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Monetized Estimated Quality-adjusted Life Year (QALY) Losses for Non-fatal Injuries

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Abstract

Background: Quality-adjusted life years (QALY) provide a means to compare injuries using a common measurement, which allows quality of life and duration of life from an injury to be considered. A more comprehensive picture of the economic losses associated with injuries can be found when QALY estimates are combined with medical and work loss costs. This study provides estimates of QALY loss.

Methods: QALY loss estimates were assigned to records in the 2018 National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP). QALY estimates by body region and nature of injury were assigned using a combination of previous research methods. Injuries were rated on six dimensions, which identify a set of discrete qualitative impairments. Additionally, a seventh dimension, work-related disability, was included. QALY loss estimates were produced by intent and mechanism, for all ED-treated cases, by two disposition groups.

Results: Lifetime QALY losses ranged from 0.0002 to 0.388 for treated-and-released injuries, and from 0.031 to 3.905 for hospitalized injuries. The one-year monetary value of QALY losses ranged from $136 to $437,000 among both treated and released and hospitalized. The lifetime monetary value of QALY losses for hospitalized injuries ranged from $16,000 to $2.1 million.

Conclusions: These estimates provide information to improve knowledge about the comprehensive economic burden of injuries; direct cost elements that can be measured through financial transactions do not capture the full cost of an injury. Comprehensive assessment of the long-term cost of injuries, including quality of life losses, is critical to accurately estimate the economic burden of injuries.

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Disclaimer: The findings and conclusions in this manuscript are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Ethics Approval Statement: This study does not involve human participants.

Keywords

QALY; Injury; Work loss cost; Medical cost

BACKGROUND

In order to generate a more complete estimate of the economic burden of injuries, it is necessary to include an estimate of the quality of life (QoL) lost as a result of injury. The quality-adjusted life year (QALY) is a measure of disease or injury burden that captures both the quality and the duration of life lived post disease or injury. QALYs, either monetized or unmonetized, are used in studies of injury costs and of treatment and prevention benefits from many perspectives including those of society, of victims and their families, and of the health care system when analyzing its ability to cost-effectively produce and preserve health. In analyses of preventive intervention, the expected QALY gain represents the unmonetized or monetized value of injury risk reduction across a target population.

In 2013 it was estimated that nonfatal injuries accounted for over $456 billion in lifetime medical and work loss costs in the United States.[1] In 2018 an estimated 23 million injuries were seen in an emergency department (ED).[2] Injuries are classified by intent either as unintentional, violence-related, or undetermined and have several mechanisms such as poisoning, falls, and motor vehicle crashes (MVC).[3] The total lifetime economic burden of injury differs by mechanism and intent. For example, in 2013 it was found that the total lifetime costs of unintentional injuries were more costly than assault or self-harm injuries.[1] Further, costs of injuries also differ at the per-event level by disposition (i.e., includes treated and released vs. hospitalized). All types of injuries had a higher associated cost when they occurred in visits with hospitalization.[1]

QALYs provide a means to compare different types of injuries using a common measurement, which allows incorporation of the quality of life and duration of life from an injury to be considered. When QALY estimates are combined with medical and work loss costs they can help to provide a more comprehensive picture of the economic losses associated with injuries. A QALY typically takes a value between 0 and 1, where 0 represents death and 1 represents perfect health. A loss of one QALY is the equivalent of losing one year of life in perfect health.

There is limited literature on QALY losses for injuries comprehensively in the United States (U.S.). Previously published literature identifies QALYs for traumatic brain injury (TBI)[4] or road injuries.[5, 6] Additionally, there is research that identifies QALY losses in European countries.[7] There is literature that identifies quality of life cost for hospital treated non-fatal injuries, however it does not produce individual QALY loss estimates for specific injuries.[8] The present study contributes to the literature in three key ways. First, to our knowledge this is the first study in 25 years to produce QALY loss estimates for non-fatal injuries by type of injury and the second study to estimate the QALY loss associated with non-fatal injuries in the United States by mechanism, intent, and disposition, classifications that are meaningful to U.S. injury public health. Additionally, this study uses data on hospital ED visits from National Electronic Injury Surveillance System-All Injury

Program (NEISS-AIP), which has a higher level of detail on injuries and uses trained coders for injuries leading to better accuracy for diagnoses codes, allowing for greater precision in matching with QALY values. Finally, this study provides contemporary estimates of QALY loss with data from 2018. This study deals strictly with non-fatal injuries so its QALYs do not include mortality measure.

METHODS

QALY loss estimates were assigned to records in the 2018 NEISS-AIP, the most recent year of data available at the time of analysis. NEISS-AIP collects data on initial visits for non-fatal injuries treated in a hospital ED. Visits were classified into two dispositions: treated and released and hospitalized (which includes transfers). Visits classified as observations, leaving against medical advice, or unknown were removed from the dataset.

