**Title:** Global contribution of violence to lifetime uncertainty

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**Abstract [250]:**

Uncertainty around age at death, or lifetime uncertainty, is a key public health indicator and a marker of inequality in survival. By definition, violence and conflict create uncertainty in individuals’ lives, likely to influence the predictability of their lifespan. However, the relationship between violence and lifetime uncertainty has not yet been addressed. This study fills this gap by analysing whether and how violence influences the dispersion in ages at death, the metric most commonly used to measure lifetime uncertainty. Using mortality data by sex for 163 countries from the Global Burden of Disease Study and information on violence from the Global Peace Index between 2008-2017, we first find a strong positive correlation between levels of violence and lifetime uncertainty. In the Middle East, conflict-related violence is the most important cause-of-death contributor to lifetime uncertainty. In Latin American countries, this role is played by homicides and interpersonal violence. Our study further shows that, regardless of the type of violence, violence at young ages affect overwhelmingly lifetime uncertainty. Although the effects of violence are larger in magnitude for men, the consequences remain considerable for adolescent girls and women in their early reproductive years. Overall, our study points at a double burden of violence on longevity: not only does violence shorten individual lives, but also makes length of life less predictable.

**Main text [3500]:**

Uncertainty about the future – survival in particular – is a fundamental condition of human life, exerting a large influence on people’s behaviour. In any long-term decision-making process over the life course, individuals face uncertainty about when death will happen. Most research on uncertain lifetimes, measured by an index of variation or spread in ages at death, focuses on how this unpredictability affects individual consumption and distribution of resources.1-5 Recently, research has analysed how social determinants, such as education or income, affect lifetime uncertainty and found that socially disadvantaged groups tend to experience higher uncertainty about their age at death.6-11 Exposure, to violence – a fundamental state of vulnerability – is another social determinant of health which can affect lifetime uncertainty with important social and psychological implications.12 Greater uncertainty in life suggests insufficient or failing policies to protect individuals and indicates that health improvements at the societal level are not evenly distributed. The link between violence and lifetime uncertainty has not yet been comprehensively studied. We hypothesize that violence works as a key determinant of increases in lifetime uncertainty in contexts with ongoing conflicts and/or high levels of violence.

Globally, levels of lifetime uncertainty have declined over time, but vary considerably between countries.13-19 Most of this decline first came about from reductions in premature deaths, especially infant and maternal mortality, and mortality from infectious diseases.20 More recently, reduced cancer has helped to reduce inequality in length of life within high-income countries.20,21 Lower life expectancy is usually associated with greater uncertainty.17-19

Studies relating violence to quality of life often rely on subjective measures.22 Fear of crime, for example, depends on how individuals perceive their environment and, therefore, might lead to a mismatch between the real uncertainty and how it is perceived.23 Females are more likely to report significant levels of vulnerability in normal times, but experience lower levels of victimisation when violence increases.24 Certainly, this has an immediate effect on quality of life,25 causing higher levels of stress, anxiety and other mental health issues for individuals26 while promoting segregation at the population level.24,27 Our aim is to complement such studies based on subjective quality of life indicators with an objective quantity of life measure of lifetime uncertainty to provide a more comprehensive understanding of the burden of violence on individuals and societies.

