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Neurodevelopmental and psychosocial risk factors in serial killers and mass murderers



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ABSTRACT

Multiple and serial murders are rare events that have a very profound societal impact. We have conducted a systematic review, following PRISMA guidelines, of both the peer reviewed literature and of journalistic and legal sources regarding mass and serial killings. Our findings tentatively indicate that these extreme forms of violence may be a result of a highly complex interaction of biological, psychological and sociological factors and that, potentially, a significant proportion of mass or serial killers may have had neurodevelopmental disorders such as autism spectrum disorder or head injury. Research into multiple and serial murders is in its infancy: there is a lack of rigorous studies and most of the literature is anecdotal and speculative. Specific future study of the potential role of neurodevelopmental disorders in multiple and serial murders is warranted and, due to the rarity of these events, innovative research techniques may be required.

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"I am relieved to see this verdict. The temptation for people to fob him off as a madman has now gone." Survivor of Anders Breivik shooting in Norway.

1. Introduction

The question as to why anyone would wish to kill large numbers of their fellow human beings is unanswered and debates around predisposing and precipitating factors continue. We have systematically reviewed the literature regarding mass and serial killing. These are rare events and, consequently, the peer reviewed literature is sparse and leads to conflicting findings. A systematic review is warranted for two reasons: first, despite their rarity, these events have a profound impact on societies, second, a clearer understanding of the antecedents of these events may help elucidate the mechanisms of extreme violence, potentially leading to preventative strategies.

Murder is the killing of one person by another person with "malice aforethought"; there may or may not be premeditation. Generally, a person who murders restricts his or her act to one victim. A mass murderer, however, kills three or more victims over a short period of time — typically hours but sometimes over days (<http://www.encyclopedia.com/doc/1G2-3407200189.html>). In contrast, serial killers murder their victims separately and over a period of time, with a cooling-off period between murders. Traditionally, a serial killer is defined as an individual who has killed three or more people (Holmes & Holmes, 2010). Serial killing may continue for years until the perpetrator is caught or turns himself/herself in to the authorities (<http://www.encyclopedia.com/doc/1G2-3407200189.html>).

1.1. Prevalence of multiple homicide

Attempts to estimate the numbers of serial murder victims have varied greatly (Quinet, 2007). This may have resulted from several factors (Jenkins, 2005): when apprehended, serial killers may overestimate the number of their victims (Fox & Levin, 2005; Quinet, 2007); gaining access to serial killers in order to conduct research interviews is difficult (Silvio, McCloskey, & Ramos-Grenier, 2006) and incidence and prevalence of serial murder is difficult to determine, since accurate statistics are not kept (Brantley & Kosky, 2005; Myers, Reccoppa, Burton, & McElroy, 1993; Schlesinger, 1998). A further challenge is that there is no single, generally accepted definition for serial homicide (Ferguson, White, Cherry, Lorenz, & Bhimani, 2003). Caution is needed when looking at longer-term homicide trend figures, primarily because they are based on the year in which offenses are recorded by the police rather than the year in which the incidents took place. Also, where several people are killed by the same principal suspect, the number of homicides counted may be the total number of persons killed rather than the number of incidents. For example, the victims of the Cumbrian shootings on 2nd June 2010 are counted as 12 homicides rather than one incident in the 2010/11UK data (Smith et al., 2012). It is not, therefore, possible to trace with a sufficient degree of precision or accuracy recent or long-term trends in the prevalence and incidence of serial murder (Egger, 1984; Jenkins, 2005; Kiger, 1990). The true rate of occurrence is not known for any country at any time. Therefore, it is not yet possible to study temporal trends or to make international comparisons (Dietz, 1986; Duwe, 2004; LaFree, 1999a, chap. 7, 1999b; Salfati, 2001). There are also differences in legal definitions of crime between countries (Vetere & Newman, 1977). Serial killing cannot therefore be predicted with any confidence (Brittain, 1970; Meloy, 2000). Trying to elucidate the prevalence of serial killing is also made difficult because of cases where we are not aware the murders have taken place, cases in which murders are known to have taken place but no connection has been made between them and/or cases where the perpetrator is still at large.

Despite the lack of knowledge about prevalence of mass and serial killings, there has been considerable speculation about the role of

various psychosocial and biological factors in the etiology of these events and research findings offer conflicting evidence. For example, in a retrospective study of the forensic psychiatric evaluations of 57 adolescent offenders accused of a homicide, 64% had developmental problems. Yet, use of multiple and excessive violence was not related to having developmental problems (Hagelstam & Häkkänen, 2006). Söderström (2005) also found that childhood-onset neuropsychiatric disorders were common among violent offenders. Most frequent were disruptive behavior disorders, such as ADHD and conduct disorder, but a substantial minority had ASDs, tic disorders and mental retardation/learning disabilities (Söderström, 2005).

We consider some of these psychosocial and neurodevelopmental risk factors below. Silva, Leong, and Ferrari (2004) suggest the presence of an association between ASD and serial homicidal behavior which has also been suggested by others (e.g., Fitzgerald, 2001). This has led us to explore the phenomenon of serial and mass killings in relation to these risk factors in a unique systematic review of the literature. To examine ASD as a risk factor is particularly timely given the recent shooting cases of Adam Lanza, James Holmes, and Anders Breivik, all of whom have been considered to have autistic features (<http://www.zerohedge.com/news/2012-12-15/newtown-shooter-had-asperger-syndrome-and-some-us-gun-facts>; <http://www.dailymail.co.uk/news/article-2156530/Anders-Behring-Breivik-rare-forms-Aspergers-Tourette-s-syndromes-says-Norways-leading-psychiatrist.html>). Fitzgerald (2010) has suggested that Autistic Psychopathy may underlie the motivation of some of these serial killers. He suggests a new diagnosis Criminal Autistic Psychopathy, a subcategory of Asperger's syndrome.

In addition to ASD, we also explored head injury as it has been shown that this is more prevalent in serial killers, with one study suggesting that one in four serial killers had suffered either a head injury or (more rarely) a condition affected the brain — such as meningitis during their early years (Stone, 2009). However, this has rarely been investigated in the peer reviewed literature and it typically only explored using samples of single homicide cases. Certainly the combined effects of psychosocial stressors, head injury, and ASD have never previously been examined in a systematic review.

After an extensive review, we found very little mention of Attention Deficit Hyperactivity Disorder (ADHD) in the literature and biographies of killers (Stone, 2009). Once notable exception to this was an autobiography of serial killer Richard Ramirez who had ADHD as a child (Carlo, 1996).

