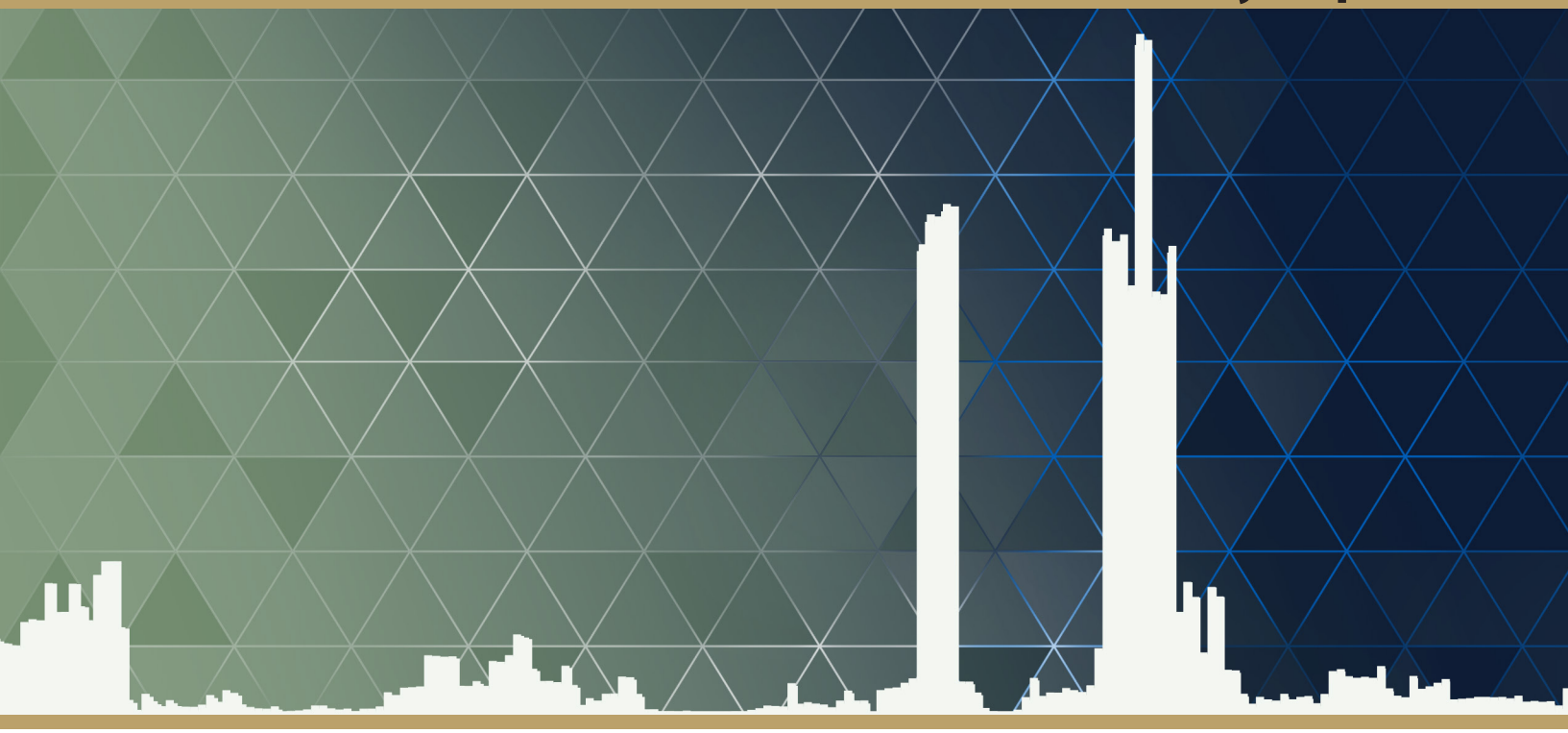
# WARTIME FATALITIES
## IN THE NUCLEAR ERA

**National Security Report**



Lauren Ice | James Scouras | Edward Toton

APL
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

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Lauren Ice

James Scouras

Edward Toton

JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

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This version includes minor stylistic text changes and is organized differently (with appendix material incorporated in the main text).

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Figure 1. The G.I. Joe Chart. Original source unknown; authors believe chart was produced before or during 1998.

Figure 2. U.S. Nuclear Policy in the 21st Century (1998) Wartime Fatalities Chart. From Robert Joseph and Ronald Lehman, project directors, *U.S. Nuclear Policy in the 21st Century: A Fresh Look at National Strategy and Requirements, Final Report* (Washington, DC: Center for Counterproliferation Research, National Defense University; Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 1998).

Figure 3. 2018 *Nuclear Posture Review* Figure. Office of the Secretary of Defense, *Nuclear Posture Review* (Washington, DC: US Department of Defense, 2018).

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## Summary

Senior leaders in the US Department of Defense, as well as nuclear strategists and academics, have argued that the advent of nuclear weapons is associated with a dramatic decrease in wartime fatalities. This assessment is often supported by an evolving series of figures that show a marked drop in wartime fatalities as a percentage of world population after 1945 to levels well below those of the prior centuries. The goal of this report is not to ascertain whether nuclear weapons are associated with or have led to a decrease in wartime fatalities, but rather to critique the supporting statistical evidence. We assess these wartime fatality figures and find that they are both irreproducible and misleading. We perform a more rigorous and traceable analysis and discover that post-1945 wartime fatalities as a percentage of world population are consistent with those of many other historical periods.

The strategy of nuclear deterrence has an inescapable inherent risk. So long as nuclear weapons exist, the world gambles that deterrence of nuclear war will not fail; conventional wars will not escalate to nuclear wars; substate actors will not come into possession of nuclear devices; and false alarms, miscommunications, and technical malfunctions will not lead to accidental use. Any nuclear use could escalate to unconstrained nuclear warfare, which would be devastating to humanity and much of life on earth for generations.

At the same time, however, some nuclear strategists and senior defense officials have argued that the prospect of nuclear devastation has deterred wars among great powers with a concomitant reduction in wartime fatalities compared with the centuries preceding the advent of nuclear weapons, most notably compared with the world wars of the twentieth century. As do all arguments that seek to influence US nuclear policy, this merits close analytic scrutiny.

Analysts have studied wartime fatalities over time for evidence that the specter of nuclear war has deterred conventional wars. One particular histogram of wartime fatalities produced in the late 1990s has been especially influential in the defense community. This figure depicts wartime fatalities, normalized by world population, from the end of the Second World War to the 1990s as unprecedentedly low compared with all other time periods since the year 1600. The figure and derivative versions it has inspired have been used to illustrate this suggested benefit of nuclear weapons, with the most recent use in the 2018 *Nuclear Posture Review* (NPR) by the Office of the Secretary of Defense (OSD).[1] Because of the influence of these figures in the defense community, it is important that their analytic basis is understood and either verified or refuted.

Thus, the goal of this report is neither to analyze the ability of nuclear weapons to effectively deter conventional warfare nor to determine whether a causal link exists between the advent of nuclear weapons and a decrease in wartime fatalities. Rather, our goal is to assess these histograms of wartime fatalities and the statistical analysis on which they are based. These histograms have been invoked by some to support the argument that nuclear weapons have reduced wartime fatalities and regardless of whether this conclusion is valid, it is undermined by the fundamental errors in the supporting histograms.

We begin with a discussion of the original figure at issue and how it has been used and transformed over the years. Next, we attempt to reproduce the original figure by using the cited data sources, only to find it irreproducible and the presentation of the results misleading. In addition, we assess the most recent variant of the figure used in the 2018 NPR and find similar analytical errors as the original.[2]

In the latter sections of the report, we present a more rigorous and traceable analysis of wartime fatality statistics and observe that wartime fatalities after World War II are consistent with those of many historical periods since the year 1600. Last, we discuss the validity of conclusions that can

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[1] Office of the Secretary of Defense, *Nuclear Posture Review* (Washington, DC: US Department of Defense, 2018).

[2] An earlier perspective criticizing the NPR figure in the context of residual risk of nuclear war and risk acceptance is found in James Scouras, "Nuclear War as a Global Catastrophic Risk," *Journal of Benefit-Cost Analysis* 10, no. 2 (2019): 274–295.

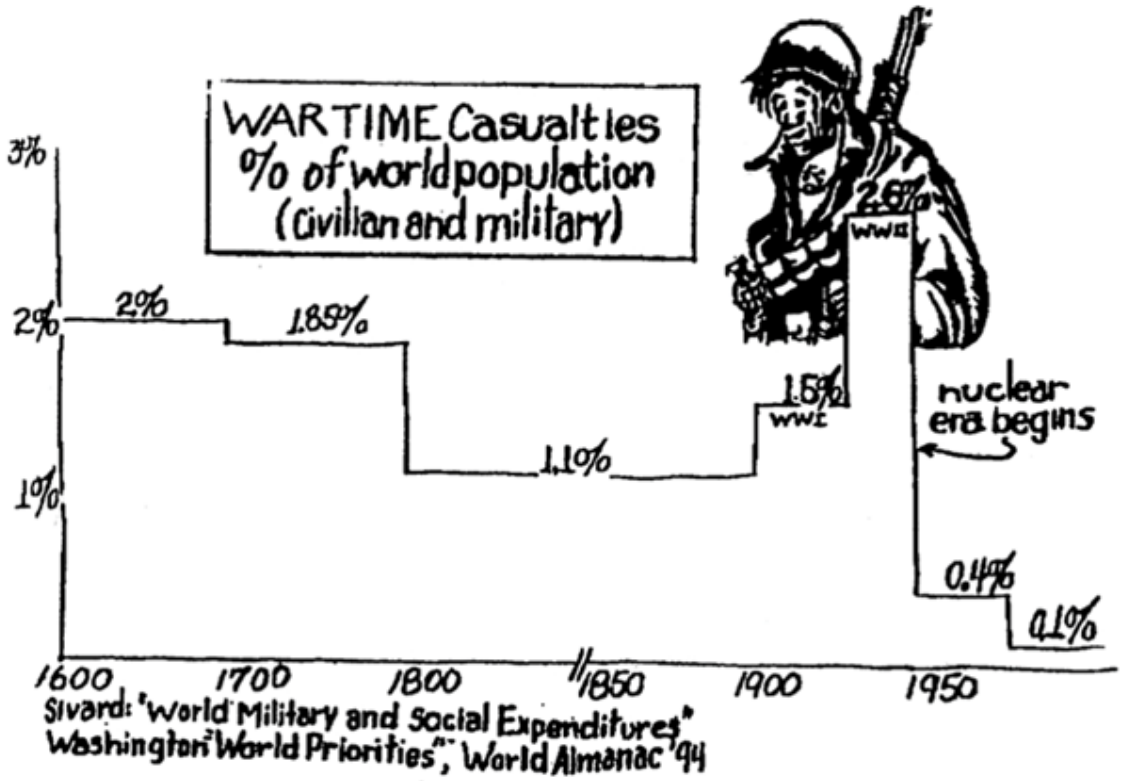



**Figure 1. The G.I. Joe Chart**

be drawn from these histograms. How nuclear deterrence has affected conventional warfare cannot be determined from statistical analyses of wartime fatalities alone.

