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Clinical Investigations

Burden of Hip Fracture in Iran

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Abstract. To measure the burden caused by hip fracture in Iran and to compare it with other parts of the world, we applied the Global Burden of Disease (GBD) method created by the World Health Organization. The GBD method uses disability-adjusted life years (DALY), which is comprised of years of life lost (YLL) and years of life lived with disability (YLD). To calculate YLD, incidence of hip fracture was obtained from the Iranian Multicenter Study on Accidental Injuries, a large-scale nationwide prospective study. Disability weights were applied to the remaining duration of disease. To calculate YLL, remaining years of potential life at any age at death were calculated using the standard life table. A discount rate of 3% and age weighting were applied. Hip fracture generated 16,708 DALYs, comprising 8,812 (52.7%) YLL and 7,896 (47.3%) YLD. Iran accounted for 0.85% of the global burden of hip fracture and 12.4% of the burden of hip fracture in the Middle East. The female to male ratio in Iran (1.1) was lower than the global (2.2) and the Middle Eastern (1.4) ratios and higher than the ratios in China and India (1.0 and 0.9, respectively). In conclusion, hip fracture is not as much a cause of disease burden in Iran as in the developed regions of the world. We recommend utilization of the standardized GBD method to calculate burden of osteoporosis in different countries and to set local priorities according to these measures.

Key words: Burden of disease — Disability-adjusted life year — Hip fracture — Iran – Osteoporosis

Hip fracture is the most serious clinical outcome of osteoporosis, incurring high morbidity, mortality, and health-care expenditure [1, 2]. As improvements in life expectancy yields growing numbers of fracture-prone elderly individuals, the health and economic burden of hip fracture will rise in the future [3–5]. The number of elderly individuals is increasing more rapidly in the developing countries of Asia, the Middle East, Africa, and South America; and it has been estimated that about 70% of the 6.26 million cases of hip fracture in the year 2050 will occur in these populations [3]. Hip fractures are shown to be responsible for substantial costs related to hospitalizations, surgery, outpatient care, long-term care, disability, and premature death [6–8].

Disability-adjusted life years (DALYs), as a more general approach to quantifying the burden of diseases, has been used in the Global Burden of Disease (GBD) study launched by the World Health Organization (WHO) in the 1990s [9]. DALY is a composite measure of potential years of life lost due to premature death and equivalent years of healthy life lost due to disability. DALY offers a standardized, nonmonetary measure of morbidity and mortality that is comparable across various conditions and geographic regions and serves as a useful tool for resource allocation and burden of disease assessments [10, 11]. Few studies have used DALYs to assess the burden of hip fractures worldwide [12]. As the impact of premature mortality and disability due to a given condition may vary in different parts of the world, rational policies require solid data about burden of disease within a territory to allocate the proper resources. To date, the burden of hip fractures in Iran has not been established. In the present study, we have estimated the burden caused by hip fractures in Iran in the year 2005 and compared it against the burden of hip fractures worldwide and in the Middle Eastern crescent.

Materials and Methods

A detailed description of the GBD method and underlying assumptions has been published elsewhere [9]. Briefly, to calculate DALYs for a given condition, the years of life lost due to premature mortality (YLL) are added to the number of years lost due to disability (YLD) from incident cases of the disease: DALY = YLL + YLD.

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YLL

YLL due to hip fracture were computed from the number of hip fractures and premature deaths. The number of deaths after hip fracture for each age and sex was calculated using the method shown in the Appendix. 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 [13]. Counts of death were aggregated into 5-year groups of age for each gender, and years of potential life lost were calculated based on the midpoint of the age range. According to the WHO report, life expectancy in Iran is now estimated at 72 years for women and 70 years for men [14]. We also calculated the hip fracture YLL and DALY considering these life expectancies.

The excess mortality after hip fracture may be partly due to comorbidity. It has been suggested that approximately 25% of deaths associated with hip fracture are causally related to the hip fracture event [15]. We used this assumption in the base case calculation to take the effect of comorbidities into account. The impact of attributing 50% or all of deaths to the hip fracture event and the effect of attributing all hip fracture-associated deaths to comorbidity were also examined in the sensitivity analysis.

