CLINICAL RESEARCH STUDY

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Lifetime Risk of Death From Firearm Injuries, Drug Overdoses, and Motor Vehicle Accidents in the United States

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ABSTRACT

BACKGROUND: News media and policy makers frequently discuss deaths from firearms, drug overdoses, and motor vehicle accidents. However, this information is generally presented as absolute numbers or annual rates. Cumulative lifetime risk may be an additional useful metric for understanding the impact of these causes of death.

METHODS: Data on all-cause firearm, drug overdose, and motor vehicle accident deaths were obtained from the US Centers for Disease Control and Prevention (CDC) for the year 2018. Age-specific death rates were used to estimate the cumulative risk of firearm, drug overdose, and motor vehicle accident deaths from birth to age 85 after accounting for other causes of death.

RESULTS: The lifetime risk of death from firearms, drug overdoses, and motor vehicle accidents was 0.93% (95% confidence interval [CI], 0.92%-0.94%), 1.52% (95% CI, 1.51%-1.53%), and 0.92% (95% CI, 0.91%-0.93%), respectively. Black males had a 2.61% (95% CI, 2.55%-2.66%) lifetime risk of firearm death, indicating that 1 out of 38 black males will die from firearms if current death rates persist. Residents of West Virginia had a 3.54% lifetime risk of drug overdose death, equivalent to 1 out of every 28 residents dying from overdoses.

CONCLUSIONS: The lifetime risk of death from firearms, drug overdoses, and motor vehicle accidents is substantial and varies greatly across demographic subgroups and states.

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KEYWORDS: Drug overdoses; Firearm injuries; Motor vehicle accidents

INTRODUCTION

News media and policy makers frequently discuss deaths from firearms, drug overdoses, and motor vehicle accidents. Numerical details about these 3 causes of death are usually presented in news stories and in government reports as absolute numbers (eg, 67,000 drug overdose deaths last year) or as annual rates (eg, 12 motor vehicle accident deaths/100,000 population). But people often have difficulty appreciating the magnitude of both large numbers (such as tens of thousands of deaths) and small numbers (such as a death rate of 0.00012).[1,2] Cumulative lifetime risk may be a useful metric for understanding the impact of these causes of death.[3] Moreover, previous research indicates that patients prefer to receive cumulative risk estimates, perceive such estimates as indicating higher risk, and are more willing to receive treatment when presented with the lifetime risk of a disease.[4,5]

A study based on 1992-1994 data estimated lifetime risk of death from motor vehicle accidents, but such deaths have decreased since then.[6,7] In addition, the lifetime risk of deaths from firearms and drug overdoses have not previously been quantified. As a result, this study sought to determine the lifetime risk of death from these 3 causes for

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the United States as a whole; for race, ethnicity, and gender subgroups; and for individual states.

METHODS

Data

Data on population size and all-cause, firearm, drug overdose, and motor vehicle accident deaths were obtained from the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research (CDC WONDER) system for the year 2018.[8] As defined in CDC WONDER, firearm deaths correspond to the International Statistical Classification of Diseases (ICD-10) codes U01.4, W32-W34, X72-X74, X93-X95, Y22-Y24, and Y35.0, whereas motor vehicle accident deaths (including deaths of pedestrians and cyclists involving motor vehicles) correspond to codes V02-V04, V09.0, V09.2, V12-V14, V19.0-V19.2, V19.4-V19.6, V20-V79, V80.3-80.5, V81.0-81.1, V82.0-V82.1, V83-V86, V87.0-V87.8, V88.0-V88.8, V89.0, and V89.2.[8] As defined by the National Institute on Drug Abuse, drug overdose deaths correspond to codes X40-X44, X60-X64, X85, and Y10-Y14.[9] Population size and deaths were categorized into 5-year age groups except for the 2 youngest age groups, which were categorized as <1 year and 1-4 years. These data were obtained for the United States as a whole; for race, ethnicity, and gender subgroups; and for individual states. The first 4 columns in the Appendix available online display the data obtained for the United States for all-cause and firearm deaths. All analyses are based on the underlying cause of death (ie, the disease or injury that led directly to death based on entries by a physician on a death certificate).[8]

CLINICAL SIGNIFICANCE

- There is a substantial lifetime risk of death from firearms, drug overdoses, and motor vehicle accidents in the United States.
- This risk varies greatly across demographic groups and states.
- Health providers are uniquely positioned to advocate for measures to reduce these deaths.

