

The Global Burden of Unintentional Injuries and an Agenda for Progress

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According to the World Health Organization, unintentional injuries were responsible for over 3.9 million deaths and over 138 million disability-adjusted life-years in 2004, with over 90% of those occurring in low- and middle-income countries (LMIC). This paper utilizes the year 2004 World Health Organization Global Burden of Disease Study estimates to illustrate the global and regional burden of unintentional injuries and injury rates, stratified by cause, region, age, and gender. The worldwide rate of unintentional injuries is 61 per 100,000 population per year. Overall, road traffic injuries make up the largest proportion of unintentional injury deaths (33%). When standardized per 100,000 population, the death rate is nearly double in LMIC versus high-income countries (65 vs. 35 per 100,000), and the rate of disability-adjusted life-years is more than triple in LMIC (2,398 vs. 774 per 100,000). This paper calls for more action around 5 core areas that need research investments and capacity development, particularly in LMIC: 1) improving injury data collection, 2) defining the epidemiology of unintentional injuries, 3) estimating the costs of injuries, 4) understanding public perceptions about injury causation, and 5) engaging with policy makers to improve injury prevention and control.

accidental falls; burns; developing countries; drowning; motor vehicles; poisoning; wounds and injuries

Abbreviations: LMIC, low- and middle-income countries; UNICEF, United Nations Children's Fund.

INTRODUCTION

Injuries are a health concern in every country around the world, causing over 5 million deaths per year or 16,000 deaths per day (1). Of those, according to the World Health Organization's Global Burden of Disease Study estimates, unintentional injuries accounted for more than 3.9 million deaths in 2004. Five of the 15 leading causes of death in persons 15–29 years of age are unintentional injury related, including road traffic injuries, drowning, burns, poisoning, and falls (1). As global dissemination of prevention and early intervention techniques have substantially reduced the burden of infectious diseases, unintentional injuries are increasing in significance as a public health problem.

Deaths represent just a small proportion of the injury burden; nonfatal health outcomes represent a large component of the injury burden. A substantially higher number of injuries result in potentially life-long disability, significant psychological trauma, and subsequent financial loss. Because injuries usually occur in young healthy individuals, the number of years lived with disability as the result of an injury is usually very large. According to the World Health

Organization, up to 50% of young children with unintentional injuries that present to a hospital are left with some form of disability (2). The major unintentional injury-related causes of disability-adjusted life-years lost annually include road traffic injuries (17.5%) and falls (12.2%) (3).

The burden of injuries worldwide is disproportionately concentrated in low- and middle-income countries (LMIC). According to the World Health Organization, over 91% of unintentional injury deaths and 94% of disability-adjusted life-years were lost in LMIC in 2004. Unintentional injuries accounted for over 7% of total deaths and over 9% of total disability-adjusted life-years in these countries. The highest injury burden often occurs in those countries with the weakest evidence to guide intervention strategies, the fewest resources, and the least developed infrastructure to effect change.

This paper presents the global burden of unintentional injuries based on year 2004 data from the World Health Organization Global Burden of Disease Study estimates, highlighting differences in high- versus low- and middle-income countries. It explores disaggregated data by World Health Organization regions and by external cause of injury

as defined in the global burden of disease. In addition, selected individual studies are also included to illustrate country-level data. This paper highlights gaps in existing knowledge and presents an epidemiologic research agenda for unintentional injuries as recommended by the authors based on actions that have high impact and strong feasibility. Intentional injuries (violence) and occupational injuries, while important, are not considered in this paper.

MATERIALS AND METHODS

At the center of the causal pathway for injuries is the agent-host interaction. The agent, which in the case of injuries is energy, is absorbed by the host to cause injury. When the energy exceeds the tolerance of human tissue, injury occurs (4). According to the *International Classification of Diseases*, unintentional injuries are classified by cause based on the type of kinetic, chemical, or other type of energy that leads to the injury (<http://www.who.int/classifications/apps/icd/icd10online/>). Causes of unintentional injuries include transportation (land, air, and water); unintentional falls; unintentional discharge of a firearm or weapon; drowning; fire, smoke, and burns; poisoning; and other and unclassified unintentional causes (5, 6).

The first Global Burden of Disease Study in 1990 quantified the impact of more than 100 diseases and injuries in 8 regions of the world (7). It was updated for the year 2001 by the World Health Organization on the basis of new data from several sites particularly in LMIC (8). This has been further updated for 2004 and includes estimated deaths and disability-adjusted life-years lost for 192 member states, as well as regional and global estimates (9). The evolution and compilation of the Global Burden of Disease Study estimates, as well as its limitations, have been previously described (10, 11). This paper uses year 2004 Global Burden of Disease Study data to explore the burden of unintentional injuries including the associated World Health Organization data on population level (global, regional), cause of injury, age, and gender to calculate rates for deaths and disability-adjusted life-years lost; this analysis enhances and updates previously published papers on Global Burden of Disease Study estimates (7, 8, 12). In this paper, we use World Health Organization-reported summary measures of deaths: years of life lost, years lived with disability, and disability-adjusted life-years lost. Years of life lost are calculated by multiplying the number of deaths by the life expectancy at the age of death; therefore, years of life lost will be higher in fatalities that occur earlier in life. Years lived with disability represent the years of life lost due to disability and thus capture nonfatal health outcomes. Disability-adjusted life-years represent the overall disease burden by adding together years of life lost and years lived with disability for each disease. Methodological details of years of life lost, years lived with disability, and disability-adjusted life-years have been well published in the literature (13, 14).

