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ORIGINAL ARTICLE

Burden of spinal cord injury in Tehran, Iran

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Study Design: Investigation of burden of traumatic spinal cord injury (SCI) using disease modeling.
Objectives: The present paper is intended to estimate the SCI burden for the year 2008.
Setting: Tehran, capital of Iran.
Methods: Epidemiological data needed to calculate Disability-Adjusted Life-Years (DALYs) for SCI, was estimated according to prevalence, duration and relative risk of mortality using DISMOD software. For DALY calculation, the years of life lost because of premature mortality (YLL) was added to the number of years lost because of disability (YLD). To calculate DALYs for SCI, first year DALY calculated separately and for the next years, the DALY was assessed for six different clinical presentations of traumatic SCI including quadriplegia, quadriparesis, paraplegia, paraparesis, hemiplegia and hemiparesis.
Results: In first year following SCI, the DALY was 3772 years, which has 0.5 DALY per 1000 people and YLL/DALY was 89.3%. Following the first year, the DALY was 435 for quadriplegia, 163 for quadriparesis, 868 for paraplegia, 164 for paraparesis, 26 for hemiplegia and 14 for hemiparesis. The total YLL for traumatic SCI was 4077 years and total YLD was 1364 years (total YLL/DALY was 74.9%) and total DALY was 5441 years, (M/F = 2.0), which has 0.7 DALY per 1000 people in Tehran in 2008.
Conclusions: This study showed a high burden for SCI. Identifying the risk factors of SCI, and performing cost-effective preventive interventions for reducing burden of SCI is recommended.
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Keywords: spinal cord injury; burden of disease; DALY; Tehran

Introduction

The World Health Organization (WHO) started the Global Burden of Disease (GBD) study in the 1990s to obtain a comprehensive summary and information on disease and injury. The study aimed to determine global priority for health research and to assist international health planning.[1]

The disability-adjusted life year (DALY) was designed to compare and analyze the burden of disease. A DALY is equal to the loss of 1 year of 'healthy' life and it can be used for measurement of the burden of disease in a population. It measures the gap between current health and an ideal condition where everyone lives to an old age without disease and disability. The DALY is of value as a means for health policy and planning.[2]

Injuries are a major cause of morbidity and mortality in developing and developed countries.[2] Injuries, which account for 10% of global mortality, are often ignored as a major cause of death and may require innovative strategies to reduce their burden. However, according to a report from Iran in 2003, among disease groups, injuries has the highest burden of disease (DALY) which includes 28% of DALY—36.5% in male and 18% in female patients; and the first cause of years of life lost because of premature mortality (YLL).[3]

Spinal trauma complicated by injury to the spinal cord is a devastating event on a personal and family level, as well as a tremendous financial burden to society because of its attendant morbidity, expense and prolonged treatment requirements.[4] Among all causes of injury-related morbidities, spinal cord injury (SCI) has one of the highest burdens because of permanent disability.[2] Moreover, it is associated with relatively high rates of mortality. Saunders *et al*.[5] have reported that among all injury-related deaths, traumatic SCI accounts for 8% of deaths.

In spite of these facts, a few researchers have attempted to calculate the burden of SCI.[6,7] This paper is intended to estimate the SCI burden for the year 2008 in Tehran, capital of Iran.

Methods

To calculate Disability-Adjusted Life-Years (DALYs) for SCI, the years of life lost because of premature mortality (YLL)

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was added to the number of years lost because of disability (YLD), that is, DALY = YLL + YLD.

We used disease-modeling software[8] version 2. The software provides an internally consistent set of epidemiological indices including incidence, prevalence, remission, duration, mortality, case fatality and relative risk of mortality of disease. For this purpose, the data on population structure and general mortality rates and at least three of the above-mentioned epidemiological indices are necessary. To calculate YLL, age-specific mortality rates were multiplied by age-specific standard expected YLL and population numbers.[9] To calculate the remaining years of potential life at any age at death, we used the standard model life table West Level 26 with a life expectancy at birth of 82.5 years for women and 80 years for men.[10]

YLD is estimated by multiplying age-specific incidence rates by an average duration of each incident case (or, more precisely, of the associated disability until death or recovery) and average disability weight. In this study, we used disease-modeling software and calculated epidemiological parameters needed to estimate DALYs using estimates of prevalence, duration and relative risk of mortality/or case fatality. To calculate DALYs, we used Excel Template designed by WHO for the GBD study.