Statistical Analysis

Because it is impractical to follow a cohort of individuals over an entire lifetime to determine cumulative risk, lifetime risk was estimated using a life-table approach.[10,11] A hypothetical cohort of 100,000 individuals was followed from birth to the end of age 84 using a competing risks framework (see Appendix). For each age group, all-cause and firearm deaths were estimated by multiplying the population size at the beginning of the interval with 1) actual population all-cause and firearm death rates and 2) the number of years in the interval. For example, the number of all-cause deaths expected during the 1- to 4-age interval is 99,442.2 × 24.0/100,000 × 4 = 95.5. Similarly, the number of firearm deaths expected is 99,442.2 × 0.6/100,000 × 4 = 2.4. The number of all-cause deaths in the interval was subtracted from the population at the beginning of the interval to obtain the population alive at the beginning of the next interval; in this case, 99,442.2 − 95.5 = 99,346.7. This process was repeated until the end of age 84, and the total firearm deaths across all years were summed to obtain lifetime risk. Lifetime risk is presented as both a cumulative probability (in this case, 0.93%) and as the inverse of the risk, calculated as 100/risk (ie, 1 out of 108 individuals would be expected to die from firearms). A similar approach was used to determine lifetime risk of death from drug overdoses and motor vehicle accidents. Age 85+ was not included because population sizes and cause-specific number of deaths are not available via CDC WONDER for 5-year intervals beyond age 85.

A similar approach was used to analyze data for race, ethnicity, and gender subgroups and for each state. Confidence intervals for lifetime risks were estimated using a bootstrap approach. For example, each of the 15,962,067 Americans ages 1-4 years who were alive in 2018 may be categorized as 1) dead from any cause or 2) alive at the end of the year (see Appendix). An all-cause bootstrap sample was created by sampling 15,962,067 individuals from this population with replacement (so the same person may be chosen more than once). This process was performed separately for each age group and then aggregated across all age groups. Similarly, all Americans may be categorized as 1) dead from firearms or 2) not dead from firearms at the end of 2018. A firearm bootstrap sample was created from this population. These 2 bootstrap samples were used to estimate all-cause and firearm death rates and then life-table-based lifetime risk. This process was repeated 1000 times and the 2.5 and 97.5 percentile values of the distribution of calculated lifetime risks were used as confidence intervals. A similar process was used for estimating other confidence intervals. All statistical analyses were performed using JMP version 14.0 (SAS Institute, Cary, North Carolina).

RESULTS

In 2018, there were a total of 2,839,205 deaths in the United States, including 39,740 from firearms, 67,367 from drug overdoses, and 39,404 from motor vehicle accidents (Table 1). Black males had the highest death rates from firearms, black and white males had the highest death rates from drug overdoses, and Native American males had the highest death rates from motor vehicle accidents. Asian American females had the lowest death rate for all 3 specific causes.

For the overall population, the lifetime risk of death from firearms, drug overdoses, and motor vehicles was 0.93%, 1.52%, and 0.92%, respectively (Table 2). Black males had a 2.61% lifetime risk of death from firearms, indicating that 1 out of 38 black males will die from firearms if current death rates persist. By contrast, Asian American females had a

Table 1 Deaths in the United States in 2018

Group	Population Size	Number of Deaths (Rate per 100,000) All-Cause	Firearms	Drug Overdoses	Motor Vehicle Accidents
All individuals	327,167,434	2,839,205 (867.8)	39,740 (12.1)	67,367 (20.6)	39,404 (12.0)
Asian American females	11,244,827	37,214 (330.9)	118 (1.0)	246 (2.2)	387 (3.4)
Asian American males	10,356,237	39,663 (383.0)	523 (5.1)	618 (6.0)	644 (6.2)
Black females	24,045,602	166,783 (693.6)	1178 (4.9)	2709 (11.3)	1736 (7.2)
Black males	22,217,244	182,070 (819.5)	8781 (39.5)	6734 (30.3)	4628 (20.8)
Hispanic females	29,637,561	91,674 (309.3)	497 (1.7)	1487 (5.0)	1564 (5.3)
Hispanic males	30,234,185	113,045 (373.9)	3521 (11.6)	4845 (16.0)	4559 (15.1)
Native American females	2,363,298	9129 (386.3)	78 (3.3)	287 (12.1)	230 (9.7)
Native American males	2,375,990	11,639 (489.9)	399 (16.8)	493 (20.7)	540 (22.7)
White females	128,385,028	1,167,610 (909.5)	4411 (3.4)	19,184 (14.9)	9098 (7.1)
White males	126,179,208	1,225,097 (970.9)	24,252 (19.2)	37,096 (29.4)	22,141 (17.5)

