**Supplement**

**Psychotic Symptoms in Mass Shootings vs. Mass Murders Not Involving Firearms: Findings from the Columbia Mass Murder Database**

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**Methods**

**Identification of Sources of Incidents of Mass Murder**

Sources of potential cases of mass murder were identified in the following manner (Supplemental Table 1 and Supplemental Figure 1): First, we identified three databases which are widely known within the forensic research community; specifically, the Stanford Mass Shootings in America database, Murderpedia.org and the Mother Jones database. We also identified the article “Mass Murder, Mental Illness and Men” in *Violence and Gender*, which includes a list of mass murderers. Second, the authors entered the phrases “mass murder database,” “mass shooter database,” “list of mass murders,” and “list of mass shootings” into the internet search engine Google, which led to the Everytown for Gun Safety listing, econojwatch.org, the Amok Fandom lists of familicides and rampage killers, and the Gun Violence Archive. This method also led to the “Mass Shootings in the United States” list published in the online encyclopedia Wikipedia.com, which, in turn, led to the lists “School Shootings in the United States by Death Toll” and “Rampage Killers,” the latter of which was subdivided into separate listings of rampage killers in various geographic locations and involving diverse methods of killing.

While we sought to make our database as complete as possible, we acknowledge that we may have inevitably omitted some mass murders occurring worldwide between 1900 and 2019. We began by collating all cases from the individual databases and lists of mass murder incidents specified in our supplement, totaling 14,785 cases (Supplementary Figure 1). We ran electronic checks for duplicate cases, based upon offender names. The first and senior authors then conducted exhaustive manual checks of individual cases for duplicates associated with aliases or spelling variants of perpetrator’s names, and details of the cases, such as dates, locations, and other details. We retained only one entry for repeated cases. In some instances, mass murders perpetrated by multiple offenders were combined into single cases in our table. This process removed 2,358 incidents. We then conducted manual checks to remove cases that were outside of our parameters, including 283 which preceded the year 1900; 1,595 not associated with personal causes, but with war, state-sponsored terrorism, or gang or organized crime activity; 6,385 involving less than 3 casualties; and 1,571 more properly categorized as serial or spree killings lasting greater than seven days, or involving perpetrators who committed any two episodes of murder with any victim count more than seven days apart, irrespective of any connections between murders.

We did our best to make our database as complete as possible while prioritizing accuracy and reliability of data within cases. Thus, we further excluded 369 cases for which we lacked victim count and murder method, which we deemed the bare minimum for inclusion. While we did not require demographic information, per se, these data were available in most instances. As further checks on the accuracy of information within individual cases, we excluded 101 for which we could identify no English-language sources and 400 for which no primary sources, beyond lists on nonacademic web sites, could be found. Wherever we discovered discrepant data in primary data sources, the information given in the majority of reports was used. At least two investigators, always including a clinical psychologist (G.B.) and a psychiatrist (R.R.G.), reviewed all primary informational sources and performed double data entry. It was found that two or more primary informational sources were available for nearly all (98%) cases. We included the 2% for which only a single source was available, as long the data points we required were provided.

We have included sample sizes for all our analyses in the manuscript. Of note, for our main analyses, there were 18,410 data points in total, of which only 142 (0.77%) could not be obtained, the vast majority of which were data on perpetrator ages.

**Additional Description of Variables and Data Collection**

*Perpetrator(s)* refers to the person or persons known to have carried out a mass murder. In cases involving more than one perpetrator, the individual known to have led or directed the mass murder was regarded as the perpetrator when identifying demographic and other information. In cases in which no clear leader was identified, the perpetrators were listed alphabetically by surname and the first person listed was included as the perpetrator. *Gender* recorded that which was given for perpetrators in available reports, including transgender or non-binary gender identification wherever indicated. For unknown perpetrators, gender was given as “unknown.” Under *race*, we recorded whether a perpetrator was described in reports as being Caucasian, African American, Asian/Pacific Islander, Native American/First Nations, Hispanic, Mixed, or of unknown racial background. *Year* connotes that in which the mass murder transpired. *Age at offense* was either given in media reports or had to be estimated from a perpetrator’s birth year and the year of the mass murder (e.g., a perpetrator born on an unspecified date in 1950 who committed a mass murder on June 1, 2000 was recorded as having been “49.5” at the time of offense.).

