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Original Research

Global, regional, and national burden of injuries, and burden attributable to injuries risk factors, 1990 to 2019: results from the Global Burden of Disease study 2019

GBD 2019 Injuries Collaborators

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ABSTRACT

Objectives: In this study, the trends and current situation of the injury burden as well as attributable burden to injury risk factors at global, regional, and national levels based on the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 are presented.
Study design: To assess the attributable burden of injury risk factors, the data of interest on data sources were retrieved from the Global Health Data Exchange (GHDx) and analyzed.
Methods: Cause-specific death from injuries was estimated using the Cause of Death Ensemble model in the GBD 2019. The burden attributable to each injury risk factor was incorporated in the population attributable fraction to estimate the total attributable deaths and disability-adjusted life years. The Socio-demographic Index (SDI) was used to evaluate countries' developmental status.
Results: Globally, there were 713.9 million (95% uncertainty interval [UI]: 663.8 to 766.9) injuries incidence and 4.3 million (UI: 3.9 to 4.6) deaths caused by injuries in 2019. There was an inverse relationship between age-standardized disability-adjusted life year rate and SDI quintiles in 2019. Overall, low bone mineral density was the leading risk factor of injury deaths in 2019, with a contribution of 10.5% (UI: 9.0 to 11.6) of total injuries and age-standardized deaths, followed by occupational risks (7.0% [UI: 6.3–7.9]) and alcohol use (6.8% [UI: 5.2 to 8.5]).
Conclusion: Various risks were responsible for the imposed burden of injuries. This study highlighted the small but persistent share of injuries in the global burden of diseases and injuries to provide beneficial data to produce proper policies to reach an effective global injury prevention plan.
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Introduction

Injuries impose a considerable burden on public health, leading to more than 3200 disability-adjusted life years (DALYs) per 100,000 people in 2019.[1] According to the cause hierarchy of the Global Burden of Diseases (GBD) study, injuries are subcategorized into three groups: Unintentional injuries (occurs unplanned or caused by external factors; e.g. falls), transport injuries (including road and non-road transport injuries), and self-harm and interpersonal violence (injuries deliberately inflicted on oneself or that are due to the intentional use of physical force from another person; e.g. sexual violence).[2] Each of the subcategories contributed to more than two percent of global deaths and 2.5 percent of global DALYs in 2019.[1]

Injuries are a cause of loss of health and human resources that could be almost universally averted by improving safety and prevention programs and ensuring access to appropriate trauma care.[2] Certain modifiable risk factors, including alcohol and drug use, smoking, occupational risks, and low bone mineral density have been suggested to contribute to injury-related deaths and DALYs.[3] Moreover, low- and middle-income countries take on 88% of the total injury burden, and it has been shown that providing basic surgical care in these countries could potentially avert 21% of the global injury burden.[4] If injury-related death rates in these countries could be reduced to rates in high-income countries, more than two million lives would be saved yearly, and there would be more than 750 billion U.S. dollars associated economic benefits per year.[5]

Injury burden estimates are crucial to guide policy development and healthcare investments that aim to reduce the incidence of injuries and increase access to high-quality and timely trauma care.[6] However, there are several methodological challenges in estimating the burden of injuries, including obtaining data in data-sparse and burden-heavy areas of the world, developing adjustments for ill-defined causes of death, adjusting known biases in data such as underestimation in sexual violence data, and estimating the cause of injury separately from resulted bodily harm.[7] Although the burden of injuries is widely studied and monitored by various research methods, the GBD is the only study framework

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that routinely provides estimates of incidence, mortality, and DALYs for an exhaustive list of injuries.[2,8] The objective of this study is to present detailed information on trends and the current situation of the injury incidence, deaths, and DALYs, along with burden attributable to risk factors of injuries at global, regional, and national levels based on the GBD 2019. This study is the first of its kind that provides estimates of the burden of injuries attributable to risk factors, emphasizing the importance of changing perceptions about injury-related health loss as preventable events.

Methods

Overview

Detailed descriptions of the study design, the standardized data collection protocol, the International Classification of Disease (ICD) codes used in identifying injuries causes, and methods of the GBD 2019 have been provided before.[1,3] A brief overview of the GBD 2019 methods specific to injury burden and risk factors are presented here. The data of interest on data sources, as well as injury burden and risk factors, were retrieved from the Global Health Data Exchange (GHDx), a website developed by the Institute for Health Metrics and Evaluation (IHME).[9] An injury death was defined in the GBD 2019 as one where the injury was the primary cause of the death, and a non-fatal injury was specified as an injury necessitating medical care. The input data used in estimations consisted of 4053 sources for causes of death and 368 sources for non-fatal health outcomes. Besides, the input data for seven level-2 risk factors were 3881, 1650, 1430, 411, 178, 154, and 9 sources for tobacco, occupational risks, alcohol use, intimate partner violence, low bone mineral density, drug use, and non-optimal temperature, respectively. In the GBD 2019, injury causes were broken down into three level 2 causes: transport injuries, unintentional injuries, and self-harm and interpersonal violence. The estimates were produced for 204 countries under seven GBD super-regions, including Central Europe, Eastern Europe and Central Asia, East Asia and Oceania, high-income, Latin America and Caribbean, North Africa and the Middle East; South Asia, South East Asia, and Sub-Saharan Africa.