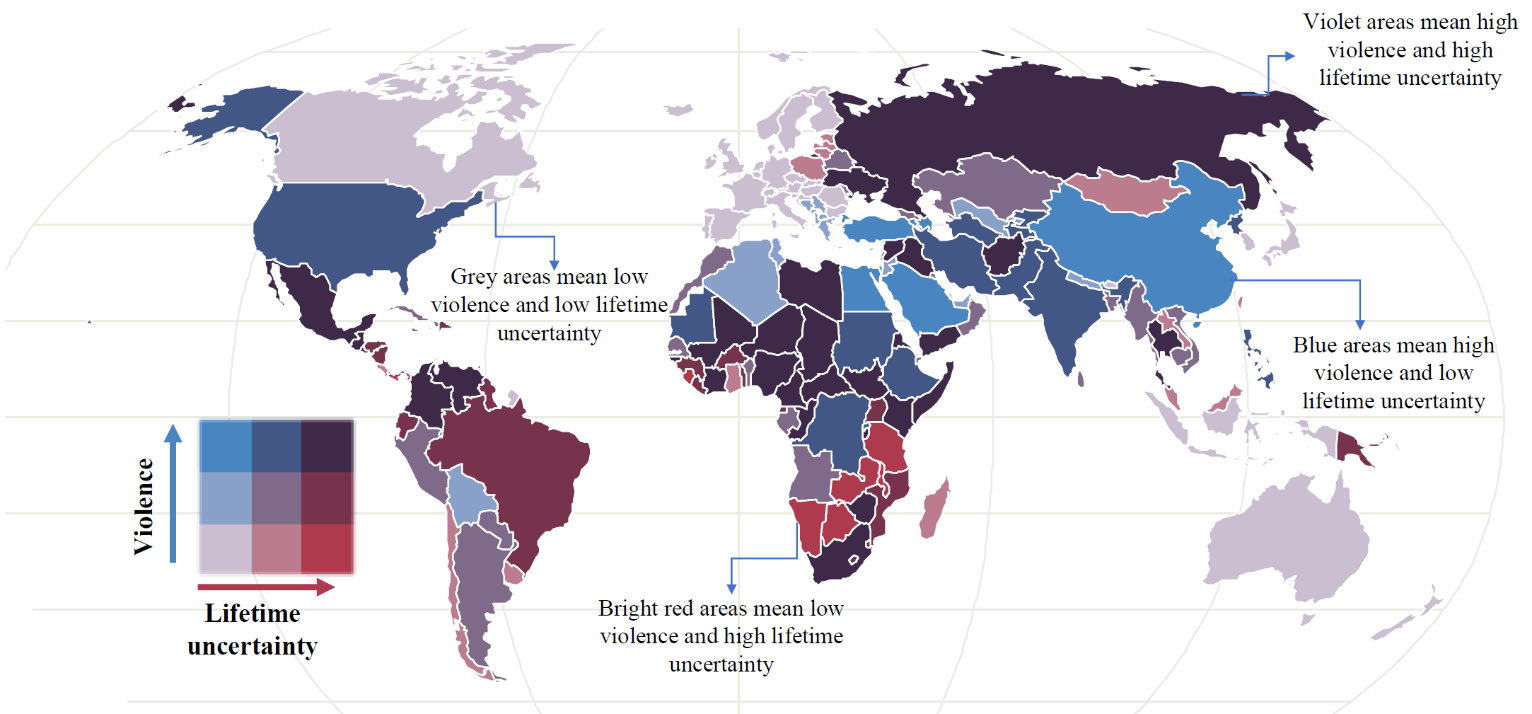
Here we study the relationship between lifetime uncertainty and violence and pose four questions seeking to fill the knowledge gap: How does lifetime uncertainty manifest itself in more violent countries? How does it compare with peaceful nations? How does this relationship compare between men and women? What is the contribution of violent deaths to the observed differences between violent and peaceful countries? To answer these questions, we use mortality data from 163 countries from the Global Burden of Disease Study (GBD) by sex (3072 life tables),28 and information on levels of violence from the Global Peace Index (GPI) for the period 2008-2017.