## The "G.I. Joe" Chart: Evolution and Use

Wartime fatalities in the nuclear era compared to those in earlier eras are quantified in various versions of a histogram of wartime fatalities, normalized by world population, spanning 1600 to the late twentieth century. The earliest known (to the authors of this report) version of this histogram is shown in Figure 1. While we have not been able to find this exact figure in published literature, for reasons we articulate later in this report, we believe it was produced before or during 1998 and provides the template for all later versions.

In this report, we will refer to this version as the "G.I. Joe" chart because of the Bill Mauldin cartoon of infantryman Joe that appears in the figure above the interval for World War II.[3] The data sources that were used to produce this figure are *The World Almanac and Book of Facts 1994*,[4] which provides data for the world population, and "Sivard: 'World Military and Social Expenditures,'" which is taken to refer to Ruth Leger Sivard's *World Military and Social Expenditures* reports,[5] some of which include tables of "War and War-Related Deaths." Because Sivard's reports only provide data for war-related fatalities, we conclude that the G.I. Joe chart actually shows wartime fatalities, not casualties as stated in its title. In the Assessment of the G.I. Joe

[3] Bill Mauldin, *Stars and Stripes*, June 21, 1944, Mediterranean edition.

[4] Robert Famighetti, ed., *The World Almanac and Book of Facts 1994* (Mahwah, NJ: World Almanac, 1993), 828.

[5] Ruth Leger Sivard, *World Military and Social Expenditures* (Washington DC: World Priorities, 1974, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1985, 1986, 1987–1988, 1989, 1991, 1993, 1996).

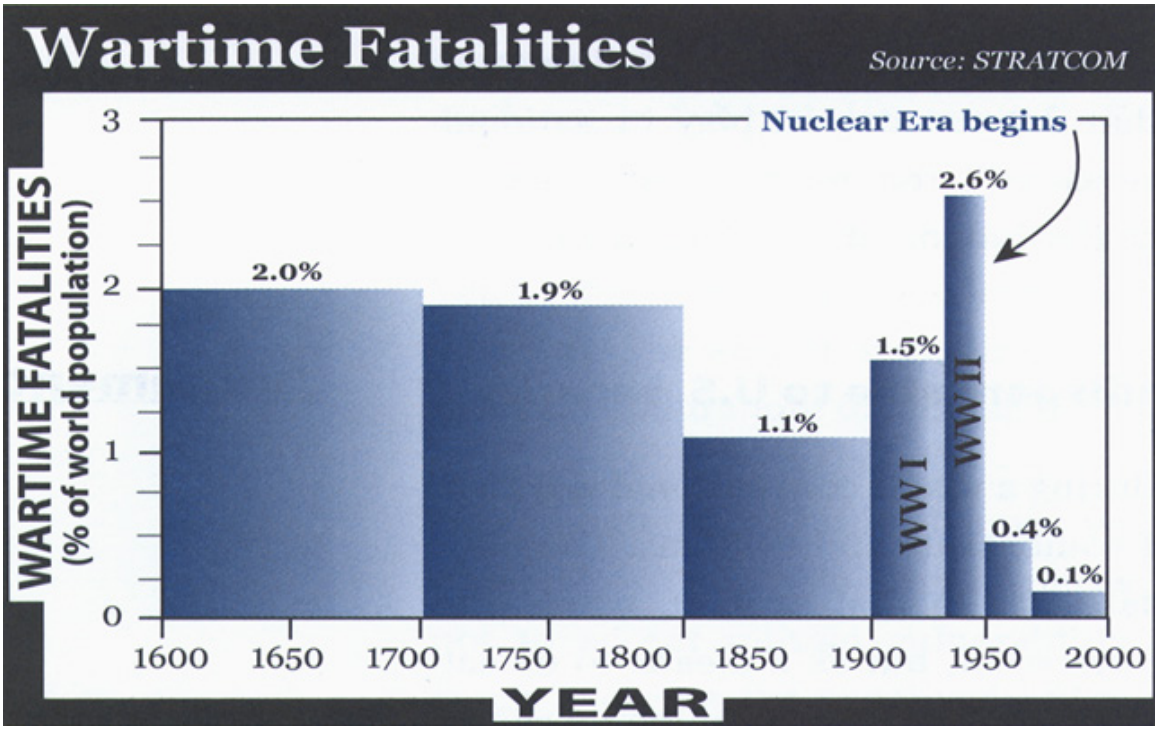



**Figure 2. U.S. Nuclear Policy in the 21st Century (1998) Wartime Fatalities Chart**

Chart section, we thoroughly explore these data sources and how the G.I. Joe chart was created.

A derivative version of the G.I. Joe chart, produced at USSTRATCOM, appeared in *U.S. Nuclear Policy in the 21st Century*,[6] which was published by the Center for Counterproliferation Research at National Defense University and the Center for Global Security Research at Lawrence Livermore National Laboratory in 1998, and is reproduced in Figure 2. This figure appeared with the caption "Wartime fatalities as a percentage of population have declined significantly in the 50 years since the nuclear era began." This figure has striking similarities to the G.I. Joe chart, which leads us to conclude this is a computer-rendered recreation of the G.I. Joe chart rather than a new analysis. Similarities between the figures include the choice of intervals for each bin and the resulting wartime fatality percentages. Additionally, the titles and labels are similarly worded, with the exception of the replacement of the word *Casualties* with *Fatalities*.

We believe the G.I. Joe chart preceded Figure 2 for several reasons. First, Figure 2 includes the correction in the title. Second, it seems implausible that someone would take a computer-rendered figure and subsequently sketch it out by hand. Third, the G.I. Joe chart cites the 1994 version of the *World Almanac* as the source for world population data, which suggests it was produced around this date. Fourth, the G.I. Joe chart includes a citation of the data sources used to produce the figure, whereas Figure 2 and the report it was published in do not. Fifth, and most convincingly, the G.I. Joe chart reports 1.85 percent for the eighteenth century, while Figure 2 rounds this to 1.9 percent.

There are several differences between the G.I. Joe chart and Figure 2. The first is that tick marks have been added to the axes; however, the *x* axis ticks

[6] Robert Joseph and Ronald Lehman, project directors, *U.S. Nuclear Policy in the 21st Century: A Fresh Look at National Strategy and Requirements, Final Report* (Washington, DC: Center for Counterproliferation Research, National Defense University; Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 1998).

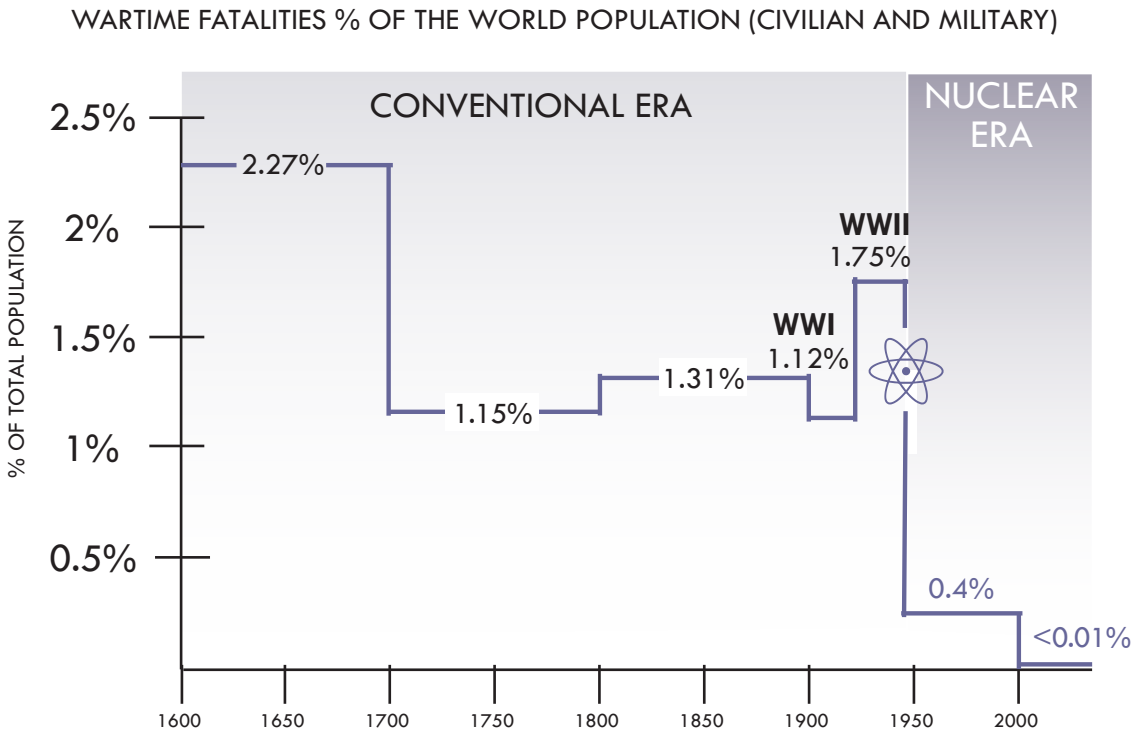



Figure 2. Wartime Fatalities Percentage of World Population
*Data from the DoD Historical Office*

**Figure 3. 2018 *Nuclear Posture Review* Figure**

are not evenly spaced, and how they correlate to the axis's year labels is not clear. The tick marks also reveal that the last bin in Figure 2 extends to the year 2000.[7] Because the height of the bin remains unchanged, we believe that the last bin was extended to 2000 yet still labeled with the same percentage (0.1 percent).[8]

Between 2006 and 2014, new versions of this histogram appeared in the published literature.[9] These subsequent versions all appear to be simple reproductions of the G.I. Joe chart with minor artificial changes, most notably the addition of two bins, one between the world wars and the other after World War II. However, these appear to be added without consideration of how additional bins should change the heights of the neighboring bins. Similarly, in all the derivative versions, the last bin has been extended to the year 2000[10] in an artificial manner, without including additional wartime fatality or world population data.

In 2018, a wartime fatalities histogram with many similarities to Figure 1 and Figure 2 appeared in

[7] Although it is not clear from Figure 1, we have concluded that the last bin in the G.I. Joe chart includes data through 1990. This is discussed further in the Assessment of the G.I. Joe Chart section.

[8] Alternatively, the bin could have been recalculated using an extended database of wartime fatalities up to the year 2000, and the change in the midpoint population could have caused the last bin to have the same (to one significant figure) wartime fatality percentage.

[9] Richard Mies, "US Nuclear Threat Can Enhance Stability," *APS News* 15, no. 6 (2006): Back Page, https://www.aps.org/publications/apsnews/200606/backpage.cfm; Richard Mies, "Strategic Deterrence in the 21st Century," *Undersea Warfare* no. 48 (2012): 12–19; Richard Mies, "Strategic Deterrence in the 21st Century," *National Security Science* (2013): 42–51; and Keith B. Payne and James Schlesinger, "Minimum Deterrence: Examining the Evidence," *Comparative Strategy* 33, no. 1 (2014): 2–103.

