



The economic burden of osteoporosis in Iran in 2020

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Abstract

Summary Osteoporosis, the most common metabolic bone disease, leads to increased susceptibility to fractures. In 2020, about 150,000 osteoporotic fractures occurred in Iran. Osteoporosis and related fractures cost the community US\$ 393 million.

Introduction

The present study aimed at estimating the economic burden of osteoporosis in Iran in 2020.

Methods We estimated the annual economic burden of osteoporosis in the above 50 years old population using a prevalence-based approach and from a societal perspective. The incidence of osteoporosis and related fractures were estimated based on meta-analysis reports in Iran and international comparisons. The direct medical and non-medical costs as well as the monetary value of quality-adjusted life-years (QALYs) lost because of fractures were estimated. Cost data were extracted from patient records, medical services prices, and previous literature.

Results A total of 154,530 osteoporotic fractures were estimated in Iran in 2020. The shares of the hip, vertebral, forearm, and other fractures were 14%, 15%, 17%, and 54%, respectively. There were also 3554 deaths from osteoporotic fractures. The economic burden of osteoporosis in Iran was estimated at US\$ 393.24 million (US\$ 2165 million purchasing power parity 2020). Direct medical and non-medical cost (47.44%), QALY loss (29.65%), and long-term care for prior hip fracture costs (9.4%) were the main component of the economic burden of osteoporosis.

Conclusion The economic burdens of osteoporosis are significant in Iran. Interventions to prevent osteoporosis and especially associated fractures, such as screening and prophylaxis, can reduce the cost of the disease and improve patients' quality of life. Further studies are needed to identify cost-effective and feasible interventions in Iran.

Keywords Cost · Economic burden · Osteoporosis · Osteoporotic fractures

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Introduction

Osteoporosis is the most common metabolic bone disease, characterized by systemic abnormalities in bone mass and microstructures, leading to increased susceptibility to fractures [1–3]. According to the World Health Organization definition, “osteoporosis is defined as a value for bone mineral density (BMD) 2.5 standard deviations (SD) or more below the young female adult mean (T-score less than or equal to -2.5 SD)” [4]. Osteoporosis, a major health problem, is associated with age-related fractures, especially in the hip, vertebrae, distal forearm, and humerus [5]. Fragility fractures are serious threats to patient's health, quality of life, and health care sustainability [6].

In recent decades, the prevalence of osteoporosis increased dramatically worldwide [1, 7], and it became a global epidemic as a socio-economic threat associated with population aging [2]. According to the International Osteoporosis Foundation report,

one-third of females and one-fifth of males aged above 50 experience osteoporotic fractures during their lives [8]. Based on the results of a systematic review and meta-analysis, the prevalence of osteoporosis in the above 50 years old population of Iran was estimated at 12% in males and 19% in females [9].

Osteoporotic fractures are associated with increased morbidity and mortality [5, 6, 10–12]. These fractures also cause heavy financial burdens for health care [1, 6, 12, 13]. The economic burden of osteoporotic fractures was estimated at € 37 billion in 2010, according to a study in 27 EU countries; and a 25% increase is projected by 2025 [4]. According to a study by Marcellusi et al., in Italy, osteoporosis imposes an annual economic burden of € 2.2 billion on average [14].

Since population aging is one of the most important factors affecting the osteoporosis incidence [1, 2] and Iran is moving toward population aging [15], being aware of the disease costs and economic dimensions of the disease is of great importance for policy-making and planning for its prevention and management; however, no comprehensive study was performed thus far on the economic aspects of osteoporosis in Iran. Therefore, the present study aimed at estimating the economic burden of osteoporosis in Iran in 2020.