Mortality

Cause-specific death from injuries was estimated using the Cause of Death Ensemble model (CODEm) in the GBD 2019, as has been described in detail previously.[1,10] The CODEm inputs consisted of mortality estimates as well as covariates with potential implications for injury-related death. Essentially, the CODEm framework uses an ensemble of multiple modeling algorithms of rates or causes fractions with varying sets of covariates that perform best with out-of-sample predictive validity testing. The years of life lost (YLLs) were computed as a function of the cause-specific death rate multiplied by the residual life expectancy of each age group.

Non-fatal health outcomes

Injuries can be classified by cause as well as nature, with the cause being the accident that led to a particular nature of injury. First, the incidence of injuries caused in the GBD 2019 were estimated using DisMod-MR 2.1, a Bayesian meta-regression tool for the evaluation of all available data on incidence, prevalence, remission, and death related to a cause. Second, for each injury cause-nature, the fraction of incident cases was estimated and multiplied by the incidence of the corresponding cause of injury. Third, the prevalence of each injury nature was derived from the multiplication of estimated incidence and duration. Disability resulted from each injury nature were then calculated by application of disability weights to the outcome prevalence and aggregated across natures of injury for each cause as years lived with disability (YLDs).

Attributable burden to risk factors

The six-step framework of comparative risk assessment (CRA) was used to estimate the attributable burden of injury risk factors in the GBD 2019.[11] The six steps of CRA are[1] the risk–outcome pairs inclusion into the analysis;[2] the relative risk calculation as a function of exposure;[3] estimation of exposure levels and distributions;[4] computation of the theoretical minimum risk exposure level (TMREL) as the counterfactual level of exposure;[5] calculation of population attributable fractions (PAF) and attributable burden;[6] and estimation of the mediating effects of various risk factors on each other to determine the burden of a combination of risk factors. A direct or indirect burden attributable to a particular risk factor was incorporated in the PAF to estimate the total attributable deaths and DALYs to that risk factor. The PAF measures the proportional reduction in the cause-specific burden that would occur if exposure to the risk factor was at the TMREL.

The summary exposure value (SEV) is the risk-weighted prevalence of exposure. The SEV ranges from 0 to 100, where the value 0 indicates there is no excess risk for the entire population while the value 100 means everyone in the population is exposed to the maximum risk.

Socio-demographic index

The Socio-demographic Index (SDI), a composite indicator of overall socio-economic development status was calculated in the GBD 2019 based on the educational attainment of those aged 15 years or older, lag distributed income per capita, and the total fertility rate among females under 25 years.[12] The SDI ranges from 0 to 1, where higher values indicate higher levels of development. Based on SDI quintiles, countries were divided into five groups: low SDI, low-middle SDI, middle SDI, high-middle SDI, and high SDI.

To account for changes in the population structure, age-standardization was performed by direct standardization of the global age structure. The rate estimates were expressed as per 100,000 population. The 95% uncertainty interval (UI) for each metric was calculated by taking 1000 samples from the posterior distribution, and using the 25th and 975th ranked draws of the uncertainty distribution.

Results

Overview

Globally, there were 713.9 million (95% UI: 663.8 to 766.9) injuries incidence and 4.3 million (3.9–4.6) deaths caused by injuries in 2019. Injuries with the all-ages death rate of 55.6 (50.7–59.6) and DALY rate of 3219.7 (2923.7 to 3551.0) accounted for 7.6% (7.0–8.0) and 9.8% (9.2–10.3) of all-cause deaths and DALYs worldwide in 2019, respectively. During 1990–2019, the age-standardized incidence rate of all injuries decreased by 12.9% (12.0–13.8), from 10,628.1 (9892.8 to 11,413.4) to 9259.4 (8601.9 to 9959.8). In the same time frame, the age-standardized DALY rate of all injuries shrank by 37.2% (32.8–41.1), with the YLLs component declining steeper than YLDs, 42.7% (37.4–47.0) vs. 11.5% (10.5–12.8).