YLD

YLD were calculated from the number of incident cases in a year times the duration of disability times the disability weight. Data on the incidence of hip fracture in Iran were obtained from the Iranian Multicenter Study on Accidental Injuries (IMSAI), a large-scale population-based study conducted in 65 cities in nine provinces from the central, western, and eastern parts of the country [16]. All the hospitals, which provide services to about 9.5 million people in the study area, were prospectively surveyed for any incident injury resulting from accidental events. All patients aged 50 years or older with radiographically confirmed proximal femur fractures were included as hip fractures. Interviewers searched emergency, surgery, and orthopedic wards of all the hospitals in the study area for any new patient admitted with an accident-related etiology. A quality-control committee systematically evaluated the performance of the interviewers in different areas [16].

The duration of disability following hip fracture was the average number of years that new cases can be expected to spend with disability resulting from hip fracture. The duration was estimated from epidemiological modeling, using the DISMOD software (see http://www3.who.int/whosis/burden/burden_dismod/dismod2_setup.zip), from estimates of hip fracture incidence, mortality, and remission rates [17]. The DISMOD software is used to model internally consistent estimates for epidemiological data used in the GBD studies [17].

The disability weights used in DALY calculations quantify societal preferences for different health states. Panels of health experts derived weights for the GBD study using person trade-off methods [9, 18]. Severity of conditions is thus weighted from 0, equal to perfect health, to 1, equal to death. In the GBD study, average disability weight for hip fracture over time has been estimated at 0.272 for each year of disability [9], which we used in the base case calculation. In the sensitivity analysis, we also calculated the impact of applying the disability weights proposed by the National Osteoporosis Foundation (NOF), which assigns disability weights of 0.468 to the first year following hip fracture and 0.170 to the subsequent year [19]. For the third and subsequent years, disability weight was discounted by 10% per year [2].

For reasons of comparability, the same age weighting and discounting adjustments used in the GBD study were applied [9]. The 3% discount rate accounts for the perception that a current year is worth more than a future year and future years need to be expressed in present value terms. An age weighting modulation quantifies the perception that a year of young adult life has greater social value than a year in the life of children or the elderly. Weights for age were removed in the sensitivity analysis.

YLL and YLD were aggregated into 10-year groups of age, and the measures for each age and gender stratum were added to produce DALY. DALYs per 1,000 of the population above 50 years were also given. Templates designed for calculation of DALY for the GBD study were used for analyses (see http://www3.who.int/whosis/menu.cfm?path=whosis,burden,burden_manual,burden_manual_other&language=english).

Results

Table 1 shows the hip fracture epidemiological data for Iran. The total Iranian population over 50 years of age numbered 8.845 million persons (4.361 million men and 4.484 million women). The total number of estimated incident cases of hip fracture was 4,968 for men and 5,151 for women. The overall incidence of hip fracture was 115.2 per 100,000 in men and 115.6 per 100,000 in women. The overall mortality rate was 89.5 per 100,000 of the population over 50 years (88/100,000 in men and 91/100,000 in women). The average duration of disability was 4 years and varied from approximately 1 to 13 years in different age groups. Compared to women, the incidence rate, prevalence, and hip fracture-related deaths were higher in men under 65 years of age and lower thereafter (Table 1). In terms of prevalence (Table 1), there were 36,725 men and women suffering from hip fracture in Iran (18,783 men and 17,943 women, female to male ratio 1.0). Hip fracture sufferers were estimated at 4.48 million worldwide (female to male ratio 2.7) [12], of which 0.82% is accounted for by Iran.