[10] The War and War-Related Death tables in *World Military and Social Expenditures* only provide data through 1995.

the NPR.[11] The figure from this report is reproduced here as Figure 3. In conjunction with the figure, the NPR text included the statement, "Since the introduction of U.S. nuclear deterrence, U.S. nuclear capabilities have made essential contributions to the deterrence of nuclear and non-nuclear aggression. The subsequent absence of Great Power conflict has coincided with a dramatic and sustained reduction in the number of lives lost to war globally." The NPR figure shows some striking similarities to the G.I. Joe chart, such as one-hundred-year intervals between 1600 and 1900 and smaller intervals during the twentieth century, as well as similar wording in the histogram titles and axis labels. However, the resulting wartime fatality percentages are markedly different—an indication that an alternative data source was used for wartime fatalities and/or world population. The similarities between the structures of the figures and the differences in the resulting percentages are discussed in detail in the Assessment of the 2018 NPR Figure section.

It is important to note that these figures are not just being used to compare the nuclear era with the world wars. The use of these figures, whose data representations span four centuries, suggests that the argument being made is that wartime fatalities as a percentage of world population in the nuclear era are lower compared with those of all other eras since 1600. This claim is also supported by the accompanying text in some of the articles in which these figures appear.

Furthermore, while some authors are careful to not claim that these figures *prove* that the advent of nuclear weapons has caused a decrease in wartime fatalities, the figures and accompanying text indicate that this is the argument being made. These figures have been reused and this sentiment has been echoed in other documents and presentations,[12] reinforcing the importance of a meticulous critique of the histograms and the conclusions drawn from them.

## Assessing the Validity of the G.I. Joe and the NPR Histograms

The goal of this section is to examine, understand, and either validate or refute the G.I. Joe chart and the NPR figure. First, we discuss the data sources used to create the G.I. Joe chart and attempt to reproduce it. We repeat this process for the NPR figure and discuss the similarities and differences between the G.I. Joe chart and the NPR figure. Finally, we critique the representation of the data in both the G.I. Joe chart and the NPR figure and discuss the merits of uniform bin sizes in histograms.

### Assessment of the G.I. Joe Chart

In this subsection, we describe our unsuccessful attempts to recreate the G.I. Joe chart using its original bin structure and cited data sources. For fatality data, the caption of the G.I. Joe chart leads us to reports titled *World Military and Social Expenditures* by Ruth Leger Sivard and published by her nonprofit organization, World Priorities. After leaving her position as a high-ranking economist for the US Arms Control and Disarmament Agency in 1972,[13] Sivard published sixteen editions

[11] Office of the Secretary of Defense, *Nuclear Posture Review*, 17.

[12] Jim Garamone, "Stratcom Commander Makes Case for Modernizing Nuclear Triad," *DoD News, Defense Media Activity*, March 31, 2017; "Is 'Zero' Really a Great Idea?" *Air Force Magazine* 97, no. 1 (January 2014); and Clark A. Murdock, *The Department of Defense and the Nuclear Mission in the 21st Century: A Beyond Goldwater-Nichols Phase 4 Report* (Washington, DC: Center for Strategic and International Studies, March 2008).

[13] Sivard started publishing reports on comparative social and military spending at the Arms Control and Disamament Agency in the 1960s. However, her reports were discontinued in 1972 after Melvin R. Laird, secretary of defense under President Nixon, complained to President Nixon that her reports were complicating the Pentagon's task of presenting the defense budget to Congress (Robert Smith, "Laird Says Arms Agency Understates Soviet Data," *New York Times*, June 9, 1970).

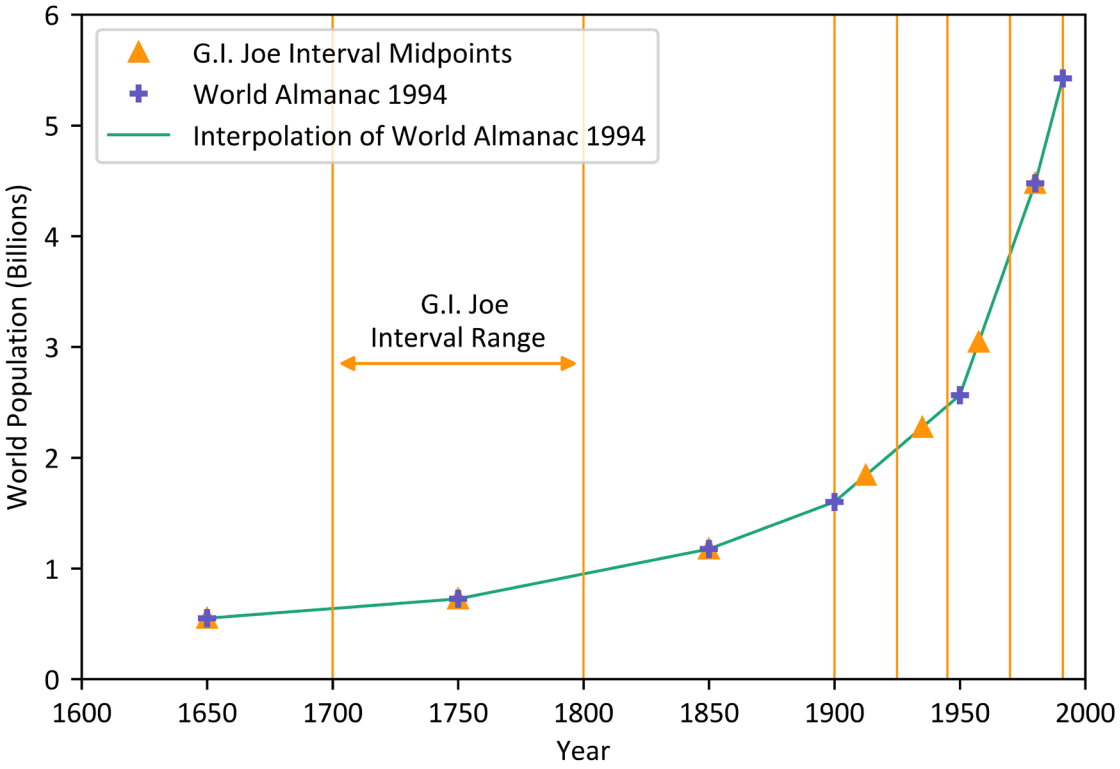



**Figure 4. World Population Estimates Used in the Reproduction of the G.I. Joe Chart**

of these reports from 1974 to 1996, nine of which included tables titled "War and War-Related Deaths." The fourteenth edition provides wartime fatalities over the longest period of time, from 1500 to 1990.[14] The sixteenth edition includes War and War-Related Deaths tables covering the years 1900 to 1995[15] and provides a five-year extension to the data. The yearly fatality rates, as determined using the combined fourteenth and sixteenth editions of *World Military and Social Expenditures*, are shown in blue in Figure 6 and Figure 9.

The War and War-Related Deaths tables in the *World Military and Social Expenditures* reports define war as "any armed conflict involving one or more governments and causing the death of 1,000 or more people per year" and provide the war's name, start and end dates, and number of civilian, military, and total fatalities. The data are geographically organized by the country where the main battle took place, with the exception of large international wars, in which case battle deaths are listed under the participating nation.

Turning to population data, the G.I. Joe chart cites the source of world population data used in the histogram as *The World Almanac and Book of Facts 1994*.[16] In this volume, world population is provided for seven dates between 1650 and 1993. The sources of the data are given as Rand McNally and Co. for data up to 1950 and the Bureau of the Census, US Department of Commerce, for data after 1950. The *World Almanac* world population data are shown with the purple marker in Figure 4.

To calculate the number of wartime fatalities as a percentage of world population, we have taken what we believe to be the same approach used to create the G.I. Joe chart. First, we closely examined the G.I. Joe chart to estimate bin boundaries, which we determined to be approximately 1601–1700,

[14] Sivard (1991).

[15] Sivard (1996).

[16] Famighetti, *World Almanac*, 828.

1701–1800, 1801–1900, 1901–1925, 1926–1945, 1946–1970, and 1971–1990.[17] Using these bin ranges, we calculated the sum of war-related deaths from *World Military and Social Expenditures 1991* for each bin. For wars that took place over a time span that crossed a bin boundary, we assumed that the war-related deaths were evenly distributed over the time span of the war. We then divided the sum of the war-related deaths by the world population at the midpoint of the bin. For the first three intervals, 1601 to 1700, 1701 to 1800, and 1801 to 1900, the *World Almanac 1994* provided the world population for the bin midpoint. To determine the world population at the midpoint for later intervals, we used a linear interpolation. The vertical orange lines and orange triangles in Figure 4 are placed at the G.I. Joe chart bin edges and bin midpoints, respectively. The green line shows the linear interpolation of the *World Almanac 1994* data.

Making the simplistic calculation described above, we attempted to reproduce the G.I. Joe histogram but found that it is not reproducible. Our attempted reproduction is shown in Figure 5 (lower) along with the original G.I. Joe chart for comparison. We have kept the same interval ranges so the two charts can be more readily compared; however, the intervals in the two charts do not line up because the reproduction uses a linear *x* axis. To help guide the eye, we added red lines to connect the interval ranges between the two figures. While there is relatively good agreement after 1900, we see a large discrepancy between the G.I. Joe chart and the reproduction in earlier centuries.

We have made several assumptions in our attempts to recreate the G.I. Joe figure, including that wartime fatalities are uniformly distributed over each war. In an attempt to reconcile the G.I Joe chart and our reproduction, we tried to relax this assumption by assigning all fatalities in each war to the first year, the midpoint, or the last year of each war. However, we find that changes in the temporal distribution of deaths over the war period produce only minute changes in the wartime fatality percentages—changes that are too small to bring the two figures into agreement.

We also assumed how the normalization by world population was determined. It is unclear from the G.I. Joe chart which year in each bin interval was used to determine the world population for that interval. In our reproduction, we assumed that fatalities are normalized by world population at the bin's midpoint. We explored several alternatives by normalizing by the world population for the years corresponding to the bin edges (the beginning of the interval, the end of the interval, and the average of the two). Additionally, we calculated the wartime fatality percentage on a yearly basis, by dividing the yearly sum of wartime fatalities by the population estimated for each year using the interpolation. We then binned these percentages into the intervals in the G.I. Joe chart. These alternative normalizations, however, cannot reconcile the discrepancies between the two figures because the reproduction does not result in wartime fatality percentages that are consistently either too high or low for all bins: the reproduced percentages are lower than the G.I. Joe percentages for the seventeenth and eighteenth centuries but higher for the nineteenth century, as shown in Figure 5. However, the alternative normalizations all result in a unidirectional shift in the reconstructed wartime fatality percentages over all bins.

Last, we do not know whether the G.I. Joe chart was created using only the fourteenth edition of *World Military and Social Expenditures*, which provided war-related death data through 1990, or whether it was extended to 1995 using the sixteenth edition. To understand the effect of this difference, we attempted to recreate the G.I. Joe chart using both options. Adding the sixteenth edition only

[17] It is unclear from the G.I. Joe chart whether the last bin ends at 1990 or was extended to 1995 using the data provided in the sixteenth edition of *World Military and Social Expenditures*.

affected the last bin of the reproduction, increasing the height of this bin to 0.27 percent.

## Assessment of the 2018 NPR Figure

The 2018 NPR figure shows some striking similarities to the G.I. Joe chart while revealing calculated percentages of wartime fatalities to be significantly different. Unlike the other G.I. Joe chart descendants, which we believe to be mainly artistic manipulations of the original, the NPR figure was produced with an independent analysis utilizing different data sources. However, we argue that the NPR figure was heavily influenced by the G.I. Joe chart and bears many of the same features and flaws.