Methods

Study design

The present cross-sectional study estimated the economic burden of osteoporosis and its related fractures in Iran in 2020 from the perspective of society. Given that the risk of osteoporosis and its associated fractures is very low in individuals aged below 50 years and the related data are limited, only the individuals aged above 50 years were enrolled in the study. The costs of osteoporosis management and resulting fractures were estimated by the fracture type, including the hip, vertebrae, forearm, and other parts (including fractures of the femur, pelvis, humerus, rib, clavicle, scapula, and sternum), in the first year of the fracture. Since the economic consequences of fractures and their impact on patients' quality of life (QoL) last more than a year, to estimate the economic burden of osteoporosis in the same duration, the fractures resulting from osteoporosis in previous years in a living individual should also be considered. Since such outcomes are greater in hip and vertebral fractures, the costs were calculated only for these two sites.

Estimation of the incidence and prevalence of osteoporosis, osteoporotic fractures, and associated deaths

In the present study, fractures associated with osteoporosis were categorized into four groups of the hip, vertebrae,

forearm, and other parts (including fractures of the femur, pelvis, humerus, rib, clavicle, scapula, and sternum). Equation 1 was used to estimate the number of osteoporotic fractures in Iran.

$$TFI = \sum_{f=1}^4 \sum_{g=1}^2 \sum_{i=50}^{100} R_{fgi} N_{gi} \quad (1)$$

where TFI is the total number of osteoporotic fractures, f is the type of fracture (including the hip, vertebrae, and forearm), g is the gender, i is the age, R is the incidence of fractures in the population, and N is the population above 50 years in Iran.

The age- and gender-specific incidences of hip fractures were estimated through a systematic review and meta-analysis in Iran [16]. Due to the lack of a study on the incidence of the forearm, vertebral, and other fractures in Iran, the approach used in the study by Hernlund et al. was utilized [4]. For this purpose, the incidences of the vertebral, forearm, and other fractures in Iran were estimated using the incidence of hip fractures to other fractures ratio in Sweden [17]. Data on the Iranian population by age and gender in 2020 were extracted from the Statistical Center of Iran website [18]. Data on the ratio of incidence of hip fractures to other fractures and other input parameters that we used to estimate the number of fractures and the economic burden of osteoporosis in Iran are shown in Supplementary Table S1.

Osteoporotic fractures increase the risk of mortality, but the size of this increase varies across fractures and the time elapsed since its occurrence [19, 20]. In the present study, the number of deaths from osteoporotic fractures in the first year of incidence was estimated using Eq. 2.

$$TFM = \sum_{f=1}^4 \sum_{g=1}^2 \sum_{i=50}^{100} R_{fgi} N_{gi} pM_{gi} rrM_{fgi} * A_f \quad (2)$$

where TFM represents the total number of deaths from osteoporotic fractures, f is the type of fracture, g is the gender, i is the age, R is the incidence of fractures in the population, N is the total population, pM is the incidence of death in the general population, rrM is the risk of death from osteoporotic fractures in the first year of incidence, and A is the percent of mortality which are directly associated with osteoporotic fractures.

The osteoporosis-associated risk of death (rrM) in the first year of hip and vertebral fractures by type of fracture was extracted from previous studies [21] and accordingly, it was assumed that the risk of death does not increase after forearm fractures. In addition, the risk of death from other osteoporotic fractures was considered the same for all age groups as 1.22 [4]. Also, since a significant share of all deaths associated with osteoporotic fractures is attributed to other diseases [4], in the present research, like previous studies, it was assumed that 30% of deaths occurring after

hip and vertebral fractures and 12% of deaths after other osteoporotic fractures are directly associated with these fractures [4, 22, 23].

A Markov model was used to estimate the number of previous hip and vertebral fractures. Details of the Markov model are reported in previous studies [24, 25]. The structure of the model is shown in Supplementary Fig. S1. The model has four health states: healthy, hip fracture, vertebral fracture, and dead. The time horizon of the model was lifetime, and the length of each cycle was 1 year. With this model, we simulated the prevalence of prior hip and vertebral fractures using incidence data in the population over 50 years of age. The parameters of the Markov model included the incidence of age- and gender-specific fractures, age- and gender-specific deaths from other reasons, and risk of death from fractures. Age- and gender-specific deaths from other reasons were extracted from the Iran life table [26] and the risk of death associated with fractures from previous studies [4, 27]. We multiplied the sex- and age-specific prevalence of prior hip and prior clinical vertebral fractures by the sex- and age-specific population of Iran to estimate the number of prior fractures present in 2020.

