Trends in the Contribution of Major Causes of Injury Death to US Life Expectancy in an International Context

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Abstract

Mortality at younger ages is dominated by injury deaths which may help to explain why life expectancy in the United States lags other countries. We examine the contribution of three major causes of injury death (Motor Vehicle Traffic Crashes, Firearms, and Drug Poisonings) to the gap in life expectancy between the US and other high-income countries. Using data from US vital statistics and the WHO Mortality Database, we show that US men now lose 1.3 years of life expectancy to these three causes, while women lose 0.6 years. Preliminary results suggest that these injuries also make a substantial contribution to the underperformance of the US explaining 22% of the 2.8 year gap with France and 55% of the 1.4 gap with Germany in life expectancy at birth in 2010. Reductions in mortality from these major injury mechanisms would significantly reduce the gap between the United States and its peer countries.

Introduction

A series of recent panels commissioned by the National Academy of Sciences have examined the reasons for the comparatively low life expectancy of the United States compared to its peer countries in Europe, East Asia, and Oceania (Crimmins, et al., 2011). In addition a large amount of research over the past decade has focused on relatively high mortality in the US despite its wealth (Banks, et al., 2006, Ho and Preston, 2010). Although much of this research has focused on adults over age 50, some recent work has concluded that mortality at younger ages accounts for a substantial fraction of American underperformance (Ho, 2013). At younger ages, mortality in the United States is dominated by injury deaths, including both intentional and unintentional injuries. For example, at ages 25-34, nearly 60% of deaths in the US are due to injuries, with 35% due to unintentional injuries (National Center for Health Statistics, 2012). Injury mortality at younger ages is of particular significance since such individuals have many additional years of expected life are in a particularly productive period in their lives. Understanding the contribution of these causes of death to US life expectancy is an important step in explaining why American life expectancy lags that of its counterpart countries.

Injury deaths can be classified based on both mechanism (external cause) of injury and manner (intent) of injury. Mechanisms of injury describe how the injury occurred, e.g., cuts, falls, or gun shots (National Center for Health Statistics, 2008). Manner or intent of injury focuses on whether the injury was on purpose, e.g., unintentional, intentional self-harm (suicide), assault (homicide), or of undetermined intent. Under this distinction, classifications of death that focus on intent such as suicide and homicide are difficult to compare to those that focus on mechanism such as drug overdoses, since individual deaths will be classified on both dimensions. To avoid problems with distinguishing between mechanism and intent of injury, our

study focuses on mechanisms. Our analysis tracks trends in the contribution of major external causes of death to US life expectancy from 1980 to 2011. The analysis largely focuses on three causes of death based on the mechanism of injury: Motor Vehicle Traffic Crashes, Drug Poisonings, and Firearms. We intend to examine possible explanations for trends in mortality from these causes in the United States as well as their contribution to the life expectancy shortfall of the United States compared to other high-income countries.

Background

Injuries are a major cause of mortality in the United States, responsible for more than 150,000 deaths each year. Although age-specific death rates for many causes of injury death rise with age, their relative importance is much greater at younger ages, prior to the onset of major chronic diseases (Murphy, et al., 2013). Injury deaths are not "accidental" in that their occurrence is not random over time, across space, and between social groups. Although the social patterning of intentional injuries (suicide, homicide) has long been known (Durkheim, 1897, Messner, et al., 2004), recent work has called attention to the importance of unintentional injury deaths in the United States (Denney and He, 2014). We focus on three major mechanisms of injury in the United States: Motor Vehicle Traffic Crashes, Firearms, and Drug Poisonings. Together, these causes represent more than 70% of all injury deaths. Understanding these mechanisms can provide insights into their impacts on US health as well as possible prevention efforts.

Motor Vehicle Traffic (MVT) Crashes have long been a major source of injury mortality in the United States. Since the 1970s and 1980s, the rate of death from MVT crashes has declined from more than 1 death for every 3,600 people in 1970 to just 1 death per 10,000 people in 2011 (National Center for Health Statistics, 2014). Declines in the rate of death from

MVT crashes reflect a large number of interacting factors including improvements in vehicle safety requirements, increases in seat belt use and regulations, reductions in driving under the influence, and improvements in road design (Cummings, et al., 2006, Jemal, et al., 2005, Robertson, 1996). Still, MVT crashes kill more than 30,000 Americans each year, and have particular significance for the international position of the United States given the strong preference for auto-commuting and the large number of miles driven in the US compared to peer countries (Transportation Research Board, 2011).