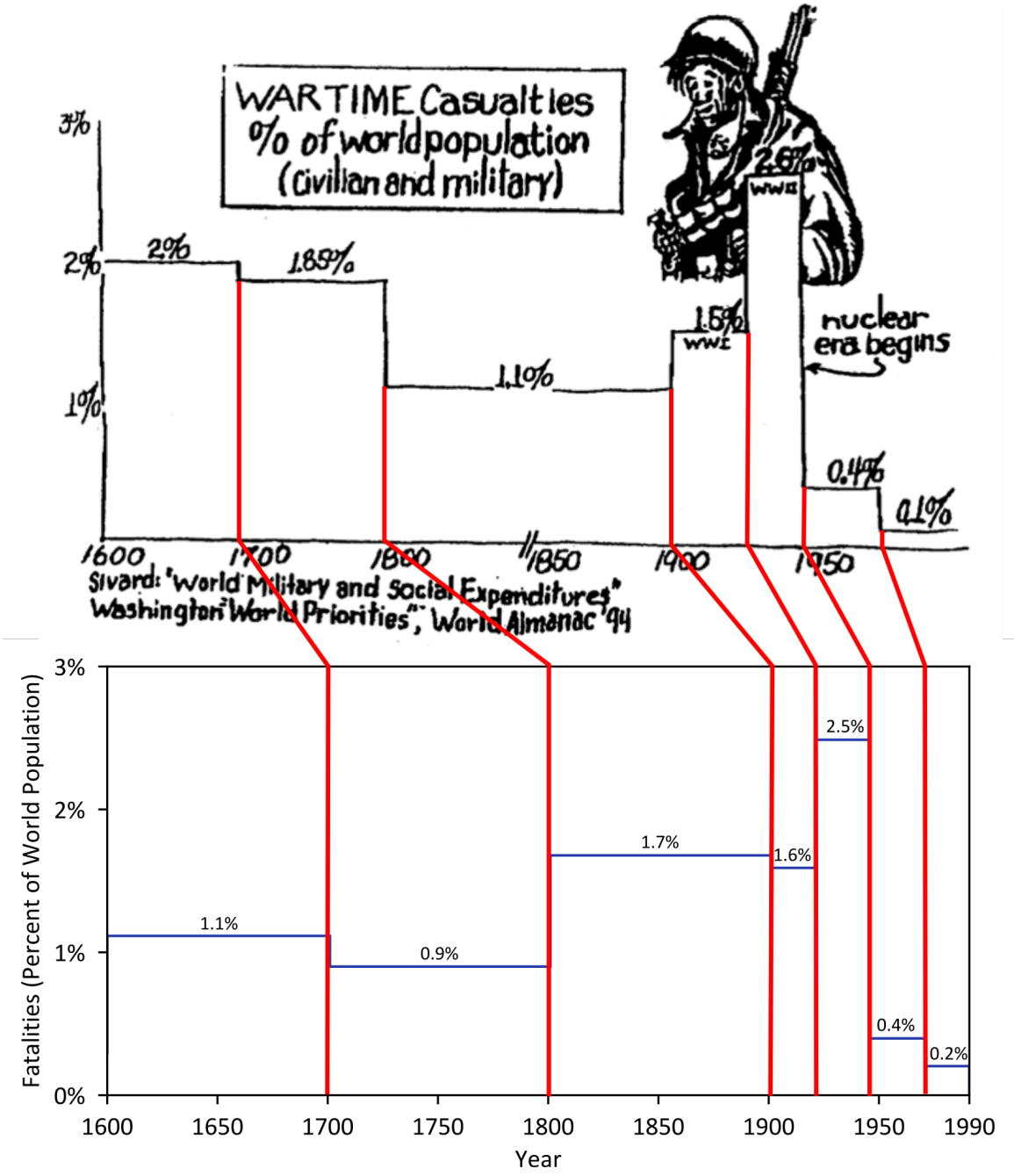



**Figure 5. Reproduction of the G.I. Joe Chart Using the Cited Data**

There are notable similarities between the G.I. Joe and NPR figures. First, both figures show wartime fatalities as a percentage of the world population (civilian and military). The titles are almost identical with the exception of the NPR figure's correction of *Casualties* to *Fatalities*. In addition, both figures highlight a clear demarcation at the beginning of the nuclear era. Other similarities are the time period over which percentages are determined and the choice of irregular histogram bin widths. Last, and most importantly, both figures show a dramatic decline in wartime fatalities as a percentage of world population during the nuclear era compared with all earlier eras.

The substantial differences in the resulting percentages between the figures stem from the use of different data sources for wartime fatalities and world population. Through email correspondence[18] with the OSD Historical Office, we have learned that the data sources used were Peter Brecke's Conflict Catalog,[19] "with some additional verification from Ruth Sivard's *World Military and Social Expenditures*, 1996." The OSD Historical Office also informed us that the world population data were from the History Database of the Global Environment (HYDE)[20] and that to normalize the wartime fatalities, they "averaged world population at the beginning of each period with the world population at the end of each period."[21]

With the information provided by the OSD Historical Office, we reproduced the NPR figure with our best estimates of the NPR interval ranges. Because of the NPR figure's formatting, we are uncertain of the exact interval ranges used in calculating the percentages. From examination of the NPR figure, we conclude that the bins are approximately 1601–1700, 1701–1800, 1801–1900, 1901–1920, 1921–1945, 1946–1999, and 2000–2017. The width of the last bin is very difficult to determine. However, because the NPR was published in early 2018, the last bin cannot extend past 2017.

The Conflict Catalog is a publicly available wartime fatality database developed by Peter Brecke. The database gives military and civilian death statistics from violent conflicts with over thirty-two fatalities per year between AD 1400 and AD 1999 and provides conflict start and end dates. The NPR figure shows the wartime fatality percentage to the present day; however, the two sources given, *World Military and Social Expenditures 1996* and the Conflict Catalog, only provide fatality data through 1995 and 1999, respectively. Therefore, we believe the authors of the NPR figure extended their analysis with another database. We found only one database of wartime fatalities that extends past 2010: the Uppsala Conflict Data Program (UCDP), which publishes war-related fatality statistics from 1989 to the present. A comparison of the yearly fatalities from the three databases (*World Military and Social Expenditures*, Conflict Catalog, and UCDP) is shown in Figure 6. For the years where the three data sets overlap, there are substantial differences in the fatality numbers. These differences stem from variations in coding practices (how war and war-related deaths are defined), verification requirements (how the number of fatalities is determined and verified), and sources. Because of these large variations, concatenating one database with another can lead to false structures in results. This phenomenon is discussed further in the Wartime Fatality Databases section. Because UCDP is significantly inconsistent with the other

[18] Email exchange with Glen Asner, deputy chief historian at the OSD Historical Office, March 2, 2018.

[19] For a description of the Conflict Catalog, see Peter Brecke, "Violent Conflicts 1400 A.D. to the Present in Different Regions of the World" (paper presented at the Peace Science Society 1999 Meeting, Ann Arbor, MI, October 1999). The catalog is available as an Excel file that can be downloaded from http://www.cgeh.nl/sites/default/files/Conflict Catalog 18 vars.xls.

[20] Kees Klein Goldewijk, Arthur Beusen, Gerard van Drecht, and Martine de Vos, "The HYDE 3.1 Spatially Explicit Database of Human-Induced Land-Use Change Over the Past 12,000 Years," *Global Ecology and Biogeography* 20, no. 1 (2010): 73–86, https://doi.org/10.1111/j.1466-8238.2010.00587.x.

[21] Email exchange with the OSD Historical Office.

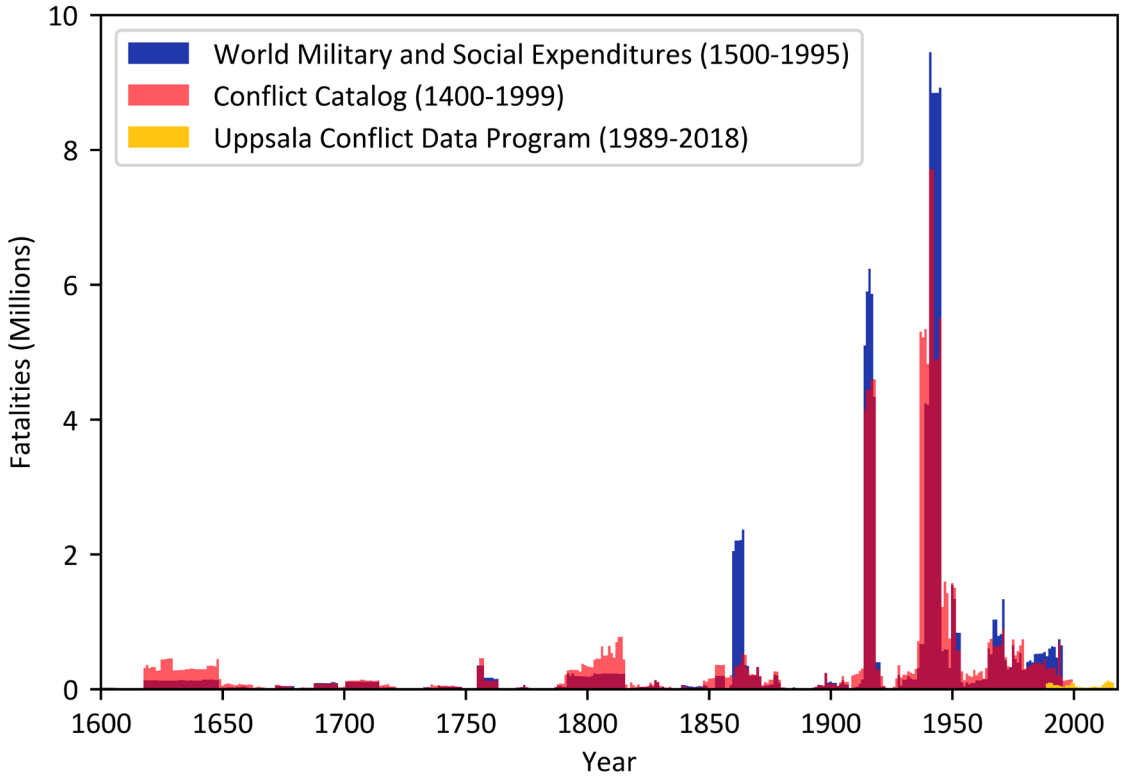



**Figure 6. Wartime Fatality Data Used for the NPR Figure**

two databases, we do not attempt to include this in our reproduction of the figure, and therefore do not attempt to recreate the last bin from 2000 to 2017.

The world population data used to produce the NPR figure are from the History Database of the Global Environment (HYDE) published by the Netherlands Environmental Assessment Agency. HYDE uses historical world population sources and derives estimates of the world population from 10,000 BCE to 2000 CE. The population data from 1600 to 2000 is given in regular intervals. Using this source, the average of the population at the first and last year of each period is calculated. The HYDE world population data and averages used to reproduce the NPR figure are shown in Figure 7. For all periods, the HYDE database provided the world population for the first and last years of each interval with the exception of the two bins with boundaries at 1945. The population at 1945 was determined by averaging the 1940 and 1950 populations, and this average was then used to calculate the averages used to reproduce the NPR figure.