Calculation of the cost of prevention and management of osteoporosis

For this purpose, three components of the cost of prevention and medication, the cost of visiting a doctor, and the cost of measuring bone density were considered.

Medication costs of prevention and management of osteoporosis were extracted from the Iranian Annual Pharma Statistics 2020. For this purpose, the drugs prescribed for osteoporosis management were identified, and their sales prices were extracted from the available statistics. Regarding medicines commonly prescribed for osteoporosis and other diseases, such as cancer, the share of osteoporosis in their sales amount was determined through consultation with experts. According to the osteoporosis guideline in Iran, to calculate the cost of physician visits, it was assumed that each patient is visited by a specialist once a year on average, and according to the distribution of ambulatory services in Iran, it was assumed that 70% of such patients refer to private offices. The average visit cost was determined according to the 2020 physician visit tariff for private and public sectors.

For calculating the cost of bone density testing with DXA scan, the number of bone density testing centers by public and private sectors was estimated according to the total number of DXA machines available in Iran, and the number of active centers by public and private sectors was multiplied by the cost of each service.

Calculation of direct (medical and non-medical) costs of osteoporotic fractures

For calculating the direct costs of osteoporotic fractures, the Borgström et al. approach was utilized in the present study [28]. For this purpose, according to Eq. 3, the total number of fractures by type was multiplied by the average cost for each patient.

Total annual acute fracture-related costs

$$= \sum_{f=1}^4 \sum_{g=1}^2 \sum_{i=50}^{100} C_{fgi}(FI_{fgi} - FM_{fgi}) + C_{fgi}FM_{fgi} \frac{X_{fgi}}{365.25} \quad (3)$$

where f indicates the fracture type (i.e., hip, vertebrae, and forearm, etc.), g is the gender, i is the age, C is the average cost per patient in the first year of fracture, FI is the number of fractures, FM is the number of death cases in the first year of fracture, and X is the average number of days from the time of fracture to death in subjects who died in the first year of a fracture.

The average direct medical and non-medical costs were estimated by fracture type per patient in the first year of fracture in a survey; the details are provided in another article [29]. In brief, hospitalization expenses were calculated by evaluating the medical files of 300 patients admitted for osteoporotic fractures in the pelvis, vertebrae, and forearm. In addition, through interviews with patients, using the patient cost questionnaire, ambulatory and direct non-medical expenses, such as informal care, travel, and time, were calculated in a year after fracture occurrence.

Since all patients with osteoporotic fractures do not need a hospital stay, hospitalization costs were calculated only for those admitted. The percentage of patients admitted for hip, vertebral, and forearm fractures was estimated at 100, 35, and 25, respectively [28, 30]. Like the study by Hernlund et al. [4], due to difficulty in finding a sufficient sample size consisting of patients with other fractures associated with osteoporosis, it was assumed that the ratio of the cost of these fractures to the cost of hip fractures is identical across countries, and the hip fracture cost to other fractures ratio in Sweden was utilized [17]. Like the study by Borgström et al., costs were adjusted for patients who died in the first year of the fracture, and it was assumed that the average time of death was 140 days after the fracture occurrence [28]; hence, 35.38% of ambulatory care expenses were considered for such cases.

Calculation of long-term care expenses for patients with hip fractures

Since patients with hip fractures become significantly disabled and require long-term care, long-term expenses were calculated only for hip fractures. For this purpose, the number of live patients with hip fractures in need of long-term care in 2020 was estimated, and the number was multiplied

by the average cost per patient. According to the results of a meta-analysis, 10–25% of patients with hip fracture require long-term care [31]; it was considered 10% in the present study. The average care cost per patient was also considered equal to the official minimum wage in 2020 (US\$ 2,639 a year).

