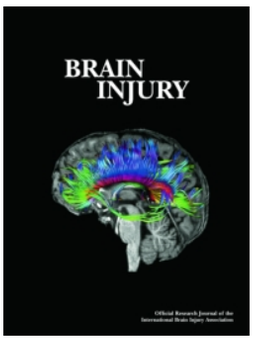

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Attempted suicide leading to acquired brain injury: a scoping review

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ABSTRACT

Objective: Conduct a scoping review of literature surrounding acquired brain injury (ABI) sustained secondary to a suicide attempt to establish the current body of research on injury outcomes and rehabilitative needs for this population.

Methods: A systematic search of the literature was conducted. Searches were conducted using terms relating to this injury etiology and search results with original or secondary data on individuals with an ABI were included for review.

Results: Thirty-two articles were reviewed. Limited data characterizing this population exists in the literature. Findings indicate that this population have generally poorer injury outcomes compared with ABI sustained through other means. Rehabilitative needs are rarely addressed, but limited commentary suggests that extensive pre-morbid conditions, severity of injuries and psychosocial support needs of this population present implications for rehabilitative supports.

Conclusion: There is a relative dearth of research examining ABI sustained secondary to a suicide attempt. Collated findings suggest these individuals are rarely recognized in the literature as a distinct ABI population with rehabilitative needs specific to this etiology. Future research should aim to address the gaps identified in the literature, including characterizing the population, establishing pre-morbid conditions and developing tailored rehabilitative support to address complex needs.

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Acquired brain injury; traumatic brain injury; suicide survivorship; suicide attempt; rehabilitation; scoping review

Introduction

The Royal College of Physicians and the British Society for Rehabilitation Medicine (2003, 1) defined Acquired Brain Injury (ABI) as an inclusive category that embraces acute (rapid onset) brain injury of any cause, including trauma-due to head injury (Traumatic Brain Injury; TBI); or post-surgical damage (e.g. following tumor removal); vascular accident (stroke or sub-arachnoid hemorrhage); cerebral anoxia; toxic or metabolic insult (e.g. hypoglycemia) and infection (e.g. meningitis, encephalitis) or other inflammation (e.g. vasculitis). In terms of persons who acquire a brain injury through a suicide attempt, the mechanism generally falls within that definition of ABI. People may sustain an ABI through a fall or being hit by a vehicle, or through a gunshot, or people may sustain an anoxic brain injury from hanging, or people may sustain a toxic or metabolic brain injury from deliberate prescription or street-drug overdose.

Very little is known about individuals who sustain an ABI secondary to a suicide attempt (2). According to the limited research on this "silent epidemic" (3), it is a rare injury thought to be associated with devastating physical, neurological and psychosocial outcomes. Due to the sub-lethal means through which they sustain their injury, it is thought that this population have greater injury severity and disability post-injury compared with other TBI populations (2,4). Furthermore, rehabilitation for these individuals is thought to be complicated by preexisting psychosocial conditions, such as substance abuse (2,4–6), depression (7–10), and pre-injury suicidality (2,3,5,11). However, research on this population is limited and difficult to extract for use in informing policy and care of these individuals.

Data relevant to this population are widely dispersed throughout TBI research. For example, violence-related TBI research uses a broad definition of violence, encompassing assault-related TBI and forms of self-inflicted TBI, such as injury sustained though a suicide attempt (12–14). Similarly, intentional TBI research incorporates constructs of self-inflicted and other-inflicted brain injuries (15), equating TBIs sustained through a suicide attempt with self-inflicted intentional brain injuries (4,6,16).

Suicide and its related terms are similarly varied throughout research in this field. "Suicide attempt" (2), "failed suicide" (17) and "parasuicide" – known colloquially as a "cry for help" (18) – have all been used in literature to describe instances of survival of an attempt to kill oneself. Varying terminology in literature surrounding TBI sustained secondary to a suicide attempt creates a lack of conceptual clarity regarding concepts being examined, presenting a challenge in extracting the data and interpreting it in a meaningful way. Furthermore, these findings from violence-related TBI and intentional TBI research are widely dispersed and largely incidental to the primary focus of the research. Therefore,

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the data are not only difficult to identify within the literature but can also be very limited in terms of characterizing this population of suicide survivors with regard to their premorbid conditions, their injury mechanism and the rehabilitative needs of them and their families

Despite these challenges, the considerable and distinct rehabilitative needs of those experiencing suicidal tendencies post-TBI (2,3,5,11) indicate that further research is needed to identify and profile those who sustain an ABI through survival of a suicide attempt. The current study aims to do so by conducting a systematic scoping review of the existing literature surrounding individuals sustaining an ABI secondary to a suicide attempt. To the best of our knowledge no systematic review on this topic has been conducted. This methodology allows for the breadth of the heterogenous and fragmented literature on this topic to be established and collated in a systematic way. This allows for gaps in the literature to be identified, which can inform recommendations for future research on the topic to help assess the needs of this population and develop tailored rehabilitative care. Scoping reviews are particularly suited to rehabilitative science where a lack of randomized control trials makes it challenging for systematic reviews to be conducted (2). This methodology is also particularly useful for clarifying complex concepts (19) such as ABI sustained through a suicide attempt.