A literature search was conducted in PubMed by using permutations of the following keywords: injury, unintentional injury, falls, drowning, burns, road traffic injuries, and developing countries. English language publications

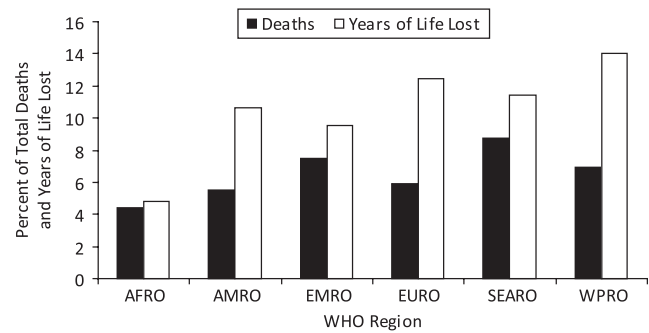


Figure 1. Percent of total deaths and years of life lost attributable to unintentional injuries by year 2004 World Health Organization region estimates. AFRO, African region; AMRO, American region; EMRO, Eastern Mediterranean region; EURO, European region; SEARO, Southeast Asian region; WHO, World Health Organization; WPRO, Western Pacific region.

from 1990 were reviewed to identify papers with data on unintentional injuries at the country level. In addition, reports and policy documents published by international agencies (World Health Organization, United Nations Children's Fund (UNICEF), World Bank) were also reviewed through a World Wide Web search in Google. Studies were then selected by the authors to illustrate global gaps in knowledge regarding the regional or national burden of unintentional injuries. Because the Global Burden of Disease Study data do not include cost information, we reviewed recently published studies to inform our discussion of the cost of unintentional injuries and how these costs differ by regional and demographic factors. We conclude the paper with our suggestions of the gaps in the existing knowledge/literature and a proposed research agenda to fill these gaps.

INJURY MORTALITY

Over 3.9 million unintentional injury deaths occur worldwide each year, responsible for 6.6% of the global mortality burden. Figure 1 shows the percentages of global deaths and years of life lost attributable to unintentional injuries by World Health Organization region. For the majority of regions, unintentional injuries comprise a significantly higher proportion of years of life lost than total deaths, because injuries occur primarily in young people and, thus, result in a larger number of years of life lost than diseases that cause a higher number of deaths but affect older populations. For example, in the European region, unintentional injuries account for 6% of deaths but over 12% of years of life lost. In contrast, unintentional injuries in the African region account for just over 4% of deaths and years of life lost because, in the African region, there remain a large number of other infectious diseases causing deaths in young children that contribute to years of life lost in a manner similar to that of injuries.

The worldwide rate of unintentional injuries is 61 per 100,000 population per year. Figure 2 shows the unintentional

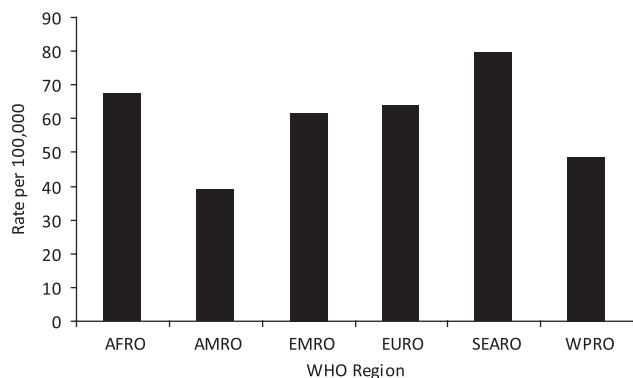


Figure 2. Unintentional injury death rate per 100,000 population by year 2004 World Health Organization region estimates. AFRO, African region; AMRO, American region; EMRO, Eastern Mediterranean region; EURO, European region; SEARO, Southeast Asian region; WHO, World Health Organization; WPRO, Western Pacific region.

injury death rate by World Health Organization region. The rate is highest in the Southeast Asian region (80 per 100,000) and lowest in the American region (39 per 100,000). The Southeast Asian region also has the highest population (over 1.6 billion), illustrating the large burden that unintentional injuries pose to that region. However, it should be noted that injuries are likely to be undercounted in countries with weak data infrastructures, and this could affect the comparison of injury rates across regions.

Overall, road traffic injuries make up the largest proportion of unintentional injury deaths (33%), followed by falls (11%) and drowning (10%). Figure 3 shows the causes of unintentional injury deaths by World Health Organization region. Road traffic injuries are a significant proportion of unintentional injury deaths in all regions; they alone kill nearly 1.3 million people every year, resulting in a mortality rate of nearly 20 per 100,000 population annually. With an increase in the number of vehicles on the roads, as well as vehicular speed, and as the mix of vehicles on roadways becomes more complex over time, the burden of road traffic injuries will likely increase. Projections by the World Health Organization indicate that, while road traffic injuries were the ninth leading cause of death resulting in 2.2% of deaths in 2004, by 2030 they will be the fifth leading cause of death resulting in 3.6% of global deaths (1).

Injury causes also demonstrate some regional patterns (Figure 3). For example, fire burns account for a higher proportion (14%) of unintentional injuries in the Southeast Asian region, while drowning represents a proportionally higher problem (16%) in the Western Pacific region. Of note, over 1 million deaths (30% of all unintentional injury deaths) are categorized as “other unintentional injury” by the World Health Organization. This category combines both *other* unintentional injury deaths (e.g., animal bites) and *unspecified* unintentional injury deaths per the *International Classification of Diseases*. This highlights the need for exploring other causes of injuries and also improved categorization of injury-related deaths in regions such as

Southeast Asia, where the “other” category comprises 39% of unintentional injury deaths.