Calculation of the number and US dollar value of QALYs lost due to osteoporotic fractures in Iran

In the present study, the QALY was used to measure intangible costs (reduced QoL). As a cost, the QALYs lost due to osteoporotic fractures were measured for the current and previous cases based on the approach used by Borgström et al. [28]. In brief, the number of QALYs lost due to osteoporosis fractures was calculated by the fracture type, and the result was multiplied by the monetary value of each QALY (Eq. 4).

Total annual value of QALYs lost due to fractures=

$$WTP \sum_{f=1}^4 \sum_{g=1}^2 \sum_{i=50}^{100} Q1_{fgi} (FI_{fgi} - FM_{fgi}) + \frac{X_{fgi}}{365.25} Q2_{fgi} FM_{fgi} + (1 - \frac{X_{fgi}}{365.25}) (FM_{gi} popQ_{gi}) + (Q2_{fgi} PF_{fgi}) \quad (4)$$

where *WPT* is willingness to pay, *Q1* and *Q2* are the reduced QoL due to fractures in the first and following years, respectively, *f* is the type of fracture, *g* is the gender, *i* is the age, *FI* is the number of fractures, *FM* is the number of deaths in the first year of fracture, *PF* is the number of previous fractures (in previous years), *X* is the average number of days from the time of fracture to death in those died in the first year of fracture, and *popQ* is the QoL of the general population.

The size of reduction in QoL due to osteoporotic fractures by the fracture type and time elapsed since fracture occurrence (*Q1* and *Q2*) were extracted from previous studies. In these studies, the impact of osteoporotic fractures on QoL was measured based on the EQ-5D questionnaire. It is a general preference-based instrument used to measure QoL in five dimensions, namely mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, and can be utilized to measure QALY [32].

Based on previous studies, the QoL in individuals with hip, vertebral, forearm, and other fractures corresponded to 0.7, 0.59, 0.96, and 0.85 of the age-specific QoL of healthy people, respectively, in the first year of fracture occurrence [33]. Hip and vertebral fractures also reduce the quality of life to 0.84 and 0.9 QoL of healthy people in the next years, respectively [33, 34]. Age- and gender-specific health-related quality of life for Iranian healthy people was extracted from the study by Emrani et al. [35]. The monetary value of each QALY was considered equal to per capita GDP, US\$ 2422.5 in 2020 [36].

Calculation of the economic burden of osteoporosis in Iran

Finally, after calculating the different types of expenditure, including the direct cost of fractures, the cost of long-term care of patients with hip fractures, the cost of reducing QoL, and the costs of prevention and management of osteoporosis, the economic burden of osteoporosis in Iran in 2020 was calculated by adding all costs. All expenditures were expressed as US dollars using the official market exchange rate (US\$ 1 = IR Rial 172,431) and purchasing power parity (PPP) exchange rate (US\$ 1 = IR Rial 31,317) for 2020 [37]. Microsoft Excel, STATA, and TreeAge software were used to analyze the data.

Sensitivity analysis

The incidence rate of hip fracture is one of the most important parameters in our study. Because a large proportion of the economic burden of osteoporosis is attributable to hip fractures, we also estimated the incidence of other fractures based on the incidence of hip fractures. Thus, a change in the incidence of hip fractures implies a change in the incidence of other fractures. We performed a deterministic sensitivity analysis embedding the lower and upper 95% confidence intervals of the incidence rate of hip fracture in Iran to assess the impact of uncertainty in this parameter on the study results.

Results

According to Iran's population in 2020, the number of osteoporosis cases was estimated to be 993,960 in males, 1,621,840 in females, and 2,615,800 in total. The number of incident and prior osteoporotic fracture cases by age and gender in Iran in 2020 is presented in Table 1. The total number of incident fractures was estimated at 154,530, of which 52.9% were males. The total number of the hip, vertebral, forearm, and other fractures was 21,136, 23,553, 26,183, and 83,658, respectively. The total number of prior hip and vertebral fractures was estimated at 337,635 in Iran in 2020, comprising 140,148 men and women with a prior hip fracture and 197,487 with a prior clinical vertebral fracture.