We reproduced the NPR figure using data sets from the combined 1991 and 1996 editions of *World Military and Social Expenditures* and the Conflict Catalog. We then normalized these data by the world population average, as described in the previous paragraph. As we did when recreating the G.I. Joe chart, we assumed that conflicts whose date ranges fell within two intervals have equal numbers of deaths for each year of the conflict. Because it was unclear how the data were extended beyond 1999 and what the OSD Historical Office meant by "with some additional verification from Ruth Sivard's *World Military and Social Expenditures*, 1996," we calculated the wartime fatality percentages using each of the databases independently and overlaid them on the same plot, as shown in Figure 8. Also included in Figure 8 are the original NPR percentages,[22] shown in

[22] In the original NPR figure, the bin from 1946 to 1999 is labeled as having a height of 0.4 percent. However, close inspection of the NPR figure reveals that the bin height is probably between 0.25 percent and 0.3 percent. We do not

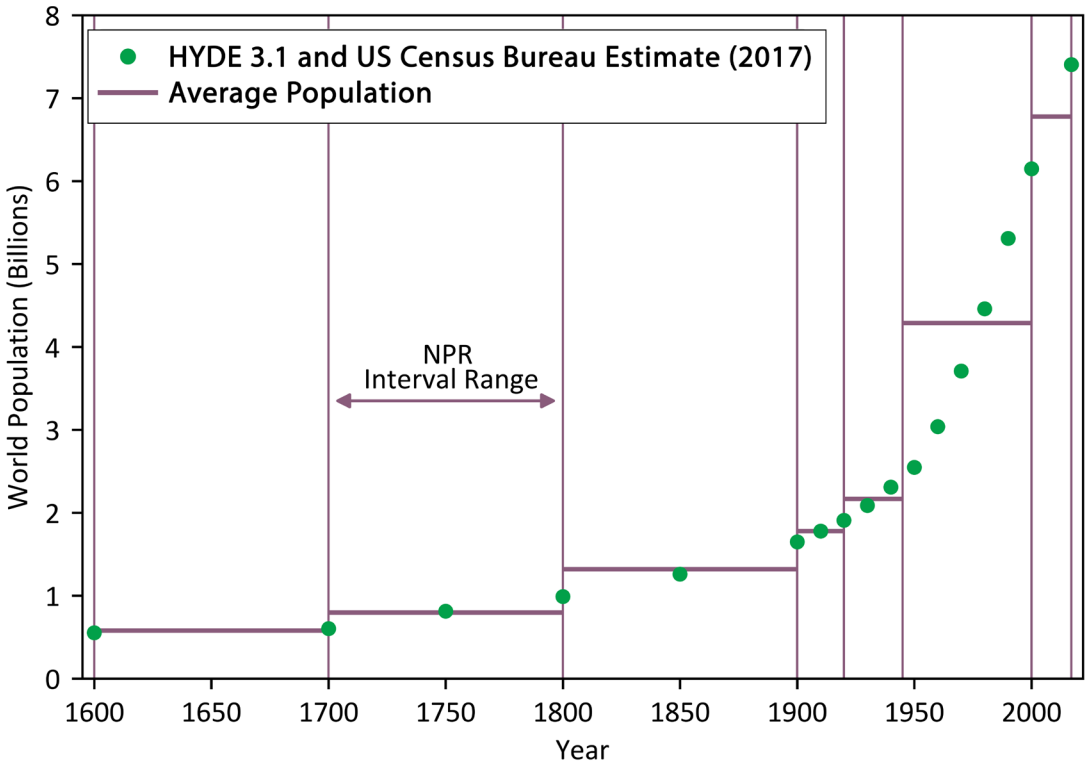



**Figure 7. World Population Data Used for the NPR Figure**

light purple. The reproduction using the Conflict Catalog shows fairly good agreement with the NPR figure for the first three bins, spanning from 1600 to 1900. It is possible the small discrepancies between our reproduction using the Conflict Catalog and the NPR percentages result from our assumption of uniform deaths over the war period. Despite the good agreement with the Conflict Catalog for the first three centuries, there is a large discrepancy in the twentieth century between the NPR figure and the reproduction. The NPR percentages are significantly lower than the percentages calculated using both the Conflict Catalog and *World Military and Social Expenditures*.

We attempted to reconcile the discrepancy between the NPR figure and the reproduction after 1900 by using methods similar to those described in the previous section, but to no avail.

know whether the error is in the bin height or the percentage label.

## Impact of Nonuniform Time Intervals

Notwithstanding our failure to replicate either the G.I. Joe chart or the NPR figure, our reproductions show a trend similar to that in the G.I. Joe and NPR figures; there appears to be a significant decrease in the percentage of wartime fatalities after the advent of nuclear weapons compared with all earlier periods. However, representation of the data with nonuniform time intervals is misleading. According to the *NIST/SEMATECH e-Handbook of Statistical Methods*, a histogram is "obtained by splitting the range of the data into equal-sized bins (called classes). Then for each bin, the number of points from the data set that fall into each bin are counted."[23] For the histograms discussed in this report, the wartime fatality data are split into bins using the dates, in years, of the conflicts. By making a bin wider, and therefore covering a longer

[23] NIST/SEMATECH, *NIST/SEMATECH e-Handbook of Statistical Methods*, accessed October 31, 2019, http://www.itl.nist.gov/div898/handbook/.

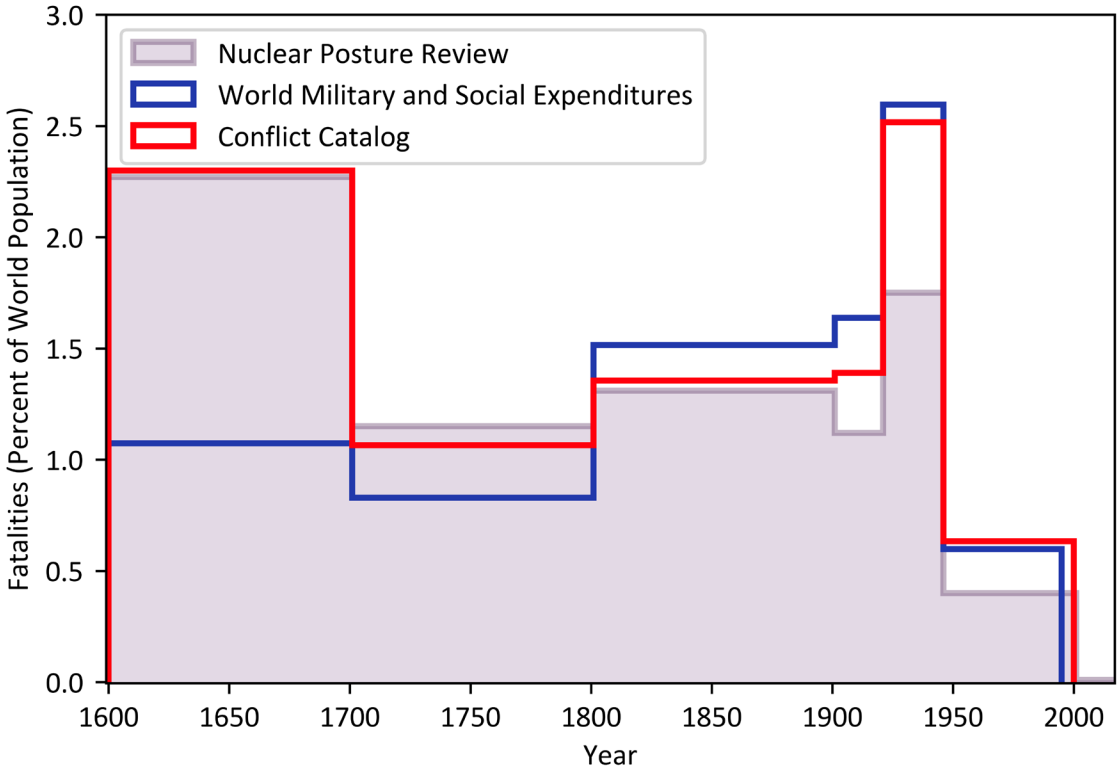



**Figure 8. Attempted Reproduction of the NPR Figure**

period of time, more wars will be included in that bin, increasing the number of wartime fatalities counted. Similarly, for narrow bins covering only a short interval of time, fewer wars will be included in that bin, decreasing the number of fatalities. Therefore, the use of nonuniform bins can introduce artificial structures and trends in wartime fatality data. While varying the bin width will also vary the world population values used for that bin, the shift in world population does not mitigate the effect of nonuniform bins—wider bins will still result in larger wartime fatality percentages than they would if they were split into narrower bins.

The apparent significant reduction of wartime fatalities as a percentage of world population in the nuclear era, compared with all other eras, is an artifact of the nonuniform bin structure used. By using large one-hundred-year bins for the first three centuries and smaller bins after 1900, the wartime fatality percentages in the first three centuries appear to be significantly higher relative to the post-1900 bins. To allow the wartime fatalities to be compared over time, it is essential to either use uniform interval sizes over the entire plot range or correct for any bin nonuniformity.

## A New Analysis of Wartime Fatalities

In this section, we present an analysis of wartime fatalities from 1600 to modern times that, contrary to the G.I. Joe chart, its descendants, and the NPR histogram, is reproducible, statistically rigorous, and displayed with uniform intervals. Alternative wartime fatality and world population data sources are examined, and the choices of bin size and normalization process are discussed.

### Wartime Fatality Databases

For our analysis, we want to determine whether there is a significant decline in wartime fatalities