*Location*, which indicates the specific geographic region in which a mass murder transpired, was separated as follows: U.S., Canada, Mexico/Central America, Africa, Asia, Australia/New Zealand, Europe, or South America. A “mid-travel between regions” category was used for mass murders carried out on airplanes or vehicles traveling between distinct locations. For mass murders based in the U.S., specific location was additionally noted according to all 50 states, Washington, D.C., and Puerto Rico/U.S. territories.

*Fatalities* excluded the perpetrator(s) in instances of death at the scene. For cases in which a pregnant female victim was killed, we recorded two fatalities in the counts; if a pregnant female victim was killed and found to have been pregnant with twins, we recorded two fatalities. We included in the victim counts persons who were wounded at the scene of a mass murder but died thereafter as a direct result of injuries sustained at the attacks, according to available reports. In instances in which news reports conflicted as to a victim count, we searched for additional sources and recorded the more frequently given count. *Suicide* recorded whether a perpetrator killed him- or herself in the midst of an attack. We did not include here perpetrators who completed suicide in separate locations, on dates subsequent to the time of a mass or spree murder. *Injured/killed at scene* records whether a perpetrator was wounded or killed by others, such as by authorities, or an armed citizen while carrying out an attack, or accidentally injured by himself or herself. We did not include here those who were injured or killed following a mass murder or killing spree, nor those who completed suicide at the scenes of their attacks.

The first (G.B.) and senior (R.R.G.) authors assigned murderer designations. Persons who were actually properly termed serial killers, because they demonstrated cooling-off periods between separate murders, or who were spree killers who murdered victims across longer than seven days, were not included in this study. For example, a mass murderer who had killed one person 20 years earlier was labeled a serial killer. Perpetrators categorized as *spree killers*, due to having killed two (or three for the current analyses) or more people in more than one location or at more than one point in time, with little to no cooling-off period, were retained for separate analysis. Spree killers who, during the course of their attacks, killed three or more victims in one location and at the same time were assigned the designation of *spree + mass murders,* but still categorized as spree killers. To be conservative, perpetrators who committed any two episodes of murder with any victim count more than seven days apart were excluded, irrespective of any connections between murders.

Lifetime psychiatric and/or neurologic symptoms, either associated with formal psychiatric diagnoses specifically assigned to perpetrators, according to available reports, or described in reports in an informal way (e.g., “The killer was described as ‘depressed and was known to regularly use marijuana’”) were recorded. These were reviewed and categorized by two clinicians (authors G.B. and R.R.G.) as follows: Symptoms of alcohol misuse, symptoms of anxiety, symptoms of an autistic spectrum disorder, symptoms of a depressive disorder, symptoms of any recreational drug use, symptoms of low I.Q., symptoms of mania/bipolar disorder, symptoms of other neurologic disorders (including seizure disorders, traumatic head injury, and neurodegenerative diseases of the central nervous system), symptoms of a paraphilia (e.g., pedophilia, hebephilia, voyeurism, sexual sadism), symptoms of post-traumatic stress disorder, symptoms of a dissociative disorder, symptoms of a personality disorder, symptoms of a psychotic disorder such as delusions, thought disorganization, or hallucinations (in the context of schizophrenia, mood disturbance, drugs or alcohol, medical illness, psychotic not otherwise specified, or any other cause), and/or symptoms of other psychiatric disorders (e.g., attention deficit hyperactivity disorder, dissociative disorder, obsessive-compulsive disorder). Where psychotic symptoms were identified in the history of a given mass murderer, the mass murder was categorized as either based on delusions/hallucinations or disorganization. Delusions or hallucinations connoted that offenders were known to have been acting in a way which was in accord with a clear delusional system (e.g., killing in response to paranoia or a belief that certain persons were “evil”) or in response to perceptual disturbances (e.g., acting in response to voices). Disorganization connoted that an offender acted in a grossly disorganized manner in which no logical thread or clear delusional or hallucinatory basis could be identified (e.g., an offender who is acutely psychotic and randomly targets strangers). There was inadequate information to further delineate specific types of delusional beliefs. Psychotic ideas which were religious or political in nature (i.e., targeting government figures one has incorporated into a delusional belief; acting in response to what is thought to be the voice of God) were included as long as they were associated with personal cause murder and not part of the belief system of an organized group. If no information about any possible neurologic or psychiatric symptoms was reported, we recorded “no known psychiatric/neurologic history.” We also reviewed all psychotic symptoms and further identified whether they temporally coincided with the mass murder event, or were present in a mass murderer’s history, prior to his or her attack. Recreational drug use and/or alcohol misuse was separately recorded as “yes” or “no” in a *drugs/alcohol* column. Legal history recorded reports of a perpetrator having been served a restraining order, investigated for domestic violence or child abuse, arrested, and/or incarcerated. Of note, we did not include information regarding legal history or symptoms of mental illness which were reported to have emerged after an act of mass murder, such as a depressive reaction or transient psychosis following an incident.