YLL, YLD, DALY and DALY per 1000 were calculated for the first year following SCI. In the first year, we used prevalence, case fatality and 1-year duration. For the next years, YLL, YLD, DALY and DALY rates per 1000 population were calculated for each six types of SCI (quadriplegics, quadriparetics, paraplegics, paraparetics, hemiplegics and hemiparetics) in different age groups and both sexes. Thus, DALY was calculated based on prevalence, relative risk of mortality and zero remission for SCI in the next years.

Disability weights

The disability weights used in DALY calculations represent societal preferences for different health states. The GBD weight for SCI used in this study is 0.725.[1]

Discount rate

Discount rate means that future life years are assigned less value than those lived today, which was considered as 3% in this study the same as the majority of burden of disease studies.[11]

Tehran population

Tehran's population census of 7 976 000 was last determined by the Statistical Centre of Iran in 2006.

Prevalence

A population-based study carried out in 2008 in Tehran, noted that the prevalence of past history of SCI was 4.4 per 10 000 population.[12] Age and sex distribution of the SCI subjects in Tehran were obtained using the data bank of the State Welfare Organization of Iran of SCI patients. These records were based on International Classification of Disease (ICD 10) codification system (Codes 14.0 and 14.1 for cervical cord injury, 24.0 and 24.1 for thoracic cord injury and 34.0 and 34.1 for lumbar cord injury) with patients registered in State Welfare Organization of Iran between June 2007 and June 2008.[13] The Tehran welfare organization recorded 496 traumatic SCI patients of which 154 were female and 342 were male patients. Table 1 shows the distribution of six types of SCI in different ages and sexes in Tehran.

Mortality

SCI-related mortality is divided into three categories depending on the location of death, that is, at the scene of accident or prehospital, during hospitalization and post-hospital. As there were no published data on SCI mortality in Iran, we extracted the relative risk of mortality from the literature.[14–19]

Prehospital or at scene mortality. Dryden *et al.*[15] reported that 71 out of 450 SCI patients died before hospitalization (15.8%). Martins *et al.*[18] reported that 64 out of 398 deaths occurred on arrival at hospital. Summating these two reports

Table 1 The distribution of six types of spinal cord injury in different ages and sexes in 496 patients under coverage of the welfare organization in Tehran, 2007–2008

Age group	*Sex*	*Quadriplegic* N (%)	*Quadriparetic* N (%)	*Paraplegic* N (%)	*Paraparetic* N (%)	*Hemiplegic* N (%)	*Hemiparetic* N (%)	*Total* N (%)
<10 years	M	0 (0.0)	0 (0.0)	2 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.4)
	F	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)
11–20 years	M	6 (0.2)	3 (0.6)	13 (1.6)	1 (0.2)	0 (0.0)	0 (0.0)	23 (4.6)
	F	1 (0.2)	0 (0.0)	8 (1.6)	1 (0.2)	0 (0.0)	0 (0.0)	10 (2.0)
21–30 years	M	18 (3.6)	8 (1.6)	53 (10.7)	9 (1.8)	2 (0.4)	0 (0.0)	90 (18.1)
	F	6 (1.2)	3 (0.6)	29 (5.8)	4 (0.8)	0 (0.0)	1 (0.2)	43 (8.7)
31–40 years	M	14 (2.8)	7 (1.4)	45 (9.1)	10 (2.0)	1 (0.2)	1 (0.2)	78 (15.7)
	F	6 (1.2)	2 (0.4)	25 (5.0)	7 (1.4)	0 (0.0)	0 (0.0)	40 (8.1)
41–50 years	M	19 (3.8)	6 (1.2)	35 (7.1)	11 (2.2)	0 (0.0)	0 (0.0)	71 (14.3)
	F	6 (1.2)	3 (0.6)	16 (3.2)	8 (1.6)	0 (0.0)	0 (0.0)	33 (6.7)
50+ years	M	15 (3.0)	6 (1.2)	39 (7.9)	17 (3.4)	1 (0.2)	0 (0.0)	78 (15.7)
	F	7 (1.4)	1 (0.2)	13 (2.6)	5 (1.0)	1 (0.2)	0 (0.0)	27 (5.4)
Total	M	72 (14.5)	30 (6.0)	187 (37.7)	48 (9.7)	4 (0.8)	1 (0.2)	342 (69.0)
	F	27 (5.4)	9 (1.8)	91 (18.3)	25 (5.0)	1 (0.2)	1 (0.2)	154 (31.0)

reveals that 135/848 (15.92%) of SCI patients died before hospitalization.