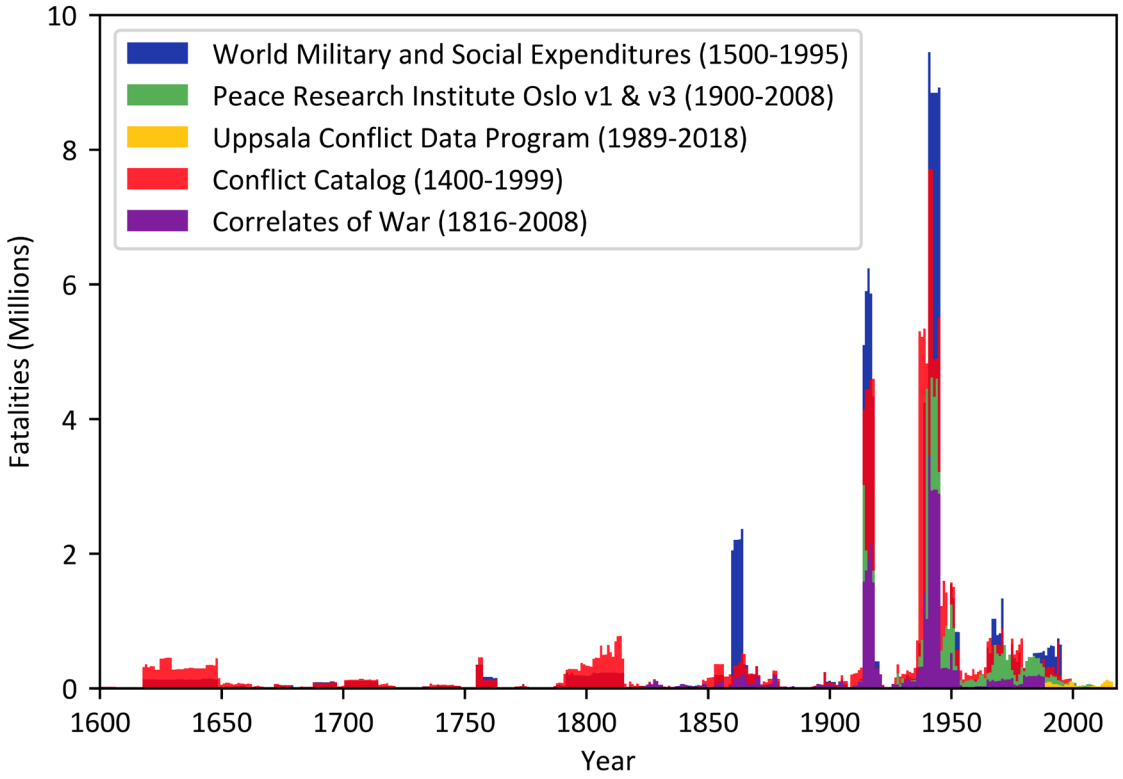



**Figure 9. Comparison of the Wartime Fatality Databases**

after the advent of nuclear weapons. To make this determination, we need a data source for wartime fatalities spanning a long period of time before and after 1945. While there are many sources of war fatality data for specific conflicts, countries, or periods of time, there are few comprehensive wartime fatality databases that include conflicts from around the globe over a long historical period and extend to relatively modern times. In our research, we identified four databases that best fit these criteria. A comparison of the fatalities from these databases is shown with single-year bins in Figure 9. The data shown in blue are the combined War and War-Related Deaths tables from the fourteenth and sixteenth editions of *World Military and Social Expenditures*,[24] which together span the years from 1500 to 1995. The database with the longest period of time covered is the Conflict Catalog,[25] which spans from 1400 to 1999 and is shown in red. Next, the Peace Research Institute Oslo[26] database has wartime fatality databases spanning from 1900 to 1998 and is shown in green. And last, the Correlates of War[27] databases span from 1816 to 2008 and are shown in purple.

In addition to these four databases, we looked into the wartime fatality data from the Uppsala Conflict Data Program (UCDP),[28] shown in yellow. This database provides wartime fatality data from 1989 to the present day, so it does not fit our criteria. However, we included this database in our study in hope that it could be used with another database to extend our analysis to the present.

[24] Sivard (1991, 1996).

[25] Brecke, "Violent Conflicts."

[26] Bethany Lacina and Nils Petter Gleditsch, "Monitoring Trends in Global Combat: A New Dataset of Battle Deaths," *European Journal of Population/Revue Européenne de Démographie* 21, no. 2–3 (2005): 145–166.

[27] Meredith Reid Sarkees and Frank Wayman, *Resort to War: 1816–2007* (Washington DC: CQ Press, 2010).

[28] Marie Allansson, Erik Melander, and Lotta Themnér, "Organized Violence, 1989–2016," *Journal of Peace Research* 54, no. 4 (2017): 574–587.

As shown in Figure 9, there are large discrepancies between the databases. To understand the source of these discrepancies, one needs to understand how these databases are formed and how the number of war-related deaths is determined.

Not all of these databases focus strictly on war, but many instead look into conflict more generally. Each database has its own definition of conflict, to which all conflicts included in the database must adhere. There are large variations in whether the database will include one-sided conflict, such as genocide, or conflicts between nonstate actors, such as gang violence. Additionally, each of the databases defines a threshold number of deaths that need to occur within a one-year period for a conflict to be considered in the database. The threshold number of deaths varies significantly between the databases, from twenty-five to one thousand annual deaths.

The methodology to determine the number of fatalities that result from each conflict also varies significantly. All the databases shown in Figure 9 include both civilian and military deaths; however, the fraction of indirect war-related deaths, such as those from conflict-induced starvation or disease, varies. Another difference between the databases comes from differences in source data and variations in the level of verification for each death. Fatality statistics can come from a wide variety of sources, including news reports, firsthand accounts, government or nongovernment organizations, and historical

**Table 1. War-Related Fatality Databases**

| Source | Years | Death Threshold (per Year) | Definition of War | Deaths | Indirect War-Related Deaths |
|---|---|---|---|---|---|
| *World Military and Social Expenditures*[a] | 1500–1990 (14th ed.) 1900–1995 (16th ed.) | 1000 | "any armed conflict involving one or more governments" | Civilian, military | Unknown |
| Conflict Catalog[b] | 1400–1999 | 32 | "an occurrence of purposive and lethal violence among two or more social groups pursuing conflicting political goals, that results in fatalities, with at least one belligerent group organized under the command of authoritative leadership" | Civilian, military | Estimates vary in the degree they include indirect deaths |
| Correlates of War[c] | 1816–2008 | 1000 (civilian deaths not included) | "sustained combat, involving organized armed forces"—excludes one-sided conflicts or massacres | Civilian, military | Yes |
| Peace Research Institute Oslo[d] | 1900–1997 (version 1.0) 1946–2008 (version 3.0) | 25 | "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths" | Civilian, military | No |
| UCDP[e] | 1989–2018 | 25 | Same as the Peace Research Institute Oslo definition | Civilian, military | No |

[a] Sivard (1996).

[b] Brecke, "Violent Conflicts."

[c] Sarkees and Wayman, *Resort to War*.

[d] Lacina and Gleditsch, *Monitoring Trends in Global Combat*.

[e] Allansson, Melander, and Themnér, "Organized Violence."

documents. Additional methodologies include estimating the number of fatalities from the number of casualties or the amount of infrastructure damage or comparing mortality rates before the conflict with those during and immediately after the conflict. A summary of the differences between the databases and coding practices used when developing the databases is presented in Table 1.

In trying to understand the discrepancies between databases, we conducted a case study of the Taiping Rebellion because of the large discrepancies for this war among several databases. The Taiping Rebellion is included in the *World Military and Social Expenditures*, Conflict Catalog, and Correlates of War databases. Taiping Rebellion information from these databases is summarized in Table 2.

**Table 2. The Taiping Rebellion Years of Conflict**

| Source | Years of Conflict | Fatalities |
|---|---|---|
| *World Military and Social Expenditures*[a] | 1860–1864 | 10,000,000 |
| Conflict Catalog[b] | 1850–1865 | 2,000,000 |
| Correlates of War[c] | 1850–1866 | 111,000 |

[a] Sivard (1996).

[b] Brecke, "Violent Conflicts."

[c] Sarkees and Wayman, *Resort to War*.

In *World Military and Social Expenditures*, the Taiping Rebellion is listed as occurring between the years 1860 to 1864 and resulting in ten million deaths[29]—significantly more fatalities over a shorter period of time than the other two databases report. Using other sources,[30] we find that the estimate of ten million deaths or more is not unreasonable. However, it is commonly accepted that the Taiping Rebellion took place between 1850 and 1865 (plus or minus a year), and it is likely that the start date of 1860 is an error in the database. Summing the large number of fatalities over an artificially shortened war period causes the average number of fatalities per year to be significantly higher than if they were distributed over a longer period of time.

The Conflict Catalog lists the rebellion as lasting from 1850 to 1865 with two million deaths. Unfortunately, the data sources for individual conflicts in the Conflict Catalog are not available.

The Correlates of War database has the Taiping Rebellion occurring between 1850 and 1866 and resulting in 111,000 deaths.[31] This, however, is an underestimate of the number of fatalities that results from how the Correlates of War categorizes different types of war. The Correlates of War database is sorted into interstate wars, extrastate wars, intrastate wars, and nonstate wars. To be included as an intrastate war, one of the combatants involved in the conflict has to be considered an "international system member." However, China did not meet the criteria to be considered an international system member until 1860. Therefore, the Taiping Rebellion is included in the Correlates of War database as both a nonstate war from 1850 to 1860 and an intrastate war from 1860 to 1866. When listed as a nonstate war, the Correlates of War lists the fatalities from the Taiping Rebellion as unknown. As an intrastate war, the number of fatalities is listed as 111,000, and it is unclear whether this value includes only the estimated number of fatalities from the last six years of the conflict.

This study of the Taiping Rebellion reveals how potential mistakes in the databases and differences in the methodologies used when developing these databases can account for some of the larger discrepancies between databases.

[29] Sivard (1991).

[30] Matthew White, "Necrometrics," *Historical Atlas of the 20th Century*, 2014, http://necrometrics.com; Gaston Bouthoul, René Carrère, and Gernot Köhler, "A List of the 366 Major Armed Conflicts of the Period 1740–1974," *Peace Research* 10, no. 3 (1978): 83–108; and the Editors of Encyclopaedia Britannica, "Taiping Rebellion," The Encyclopaedia Britannica, 2019, https://www.britannica.com/event/Taiping-Rebellion.

[31] Sarkees and Wayman, *Resort to War*.

Ideally, for our analysis, we would like to study wartime fatalities over a long period of time, ending as close to the present day as possible. This would require us to concatenate one of the larger databases, either *World Military and Social Expenditures* or the Conflict Catalog, with one of the other three databases that extend past the year 2000. Unfortunately, as careful inspection of Figure 9 reveals, there is little agreement between the databases in the years they overlap. The Correlates of War, Peace Research Institute Oslo, and UCDP databases all reveal significantly fewer wartime fatalities than the databases that include more years. Therefore, combining the databases would cause an artificial decrease in wartime fatalities at the boundary between the two databases.

To illustrate this issue, we have looked into the Gulf War in greater detail. Table 3 compares the number of fatalities listed in each database for the Gulf War. All databases include the Gulf War.

**Table 3. Database Comparison of Fatalities for the Gulf War**

| Source | Fatalities (1990) | Fatalities (1991) |
|---|---|---|
| *World Military and Social Expenditures*[a] | 200,000 | |
| Conflict Catalog[b] | 60,000 | |
| Correlates of War[c] | 1,000 | 40,000 |
| Peace Research Institute Oslo[d] | 800 | 28,245 |
| UCDP[e] | 1,058 | 21,790 |

[a] Sivard (1996).

[b] Brecke, "Violent Conflicts."

[c] Sarkees and Wayman, *Resort to War*.

[d] Lacina and Gleditsch, *Monitoring Trends in Global Combat*.

[e] Allansson, Melander, and Themnér, "Organized Violence."

Similar to the data for the Taiping Rebellion, there are significant variations between databases in the number of Gulf War fatalities. The largest outlier for the Gulf War is *World Military and Social Expenditures*,[32] which lists 200,000 fatalities (100,000 civilian and 100,000 military). The estimate of 200,000 fatalities is significantly higher than in the other databases, and unfortunately, the data source for this value is not provided. However, looking further into this estimate, we came across the work of Beth Osborne Daponte,[33] which we now believe to be the source of this value. She calculated 205,500 Gulf War fatalities: 56,000 military and 3,500 civilian direct war deaths, 111,000 indirect war deaths, and 35,000 deaths from postwar violence.[34]

Daponte's estimate of direct war deaths is similar to that in the Conflict Catalog, and the indirect war deaths and postwar violence account for the discrepancy between *World Military and Social Expenditures* and the Conflict Catalog. However, Daponte's estimate does not explain the large discrepancy between those two databases and the other three. This study underscores the issues that arise by combining databases into a single data set. Attempting to understand these discrepancies by tracking down the original data sources has proven difficult but would be necessary if combining data sets.