**Lifetime uncertainty and violence around the globe**

We use the Global Peace Index (GPI) as an indicator of the level of violence in a country.29 This index ranks the peacefulness of 163 (99.7% of the global population) countries based on three domains: 1) ongoing domestic and international conflict, 2) societal safety and security, and 3) militarisation. It is constructed using 23 indicators of violence, including the number and duration of internal conflicts, level of perceived criminality, and homicide rates.29 Europe has consistently been the most peaceful region in the world over the last decade. By 2017, the most peaceful nations were Iceland, New Zealand, Portugal, Austria and Denmark. Conversely, the Middle East and North Africa region (MENA), represents the most violent zone,29 while Latin America has the highest homicide rates in the world (***Figure 1***).30 Syria, Afghanistan, Iraq, South Sudan and Yemen, in particular, were ranked as the most violent countries. These populations have all endured armed conflicts, which have inflicted a disproportionate toll on civilians.31-33 Within Latin America, Colombia, Venezuela, and Mexico were the countries with the highest levels of violence. Venezuela and Mexico have undergone an unprecedented rise in homicides in the last decade due to political conflict and the war on drugs, respectively.12,30,34 Colombia has historically been a country with high homicide rates since the 1960s, although homicides have declined since 1996.30

Lifetime uncertainty is measured using a summary index of the similarity in ages at death based from life tables. Multiple indicators exist for this purpose.35 These include the standard deviation or the Gini coefficient of the age-at-death distribution. We use the standard deviation conditioned on surviving to age 10. There is a high correlation between these indices,14,35 and our results do not change substantially based on other indices.

**Figure 1 Global level of violence and lifetime uncertainty for males in 2017**



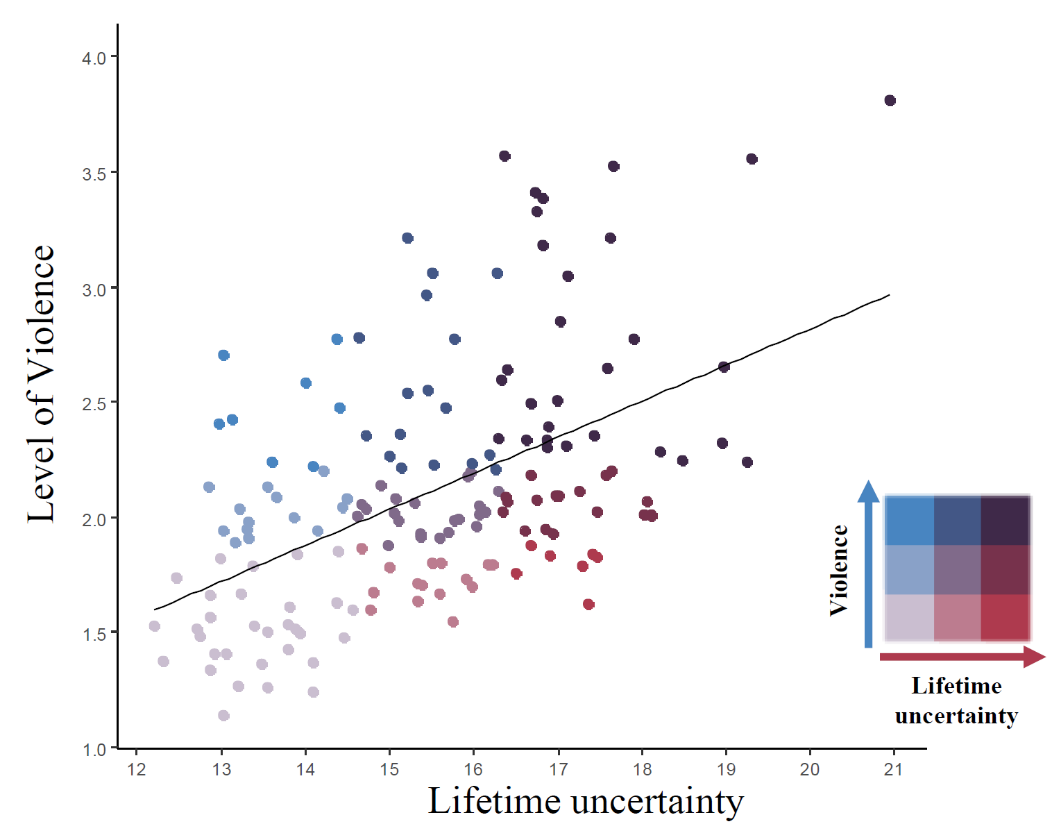
In Syria, Iraq, El Salvador, South Africa, and Venezuela, lifetime uncertainty is extraordinarily high for men and women (***Figure 1***, see Supplementary Material [SM] for females). This set of countries also share the highest levels of violence. Syria, for example, has been the most violent country in the world for the past five years, while El Salvador has presently the second highest homicide rate (after Honduras). In contrast, lifetime uncertainty is remarkably low in most countries of Northern and Southern Europe, where we also observe minimal to low levels of violence. Among the G7 countries, the USA stands out as the only country with high violence and with also much higher lifetime uncertainty than other G7 countries. Similarly, China and Russia have similar level of violence, but Russia has significantly higher lifetime uncertainty. Russia has had historically high levels of lifetime uncertainty due to violent deaths and also alcohol-related mortality.13