In the base case calculation (Table 2), hip fracture generated 16,708 DALYs in the Iranian elderly population (8,406 in men and 8,302 in women). YLD and YLL contributed almost equally to DALY (YLL 52.7%). The contribution of YLL was more evident in women (49.2% for men vs. 56.3% for women). Hip fracture yielded an overall 1.9 DALY per 1,000 of the population above 50 years of age. DALY per 1,000 of the population for each age and sex stratum increased with advancing age (Table 2). The contribution of disability to the total burden decreased from 81% in men and women aged 50–59 to 18% in those above 80 years. YLL, YLD, and DALY values were higher in men under 60 years of age and lower thereafter (Table 2).

Considering the Iranian life expectancies (72 years for women and 70 years for men), hip fracture would generate 12,369 DALYs (2,098 YLLs and 6,362 DALYs in men, 2,376 YLLs and 6,007 DALYs in women) and an overall 1.4 DALY per 1,000 of the population above 50 years of age. In this situation, YLL accounted for 36% of the total DALY (33% for men and 40% for women).

In sensitivity analysis, when age weighting was removed (Table 3), DALY increased from 16,700 to 26,600. YLL contributed to the major part of this increase. Changing assumptions concerning the excess

Table 1. Epidemiological data used for calculations

Age group (years)	Population number[a] (in thousands)		Incidence[b] (rate per 100,000)		Number of hip fractures[c]		Duration of disability[d] (years)		Estimated number of deaths[e]		Overall mortality rate[f]		Prevalence[d]	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
50–54	1,169	1,200	45.6	34.9	533	419	13.3	13.7	60	27	5.1	2.3	1,306	1,034
55–59	901	929	56.2	26.3	506	244	10	9.7	133	76	14.8	8.2	2,982	2,058
60–64	653	672	67.2	69.7	439	468	7.4	6.7	196	158	30	23.5	3,368	2,549
65–69	553	559	60.1	84.1	332	470	5.1	4.4	286	300	51.7	53.7	3,274	2,949
70–74	496	494	109.2	204.1	542	1,008	3	2.7	442	621	89.1	125.7	3,020	3,579
75–79	329	340	290.4	259.2	955	881	1.5	1.8	858	1,029	260.8	302.6	2,507	2,671
80–84	62	69	558.5	572.4	346	395	1	1.3	871	919	1,404.8	1,331.9	620	688
85+	198	221	558.5	572.4	1,106	1,265	0.9	1.2	991	948	500.5	429	1,705	2,415
Total	4,361	4,484	115.2	115.6	4,760	5,151	4	4.1	3836	4077	88	90.9	18,783	17,943

[a] Source of data is the Iranian statistical year book
[b] See Moayyeri et al. [16]
[c] Number of hip fractures = population number * incidence rate
[d] DISMOD output. See Materials and Methods
[e] See Appendix
[f] Mortality rate (rate per 100,000 of the population over 50 years) = number of deaths/population number at risk

Table 2. YLL, YLD, DALY, and DALY/1,000 in the base case (assuming 25% of deaths as causally related to hip fracture, applying the WHO disability weights with age weighting)

Age group (years)	Men				Women				Total				
	YLD	YLL	DALY	DALY/ 1,000	YLD	YLL	DALY	DALY/ 1,000	YLD	YLL	DALY	DALY/ 1,000	YLD/ DALY
50–59	2,658	657	3,315	1.6	1,727	365	2,091	1.0	4,385	1,022	5,407	1.3	0.81
60–69	901	1,049	1,949	1.6	976	1,070	2,046	1.7	1,877	2,118	3,995	1.6	0.47
70–79	513	1,489	2,002	2.4	678	2,167	2,845	3.4	1,191	3,656	4,847	2.9	0.25
80+	193	947	1,140	4.4	251	1,069	1,320	4.6	444	2,016	2,459	4.5	0.18
Total	4,265	4,141	8,406	1.9	3,631	4,671	8,302	1.9	7,896	8,812	16,708	1.9	0.47

Table 3. YLL, YLD, DALY, and DALY/1,000 population over 50 years with changes in assumptions on age weighting and excess mortality