The results of the sensitivity analysis are presented in the supplementary file (Supplementary Tables S2 through S13). According to these results, the total number of osteoporotic fractures occurring was estimated to range from 114,652 to 209,734. The lower and upper limits of the hip, vertebral, forearm, and other fractures were estimated to

Table 1 Estimated number of incident and prior osteoporotic fractures stratified by age and fracture type in Iran, 2020

Gender	Age group (years)	Incident fractures					Prior fractures			Population at risk
		Hip	Vertebral	Forearm	Other	Total	Hip	Vertebral	Total	
Male	50–59	1985	3786	3329	18,482	27,582	7784	14,657	22,440	4,160,000
	60–69	1771	3310	2529	12,771	20,381	17,763	33,303	51,066	2,563,000
	70–79	2478	2908	897	8547	14,830	18,177	29,572	47,749	1,053,000
	80+	3821	2638	774	11,734	18,967	23,980	29,068	53,048	507,000
	Total	10,055	12,643	7529	51,534	81,761	67,704	106,599	174,303	8,283,000
Female	50–59	800	2025	5652	6362	14,839	3299	8310	11,608	4,117,000
	60–69	2297	3380	6728	8659	21,064	13,795	25,454	39,249	2,694,000
	70–79	3563	3458	4308	8727	20,056	23,062	30,321	53,384	1,210,000
	80+	4421	2047	1966	8375	16,809	32,288	26,802	59,090	515,000
	Total	11,081	10,910	18,654	32,124	72,769	72,444	90,887	163,331	8,536,000
Both	50–59	2785	5811	8980	24,844	42,420	11,083	22,966	34,049	8,277,000
	60–69	4068	6690	9257	21,430	41,445	31,557	58,758	90,315	5,257,000
	70–79	6041	6366	5206	17,275	34,888	41,240	59,893	101,133	2,263,000
	80+	8242	4685	2740	20,110	35,777	56,269	55,870	112,138	1,022,000
	Total	21,136	23,553	26,183	83,658	154,530	140,148	197,487	337,635	16,819,000

be 15,821 to 28,432; 17,451 to 32,007; 20,217 to 34,106; and 61,162 to 115,188, respectively (Supplementary Tables S2 and S8).

According to Table 2, there were 3554 deaths associated with osteoporotic fractures, with an incidence of 21.13 per 100,000 people above 50 years. The numbers of deaths associated with hip, vertebral, and other fractures were 1334, 1157, and 1064, respectively. Based on the results of the sensitivity analysis, the lower and upper bounds of deaths related to osteoporotic fractures were 2656 and 4790, respectively (see Supplementary Tables S3 and S9).

Table 3 shows direct costs by hospitalization and ambulatory care services, including non-medical direct costs. Direct costs of other fractures (59.8%) accounted for the largest share, followed by hip (25.79%), vertebral (9.14%), and forearm (5.26%) fractures. Also, hip, vertebral, and other fractures had the highest number of deaths in the first year of occurrence. The share of the hip, vertebral, forearm and other fractures in the total direct costs was 25.79%, 9.14%, 5.26%, and 59.80%, respectively (see Table 3).

Table 2 Estimated number and incidence (per 100,000 people) of deaths directly attributable to fractures within the first year in Iran, 2020