Although the large discrepancies in the number of wartime fatalities among the databases can be explained by understanding how the databases are developed, this analysis did not clearly indicate which database is most accurate or appropriate to use in this study. For this analysis we will use the Conflict Catalog and *World Military and Social Expenditures 1991* war-related death data extended

[32] Sivard (1996).

[33] Her calculation of Gulf War fatalities was so controversial it ultimately resulted in her being fired from the US Census Bureau. Barton Gellman, "Census Worker Who Calculated '91 Iraqi Death Toll Is Told She Will Be Fired," *Washington Post*, March 6, 1992.

[34] Beth Osborne Daponte, "A Case Study in Estimating Casualties from War and Its Aftermath: The 1991 Persian Gulf War," *PSR Quarterly* 3, no. 2 (1993): 57–66.

to 1995 using the sixteenth edition of the report. We chose to compare these two databases because they include deaths globally over a large time span and because of their prior use in the producing the G.I. Joe and NPR figures. Additionally, we do not combine these databases with others to increase the time range, as doing so would introduce additional flaws and inconsistencies into the results.

## World Population

There are many sources of world population estimates, and fortunately the differences among them are relatively small. Figure 10 shows the world population from 1600 to 2016 from various sources including those used in the G.I. Joe and NPR figures. Both *The World Almanac 1994* and HYDE 3.1 world population data are in good agreement with the other sources, especially after the year 1900. For our new analysis, we used a linear interpolation (shown as a purple line) of the full data set shown in Figure 10. For years where more than one source provided a world population value, we used the average between the sources in the interpolation.

## Interval Selection

Even with uniform bins, the choice of interval (bin) size can alter how the histogram is viewed and interpreted. Determining a bin size that works best for a histogram strongly depends on the number of data points and the distribution of data over the range being studied. When looking at sparse data, large bin widths can help to avoid high statistical fluctuations and to reveal large-scale patterns in the data not easily noticed with small binning. However, for the wartime fatality data, the statistical uncertainties are minuscule compared with the systematic uncertainties, discussed in the Uncertainties section. Therefore, we have decided to use yearly binning. This representation reveals

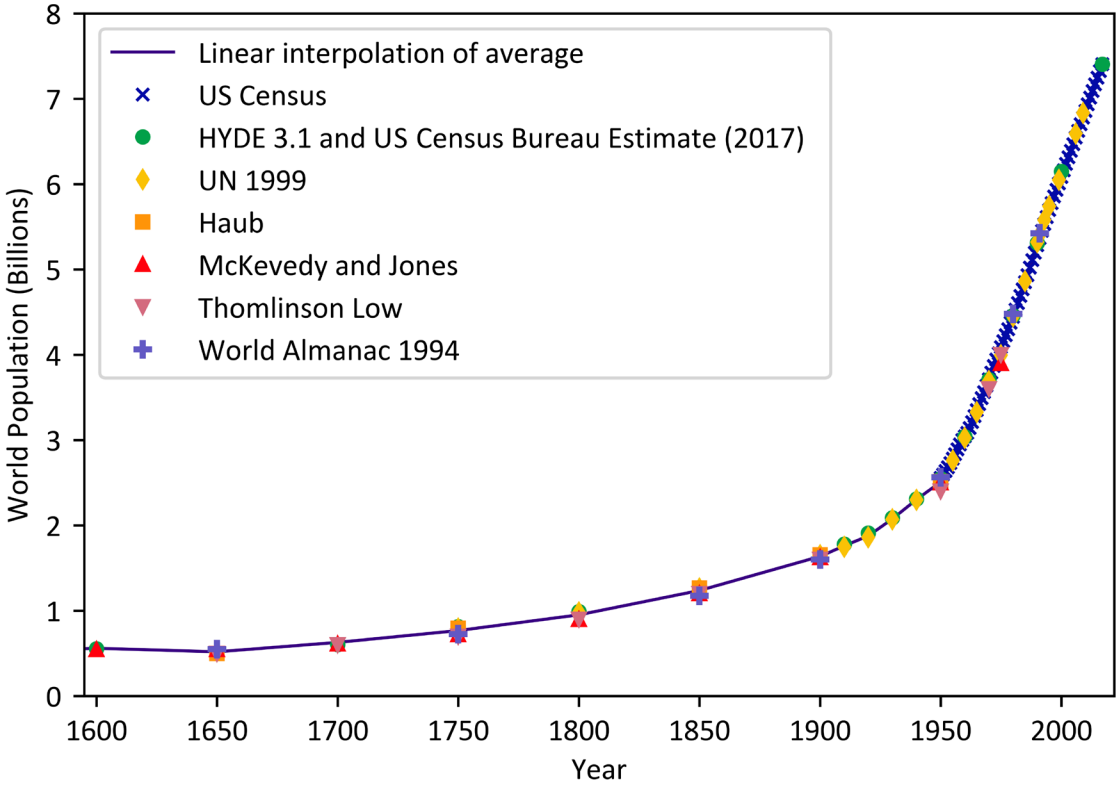



**Figure 10. Comparison of the World Population Estimates from 1600 to 2016**

details in the wartime fatality trend that are missed with larger binning and allows one to recognize individual wars and quiescent periods.

Additionally, using yearly bins helps to mitigate potential issues with normalization. For the G.I. Joe chart, we believe the percentage of wartime fatalities was calculated using an estimate of the world population at the midpoint of the bins. For the NPR figure, an average of the population at the first and last point of the interval was used. However, a more meaningful normalization would divide the total number of war-related deaths over an extended period of time by the total number of people who were alive during that period. For very small intervals of time, the world population and the total number of people who lived during that interval converge. However, as the interval of time grows, the total number of people who lived during an interval and the population at any one time diverge. Therefore, by using smaller intervals, the discrepancy between the population and the total number of people who lived during that interval decreases.

The format of the wartime fatality data from *World Military and Social Expenditures* and the Conflict Catalog set a lower bound on bin size to one year. However, yearly binning does rely on the assumption that war deaths are evenly distributed over the entire period of a conflict. This assumption will lead to inaccuracies within wars; however, the long-term structure will be more representative of the actual percentage of a population killed by war.

## Results

Figure 11 shows our results of annual wartime fatalities as a percentage of world population from 1600 to the late 1990s. We created Figure 11a using the combined War and War-Related Death tables from the fourteenth and sixteenth editions of *World Military and Social Expenditures* and Figure 11b using the Conflict Catalog. These fatality data are normalized by the annual estimate of world population as determined using a linear interpolation of a variety of population sources. Conflicts with over one million deaths in total are labeled.

The yearly interval selection in Figure 11 reveals that although we are in an era marked by relatively low levels of wartime fatality percentages, especially compared with the first half of the twentieth century, the fatality percentages in the nuclear era are not unprecedented. They are similar, and even slightly higher in some cases, to those during extended periods of time before World War I.[35] This is in contrast to the G.I. Joe chart and NPR figure, which appear to show that the nuclear era has significantly fewer wartime fatalities (normalized by world population) than all other periods since 1600.

### Uncertainties

While the uncertainty in the wartime fatality percentages is difficult to quantify with the available data, we know it to be large and temporally and geographically dependent. None of the wartime fatality databases or world population data studied for this report provide uncertainties, and while we cannot quantify uncertainties ourselves without the original fatality and population data sources and methodologies, we can discuss a few of the possible sources.

Determining the number of fatalities resulting from a war is a challenging and imprecise study that requires combining multiple data sources with diverse methodologies. As shown in Figure 9, there is large variation among fatality databases. This

[35] For a detailed statistical analysis of wartime fatality trends see Aaron Clauset, "Trends and Fluctuations in the Severity of Interstate Wars," *Science Advances* 4, no. 2 (2018): eaao3580, 1–9, https://doi.org/10.1126/sciadv.aao3580. That analysis reveals that the "postwar pattern of relative peace would need to endure in its current form for at least another 100 years before it would become statistically unusual enough to justify a claim that it represents a genuine trend."

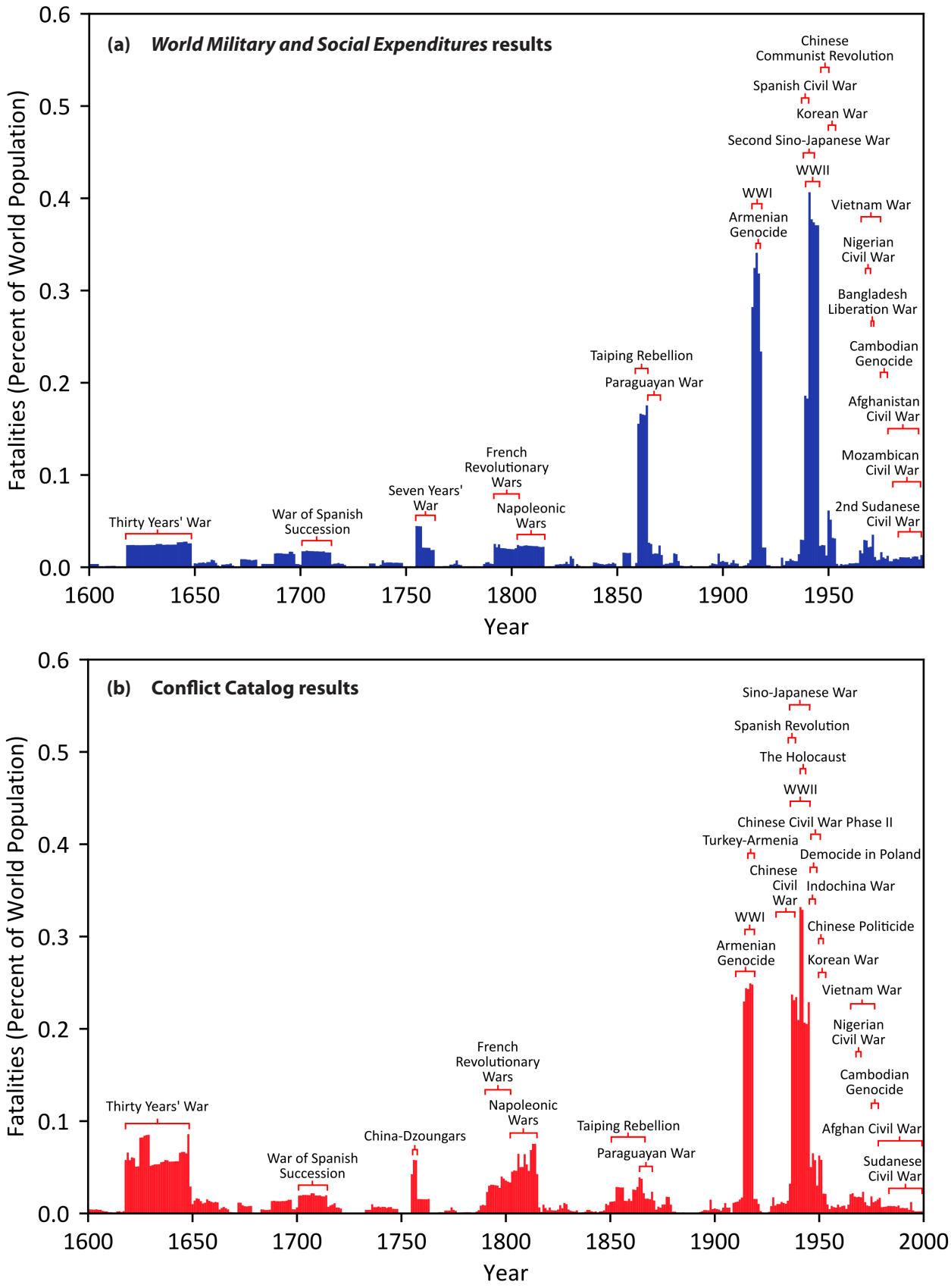



**Figure 11. Wartime Fatalities as a Percentage of World Population**

variation can be largely attributed to coding and verification differences, as discussed in the Wartime Fatality Databases section; however, variations are also a result of the uncertainties inherent to the methodologies used to determine fatality statistics. Many statisticians and historians who study fatalities will use a variety of methodologies to determine the number of fatalities, as discussed in the Wartime Fatality Databases section. The uncertainties related to each of these methodologies vary significantly and can be difficult to determine.