A summary of all pertinent details of a given mass or spree murder were recorded in the database. Notes regarding variables was a free-text cell in the database, allowing a rater to record the justification for a given notation (e.g., “sources say nine victims; one was pregnant, so recorded 10 victims;” “no sources available in English;” “type of weapon not specified in reports”).

Finally, we recorded any firearms used in each mass murder by name, type, brand, and caliber, if known (e.g., “.30-.35 rifle,” “25 ACP pistol”). If only general type of firearm was known, we recorded, for instance, “unidentified shotgun” or “unspecified handgun.” Firearms were divided into “non-automatic,” “semi-/fully-automatic,” “both,” and “type not specified.” For cases in which no firearm was used, “not applicable” was assigned.

When we discovered discrepant information among primary data sources (e.g., discrepant victim counts, sometimes because some sources did not review media reports providing information on victims who died in the days following injury during a mass murder; inconsistent perpetrator ages; name spellings), the information provided in the majority of reports was used. At times, it was discovered that certain perpetrators used aliases, such that they might be listed under different names in separate databases. These were combined into single entries in our database, with the aliases given in brackets as “[a.k.a.].”

At least two investigators, always including a clinical psychologist (G.B.) and psychiatrist (R.R.G.), reviewed all primary informational sources and performed double data entry. Sources for all entries were recorded. Two or more primary informational sources were available for all but 2% of cases. Multiple news stories from the same publication or website, and wire-service stories published in multiple publications, were recorded as one primary source. For each case, we collected information on year, country, state (if U.S.-based), gender, ethnicity, race, age, victim count, whether the perpetrator was injured or killed at the scene, psychiatric symptom history, history of recreational drug use or alcohol abuse, legal history, and, if relevant, firearm type.

**Results**

The Post-1970 Era of Mass Murder in the U.S

We conducted additional analyses limiting the sample to mass murder occurring after 1970 in the U.S. (i.e., the modern era of mass murder). For these analyses, we included 734 instances of mass murder. These 734 mass murders accounted for 3,649 victims (average 5.0 deaths per event, SD=7.8). When the sample was limited to the 734 post-1970 cases in the U.S. (Supplemental Table 2), findings were similar to those from the whole sample, except that differences in legal history and race were no longer significant. Additionally, in the post-1970 era of mass murder in the U.S., mass murderers who used firearms tended to be older (p<0.01) than those who employed other methods.

Mass Shooters Using Non-Automatic vs. Semi- or Fully-Automatic/Assault-Style Firearms

We were able to identify whether firearms were of the non-automatic or semi-automatic/fully-automatic/assault-style (heretofore referred to as “semi- or fully-automatic”) types for 651 of the 855 mass shooters. Since semi-automatic firearms only became widely commercially available in the mid-to-late 1960s, we limited these analyses to mass shootings after 1970. Data were available for 565 cases (Supplemental Table 4). Just over half (51%) used non-automatic weapons, while 41% used semi- or fully-automatic firearms, and 9% used both types. For these analyses, we combined the “semi- or fully-automatic” and “both” groups in Supplemental Table 4.

Important differences emerged between the two groups. The average number of fatalities per incident was higher when a semi- or fully-automatic firearm was used (mean 6.4 [5.6] vs. 4.8 [3.7]; p<0.01). U.S.-based mass shooters were much less likely to use semi- or fully-automatic firearms than those based in other countries (X2=26.6, p<0.01). Mass shooters using semi- or fully-automatic firearms were more likely to complete suicide (X2=5.7, p=0.02) than those using non-automatic firearms. We observed no differences in gender, age, legal history, likelihood for the perpetrator to be injured or killed at the scene by others, history of psychotic symptoms or symptoms any other psychiatric disorder, or recreational drug use/alcohol misuse between mass shooters who used non-automatic vs. semi- or fully-automatic firearms.