INJURY MORBIDITY

Deaths represent only the proverbial “tip of the iceberg” of the true burden of unintentional injuries; many injury events are not fatal but do result in significant sequelae that affect people throughout their lives. Unintentional injuries were responsible for more than 138 million disability-adjusted life-years lost in 2004. Figure 4 shows the rate per 100,000 population of disability-adjusted life-years and years lived with disability by World Health Organization region for both high-income countries and LMIC. The rates for disability-adjusted life-years are highest in regions with many developing countries: Southeast Asia (3,065 per 100,000), Eastern-Mediterranean (2,825 per 100,000), and Africa (2,743 per 100,000). Notably, the rate for years lived with disability is highest in the Eastern Mediterranean region (1,194 per 100,000) despite its small population and relatively higher proportion of higher income countries, indicative of the nonfatal impact of injuries.

Overall, disability-adjusted life-years lost show similar proportions by cause as unintentional injury deaths. Road traffic injuries account for approximately one-third of unintentional injury disability-adjusted life-years in all regions. Poisoning is most significant in the European region (15% of disability-adjusted life-years vs. $\leq 6\%$ in other regions), and drowning stands out in the Western Pacific region (14% of disability-adjusted life-years vs. $\leq 9\%$ in other regions), which has countries like China and Vietnam with deltas, rivers, and many other water bodies.

INJURIES IN LOW- AND MIDDLE-INCOME COUNTRIES

Regional data

The vast majority, over 3.5 million or 91%, of unintentional injury deaths occur in people in LMIC. When standardized per 100,000 population and compared with high-income countries, the death rate is nearly double in LMIC (65 vs. 35 per 100,000), and the rate for disability-adjusted life-years is more than triple in LMIC (2,398 vs. 774 per 100,000). This means that more people are injured, they suffer more nonfatal health outcomes, and more die as a result of injuries in LMIC.

Figure 5 shows the percentage of unintentional injury deaths that occur in LMIC by World Health Organization subregions. The LMIC in the Southeast Asian region contribute over 34% of the global unintentional injury deaths. Although Southeast Asia’s LMIC also contain the largest number (1.67 billion) of people, the LMIC in the Western Pacific region (with over 1.5 billion people) contribute a much smaller proportion or only 20% of the global unintentional injury deaths. An analysis of the injury burden in children less than 5 years of age in South Asia showed a mortality rate of 33.9–850.7 deaths per 100,000 children. The overall incidence of injuries derived from community-based studies in this region was 8,870 cases per 100,000 children per year (15).

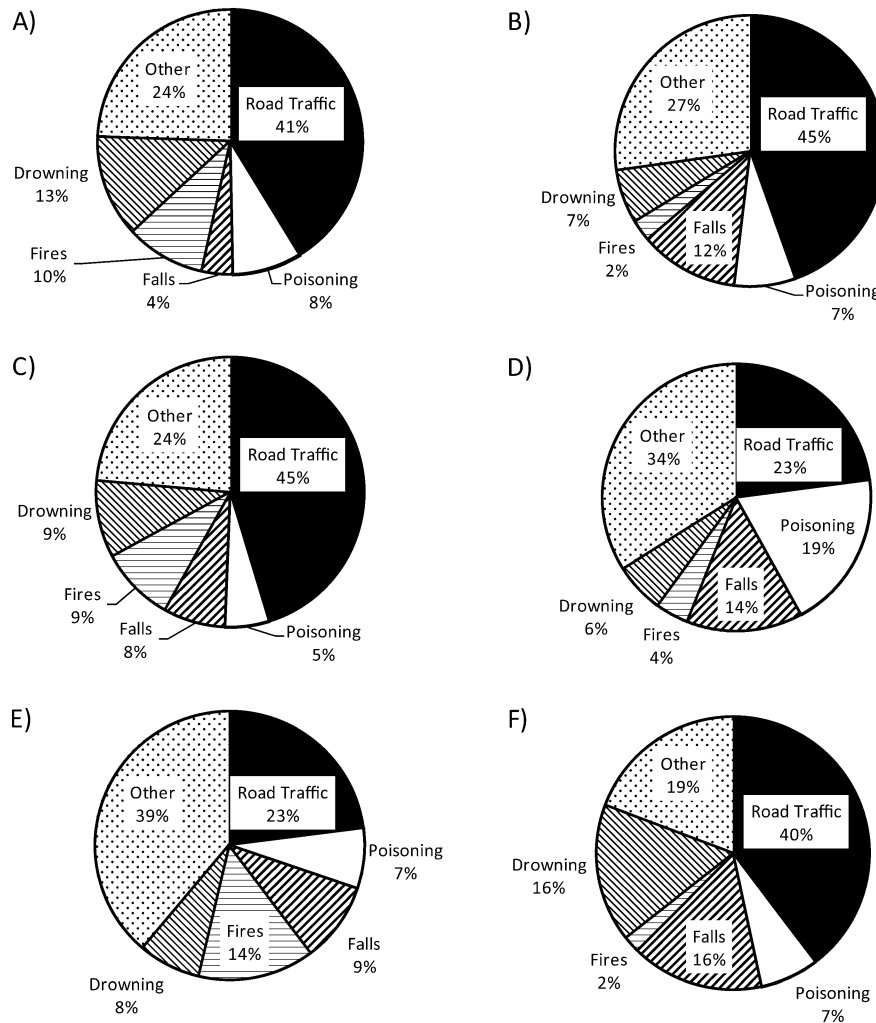


Figure 3. Proportion of unintentional injury deaths, by cause, by year 2004 World Health Organization region estimates: American region (A), African region (B), European region (C), Eastern Mediterranean region (D), Southeast Asian region (E), and Western Pacific region (F). “Other” combines *other* unintentional injury deaths (e.g., animal bites), as well as *unspecified* unintentional injury deaths, per the *International Classification of Diseases*.