The research question of this review is: What is known from existing literature about individuals who sustain an ABI secondary to a suicide attempt, their injury outcomes and rehabilitative needs?

Method

The scoping review was conducted using the 5-stage framework developed by Arksey and O'Malley (2005, 20) and supplemented by Levac, Colquhoun and O'Brien (2010, 18). These stages are (1) identify the research question (2), identify relevant studies (3), study selection (4), charting the data and (5) reporting results.

Identifying the research question

The concept, target population and outcome of interest must first be established to develop the research question. The central concept of this study is acquired brain injury (ABI) including traumatic brain injury (TBI) sustained secondary to a suicide attempt. Individuals sustaining this injury comprise the target population. TBI sustained through assault or accidental means are excluded. The neurological, psychosocial and physical injury outcomes comprise one outcome of interest. The second outcome of interest comprises the neurological, psychological and physical rehabilitative needs of this population.

Identifying relevant studies

A two-step strategy was employed to identify relevant studies. The first step involved planning systematic searches of four electronic databases: PsycInfo, PubMed, Science Direct and CINAHL. A search strategy was developed from the key terms in the research question. This search strategy was informed by the technical skills of a qualified librarian in <name of university removed for anonymous review>, which enabled the identification of relevant databases and key words to ensure a comprehensive scope of the literature. This search strategy was then refined based on preliminary search results. A number of overlapping terms were used in order to ensure the best possible scope of studies would be included. The final search strings employed across the four databases were a combination of key terms from the research question and database-specific index terms relating to the topic. The final search strings used are presented in Table 1.

Study selection

Studies were included for screening if they (a) contained original or secondary data on a population or individual with an ABI sustained secondary to a suicide attempt (e.g. the individual(s) may be a sub-group of the overall sample of individuals with an ABI), (b) were published during or before 2017, (c) published in the English language and (d) were peer-reviewed publications. Studies were excluded if they focused exclusively on suicide attempts following an ABI (i.e. if the suicide attempt occurred after the ABI and was not the cause of injury).

The database search results were uploaded to Covidence, an online screening and data extraction tool, which was used to identify and remove duplicates. The remaining articles' titles and references were then screened by the researcher to ensure all duplicates had been removed. Screening of the articles took place in two stages. Firstly, two researchers read the titles and abstracts of the search results independently using the aforementioned inclusion and exclusion criteria, compared results and resolved any conflicts that arose. References and citations of the included articles were then searched by the primary researcher for any additional articles that might be relevant to the research question. The second stage of this screening process involved two researchers

Table 1. Search strategy.

Database	Search String
PsycInfo	"suicide*" OR "suicide" OR "violence" OR "intentional" AND "brain injury" OR "head injury" OR "brain damage"
PubMed	"suicide" OR "suicide/attempt" OR "suicide/attempted" OR "suicide/attempting" OR "suicide/attempts" OR "suicide/parasuicide" OR "suicide/self-harm" OR "suicide/self-inflicted" OR "suicide/self-injury" OR "suicide/self-mutilation" OR "suicide/suicide attempt" OR "suicide/suicide attempts" OR "suicide/violence" OR "suicide and self-harm" OR "suicide and self-injury" AND "brain injury" OR "brain injury admissions" OR "brain injury and neurorehabilitation" OR "brain injury and rehabilitation program" OR "brain injury incidents" OR "brain injury induced cognitive deficits"
Science Direct	"suicide" AND "brain injury" **Incl. topics**: patient, TBI, child, brain injury, suicide, mental health, head injury, traumatic brain, suicide attempt
CINAHL	"injuries, self-inflicted" OR "suicide, attempted" AND "brain injury" OR "brain injuries"

reading the retained articles in full independently and selecting articles for inclusion based upon the inclusion and exclusion criteria.

Data charting

A number of data charting forms were designed for data extraction from the selected studies. The first form extracted descriptive data to characterize the included studies in terms of settings, sample size and, where reported, a breakdown of the injuries sustained through a suicide attempt versus other means. Data were also extracted on the terminology used in each article to refer to the suicide attempt, in order to determine whether a common terminology existed. This form extracted information relevant to the first component of the research question which aimed to characterize the current body of evidence on an ABI sustained secondary to a suicide attempt. Two further forms were developed to extract and collate data on the population's demographics, pre-morbid characteristics, injury demographics and commentary on rehabilitative needs. These forms addressed the remaining outcomes of interest regarding injury outcomes and rehabilitative needs of this population.

Reporting results

Results were reported using recommendations by Levac et al (2010, 19). Due to the wide variation of study designs and variables that are reported in the selected papers, a qualitative rather than quantitative analysis was conducted (for a discussion on the differences between quantitative and qualitative review analysis, see Carter et al., 2011) (21). This approach differs from systematic reviews that conduct a thematic synthesis of qualitative research (e.g. Thomas & Harden, 2008) (22). This approach was adopted in order to identify and compile any common findings in the literature that contributed to the research question, in terms of study design, participants, settings, terminology, injury outcomes and rehabilitative needs. Studies were analyzed under these headings and three tables were constructed to collate and summarize the findings (see Tables 2–4).

Table 2. Included studies.