Deaths due to firearms have declined as well since the early 1990s, and much of this decline reflects reductions in homicide deaths (Centers for Disease Control and Prevention, 2011). Although more than 30,000 people died from firearm-related events in 2011, 62% were classified as suicide and 34% were due to homicide (the remaining 4% were unintentional, undetermined or other). Indeed, relatively widespread access to firearms in the United States has been identified as a primary explanation for the comparatively high case-fatality ratio (percent of attempts successful) of suicide among Americans, particularly men (Miller, et al., 2012). Although firearm deaths may respond somewhat to regulations (Rodríguez Andrés and Hempstead, 2011), the large decline since 1990 has been more difficult to explain. Despite this progress, firearm-related mortality remains an important determinant of Americans' mortality disadvantage compared to other high-income countries at younger adult ages (Ho, 2013, Richardson and Hemenway, 2011).

The burden of drug poisoning in the US has become clear in recent years as the number of deaths increased rapidly from less than 8,500 in 1990 to more than 40,000 in 2011 (Chen, et al., 2014). The trend of increasing drug poisoning death rates has led to increased attention to the processes that drive death from drug poisoning and the variation in these processes across

population subgroups (Kochanek, et al., 2013). Like MVT crashes and firearm related deaths, males have higher drug poisoning death rates than females. However, in contrast to other causes of injury death, the age group with the highest mortality from drug poisoning is those aged 45-54 (Warner, et al., 2011).

Contribution and Planned Analyses

Our goal in this analysis is to examine the contribution of three major causes of injury death to US life expectancy levels between 1980 and the present. We have three primary aims in the analysis:

1) Examine the number of years of life expectancy lost in the United States to mortality from Motor Vehicle Traffic Crashes, Firearms, and Drug Poisonings between 1980 and the present.
2) Examine differences in these values between the US and other high-income countries.
3) Examine how these differences contribute to the gap in life expectancy between the US and other high-income countries.

Data

Life expectancies and age-adjusted death rates will be calculated using data from the National Vital Statistics System multiple cause-of-death mortality file (MCD) for the US and from the World Health Organization (WHO) Mortality Database for other high-income countries. Data for the US cover the period 1980 – 2011, while periods of available data from other countries differ. The MCD files contain mortality microdata from annual death certificates complied by the National Center for Health Statistics. We use MCD data in order to calculate annual death rates from each cause of death. The WHO Mortality Database is maintained by the WHO Statistical Information System (WHOSIS) and contains counts of deaths by cause and

population totals for five-year age groups in a wide variety of countries (World Health Organization, 2011).

Major Causes of Death

As stated above, injury-related deaths are classified according to both mechanism and manner/intent. Mechanism refers to the specific factors or circumstances that contribute to the injury, while manner/intent focuses on whether the death was intentional or unintentional. Our focus is on the mechanism of injury, which is important for developing possible prevention efforts as well as improving our understanding of the social determinants of mortality. We focus on the three major mechanisms of injury death, Motor Vehicle Traffic Crashes, Firearms, and Drug Poisonings.[1] Combined, they are responsible for more than 100,000 deaths per year, and two-thirds of all injury mortality. Table 1 catalogs the ICD9 and ICD10 codes used to classify these causes of death.

Methods

We calculate the number of years of life expectancy lost to individual causes of death using a counterfactual approach. First, we calculate life expectancy at birth using standard methods and using observed all-cause death rates. Assume $\mu(x)$ is the all-cause death rate at age *x*. The fraction left surviving at age *x* is given by

$$l(x) = e^{-\int_0^x \mu(a)da}$$

Then life expectancy at birth is given by

$$e_0 = \int_0^\infty l(x)$$

[1] In 2011, 99% of all deaths due to MVT crashes are classified as unintentional. 62% of firearm deaths were suicides, 34% were homicides, and 4% were unintentional, undetermined or other. Of drug poisoning deaths, 80% were unintentional, 13% were suicides, 7% were of undetermined intent, and less than 1% were homicides (Chen, et al., 2014).