Gender	Age group (years)	Hip		Vertebral		Others		Total	
		N	Incidence rate	N	Incidence rate	N	Incidence rate	N	Incidence rate
Male	50–59	44	1.05	96	2.31	37	0.89	177	4.24
	60–69	66	2.58	129	5.03	72	2.79	267	10.40
	70–79	284	27.01	244	23.16	176	16.73	704	66.89
	80+	215	42.39	125	24.70	242	47.69	582	114.78
	Total	609	7.35	594	7.17	526	6.36	1729	20.88
Female	50–59	8	0.19	25	0.59	8.45	0.21	40	0.99
	60–69	65	2.43	107	3.98	41	1.51	214	7.93
	70–79	285	23.53	277	22.91	165	13.60	727	60.04
	80+	367	71.19	153	29.80	324	62.92	844	163.91
	Total	725	8.49	562	6.59	538	6.30	1825	21.38
Both	50–59	52	0.62	121	1.46	45	0.55	218	2.63
	60–69	131	2.50	236	4.49	112	2.14	480	9.13
	70–79	569	25.15	521	23.02	341	15.06	1431	63.23
	80+	582	56.90	279	27.27	566	55.37	1426	139.54
	Total	1334	7.93	1157	6.88	1064	6.33	3554	21.13

Table 3 Estimated direct cost (medical and non-medical) of incident osteoporotic fractures in Iran, 2020

Type of fracture	Number of incident fracture	Number of deaths in the first year after fracture	Mean costs per patient (US\$)		Total direct costs of the incident fractures (US\$)			
			Medical cost	Non-medical cost	Medical cost	Non-medical cost	Total	Percent
Hip	21,137	4445	2312	1727	25,141,445	22,962,618	48,104,063	25.79
Vertebral	23,553	3855	712.9	487.8	9,591,423	7,465,369	17,056,792	9.14
Forearm	26,183	109	316.8	226	5,551,506	4,266,548	9,818,054	5.26
Other fracture	83,658	3547	1271.5	949.8	55,625,136	55,931,720	111,556,856	59.80
Total	154,531	11,956			95,909,510	90,626,255	186,535,765	100

According to Table 4, with age increase, the number of people with previous hip fractures, the number of morbidities resulted from hip fractures, and, consequently, the long-term care costs increase so that the age group above 80 years had the highest share in expenses in both males and females. The total cost of long-term care for disabilities associated with hip fractures in 2020 was US\$ 17,865,254, US\$ 19,116,121, and US\$ 36,981,375 for males, females, and in total, respectively.

According to Table 5, the total number of QALYs lost due to osteoporosis in Iran in 2020 was estimated at 48,129, of which approximately 56% were males. Of the total QALYs lost, 42.52% were due to fractures associated with osteoporosis and 55.28% to previous hip and vertebral fractures, and 2.20% of premature deaths were due to osteoporotic fractures.

Based on the results of the sensitivity analysis, the lower and upper limits of QALYs lost due to osteoporosis in Iran in 2020 were 35,652 and 65,325, respectively (see Supplementary Tables S6 and S12).

Table 4 Estimated cost of long-term disability due to hip fractures in Iran, 2020

Gender	Age group (years)	Number of disabled patients	Cost of long-term disability (US\$)	Percent
Male	50–59	778	2,053,958	11.50
	60–69	1776	4,687,075	26.24
	70–79	1818	4,796,461	26.85
	80+	2398	6,327,760	35.42
	Total	6770	17,865,254	100
Female	50–59	330	870,426	4.55
	60–69	1379	3,640,031	19.04
	70–79	2306	6,085,582	31.83
	80+	3229	8,520,082	44.57
	Total	7244	19,116,121	100
Both	50–59	1108	2,924,384	7.91
	60–69	3156	8,327,105	22.52
	70–79	4124	10,882,043	29.43
	80+	5627	14,847,842	40.15
	Total	14,015	36,981,375	100

In total, osteoporosis had an economic burden of US\$ 393.24 million (US\$-PPP 2165 million) in Iran in 2020. Among these, direct medical and non-medical (47.44%), QALY loss (29.65%), and long-term care costs for people with previous hip fractures (9.40%) were the main determinants of the economic burden of osteoporotic fractures (see Table 6 and Fig. 1).

According to the results of the sensitivity analysis, the total economic burden of osteoporosis in Iran in 2020 was estimated to be between US\$ 305.11 million (US\$-PPP 1680 million) and US\$ 515.04 million (US\$-PPP 2836 million) (Supplementary Tables S7 and S13).

