Original Article

Determination of the Burden of Spinal Cord Injury and Limb Amputation as a Result of the Bam Earthquake in 2004

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Abstract

Background and Objectives: This study aimed at investigating the burden of injuries, including spinal cord injuries and limb amputation, caused by the Bam earthquake. **Materials and Methods:** The data related to morbidity of spinal cord injuries were collected from records provided by State Welfare Organization of Iran. Then, morbidity and mortality data for amputation and also mortality of spinal cord injuries were obtained from a previous study using the network scale-up method. Then, we followed the World Health Organization guidelines to assess the burden of this disease, and then years of life lost (YLL) and years of life lost due to disability (YLD) were calculated. **Results:** The disability-adjusted life years (DALYs) caused by the spinal cord injury were 15,435 years. YLL due to premature mortality was 13,134 and YLD was 2301 years and the number of DALY caused by limb amputation was equal to 2184, all of which were due to YLD. **Conclusions:** According to the results of the present study, spinal cord injuries and amputations resulting from the earthquake impose many burdens on society. This provides outcomes and evidence for policymaking and planning in the field of health care for policymakers.

Keywords: Amputation, disability-adjusted life years, spinal cord injury, years of life lost due to disability, years of life lost due to premature mortality

Introduction

Natural disasters are occurring across the nations of the world, and sometimes, they leave very devastating impacts on societies in terms of health.[1] Earthquakes, in particular, are likely to result in many disabilities in developing countries. Some of the fatal and permanent injuries following the earthquakes are spinal cord injuries and amputations.[2,3] One of the main reasons of spinal cord injury is inadequate knowledge of volunteers or rescuers on how to correctly transfer and save trapped victims.[2] In some earthquakes, the burden related to spinal cord injury was very high; for example, the earthquake in Pakistan on October 8, 2005, left approximately 600 patients with spinal cord injury.[4]

To make plans and decrease the burden of the problem, we need to have an estimation of the extent of the problem. Disability-adjusted life year (DALY) is an epidemiological index to estimate the burden of the problem. DALY is the sum of the years of life lost (YLL) due to premature death (YLL), and finally, years of life lost due to disability (YLD) from nonfatal consequences of diseases and injuries in society.[5,6]

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Iran ranks four throughout the world in experiencing destructive earthquakes.[7] The Bam earthquake is among the most destructive ones, which occurred in 2003 resulting with many causalities and deaths, and the total number of people who died in the earthquake was estimated as 54,041 people, the death rate caused by spinal cord injury was estimated as 622, and the total number of cases with legs and/or hand amputations was estimated as 519.[8]

The aim of this study was to quantify the burden of spinal cord injuries and amputations caused by the Bam earthquake through calculation of DALY based on age and sex groups.

Materials and Methods

In this cross-sectional study, the secondary data of spinal cord injury and leg and arm amputations were used.

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Table 1: The estimates of disease burden resulting from spinal cord injury caused by the Bam earthquake separated by age and sex

Age	Men			Women			Total person		
	Population	DALY	DALY/1000	Population	DALY	DALY/1000	Population	DALY	DALY/1000
0-4	14,731	-	-	14,175	-	-	28,906	-	-
5-14	41,562	17	0.4	42,235	-	-	83,797	17	0.2
15-29	31,475	3585	113.9	33,263	624	18.8	64,738	4209	65
30-44	18,523	5290	285.6	18,999	332	17.5	37,522	5622	149.8
45-59	8237	2062	250.4	8991	2235	248.6	17,228	4279	249.4
60+	8634	1270	147.1	8062	19	2.3	16,696	1289	77.2
Total	123,162	12,225	99.3	125,725	3210	25.5	248,887	15,435	62

DALY: Disability-adjusted life years

Table 2: The burden of the diseases caused by the limb amputation in Bam earthquake separated by age and sex