Disability-adjusted life-years lost from unintentional injuries also disproportionately affect LMIC; over 130,000 (or 94%) of unintentional injury disability-adjusted life-years are lost in these countries. Road traffic injuries and “other” unintentional injuries contribute 29% and 37% of unintentional injury disability-adjusted life-years in LMIC, respectively. Annually, falls result in losses of over 15 million disability-adjusted life-years, and drowning results in over 10 million disability-adjusted life-years lost. An analysis of the global burden of musculoskeletal injuries found that the rates of extremity injuries from falls and road traffic ranged from 1,000 to 2,600 per 100,000 per year in LMIC compared with 500 per 100,000 per year in high-income countries (16).

When comparing LMIC with high-income countries, not only is the absolute number of deaths and disability-adjusted life-years from unintentional injuries higher in LMIC, but the distribution of deaths and disability-adjusted life-years

among various causes of unintentional injuries also differs (Figure 6). Road traffic injuries result in 41% of disability-adjusted life-years lost due to unintentional injuries in high-income countries while only 29% in LMIC. Poisoning is the fourth highest cause of deaths and disability-adjusted life-years in high-income countries, while it accounts for a smaller proportion of unintentional injuries in LMIC.

There are also regional differences in the mechanisms of certain injuries. For example, when breaking down road traffic injuries by user group, 60% of traffic fatalities occur in motorized 4-wheeled cars in high-income countries compared with 34% in low-income countries. Pedestrians account for an average of 45% of road traffic fatalities in low-income compared with 18% in high-income countries (17). Patterns of unintentional ingestions also differ in high-income versus LMIC. Several studies have shown that kerosene and paraffin are 2 of the most common poisons ingested by children in developing countries (18–22);

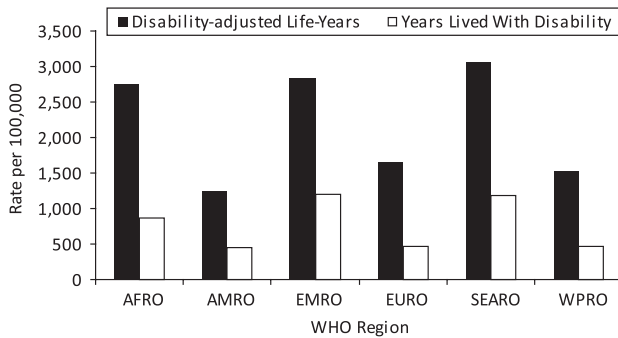


Figure 4. Rate per 100,000 population of disability-adjusted life-years and years lived with disability due to unintentional injuries by year 2004 World Health Organization region estimates. AFRO, African region; AMRO, American region; EMRO, Eastern Mediterranean region; EURO, European region; SEARO, Southeast Asian region; WHO, World Health Organization; WPRO, Western Pacific region.

studies in India showed that petrol products accounted for 40%–60% of all poisonings (23, 24). These substances are rarely a cause of unintentional poisoning in high-income countries. Scald injuries are of relatively higher importance than open flames in higher-income settings and in younger children; however, in many LMIC and among older adults, open-flame injuries remain the most important cause of burns (25–30).

Although the Global Burden of Disease Study data provide the most comprehensive health sector injury data available, their reporting at the regional level presents many challenges. While there are commonalities by geographic region and income strata, as we have presented above, within each of these categories exists great heterogeneity. Individual countries, which are the reporting unit to the World Health Organization, differ with regard to the quality of data and data collection protocols. Countries also differ with regard to the risk factors for injury and the infrastructure to respond to injuries. Thus, the trends presented above

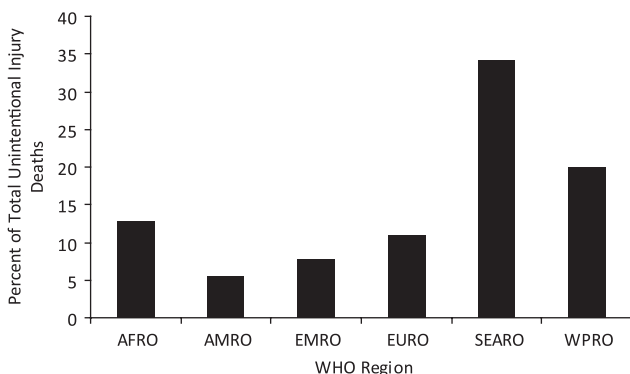


Figure 5. Percent of total unintentional injury deaths in low- and middle-income countries by year 2004 World Health Organization region estimates. AFRO, African region; AMRO, American region; EMRO, Eastern Mediterranean region; EURO, European region; SEARO, Southeast Asian region; WHO, World Health Organization; WPRO, Western Pacific region.

cannot be attributed equally to all areas within a region, but the presentation of these regional data does provide a geographic snapshot of injury patterns.