Discussion

The present study was the first one to calculate the economic burden of osteoporosis in Iran. In the study, expenditures were calculated based on a prevalence-based approach from the community perspective in 2020. According to the findings, osteoporosis had an economic burden of US\$ 393.24 million (US\$-PPP 2165 million) in 2020 in Iran.

Osteoporotic fractures impose a heavy economic burden on health systems and society worldwide [4, 13, 38, 39]. Osteoporotic fractures imposed an economic burden of € 27 billion in 27 EU countries in 2010, projected to increase by 25% by 2025 [4]. The economic burden of osteoporotic fractures in Turkey in 2019 was estimated at US\$ 455 million [40], and that of Austria in 2008 was € 685.2 million [38].

Osteoporosis imposes an economic burden of € 2.2 billion on average annually in Italy, € 8091 per patient on average [14]. The total cost of care for osteoporosis increased from US\$ 3976 million to 5126 million in South Korea from 2008 to 2011, representing an annual increase of 9.2% [41]. According to a study by Svedbom et al., the economic burden of osteoporotic fractures in Switzerland was estimated at CHF 2.05 billion, projected to increase by 29% by 2025 compared to 2010 [42]. Also, the burden of hospitalization and hospital costs for osteoporotic fractures were higher than those of heart attack, stroke, and breast cancer among females aged 55 and above in the USA in 2000 and 2011;

Table 5 Estimated number and monetary value of QALYs lost due to osteoporotic fractures in Iran, 2020

Gender	Age group (years)	QALYs lost due to incident fractures				QALYs lost due to prior fractures		QALY lost due to deaths directly attributable to fractures			Total	Monetary value of QALYs lost (US\$)
		Hip	Vertebral	Forearm	Other	Hip	Vertebral	Hip	Vertebral	Other		
Male	50–59	470	1224	105	2186	1228	693	15	28	17	5966	14,451,648
	60–69	411	1049	78	1481	2747	1545	22	36	33	7402	17,934,209
	70–79	510	818	25	880	2494	1217	84	61	72	6161	14,924,926
	80+	794	750	21	1220	3323	1209	64	32	99	7512	18,197,045
	Total	2185	3841	229	5767	9792	4664	185	156	221	27,040	65,507,828
Female	50–59	169	586	159	673	465	352	2	6	4	2416	5,854,381
	60–69	466	937	182	879	1866	1033	19	26	16	5425	13,141,901
	70–79	664	881	107	814	2867	1131	76	63	61	6664	16,140,953
	80+	729	461	43	691	3551	884	87	31	105	6582	15,948,063
	Total	2028	2865	491	3057	8749	3400	185	126	186	21,087	51,085,298
Both	50–59	639	1810	264	2859	1693	1045	17	34	21	8382	20,306,029
	60–69	877	1987	260	2360	4613	2578	41	63	49	12,828	31,076,110
	70–79	1174	1699	132	1693	5361	2348	161	124	132	12,824	31,065,879
	80+	1524	1211	65	1910	6874	2093	151	62	205	14,095	34,145,108
	Total	4214	6707	721	8822	18,541	8064	370	282	407	48,129	116,593,126

Table 6 Economic burden of osteoporosis in Iran, 2020

Cost item	Cost (US\$)		Percent
	Official market exchange rate	Purchasing power parity exchange rate	
Pharmacological prevention	26,003,033	143,170,945	6.61
Specialist visit	6,071,090	33,427,014	1.54
BMD test	21,058,749	115,948,049	5.36
Direct medical cost of osteoporotic fractures	95,909,510	528,071,291	24.39
Direct non-medical cost of osteoporotic fractures	90,626,254	498,982,040	23.05
Long-term care of hip fractures	36,981,375	203,616,953	9.40
Monetary value of QALYs lost due to osteoporosis	116,593,126	641,953,880	29.65
Total	393,243,137	2,165,170,172	100.00