Age and sex distribution of injuries

Overall, men with an age-standardized incidence rate of 10,914.7 (10,139.8 to 11,737.3) were at considerably higher risk of injuries

compared to women with 7538.7 (6992.9 to 8125.7) in 2019. Incidence rates were almost the same, with some variations in women among all age groups up to the 65–69 age group in 2019. In contrast, incidence rates in men increased after the under 1 age group, making a peak in the 20–24 age group, followed by a steady decrease until the 65–69 age group. In both sexes, incidence rates of injuries increased from the 70–74 age group, with women having steeper growth (Fig. 1). In 2019, injury incidence rates of men were significantly higher than women from age 15 up to 54, whereas women's incidence rate of injuries were higher in the 80+ age group. The age-standardized death rate of men due to injuries was notably higher than women in 2019, with 76.7 (69.7–83.0) and 33.2 (29.7–36.4), respectively. Men had higher death rates due to injuries in all age groups in 2019. Despite no significant difference in incidence rates among age groups between 1990 and 2019, both death and DALY rates of all age groups were consistently lower in 2019 (Appendix 1).

Geographical distribution of injuries

Among seven GBD super-regions, Central Europe, Eastern Europe, and Central Asia with 18,118.4 (16,496.1 to 19,750.5) experienced the highest age-standardized incidence rate in 2019, followed by high-income (13,694.8 [12,475.3 to 14,988.8]) and Latin America and Caribbean (9747.2 [8989.8 to 10,561.9]). Central Europe, Eastern Europe, and Central Asia with 4168.5 (3712.6 to 4748.9) had the most injury-related age-standardized DALY rates, whereas high-income with 2250.1 (1981.6 to 2588.4) had the least. High SDI countries with 13,785.1 (12,597.4 to 15,021.3) had the highest age-standardized incidence rate of injuries, and middle SDI countries with 7254.9 (6951.6 to 8144.5) had the lowest in 2019. There was an inverse relationship between age-standardized DALY rate and SDI quintiles in 2019, with low SDI countries (4019.0 [3532.5 to 4549.3]) and high SDI countries (2395.5 [2120.2 to 2743.7]) experiencing the highest and lowest rates, respectively (Appendix 2).

All-age incidence, deaths, YLLs, YLDs, and DALYs of injuries in 2019 by country is presented in (Appendix 3). New Zealand (32,242.0 [29,602.0 to 35,076.8]), Australia (27,590.1 [24,162.0 to 31,132.5]), and Slovenia (26,547.0 [23,951.5 to 29,453.4]) had the highest age-standardized incidence rate of injuries in 2019 (Appendix 4). From 1990 to 2019, Yemen with 99.1% (80.6–120.5) had the highest growth in age-standardized incidence rate, followed by Syrian Arab Republic (72.8% [63.4 to 82.2]), and Afghanistan (65.0% [57.2 to 73.6]). Afghanistan (217.5 [196.5 to 247.2]), Lesotho (166.8 [124.5 to 212.5]), and Central African Republic (147.6 [115.6 to 189.4]) were the leading countries in the age-standardized death rate of injuries in 2019 while Singapore (14.1 [13.2 to 14.9]), Malta (20.2 [18.2 to 22.1]), and Ireland (20.3 [19.0 to 21.5]) were the last countries in this regard (Appendix 5 and 6).

Injuries risk factors

Globally, low bone mineral density was the leading risk factor of injuries deaths in 2019 with a contribution to 10.5% (9.0–11.6) of total injuries age-standardized deaths, followed by occupational risks (7.0% [6.3–7.9]) and alcohol use (6.8% [5.2 to 8.5]). Meanwhile, occupational risks (276.7 [245.3 to 313.2]), low bone mineral density (206.8 [167.9 to 248.7]), and alcohol use (198.9 [150.7 to 251.6]) had the highest injury-related attributable age-standardized DALY rate in 2019 (Appendix 7). Among injury risk factors, drug use with 8.3% (−5.4 to 22.2) and tobacco with −21.3% (−22.7 to −20.0) change in age-standardized SEV over the 1990–2019 period had the most growth and decline in exposure, respectively. Nonetheless, except for non-optimal temperature, age-standardized DALY rate of injuries attributed to all seven risk factors of injuries shrank during 1990–2019.

Alcohol use was the leading risk factor for injuries in Central Europe, the Eastern Europe, and Central Asia (521.7 [389.6 to 659.6]), high-income (271.7 [199.0 to 346.0]), and Latin America and Caribbean (393.1 [292.9 to 508.9]) in terms of attributable age-standardized DALY rate in 2019. On the other hand, occupational risks in North Africa and Middle East (214.3 [193.9 to 239.8]), Southeast Asia, East Asia, and Oceania (276.1 [229.1 to 329.2]), and Sub-Saharan Africa (374.3 [338.7 to 413.9]) was the dominant risk factor of injuries in 2019 (Fig. 2). Notably, low bone mineral density with 335.5 (275.5–397.9) was the foremost injury risk factor of South Asia in the attributable age-standardized DALY rate. In 2019, the age-standardized DALY rate of injuries attributable to alcohol and drug use had a positive and intimate partner violence and occupational risks had a negative association with SDI quintiles.