We calculate a new death rate with each studied cause (MVT crashes, firearms, drug poisonings) absent, and recalculate life expectancy using the new counterfactual death rate

$$\mu^*(x) = \mu(x) - \mu^i(x)$$

$$l^*(x) = e^{-\int_0^x \mu^*(a)da}$$

$$e_0^* = \int_0^\infty l^*(x)$$

where $\mu^*(a)$ is the counterfactual death rate in the absence of mortality from cause i ($\mu^i(a)$) The difference between e_0^* and e_0 is intended to reflect the number of years of life expectancy gained by the removal of deaths from the specific studied cause. This approach makes fewer assumptions and is less computationally intensive than standard decomposition methods, but gives similar results (Rostron and Wilmoth, 2011).

We intend to compare these values to those of other high-income countries in order to examine the contribution of these causes of death to the shortfall in US life expectancy over time. We will examine a similar set of countries to that used by National Research Council panels and associated studies (Ho, 2013). These countries are similar to the United States both in term of economic development as well as for the availability of comparable mortality data (National Research Council, 2011). We report preliminary results for comparisons between the US and France and Germany.

Preliminary Results

Figure 1 shows trends in mortality from motor vehicle traffic crashes, firearms, and drug poisoning from 1979 to 2012. During this period, the age-adjusted death rate for MVT crashes and firearms declined considerably, while mortality from drug poisonings rose from fewer than 3 deaths per 100,000 to more than 15. Drug poisonings now have the highest rate among the three

mechanisms studied for men and women combined, although the rates are relatively similar across the three causes in 2011.

Table 2 shows the years of life expectancy lost by sex to each of the three causes of injury death between 1980 and 2011. These values show similar trends to those in Figure 1, but the quantified number of years of life expectancy lost is informative. In 1980, MVT crashes and firearms were responsible for the largest number of years of life expectancy lost, particularly among men. For men, the number of years lost to the two causes combine declines from 1.4 in 1980 to 0.87 in 2011, while the number of years lost to drug poisonings rose rapidly from less than 0.1 years to 0.43 years. Similar patterns were observed among women, although the number of years of life expectancy lost are lower than for men. Men experience an overall decline in the number of years of life expectancy lost to all external causes of death (2.46 years to 1.94 years). The number of years of life expectancy lost for women declines between 1980 and 1990, but by 2011 returns to the 1980 level.

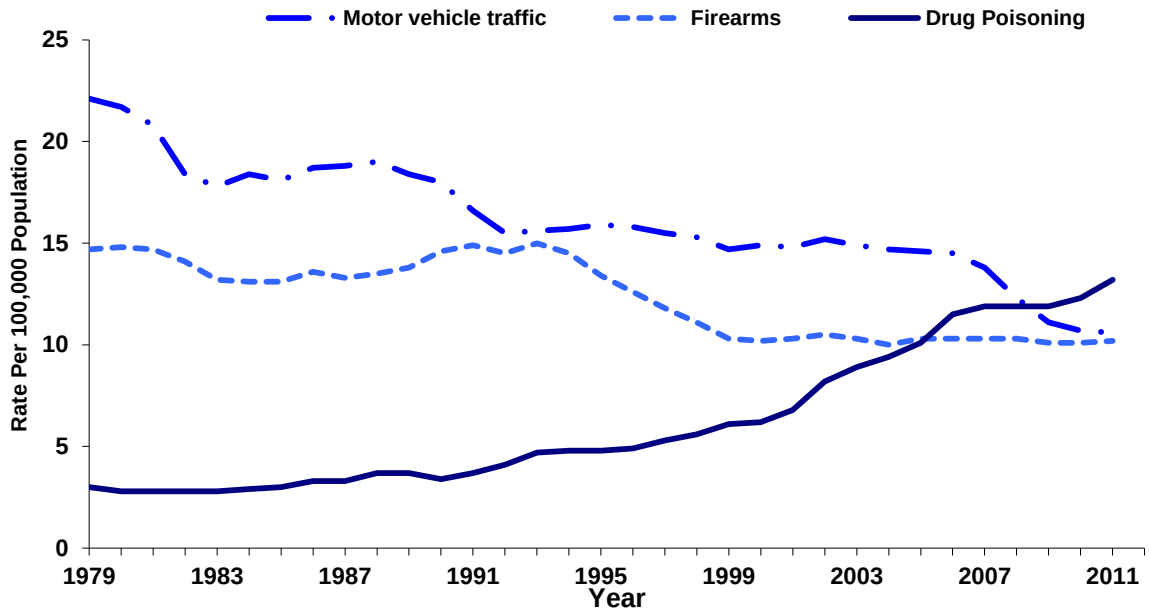
Figure 2 presents preliminary comparisons of the US to France and Germany. US life expectancy at birth lags that of France by 2.8 years and Germany by 1.4 years. The three injury mechanisms cost Americans 0.6-0.8 years of life expectancy more than their French and German counterparts, and make a substantial contribution to the gap in life expectancy. With respect to France, MVT crashes, firearms, and drug poisonings explain 22% of the total life expectancy gap, with the largest contribution to the gap coming from drug poisonings (9%). Compared to Germany, the three injury mechanisms account for 55% of the gap, with firearms and drug poisonings each explaining 20% of the difference. These contributions are particularly striking given that these causes of death account for no more than 5% of deaths in each country. If the US