Age weighting	Exess mortality (%)	Men				Women				Total				
		YLD	YLL	DALY	DALY/ 1,000	YLD	YLL	DALY	DALY/ 1,000	YLD	YLL	DALY	DALY/ 1,000	YLL/ DALY (%)
+	25	4,265	4,141	8,406	1.9	3,631	4,671	8,302	1.9	7,896	8,812	16,708	1.9	52.7
–	25	5,492	7,397	12,889	3.0	4,935	8,794	13,730	3.1	10,427	16,191	26,618	3.0	60.8
+	50	4,265	8,282	12,547	2.9	3,631	9,342	12,973	2.9	7,896	17,624	25,520	2.9	69.1
–	50	5,492	14,794	20,286	4.7	4,935	17,588	22,524	5.0	10,427	32,382	42,810	4.8	75.6
+	100	4,265	16,565	20,829	4.8	3,631	18,684	22,315	5.0	7,896	35,248	43,144	4.9	81.7
–	100	5,492	29,588	35,080	8.0	4,935	35,177	40,112	8.9	10,427	64,765	75,192	8.5	86.1
+	0	4,265	0	4,265	1.0	3,631	0	3,631	0.8	7,896	0	7,896	0.9	0.0
–	0	5,492	0	5,492	1.3	4,935	0	4,935	1.1	10,427	0	10,427	1.2	0.0

mortality causally related to hip fracture had a large impact on DALYs. When the excess mortality was assumed to be 50% rather than 25%, total DALYs increased from 16,700 to 25,500 with age weighting and from 26,600 to 42,800 without age weighting (Table 3). When the disability weights suggested by the NOF were used in place of the WHO's, YLD decreased from 10,400 to 8,600. Likewise, the contribution of YLD to DALY decreased from 39.1% to 34.6% (Table 4).

To compare the burden of hip fracture in Iran with other regions, we applied the same assumptions used in the study by Johnell and Kanis [12], who assessed the worldwide burden of hip fracture for the year 1990. Iran accounted for 0.85% of the burden of hip fracture

Table 4. YLL, YLD, DALY, and DALY/1,000 with changes on assigned disability weights (not weighted for age)

Age group (years)	WHO[a]			NOF [b]		
	YLD	DALY	DALY/1,000	YLD	DALY	DALY/1,000
50–59	4,971	6,316	1.5	2,737	4,082	1.0
60–69	2,517	5,822	2.4	2,020	5,325	2.2
70–79	1,980	8,858	5.3	2,293	9,171	5.5
80+	958	5,623	10.2	1,532	6,197	11.3
Total	10,427	26,618	3.0	8,583	24,774	2.8

[a] Assigns 0.272 disability weight for each year following fracture.
[b] Assigns 0.468 disability weight to the first year following fracture, 0.170 to the second year, and 10% discount per year for subsequent years.

Table 5. DALY and DALY/1,000 of the population above 50 years lost due to hip fracture in different regions of the world and Iran (not weighted for age)

	Total DALY (in thousands)		DALY/1,000 of the population above 50 years		
	Men	Women	Men	Women	F/M
Iran (present study)	11.7	13.1	2.8	2.9	1.1
Middle Eastern crescent[a]	83	116	3.0	3.9	1.4
Established market economies[a]	334	1,076	3.3	8.4	3.2
Formerly socialist economies[a]	93	339	2.4	5.9	3.6
Latin America and Caribbean[a]	52	98	1.9	3.2	1.9
China[a]	188	179	2.0	1.9	1.0
India[a]	114	101	1.9	1.8	0.9
Other Asia and islands[a]	51	77	1.2	1.7	1.4
Sub-Saharan Africa[a]	9	11	0.4	0.4	1.2
World[a]	924	1998	2.2	4.3	2.2

[a] According to Johnell and Kanis [12]

worldwide and 12.4% of the burden of hip fracture in the Middle East (Table 5). The female to male ratio in Iran (1.1) was lower than the global (2.2) and the Middle Eastern (1.4) ratios and higher than the ratios in China and India (1.0 and 0.9, respectively). The DALY per 1,000 (in the population above 50 years) for Iranian men (2.8) was lower than the estimate for the world's men (2.2). This measure for Iranian women (2.9) was also lower than that of their counterparts worldwide (4.3) (Table 5).