Study	Study design	Sample (N)	Injury Breakdown
Baldursdottir et al., 2010 (23)	Retrospective cohort study	N = 14	SA = 8/14 (57%) Accidental = 4 (29%) Unknown = 2 (14%)
Berlyne et al., 1968 (6)	Single-case study	N = 1	N/A
Bertisch et al., 2017 (4)	Retrospective cohort study	N = 399	Assault = 310/399 (77.7%) SA = 89/399 (22.3%)
Brenner et al., 2009 (1)	Retrospective matched case-control study	N = 309	SA = 79 (25.6%) Unintentional = 230 (74.4%)
Caird et al., 2000 (24)	Retrospective cohort study	N = 3	N/A
Collins et al., 1990 (7)	Single case study	N = 1	N/A
de Oliveira-Souza et al., 2001 (22)	Single case study	N = 1	N/A
Diesing et al., 2006 (25)	Single case study	N = 1	N/A
El Maaytah et al., 2006 (26)	Single case study	N = 1	N/A
Heinrichs et al., 1990 (27)	Single case study	N = 1	N/A
Kapur et al., 2009 (28)	Single-case study	N = 1	N/A
Kaufman et al., 2015 (8)	Single case study	N = 1	N/A
Kim et al., 2008 (3)	Retrospective cohort study	N = 17,620	**Intentional**: 1,409 (8%) Si-TBI = 389 (27.6%) Oi-TBI = 1,020 (72.4%) **Unintentional**: 16,211 (92%)
Kim et al., 2011 (5)	Retrospective cohort study	N = 15,684	**Intentional**: Si-TBI = 629 (4.1%) Oi-TBI = 1,027 (6.7%) **Unintentional**: 13,582 (89.1%)
Klonoff et al., 1995 (9)	Retrospective cohort study	N = 111	SA = 2/14 (14.2%)
Koike et al., 2013 (29)	Single case study	N = 1	N/A
Kriet et al., 2005 (30)	Retrospective cohort study	N = 11	All injuries due to SA
Machamer et al., 2003 (11)	Prospective cohort study	N = 752	SA = 12/752 (1.6%)
Mackelprang et al., 2014 (31)	Prospective cohort study	N = 559	SA = 8/559 (1.4%)
Matthey et al., 1996 (32)	Single case study	N = 1	N/A
Medalia et al., 1991 (10)	Prospective cohort study	N = 2	SA = 2
Megna et al., 2001 (33)	Single case study	N = 1	N/A
Oluwole, 2011 (34)	Prospective cohort study	N = 266	SA = 2/226 (1%)
Parmelee et al., 1989 (2)	Prospective cohort study	N = 10	N/A
Salim et al., 2006 (35)	Retrospective cohort study	N = 63	All injuries sustained via SA
Simpson & Tate, 2002 (36)	Retrospective cohort study	N = 172	SA = 10 (5.8%) 1 potentially undiagnosed SA (0.58%)
Singhal et al., 2002 (37)	Retrospective cohort study	N = 3	SA = 3
Smilowska et al., 2015 (38)	Single case study	N = 1	N/A
Takeuchi et al., 2009 (39)	Single-case study	N = 1	N/A
Teasdale et al., 2001 (40)	Retrospective cohort study	N = 145, 440	SA = 369/145,440 (0.8%)
Tsuei et al., 2005 (41)	Retrospective cohort study	N = 132	SA = 10/40
Vrankovic et al., 1998 (42)	Retrospective cohort study	N = 39	SA = 34/39 Survived = 12/34 (35.2%) **Remaining**: 8/12 (23.5%) due to SA

Abbreviations: N/A, not applicable; SA, suicide attempt; Si-TBI, self-inflicted traumatic brain injury; Oi-TBI, other-inflicted traumatic brain injury.

Results

The searches returned a total of 595 articles from the selected databases (see Figure 1). These were exported to Covidence where 93 duplicates were removed. Titles and abstracts were then screened by the primary researcher manually and a further two duplicates were removed. Five hundred papers were retained for title and abstract screening. A total of 106 articles were deemed compliant with the inclusion and exclusion criteria and were retained for full text screening. During full text screening, citations and reference lists of these articles were hand-searched. Four additional papers were identified through hand-searching and retained for review. A total of 78 articles were excluded from review due to a) attempted suicide not being explicitly stated as a cause of ABI (n = 34), b) a focus on suicide post-ABI (n = 25) or c) ABIs not being reported as an outcome of a suicide attempt (n = 19) Thirty-two articles were included for review.

Overview of studies

The most frequently used study design was a retrospective study, which used secondary data from national TBI databases from the U.S. or hospital admission registries regarding ABI from various countries (n = 14) (4–6,10,24,30,31,35–37,40–42). Single-case studies were the second most frequent study design among the included studies, defined as papers describing just one participant who had sustained an ABI secondary to a suicide attempt (n = 13) (7–9,23,25–29,32,33,38,39). The remaining five studies were prospective cohort studies, using either adult or teenage populations with ABIs (3,11,12,34,43) (see Table 2).

Sample sizes varied markedly across the included studies due to the heterogeneity of study designs and ranged from single case studies to n = 145, 440 (41) (see Table 2). The prevalence of individuals with an ABI sustained secondary to a suicide attempt, when estimated, also varied greatly ranging 0.8% (41) to 57% (24). Of the 32 papers included for review, a total of 13 included participants with an ABI secondary to a suicide attempt alongside a larger cohort comprising those with an ABI from varying etiologies. Just three papers exclusively focused on those whose ABI was directly caused by a suicide attempt (3,35,37).