Causes of injuries

Among the level-2 causes of injuries, unintentional injuries had the highest all-ages incidence rate with 7235.0 (6653.8 to 7885.3), followed by transport injuries (1379.0 [1163.8 to 1613.6]) and self-harm and interpersonal violence (613.0 [510.2 to 718.7]). Similarly, unintentional injuries were the leading cause of injuries burden in terms of both all-ages death and DALY rates, with 22.9 (20.0–25.2) and 1338.9 (1149.2 to 1547.5), respectively (Appendix 8). While the age-standardized incidence rate of transport injuries grew by 7.7% (5.4–9.8) over the 1990–2019 period, it had a declining trend for self-harm and interpersonal violence (−39.3% [−41.0 to −37.6]) and unintentional injuries (−12.8% [−13.7 to −11.8]) (Appendix 9); meanwhile, both age-standardized death and DALY rates of all three level-2 causes of injuries decreased during 1990–2019, with unintentional injuries having the sharpest decline (Appendix 10 and 11).

In all age groups, unintentional injuries had the highest incidence rate among level-2 causes of injuries, followed by transport injuries, and self-harm and interpersonal violence in 2019 except under 1 and 1–4 age groups in which self-harm and interpersonal violence exceeded transport injuries (Fig. 1). Self-harm and interpersonal violence were the leading level-2 causes of injury burden of ages 15 to 39 regarding both death and DALY rates in 2019 (Appendix 12). In 2019, the DALY rate of injuries related to self-harm and interpersonal violence shrank persistently after the 20–24 age group, whereas the DALY rate of unintentional injuries escalated continuously (Fig. 3).

Unintentional injuries were the leading level-2 cause of injury in all seven GBD super-regions regarding the age-standardized incidence rate in 2019; however, self-harm and interpersonal violence in Latin America and the Caribbean (1751.4 [1599.6 to 1916.1]) and transport injuries in North Africa and the Middle East (1365.1 [1145.2 to 1576.0]) were the foremost causes in age-standardized DALY rate (Appendix 2).

Road injuries

Among level-3 causes of injuries, road injuries with all-ages incidence rate of 1334.0 (1122.8 to 1567.4) in 2019 was the third leading cause of incidence; however, road injuries caused most injury-related DALYs, with an all-ages rate of 942.2 (837.9–1036.4) (Appendix 8). From 1990 to 2019, although the age-standardized incidence rate of road injuries grew by 8.9% (6.5–11.0), both age-standardized death and DALY rates decreased by 31.6% (25.0–38.9) and 31.0% (25.4–37.1), respectively (Appendix 9-11). In contrast to the declining pattern of age-standardized DALY rate of road injuries up to the 10–14 age group, there was a sharp rise in early adulthood peaking at the 20–24 age group, followed by a steady state (Appendix 13-15). There was a significant disparity between women

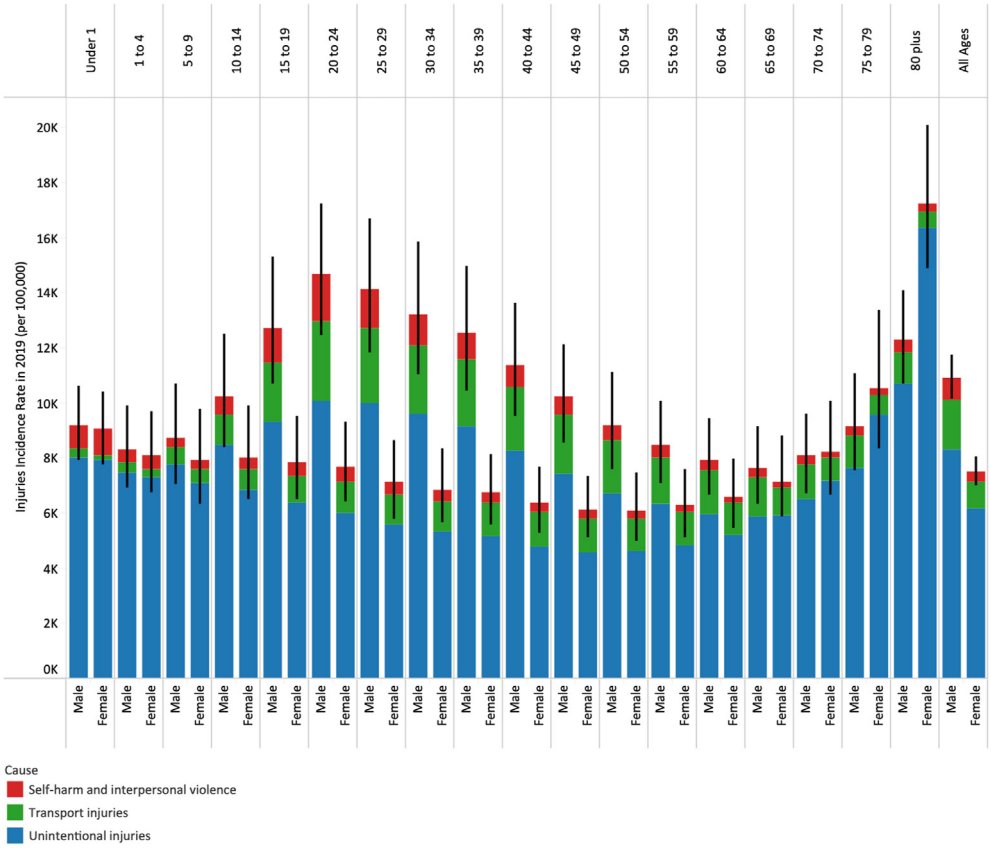


Fig. 1. Incidence rate of injuries in 2019 for sexes and age groups, colored by level-2 causes of injuries with 95% uncertainty intervals.