QALY estimates by body region and nature of injury were assigned in four stages using previously published research methods.[5, 9] Stage 1 used the Hirsch et al.[10] ratings by an expert panel of physicians who reported functional capacity losses over time for most injuries listed in *The Abbreviated Injury Scale, 1980 Revision* (AIS-80).[11] The Hirsch expert panel deliberately restricted its ratings to functional capacity losses, as those are objective medical facts. The panel recognized that it did not have expertise on the effects of injury on role function (usual activities) and that psychological impacts of injury were determined by details of the injury event and the injury victim's behavioral health and resiliency pre-injury as well as the physical losses, meaning they were not predictable by diagnosis. The panel rated physical impairment nature and duration by diagnosis along six dimensions of functioning: mobility, cognitive, cosmetic, sensory, pain, and daily living. Each dimension was defined by four levels of impairment – slight, moderate, severe, and maximum or total. The panel described the typical recovery trajectory based on the time spent at each level of impairment during the first year after injury, in years two through five, and in year six onward. It also assessed variations in recovery trajectory by patient age.

AIS-1 injuries, which are the least severe injuries (e.g., contusions, abrasions),[10] and non-traumatic injuries (such as non-severe and hospital-admitted burns, submersion, lead poisoning, frostbite, and electric shock) were not mapped by Hirsch et al. AIS-1 injuries were assigned impairments of 0 in this stage.[5] Other sources provided impairment ratings for the non-traumatic injuries.[12–14] The Appendix gives further information and an example.

The second stage added a seventh role-oriented dimension, work-related disability to the six dimensions of physical functioning. This dimension was calculated using the same work disability values previously used to estimate work loss for WISQARS.[15] Those values are based on temporary and permanent disability data from more than 450,000 worker injuries. This seventh dimension constitutes the only QALY loss estimated for AIS-1 injuries.

In the third stage, health-related utility weights were assigned to each level of each dimension of functional capacity loss and to the work-related role loss. Those weights had been determined through a systematic review of the utility-based QALY scoring literature.

[6] The review determined medians of utility scores that preference-based questionnaires assigned to the dimensions and functional loss levels included in the QALY assessment.

Because the WISQARS cost framework explicitly values the wage loss resulting from nonfatal injury, to avoid double-counting, the utility weight associated with the percentage of earning capacity lost to an injury was calculated net of earnings loss and represents the value, e.g., of social interactions in the workplace and feeling productive. In removing the income loss, the utility weight calculation for work disability relies on the value of statistical life (VSL), which is the amount that a large group of people are willing to pay in the expectation of saving one life. That value was calculated using the VSL prescribed by the US Department of Health and Human Services of $9.6 million in 2014 dollars.[16] Additional information and an example can be found in the Appendix, and elsewhere in more detail.[14]

Finally, impairment estimates were merged with the 2018 NEISS-AIP data by admission status (treated/released and hospitalized), NEISS injury diagnosis and body part,[17] age group (0–15, 16–45, 46–65, >65), and three mechanism or intent categories: traffic, violence, and all others. QALY estimates were calculated by intent and mechanism. Injuries were grouped by intent (unintentional/unknown/undetermined and violence-related) where violent intents were further classified into assault, self -harm, and legal intervention. QALY losses were calculated using NEISS injury diagnosis, body part, and age group. Estimates were produced by intent and mechanism, for all ED-treated cases, by two disposition groups: treated and released, and hospitalized. Life expectancy was discounted by 3% and based on life tables published by the National Center for Health Statistics.[18] QALYs were calculated for one-year and lifetime loss. In addition, the QALY loss per injury was monetized by multiplying by a value of $530,000 per QALY.[19] SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) was used to conduct all statistical analyses. The public was not involved in the design of this secondary analysis of existing data sets.

RESULTS

Table 1 reports the average estimated QALY loss and cost per nonfatal injury by intent and ED disposition. A person with an injury of unintentional /unknown /undetermined intent who is treated and released is estimated to lose an average of 0.093 QALY during the year following the injury. This first-year QALY loss is valued at almost $50,000. Those with a violence-related injury who are treated and released had first-year QALY losses between 0.018 and 0.155 years, with an estimated monetary value between $9,700 and $82,000. A similar pattern holds for those who are hospitalized as a result of their injury. A person hospitalized with an injury of unintentional/unknown/undetermined intent is estimated to lose an average of 0.241 QALY during the year following the injury, with an estimated monetary value of almost $128,000. Those with a violence-related injury who are hospitalized had first-year QALY losses between 0.045 and 0.255, with a monetary value between $24,000 and $127,000. Lifetime QALY losses ranged from 0.033 to 0.300 for treated-and-released injuries, and from 0.119 to 0.550 for hospitalized injuries. The lifetime monetary value of QALY losses for hospitalized injuries ranged from $63,000 to $292,000.