Terminology used in the literature to describe and report on this injury mechanism varied greatly (Figure 2 presents a word cloud to illustrate the variation in terminology). The most commonly used terms in the included studies to describe this etiology were "self-inflicted injury" (n = 9) and "attempted suicide"

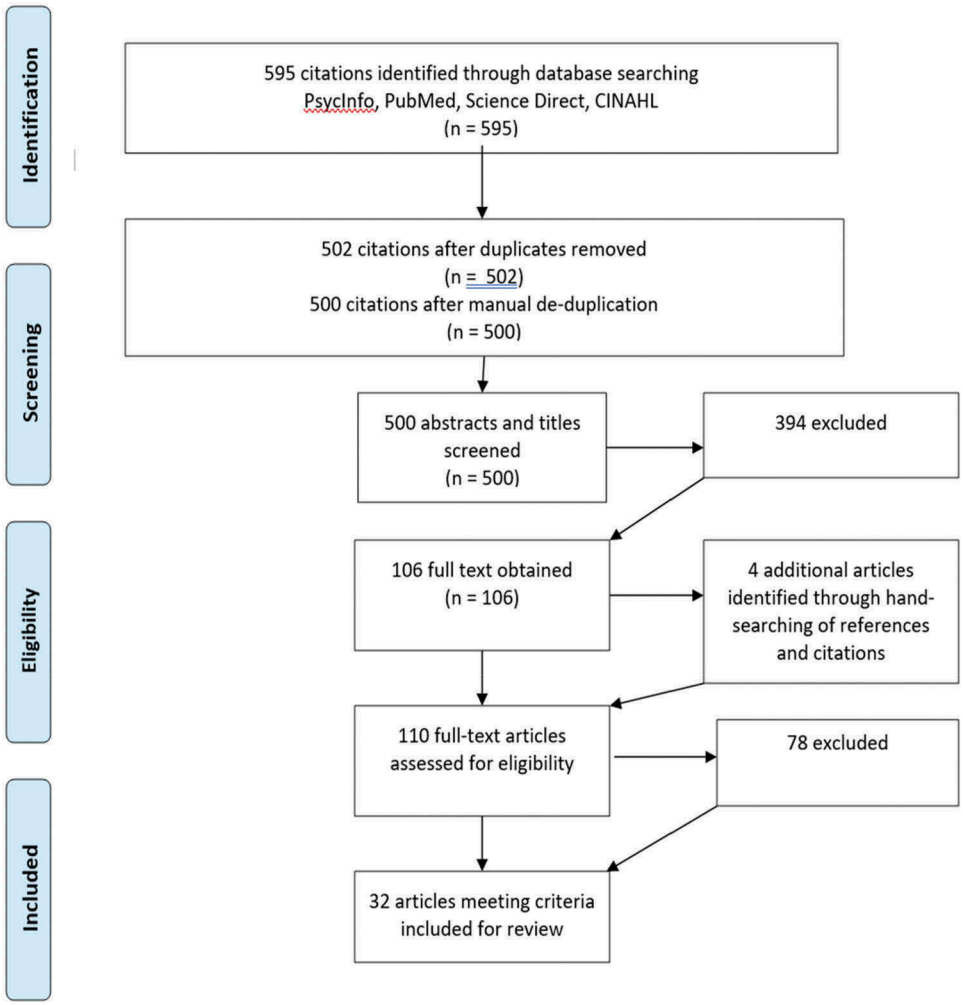

Figure 1. PRISMA flow diagram.

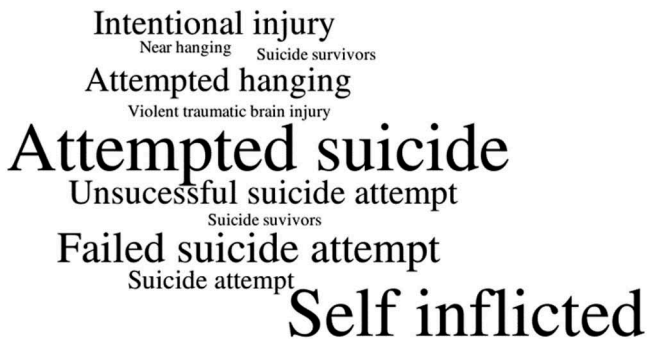

Figure 2. Word cloud representing terminology used in literature to describe a TBI sustained secondary to a suicide attempt.

(n = 8). "Self-inflicted injury" was often used under the broader term of "intentional injury", which encompassed "other-inflicted TBI" and "self-inflicted TBI" (4,6). Seven of the studies used the terms "unsuccessful suicide attempt" (10,35,37,41,43) or "failed suicide attempt" (9,28). Two studies described individuals sustaining a TBI secondary to suicide attempt as "suicide survivors" (3,42). "Violent TBI" was a broad term used in a similar way to "intentional injury", encompassing "assault" and "self-inflicted" TBIs (12).

Demographics and pre-morbid characteristics

Within the single case studies, slightly more females (n = 7) than males (n = 6) with this injury were reported on (see Table 3). However, of the six studies using mixed-sex samples, all reported a male majority in their sample. In addition, a further six studies had all male samples whereas no studies had all female samples. Seven studies did not report a sex breakdown. In general, the trend indicates more data is available on males than females.