	Location	Alcohol use	Drug use	Intimate partner violence	Low bone mineral density	Non-optimal temperature	Occupational risks	Tobacco
Socio-Demographic Index	High SDI	258.8 (188.5-330.1)	23.2 (13.1-36.4)	19.1 (13.2-26.0)	189.0 (147.2-239.5)	-68.5 (-88.3--49.5)	169.2 (137.9-211.2)	13.2 (8.9-18.8)
	High-middle SDI	257.2 (199.2-321.7)	9.8 (5.3-16.1)	22.5 (15.4-31.6)	181.2 (143.6-225.3)	-108.4 (-143.7--79.5)	222.3 (189.0-263.4)	16.0 (11.2-22.2)
	Middle SDI	185.4 (141.8-236.0)	4.4 (2.3-7.3)	24.9 (17.1-34.5)	194.2 (158.5-229.3)	-47.9 (-69.9--12.7)	250.0 (218.5-287.6)	15.4 (11.0-20.6)
	Low-middle SDI	170.3 (124.8-222.7)	4.9 (2.5-9.0)	24.0 (16.2-33.8)	272.0 (225.4-318.8)	8.6 (-26.4-85.3)	328.3 (279.2-383.1)	20.4 (14.9-27.0)
	Low SDI	127.8 (93.2-169.2)	2.3 (1.2-4.0)	31.8 (20.7-45.1)	249.7 (212.3-287.7)	18.0 (-17.7-92.2)	456.2 (405.4-513.2)	14.8 (10.6-19.8)
GBD Super-Regions	Central Europe, Eastern Europe, and Central Asia	521.7 (389.6-659.6)	25.5 (13.4-42.3)	22.7 (15.3-32.1)	215.5 (163.4-277.8)	-266.6 (-369.4--184.8)	236.9 (197.9-290.5)	21.0 (14.8-29.4)
	High-income	271.7 (199.0-346.0)	23.1 (13.1-35.8)	18.5 (12.8-25.1)	177.6 (137.7-226.1)	-78.2 (-98.3--59.0)	179.8 (145.2-227.6)	12.5 (8.4-18.0)
	Latin America and Caribbean	393.1 (292.9-508.9)	4.9 (2.5-8.2)	34.3 (22.6-49.0)	167.8 (136.7-197.1)	5.8 (-33.5-82.3)	261.2 (231.4-298.7)	9.0 (6.4-12.2)
	North Africa and Middle East	31.4 (20.9-43.9)	3.0 (1.5-5.2)	29.0 (20.1-38.3)	174.8 (136.6-207.6)	-30.4 (-54.1-16.7)	214.3 (193.9-239.8)	11.7 (8.0-15.9)
	South Asia	126.1 (85.6-176.7)	4.6 (2.1-8.9)	18.2 (12.2-26.4)	335.5 (275.5-397.9)	16.0 (-17.2-87.7)	322.8 (253.1-411.9)	21.8 (15.8-29.4)
	Southeast Asia, East Asia, and Oceania	162.5 (120.1-208.8)	3.8 (1.9-6.5)	22.9 (14.8-33.5)	175.7 (139.0-209.2)	-73.9 (-99.0--41.7)	276.1 (229.1-329.2)	17.9 (12.9-24.1)
	Sub-Saharan Africa	189.7 (141.8-242.6)	3.7 (1.9-6.2)	38.0 (25.2-53.9)	195.5 (167.0-224.7)	27.4 (-10.0-98.4)	374.3 (338.7-413.9)	8.0 (5.8-10.8)

Fig. 2. Age-standardized attributable DALY rate of injuries' risk factors in 2019 by location and SDI quintile. DALY, disability-adjusted life year; SDI, Socio-demographic Index.

and men in the burden of road injuries in 2019, with men enduring more than double the DALY rate compared to women. North Africa and the Middle East, with 1306.6 (1096.2 to 1509.1), had the highest age-standardized DALY rate of road injuries, while high income with 458.9 (427.9–491.7) had the lowest rate. SDI and burden of road injuries had a definite inverse association in 2019, with a low SDI (1152.2 [977.1 to 1331.5]) and high SDI (562.1 [515.8 to 617.6]) countries experiencing the most and the least age-standardized DALY rate, respectively. Occupational risks with attribution to 15.3% (13.7–17.2) of the age-standardized DALY rate in 2019 was the