Discussion

To the best of our knowledge, this study represents the first in Iran and the second in the world to estimate the burden of hip fracture using the GBD method. The present study shows a detailed methodological description and challenges of the hip fracture DALY analysis and comparisons. The distinguishing feature of studies undertaken in this manner is that they permit comparisons across diseases and regions [9]. Unlike other types of cost-effectiveness analyses, in which monetary costs are the basis for calculation of disease burden, the GBD method considers other parameters imposing burden on the health system of a community. Some of these factors are the population structure of the community, incidence of the disease, excess mortality related to the disease, remission rate, and duration of the disease.

Iran generated 0.85% of the worldwide burden of hip fractures according to our results. Hip fracture in Iran accounted for 0.82% of the worldwide prevalence, which shows consistency of our results. Female to male ratios for DALY and prevalence of hip fracture in Iran (1.1 and 1.0, respectively) were considerably lower than those worldwide (2.2 and 2.7, respectively) [12]. However, these figures were also consistent with each other.

To date, the burden of all-cause diseases in terms of DALY has not been established in Iran. However, according to the data available so far, hip fracture accounts for about 0.7% of the burden imposed by different diseases in Iran (F. Abolhassani, personal communication). This is particularly less than the 1.4% of burden of disease accounted for by hip fracture in countries with established market economies (EMEs) in 1990 [12]. As this fraction for EMEs is projected to be higher now, the difference between proportional burden of hip fracture in Iran and such countries is likely to be

more. This may be due to the higher life expectancy and the greater number of fracture-prone elderly individuals in the EME countries. Moreover, due to higher burden of conditions such as traffic accidents, psychiatric problems, infectious diseases, and iron-deficiency anemia in Iran (F. Abolhassani, personal communication), the proportional contribution of hip fracture to the burden of diseases in Iran deflates. As studies estimating the burden of hip fracture in terms of DALY have not been conducted previously in Iran, we cannot display the trend in our country.

Estimates of Iran's contribution to the global burden of hip fracture (0.85%) should be regarded cautiously. The only estimate of the global burden of hip fracture available before this study was for the year 1990 [12]. This estimate is projected to be higher now (O. Johnell, personal communication). Therefore, Iran's contribution to the global burden of hip fracture may be overestimated. In addition, another challenge to the GBD method is that it uses the standard expected years of life lost approach in determining life expectancy so that premature death has the same weight in different countries. However, actual life expectancy varies in different countries. The standard is chosen to be the current maximum global life expectancy (82.5 years) to avoid negative values. Therefore, YLL are overestimated in countries where actual life expectancy is less than the maximum [20]. The lower the life expectancy in a community, the greater the overestimation in YLL measures. Using Iranian life expectancies (72 years for women and 70 years for men), we observed that YLL decreased from 8,812 to 4,474 and the contribution of YLL to DALY decreased from 52.7% to 36%. It should be noted that Iranian life expectancies have shown a significant rise in the last two decades and are likely to continue on this trend [14]. This indicates that Iranian health policy makers should consider recalculation of the burden of geriatric diseases (like osteoporotic hip fracture) in short intervals to account for such population structural changes.

The choice of epidemiological data used in burden of disease calculations is crucial. The greatest confidence in this study can be placed on hip fracture incidence, which stands on sound methodology from a large population-based study [16]. Compared to other studies, Iranian age-standardized incidence rates were considerably lower than those of all Western countries. When compared with the rates from other Asian countries, Iranian females had the lowest rates after China [16]. Iran's lower incidence rates and female to male ratios may be in part due to the differences in genetic and lifestyle factors and need further evaluations. A major concern is the possibility of underregistration of hip fractures as an explanation for the observation of lower incidence rates in Iran. However, considering the acceptable methods and the elaborate quality control used in the IMSAI [16], underascertainment of hip fractures and differential ascertainment between men and women seem to be less likely.