1.2. Autism spectrum disorders (ASDs)

Various follow-up studies suggest that people with ASDs are no more likely to commit violent crime than the general population, and may even be less likely (Mouridsen, Rich, Isager, & Nedergaard, 2008; Woodbury-Smith, Clare, Holland, & Kearns, 2006). In a study of penal register data regarding Hans Asperger's original group of 177 patients, the rate and nature of crimes committed by these individuals were no different from the general population. In the case records spanning 22 years and 33 convictions, there were only three cases of bodily injury, one case of robbery and one case of violent and threatening behavior (Hippler, Viding, Klicpera, & Happé, 2010). Despite this, media and academic reporting of violent crime committed by offenders with ASDs has served to generate a speculative association between ASDs and offending behavior (Allen et al., 2008; Mukaddes & Topcu, 2006; Murphy, 2010) and some studies, including research with mentally abnormal offenders incarcerated in special hospitals, suggest that the prevalence of ASD may be greater than that of the general population (Scragg & Shah, 1994). The question of whether or not there is a link between ASD and extreme violence is still unanswered because empirical research investigating offenders with ASDs is relatively rare (Browning & Caulfield, 2011; Dein & Woodbury-Smith, 2010) and largely consists of case reports and surveys of criminal groups (Baron-Cohen, 1988;

Barry-Walsh & Mullen, 2004; Cooper, Mohamed, & Collacott, 1993; Overall & LeCouteur, 1990; Hall & Bernal, 1995; Kohn, Fahum, Ratzoni, & Apter, 1998; Mawson, Grounds, & Tantam, 1985; Silva, Ferrari, & Leong, 2002a, 2002b; Silva, Ferrari, & Leong, 2003; Silva, Smith, Leong, Hawes, & Ferrari, 2003; Silva, Wu, & Leong, 2003; Simblett & Wilson, 1993).

1.3. Psychosocial mediators

Cleary and Luxenburg (1993), in a study of more than 60 serial murderers, found that psychological and/or physical abuse was a pervasive characteristic of serial killers' childhoods consistent with numerous other studies and case reports (De Becker, 1997; Inguito, Sekula-Perlman, Lynch, & Callery, 2000; LaBrode, 2007; Mitchell & Aamodt, 2005; Mouzos & West, 2007; Myers, 2004; Myers, Gooch, & Meloy, 2005; Norris, 1988; Ressler & Shachtman, 1992; Stone, 1989). There is however significant variation in the prevalence of childhood abuse across studies (Beasley, 2004; Mitchell & Aamodt, 2005). Hickey (1997) reported that among a group of 62 male serial killers, 48% had been rejected as children by a parent or some other important person in their lives. Research into the impact of childhood abuse and neglect on violent behavior of adults who became serial killers concluded that adults who had been physically, sexually, and emotionally abused as children were three times more likely than were non-abused adults to act violently as adults (Dutton & Hart, 1992). Others have found humiliation (Hale, 1994; Ressler, Burgess, & Douglas, 1988; Stone, 1989) and narcissistic injury (i.e., a perceived threat to a narcissist's self-esteem) (Stone, 1989) earlier in life predating and directly contributing to the murder. However, such findings lack comparison groups drawn from non-offending populations for which the same operational definitions of trauma have been applied. Consequently, it is difficult to conclude if and to what extent serial killers have suffered more as children than others do (Fox & Levin, 1998).

Numerous cases describe early adoptions, neglect and abandonment as some of the childhood characteristics possibly accounting for violent crime (Burgess, Prentky, Burgess, Douglas, & Ressler, 1994; Kirschner & Nagel, 1996; Moes, 1991; Pollock, 1995) and serial killing (Claus & Lidberg, 1999; Whitman & Akutagawa, 2004). Adoption studies have also shown that if a child's biological parents and their adoptive parents are both violent, 40% will be criminal compared to 12.1% if only the genetic factor were present, 6.7% if just a violent environment and only 2.1% will be criminal if they have none of the above risk factors. Therefore, a combination of both genetic and environment risk factors put the individual at significantly greater risk of becoming criminal later in life (Cloninger, Sigvardsson, Bohman, & von Knorring, 1982). Other authors have speculated that there might be a connection between adoption and absence of primary care-taker during the first three months of life (Fox & Levin, 1994).

1.4. Sexual deviancy and fantasies

Fantasy is considered by some to be the underlying basis for serial murder (Ressler et al., 1988). Much of the forensic literature has concentrated on the paraphilic fantasy as a dry run for solitary rape–murder and serial sexual homicide (Prentky et al., 1989; Schlesinger, 2000). Despite an overwhelming agreement among these authors that a preoccupation with sadistic or controlling sexual fantasies increases the risk of murderous behavior, there is controversy as to whether or not these fantasies are rooted in dissociative trauma (Carlisle, 2000; Lewis, 1998; Meloy, 1997; Stein, 2004). Former FBI profiler Ressler and Shachtman (1992), largely responsible for the theoretical views that prevail in the forensic literature, strongly reject the idea that sexual violence is primarily rooted in childhood trauma. Rather they believe that it stems from an overreliance on sexual and aggressive fantasies developed in response to various threats, only some of which may involve

child maltreatment. The fantasies supposedly constitute a cognitive rehearsal for sexual murder, but, the theory goes, because repetition erodes the fantasies' masturbatory power over time, the individual begins to seek out opportunities to act upon them (Stein, 2004). Support for this model comes from studies of male sexual killers and sadistic offenders, many of whom showed an intrusive fantasy life as evidenced by higher rates of paraphilias and violent fantasies (Silva et al., 2004; Scott, 1996). It has also been suggested that autistic psychopathology may be an important factor in promoting dangerous sexual fantasies in some serial killers.

1.5. Neurochemistry of violence

The possibility of a biological or genetic basis for serial murder is an unresolved issue at present (DeHart & Mahoney, 1994). However, associations have been reported between neuro-chemical imbalance and aggression. Low serotonergic activity in humans has been related to impulsive, self-destructive violence (Söderström, Blennow, Manhem, & Forsman, 2001) while increased synaptic serotonin levels have been linked to aggression (Baron-Cohen, 2011; Bell, Abrams, & Nutt, 2001; Raine, 1993; Raine, Lencz, & Scerbo, 1995; Volavka, 1995, 1999). Dopamine and norepinephrine generally enhance aggression (Raine, 1993) and numerous studies have found signs of aberrant dopaminergic function in attention deficit hyperactivity disorder, autism, and schizophrenia (Söderström et al., 2001). Testosterone is clearly implicated in aggression, but its effects, particularly in primates, interact with social factors (Miller, 2000). Monoamine oxidase A (MAO-A) is an enzyme involved in the metabolism of neuroepinephrine, serotonin and dopamine and its levels are genetically determined. Men with low MAOA activity are three times more likely to be convicted of a violent crime by the time they are 26 years old than men with high MAOA activity (Heide & Solomon, 2006). Hormones of the hypothalamic-pituitary-adrenal axis, involved in the stress response to threatening situations, also play an important and complex role in the regulation of aggression (Barzman, Patel, Sonnier, & Strawn, 2010). Hypoglycemia is associated with impulsive, violent behavior, and the link may be mediated via serotonergic mechanisms and alcohol consumption (Volavka, 1995, 1999).

1.6. Evolutionary psychology perspective of violence

Another perspective of human aggression, which must be acknowledged, is the evolutionary psychological account. The perspective argues that human aggression might have evolved as a way of, for instance, negotiating status and power hierarchies, discouraging aggressive behavior from rivals, and discouraging mates from sexual infidelity (Beaver, Nedelec, Schwartz, & Connolly, 2014; Buss & Shackelford, 1997; Goetz, 2010). However, a thorough discussion of this perspective is outside the scope of this review.

It is important to acknowledge here that neurodevelopmental disorders such as autism spectrum disorders or head injury also occurs in other violent criminals besides the extremely violent subgroup we focus on in this review. For instance, some interesting studies have investigated the relationship between neurodevelopmental disorders and violent criminality (i.e., Lundström et al., 2013). Söderström (2005) found childhood-onset neuropsychiatric disorders to be common among violent offenders. The association between brain injury and both violent and non-violent criminal behavior has also been investigated empirically (e.g., Gansler et al., 2009; Grafman, Schwab, Warden, & Pridgen, 1996, for review see Raine, 2008).