Integral to this analysis is the understanding of how uncertainties vary between time periods and conflict locations. Historical estimates of wartime fatalities depend on record keeping from the era and geographical location of the conflict. As we go farther back in time, we expect that the uncertainties will grow, especially in developing and recently developed parts of the world where older conflicts might be missing from the databases. Evidence of this in the databases can be found in the low number of conflicts outside of Europe, North America, and Asia before 1800.

Similarly, even considering only the modern era, record keeping practices significantly differ by location. In underdeveloped and developing countries, record keeping during a conflict will be lacking, especially when concerning marginalized communities that might be the target of violence. Nonetheless, for all parts of the world, counting the number of fatalities from war can be difficult, and some of the original data sources might have reason to falsify the numbers. Governments, humanitarian organizations, and newspapers might inflate the number of fatalities to garner sympathy or to attempt to gain international support and aid. Similarly, governments might deflate the numbers to avoid intervention or civil unrest or to appear more resilient to adversaries.

Adding to these complications are deaths not resulting directly from battle wounds. Extending the definition of wartime fatalities to include deaths resulting from degraded sanitation, famine, and destroyed or overutilized medical resources as a result of war forces the statistician to understand prewar conditions and to successfully extrapolate those conditions to estimate the number of fatalities that would have occurred if the war had not taken place.

The uncertainties from world population estimates are more straightforward but also vary with time period and geography. Also, the linear interpolation, especially between world population values before 1900, where the data points are less frequent, adds to the uncertainty more than in recent periods where only short time differences are interpolated.

## Interpreting Statistical Analyses

Our analysis of wartime fatalities reveals that the nuclear era has experienced levels of wartime fatalities as a percentage of world population that are consistent with those of many historical eras since 1600. However, such statistical analyses of historical wartime fatalities cannot provide any indication of the number of wartime fatalities that would have occurred between the end of World War II and the present day if nuclear weapons had not been invented—fatalities might have been higher or even lower. Therefore, our analysis does not, and is unable to by design, prove or disprove the hypothesis that nuclear weapons have helped to reduce wartime fatalities. Warfare is complex, and trends in wartime fatalities could be attributed to many factors besides nuclear weapons, including advancements in battlefield medicine, changes to conventional weaponry, and changes to relationships between nations, such as international alliances and trade agreements. Establishing a causal relationship would require a multidisciplinary analysis to try to understand how the world would have developed without nuclear weapons and whether/how nuclear weapons have prevented conflicts or kept conflicts from escalating.

## Summary and Conclusions

An evolving series of histograms showing wartime fatalities as a percentage of world population over four centuries has been used by prominent nuclear strategists and senior defense officials for nuclear weapons advocacy. These histograms suggest that the advent of nuclear weapons correlates with a significant decline in wartime fatalities. In this report, we assess the G.I. Joe chart, which we believe to be the original version of these histograms. We attempt to recreate the G.I. Joe chart from the cited data sources and find that it is irreproducible and that reasonable variations in the methodology used to produce the histogram do not resolve this problem. Furthermore, we find the irregular interval selection to be misleading because it creates an artificial trend in the histogram indicating a significant decline in wartime fatalities since the advent of nuclear weapons. When the irregular bin sizes are accounted for and other analytic flaws are addressed, we find the number of wartime fatalities as a percentage of world population since 1945 to be consistent with those of many other periods of time before the advent of nuclear weapons.

Additionally, we assess a recently published version of this histogram, which appeared in the 2018 NPR. While the NPR figure appears to be a fresh analysis looking at the percentage of the world population that perished due to warfare from 1600 to the present day, it repeats the primary errors found in the original G.I. Joe analysis. We find that the NPR figure is also irreproducible using the methodology and data sources provided by the OSD Historical Office and that the irregular bins used in the figure result in the same artificial trend seen in the G.I. Joe chart.

We have conducted a new analysis of wartime fatalities over time that eliminates the irregular bin structure and other primary flaws of the previous analyses discussed in this report. Our analysis reveals that the percentage of wartime fatalities after World War II is consistent with wartime fatalities in many historical periods, refuting the analytic finding that we are living in an era of unprecedentedly low wartime fatalities. The uncertainties in our analysis are large but are difficult to quantify from the available data. They stem from large uncertainties in the number of war-related deaths, which vary significantly over time and geographical location. Additionally, there are large discrepancies among wartime fatality databases stemming from how they define war, which deaths qualify as war-related deaths, and the level of verification required for each death.

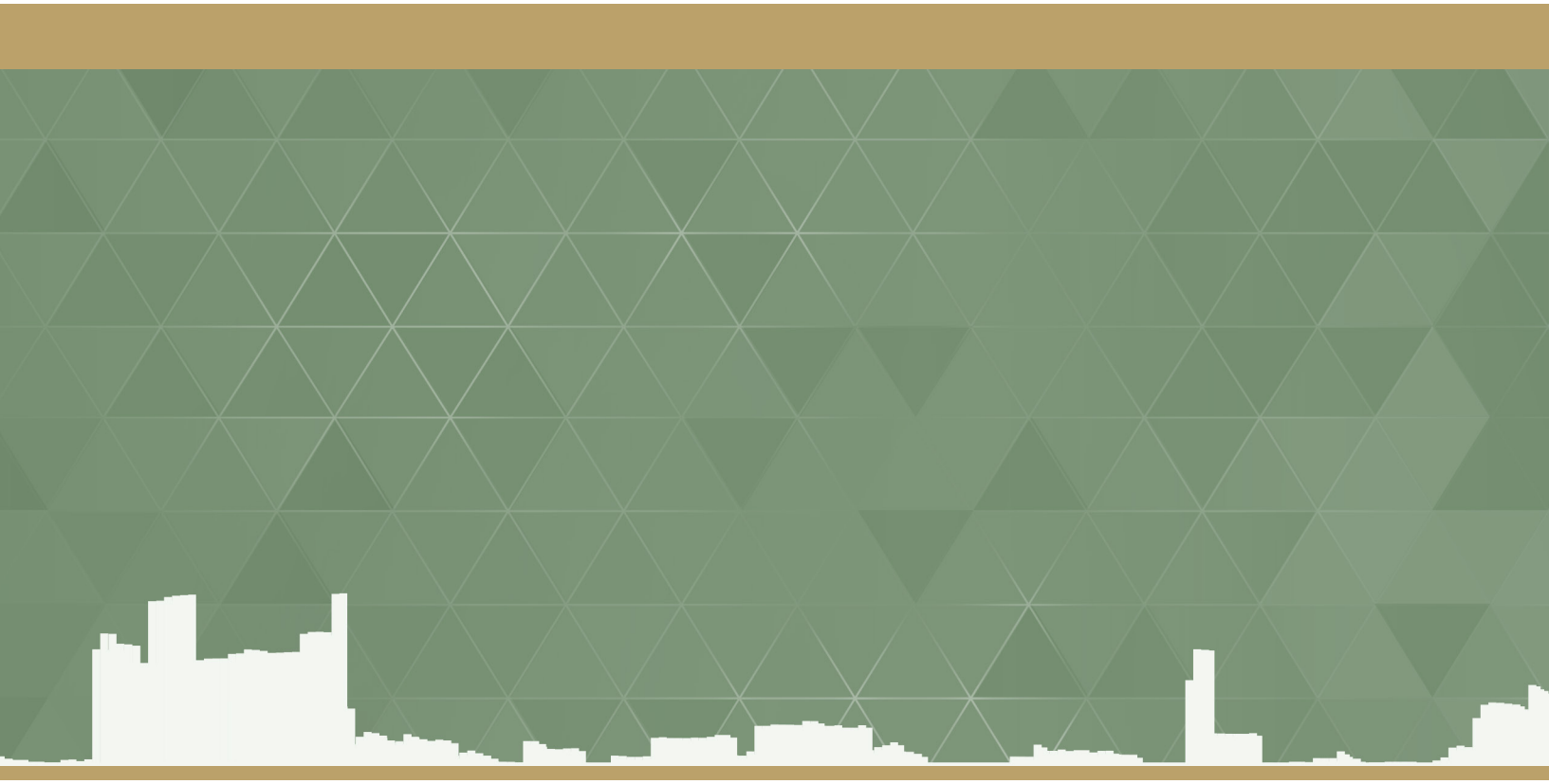
Finally, it is important to understand the limitations of this type of statistical analysis in determining a causal relationship between the advent of nuclear weapons and any change in the number of wartime fatalities. Such an analysis can show a correlation between the two, but a complex multidisciplinary analysis would be required to establish a causal connection. Understanding the potential for nuclear weapons to deter great powers from waging conventional wars and to limit the loss of life in such wars is a worthy pursuit that deserves thorough consideration. Decisions vital to international security must be based on rigorous and traceable analysis.

## About the Authors

Lauren Ice is a national security analyst at the Johns Hopkins University Applied Physics Laboratory (APL). In this role, she has worked on a variety of projects related to nuclear deterrence, climate change, Arctic operations, and quantum information systems. Dr. Ice earned her PhD in physics from Arizona State University.

James Scouras is a senior scholar at the Johns Hopkins University Applied Physics Laboratory (APL) where he focuses on global catastrophic risks. He was formerly chief scientist of the Defense Threat Reduction Agency's Advanced Systems and Concepts Office. Prior to that, he was program director for risk analysis at the Homeland Security Institute, held research positions at the Institute for Defense Analyses and the RAND Corporation, and lectured on nuclear policy in the University of Maryland's General Honors Program. Among his publications are the book *A New Nuclear Century: Strategic Stability and Arms Control* (Praeger, 2002), coauthored with Stephen Cimbala, and his edited volume *On the Risk of Nuclear War* (APL, 2021). Dr. Scouras earned his PhD in physics from the University of Maryland.

Edward Toton's career spans government, academic, and commercial basic research and exploratory development. He is now president of a private consulting firm. His previous positions including technical management of Department of Defense-sponsored research in the Strategic Defense Initiative and technical support to the Commission to Assess the Threat to the United States from Electromagnetic Pulse. His research includes assessments of general-purpose readiness for electromagnetic pulse threats, methodology development for the assessment of lethality of Strategic Defense Initiative weapon concepts, characterization of the effectiveness of operational neutralization schemes for suppression of biological aerosols, fuel loadings for assessing the likelihood of global catastrophes from nuclear war, and the impact of the invention and existence of nuclear weapons on conventional warfare. Dr. Toton holds a PhD in theoretical physics from the University of Maryland.



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY