Outcome variables*** | ***Mean (SD)*** | | ***F*** | ***p*** | ***$\eta^2$*** |
|---|---|---|---|---|---|
| | ***Who experienced S-AICs (with or without TBIs) (n = 60)*** | ***Who had not experienced S-AICs (with or without TBIs) (n = 153)*** | | | |
| PTSD | 0.31 (0.86) | - 0.10 (1.02) | 7.66 | **0.006*** | 0.04 |
| Depression | 0.22 (1.02) | - 0.09 (0.97) | 4.01 | **0.04*** | 0.02 |

| | | | | | |
|---|---|---|---|---|---|
| Anxiety | - 0.03 (0.88) | 0.01 (1.05) | 0.06 | 0.81 | .001 |

PTSD: Post Traumatic Stress Disorder, TBIs: Traumatic Brain Injuries, AICs: Alterations in Consciousness, SD: standard deviation, *significant at $p < 0.05$, $\eta^2$: Eta squared for the effect size.


0.0069
PTSD (Z-scores)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Yes
No
Experience of S-AIC
A. PTSD
0.0485
Depression (Z-scores)
Yes
No
Experience of S-AIC
B. Depression
0.6855
Anxiety (Z-scores)
Yes
No
Experience of S-AIC
C. Anxiety


A
0.0462
PTSD (Z-scores)
Frequency score
B
0.0034
Depression (Z-scores)
Frequency score
C
Anxiety (Z-scores)
Frequency score
D
0.0023
PTSD (Z-scores)
Recency score
E
0.0025
Depression (Z-scores)
Recency score
F
0.0202
Anxiety (Z-scores)
Recency score