The sometimes conflicting and patchy research literature suggests that there may be a complex interaction between pre-existing neurodevelopmental problems (moderators), environmental insults experienced during development such as head injury or childhood maltreatment (mediators) and serial or mass killing. Although various neurodevelopmental factors could be implicated in the etiology

of serial/mass killing, most research and speculation has centered around the role of ASD (Silva et al., 2004) and head injury (Freedman & Hemenway, 2000; Grafman et al., 1996; Langevin, Ben-Aron, Wright, Marchese, & Handy, 1988; Pallone & Hennessy, 1998; Sarapata, Herrmann, Johnson, & Aycock, 1998) and we have, therefore, decided to focus on these two factors in our review in addition to investigating the role of psychosocial factors. The review will ask whether having a diagnosis of ASD (a moderator) as well as additional mediators (such as having a brain injury and experiencing trauma during childhood) increases the likelihood of becoming a serial killer. Our hypothesis is that both neurodevelopmental and psychosocial factors interact in the development of these rare but extremely negative outcomes.

2. Methods

Following the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines (Liberati et al., 2009), internet-based bibliographic databases were searched to access studies/books (published and in progress) which involved serial killers, violent crime, psychopathy (or narcissistic personality disorder), and Autistic Spectrum Disorders. The following databases were searched: Web of Knowledge and PsycINFO. We also examined book chapters, whole books and electronic documents available locally, and through the United Kingdom's inter-library loan system.

The search was limited to human populations and the English language. Duplicates were excluded prior to the retrieval of references.

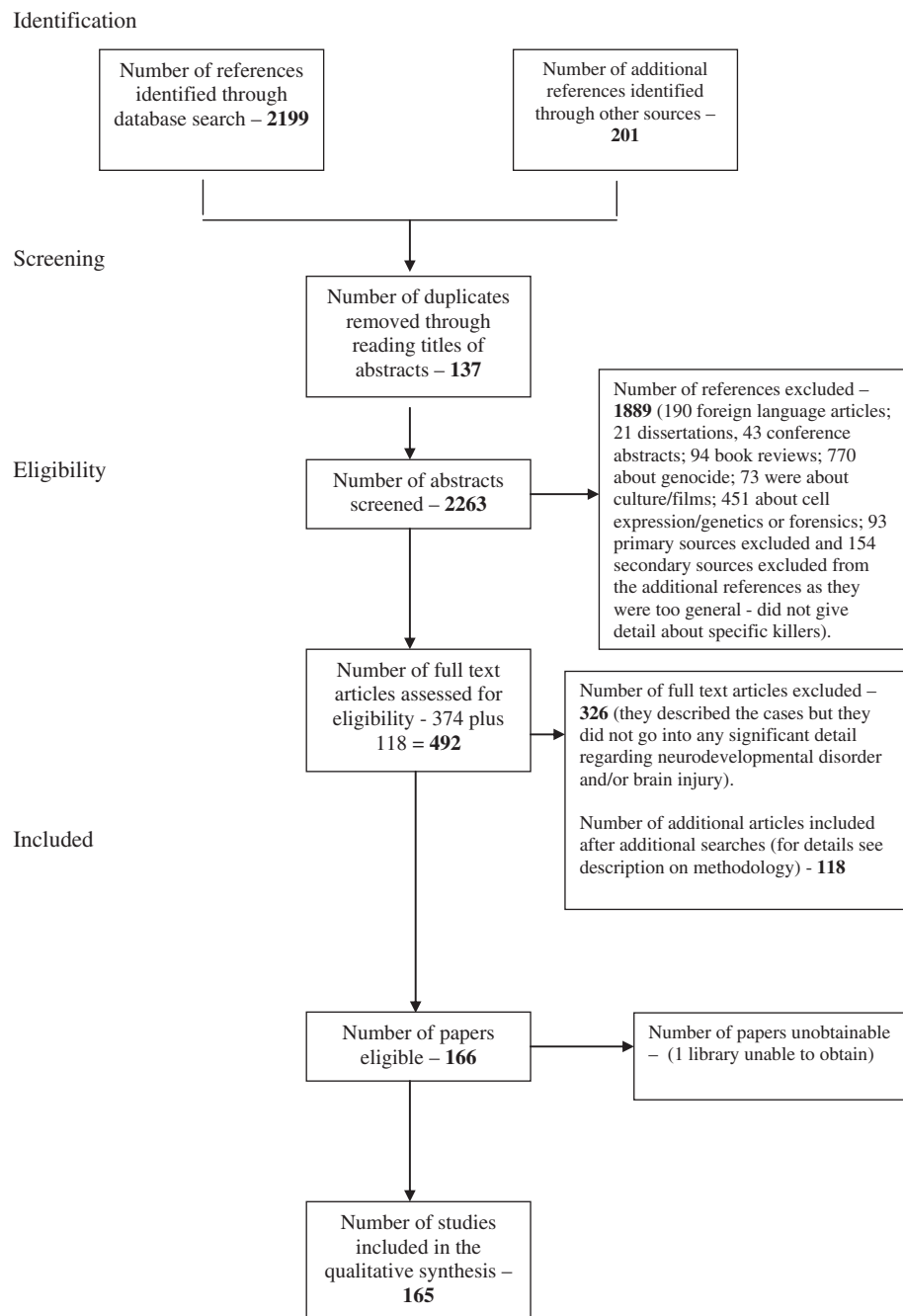


Fig. 1. PRISMA literature selection flowchart.

Abstracts for each reference were obtained and screened using the following criteria:

The search terms that were entered in the two databases were: (autis* [AND] Serial killer*); 'serial killer'; (Psychopathy [AND] Autis*); (Murder [AND] Autis*); (Killers [AND] Autis*); ('Brain injury' [AND] 'serial killer'); ('Violent crime' [AND] 'asperger'); ('mordare'); ('narciss** [AND] 'Asperger'); ('mass killing** [OR] 'mass murder**'). Search criteria entered in the two databases (PsycINFO and Web of Knowledge) were identical.

Inclusion criteria:

1. Human study population
2. Covers the behavior of mass/serial killers and/or autism spectrum disorders (ASDs).
3. Covers any association between mass/serial killers and brain injury.
4. Covers any relation between violent crime/criminal behavior and ASDs.
5. Covers the distinction/overlap between (either behavioral or neurological) narcissistic personality disorder and ASDs.
6. Covers the distinction/overlap (either behavioral or neurological) between psychopathy and ASDs.

Exclusion criteria:

1. Paper not published in English
2. Dissertations
3. Book reviews
4. Conference abstracts/proceedings.

The process of eliminating non-relevant papers can be seen in Fig. 1 (following PRISMA guidelines) below.

Because the peer-reviewed literature was so limited, we paid particular attention to additional sources of literature. These included online articles; newspaper articles; court transcripts and in particular two comprehensive online resources: (1) <http://murderpedia.org/> (The Encyclopedia of Murderers) which has 5410 entries, and (2) <http://maamodt.asp.radford.edu/Serial%20Killer%20Information%20Center/Project%20Description.htm>, a Serial Killer Information Centre headed by Dr. Mike Aamodt at the Department of Psychology, Radford University, Radford, VA, United States of America. The serial killer information center was created to provide students, researchers, and the media with accurate data on serial killers. The project began in 1992 and data are added and revised on a continual basis. To date, the Radford Serial Killer Database contains data on 2750 serial killers with online access to information on 196 of these killers.