The youngest age reported for an individual with an ABI sustained secondary to a suicide attempt was nine years old (24,35), while the oldest age reported was 78 years (36). The most prominent age bracket found across studies was 31–45 years (n = 16). Seven studies included participants aged 46 – 70+ years and five did not report on the age.

A large subset of studies did not report on pre-morbid conditions of those with an ABI secondary to a suicide attempt (n = 15). Among those that did, there was much heterogeneity (see Table 3). The most frequently reported pre-morbid condition was substance abuse (n = 9) followed by previous suicide attempts (n = 5) and depression (n = 4). Variations of bipolar disorder (n = 2) were also reported (35,38).

Injury outcome demographics and outcomes

Outcome measures to document the impact of the ABI were grouped into four categories: 1) functional outcomes, 2) neurological outcomes, 3) psychosocial outcomes and 4) quantitative injury outcomes (see Table 4). The most commonly used outcome measure was neurological outcomes (i.e. brain imaging) (n = 26). The next most frequently used measures were functional outcome measures, consisting of a number of psychometric scales measuring cognitive ability (e.g. memory) and motor skills (i.e. physical disability) (n = 24). Psychosocial measures were used in only seven of the 32 studies (see Table 4). Quantitative measures of injury were used in five studies to characterize the injury severity in terms of length of stay (LOS) in acute care (2,4), duration of post-traumatic amnesia (PTA) (2), injury severity scores (ISS) (4,5,12) and rates of discharge against medical advice (DAMA) (5) for those sustaining an ABI secondary to a suicide attempt.

Injury outcomes reported in these studies varied in accordance with the measures used. The majority of studies focused on functional outcomes (n = 23), reporting on physical disabilities (n = 7) or memory impairments (n = 10) and a number of highly specific cognitive deficits. Depression was the most frequently reported psychosocial outcome, albeit a small number of studies (n = 3) (3,10,31). Two of these studies report depression as a prominent outcome of TBI sustained secondary to a suicide attempt (3,10), while the third study reported low levels of depression among this population (44). Five studies report outcomes relating to suicidality for this population, including suicidal ideation (n = 4) (3,10,34,36) and post-injury suicide attempts (n = 1) (41). One study reported no suicidal recidivism post-injury in their sample of individuals with a TBI sustained secondary to a suicide attempt (36). Quantitative measures applied to this population's injury outcomes indicate that length of stay in acute care is longer on average for this population than for other TBI populations (2,6). Duration of PTA is also reported to be longer (2), while DAMA rates were found to be higher for those with a TBI sustained secondary to a suicide attempt compared to other TBI populations (4).

Rehabilitative needs

Seven studies out of the 32 reviewed addressed rehabilitative needs of those sustaining an ABI secondary to a suicide attempt in their findings. Of these seven, four studies recommended that clinicians be aware of pre-morbid conditions when treating an individual with this injury, due to potential influence on their rehabilitation (2,5,7,34). One study recommended that the mechanism of the injury should be known by clinicians, due to the poorer outcomes associated with TBI sustained secondary to a suicide attempt compared with other TBI populations (6). Higher rates of DAMA compared with other TBI populations also prompted recommendations of further research to improve management of this population in rehabilitative settings (6). Social support was cited by two papers as an important component in rehabilitation for those with TBI sustained secondary to a suicide attempt (3,5), for both the individual sustaining the injury and their families. In total, 25 studies did not comment on rehabilitative needs of this population.

Discussion

The findings presented here represent the first systematic review of the literature, using a scoping methodology, on individuals sustaining an ABI secondary to a suicide attempt and provide an organized knowledge base of the current

Table 3. Demographics and pre-morbid characteristics.