Methods of Mass Murder by Means Other than Firearms

Mass murders committed without firearms (Supplemental Table 5) were perpetrated by butchering/hacking/slashing/stabbing (25%), followed by multiple methods (20%), arson/burning (14%), and explosives (10%). No other method was observed in more than 10% of cases. Among individuals in the U.S. who committed mass murder without a firearm (Supplementa1 Table 6), most did so by using multiple methods (31%), followed by butchering/hacking/slashing/stabbing (20%), arson/burning (15%) and beating/bludgeoning (10%). No other method was observed in more than 10% of cases.

Percentage of Mass Murderers in Each Region with Psychotic Symptoms

We have also included the percentage of total mass murderers with a history of psychotic symptoms in each of our examined regions (Supplemental Table 7).

**Discussion**

We note that our work drew from media, police, and court reports, many of which were collected retrospectively, and that fewer details were available regarding earlier and international mass murders due to advances in media and technology over time, as well as inconsistent reporting. We also confined ourselves to articles available in English, which may have underreported mass murders in non-English-speaking countries. We acknowledge that these methods may have introduced some degree of sampling bias and limit the comprehensiveness of our dataset. To minimize such challenges, previous research has typically confined itself to mass murder cases— generally only mass shootings— in the post-1970 era in the U.S. alone. Anticipating this potential criticism, we analyzed a subset of the database, limited to post-1970 mass murders, subdivided by use of firearms and other means, in the U.S. versus other nations. We feel that this more granular examination has contributed, in potentially important ways, to what has already been established about post-1970 mass murders worldwide. This includes the finding that, in the U.S., when either psychotic or non-psychotic individuals with mental illness perpetrate a mass shooting, they tend to use semi- or fully-automatic weapons, rather than non-automatic firearms. It is presently unclear whether there is any explanation for this phenomenon, beyond cultural factors (Stone & Brucato, 2019) and wide availability of firearms in the U.S. (Reeping et al., 2019).

It is also possible that psychiatric illness was underreported or unrecognized in reports of mass murder incidents. We took several steps to help minimize potential limitations: First, we included a group of mass murderers who did not use firearms in the U.S. and worldwide. Second, we confirmed that details regarding perpetrators’ backgrounds, psychiatric histories and attacks were consistent across at least two primary sources in 98% of cases. Third, two clinicians reached consensus on the category of murder (i.e., mass vs. spree), presence of symptoms of psychiatric or neurologic illness, history of legal history, and recreational drug use and alcohol misuse.

In terms of overall psychiatric and neurologic symptoms among mass murderers, a history of psychotic symptoms was the most frequently identified (11%), with a similar number showing histories of depressive symptoms (10%). Also common were personality disorders, including paraphilic symptoms (5%). Symptoms of all other psychiatric and neurologic disorders were noted among 1% or less of mass murderers. In the overall sample, rates of non-psychotic symptoms did not significantly differ between those who committed mass murder using firearms vs. other methods, nor did recreational use of drugs or alcohol misuse. Legal history, as noted, was significantly more common among mass shooters. When the sample was isolated to only worldwide mass shootings from 1900-2019, psychotic symptoms did not distinguish perpetrators from the U.S. compared to those outside of the U.S., but perpetrators in the U.S. were significantly more likely to have histories of non-psychotic psychiatric or neurologic symptoms, recreational drug use or alcohol misuse, and legal history. When the sample was isolated to only post-1970 mass murders of any type based in the U.S., only history of psychotic symptoms distinguished those who did and did not use firearms, proving significantly more prevalent among non-shooters. Finally, when the sample was isolated to only post-1970 mass shootings based in the U.S., those who used semi- or fully-automatic firearms, as opposed to non-automatic firearms, were not only significantly more likely to have histories of psychotic symptoms, but also to have non-psychotic psychiatric or neurologic symptoms, while the opposite was true for individuals who used drugs or misused alcohol, at trend level. Here, legal history did not distinguish between groups.

There are several reasons why rates of psychotic symptoms might have been lower or higher in other reports. First, our study examined the presence of any psychotic symptoms, whereas previous research may have categorized a mass murderer as psychotic only if the individual had been given a full diagnosis of a psychotic disorder, such as schizophrenia or a delusional disorder. Second, based upon our finding that the percentage of mass murderers with psychotic symptoms in the post-1970 era was lower than the earlier era, we would expect that studies exclusively examining post-1970 cases, as has generally been the case with prior research on mass murder, would yield a lower percentage of cases characterized by psychosis. Third, given that previous research on mass murder has often confined itself to mass shootings, and in light of our finding here that firearms are associated with mass murderers who do not exhibit psychosis, we would expect different prevalence rates.