Killers were only included in the analysis if they were apprehended after 1985. We chose this cut-off point because there has been a dramatic increase in the recognition of ASD (Mesibov, Fuentes, Prior, & Wing, 2006). Killers were also only included if they had killed more than three people (Dietz, 1986). A large proportion of the literature found in the PRISMA search on mass murderers and serial killers did not

discuss whether the individual had received a diagnosis of ASD or had sustained a head injury. Additional searches were, therefore, carried out on all 404 killers that were found (106 included in the results and 82 apprehended after 1985 that had no evidence of head injury or ASD). Detailed case summaries were written on each killer and these are available from the first author on request. The name of the killer was entered into the search engine 'Google' followed by 'AND' and each of the following search terms were explored separately: 'brain'; 'head injury'; 'asperger'; 'autis*' and, in some cases, 'murder' if the name alone was failing to produce relevant sites. In these searches, numerous resources were examined in detail including court transcripts; newspaper articles and other online resources. For each search, a minimum of five resources, specifically chosen for their relevance, were examined. In total (after screening for relevance by title and abstract), 490 articles/books were examined in detail for reference to ASD in killers and/head injury.

Head injury was indicated if there was mention of trauma to the head which may or may not have lead to unconsciousness. A killer was entered into the definite head injury category if they had received a brain scan which revealed damage to the brain and/or it was mentioned that there was a loss of consciousness as a result of head trauma. Killers were categorized as having possible head injury when there was only a mention of head injury but not any consequences (i.e., lack of consciousness).

3. Results

None of the eligible studies extended beyond single case reports. Of the 165 articles/books/web resources included in the results section, there were: 22 were peer reviewed articles, 118 web resources, 20 books, 4 book chapters, and 1 policy/public report. The number of primary sources totalled 26, and the number of secondary sources was 139. Table 1 shows the search criteria and returned searches carried out on Web of Knowledge, Table 2 shows the search criteria and returned searches carried out on PsycINFO.

Our searches of both peer reviewed literature and other sources found information on 404 killers. Of these, 21 were removed as no further information could be obtained other than how many they had killed. A further 82 were excluded because they were apprehended before 1985, and 62 were removed as they had killed fewer than three people. This left 239 eligible killers. Of these 239 killers, 133 had no evidence of either brain injury or ASD. (Details on all 106 killers are available on request). Of the 239 eligible killers, 106 were found to have evidence of ASD and/or head injury, 58 were mass murderers and 48 were serial killers (who had all killed three or more people).

Among all the 239 eligible killers, 28.03% (N = 67) had definite, highly probable or possible ASD of which 5 (7.46%) also had a head injury. 21.34% (N = 51) had had a definite or suspected head injury of which 13.72% (N = 7) also had evidence of ASD traits. Out of the 106

Table 1
Searches conducted.

Web of knowledge search criteria	Total no. returned	No. of duplicates	No. read	No. of foreign articles	Book reviews	Conference abstracts	Dissertations	Date search carried out
Autis*	3	2	1	0	0	0	0	19th June 2012
[AND] serial killer*								
'serial killer'	758	0	105	33	49	13	0	16th August 2012
Psychopathy	123	10	45	4	0	1	0	20th of June 2012
[AND] autis*								
Murder [AND] autis*	4	2	2	1	0	0	0	27th August 2012
Killers [AND] autis*	27	3	0	0	0	0	0	20th June 2012
'Brain injury' [AND] 'serial killer'	1	1	0	0	0	0	0	26th August 2012
'Violent crime' [AND] 'Asperger'	10	6	3	0	0	0	0	27th August 2012
'Mordare'	4	0	0	2	0	0	0	26th August 2012
'Narciss** [AND] 'Asperger'	3	3	0	0	0	0	0	27th August 2012
'Mass killing** [OR] 'mass murder**'	609	40	26	112	12	27	1	28th November 2012
Total	1542	65	182	152	61	41	1	

Table 2
Searches conducted.

PsycINFO search criteria	Total no. returned	No. of duplicates	No. read	No. of foreign articles	Book reviews	Conference abstracts	Dissertations	Date search carried out
Autis*	2	0	0	0	0	0	0	27th August 2012
[AND] serial killer*								
"Serial killer"	144	38	64	6	1	0	10	17th August 2012
Psychopathy	114	23	37	4	2	1	1	27th August 2012
[AND] autis*								
Murder [AND] autis*	21	2	1	4	0	0	0	27th August 2012
Killers [AND] autis*	14	0	1	0	0	0	0	20th June 2012
'Brain injury' [AND] 'serial killer'	3	0	1	0	0	0	0	26th August 2012
'Violent crime' [AND] 'Asperger'	9	4	2	0	0	0	0	19th August 2012
'Mordare'	0	0	0	0	0	0	0	27th August 2012
'Narciss'" [AND] 'Asperger'	9	0	3	0	0	0	0	24th August 2012
'Mass killing*" [OR] 'mass murder**'	341	5	83	24	30	1	9	28th November 2012
Total	657	72	192	38	33	2	20	

killers with ASD and/or head injury, 55% (N = 58) had experienced psychosocial stressors. Fig. 2 is a Venn Diagram to show the proportion of overlaps of the above and also, as discussed below, the overlaps between both head injury and/or ASD and psychosocial stressors. Tables 3–5 detail the killers with a definite, probable, or possible diagnosis of ASD. Tables 6–7 detail the killers with a definite head injury and possible head injury, respectively. Evidence of any possible head injury is noted in the ASD Tables, and possible ASD is also noted in the head injury tables. Across all the tables, existence of psychosocial stressors is entered. Psychosocial stressors included significant traumatic events during childhood such as the death of a close family member; major surgery/illness; psychological, physical, and/or sexual abuse.

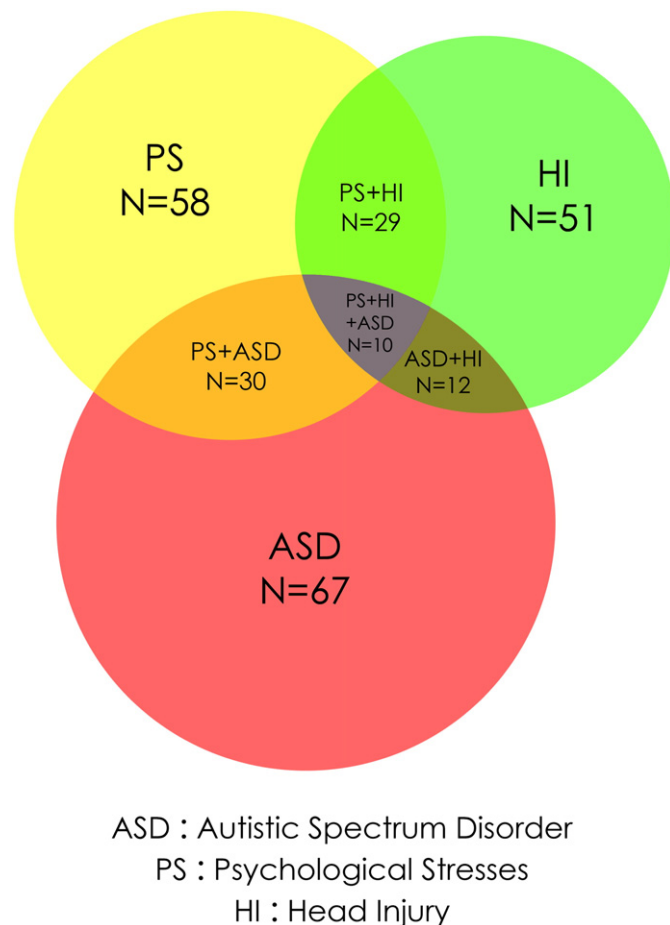


Fig. 2. Venn Diagram shows the proportion and overlaps between both head injury and/or ASD and psychosocial stressors.