Table 2 Lifetime Risk of Death From Firearms, Drug Overdoses, and Motor Vehicle Accidents.*

Group	Lifetime Risk (95% Confidence Interval) 100/Lifetime Risk Firearms	Drug Overdoses	Motor Vehicle Accidents
All individuals	0.93% (0.92%-0.94%) 108	1.52% (1.51%-1.53%) 66	0.92% (0.91%-0.93%) 109
Asian American females	0.08% (0.07%-0.10%) 1225	0.16% (0.14%-0.18%) 617	0.34% (0.31%-0.39%) 291
Asian American males	0.38% (0.35%-0.42%) 260	0.43% (0.40%-0.47%) 231	0.56% (0.52%-0.61%) 178
Black females	0.35% (0.33%-0.37%) 287	0.85% (0.81%-0.88%) 118	0.56% (0.53%-0.59%) 178
Black males	2.61% (2.55%-2.66%) 38	2.29% (2.24%-2.35%) 44	1.54% (1.50%-1.58%) 65
Hispanic females	0.12% (0.11%-0.14%) 802	0.41% (0.39%-0.43%) 245	0.48% (0.46%-0.51%) 207
Hispanic males	0.87% (0.84%-0.90%) 115	1.24% (1.20%-1.28%) 81	1.26% (1.22%-1.31%) 79
Native American females	0.24% (0.19%-0.30%) 411	0.94% (0.84%-1.06%) 106	0.79% (0.67%-0.91%) 127
Native American males	1.26% (1.13%-1.40%) 79	1.52% (1.39%-1.66%) 66	1.75% (1.60%-1.91%) 57
White females	0.27% (0.26%-0.27%) 374	1.14% (1.12%-1.16%) 88	0.55% (0.54%-0.56%) 181
White males	1.44% (1.42%-1.46%) 69	2.13% (2.11%-2.15%) 47	1.30% (1.29%-1.32%) 77

*For example, the lifetime risk of death from drug overdose in the United States is 1.52%, indicating that 1 out of every 66 Americans will die from drug overdoses if current death rates persist.

0.08% lifetime risk of death from firearms. White males had a 2.13% lifetime risk of death from drug overdoses, indicating that 1 out of 47 white males would be expected to die from drug overdoses. Native American males had a 1.75% lifetime risk of death from motor vehicle accidents.

Lifetime risks also varied greatly across states, with some having especially striking overdose risks (Table 3). For example, residents of West Virginia had a 3.54% lifetime risk of death from overdoses, indicating that 1 out of 28 would be expected to die from overdoses. Residents of Mississippi had the highest lifetime risks for firearm deaths and motor vehicle accidents. The states with the lowest lifetime risks of death from firearms, drug overdoses, and motor vehicle accidents were Rhode Island, South Dakota, and New York, respectively.

Table 3 Lifetime Risk of Death From Firearms, Drug Overdoses, and Motor Vehicle Accidents by State.