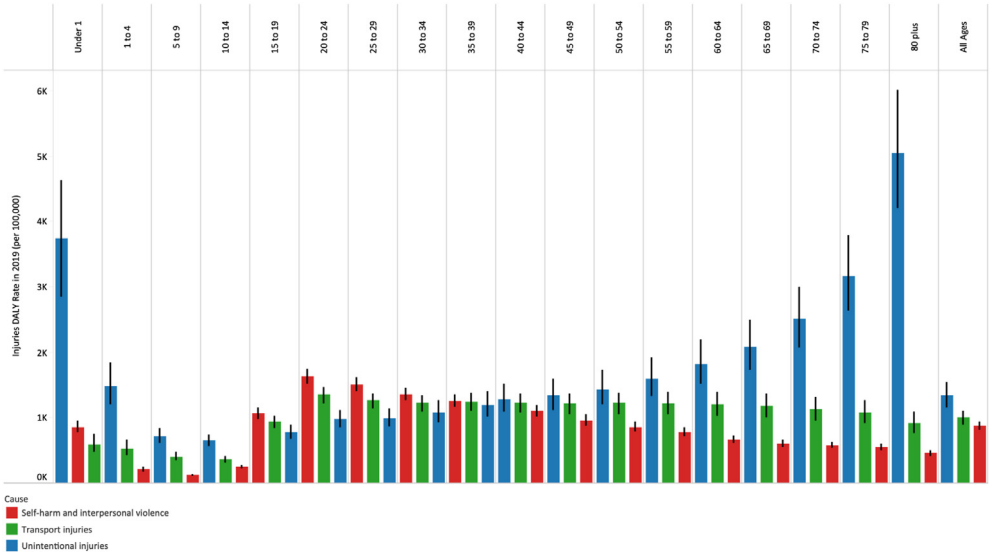


Fig. 3. Level-2 causes of injuries DALY rate in 2019 by age group with 95% uncertainty intervals. DALY, disability-adjusted life year.

leading risk factor of road injuries, followed by low bone mineral density (6.6% [5.5 to 7.3]) and alcohol use (6.1% [3.4 to 9.1]).

Falls

Falls was the foremost level-3 cause of injury in all-ages incidence rate with 2804.4 (2429.1 to 3214.5) as well as the second leading cause in terms of all-ages DALY rate with 508.7 (420.2–614.0) in 2019 (Appendix 8). There was an unceasing growth in the DALY rate of falls from early adulthood onward in 2019 (Appendix 13-15). Men with 580.6 (458.3–689.7) had a higher age-standardized DALY rate due to falls compared to women (407.7 [328.1 to 504.8]) in 2019. South Asia with 729.7 (621.5–856.6) and Sub-Saharan Africa with 279.9 (233.9–329.5) had the highest and lowest age-standardized DALY rate of falls in 2019, respectively. There was no clear association between SDI and the burden of falls, with low-middle SDI countries having the highest (597.6 [510.0 to 693.8]) and middle SDI countries having the lowest (442.0 [357.7 to 526.4]) age-standardized DALY rate in 2019. Low bone mineral density was the most influential risk factor of falls, with attribution to 25.2% (22.0–27.1) of the age-standardized DALY rate in 2019. Other risk factors of falls included occupational risks, alcohol use, and tobacco with 9.6% (8.6–10.9), 5.0% (2.3–8.5), and 1.9% (1.4–2.4) attribution to age-standardized DALY rate of falls, respectively.

Self-Harm

Self-harm, despite a relatively low all-age incidence rate (64.2 [54.8 to 75.9]) compared to other level-3 causes of injuries was the third leading cause of injuries in the all-ages DALY rate (441.0 [398.1 to 484.6]) in 2019 (Appendix 8). During 1990–2019, the age-standardized incidence rate of self-harm decreased by 31.8% (30.9–32.6) (Appendix 9). Over the same period, both age-standardized death and DALYs rates of self-harm shrank by 38.9% (32.7–43.9) and 38.9% (33.0–44.3) (Appendix 10 and 11). There was an escalation of the DALY rate from the 10–14 age group peaking at the 20–24 age group, followed by an unvarying declining trend in 2019 (Appendix 13-15). Men had a consistently higher DALY rate due to self-harm in all age groups compared to women in 2019. Central Europe, Eastern Europe, and Central Asia with 835.3 (758.2–944.2) had the highest age-standardized DALY rate of self-harm in 2019, while North Africa and the Middle East, with 209.2 (173.7–256.0), had the lowest rate. Globally, the dominant risk factor of self-harm in 2019 was alcohol use, with an age-standardized attributable DALY rate of 59.0 (30.9–87.6), equivalent to 13.9% (7.3–20.5) of total self-harm age-standardized DALY rate.