3.1. ASD with evidence of head injury analysis

Of those with definite, highly suspected, or possible/probable ASD, 5 (8.33%) also had a head injury. All 6 of those with a definite diagnosis of ASD also had psychosocial stressors, such as sexual abuse and severe bullying, compared to nearly 80% (16) of those in whom ASD was highly probable and 8 (24%) in those where ASD was possible. For the six individuals with definite ASD, none had clear accounts of diagnostic assessments involving standardized assessment tools described in the literature. In all six case reports, it was simply stated that the individual had a diagnosis of ASD with no further information. For those with highly probable ASD, the majority of these individuals were included here because it was suggested that they have ASD in peer reviewed articles, and/or it has been suggested by a psychiatrist/psychologist in articles/books/online resources. For those with possible/probable ASD, accounts varied from being described as 'odd' to being a loner, with few friends or withdrawn. In many cases, we have included the individual in the category of "possible ASD" because of suggestive descriptions – such as the individual being "a loner" – that may not have used diagnostic or symptomatic language.

3.2. Case study: Jeffrey Dahmer

The case of Jeffrey Dahmer provides an excellent case study of a serial killer who is highly likely to have had ASD in addition to experiencing psychosocial stressors during childhood. Dahmer murdered 17 men and boys between 1978 and 1991, with the majority of these occurring between 1987 and 1991. Dahmer's murders involved rape, dismemberment, necrophilia, and cannibalism. He made crude attempts to lobotomize some of his victims by injecting muriatic acid into their brains (Bennett, 1993). At the time of his arrest, the remains of 11 of his guests, including 4 severed and refrigerated human heads, and 7 skulls, were found on his premises (Nichols, 2006). While Dahmer was not clinically assessed and diagnosed with an ASD, there is overwhelming evidence (both peer reviewed and in a plethora of books specifically about this serial killer) to suggest that he displayed numerous indications of Asperger syndrome which is why we have chosen to discuss this as an example of a serial killer with ASD and psychosocial stressors. Silva et al. (2002a, 2002b, 2002c) argue that he suffered from a form of high-functioning ASD psychopathology, namely Asperger's disorder which is also suggested by Strubel (2007) who emphasized Dahmer's social skills deficits (however, see Nichols, 2006). Dahmer was also unattached during childhood and failed to bond with anyone (Egger, 1998). Further, he was known to lack reciprocal social interaction, a situation that was closely linked to his inability to make close friendships with his peers (Davis, 1991), and he was a loner as a child (Palermo, 2008, chap. 6). His teacher noted that he was shy and rigid, unhappy, and did not make friends easily (Carlin, 2011). Friends regarded him

Table 3
Killers with a definite diagnosis of ASD.^a

Name	Head injury ^b	Psychosocial stressors ^c	Best resource available ^d
Martin Bryant	No evidence	Yes	Cantor et al. (2000), Freckelton (2012, chap. 16), Sale (2008, chap. 11).
Robert Clive Napper	No evidence	Yes	http://murderpedia.org/male/N/n/napper-robert.htm
Wolfgang Zaugg (John Ausonius)	No evidence	Yes	http://www.dagbladet.no/2012/01/25/nyheter/innenriks/terror/19925148/
Nicky Reilly	No evidence	Yes	http://www.dagbladet.no/2012/01/25/nyheter/innenriks/terror/19925148
Ragnar Nilsson	No evidence	Yes	http://www.dagbladet.no/2012/01/25/nyheter/innenriks/terror/19925148/
Cary Stayner	No evidence	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Stayner,%20Cary%20-%202005.pdf http://murderpedia.org/male/S/s/stayner-cary.htm

^a [The autism spectrum disorders (ASDs) are a group of conditions characterised by impairments in reciprocal social interaction and communication, and the presence of restricted and repetitive behaviors].

^b [Head injury was indicated if there was coverage of trauma to the head which may or may not have led to unconsciousness. A definite head injury was situations where a brain scan revealed damage to the brain and/or it was mentioned that there was a loss of consciousness in addition to head trauma.].

^c [Psychosocial stressors included significant traumatic events during childhood such as the death of a close family member; major surgery/illness; psychological, physical and/or sexual abuse].

^d [The best resources are the ones that we found that specifically mentioned ASD or head injury and/or were the most comprehensive].

as odd and bizarre (Martens & Palermo, 2005). He had difficulty with nonverbal communication, such as a dearth of facial expression, and his unusual gaze which were also consistent with nonverbal social deficits often encountered in individuals with ASD (specifically Asperger syndrome) (Volkmar & Klin, 2000), a finding that was noted since early childhood (Dahmer, 1994; Masters, 1993). Lionel Dahmer described his son as having a body posture that made him appear rigid, unusual in the straightness of his body with a sense that the knees were locked and the feet dragging stiffly (Dahmer, 1994; Tithcott, 1997). This general bodily awkwardness or 'mechanical' type of body posture

is often found in individuals with ASD (Ghaziuddin & Butler, 1998). The symptoms of ASD tend to be recognized at age three or shortly thereafter (Volkmar & Klin, 2000), which is consistent with the report by Dahmer's father, who noted symptoms (i.e., unusual rigid body kinetics) at about four years (Dahmer, 1994). ASD also tends to be associated with the tendency for repetitive thinking and behaviors (APA, 2000) which were also found in Dahmer who exhibited persistent interests in human bodies, bodily sounds, and their component parts. He also spoke in flat monotone which is also a common feature of ASD (Masters, 1993).

Table 4
Killers where ASD was highly suspected.

Name	Head injury	Psychosocial stressors	Best resource available
Seung-Hui Cho	No evidence	Yes	Lee, Lee, and Ng (2007).
Theodore Kaczynski	No evidence	Yes	Silva, Ferrari, and Leong (2003), Sperber (2010, chap. 10).
Terry Nichols	No evidence	No	MacNeil (2007), http://www.google.com/search?q=Controversial+theory+links+autism+violent+behavior+a0166189664%22+site:www.thefreelibrary.com
Jeffrey Dahmer ^a	No evidence	Yes	Strubel (2007), Masters (1993), Silva et al. (2002a, 2002b, 2002c). Dahmer (1994).
Joel Rifkin	No evidence	Yes	Silva, Leong, Smith, Hawes, and Ferrari (2005), Mladinch (2001), Pulitzer and Swirsky (1994), Eftimiades (1993).
Anders Breivik	No evidence	Yes	http://www.dailymail.co.uk/news/article-2156530/Anders-Behring-Breivik-rare-forms-Aspergers-Tourette-s-syndromes-says-Norways-leading-psychiatrist.html (Website 3). Wessely (2012), Måseide (2012).
Thomas Hamilton	No evidence	Yes	Cullen (1996), Ramsland (2011)
Mattias Flink	No evidence	Yes	Website 2 – "Flink can be sick" Can Mattias Flink, the serial killer from Falun, suffer from Asperger's syndrome – an autism-like illness among other things may mean severe social disruption? Retrieved on the 10th of August 2012, http://www.dt.se/brottsplats/1.3106597-flink-kan-vara-sjuk
Dylan Klebold	No evidence	Yes – conflict with brother.	http://www.allvoices.com/contributed-news/6012871-the-cumbrian-shootings-and-the-mind-of-the-mass-shooter-echoes-of-columbine-and-dunblane
Robert Berdella	No evidence	Yes	Fitzgerald (2010).
Michael Lee Lockhart	Yes possible	Yes. (says he was sexually abused but no evidence).	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Lockart,%20Michael%20Lee%20_2012_.pdf http://murderpedia.org/male/L/l/lockhart-michael-lee.htm
Keith Hunter Jespersen	Yes possible	Yes	Fitzgerald (2010).
Timothy McVeigh	No evidence	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Jespersen,%20Keith%20-%20spring,%202006.pdf Fitzgerald (2010).
Peter Mang	Yes	Yes	http://www.dagbladet.no/2012/01/25/nyheter/innenriks/terror/19925148/
Harold Frederick Shipman	No evidence	Yes	Whittle and Ritchie (2000), Fitzgerald (2010).
Ricky Lee Green, Jr.	Possible	No evidence	Fitzgerald (2010).
Javed Iqbal	No evidence	No	http://murderpedia.org/male/G/g1/green-ricky-lee.htm Fitzgerald (2010).
Tim Kretschmer	No evidence	No	http://www.murderpedia.org/male/I/i/iqbal-javed.htm
Marc Lepine	Possible	Yes	http://www.dagbladet.no/2012/01/25/nyheter/innenriks/terror/19925148/ http://murderpedia.org/male/L/l/lepine-marc.htm
Pekka-Eric Auvinen	No evidence	No	Langman (2009).
Matti Juhani Saari	No evidence	Yes	http://www.dagbladet.no/2012/01/25/nyheter/innenriks/terror/19925148/ Langman (2009).

^a A further nine resources are included in the results section in the discussion of Jeffrey Dahmer (one book chapter; five books and three peer reviewed articles).

Table 5

Killers where ASD was possible/probable.

Name	Head injury	Psychosocial stressors	Best resource available
Jiverly Antares Wong	No evidence	Yes	http://murderpedia.org/male/W/w/wong-jiverly.htm http://www.fbi.gov/stats-services/publications/school-shooter
George Jo Hennard	None found on autopsy.	Yes	Stone (2009). http://www.nytimes.com/1991/10/18/us/portrait-of-texas-killer-impatient-and-troubled.html?pagewanted=all&src=pm http://murderpedia.org/male/H/h/hennard-george-jo.htm
Petri Erkki Tapio Gerdt	No evidence	No	http://murderpedia.org/male/G/g/gerdt-petri.htm
Jeffrey Weise	No evidence	Yes	http://murderpedia.org/male/W/w/weise-jeffrey.htm
David Malcolm Gray	No evidence	No	http://murderpedia.org/male/G/g/gray-david.htm Cantor et al. (2000).
Gang Lu	No evidence	No evidence	http://murderpedia.org/male/L/l/lu-gang.htm
Frederick Davidson	No evidence	No evidence	http://murderpedia.org/male/D/d/davidson-frederick-martin.htm
Larry Ashbrook	No evidence	No evidence	http://murderpedia.org/male/A/a/ashbrook-larry.htm
Kimveer Gill	No evidence	No	http://murderpedia.org/male/G/g/gill-kimveer.htm
Frank Vitkovic	No evidence	No	Cantor et al. (2000).
Michael Ryan	No evidence	No	Kon (1994), Cantor et al. (2000).
Maury Travis	No evidence	No	http://murderpedia.org/male/T/t/travis-maury.htm
John Justice Jr	No evidence	No evidence	http://www.people.com/people/archive/article/0,,20092208,00.html
Kyle Huff	No evidence	No evidence	Fox, Burgess, Levin, Wong, and Burgess (2007).
Michael Carneal	No evidence	None	http://murderpedia.org/male/C/c/carneal-michael.htm Langman (2009).
Robert Dreesman	No evidence	No	http://murderpedia.org/male/D/d/dreesman-robert.htm Kelleher (1997).
Jared Loughner	No evidence	No evidence	http://murderpedia.org/male/L/l/loughner-jared.htm http://www.cbsnews.com/8301-3460_162-7227843.html
Asa Coon	No evidence	No evidence	http://oddculture.com/weird-news-stories/teen-gunman-on-rampage-at-successtech-academy-high-school-in-cleveland/
Leonard Fraser	No	Yes	Stone (2009). http://maamodt.asp.radford.edu/psyc%20405/serial%20killers/Fraser,%20Leonard%20fall,%202007_.pdf
Gary Evans	No evidence	Yes	http://maamodt.asp.radford.edu/psyc%20405/serial%20killers/Evans,%20Gary%20-%20fall,%202005.pdf
Richard Durn	No evidence	No evidence	http://murderpedia.org/male/D/d/durn-richard.htm
Thomas Dillon	No evidence	No evidence	http://murderpedia.org/male/D/d/dillonthomas.htm
Ronald Taylor	No evidence	No evidence	http://murderpedia.org/male/T/t/taylor-ronald.htm
George Sodini	No evidence	No evidence	http://murderpedia.org/male/S/s/sodini-george.htm http://www.ctvnews.ca/gunman-in-health-club-shooting-a-48-year-old-loner-1.422779
Wade Frankum	No evidence	Yes	Cantor et al. (2000). http://www.murderpedia.org/male/F/f/frankum-wade.htm
Wayne Nance	No evidence	No evidence	http://murderpedia.org/male/N/n/nance-wayne-nathan.htm http://news.google.com/newspapers?id=1346&dat=19861026&id=yroOAAAIBAJ&sjid=vfsDAAAIBAJ&pg=6937,3876517
Carl Drega	No evidence	No evidence	http://murderpedia.org/male/D/d/drega-carl.htm
Jon Scott Dunkle	No	Yes	http://maamodt.asp.radford.edu/psyc%20405/serial%20killers/Dunkle,%20Jon%20Scott.pdf http://murderpedia.org/male/D/d/dunkle-jon.htm
Michael McDermott	No evidence	No evidence	http://en.wikipedia.org/wiki/Wakefield_massacre http://murderpedia.org/male/M/m/mcdermott-michael.htm
Steven Kazmierczak	No evidence	No evidence	http://murderpedia.org/male/K/k/kazmierczak.htm
Robert Steinhäuser	No evidence	No evidence	http://murderpedia.org/male/S/s/steinhauser-robert.htm
James Floyd Davis	No evidence	Yes	http://murderpedia.org/male/D/d/davis-james-floyd.htm http://www.law.stanford.edu/sites/default/files/child-page/266901/doc/slspublic/Hannah_Lommers_Johnson.pdf
Valery Fabrikant	No evidence	No evidence	Kelleher (1997). http://www.murderpedia.org/male/F/f/fabrikant-valery.htm

Some of the psychosocial stressors experienced by Dahmer during childhood related to his dysfunctional family where frequent quarrels between his parents took place. His mother suffered with depression and suicidal ideation, and his father was often absent as he was absorbed in his career and obtaining his PhD in Chemistry (Palermo, 2008, chap. 6). Two months short of his fourth birthday, he underwent surgery to repair a double hernia which proved to be a traumatic experience. At age 10, Jeffrey felt guilty about his mother's mental disorders because he believed that he was the cause of her suffering (Martens, 2011). Jeffrey's father reports that he had been sexually abused by a neighbor at age 8 although this is denied by Jeffrey (Dahmer, 1994; Dvorchak & Holeywa, 1991). Jeffrey's father had morbid trends and preoccupations of his own, at least in his youth (Dahmer, 1994, p. 51). Lastly, Dahmer was greatly ambivalent about his homosexual tendency and was frustrated by it. Some believe this frustration was later channeled into sadistic behavior against people who accepted his homosexual advances (Jentzen et al., 1994).

3.3. Head injury with possible ASD traits analysis

Of those with a definite or possible head injury, 7 (15%) also had evidence of ASD traits. Of those 16 cases with a definite head injury, 13 (81%) also had psychosocial stressors, such as childhood abuse and alcoholic parents, who fought physically in front of their children. Of those 30 cases with a possible head injury, 16 (53%) also had documented psychosocial stressors such as sexual and physical abuse. The vast majority of references to head injury do not go into detail about the consequences.

3.4. Case study: Richard Ramirez — “night stalker”

The case of Richard Ramirez provides a case study of a serial killer who sustained both numerous head injuries and suffered multiple psychosocial stressors. He was convicted of killing 13 people between June

Table 6
Killers with a definite head injury.

Name	Evidence of ASD	Psychosocial stressors	Best resource available
Arthur Shawcross	No evidence	Yes	Stone (2009), Ramsland (2011).
Richard Ramirez	Possible	Yes	Carlo (1996), Stone (2001, 2009). http://www.mayhem.net/Crime/serial2.html http://murderpedia.org/male.R/r/ramirez-richard.htm http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Ramirez,%20Richard%20_spring%202007_.pdf
Frederick Walter Stephen West	No evidence	Yes	Boduszek and Hyland (2012). http://murderpedia.org/male.W/w/west-frederick.htm Stone (2001).
Bobby Joe Long	No evidence	Yes	http://fatmammymcat.blogspot.co.uk/2007/10/head-injuries-and-serial-killer.html Fox and Levin (2005).
Kipland Philip "Kip" Kinkel	No	No	https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/4583/790lr1081.pdf?sequence=1 http://eprints.utas.edu.au/494/1/Shame_-_The_root_of_violence.pdf Lachmann (2006). Myers et al. (2008).
Khomiakov Victor Yu	Possible	Yes	http://www.murderpedia.org/male.Z/z/zethraeus-tommy.htm
Tommy Zethraeus	No evidence	No evidence	http://murderpedia.org/male.D/d/deford-ray-martin.htm
Raymond Martin DeFord	No evidence	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Clark,%20Hadden%20_2005_.pdf
Hadden Clark	No	Yes	http://www.dprc.us/paul_dennis_reid.htm
Paul Dennis Reid	No evidence	No evidence	http://justiceaction.org.au/cms/images/stories/CmpgnPDFs/malbakcases05_09_2012.pdf
Malcolm Baker	No evidence	Yes	http://www.ca11.uscourts.gov/opinions/ops/200715876.pdf
Curtis Windom	No evidence	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Rolling,%20Danny%20-%202004.pdf
Danny Rolling	No	Yes	http://murderpedia.org/male.C/c/chikatilo.htm Fitzgerald (2010).
Andrei Chikatilo	Yes	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Chikatilo,%20Andrei%20_fall,%202007_.pdf http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Sells,%20Tommy%20Lynn%20-%202005.pdf http://murderpedia.org/male.S/s/sells-tommy-lynn.htm Fanning (2007).
Tommy Lynn Sells	No	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Dodd,%20Westley%20Allan.pdf http://murderpedia.org/male.D/d1/dodd-westley-allan.htm
Westley Allan Dodd	No evidence	Yes	

28th 1984 and August 24th 1985. He grew up in El Paso, Texas, as the youngest of five children in a Mexican-American family. Richard's great-grandfather and father had been extremely abusive physically toward their sons down the generations as a means of instilling discipline (Stone, 2009). Richard was exposed to sexual sadism by his violent cousin (Carlo, 1996; Stone, 2001). He also saw a relative murdered by another relative at the age of 12 (Carlo, 1996). Both of his parents were exposed to nuclear radiation in Mexico. Following immigration to the U.S., his mother worked mixing toxic chemicals for an extended period. She collapsed at work when five months pregnant with Richard (<http://www.mayhem.net/Crime/serial2.html>). When Richard Ramirez was two, he was nearly killed by a dresser that fell on top of him, knocking him unconscious and giving him a deep gash on his forehead. When Ramirez was five, he was knocked unconscious and received a head laceration from a swing in the park being used by his sister. Richard was first discovered to have epilepsy in fifth grade (Carlo, 1996). According to Dr. Ronald Geshwind, a number of people who suffer from temporal lobe epilepsy have altered sexuality and hyper-religious feelings, are hypergraphic (have a compulsion to write), and are excessively aggressive. Years later, Richard was diagnosed as having temporal lobe epilepsy. It is also interesting that the literature on Ramirez contains suggestive descriptions of ASD traits, such as preferring his own company in childhood (Carlo, 1996), and an inability to forge any lasting and harmonious attachment to anyone (Stone, 2009).

4. Discussion

Despite an exhaustive search of as wide a range of international sources of data as possible, reports on fewer than 400 serial/mass killers were found since 1985, suggesting that serial and mass killings are rare. The most striking finding in our systematic review is the lack of rigorous research on mass and serial killers. All peer reviewed papers are single case reports with only a few retrospective studies with larger numbers of subjects. The rarity of cases means that these individuals are unlikely

to be part of general population studies or even clinical studies, except those focussed on very atypical populations such as inmates of special hospitals for violent and mentally disordered offenders. In both the peer reviewed and non-peer-reviewed literature, detailed clinical accounts of diagnostic assessments using standardized tools were rare. Media reporting of violent crime committed by persons with symptoms associated with autism spectrum disorders may generate a harmful stereotype. This review highlights that although the percentage of individuals considered to have a neurodevelopmental disorder is higher than would be expected in the general population, this is nowhere near as high as indicated in the media.

Because the great majority of case reports came from non-peer-reviewed sources, such as books and databases such as Murderpedia and the Radford University Database on Serial Killers, our findings are clearly limited. The problems with the quality of the literature are compounded by the differing reporting strategies across the world, and the fact that serial killing, in particular, may go unrecognized. We can, therefore, make no accurate estimations regarding the prevalence of serial/mass killing, and it is challenging to see patterns across population that allow us to draw conclusions regarding etiology. There may also have been bias involved in the selection of cases, due to the lack of rigorous sources available. We did not use a risk of bias tool because one does not exist for case studies. To limit this bias, the lead author discussed the inclusion of papers with all the other authors. Lastly, due to the large scale of this literature search it is possible that some names may have been missed.