Levels of violence are strongly positively correlated with lifetime uncertainty. Countries that experience high levels of violence also experience high levels of lifetime uncertainty. This relationship holds true for most regions, except for some countries in Southern Africa, which experience high levels of lifetime uncertainty but without high levels of violence [more on this, possibly HIV]. Peaceful countries all enjoy low lifetime uncertainty (***Figure 2*** [sensitivity of GPI]). The most violent instead tend to have higher lifetime uncertainty. Between 2008 and 2017, men and women living in the most dangerous countries showed a positive association with higher uncertainty in lifetime (correlation between level of violence and life uncertainty is 0.52 and 0.44 for men and women, respectively). Moreover, the strong relationship between lifespan uncertainty and life expectancy implies that those countries with high levels of violence experience lower levels of life expectancy than the peaceful ones.14 For example, in Mexico, after six decades of improvements, life expectancy stagnated after 2005 due to the rise in homicides.34 During this period, lifespan inequality increased for the most violent regions of the country.12 In Venezuela, life expectancy stagnated between 1996 and 2013, while lifetime uncertainty increased due to the rise in violence for men.36 As of 2017, our results show that males in Syria and Afghanistan had a life expectancy at age 10 of x and y years respectively, while in Iceland and New Zealand it was z years, a gap of almost 14 years. [something about inequality or disparities?] This is important because lifetime uncertainty is a measure of how the length of life varies and the GPI measures the level of violence in a country. Although, in principle, the two indicators could be unrelated to each other – i.e. a peaceful country could suffer high lifetime uncertainty, while a violent country could show lower mortality and uncertainty in life – we consistently observe the highest levels of lifetime uncertainty in countries with the greatest levels of violence. This suggests that violent countries tend to have a double burden in terms of life expectancy and lifetime uncertainty: not only, on average their population live shorter lives, but also their life is less predictable. [more sociology here?] Israel is the only country which displays a different behaviour. Here, although measures of violence are relatively high, lifetime uncertainty is low.

Lifetime uncertainty is lower for women than for men, and also correlates less with levels of violence (correlation of 0.44). We hypothesise that this difference results from higher mortality at young and working ages for males. This is usually referred to as the ‘young-mortality’ hump and it is an important explanatory factor of gender differences in mortality.37 For example, war-related deaths are five times higher for men than for women, and homicide rates in Latin America are 10 times higher for men than for women.38 This highlights the importance of premature mortality on lifetime uncertainty in contexts of high violence. [more on this, see also outlook section Ridhi?]