Country-specific examples

The majority of country-level injury surveillance has occurred in high-income countries. In the United States, according to ongoing surveillance conducted by the Centers for Disease Control and Prevention, approximately 12,175 children aged 19 or fewer years die each year from an unintentional injury, with the highest rates being in American Indians and Alaska Natives (31). A review of over 7,200 deaths from the United Arab Emirates in children aged less than 15 years showed that injuries comprised nearly 30% of all deaths, with road traffic injuries being responsible for 68.3% of injury-associated deaths (32).

Injury data have now become more available from several LMIC. A study from South Africa showed that injuries accounted for 14.3% of all disability-adjusted life-years lost in the country in the year 2000 (33). A study based on the National Health Survey of Pakistan reported an overall annual incidence of unintentional injuries in children less than 5 years of age of 47.8 per 100,000 (95% confidence Interval: 36.6, 59.0), totaling approximately 1.1 million unintentional injuries per year (34). A pilot surveillance study in children less than 11 years of age in Bangladesh, Colombia, Egypt, and Pakistan of 1,559 injured children found that the majority of injuries (56%) were from falls, followed by road traffic injuries (22%) and then burns (13%) (35). A study from Peru showed that injuries accounted for 10.8% of all deaths between 1996 and 2000 (36).

Of note, local or national data may be an under- or overestimate of the true burden of injuries depending on the nature of the information system. For example, the government of India reported that 82,700 people died in 2002 from road traffic injuries, while the World Health Organization estimate for India for 2002 was 189,000 deaths (37). Local studies can also augment or refine data from ongoing surveillance; another study in India showed that there were 163,000 burn-related deaths in the country in 2001, which is close to the 147,000 estimated by the World Health Organization in 2002 but is 3 times higher than the number reported by Indian police statistics (38). These discrepancies also reveal the inherent limitations of data sources depending on the sector and primary motivation for collecting information; it is the result of this divergence that health sector and police data often differ in countries for estimating road traffic injuries.

UNINTENTIONAL INJURIES BY AGE AND GENDER

Overall, the number of unintentional injuries in males exceeds that in females; the World Health Organization estimated a total of over 2.5 million deaths and over 87 million disability-adjusted life-years in males and nearly 1.4 million deaths and over 51 million disability-adjusted life-years in females in 2004. With the exception of fire-related deaths, the number of each cause-specific unintentional injury death was higher in males. For most fatal unintentional injuries,

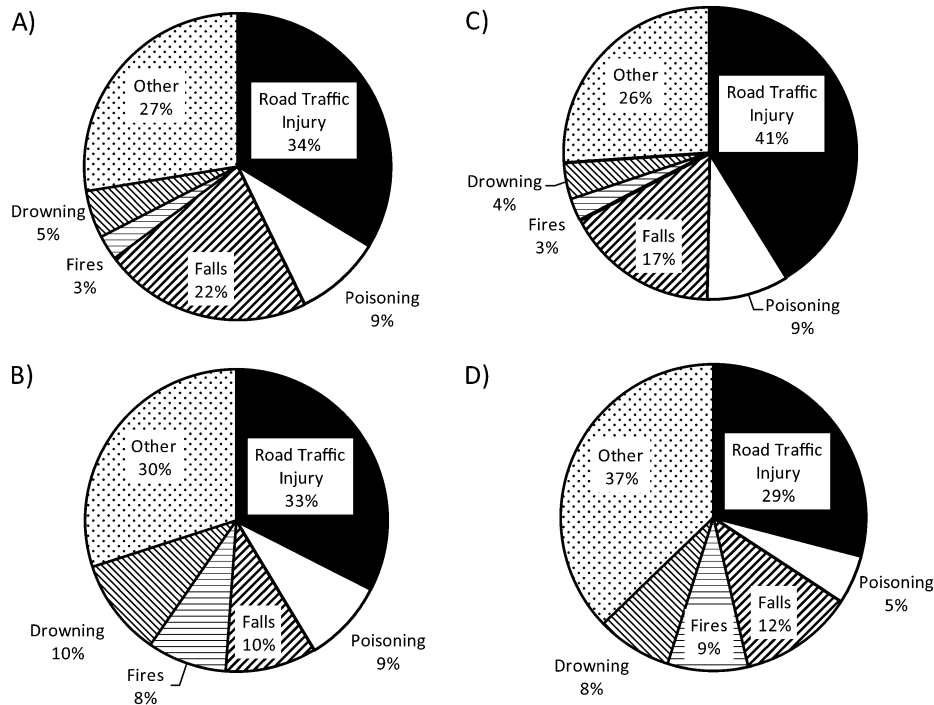


Figure 6. Distribution by cause of unintentional injury deaths in high-income countries (A), deaths in low- and middle-income countries (B), disability-adjusted life-years in high-income countries (C), and disability-adjusted life-years in low- and middle-income countries (D) by year 2004 World Health Organization region estimates. "Other" combines other unintentional injury deaths (e.g., animal bites), as well as unspecified unintentional injury deaths, per the *International Classification of Diseases*.

the gender gap increases with age; in children aged 5–9 years, the male death rate is over 30% higher than that of females, and by 10–14 years of age, that discrepancy increases to 60%.