Table 2 reports the average estimated QALY loss and cost per nonfatal injury by mechanism and ED disposition among all intents of injury. Among those who were treated and released, one-year QALY losses ranged between 0.000 for drowning/submersion and 0.178 for falls. The associated monetary losses ranged from $136 to $94,000. Similarly, lifetime QALY losses among those treated and released ranged from 0.000 for drowning/submersion to 0.388 for falls, resulting in a monetary loss of $231 to $206,000. Among those hospitalized, one-year QALY losses ranged from 0.018 for poisoning to 0.824 for drowning/submersion, resulting in monetary losses of $9,400 to $437,000. Lifetime QALY losses for those hospitalized ranged from 0.031 for poisoning to 3.905 for drowning/submersion; monetary losses ranged from $16,000 to $2.1 million.

Among those with unintentional injuries that were treated and released, one-year and lifetime QALY losses were lowest for drowning, poisoning, foreign body, and inhalation/suffocation (0.000–0.009) (Data not reported). Among those hospitalized, one-year QALY losses were lowest for poisoning, inhalant, foreign body, and other specified (0.018–0.081) and lifetime QALY losses were lowest for poisoning, foreign body, dog bite, and other specified (0.027–0.148). The highest one-year treated-and-released QALY losses were for pedal cyclist and fall (0.127–0.178), and lifetime QALY losses were highest for pedestrian, other transport, and fall (0.246–0.388). The highest one-year hospitalized QALY losses were for pedestrian, fall, and drowning (0.357–0.824), and lifetime QALY losses were highest for pedestrian, fall, and drowning (0.753–3.906).

Among those with violence-related injuries that were treated and released, one-year and lifetime QALY losses were lowest for drowning, poisoning, foreign body, and machinery (0.000–0.005) (Data not reported). Among those hospitalized, one-year and lifetime QALY losses were lowest for poisoning, natural/environmental, foreign body, and other specified (0.014–0.078). The highest one-year and lifetime treated-and-released QALY losses were for other transport and fall (0.200–0.446). The highest one-year and lifetime hospitalized QALY losses were for pedal cyclist and drowning (0.825–3.885).

DISCUSSION

This study provides quality of life loss values and monetary valuations by both injury intent and injury mechanism using the NEISS-AIP. These estimates are valuable for public health approaches that address injuries by mechanism and intent—for example, self-harm and suicide, homicide, falls, and motor vehicle injuries. Additionally, they provide information to improve knowledge about the comprehensive economic burden of injuries; direct cost elements that can be measured through financial transactions, such as medical care and lost work productivity, do not capture the full cost of an injury. In addition, estimates by injury type, can help to quantify per-person experiences with injuries over the long term, contributing to expanded analysis opportunities to compare comprehensive long-term injury costs to the cost of public health injury prevention efforts.

This study is subject to at least three limitations. First, these estimates are specific to an important and long-standing nonfatal injury surveillance system, NEISS-AIP. This study's estimates will allow researchers to accurately and systematically describe the quantity and

value of quality of life losses reported in that data source. Since NEISS-AIP is an ED-based sample, it excludes injuries treated in non-hospital settings, such as doctor's offices or urgent care, and those admitted directly to a hospital without an ED visit. Thus, these estimates do not include those treated outside the ED or who did not seek medical care. Second, ideally the QALY losses over time for each of the hundreds of injuries assessed would be determined by enrolling statistically valid patient samples by diagnosis and tracking their recovery longitudinally. That effort would be prohibitively expensive and burdensome. Instead, we built QALY losses by applying utility based QALY weights to physician reports of objectively measurable functional losses and administrative data on work-related role impairment. Those clinical reports of typical recovery arcs are several decades old;[10] they might not accurately reflect current recovery arcs, given advances in medicine since 1983. Although more recent studies of injury impairment have surveyed patients directly about their experiences [20] or used general population surveys to rank impairment descriptions of different health states,[21] these studies covered only modest numbers or broad categories of injury. Preliminary comparisons of selected broad diagnosis groups, however, suggest that if anything the clinical estimates of functional recovery were over-optimistic. Finally, only one diagnosis per injury episode was taken into account in estimating QALY losses; in the case of a person with multiple injuries, the estimates presented here likely undercount quality of life losses

CONCLUSION

Quality of life losses are an important element in public health analysis of illness and injuries. Estimates presented here indicate that the total cost of injuries extends beyond direct costs such as medical care and lost work productivity. Comprehensive assessment of the long-term cost of injuries, including quality of life losses, is critical to accurately estimate the economic burden of injuries.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Conflicts of interests/Competing interests/Funding statement:

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What is already known on this subject

- QALYs provide a means to compare different types of injuries, incorporating of the quality of life and duration of life from an injury.
- The total lifetime economic burden of injury differs by mechanism and intent.