**References**

Reeping, P. M., Cerda, M., Kalesan, B., Wiebe, D. J., Galea, S., & Branas, C. C. (2019). State gun laws, gun ownership, and mass shootings in the US: cross sectional time series. *The British Medical Journal*, 364, l542. doi:10.1136/bmj.l542

Stone, M.H., & Brucato, G. (2019). The New Evil: Understanding the Emergence of Modern Violent Crime. Amherst, NY: Prometheus Books.

**Supplemental Table S1.** List of Sources of Incidents of Mass Murder

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Minimum # of Victims** | **Geographic Scope** | **Methods Examined** | **Mass Murder Type (Personal/Sponsored)** | **Period** | **Notes** |
| **Stanford Mass Shootings in America database**  *https://library.stanford.edu/projects/mass-shootings-america* | | | | | |
| 3 (not necessarily fatalities) | U.S. only | Firearms | Personal | 1966-2016 |  |
| **Stone (2015) “Mass Murder, Mental Illness and Men” Article**  *Violence and Gender, March 12, 2015, Volume 2, Issue 1* | | | | | |
| 1 | U.S. only | Any means | Personal | 1913-2015 |  |
| **Murderpedia**  *Murderpedia.org* | | | | | |
| 0\* | International | Any means | Personal and Sponsored | Begins before 1900 |  |
| **Mother Jones Database**  *https://www.motherjones.com/politics/2012/12/mass-shootings-mother-jones-full-data/* | | | | | |
| 4 (until 2012)  3 (starting Jan. 2013) | U.S. only | Firearms | Personal | 1982-Present | Min. victim count was modified to 3 beginning in Jan. 2013 with Congressional definition |
| **Everytown Report (FBI Data)**  *https://everytownresearch.org/wp-content/uploads/2015/08/MassShooting-080715-9.pdf* | | | | | |
| 4 | U.S. only | Firearms | Personal and Sponsored | 2009-2015 |  |
| **Wikipedia** | | | | | |
| List of Mass shootings in the United States  *https://en.wikipedia.org/wiki/List\_of\_mass\_shootings\_in\_the\_United\_States* | | | | | |
| 0\* | U.S. only | Firearms | Personal and Sponsored | 1922-Present |  |
| List of School Shootings in the United States by Death Toll *https://en.wikipedia.org/wiki/List\_of\_school\_shootings\_in\_the\_United\_States\_by\_death\_toll* | | | | | |
| 4 (includes perpetrator, if applicable) | U.S. only | Firearms | Personal and Sponsored | Begins before 1900 |  |
| List of Rampage Killers  *https://en.wikipedia.org/wiki/List\_of\_rampage\_killers* | | | | | |
| 2 | International | Any means | Personal and Sponsored | Begins before 1900 | Some criteria include injured victims |
| **Amok**  *https://amok.fandom.com/wiki/Amok\_Wiki* | | | | | |
| 0\* | International | Any means | Personal and Sponsored | Begins before 1900 | Some criteria include injured victims |
| **Gun Violence Archive**  *https://www.gunviolencearchive.org/* | | | | | |
| 0\* | U.S. only | Firearms | Personal and Sponsored | 2014-Present |  |
| **Lott & Moody (2019), “Is the United States an Outlier in Public Mass Shootings? A Comment on Adam Lankford.”**  *https://econjwatch.org/File+download/1106/LottMoodyMar2019.pdf?mimetype=pdf* | | | | | |
| 0\* | International | Firearms | Personal and Sponsored | 1998-2012 |  |

\*These databases included cases with zero fatalities.