Discussion

The current study reports the latest global, regional, and national incidence and burden of injuries and the responsible risk factors for overall injuries using the most updated GBD 2019 data to shed light on the pathway to curb the massive worldwide burden of injuries. The major findings of this study were the small but persistent share of injuries in the global burden of diseases and injuries, reaching almost one-tenth of the burden in terms of both deaths and DALYs. Among various types of injuries, unintentional injuries were responsible for the greatest share of this burden. Among the global population, the male sex was significantly higher at risk of injuries. The regional distribution of injuries varied profoundly in different categories of regions and countries, and some sub-categories of injuries were more prominent in specific regions showing disparities in the burden of injuries. Regarding the socioeconomic status, it was remarkable that SDI had an inverse relationship with injuries' DALYs, and countries with lower SDI received the highest burden of injuries. Also, various metabolic, behavioral, and occupational risks were responsible for the imposed burden of injuries with some variations in the measures of burden.

A holistic approach to the burden of injuries and its trend through the years may not be wise due to the different nature of various causes contributing to the burden of injuries. Instead, breaking this burden into sub-categories like what was presented in this study may help more effectively understand this health issue and take action about it. In this regard, transport injuries, unintentional injuries and self-harm were the top contributors to the burden of injuries in the study period with some variations.

Among these causes, transport and road injuries were at a major point of focus in recent decades. A specific Sustainable Development Goal target (SDG target 3.6) was also dedicated to halving the number of global deaths and injuries from road traffic accidents by 2030. Although global authorities supported this target by

developing, suggesting, and implementing various programs at multiple levels, like road safety and sustainable transport plans for all countries,[13] investigating the road injuries burden trend indicates a significant failure in the effectiveness and sufficiency of these actions and necessitate more global and local efforts in this regard.[2,14,15] Considering all the available evidence, the one concrete fact is that improving road infrastructures, strengthening road safety legislation, and enhancing the quality and safety of vehicles could successfully lead to lower road injuries, mortalities, and the following burden.[16,17]

Alongside transport injuries, unintentional injuries with two major components of falls and drowning compose a significant share of the global burden of injuries. Considering the diverse pattern of the mentioned causes and their incidence and burden measures among countries and locations, specific regional and national plans seem essential to improve the concern about unintentional injuries in all ages.[18–20] However, the declining trend of DALYs for injuries with a steeper decline in YLLs might be due to unintentional and transport injuries, which are two main components of the burden of injuries have become less lethal due to improvements in health care and better preventive and safety measures. Among these types of injuries, fall-related injuries are a major public health issue affecting adults of all ages with a more prominent economic and disability burden on older people.[21,22] Multiple covariates affect the rate and burden of fall-related injuries, including age, education, sex factors, and various comorbidities like non-communicable diseases and neurological disorders.[23–26] For example, non-fatal fall-related injuries affect women significantly more than men.[24] This evidence highlights the need for the development and implementation of fall-related injury prevention programs, especially in older populations, to reduce disabilities and costs and improve the quality of life of the more vulnerable patients.[27,28]

Discussing self-harm as the third major contributor to the burden of injuries shall not be neglected here by the proposed targeted interventions for the vulnerable populations and the primarily responsible risk factors like mental and substance use disorders.[29,30] Among the drivers of the self-harm burden, suicide is the main contributor that, like other causes of injury, has variations and inducers like age, sex, and socio-economic status that need to be recognized for better management.[31,32] In this regard, large-scale population-wide studies have found major biopsychosocial risk factors important in the incidence of suicide and other forms of self-harm.[33] Many global and national programs have been implemented to handle this public health issue; however, a major paradigm shift in the management of this cause of burden is needed by devoting resources to implement multilevel suicide prevention strategies that improve accessibility of care for at-risk people, increase awareness-raising and service provision, and restrict access to means of suicide.[34] Besides, focusing on the younger population trying to detect suicidal ideation and anxiety, and enhancing social connectedness has shown to be an effective measure in controlling the burden of self-harm.[35,36]

The male population is significantly more vulnerable to the burden of injuries globally. This difference was apparent in both incidence and burden measures of deaths and DALYs. This difference has been suggested to exist due to two major factors of greater exposure to causes of injuries, especially road injuries, and higher rates of risky behaviors and injuries' risk factors in men.[37,38] The higher burden of injuries in men could be due to greater levels of injury severity in males, leading to poorer outcomes.[39] Also, the postinjury quality of life and recovery significantly depend on sexual differences, necessitating the proper policies and actions to save the more susceptible share of the global population.[40]