reduced its death rates from these three causes to the levels of Germany, life expectancy would increase by 0.75 years.

Comment and Next Steps

We examine the contribution of major causes of injury death to US mortality levels and life expectancy. We focus on Motor Vehicle Traffic Crashes, Drug Poisonings, and Firearms. These causes of death are significant for their dominance of injury mortality, their contribution to US mortality levels over time, and for their contribution to the gap in life expectancy between the US and France and Germany. The United States experiences rates of death from these causes that are substantially higher than their counterparts in Europe and North America, particularly for motor vehicle traffic crashes and firearm deaths (Evans, 2014). The age-adjusted death rate from MVT crashes in the US is twice as high as in Canada, and nearly 4 times as high as in the Netherlands (Transportation Research Board, 2011). Preliminary results suggest that these major causes of injury death are important reasons for the shortfall of US life expectancy, explaining 0.6 to 0.8 years of the gap between the US and France and Germany. Our next steps will be to expand our international comparisons to all OECD countries with available data and examine the contribution of trends over time in each cause of death to the divergence between the United States and its counterpart countries during the latter decades of the 20th century and the first decade of the 21st century.

Figure 1: Deaths rates* per 100,000 population for the three leading causes of injury† death: United States, 1979--2011



*Age-adjusted to the 2000 U.S. standard population.
† Injuries are from all manners, including unintentional, suicide, homicide, undetermined intent, legal intervention, and operations of war. Drug poisoning deaths include those resulting from drug overdose, those resulting from other misuse of drugs.
§ In 1999, *International Classification of Diseases, 10th Revision* (ICD-10) replaced the previous revision of the ICD (ICD-9). This resulted in approximately 5% fewer deaths being classified as motor-vehicle traffic--related deaths and 2% more deaths being classified as poisoning-related deaths. Therefore, death rates for 1998 and earlier are not directly comparable with those computed after 1998. Little change was observed in the classification of firearm-related deaths from *ICD-9* to *ICD-10*.
Sources: National Vital Statistics System, mortality data from CDC WONDER, compressed mortality file, underlying cause-of-death, available at http://wonder.cdc.gov/mortsql.html (for 1979--2011 rates).

Table 1: ICD Codes for Major External Injury Mechanisms

Mechanism	ICD9 Code	ICD10 Code
Firearms	E922.0–E922.9, E955.0–E955.4, E965.0–E965.4, E985.0–E985.4, E970	U01.4,W32–W34,X72–X74,X93–X95,Y22–Y24,Y35.0
Motor Vehicle Traffic Crashes	E810–E819, E958.5, E988.5	V02–V04[.1,.9], V09.2, V12–V14[.3–.9], V19.4–V19.6, V20–V28[.3–.9], V29–V79[.4–.9], V80.3–V80.5, V81.1, V82.1, V83–V86[.0–.3], V87.0–V87.8, V89.2
Drug Poisonings	E850–E858, E950.0–E950.5, E962.0, E980.0–E980.5	X40–X44, X60–X64, X85, Y10-Y14