**Supplemental Table 2.** Description of the Sample When Limited to the Post-1970 Era of Mass Murder in the U.S.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Overall Sample (n=734)** | | **Non-Firearm (n=159)** | | **Firearm (n=575)** | | **Difference between groups** |
| **Variable** | **n** | **Mean (SD) or %** | **n** | **Mean (SD) or %** | **n** | **Mean (SD) or %** | **p-valuea** |
| **Gender** |  |  |  |  |  |  |  |
| Male | 673 | 92% | 129 | 81% | 544 | 95% | **<.01** |
| Female | 54 | 7% | 28 | 18% | 26 | 5% | **<.01** |
| Transgender | 2 | <1% | 0 | 0% | 2 | <1% | N/A |
| Unknown | 5 | <1% | 2 | 1% | 3 | <1% | N/A |
| **Race** |  |  |  |  |  |  |  |
| Caucasian | 378 | 51% | 85 | 53% | 293 | 51% | 0.58 |
| African American | 191 | 26% | 39 | 25% | 152 | 26% | 0.63 |
| Asian/Pacific Islander | 43 | 6% | 6 | 4% | 37 | 6% | 0.21 |
| Hispanic | 79 | 11% | 22 | 14% | 57 | 10% | 0.16 |
| Native American/First Nations | 8 | 1% | 0 | 0% | 8 | 1% | N/A |
| Mixed/More Than One Race | 1 | <1% | 0 | 0% | 1 | <1% | N/A |
| Unknown | 34 | 5% | 7 | 4% | 27 | 5% | 0.88 |
| **Age** | 729 | 31.6 (11.2) | 157 | 28.7 (8.7) | 572 | 32.4 (11.6) | **<.01** |
| **Fatalities** | 734 | 5.0 (7.8) | 159 | 6.0 (14.9) | 575 | 4.7 (4.0) | 0.07 |
| **Completed Suicide at Scene** | 181 | 25% | 14 | 9% | 167 | 29% | **<.01** |
| **Perpetrator Injured at Scene** |  |  |  |  |  |  |  |
| No | 673 | 92% | 152 | 96% | 521 | 91% | **0.04** |
| Non-Fatally Injured (by Others) | 21 | 3% | 1 | <1% | 20 | 3% | N/A |
| Accidentally Non-Fatally Injured (by Self) | 10 | 1% | 5 | 3% | 5 | <1% | N/A |
| Killed (by Others) | 30 | 4% | 1 | <1% | 29 | 5% | **0.01** |
| **History of Psychotic Symptoms** | 76 | 10% | 31 | 19% | 45 | 8% | **<.01** |
| **Non-Psychotic  Psychiatric/Neurologic Symptoms** | 156 | 21% | 26 | 16% | 130 | 23% | 0.09 |
| **Recreational Drug Use/Alcohol  Misuse** | 204 | 28% | 48 | 30% | 156 | 27% | 0.45 |
| **Legal History** | 197 | 27% | 37 | 23% | 160 | 28% | 0.25 |

**a**Differences are assessed using ANOVA for continuous measures and chi-square test for categorical measures.

**N/A** Chi-square test was not a valid test due to low expected cell counts.

**Supplemental Table 3.** Multiple Logistic Regression Analysis of Predictors of Firearm Usage (N=1,221)a

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Estimate** | **Standard Error** | **p-value** |
| **Gender (ref = Female)** |  |  |  |
| Male | 1.518 | 0.261 | **<.01** |
| Transgender | 1.058 | 1.690 | 0.53 |
| Unknown | -0.341 | 1.439 | 0.81 |
| **Race (ref = Asian/Pacific Islander)** |  |  |  |
| African American | 0.806 | 0.312 | **<.01** |
| Caucasian | 0.909 | 0.258 | **<.01** |
| Hispanic | 0.560 | 0.347 | 0.11 |
| Mixed/More Than One Race | 0.908 | 1.433 | 0.53 |
| Native American/First Nations | 1.935 | 1.224 | 0.11 |
| Unknown | 1.300 | 0.525 | **0.01** |
| **Age** | 0.006 | 0.007 | 0.39 |
| **Location (ref = Asia)** |  |  |  |
| Africa | 0.100 | 0.536 | 0.85 |
| Australia or New Zealand | -0.040 | 0.442 | 0.93 |
| Canada | 0.403 | 0.479 | 0.40 |
| Europe | 0.120 | 0.322 | 0.71 |
| Mexico/Central America | 0.332 | 0.954 | 0.73 |
| Mid-Travel between Regions | 0.085 | 0.726 | 0.91 |
| South America | 1.005 | 0.713 | 0.16 |
| U.S. | 1.201 | 0.273 | **<.01** |
| **Fatalities** | -0.048 | 0.012 | **<.01** |
| **Completed Suicide at Scene** | 0.987 | 0.182 | **<.01** |
| **Perpetrator Injured at Scene (ref = No)** |  |  |  |
| Accidentally Non-Fatally Injured (by Self) | -1.097 | 0.574 | 0.06 |
| Non-Fatally Injured (by Others) | 1.353 | 0.571 | **0.02** |
| Killed (by Others) | 1.737 | 0.468 | **<.01** |
| **History of Psychotic Symptoms** | -0.722 | 0.213 | **<.01** |
| **Non-Psychotic Psychiatric/Neurologic Symptoms** | 0.007 | 0.192 | 0.97 |
| **Recreational Drug Use/Alcohol Misuse** | -0.165 | 0.175 | 0.35 |
| **Legal History** | 0.099 | 0.186 | 0.60 |
| **Year** | 0.011 | 0.003 | **<.01** |