Geographic and socio-economic disparities in the burden of injuries existed at numerous levels in the current investigation of data. The major underlying cause for the higher burden of injuries in developing and low- and middle-income countries has been proposed to be the fact that, unfortunately, injuries receive lower priority in public health programs in these countries, resulting in a great neglected share of the burden of diseases and injuries.[41,42] This lack of priority could possibly be a result of a lack of epidemiologic data and evidence in these areas, cultural and social restrictions regarding the burden of injuries and insufficient injury prevention programs, lack of solid multisectoral connections and efforts in health systems, and lack of proper and specific intervention for each country at a greater risk of the burden of injuries.[41] These factors are associated with the weaker socio-economic states and essential infrastructure result in a higher burden of injuries in developing areas.[43,44] An example of such constraints in these areas are limited implementation of cost-effective safety measures such as seatbelt and helmet use by car and motorcycle drivers, emphasizing the need for enhancement of road safety compliance globally and regionally.[45–47]

Following the role of the socio-economic state in the burden of injuries, it is essential to mention the controversy on the role of gross domestic product (GDP) per capita and economic development on the burden of road injuries and other transport injuries as one of the significant contributors to the burden of injuries. Many studies in developing countries and other areas of the world have shown that GDP growth results in higher motorization rates and subsequent increases in road traffic injuries and related deaths and disabilities.[48–51] Therefore, this evidence indicates more strict measures and approaches in higher-income areas and residents.[51] However, it was strongly examined and showed that income level and road injury burden follow an inverted U curve, meaning the higher burden of injuries in areas with very low and very high income, and the turning point of burden varies in different societies with different levels of income.[16,43,50]

Considering validated risk factors responsible for the burden of injuries is a substantial part of approaching this burden. In this study, a combination of diverse risk factors was at the top rank of risks regarding their attributable burden. We discuss low bone mineral density and alcohol use as leading risks in the imposed burden here. Low bone density as a major risk of mortality due to falls—as a significant share of unintentional injuries discussed before—has shown to have a growing burden in recent years, that its real burden seems to be neglected and needs to be taken care of before the frailty ages, when the major attributable burden to this risk factor happens.[52,53] Implementing practice frameworks and global plans like the International Osteoporosis Foundation's Capture the Fracture Campaign is beneficial to alleviate the burden of fractures in the elderly due to low bone mineral density and improves patient care.[54] Alcohol use was another remarkable risk factor in the findings of this study that is responsible majorly for road injuries, and also for self-harm and interpersonal violence as important causes of injuries.[55] Although excessive alcohol use results in various fatal and non-fatal burdens, what matters here is the trauma-related death and disability, especially in the younger proportion of the population, leading to a more noticeable burden of injuries.[56,57] Therefore, appropriate global policies and strategies are needed to handle the considerable and avoidable burden of alcohol use.[58] Suggested policies to reduce harmful alcohol consumption and associated injuries have been increasing the price and tax on alcohol beverages, which has proved to be an effective tool to control this issue in some countries.[59,60] Other behavioral and psychological risk factors are also related to the burden of injuries, which need further investigation.[61,62]

The primary limitations of this study lie behind the data collection, modeling, and estimation process that introduces the availability of input data as its main concern.[63] However, each GBD iteration tries to improve the results by enhancing the data collection process. The latest GBD 2019 refined the identification and measurement methods of outcomes to overcome this issue.[1] Also, risk factors attributable burden estimations received reassessments of dose-response relationships for some risks to improve results.[3] One of the main limitations of this study was the availability of primary data on injuries. Nevertheless, GBD has been implementing several predictor models to overcome the availability and accuracy of the primary data to overcome this limitation. Moreover, limitations regarding injuries were specifically about the newly added police data for road injuries and interpersonal violence to aid complete the insufficient data of vital registries from some countries; however, assessments of the recruited data with vital registries in countries with decent data quality showed a widespread discrepancy proposing a major underestimation of factual death rates. To overcome this concern, GBD 2019 only employed the new data in cases where the reported police data were higher than vital registration statistics.[1] Underestimation of certain types of injuries and differences in such biases across cultures and regions could be another limitation to be declared. Despite the mentioned limitations, this study tried to present the most updated and available statistics of injury epidemiology, which should be considered its main strength.

Conclusion

This study investigated the growing burden of injuries globally, which is reaching almost one-tenth of the total global burden of diseases and injuries. Among the various types of injuries, unintentional injuries were responsible for the greatest share of this burden, and also males were more susceptible to this burden globally. Regional variations in the burden of injuries still exist, but this burden is remarkable in all areas, with significant impacts in all dimensions. Appropriate data, besides decent policies, are the essential tools to address the global burden of injuries. What we presented in this study was an effort to help both these measures for the ultimate goal of an effective global injury prevention plan.

Author statements

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Author contributions

Please see appendix 16 for more detailed information about individual author contributions to the research, divided into the following categories: managing the overall research enterprise; writing the first draft of the manuscript; primary responsibility for applying analytical methods to produce estimates; primary responsibility for seeking, cataloguing, extracting, or cleaning data; designing or coding figures and tables; providing data or critical feedback on data sources; developing methods or computational machinery; providing critical feedback on methods or results; drafting the manuscript or revising it critically for important intellectual content; and managing the estimation or publications process.

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Appendix A. Supplementary data

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