Study	Setting	Sex	Age	Pre-morbid characteristics
Baldursdottir et al., 2010 (23)	Hospital admissions	SA = 14 males	9–24 years	NR
Berlyne et al., 1968 (6)	Hospital admission	SA = 1 male	39 years	Auditory hallucinations Sleep impairment Anorexia Depression
Bertisch et al., 2017 (4)	Traumatic Brain Injury Model Systems National Database	**Self-inflicted**: 71 males 18 females	35.9–14.4 years	- Heavy drinking (40%) -Previous SAs (62.5%)
Brenner et al., 2009 (1)	Traumatic Brain Injury Model Systems National Database	SA = 67 male and 12 females	37.7 years (mean)	- Previous SAs (30.4%) - Substance abuse (59.5%)
Caird et al., 2000 (24)	Hospital admissions	SA = 3 males	24 years 29 years 33 years	NR
Collins et al., 1990 (7)	Psychiatric unit	SA = 1 female	18 years	Depression
de Oliveira-Souza et al., 2001 (22)	Rehabilitation facility	SA = 1 female	18 years old	NR
Diesing et al., 2006 (25)	Neurology center	SA = 1 female	15 years	NR
El Maytaah et al., 2006 (26)	Hospital admission	SA = 1 male	26 years	NR
Heinrichs et al., 1990 (27)	Neuropsychiatric unit	SA = 1 female	35 years	Drug abuse
Kapur et al., 2009 (28)	Hospital admission	SA = 1 female	Mid forties	- Substance abuse - Depression - Previous SAs
Kaufman et al., 2015 (8)	Hospital admission	SA = 1 male	32 years	- Major depression - Social anxiety - Impulse control disorder
Kim et al., 2008 (3)	Ontario Trauma Registry	**Self-inflicted**: 285 males 104 females	39.3 years (mean)	Alcohol/drug abuse (47%)
Kim et al., 2011 (5)	Ontario Trauma Registry	NR for intentional injury	16–64 years	Alcohol and drug abuse
Klonoff et al., 1995 (9)	Outpatient day treatment program	SA = 1 male and 1 female	NR	- Manic depressive disorder - Depression
Koike et al., 2013 (29)	Hospital admission	SA = 1 male	21 years	NR
Kriet et al., 2005 (30)	Hospital admission	SA = 8 male and 3 females	9–76 years	- Bipolar affective disorder (9%)
Machamer et al., 2003 (11)	Clinical research	SA breakdown NR	**Violent injury (incl. SA's)**: 33.4 years (mean)	- Alcoholism (40%) - Psychiatric conditions (12%) - Drug abuse (30%)
Mackelprang et al., 2014 (31)	Hospital admissions	SA breakdown NR	18–60+ years	Suicidal ideation (0.7%)
Matthey et al., 1996 (32)	Rehabilitation center	SA = 1 female	NR	NR
Medalia et al., 1991 (10)	Rehabilitation facility	SA = 2 males	26 years 28 years	- Previous SAs - Substance abuse
Megna et al., 2001 (33)	Rehabilitation programme	SA = 1 female	46 years	- Bipolar mood disorder
Oluwole, 2011 (34)	Hospital admissions	SA breakdown NR	< 12 years 26–50 years	Seizures
Parmelee et al., 1989 (2)	Rehabilitation facility	SA = 8 males and 2 females	13–19 years	- Drug abuse (70%) - Alcohol abuse (60%) - Previous SAs (30%)
Salim et al., 2006 (35)	Trauma registry/hospital admissions	SA = 12 males	31 ± 21 years	NR
Simpson & Tate, 2002 (36)	Outpatients of rehabilitation center	SA breakdown NR	NR	NR
Singhal et al., 2002 (37)	Hospital admissions	SA = 3 males	17 years 24 years 57 years	NR
Smilowska et al., 2015 (38)	Hospital admission	SA = 1 male	27 years	NR
Takeuchi et al., 2009 (39)	Hospital admission	SA = 1 male	29 years	NR
Teasdale et al., 2001 (40)	Hospital admissions	SA breakdown NR	NR	NR
Tsuei et al., 2005 (41)	Trauma registry	SA breakdown NR	NR	NR
Vrankovic et al., 1998 (42)	Hospital admissions	SA = 34 males and 5 females	15–78 years	NR

Abbreviations: NR, not reported; SA, suicide attempt.

literature on this population. An assessment of risk of bias was conducted on this scoping review to assess the extent to which bias may have influenced these findings (see Figure 3), the results of which indicated there was a low risk of bias.

Characterizing the population

The prevalence of this etiology ranged from 0.8% to 57% as a proportion of all causes of ABI. However, these findings may not represent the salience of this injury accurately. They

Table 4. Injury demographics and outcomes.

Study	Injury Mechanism (means of SA)	Types of injury measures	Injury Outcome	Commentary on rehabilitative needs
Baldursdottir et al., 2010 (23)	Hanging	Functional Neurological	- Good cerebral performance in 5/8 SA-TBI individuals	No
Berlyne et al., 1968 (6)	Hanging	Functional	Severe memory impairment - Apathy	Yes – psychiatric assessment and treatment of the disorder that led to the suicide is necessary.
Bertisch et al., 2017 (4)	Firearm	Functional Neurological Psychosocial	SA-TBI group have more severe injuries compared with assault-related TBI group.	Yes – intervention strategies for this population should have more detailed emphasis on substance use, mental health issues, access to care and social support.
Brenner et al., 2009 (1)	- Firearm (73%) - Jumping/lying in front of object (23%) - Other (4%)	Quantitative Functional	- PTA and LOS longer in SA-TBI group than in controls - Greater disability and poorer functional status in SA-TBI group.	Yes – SA TBIs have preexisting psychiatric and psychosocial liabilities, requiring greater resources to treat. e.g. Tailored inpatient rehabilitative services and assessment of suicide risk incl. pre- and post-injury factors.
Caird et al., 2000 (24)	Captive pistol bolt	Functional Neurological	Marked short-term memory deficits	No
Collins et al., 1990 (7)	Hanging	Functional Neurological	Prominent anoxic disturbance Poor coordination	No
de Oliveira-Souza et al., 2001 (22)	Firearm	Functional Neurological	Executive amnesia	No
Diesing et al., 2006 (25)	Hanging	Functional Neurological	Autonomic dysregulation Catatonic posturing	No
El Maaytah et al., 2006 (26)	Hanging	Functional Neurological	Bruxism Speech deficit Feeding deficit Incontinence	No
Heinrichs et al., 1990 (27)	Carbon monoxide poisoning	Functional Neurological	Impulsive and aggressive behavior Severely impaired memory	No
Kapur et al., 2009 (28)	Firearm	Functional Neurological	Right-side weakness Impaired memory	No
Kaufman et al., 2015 (8)	Nail gun head injury	Functional Neurological	Hypersexuality	No
Kim et al., 2008 (3)	Jumping from high places (32.1%) Firearms (30.6%) Hanging (15.9%) Jump before moving objects (13.6%) Other means (7.7%)	Quantitative	- Higher ISS and LOS scores for SA-TBI group - SA-TBI had greatest discharge mortality	Yes – important for clinicians to be aware of mechanism of injury.
Kim et al., 2011 (5)	NR	Quantitative	Higher rates of DAMA in self-inflicted TBI then in other-inflicted TBI	Yes – future research on DAMA in this population is warranted, as well as on quality and management of rehabilitation for these individuals.
Klonoff et al., 1995 (9)	High speed vehicle accident (50%)	Psychosocial	Klonoff et al., 1995 9	High speed vehicle accident (50%)
Koike et al., 2013 (29)	Overdose of insulin	Functional Neurological	Permanent brain damage Apathy Lack of facial expression Severe short-term memory and higher intellectual processes.	No
Kriet et al., 2005 (30)	Firearm	Functional Neurological	Full recovery (4/9) Mild expressive aphasia (3/9) Anosmia (2/9) Seizures Mod. Cog. Disorder Emotional lability	No
Machamer et al., 2003 (11)	NR	Functional Neurological Quantitative	Violent head injuries (suicide and assault) were less severe than nonviolent injuries	No