a The number of observations used in the regression analysis is less than the total N=1,315 due to missing data and listwise deletion.

**Supplemental Table 4.** Description of Worldwide Mass Shootings Post-1970

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Overall Mass Shooting Sample (n=565)** | | **Non-Automatic (n=287)** | | **Semi- or Fully-Automatic + Both (n=278)** | | **Difference between groups** |
| **Variable** | **n** | **Mean (SD) or %** | **n** | **Mean (SD) or %** | **n** | **Mean (SD) or %** | **p-valuea** |
| **Gender** |  |  |  |  |  |  |  |
| Male | 537 | 95% | 270 | 94% | 267 | 96% | 0.28 |
| Female | 25 | 4% | 14 | 5% | 11 | 4% | 0.59 |
| Transgender | 2 | <1% | 2 | <1% | 0 | 0% | N/A |
| Unknown | 1 | <1% | 1 | <1% | 0 | 0% | N/A |
| **Race** |  |  |  |  |  |  |  |
| Caucasian | 314 | 56% | 158 | 55% | 156 | 56% | 0.80 |
| African American | 112 | 20% | 67 | 23% | 45 | 16% | **0.03** |
| Asian/Pacific Islander | 57 | 10% | 18 | 6% | 39 | 14% | **<.01** |
| Hispanic | 55 | 10% | 29 | 10% | 26 | 9% | 0.76 |
| Native American/First Nations | 6 | 1% | 3 | 1% | 3 | 1% | N/A |
| Mixed/More Than One Race | 2 | <1% | 1 | <1% | 1 | <1% | N/A |
| Unknown | 19 | 3% | 11 | 4% | 8 | 3% | 0.53 |
| **Age** | 547 | 31.8 (11.7) | 285 | 32.4 (12.0) | 262 | 31.1 (11.3) | 0.21 |
| **Location** |  |  |  |  |  |  |  |
| U.S. | 431 | 76% | 245 | 85% | 186 | 67% | **<.01** |
| Canada | 10 | 2% | 5 | 2% | 5 | 2% | N/A |
| Mexico/Central America | 2 | <1% | 1 | <1% | 1 | <1% | N/A |
| Africa | 11 | 2% | 3 | 1% | 8 | 3% | 0.12 |
| Asia | 47 | 8% | 6 | 2% | 41 | 15% | **<.01** |
| Australia or New Zealand | 10 | 2% | 7 | 2% | 3 | 1% | N/A |
| Europe | 43 | 8% | 15 | 5% | 28 | 10% | **0.03** |
| South America | 9 | 2% | 4 | 1% | 5 | 2% | N/A |
| Mid-Travel between Regions | 2 | <1% | 1 | <1% | 1 | <1% | N/A |
| **Fatalities** | 565 | 5.6 (4.8) | 287 | 4.8 (3.7) | 278 | 6.4 (5.6) | **<.01** |
| **Completed Suicide at Scene** | 161 | 28% | 69 | 24% | 92 | 33% | **0.02** |
| **Perpetrator Injured at Scene** |  |  |  |  |  |  |  |
| No | 502 | 89% | 262 | 91% | 240 | 86% | 0.06 |
| Non-Fatally Injured (by Others) | 22 | 4% | 10 | 3% | 12 | 4% | 0.61 |
| Accidentally Non-Fatally Injured (by Self) | 3 | <1% | 1 | <1% | 2 | <1% | N/A |
| Killed (by Others) | 38 | 7% | 14 | 5% | 24 | 9% | 0.07 |
| **History of Psychotic Symptoms** | 49 | 9% | 22 | 8% | 27 | 10% | 0.39 |
| **Non-Psychotic  Psychiatric/Neurologic Symptoms** | 134 | 24% | 60 | 21% | 74 | 27% | 0.11 |
| **Recreational Drug Use/Alcohol  Misuse** | 145 | 26% | 83 | 29% | 62 | 22% | 0.07 |
| **Legal History** | 130 | 23% | 71 | 25% | 59 | 21% | 0.32 |