Figure 7 shows the percentage of unintentional injury deaths that occur by age group in males and females. A higher proportion of injury deaths occur in very young and elderly females, while nearly half of unintentional injury deaths (47%) in males occur between the ages of 15 and

44 years. Figure 8 shows the unintentional injury and disability-adjusted life-years rates by age group, gender, and income stratum. Overall, the mortality burden is substantially higher in LMIC for all age groups and both genders. The unintentional injury rate in males peaks at ages 15–60 years in both high-income countries (~8 per 100,000) and LMIC (~20 per 100,000); however, the spike in injury rates seen in the ≥80-year age group particularly in females in high-income countries (12 per 100,000) is not seen in

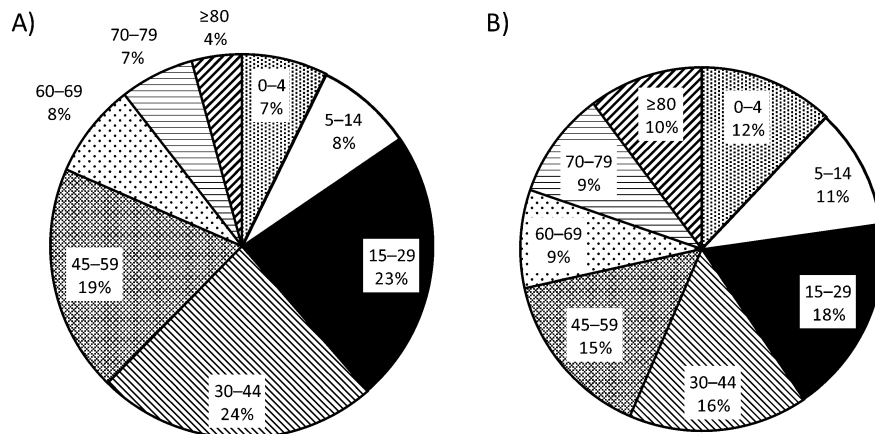


Figure 7. Proportion of unintentional injury deaths, by age group, in males (A) and females (B), by year 2004 World Health Organization region estimates.

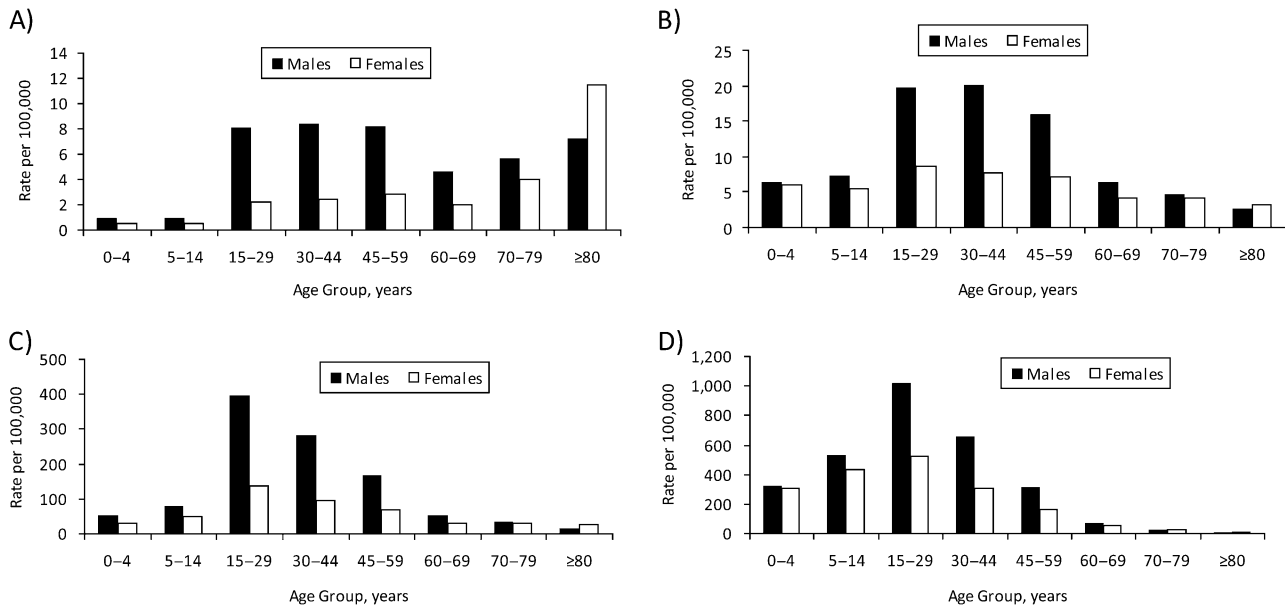


Figure 8. By age group and gender, global unintentional injury deaths in high-income countries (A), deaths in low- and middle-income countries (B), disability-adjusted life-years in high-income countries (C), and disability-adjusted life-years in low- and middle-income countries (D), by year 2004 World Health Organization region estimates.

LMIC. The rates for disability-adjusted life-years are also significantly higher in LMIC; while the highest rates in both strata occur in males aged 15–29 years, the rate for high-income countries is 400 per 100,000 while, for LMIC, it is over 1,000 per 100,000. The disability-adjusted life-years gap is particularly pronounced in the youngest (0–4 years and 5–14 years) age groups.

While males have higher death and disability-adjusted life-years rates for most injury types, studies have shown that females are at higher risk of fire-related deaths than are males. Burns ranked seventh in the World Health Organization's top 10 causes of deaths and disability-adjusted life-years for women 15–44 years of age (39). A recent study in India showed that, in 2001, 106,000 of the country's 163,000 burn-associated deaths occurred in women (38). A study of stove injuries in South Africa showed that women had higher rates of hospital admissions (45%) and a higher mortality rate (22%) than did men (40). In some settings, however, males seem to be at higher risk than women. Van Niekerk et al. (41) showed in South Africa that males had a 2.2 times higher burn mortality rate than did females, with the greatest difference occurring in the 25–38-year age group (3 male deaths per 1 female death). A study in Turkey showed that, of the 320 fire-related deaths, 71.3% were males (42). Interestingly, one review showed that, in tropical climates with year-round warm weather, there were higher rates of burns in males, while in more temperate climates, a higher proportion of burns were reported in females (43).