**Contribution of violent deaths to life uncertainty**

To test our hypothesis of the ‘young-adult’ mortality hump, we compared the 25 countries with the highest levels of violence in 2017 with an average composed of the 10 most peaceful countries in the period 2008-2017. The former group includes countries like Syria, Iraq, Yemen, South Sudan, Somalia, Central African Republic, Libya, Venezuela, Colombia, Mexico and Afghanistan shown in ***Figure 3*** (results for women and the full list of countries is shown in the SM). The latter includes, Iceland, New Zealand, Austria, Portugal, and Denmark. We identified the ages driving the difference in lifetime uncertainty between violent countries and more peaceful ones. We also analysed the contribution of homicides, war-related deaths, and other violent causes of death to lifetime uncertainty. These results represent a lower bound because violent deaths are often underestimated and underreported, especially in high-level violent settings. For example, in Mexico and Venezuela, misclassification, underreported murders, and the increasing number of missing individuals have made it difficult for researchers to estimate the current level of homicides.36,39 Similarly, the collection of credible/accurate data is particularly difficult in besieged and remote areas in Syria and Yemen.

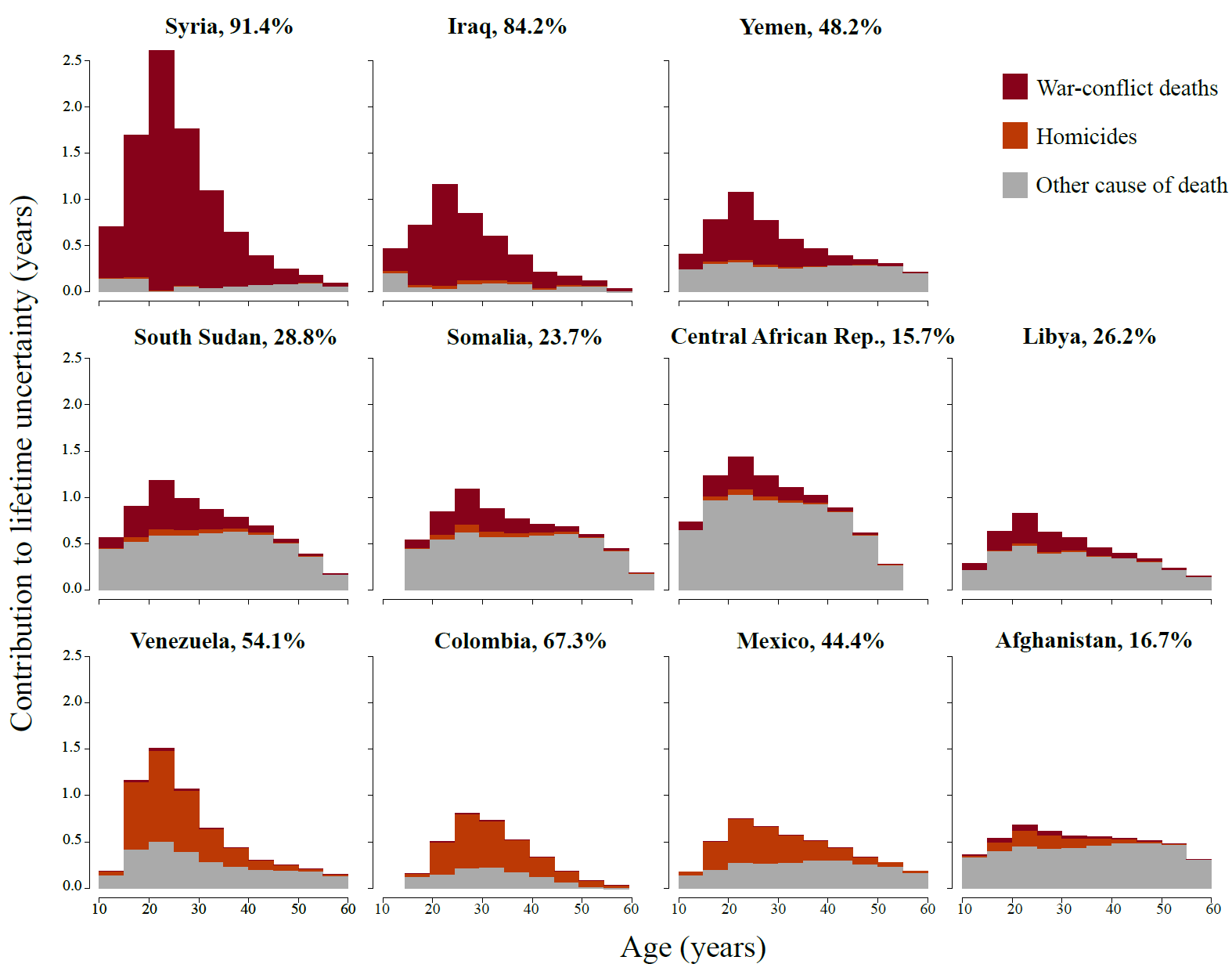


**Figure 2 The relationship between lifetime uncertainty and the level of violence in a country by in 2017 for males.**

***Figure 3*** shows the contribution of mortality by different causes to the difference in lifetime uncertainty between 18 violent countries and the 10 most peaceful countries between ages 10 and 60 years. The difference in lifespan uncertainty resulting from violence is remarkably high in the MENA region for both genders. For instance, violent deaths represent 91.4% and 55.7% of the difference for Syrian males and Iraqi females, respectively. In these countries, war-related violence contributes disproportionately to lifetime uncertainty as compared to homicides or other causes. This is especially true for young adult men. For instance, higher mortality in Syria for men aged 20-25 was responsible for 2.5 years of the xx excess years of standard deviation in age at death compared to the 10 most peaceful countries, while in Iraq and Yemen these ages contributed to a higher lifetime uncertainty by between 1 and 1.3 years. Here, as well as in African settings like the Central African Republic, Somalia and South Sudan, the female advantage is visible across almost all age categories; yet, lifespan uncertainty due to war-related deaths is higher for women approaching the start of their reproductive ages as compared to males in the same ages (about 0.8 for females and 0.5 years for males in Syria, 0.25 and 0.1 years in Yemen and 0.3 and 0.25 in Iraq). This suggests heightened vulnerability of adolescent