What this study adds

- This study uses data on hospital ED visits from National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP), allowing for greater precision in matching with QALY values.
- This study produced contemporary QALY loss estimates for non-fatal injuries in the United States by type of injury and by mechanism, intent, and disposition.

Table 1:

Average estimated quality-adjusted life year (QALY) loss and cost per nonfatal injury by intent and emergency department visit disposition, 2018 National Electronic Injury Surveillance System - All Injury Program (NEISS-AIP) (2018 USD)

	Treated and Released				Hospitalized			
	1-year		Lifetime		1-year		Lifetime	
	QALY loss	$	QALY loss	$	QALY loss	$	QALY loss	$
Unintentional/Unknown/Undetermined Intent	0.093	$ 49,537	0.200	$ 104,799	0.241	$ 127,937	0.550	$ 291,764
Violence-related								
Assault	0.155	$ 81,903	0.300	$ 158,797	0.240	$ 127,001	0.499	$ 264,503
Self-Harm	0.018	$ 9,678	0.033	$ 17,706	0.045	$ 24,063	0.119	$ 63,000
Legal Intervention	0.107	$ 56,518	0.202	$ 107,021	0.255	$ 119,441	0.504	$ 267,253

Table 2.

Average estimated quality-adjusted life year (QALY) loss and cost per nonfatal injury by mechanism and emergency department visit disposition among all injury intents, 2018 National Electronic Injury Surveillance System - All Injury Program (NEISS-AIP) (2018 USD)

	Treated and Released				Hospitalized			
	1-year		Lifetime		1-year		Lifetime	
	QALY loss	QALY cost ($)	QALY loss	QALY cost ($)	QALY loss	QALY cost ($)	QALY loss	QALY cost ($)
Motor Vehicle- occupant[a]	0.117	$ 62,263	0.231	$ 122,665	0.298	$ 157,909	0.608	$ 322,275
Motorcyclist[a]	0.084	$ 44,688	0.147	$ 77,683	0.297	$ 157,444	0.593	$ 314,415
Pedal cyclist[a]	0.127	$ 67,058	0.242	$ 127,998	0.312	$ 165,270	0.640	$ 339,247
Pedestrian[a]	0.119	$ 63,115	0.241	$ 127,925	0.357	$ 189,266	0.751	$ 398,285
Other transport[a]	0.120	$ 63,477	0.260	$ 137,972	0.312	$ 165,253	0.649	$ 344,218
Fall	0.178	$ 94,132	0.388	$ 205,722	0.361	$ 191,413	0.855	$ 452,952
Struck by or against	0.127	$ 67,122	0.255	$ 134,958	0.291	$ 153,965	0.627	$ 332,489
Cut/pierce	0.008	$ 4,180	0.013	$ 6,650	0.067	$ 35,360	0.136	$ 72,070
Overexertion	0.039	$ 20,737	0.075	$ 39,963	0.198	$ 105,007	0.291	$ 154,212
Fire/burn	0.018	$ 9,366	0.025	$ 12,988	0.139	$ 73,473	0.426	$ 225,934
Poisoning	0.003	$ 1,728	0.006	$ 3,337	0.018	$ 9,388	0.031	$ 16,302
Inhalation/suffocation	0.010	$ 5,184	0.023	$ 11,971	0.278	$ 147,238	1.189	$ 630,404
Drowning/submersion	0.000[b]	$ 136	0.000[c]	$ 231	0.824	$ 436,748	3.905	$ 2,069,602
Machinery	0.041	$ 21,780	0.117	$ 61,978	0.188	$ 99,556	0.549	$ 291,232
Foreign body	0.001	$ 601	0.002	$ 957	0.040	$ 21,354	0.062	$ 32,880
Dog bite	0.010	$ 5,526	0.017	$ 9,023	0.080	$ 42,447	0.147	$ 77,766
Other bite/sting	0.018	$ 9,419	0.030	$ 15,810	0.087	$ 46,053	0.155	$ 82,077
Firearm gunshot	0.035	$ 18,565	0.059	$ 31,147	0.166	$ 88,224	0.334	$ 177,169
BB/pellet gunshot	0.018	$ 9,585	0.031	$ 16,373	0.089	$ 47,182	0.209	$ 110,884
Natural/environmental	0.011	$ 5,794	0.018	$ 9,664	0.103	$ 54,345	0.200	$ 105,812
Other specified	0.019	$ 10,018	0.055	$ 29,403	0.028	$ 14,984	0.050	$ 26,334
Unknown/unspecified	0.064	$ 34,006	0.126	$ 66,789	0.279	$ 148,041	0.581	$ 307,731

[a]Includes traffic related, non-traffic related, and unknown transportation injuries.

[b]0.000256883

[c]0.000436646