The younger structure of the Iranian population and lower life expectancy may explain the relatively low hip fracture incidence rates in Iran. In addition, the risk of hip fractures has been described to increase with distance from the equator [21]. It has been shown that for each 10 degrees change in latitude from the equator, fracture probability increases by 0.3% in men, by 0.8% in women, and by 0.6% in men and women combined [21]. Iran is located closer to the equator than several of the other countries used for comparison, and this may at least in part explain the low incidence of hip fractures. Iranian shorter heights and shorter hip axis lengths may also contribute to the lower incidence rates [16]. Other lifestyle factors, such as higher rates of physical activity (long-distance walking, stair climbing, carrying heavy shopping) and lower rates of smoking or consumption of alcoholic beverages, may also play a role, which is discussed in detail elsewhere [16]. However, Table 5 shows an inverse relationship between the socioeconomic status of a region and the hip fracture DALY rates. Apart from the factors mentioned above, the observed difference in the DALY rates could be due to differences in the quality of the epidemiological data among these regions and more complete ascertainment of hip fracture incidence in more economically developed regions, which should be considered cautiously when comparing the rates from different regions.

In the present study, to allow for comparability with DALYs produced by other diseases and conditions, in the base case we used the disability weights derived by the WHO for the GBD study, which assigns an average disability weight of 0.272 for each year of disability. Disability and mortality contributed almost equally to the burden of hip fracture in this situation. Applying the set of disability weights suggested by the NOF [2, 19], however, might underestimate disability in Iran since they are derived from the EME, in which the quality of health care differs considerably with that of our country. Moreover, the high discount rate of 10% per annum may not be generalizable to our setting. Therefore, we believe that the WHO disability weights are more applicable to our setting. Using the NOF set of disability weights in place of the WHO's, the contribution of YLD to DALY decreased from 39.1% to 34.6% (Table 4). Our finding was in accordance with the conclusion of the GBD study that the importance of the variability of the disability weights is minor [22], especially compared to the impact of changing assumptions concerning excess mortality (Table 3) and life expectancy on DALY. It should be noted that, although disability weights derived by the WHO can be used where data are scarce and an estimate of disease morbidity is urgently needed, calculation of disability

weights for hip fracture and other osteoporotic fractures for different socioeconomic states might be the topic of excessive research and expert panel conferences from different disciplines.

DALY metric developers argue that it provides a common tool for evaluating and priority setting across a wide range of health problems and allows for the transformation of epidemiological data into informed decisions about resource allocation for health care [9–11]. However, this standard method has been scarcely used for evaluating burden of hip fracture and other osteoporotic fractures. It seems that this problem is mainly related to the lack of information (or inconsistent information) and the extreme need for disease modeling for such outcomes. Our study demonstrates that there are several knowledge gaps regarding the morbidity and mortality attributed to hip fractures. Conducting studies with the same methodology helps in the identification of such knowledge gaps. In the present study, we used epidemiological modeling to attain these parameters for our population. Although calculation of these parameters is possible via epidemiological modeling, the value of direct research in this regard should not be undermined. Data gaps need to be filled with improvements in the quality of medical registries and conduction of studies with certain methodological standards. In conclusion, although hip fracture is not as much a cause of disease burden in Iran as in the developed regions of the world, the burden of hip fracture in Iran is likely to rise due to changes in the population structure, increasing life expectancy, and changes in lifestyle, resembling Western communities. The method of DALY calculation can be considered as a standard for estimation of burden of osteoporosis outcomes and a tool for comparison with other diseases.