females in contexts where war-related violence may come in the form of gender-related sexual violence and heightened maternal mortality due to limited access to obstetric care.40-42

The contribution of homicides to lifetime uncertainty dominates in violent contexts of Latin America. This region concentrates one third of global homicides.38 Yet, age and gender-related patterns are substantially similar to countries experiencing war-type of violence. In Colombia and Mexico, lifespan uncertainty due to homicides is particularly concentrated among men aged 20-35. In Venezuela, the contribution of homicides is manifested even at younger ages, with lifetime uncertainty due to homicides for men aged 15-20 contributing more than one year to the standard deviation of ages at death. The impact of homicides is substantially more visible among men, although these still account for about 21, 14 and 11 percent of the total causes of lifetime uncertainty among Colombian, Mexican and Venezuelan women, respectively.

Overall, this analysis shows that violence in the form of armed conflicts and homicides has a substantial impact on lifetime uncertainty in populations. This impact on the unpredictability of life is overwhelmingly concentrated in young ages and predominantly influences lifespan uncertainty of men, confirming our hypothesis that gender differences are shaped by higher male violence-related mortality. It follows that countries with the lowest levels of lifespan uncertainty succeeded not only because of lower general levels of mortality at all ages, but also because deaths due to war or interpersonal violence in these contexts for both genders are almost inexistent. [what else can we say here]



**Figure 3 Contribution to male lifetime uncertainty by war-conflict deaths, homicides and other causes of death by age in 2017**

**Outlook**

Conflict and non-conflict armed violence are a phenomenon plaguing various regions of the world, with many of the crises that erupted in the past decade remaining unresolved. This progressive fall in peacefulness is having impacts on individuals’ life chances and lifetime uncertainty, and has yielded lifespans that are both shorter and less predictable. This implies that countries with high levels of violence did not benefit from the dramatic increases in both life expectancy and in the predictability of length of life that most peaceful countries experienced in the 21st century. To put this in perspective, in the period 2010-2014, males in Honduras, El Salvador, Colombia, Venezuela, and Guatemala lost over two years of life expectancy due to homicides when compared to high-income and peaceful countries.43 Similarly, the conflicts and crises in Egypt, Yemen, Libya, and Syria led to reductions in life expectancy. Life expectancy in Syria, for example, would have been 5 and 6 years higher for females and males respectively, had the crisis not occurred.44