The relative importance of drowning as a cause of injury-associated deaths varies by age and gender. For example, in males 0–4 years of age, drowning is the leading cause of etiology-specified injury deaths (responsible for

nearly 19% of unintentional injury deaths in that age group), while in females of the same age, drowning ranks behind road traffic and fires as a cause of unintentional injury deaths. Another age-specific example is falls; although most injuries disproportionately affect younger age groups, a marked rise in the rate of falls occurs with increased age.

COST OF UNINTENTIONAL INJURIES

With the combined impact of disproportionately early mortality, the need for critical and costly medical care, and the risk for extended periods of disability, traumatic injuries present a staggering cost burden to individuals, families, the medical system, and governments. The World Health Organization does not provide cost information in the Global Burden of Disease Study estimates, and few studies have estimated the economic costs associated with unintentional injuries. The most comprehensive traumatic injury cost estimates relate to road traffic injuries; a few have been done in LMIC (44, 45). An analysis by the Transport Research Laboratory of 21 developed and developing countries found that the average annual cost of road crashes was approximately 1% of the gross national product in developing countries, 1.5% in countries in economic transition, and 2% in highly motorized countries. The annual economic cost of road traffic injuries globally was over US \$518 billion and was over US \$65 billion in LMIC (46).

The majority of cost-associated studies for unintentional injuries have been done in high-income countries. In one study of unintentional injuries that occur in the home in the United States, the total societal cost was estimated to be

approximately US \$217 billion. Of that, falls accounted for by far the largest proportion (42%) of the total cost (47). In another study of childhood unintentional injuries, the total cost, which included loss of future work and quality of life, was US \$347 billion per year or US \$17,000 per child injured (48). In an analysis of falls in the elderly in Italy, Sartini et al. (49) found that the average cost of a fall-related hospitalization was over US \$8,200. In a similar analysis of older adults in the United States, Roudsari et al. (50) found a mean hospitalization cost of US \$17,483. Furthermore, costs from nonfatal falls increase with age; although the overall costs doubled from US \$4 billion to US \$8 billion in persons aged 65–74 years compared with those aged 75–84 years, the incidence of nonfatal falls varied little between the 2 age groups (51). Similarly, in the United Kingdom, the health-care cost for falls per 10,000 population was nearly US \$500,000 in persons aged 60–64 years but increased to nearly US \$2.5 million in the ≥ 75 -year age group (52).

A few cost-associated studies for unintentional injuries overall have been done in LMIC as well. A recent analysis of over 6,000 children less than 15 years of age hospitalized for unintentional injuries in China showed a mean institutional cost of US \$166 and a mean length of stay of over 17 days per injury case. Although the injury costs were not broken down overall by cause of injury, the cost associated with poisonings averaged US \$53 per case, and for scald injuries was US \$198 per case. These estimates do not include the costs to the individuals as a result of the injuries or associated costs such as loss of wages for parents (53). A community-level analysis in Vietnam showed that the total annual cost of unintentional injuries was over US \$235,000 (equivalent to the income of $\sim 1,800$ people), of which over 90% fell on individuals (54).

CHALLENGES IN REPORTING THE BURDEN OF INJURIES

The data presented in previous sections represent the most complete and comprehensive global injury mortality data available. However, these data come with many limitations. Overcoming these limitations is a critical priority for advancing injury prevention.

Data that describe injury events and that provide information related to injuries can be found from a wide variety of sources, both within (e.g., vital statistics) and outside (e.g., transportation or legal records) the health sector (55). Generally, mortality data have the highest quality; most high- and middle-income countries have some type of vital statistics system that captures the majority of deaths and their causes. Although mortality rates are most frequently reported, measures such as disability-adjusted life-years lost are helpful for reporting injuries because these measure both mortality and nonfatal health outcomes and are disproportionately higher when deaths or injuries affect the young (56, 57).

This paper uses data from the World Health Organization Global Burden of Disease Study; these data are limited by its coverage for LMIC; while the year 2004 data have more information from primary sites in LMIC, large parts of Sub-

Saharan Africa and South Asia still do not have functioning vital registration and cause-of-death reporting systems. These countries provide either official (unverified) estimates of their injury mortality to the World Health Organization or unofficial estimates modeled into the data sets. Moreover, data for unintentional injuries are limited in most settings because of inadequate reporting and lack of population-based data. In addition, there are specific definitional issues, such as burns, in the Global Burden of Disease Study data historically referred to only as fire burns but not scald burns.

Although great improvements in reporting, coding, and classification of injury mortality have been made, significant challenges remain. Many countries use hospital-based death-reporting systems, which undercount deaths that do not occur in hospitals or under medical supervision and therefore disproportionately undercount injuries (58). Although injury surveillance systems are being set up in several LMIC, they are limited mostly to a few facilities and do not provide representative data. On the other hand, several LMIC have had population-based data surveys that provide information on specific areas or age groups, such as the child injury surveys conducted by UNICEF in several Southeast Asian countries (59).