Age	Men				Women				Total person		
	Population	Limb	DALY	DALY/1000	Population	Limb	DALY	DALY/1000	Population	DALY	DALY/1000
0-14	56,293	Arm	-	-	56,410	Arm	-	-	112,703	-	-
		Leg	-	-		Leg	-	-		-	-
15-29	31,474	Arm	575	18.26	33,262	Arm	276	8.29	64,736	885	13.67
		Leg				Leg	34	1.02			
30-44	18,522	Arm	490	26.45	18,999	Arm	-	-	37,521	1299	34.62
		Leg	729	39.35		Leg	80	4.21			
45+	16,870	Arm	-		17,051	Arm	-	-	33,921	-	-
		Leg	-			Leg	-	-		-	-
Total	123,159	Arm and leg	1794	14.56	125,722	Arm and leg	390	3.10	248,881	2184	8.77

DALY: Disability-adjusted life years

Data collection

To calculate the burden of the diseases related to spinal cord injury, we used records of the State Welfare Organization for calculation of YLD. Furthermore, YLL was calculated based on the data obtained using the network scale-up method based on age and sex groups.[8,9]

In terms of burden of the diseases related to limb amputation, there were no records of such injuries; therefore, we used the scale-up method to estimate related YLL and YLD, and the details of this method were mentioned elsewhere.[8]

The population of Bam was not available in 2004; therefore, the population of the year 1996, which was officially counted, was considered as the base population with the growth rate of 3.6%;[8,10] the population of 2004 was estimated using combined population methods[11] by the Excel software with population based on different age and sex groups.[8]

Definitions and inputs

The codes for spinal cord and leg and arm injuries were defined based on ICD10; S39 to S30 was considered for the spinal cord injury and IIIA 2–29 and IIIA 2–30 for amputation.[12] YLL due to premature death was considered as immediate death, and the standard life expectancy rates at birth for males and females were 80 and 82.5, respectively, which were used to calculate YLL.[13] The disability weight of the disease was extracted from international sources, particularly published sources of the World Health Organization and texts from published sources,[14] taking into account the discount rate and the value of age using the model of the World Health Organization to calculate the burden of the disease in Excel software.[14,15] The relationships and formulas are explained in Appendix 1.

Results

Disability-adjusted life year for spinal cord injury

Estimation of years of life lost

The total YLLs due to premature death (YLL) related to spinal cord injury in men and women were 11,031 and 2103, respectively. The rates of YLL were 89.6 and 16.7/1000 in men and women, respectively.

Estimation of years lived with disability

YLD in men and women was calculated as 1194 and 1107, respectively. The rates of YLD for men and women were 9.7 and 8.8/1000, respectively.

Burden of spinal cord injury

Then, burden of disease was estimated as 15,435 years. The rates were 62 years/1000 population. There was no spinal cord injury in the age group of 0–4. Furthermore, there was a few numbers of injuries among people younger than 15-year-old. However, as the age goes up, the tolls of spinal cord injury increase and also decline at the age of 60 and over [Table 1].

Disability-adjusted life year for limb amputation

Estimation of years of life lost

The total YLLs due to premature death in both males and females were considered zero because we had no death due to limb amputation.

Estimation of years lived with disability

YLDs in men and women were calculated as 1650 and 534, respectively. The rates of YLD for men and women were 19.3 and 10/1000, respectively.

Burden of limb amputation

Then, burden of disease was estimated as 2184 years. The rate was 29.3 years/1000 people. There was no limb amputation in the age group of 0–4. Furthermore, there were a few numbers of injuries in people younger than 15 years. However, as the age goes up, the tolls of limb amputation increase and also decline around the age 50 and over [Table 2].