Despite these limitations, we are able to say that probably more than 10% of serial/mass killers have ASD and a similar proportion have had a head injury. Because accounts of systematic examination for these factors are relatively uncommon in reports on serial/mass killings, these figures are very likely to be an underestimate. Yet, both are considerably higher than would be found in the general population. Neither of these neurodevelopmental factors appears to be sufficient in the etiology of serial/mass killing as the great majority of those with ASD or head injury

Table 7
Killers with a possible head injury.

Name	Evidence of ASD	Psychosocial stressors	Best resource available
Dennis Rader	No	No	http://www.crimeandinvestigation.co.uk/crime-files/dennis-rader-the-btk-killer/biography.html http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Rader,%20Dennis%20-%202005.pdf http://murderpedia.org/male.R/r/rader-dennis.htm
Gary Ridgway	Possibly	Yes	Prothero and Hanis (2007).
Paul Charles Denyer	Possibly	No	Davis (2007). http://murderpedia.org/male.D/d/denyer-paul.htm
Juana Barraza Samperio	Possibly	Yes	Cervantes (2010), Campobasso et al. (2009), Ostrosky-Solis, Vélez-García, Santana-Vargas, Pérez, and Ardila (2008).
Leonard Lake	No	Yes	http://murderpedia.org/male.L/l/lake-leonard.htm http://www.trutv.com/library/crime/serial_killers/notorious/tick/9b.html
Harrison Graham	No	No evidence	http://murderpedia.org/male.G/g/graham-harrison.htm
Aileen Wuornos	No	Yes	DellaSanta-Percy (2003–2005). http://mysite.cdellasanta.com/pdf/aileen_wuornos.pdf
Angel Maturino Resendiz aka Rafael Resendez-Ramirez	No	No evidence	Myers et al. (2005). Kennedy (1994). Arrigo and Griffin (2004). http://www.mayhem.net/Crime/serial2.html
Alexander Pichushkin	No	No	http://murderpedia.org/male.R/r/r/resendiz-angel.htm http://bodyreport.com/article/profile-alexander-alexander-pichushkin http://murderpedia.org/male.P/p/pichushkin-alexander.htm
Juan Rodriguez Chavez	No	No evidence	http://www.trutv.com/library/crime/criminal_mind/forensics/w_hollywood_hustle/12.html http://murderpedia.org/male.C/c/chavez-juan.htm
Derrick Todd Lee	No	Yes	http://www.wwltv.com/news/local/120233949.html http://murderpedia.org/male.L/l/lee-derrick-todd.htm
John Ray Weber	No	Yes	Stone (2009).
Todd Hall	No	No	http://murderpedia.org/male.H/h/hall-todd.htm
Robert Silveria, Jr	No	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Silveria,%20Robert%20Joseph%20-%202005.pdf
Sandi Nieves	No evidence	Yes	http://www.thefreelibrary.com/FRIENDS+SAY+CONVICTED+KILLER+DEVOTED+TO+KIDS.-a083396055
Wayne Adam Ford	No	Yes	http://murderpedia.org/male.F/f/ford-wayne-adam.htm
Friedrich Leibacher	No evidence	No evidence	http://murderpedia.org/male.L/l/leibacher-friedrich.htm
David Edward Maust	No	Yes	http://www.crimezz.net/serialkiller_news/M/MAUST_david.php http://murderpedia.org/male.M/m/maust-david.htm
Eric Houston	Possibly	Yes	http://articles.latimes.com/1993-07-23/news/mn-16058_1_school-siege
Bryan Uyesugi	No	No	http://murderpedia.org/male.U/u/uyesugi-byran.htm
Colin Ferguson	No evidence	No	http://en.wikipedia.org/wiki/Colin_Ferguson_(mass_murderer) http://www.murderpedia.org/male.F/f/ferguson-colin.htm
Daryl Holton	No evidence	No evidence	http://www.clarkprosecutor.org/html/death/US/holton1097.htm
Anthony Sowell	No	Yes	http://www.callandpost.com/index.php/news/features/anthony-sowell/902-sowell-cries-during-sentencing-testimony http://murderpedia.org/male.S/s/sowell-anthony.htm
Donald Harvey	No	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Harvey,%20Donald%20-%20fall,%202005.pdf http://murderpedia.org/male.H/h/harvey-donald.htm
Richard Baumhammers	No	No	http://news.google.com/newspapers?nid=348&dat=20010505&id=cOEvAAAIBAJ&sjid=PDUDAAAIBAJ&pg=2876,745657 Americans. http://murderpedia.org/male.B/b/baumhammers.htm
Paul Runge	No	No evidence	http://caselaw.findlaw.com/il-supreme-court/1050195.html http://murderpedia.org/male.R/r/runge-paul.htm
Reginald and Jonathon Carr	No	Yes	http://www.trutv.com/library/crime/notorious_murders/classics/carr_brothers/8.html
Edgar Killen	No	No	http://bigstory.ap.org/article/ex-inmate-reputed-klansman-granted-legal-power
Thomas Edward Luther	No	Yes	http://maamodt.asp.radford.edu/Psyc%20405/serial%20killers/Luther,%20Thomas%20Edward.pdf http://murderpedia.org/male.L/l/luther-thomas.htm
Timothy Spencer	No evidence	Yes	Davis (2007). http://murderpedia.org/male.D/d/denyer-paul.htm

had also experienced psychosocial risk factors such as parental divorce, physical or sexual abuse, and major surgery during childhood. This leads us to suspect that there may be some support for our hypothesis: that to a certain degree, there is a complex interplay between neurodevelopmental and environmental factors – particularly psychosocial adversity – can potentially result in an individual being predisposed to develop into a serial/mass killer.

The gaps in our understanding about the actual mechanisms of development toward these most negative of outcomes are enormous, and it is difficult to imagine how conventional research techniques could fill these. For example, cohort studies would have to involve millions of individuals to have any chance of including someone who ends up committing these kinds of crimes, and this is clearly beyond the capacity of any funding body. It may be that research techniques used for extremely rare but dangerous diseases may need to be adapted for this purpose. For example, the World Health Organisation and European Union have developed collaborative strategies to conduct

research on rare diseases (e.g. <http://www.who.int/bulletin/volumes/90/6/12-020612/en/index.html>) and similar technology may be required to understand – and hopefully prevent – serial and mass killings. There is a need for more rigorous research/an international database so that reviews like this one can have a stronger foundation on which to report.

5. Conclusions and recommendations

Research on mass and serial killing is still at a very rudimentary stage. Yet, there are suggestions that, in at least some cases, neurodevelopmental problems such as ASD or head injury may interact in a complex interplay with psychosocial factors to produce these very adverse outcomes. New research is urgently required to understand the mechanisms underlying these forms of extreme violence so that preventative strategies can be developed. We would recommend that international collaborative research efforts be developed using

innovative techniques borrowed from the study of rare diseases. In addition, we would recommend that, in future, all serial or mass killers who are apprehended should be thoroughly assessed using standardized tools for investigating neurodevelopmental disorders including ASD and head injury. Ideally, an international research registry would be set up to record such information as this may be the only way that we will eventually be able to confidently determine the prevalence, etiological factors, and developmental trajectories associated with mass and serial killing.

Disclosure statement

The authors declare that they have no conflicts of interest.

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