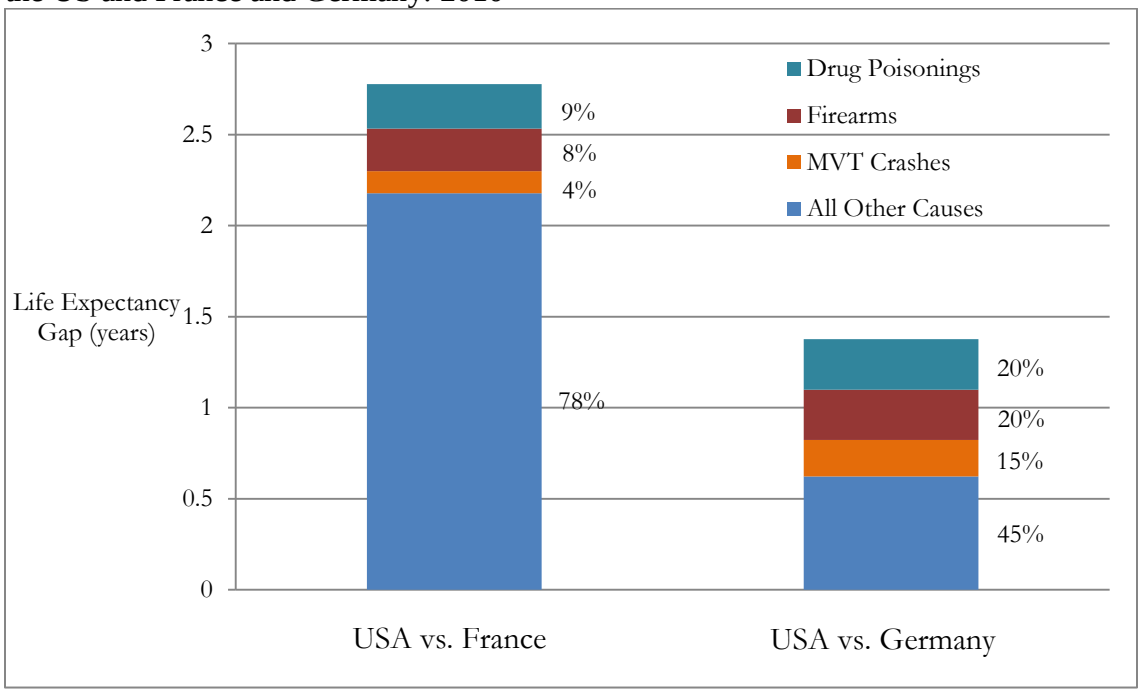
Notes: Causes of death include all manner/intent of injury (unintentional, self-inflicted, assault, undetermined). See Warner et al (2011) for analysis of comparability of causes across ICD revisions

Table 2: Years of Life Expectancy Lost to Major Injury Mechanisms of Death 1980 – 2011

	Years of Life Expectancy Lost			
Men	1980	1990	2000	2011
Motor Vehicle Traffic Crashes	0.83	0.69	0.55	0.42
Drug Poisonings	0.07	0.09	0.20	0.43
Firearms	0.59	0.64	0.46	0.45
Subtotal	1.49	1.42	1.21	1.30
All Other External Causes	0.97	0.49	0.68	0.63
Total	2.46	1.92	1.89	1.94
Women				
Motor Vehicle Traffic Crashes	0.35	0.34	0.28	0.19
Drug Poisonings	0.07	0.07	0.11	0.29
Firearms	0.14	0.13	0.08	0.09
Subtotal	0.56	0.54	0.47	0.57
All Other External Causes	0.45	0.33	0.34	0.41
Total	1.01	0.87	0.80	0.98

Notes: Causes of death focus on mechanism. Data include all manner of death (unintentional, suicide, homicide, undetermined). Years of life expectancy lost calculated as difference between life expectancy at birth calculated in the presence and absence of mortality from each cause of death

Figure 2: Contribution of Major Injury Mechanisms to Difference in Life Expectancy between the US and France and Germany: 2010



Notes: Life expectancy gap refers to number of additional years of life expected in the European country compared to the United States.
Source: Authors' calculations from WHO Mortality Database, and US vital statistics 2010

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