The double burden of lower life expectancy and higher lifetime uncertainty in contexts of high violence may be a precursor of indirect consequences on quality of life in violence-affected populations. This is because individual subjective capacity to assess how long she or he will live is instrumental when gauging the investment and consumption alternatives they have to better their everyday life. When this capacity is lacking due to increasing uncertainty in the surrounding environment, people’s expectations, decision-making and actions might be greatly hindered, impacting their overall life quality. [this discussion could be extended with some ref on quality of life depending on certainty about lifespan length]

Lifetime uncertainty is generally more pronounced among men than among women. This male-female difference raises questions about the nature and extent of differences in how individuals experience and survive violent conflicts as well as how they respond to socially mediated resources and risks in times of high levels of violence. Most combatants in armed conflicts and members of drug-cartels are men, so it is expected that men are the major direct victims of military operations. As a result women’s life expectancy usually appears less affected that of men in periods of crises.45,46 Nonetheless, from our analyses it emerges that lifetime uncertainty of women can also be highly influenced by violence in particular ages. In the MENA region, for example, peace and social order have been sharply deteriorated by years of civil violence. 47,48 At the same time, the increasing internationalisation of these armed conflicts and the consequent external military support, peculiarly in Syria and Yemen, have allowed warring factions to use highly sophisticated and more deadly weapons with huge collateral effects extending beyond combatants to women and civilians.31 Violence in the region has been further exacerbated by pre-existing widespread poverty, displacement and restrictions on livelihoods and increasing food insecurity.49 All these factors not only have shaped lifetime uncertainty in these settings and contributed to the gap with more peaceful regions; they have also further magnified pre-existing structural patterns of disadvantage for women and fundamental imbalances in gender relations at young ages, thereby making young girls more susceptible to unpredictable lifespan duration.50

In some Latin American countries homicide rates increased disproportionately.51In Mexico, male homicide rates more than doubled between 2007 and 2012.52,53 Male life expectancy thus declined between 2005-10.34,54 This epidemic of violence is related to specific policies trying to mitigate drug cartels operations and it has had unprecedented negative consequences in the last ten years of Mexico’s population health.55-58 Nonetheless, this has brought enormous consequences to women and their health. Over 31 thousand females have been victims of homicide in Mexico in the new century.52 Homicides are the ultimate form of violence, but living in violent environments or experiencing other types of violence brings health and social burdens, particularly for children and women.59 For example, victims of violence are at higher risk of depression, alcohol abuse, suicidal behaviour, psychological problems, among others, over their life course.60-63 Even witnessing violence can affect individual wellbeing. Those who witness violence have higher rates of post-traumatic stress disorder, depression and are more likely to externalise behaviours.64,65 Women who witnessed violent acts in particular are twice as likely to experience depressive and anxiety symptoms compared to those who did not witness violence.66 Research has shown that living in and witnessing violence increases the normalisation of violence and acceptance of violent relationships for women even in the household. This in turn fosters the ‘cycle of violence’, extending it to family relationships, with further detrimental effects on lifespan uncertainty.

Describing the landscape of lifetime uncertainty and violence enabled us to reveal the link between these two central components in light of the increasing prevalence of violence in its diverse forms in today’s world. This is the first study to find a positive association between levels of violence and lifetime uncertainty in a global scale and showed the power of analysing the consequences of violence using measures of uncertainty around the timing of death. Our study revealed that in contexts of high violence, lifetime uncertainty is linked to high premature mortality12,13,18 and that such early deaths are the driving factor behind the gap with peaceful nations. This link is likely governed by fundamental and complex psychological, sociological and biological factors, which can and should be further explored. In particular, our framework will yield further insights into the consequences of violence when applied to specific countries or subgroups within populations and may lead to new results if used to explore the effect of violence by socioeconomic status, education, or other social determinants of violence.