**a**Differences are assessed using ANOVA for continuous measures and chi-square test for categorical measures.

**N/A** Chi-square test was not a valid test due to low expected cell counts.

**Supplemental Table 5.** Methods of Non-Firearm-Associated Mass Murder for the Entire Sample, 1900-2019

|  |  |
| --- | --- |
| **Method** | **Frequency (N=460) [%]** |
| **Butchering/Hacking/Slashing/Stabbing** | 113 [25%] |
| **Multiple (Primarily Involving Stabbing/Slashing and Another Method)** | 91 [20%] |
| **Arson/Burning** | 64 [14%] |
| **Explosives** | 44 [10%] |
| **Beating/Bludgeoning** | 38 [8%] |
| **Axing** | 22 [5%] |
| **Intentionally Driving Vehicle into People/Intentionally Crashing Vehicle** | 22 [5%] |
| **Strangling/Garroting/Hanging** | 16 [3%] |
| **Poisoning** | 15 [3%] |
| **Intentionally Crashing Aircraft** | 9 [2%] |
| **Drowning** | 9 [2%] |
| **Gassing by Carbon Monoxide** | 6 [1%] |
| **Suffocating/Smothering** | 4 [<1%] |
| **Cutting Throat (s)** | 5 [<1%] |
| **Starving** | 1 [<1%] |
| **Throwing from Heights** | 1 [<1%] |

**Supplemental Table 6.** Methods of Non-Firearm Associated Mass Murder for the U.S.

|  |  |
| --- | --- |
| **Method** | **Frequency (N=198) [%]** |
| **Multiple (Primarily Involving Stabbing/Slashing and Another Method)** | 61 [31%] |
| **Butchering/Hacking/Slashing/Stabbing** | 39 [20%] |
| **Arson/Burning** | 29 [15%] |
| **Beating/Bludgeoning** | 19 [10%] |
| **Strangling/Garroting/Hanging** | 12 [6%] |
| **Intentionally Driving Vehicle into People/Intentionally Crashing Vehicle** | 10 [5%] |
| **Explosives** | 7 [4%] |
| **Drowning** | 6 [3%] |
| **Gassing by Carbon Monoxide** | 5 [3%] |
| **Suffocating/Smothering** | 4 [2%] |
| **Axing** | 2 [1%] |
| **Poisoning** | 2 [1%] |
| **Starving** | 1 [<1%] |
| **Throwing from Heights** | 1 [<1%] |
| **Intentionally Crashing Aircraft** | 0 [0%] |
| **Cutting Throat (s)** | 0 [0%] |

**Supplemental Table 7.** Percentage of Mass Murderers in Each Region with Psychotic Symptoms.

|  |  |  |
| --- | --- | --- |
| **Geographic**  **Region** | **Total Number of Mass Murders** | **Percentage of Mass Murders with History of Psychotic Symptoms** |
| U.S. | 824 | N=92 (11.2%) |
| Canada | 30 | N=9 (30%) |
| Mexico/Central America | 8 | N=0 (0%) |
| Africa | 33 | N=3 (9.1%) |
| Asia | 200 | N=18 (9.0%) |
| Australia or New Zealand | 37 | N=5 (13.5%) |
| Europe | 143 | N=24 (16.8%) |
| South America | 21 | N=0 (0%) |
| Mid-travel between different regions | 19 | N=0 (0%) |

**Supplemental Figure 1**. Flow Diagram of Search Results of Potential and Final Incidents of Mass and Spree Murder.

**Supplemental Figure 2.** Across Type Comparison of the Percentage of Mass Murderers with a History of Psychotic Symptoms by Epoch and Location. The percentages of mass murderers with a history of psychotic symptoms are: Pre-1970, Non-U.S. Firearm 14.58, Non-Firearm 23.08; Pre-1970, U.S. Firearm 13.73, Non-Firearm 23.08; Post-1970, Non-U.S. Firearm 5.52, Non-Firearm 13.71; Post-1970, U.S. Firearm 7.83, Non-Firearm 19.50.