	Lifetime Risk (100/Lifetime Risk)		
	Firearms	Drug Overdoses	Motor Vehicle Accidents
Alabama	1.59% (63)	1.16% (86)	1.62% (62)
Alaska	1.57% (64)	1.06% (94)	0.94% (106)
Arizona	1.23% (81)	1.77% (57)	1.11% (90)
Arkansas	1.43% (70)	1.10% (91)	1.36% (74)
California	0.61% (164)	1.03% (97)	0.83% (121)
Colorado	1.19% (84)	1.28% (78)	0.94% (107)
Connecticut	0.40% (252)	2.23% (45)	0.65% (154)
Delaware	0.87% (115)	3.09% (32)	0.92% (109)
District of Columbia	1.16% (86)	2.99% (33)	0.46% (219)
Florida	1.02% (98)	1.64% (61)	1.13% (88)
Georgia	1.21% (83)	0.98% (102)	1.12% (90)
Hawaii	0.34% (298)	1.14% (88)	0.65% (154)
Idaho	1.33% (75)	1.10% (91)	1.14% (88)
Illinois	0.82% (122)	1.56% (64)	0.73% (138)
Indiana	1.11% (90)	1.82% (55)	0.98% (102)
Iowa	0.70% (143)	0.70% (142)	0.89% (112)
Kansas	1.11% (90)	0.91% (110)	1.11% (90)
Kentucky	1.26% (79)	2.16% (46)	1.27% (79)
Louisiana	1.56% (64)	1.79% (56)	1.29% (77)
Maine	0.89% (113)	1.96% (51)	0.88% (113)
Maryland	0.88% (113)	2.76% (36)	0.67% (150)
Massachusetts	0.28% (351)	2.36% (42)	0.44% (225)
Michigan	0.98% (102)	1.94% (52)	0.76% (132)
Minnesota	0.62% (161)	0.86% (117)	0.70% (142)
Mississippi	1.69% (59)	0.77% (131)	1.74% (57)
Missouri	1.60% (62)	1.94% (51)	1.18% (85)
Montana	1.36% (73)	0.91% (110)	1.30% (77)
Nebraska	0.75% (134)	0.55% (183)	1.01% (99)
Nevada	1.42% (70)	1.67% (60)	0.90% (111)
New Hampshire	0.85% (118)	2.52% (40)	0.84% (119)
New Jersey	0.37% (272)	2.39% (42)	0.53% (189)
New Mexico	1.59% (63)	1.93% (52)	1.42% (70)
New York	0.32% (312)	1.39% (72)	0.42% (239)
North Carolina	1.04% (96)	1.60% (63)	1.16% (86)
North Dakota	0.87% (115)	0.73% (137)	1.06% (95)
Ohio	0.99% (101)	2.53% (39)	0.78% (129)
Oklahoma	1.27% (79)	1.36% (74)	1.35% (74)
Oregon	0.96% (104)	0.96% (104)	0.90% (111)
Pennsylvania	0.96% (104)	2.57% (39)	0.75% (133)
Rhode Island	0.27% (370)	2.22% (45)	0.49% (202)
South Carolina	1.31% (77)	1.63% (61)	1.53% (65)
South Dakota	1.05% (95)	0.51% (196)	1.40% (71)
Tennessee	1.33% (75)	1.95% (51)	1.22% (82)
Texas	0.96% (104)	0.80% (125)	1.04% (96)
Utah	1.05% (95)	1.62% (62)	0.69% (145)
Vermont	0.97% (103)	1.87% (53)	0.89% (112)
Virginia	0.94% (107)	1.24% (81)	0.82% (122)
Washington	0.84% (119)	1.14% (88)	0.71% (142)
West Virginia	1.35% (74)	3.54% (28)	1.32% (76)
Wisconsin	0.80% (126)	1.40% (72)	0.82% (121)
Wyoming	1.65% (61)	0.90% (111)	1.30% (77)

DISCUSSION

The lifetime risk of death from firearms, drug overdoses, and motor vehicle accidents is substantial and varies considerably by race, ethnicity, gender, and location. For instance, black males have a 33-fold higher risk of death from firearms compared with Asian American females, and white males have 13-fold higher risk of death from drug overdoses compared with Asian American females. Residents of West Virginia, Delaware, and the District of Columbia have a lifetime risk of drug overdoses that is twice the national average. Strengths of the study include use of the most recently available national data, mortality figures that are based on official death certificates, analyses that account for competing causes of death, and precise risk estimates with narrow confidence intervals based on a large population.

These results are consistent with previous research on demographic differences in death rates from firearms, drug overdoses, and motor vehicle accidents.[12-15] For example, a study using 2010-2012 data found that males were 6 times more likely than females to die from firearms.[12] A study based on 1992-1994 data estimated lifetime risk of death from motor vehicle accidents at 0.69%-1.69% for various race and gender subgroups.[6] However, motor vehicle accident death rates have decreased by 20% over the last 2 decades.[8] By contrast, firearm deaths have increased by 20% and drug overdose deaths have increased more than 300% over the same time period.[8,16] Other researchers have used similar methods to determine lifetime risk of several medical conditions.[11,17-23] For example, the lifetime risk of developing end-stage renal disease is estimated to be 2%-8%, stroke is 21%-25%, and diabetes is 33%-39%.[17,20,23]

Although absolute numbers of deaths or annual death rates describe mortality over a short time period, lifetime risk may be a useful method to convey information on long-term consequences. Lifetime risk estimates may help both the public and policy makers to better appreciate the impact of deaths from the 3 causes. Policy makers can deploy a variety of measures to reduce population exposure to firearms, potentially lethal drugs, and unsafe vehicle operation. It is worth noting that there are other important impacts besides death, including nonfatal injuries, economic costs, and effects on victims' relatives. For example, nonfatal firearm injuries, which often result in hospitalization and disability, are twice as frequent as fatal ones.[12] A recent economic analysis estimated that the economic burden

of prescription opioid overdose, abuse, and dependence exacts a toll of $78.5 billion annually in health care costs, criminal justice costs, and lost productivity.[24] A study of families of motor vehicle accident victims found that many experienced prolonged depression and poor functioning.[25]