Hospital mortality. In a study of 217 male and 80 female patients with SCI ranging in age from 15 to 96 years, Furlan *et al.*[16] showed the mean in-hospital mortality rate of 5.7%.

One-year post-hospital mortality. Catz *et al.*[14] evaluated 1-year survival rate for SCI patients who were discharged from a hospital, and were transferred to a rehabilitation center. Twelve out of 250 patients died in the first year after injury (4.8%).

Thus, first year case fatality for SCI is the summation of prehospital (15.92%), hospital (5.7%) and posthospital (4.8%) loss of life, which was 24.5%.

Relative risk of mortality (RRM) for SCI patients after 1 year
After the first year, relative risk of mortality (RRM) for each of the six types of SCI were obtained from two studies.[17,19] Shavelle *et al.*[19] calculated RRM in SCI. They showed that persons who are injured young can expect a life expectancy of approximately 83% of normal life in the setting of minimal SCI (RRM = 1.20). Krause *et al.*[17] designed a statistical model to find independent predictors of mortality. Their final statistical model analyzed 1265 subjects including 188 deaths. Using the presence of paraparesis as a base (Hazard Ratio or HR = 1), they calculated HR for the other three types of SCI as follow: quadriplegics (C5–C8), 2.87, quadriparetics, 1.29 and paraplegics, 2.58. As they have not reported RRM for hemiplegics and hemiparetics, we considered their HR equal to the paraplegics and paraparetics, respectively. All these numbers were multiplied by RRM of minimal SCI (1.20).

The risk of SCI mortality was inhomogeneous in male and female patients in different studies. Lidal *et al.*[20] showed a higher risk in female patients (SMR of 1.8 for men and 4.9 for women). On the other hand, Saunders *et al.*,[5] showed that there was lower mortality in women (0.9/1), but no difference in other studies (Saunders *et al.*[5]). Shavelle *et al.*[19] showed that male OR was 1.27. Therefore, in this study, we estimated similar mortality for both sexes.

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

Results

Table 2 demonstrates the estimated incidence of SCI in male and female patients in different ages based on disease modeling in Tehran in 2008.

DALY in the first year after SCI
In the first year following SCI, the YLL was 2297 and 1071 years for male and female patients, respectively (M/F = 2.14), which provided a total YLL of 3368 years. In both male and female patients the highest YLL was observed in 15–29 year olds, which was 993 and 457 years successively. With regard to the YLD, the total value was 404 years (278 years in male and 126 in female patients; M/F = 2.21). Again, the highest YLD was seen in 15–29 year olds in both male and female patients (110 years and 50 years, respectively). DALYs' first year following traumatic SCI in Tehran was 3772 years or 0.5 DALY per 1000 people. First year YLL/DALY was 89.3%. The values were 2575 in male and 1197 in female patients.

Table 2 The estimated incidence of spinal cord injury in male and female patients in different ages based on disease modeling

Age	*Male patients (incidence/1000)*	*Female patients (incidence/1000)*
0–4 years	0.0259	0.0122
5–14 years	0.0441	0.0209
15–29 years	0.1144	0.0541
30–44 years	0.1335	0.0626
45–59 years	0.0972	0.0457
60–69 years	0.0721	0.0345
70+ years	0.0722	0.0345
Total	0.0984	0.0465

Table 3 First year YLL/YLD, DALYs and DALYs/1000 person per sex and age following spinal cord injury in Tehran in 2008