**Methods & Data [3000]**

**Data.** We used mortality estimates for 163 countries from the Global Burden of Disease Study.28 GBD is an observational epidemiological study widely used to analyse trends in mortality and morbidity from major diseases, injuries and risk factors in a global perspective. These data are provided in 5-year age intervals with the highest interval concentrating deaths above age 85. We focus on three main causes of death related to violence ***Table 1*** for code of the International Classification of Diseases [ICD10]): 1) homicide, 2) other violence (mostly war, state, and terrorist), and 3) all other causes.

To measure the levels of violence (or peacefulness) we use the Global Peace Index (GPI). GPI has been systematically calculated in the period that we study 2008-2017.29 It ranks the 163 countries according to the level of peacefulness. It is based on 23 qualitative and quantitative indicators that measure the state of peace using three domains: the level of societal safety and security, the extent of ongoing domestic and international conflict, and the degree of militarization. It is the most comprehensive index at a global scale and, therefore, a primary source of this study. The R-code to get the data is available at [URL].

**Demographic methods.** To more accurately measure the age-at-death distributions for each country we ungrouped the 5-year age intervals to single ages and distributed the deaths above age 85 with the penalized composite model assuming that deaths follow a Poisson distribution and calculated age-specific mortality rates.67 We constructed life tables for each country, sex, and year following standard demographic techniques.68 From these, lifespan uncertainty conditional on surviving to age 10 were calculated.

To disentangle the effect of violent deaths we calculated life expectancy and lifespan uncertainty in absence of these following the cause-deleted life table methodology.68 Additionally, we decomposed the difference in lifespan uncertainty between violent countries and RPR using the linear integral model for decomposition.69 All procedures were done using the R software,70 and are fully reproducible from the public repository [URL].

**Life span uncertainty indicator.** Several indices, highly correlated, to measure lifespan uncertainty exist.35,71 We chose the standard deviation of longevity conditional on surviving to age 10. This indicator has the advantages of being widely used as dispersion indicator in statistics, easy to interpret, decomposable into age- and cause-specific components, and is expressed in years. In life table notation the standard deviation () is given by

Where and denote the age-at-death density function, life expectancy at age 10, and the open-aged interval (110+ in our case), respectively. We condition to age 10 to capture the onset of violent deaths, which [x%, Tim?] occur over this age, and because infant mortality conceals mortality dynamics of adult ages.72

**Robustness check with life disparity.** All figures were replicated using “life disparity” or average life lost. This indicator has been used in several lifespan uncertainty studies, including one focusing on homicide mortality.12 The indices differ in their sensitivity to changes in mortality and in properties and is measured in years, allowing a direct comparison with the standard deviation. While some variations in the levels of lifetime uncertainty were observed, the main results and conclusions of our study are supported.

**Robustness check conditioning on surviving to different ages.**

**Selection of violent countries and construction of the robust peaceful region (RPR).** We focus on the worst and best performers of GPI to compare the burden of violence on lifespan uncertainty. The “Best Performers” category includes all countries that ranked in the top ten over the period 2008-2017: Australia, Austria, Belgium, Canada, Switzerland, Czech Republic, Denmark, Finland, Ireland, Iceland, Japan, Norway, New Zealand, Portugal, Singapore, Slovenia and Sweden. The “Most Violent” category includes the 25 worst performers countries that scored a low or very low level of GPI in 2017. [Let’s create a table with both the peaceful, violent and life uncertainty levels, gpi] To have more robust comparisons of lifetime uncertainty between violent countries and a peaceful environment, we constructed a “Robust Peaceful Region” based on the best performers of GPI. It was determined by the weighted mean of age-specific death rates by sex of the Best Performers. The weights were constructed according to the instances each country appeared in the top ten.

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**Author contributions:**

**Competing interests:** Non-declared.

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