The infrastructure for mortality and health databases vary considerably around the world (1, 57). Developed regions have electronic databases that provide summary statistics through World Wide Web-based queries, such as the WISQARS system that describes injury mortality and morbidity in the United States and is maintained by the Centers for Disease Control and Prevention (<http://www.cdc.gov/injury/wisqars/index.html>) and the European Health for All Database that provides all-cause mortality rates, maintained by the World Health Organization Regional Office for Europe (<http://data.euro.who.int/hfad/>). Years of life lost are also included as a global health indicator in the World Health Organization Statistical Information System (<http://www.who.int/whosis/en/>). Other countries maintain tabulated mortality statistics that are not integrated into a queryable database, and many developing countries have paper-based systems with rates based on projections and estimates rather than actual counts.

In addition to variance in the quality of mortality data systems, variance is high in the quality of injury coding. For example, one review of the external cause of mortality in the European region found that only 23 of 52 countries were using the full coding scheme, and only 3 countries could be considered as having high quality of data on injury occurrence (60). A comparative study of Sweden, Australia, Taiwan, and the United States found that as many as 33% of death records had an unclassifiable cause of death (61). The International Collaborative Effort on Injury Statistics is an ongoing collaboration of international researchers whose goal is to reduce disparity in cause-of-injury coding (62). This effort has led to many tools to help code and classify injuries (http://www.cdc.gov/nchs/injury/ice/ice_projects.htm). Because most collaborating countries have electronic mortality and morbidity data, the International Collaborative Effort has traditionally focused on more developed countries. These tools, however, will be helpful to developing countries as their health infrastructures grow.

The challenges to collecting complete and accurate mortality data are minimal in comparison to the challenges to collecting data for nonfatal injuries. Only countries with highly developed health infrastructures have national surveillance for nonfatal injuries, and these are a small proportion of even developed countries. Many countries have data from individual hospital registries, while many of the most health-vulnerable countries in Sub-Saharan Africa and Southeast Asia have no nonfatal injury data systems at all. The data challenges that result from disparities in the level of health infrastructure yield rates that can be difficult to compare. Several other efforts to collect international injury mortality data have found that differences in death certification systems, methods of data collection, and definitions of variables severely challenge international comparisons (3, 62).

To accurately quantify the burden of unintentional injuries and eventually to track trends in injury rates with the introduction of various prevention interventions require ongoing systematic surveillance. Surveillance efforts need to focus on 2 priorities: enhanced data quality and the establishment of registry systems to track injury trends. The burden of injury is disproportionately born by LMIC, and these countries are also the least likely to have established surveillance systems to monitor injury trends (63). Surveillance systems and population-based data are needed to identify and track trends in injuries for research and prevention efforts, and they are also necessary to attract the attention of policy makers and community leaders. Toward this end, guidelines for injury surveillance and community-based surveys have been released by the World Health Organization and can be used to promote better data from LMIC (6).

PROPOSED AGENDA

As a result of the challenges described above, this paper proposes a general research agenda for investment and action for injury prevention and control (Table 1). This builds on the work of the World Health Organization, UNICEF, and others in highlighting specific needs for data at local, national, and global levels (9, 64). This paper calls for more thinking around 5 core areas that need research investments and capacity development, especially in LMIC. Developing better and sustainable systems of collecting regular injury data is important and needs to go hand in hand with training of human resources personnel who can conduct and analyze such information. Although each country must decide individually which steps are the most feasible and will yield the highest impact, the domains of this agenda represent the basic elements of a comprehensive approach to injury control.

Understanding the nature and types of interventions that are relevant to each context and then learning how to implement them effectively are an important agenda for developing countries in particular. Estimating the costs of injuries to define the impact and then highlighting the cost-effectiveness of injury interventions to local and national policy makers are important for influencing policies that are friendly to injury prevention and control (Table 1).

Table 1. Proposed Capacity Development and Research Agenda for Unintentional Injuries

Domain	Agenda
Epidemiology	Sustainable injury surveillance systems Periodic population-based surveys (with other health surveys) Specific registries focused on types of injuries (e.g., trauma registries)
Interventions	Operations research on development/implementation Effectiveness studies Long-term impact studies
Economic analysis	Cost of injuries to society Cost-effectiveness of interventions Capturing externalities of injuries Measuring investments for safety
Social sciences	Attitudes and perceptions around injury causation Testing social marketing and other communication strategies
Policy	Policy analysis for injuries in health Intersectoral action analysis for injuries Gap analysis for national legislation/regulations

Understanding the attitudes and perceptions of people as to how they view injury causation and learning how to influence behavior are important for public engagement and the success of interventions. Finally, active efforts to engage with policy makers, to understand the intersectoral nature of injury prevention and control, and to explore opportunities for reducing the burden of injuries through collaborations are also part of the research agenda for unintentional injuries. These broad areas would need further specification at the regional and national levels, depending on the nature and type of unintentional injury burden, as evidenced by earlier sections of this paper. So, research on drowning interventions would make sense for the Southeast Asian or Western Pacific regions, while road traffic injury interventions would be appropriate in most other regions. The broad domains identified here are meant to stimulate further reflection at the country level.

CONCLUSION

This paper presents evidence that unintentional injuries pose a significant health burden throughout the world, particularly in LMIC. Many countries, especially those with poorly developed public health infrastructures, have not prioritized injury prevention as a public health problem. Because 90% of the world's population lives in low- and middle-income countries, basic research to identify the burden of injuries, their causes, and consequences is critically needed in order to establish the evidence base necessary for effective intervention and prevention programs. While appreciating existing efforts, we call for more investments in

relevant research for action, especially in the developing world.

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