Discussion

The purpose of this study was to estimate the burden of the diseases related to spinal cord injuries and amputations caused by the Bam earthquake. DALY of spinal cord injury as a result of the Bam earthquake was estimated as 15,435 years. To the best of our knowledge, there is no evidence on the estimation of the burden of spinal cord injuries after disaster. Nevertheless, in a study conducted by Naghavi *et al*., DALY related to all causes of mortalities in 2003 was estimated as 2.789 million, with 968,080 related to the Bam earthquake.[16] Taking into account the above information, 2% of the total DALYs in Iran in 2003 could be due to spinal cord injury and amputation, which reflects the considerable burden.

Among age groups, the most DALYs related to spinal cord injury happened in the middle-age groups, while in nondisastrous situations, the injuries are occurred mainly due to car accidents, the majority of which happen to young people,[17] These differences in age groups in disastrous and nondisastrous situation could highlight contribution of the role of age in these injuries. Middle-age groups are more likely to have the role of a parent and as a result of that be responsible to help children which in turn put their lives at risk during a disaster. However, performing risky behaviors such as ignoring driving rules or fast driving might be more prevalent among young people and that might explain a higher prevalence of car accidents among them.

YLL due to premature mortality in men was much higher than that in women. Similar with our study, the results in nondisastrous situations show that men are more likely to experience spinal cord injury, for example, a study conducted by Naghavi *et al*. found that YLL of the spinal cord injury among men was 2297, which was approximately twice as much as that in women.[16]

In our study, YLDs in men and women with spinal cord injury were estimated as 1194 and 1107 years, respectively. The corresponding figures in nondisastrous situations were estimated as 278 and 126 in men and women, respectively, showing a higher rate in men. The crude numbers of YLD are affected by several factors including the number of injuries, comorbidities in companion with spinal cord injuries, and demographic characteristics of the population. Therefore, a higher number of YLD in disastrous situations might be due to any of the mentioned factors.

Furthermore, we found that YLDs caused by the disease in men and women with limb amputation were 1650 and 534, respectively, which shows a higher number in men; this is probably due to men's behavior in earthquake to rescue the children's lives and probably due to the high resistance of men who survived under the debris, and they have suffered amputations.

DALY is an important tool for policymakers and could be a summary measure for decision-makers. This study was the first effort to calculate spinal cord injury and limb amputation to provide sound evidence of the burden of these problems. However, we acknowledge that there are limitations with the current study. First, there might be comorbidities accompanied by spinal cord injuries that we failed to take them into account. Furthermore, the data related to amputation of limbs were not available, and we had to estimate them, which might not be very precise.

Conclusions

Spinal cord injuries and limb amputation occurred in a considerable rate in the Bam earthquake, and men were more likely to experience them. Since disasters are occurring in growing rates globally, sound evidence could help policymakers with decision-making, and the estimation of DALY could be a valuable tool for presenting relevant evidence.

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Conflicts of interest

There are no conflicts of interest.

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Appendix

Appendix 1: Formulas for calculating of Disability-adjusted life year (DALY)

$$YLL\ (3.1) = N\,Ce^{(ra)}/(\beta+r)^2\,(e-[\beta+r]\,[L+a]\,[-(\beta+r)\,(L+a)-1]-e-[\beta+r]\,a[-(\beta+r)\,a-1])$$

In this regard:

- N = the number of dead persons in a given age and gender.
- L = standard life expectancy dead persons at the same age and sex specific
- R = discount rate that is equal to 0.03
- B = contract rates in calculating age value that is equal to 0.04
- C = constant is 0.1658.

$$YLD\ (3.1) = I \times DW \times Ce^{(ra)}/(\beta+r)\,2\,(e-[\beta+r]\,[L+a]\,[-(\beta+r)\,(L+a)-1]-e-[\beta+r]\,a[-(\beta+r)\,a-1])$$

In this regard:

- I = number of new cases of an illness or injury at a given time
- L = duration of the disease or condition
- DW = weight or effect of impairing
- R = discount rate that is equal to 0.03
- B = contract rates in calculating age value that is equal to 0.04
- C = constant is 0.1658.

$$DALY = YLL + YLD$$