(*Continued*)

Table 4. (Continued).

Study	Injury Mechanism (means of SA)	Types of injury measures	Injury Outcome	Commentary on rehabilitative needs
Mackelprang et al., 2014 (31)	NR	Functional Psychosocial	SI reported in half of self-inflicted TBI's follow-up	Yes – preexisting psychiatric conditions need to be assessed due to influence on increased risk of post-injury SA in this population.
Matthey et al., 1996 (32)	Hanging	Functional Neurological	Impaired memory Blunted affect	No
Medalia et al., 1991 (10)	Hanging	Functional Neurological	Severe memory deficits	No
Megna et al., 2001 (33)	Overdoes of lithium carbonate	Functional	Severe ataxia	No
Oluwole, 2011 (34)	NR	Functional Neurological	Severe brain injury Seizures	No
Parmelee et al., 1989 (2)	Firearm (40%) Insulin overdose (10%) Hanging (10%) Electrocution/fall (10%) Jumping from height (10%) Carbon monoxide poisoning (10%) Drove into oncoming truck (10%)	Functional Neurological Psychosocial	- Physical disability (quadriplegia, blindness) - Memory deficits - Behavioral deficits - Depression - Suicidal ideation - Seizures - Paranoia - Sleep disturbance	Yes – Need to facilitate patients and families' acceptance of suicide attempt and acceptance of permanent disability and preexisting psychological condition(s).
Salim et al., 2006 (35)	Hanging	Functional Neurological Quantitative	Severe or permanent disability (3.5%)	No
Simpson & Tate, 2002 (36)	Single-driver car crashes	Psychosocial	Low suicidal ideation and hopelessness.	No
Singhal et al., 2002 (37)	Hanging Carbon monoxide poisoning	Functional Neurological	Dystonia Psychosis Memory deficits Visuospatial deficits	No
Smilowska et al., 2015 (38)	Firearm	Functional Neurological	Impaired swallowing Impaired facial movement Impaired walking	No
Takeuchi et al., 2009 (39)	Hanging	Functional Neurological	Anoxic brain injury	No
Teasdale et al., 2001 (40)	NR	Psychosocial	Subsequent suicide attempt	No
Tseui et al., 2005 (41)	NR	Functional Neurological	NR	No
Vrankovic et al., 1998 (42)	Firearm	Functional Neurological	Brain odema No suicide recidivism	No

Abbreviations: DAMA, discharge against medical advice; LOS, length of stay in acute care; PTA, post-traumatic amnesia; SA-TBI, TBI sustained through a suicide attempt; TBI, traumatic brain injury.

may overestimate the prevalence, due to the large volume of single-case studies and small sample studies included for review, or underestimate, due to the aggregating of suicide attempts with other intentional means of sustaining an ABI. Reporting of undiagnosed suicide attempts as falls or single-driver high speed motor vehicle accidents could also misrepresent the prevalence of this injury (10,31). Previous research estimates that for every completed suicide, there are 12–15 suicide attempts presenting for emergency care (45), however this finding in literature represents those surviving with injuries other than ABIs. In combination, these factors indicate the complexities of attempting to determine the prevalence of ABIs secondary to a suicide attempt.

Data from the reviewed articles indicate that individuals sustaining an ABI secondary to a suicide attempt are reported as being more commonly male and aged 31–45 years. However, there was no report of sex or age in a significant number of the included studies, therefore the demographic available for extraction may not accurately characterize this population.