Age	*P*	*Male patients*				*Female patients*				*Both male and female patients*		
		YLL/ DALYs *(%)*	*DALYs*	*DALYs per 1000*	*P*	*YLL/ DALYs (%)*	*DALYs*	*DALYs per 1000*	*P*	*YLL/ DALYs (%)*	*DALYs*	*DALYs per 1000*
0–4 years	234 131	91.8	49	0.2	222 800	90.9	22	0.1	456 931	91.5	71	0.2
5–14 years	514 665	90	160	0.3	490 990	90.7	75	0.2	1 005 655	90.2	235	0.2
15–29 years	1 348 606	90	1103	0.8	1 291 414	90.1	507	0.4	2 640 020	90.1	1610	0.6
30–44 years	948 147	89.3	840	0.9	910 440	89.5	389	0.4	1 858 587	89.3	1229	0.7
45–59 years	589 581	87.7	334	0.6	573 833	88.1	160	0.3	1 163 414	87.9	494	0.4
60–69 years	198 380	82.8	58	0.3	181 438	85.7	28	0.2	379 818	83.7	86	0.2
>70 years	152 909	77.4	31	0.2	146 549	81.3	16	0.1	299 458	78.7	47	0.2
Total	3 986 419	89.2	2575	0.6	3 817 464	89.5	1197	0.3	7 803 883	89.3	3772	0.5

P: population.
YLL: years of life lost because of premature mortality.
YLD: years lost because of disability.
DALY: disability-adjusted life year.

Table 4 YLL/DALY, and DALYs after first year following different clinical presentations of spinal cord injury in Tehran in 2008

	Quadriplegic		*Quadriparetic*		*Paraplegic*		*Paraparetic*		*Hemiplegic*		*Hemiparetic*		*Total DALY*
	YLL/ DALY (%)	*DALY*	*YLL/ DALY (%)*	*DALY*	*YLL/ DALY (%)*	*DALY*	*YLL/ DALY (%)*	*DALY*	*YLL/ DALY (%)*	*DALY*	*YLL/DALY*	*DALY*	
Males													
0–4	0	2	—	0	5.9	17	0	12	—	0	—	0	31
5–14	4.5	22	0	1	11.9	42	0	14	—	0	—	0	79
15–29	15	100	1.6	62	33.8	148	15	20	0	6	—	0	336
30–44	31.6	76	11.1	18	46.3	121	7.4	27	33.3	3	0	8	253
45–59	68.1	47	30	10	69.9	83	12.5	24	25	4	0	2	170
60–69	84.2	19	50	4	73.9	46	28.6	7	50	2	—	0	78
>70	77.8	27	75	4	74.3	70	57.1	7	100	2	—	0	110
Total	36.9	293	11.1	99	48.2	527	13.6	110	29.4	17	0	10	1056
Females													
0–4	0	1	—	—	0	20	0	7	—	0	—	0	28
5–14	0	10	—	—	2.5	40	0	7	—	0	—	0	57
15–29	6.5	46	0	36	10.4	96	0	10	0	5	—	0	193
30–44	20.7	29	0	16	22.2	63	0	12	0	1	0	3	124
45–59	66.7	21	14.3	7	57.4	47	9.1	11	0	1	0	1	88
60–69	92.5	14	50	2	82.1	28	33.3	3	0	1	—	0	48
>70	85.7	21	66.7	3	87.8	49	75	4	100	1	—	0	78
Total	37.3	142	6.25	64	34.6	343	9.3	54	11.1	9	0	4	616

YLL: years of life lost due to premature mortality.
YLD: years lost with disability.
DALY: disability-adjusted life year.

The highest DALY was calculated in 15–29 year olds with the values of 1103 and 507 years for male and female patients, respectively. Table 3 shows the details.

DALYs in next years in different types of SCI

Quadriplegia. The YLL was 108 and 53 years in males and females, respectively, which provided total YLL of 161 years. With regard to the YLD, the total value was 274 years (186 years in male and 88 in female patients). DALYs was 435 years. The values were 293 in male and 142 in female patients. The highest DALY was calculated in the 15–29 year group with the values of 100 and 46 years for male and female patients, respectively. Table 4 shows the details.

Quadriparesis. The YLL was 11 and 4 years, respectively, in male and female patients, which provided a total YLL of 15 years. With regard to YLD, the total value was 149 years (88 years in male and 61 in female patients). DALYs was 163 years. The values were 99 in male and 64 in female patients. The highest DALY was calculated in 15–29 year olds with the values of 62 and 36 years for male and female patients, respectively (Table 4).

Paraplegia. The YLL was 254 and 118 years, respectively in male and female patients, which provided a total YLL of 372 years. With regard to YLD, the total value was 495 years (272 years in male and 223 in female patients). DALYs was 868 years. The values were 527 in male and 341 in female patients. The highest DALY was calculated in the 15–29 year group with the values of 148 and 96 years for males and female patients, respectively (Table 4).