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Appendix

To calculate the number of deaths associated with hip fracture, the following template was applied. As an example, for females at the age of 52, estimated number of deaths among current 52-year-old women experiencing hip fracture this year was summed with the number of deaths of those experiencing hip fracture last year at the age of 51 dying 1 year after fracture and those experiencing hip fracture 2 years ago at the age of 50 dying 2 years after fracture. The appropriate age- and sex-specific mortality rates for each year following fracture were applied to the number of incident hip fractures in Iran for that age and sex after subtracting

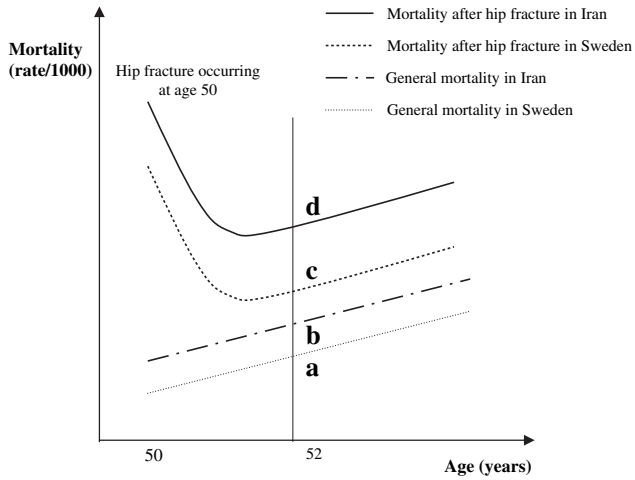

Fig. 1. Mortality rates (per 1,000) for years after hip fracture and of the general population of Iran and Sweden.

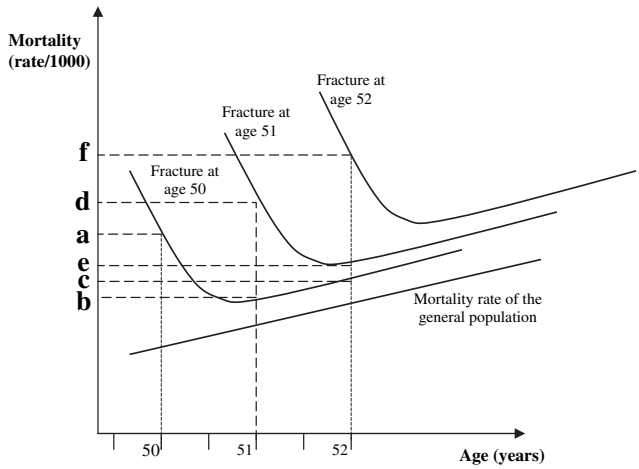

Fig. 2. Mortality rates (per 1,000) for the years following a hip fracture occurring at ages 50, 51, and 52 years and the general population.

The following template was used to calculate the number of deaths for all ages and continued until the maximum expected life expectancy.

Number of hip fractures at age (N) = population at age i * incidence of hip fracture at age

Number of deaths at age (years)	Number of deaths from fracture occurring: Current year[a]	1 year ago	2 years ago
50	$= N_{50} * a/2$		
51	$= N_{51} * d/2 + N_{50} * b$		
52	$= N_{52} * f/2 + N_{51} * e + [N_{50} - (N_{50} * b)] * c$		

[a] Mortality rate at 6 months after fracture was used to calculate the number of deaths following a current-year fracture (according to Kanis et al. [15]). The rate was divided by 2 to account for the half-year period

the estimated number of deaths of the previous years. The proportional excess death after hip fracture (compared to the general population of Sweden) was applied to the mortality rate of the Iranian general population to attain an estimate of the Iranian mortality rate after hip fracture for each age and sex [12, 15]. It was assumed that the proportional excess mortality in Iran was similar to that of Sweden (for each age and sex it was assumed that hip fracture mortality/mortality of the general population for Iran = hip fracture mortality/mortality of the general population for Sweden). For instance, the mortality rate for Iranian patients at the age of 52, two years after a hip fracture was calculated as $d = (c/a) * b$, as depicted in Figure 1.

To calculate the number of deaths after hip fracture, the age and sex specific mortality rate for each year following fracture was applied to the estimated number of incident hip fractures for that age and sex after subtracting the estimated number of deaths of the previous year (Fig. 2).

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