All included studies reported that their sample or subsample had an ABI sustained through a suicide attempt. However, fifteen studies did not report on pre-morbid conditions for their samples. Those that did report on pre-morbid conditions indicate that substance and/or depression prior to the suicide attempt are frequently reported in this population. Among individuals who compete a suicide attempt, around 90% have a diagnosable psychiatric illness (46), therefore an examination of pre-morbid conditions in this population is warranted. This highlights how underdeveloped this field is in terms of understanding this etiology. Many of the single-case studies included have a primarily neurological focus, aiming to map a functional deficit onto a neurological injury. However, even prospective and retrospective studies that explicitly report on the injury outcomes did not account for pre-morbid conditions in some cases. Those that did frequently reported that pre-morbid conditions have a significant impact upon injury outcome. ABI recovery is complex due to the confluence of cognitive and emotional difficulties, however for this population the added factor of preexisting psychiatric conditions likely compounds this recovery further (2,3).

Injury outcome

Neurological and functional outcomes were the most frequently reported injury outcomes, with focus on physical and memory impairments. In general, findings indicate poorer functional injury outcomes for this population compared with other ABI populations, due to the more severe injuries sustained via means intended by the individual to be lethal. This finding is consistent with previous research comparing self- and other-inflicted violent TBIs (13,14).

Of the six studies that did report on psychosocial injury outcomes, four reported on suicidality (2,3,7,34). Increased likelihood of post-injury suicide attempts in those sustaining a TBI through attempted suicide has raised concern in literature (10,47,48). The limited data reporting on this indicates that these concerns are well founded, as subsequent suicide attempts have been found to be more likely in those whose TBI is the result of a suicide attempt compared with those who sustain their TBI through other means (40). Given the vast body of literature that exists surrounding suicidality following a TBI (31,44), it is surprising more attention has not been directed to suicidality as an injury outcome in this population. One study reported no suicidal recidivism in individuals with a TBI sustained through a suicide attempt (36), which conflicts with this small body of evidence, indicating that this area needs to be examined further.

Rehabilitative needs

Rehabilitative needs of this population are rarely addressed in the literature. The findings presented here indicate that this population have significant needs that are specific to their injury etiology. The lack of evidence-based commentary indicates a dearth of tailored rehabilitative services for this population. The generalizability of evidence-based rehabilitative care for TBI to this population has been questioned in literature, as the evidence base is largely generated by research using samples comprised of those with self and other -inflicted TBIs (2). Findings from this review indicate that this may not sufficiently address the needs of these individuals, due to the complicating factors of pre-morbid conditions (2–5,7,34) and the psychosocial support needs of the individual and the family (3,5). Findings suggest that a comprehensive account of pre-morbid conditions, including medical and mental health, could be pertinent in informing rehabilitative supports for the individual and their families, as it is likely that these conditions compound the rehabilitative process and could be contributing to the poorer injury outcomes for this population indicated by the findings.

There exists a very small body of research surrounding palliative care of this population, involving patients treated in hospice settings for life-limiting injuries sustained by a suicide attempt that are not immediately life-threatening (49,50). This research, comprising just two studies, highlights important components of care that could be applied to this population. It acknowledges the polytrauma experience by the individual, the need for interdisciplinary care and emphasizes the importance of supporting the individuals and their families in acceptance of this "double hardship" – the knowledge of how the injury occurred and the extensive disabilities sustained (3). This population carries a significant burden of mental illness as well as estranged interpersonal relationships and limited psychosocial supports, and rehabilitation supports should reflect these needs (50).

Limitations

There a number of limitations to this study that should be considered. Firstly, given that this study implemented a scoping review framework, it is considered pertinent to acknowledge that relevant papers may have been omitted. Every effort was made to ensure an exhaustive search was conducted and a comprehensive representation of the current literature was established, however the researchers acknowledge that this cannot be guaranteed.

Secondly, the scoping review methodology includes no assessment of quality of studies. This is a common criticism of scoping reviews (51,52). As such, the limited data reporting on demographics, injury outcome and rehabilitation needs may vary in quality of design, and the findings extracted from these studies should be interpreted accordingly. It should be noted that this review was assessed for risk of bias in interpretation of the findings using the ROBIS tool (53) and was found to have low risk of bias (see **Appendix**).

Recommendations for future research

Lack of an established nomenclature for this ABI population and their injury etiology in literature creates significant difficulty in collating findings and using them to inform evidence-based practice. This is prohibitive to the development of the field and needs to be addressed in order to make advancements. Categories of intentional and violent TBI are too broad to characterize this injury accurately, while concepts of success and failure appear inappropriate to apply to suicide. Developing accurate and appropriate terminology to the study of this etiology is an imperative first step in developing this field.

A number of significant gaps in the literature were identified regarding injury outcomes and rehabilitative needs. Future research seeking to characterize this injury etiology should recognize the potential influence of pre-morbid conditions on injury outcome for this population. It is important to identify and report on the varying pre-morbid conditions that may be presented in the individual sustaining an ABI secondary to a suicide attempt to develop an understanding of the injury outcome trajectory. This would contribute significantly to informing care and rehabilitation of the individual, whose recovery is likely compounded by preexisting mental health issues.

Finally, given the complex nature of this injury it is suggested that a biopsychosocial model of care be explored (54,55). Finding suggest that there are a number of interacting functional and psychosocial factors to be addressed in caring for these individuals. The lack of evidence-based findings regarding rehabilitation highlights a significant gap in the research, indicating rehabilitative services have not been equipped with the knowledge to meet these needs fully. Tailored approaches to care for these individuals and their families using interdisciplinary teams that reflect their extensive needs should be explored.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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