Paraparesis. The YLL was 15 and 5 years, respectively in male and female patients, which provided a total YLL of 20 years. With regard to YLD, the total value was 145 years (95 years in male and 50 in female patients). DALYs was 164 years. The values were 110 in male and 54 in female patients. The highest DALY was calculated in the 30–44 year age group with the values of 27 and 12 years for male and female patients, respectively (Table 4).

Hemiplegia and hemiparesis. The YLL was 7 and 0 years, respectively in hemiplegics and hemiparesis. With regard to YLD, the total value was 19 and 13 years in hemiplegics and hemiparesis, respectively. DALYs was 26 and 13 years in hemiplegics and hemiparesis, respectively (Table 4).

Total DALYs. The total YLL for Traumatic SCI was 4077 years and total YLD was 1364 years and total DALY was 5441 years, which has 0.7 DALY per 1000 people. Total YLL/DALY was 74.9%. Total DALY was 3631 years (0.9 DALYs lost per 1000 population) for men and 1811 years (almost 0.5 DALYs lost per 1000 population) for women in Tehran in 2008.

Discussion

In the first year following SCI, the YLL and YLD were 3368 and 404 years, respectively. Therefore, the first year DALY was 3772 years, which has 0.5 DALY per 1000 people. First year YLL/DALY was 89.3%. Following the first year, the YLL and YLD were assessed for different clinical presentations of traumatic SCI including quadriplegia, quadriparesis, paraplegia, paraparesis, hemiplegia and hemiparesis. The total

YLL for traumatic SCI was 4077 years and total YLD was 1364 years (total YLL/DALY was 74.9%) and total DALY was 5441 years, which has 0.7 DALY per 1000 people in Tehran in 2008.

The DALY has been widely adopted internationally. It has been used in the burden of disease studies and in attempts to estimate the global burden of disease.[1] Injuries caused 28% of the total DALYs in Iran, and accounted for 60.4 DALYs lost per 1000 of the population in Iran.[3]

Fifty-three percent of the total numbers of DALYs in Iran were in male patients, and 47% of DALYs were in female patients.[3] As expected, this study showed almost twice higher burden of SCI in male patients.

The age distribution of SCI patients, 15–44 years, experienced a DALY of 3745, which is more than 2/3 of the total SCI DALY in Tehran.

Limitations

Owing to the importance of the disease estimation as the basis of health planning, a study of burden of disease using local data is by far the best; however, using data from other regions for calculation of burden of disease is acceptable. Supplementing observed data with expert knowledge may help to overcome a lack of data.[1] This strategy was employed in this study as we used some reported data on SCI from other countries.

Comorbidities were not assessed in the burden of SCI. Spine fracture is a common injury associated with SCI, which causes short-term disability with a weight of 0.266.[1] Multiple injuries of other organs can also be associated with SCI.

Data for population of Tehran was available at 2006, but the data for prevalence was from 2008. This difference between Tehran population and SCI prevalence is a limitation of the study.

DALY calculation was divided into two parts; first year DALY, and the next year's DALYs for six different types of SCI. A separate analysis was done for two reasons. First, there were no details on the cause of death at the scene of the accident or prehospital for six different types of SCI. Second, there are small chances of SCI cure in the first 6–12 months.[4]

Implications for prevention

This study showed a high burden of 0.7 per 1000 population for SCI in Tehran in 2008. These results can be applicable for the urban population of 48 682 474 in Iran, which represents a multicultural collection of people from all over the country. Iran is in the eastern Mediterranean region, classified as subregion B group according to the WHO. This region has an average gross domestic product (GDP) per capita of $10 208.[21] According to WHO recommendations, when the costs of an intervention is one to three times the GDP per capita to avert 1 DALY of a disease, the intervention is called cost-effective. If an intervention is less than 1 GDP per capita with the same result it is very cost-effective and if the cost of intervention is more than three times the GDP, the intervention is not cost-effective. Thus, any intervention of less than $30 624/1 DALY saving will be acceptable. Identifying the risk factors of SCI, preparation of resources and performing cost-effective preventive interventions for reducing the burden of SCI is recommended.

Conflict of interest

The authors declare no conflict of interest.

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