These findings also have important implications for health providers and researchers. Health providers are uniquely positioned to advocate for measures likely to reduce deaths. They can ask patients about the presence of firearms in the home, review safe storage practices, and screen for depression or a previous history of violence.[26] Providers can limit or avoid prescribing drugs with overdose potential and carefully monitor patients on such drugs.[27] They can talk to patients about using seat belts and motorcycle helmets and can screen for alcohol dependence.[28] Researchers can examine the relative importance of individual-, community-, and policy-level factors that may explain the extensive variation in lifetime risk across demographic groups and states. They can also develop and test better methods for conveying information about the impact of these 3 conditions to the public and policy makers.

Several limitations must be considered in interpreting these results. The standard method used in this study for estimating lifetime risk assumes that future death rates will match those of the current year.[3] Such long-term extrapolations may under- or overestimate actual future risks. Moreover, lifetime risk estimates may be less relevant to individuals who have already survived for several decades.[6] The lifetime risk estimates in this analysis are average values, and different individuals may have substantially lower or higher risks. A small number of deaths among individuals ages 85+ were excluded from the analyses. This exclusion would be expected to slightly decrease estimated lifetime risk. There may be some misclassification of causes of death on death certificates. Finally, many deaths from firearms, drug overdoses, and motor vehicle accidents affect young adults. However, lifetime risk calculations do not focus on years of life lost and may not adequately capture the societal impact of deaths in this age group.

CONCLUSION

In conclusion, there is a substantial lifetime risk of death from firearms, drug overdoses, and motor vehicle accidents in the United States. The marked variation in lifetime risk across demographic groups and states, the sizeable changes in the numbers of these deaths over the past decades, and the much lower cause-specific death rates in other developed countries suggests that many of these premature causes of death should be preventable.[8,29-31]

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SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjmed.2020.03.047.

APPENDIX. LIFE TABLE ANALYSIS OF ALL-CAUSE AND FIREARM DEATHS FROM BIRTH TO END OF AGE 84 YEARS

	Actual deaths			Simulated cohort		
Age (years)	Population Size	All-cause (rate/100,000)	Firearm (rate/100,000)	Alive beginning of interval	All-cause deaths in interval	Firearm deaths in interval
<1	3,848,208	21,467 (557.8)	7 (0.2)	100,000.0	557.8	0.2
1-4	15,962,067	3830 (24.0)	91 (0.6)	99,442.2	95.5	2.4
5-9	20,195,642	2330 (11.5)	70 (0.3)	99,346.7	57.1	1.5
10-14	20,879,527	3120 (14.9)	367 (1.8)	99,289.6	74.0	8.9
15-19	21,097,221	10,380 (49.2)	2807 (13.3)	99,215.6	244.1	66.0
20-24	21,873,579	19,774 (90.4)	4604 (21.0)	98,971.6	447.4	103.9
25-29	23,561,756	27,461 (116.5)	4466 (19.0)	98,524.2	573.9	93.6
30-34	22,136,018	31,383 (141.8)	3634 (16.4)	97,950.3	694.5	80.3
35-39	21,563,587	37,617 (174.4)	3331 (15.4)	97,255.8	848.1	74.9
40-44	19,714,301	42,763 (216.9)	2696 (13.7)	96,407.8	1045.5	66.0
45-49	20,747,135	64,873 (312.7)	2670 (12.9)	95,362.2	1491.0	61.5
50-54	20,884,564	99,964 (478.7)	2653 (12.7)	93,871.2	2246.8	59.6
55-59	21,940,985	160,963 (733.6)	2903 (13.2)	91,624.4	3360.8	60.5
60-64	20,331,651	213,873 (1051.9)	2450 (12.1)	88,263.7	4642.2	53.4
65-69	17,086,893	251,246 (1470.4)	1992 (11.7)	83,621.4	6147.8	48.9
70-74	13,405,423	292,532 (2182.2)	1670 (12.5)	77,473.6	8453.1	48.4
75-79	9,267,066	321,745 (3471.9)	1419 (15.3)	69,020.4	11,981.6	52.8
80-84	6,127,308	353,460 (5768.6)	946 (15.4)	57,038.8	16,451.7	43.9
				Total firearm deaths		926.8
			Lifetime risk (926.8/100,000)			0.93%
			100/risk			108