BMD bone mineral density, *QALY* quality-adjusted life-year

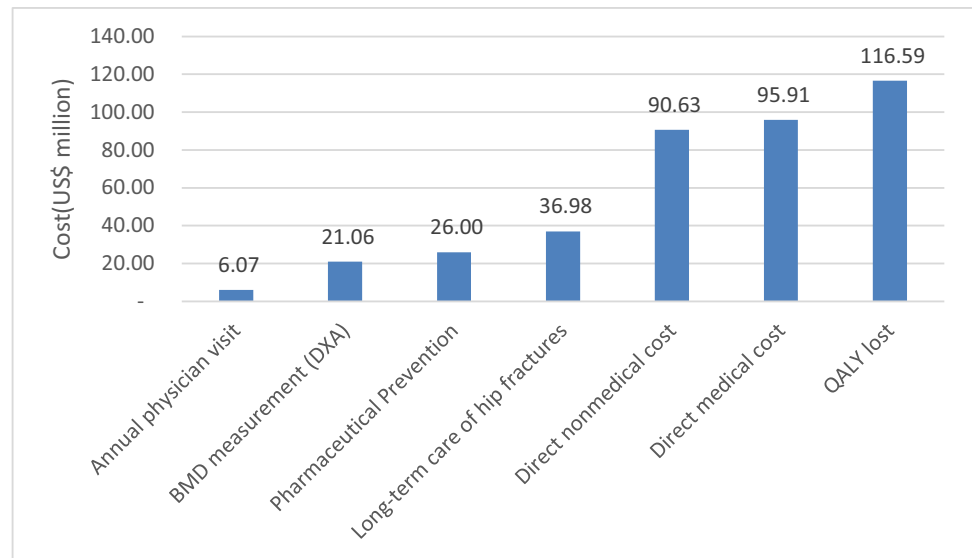
hence, osteoporotic fractures accounted for 40% of hospitalization and annual costs among mentioned diseases [43].

In the present study, direct medical and non-medical (47.44%), QALYs lost (29.65%), long-term care for people with previous hip fractures (9.40%), bone mineral density measurement (5.36%), prophylaxis (6.61%), and physician visit (1.54%) costs were the determinants of the economic burden of osteoporotic fractures in Iran. The main determinants of the economic burden of osteoporotic fractures varied across studies. Approximately 80% of the economic burden of osteoporosis in Italy was associated with hospitalization, 16% to medication, 3% to outpatient visits, and 0.6% to social security costs [14]. In the EU, 66% of the

economic burden of fractures accounted for new fractures, 29% for long-term care of patients with fractures, and 5% for prophylaxis. Fractures also resulted in the loss of 1.18 million QALY units [4].

The largest share of osteoporotic fracture costs in Austria accounted for the opportunity cost of care provided by family members (30.2%) and inpatient care (26.6%) [38]. In Switzerland, 76% of the economic burden of osteoporotic fractures accounted for new fractures, 21% for long-term care of patients with fractures, and 3% for prophylaxis. Also, 24,000 QALYs are lost due to osteoporotic fractures [42]. In South Korea, of the total health care cost for osteoporosis, the share of hospitalization was 40%, ambulatory care 31%,

Fig. 1 Economic burden of osteoporosis in Iran, 2020



and drug prescription 29% [41]. In Turkey, the highest economic burden of osteoporotic fractures accounted for hospitalization (47%), surgical (26%), and patient productivity (23%) costs [40].

Clinical outcomes of hip fractures are more than other fractures [1]. Hip fracture with a mortality rate of 20–24% in the first year of the fracture causes the most morbidity [39]. Also, since hip fracture requires hospitalization, it is the most costly outcome of osteoporosis. About 50% of the deaths associated with osteoporotic fractures in 2010 in Europe accounted for hip fractures [4]. The direct costs of hip fractures in Iran in 2010 were estimated at US\$ 28 million, projected to increase to US\$ 250 million by 2050 [44]. According to a study in Spain on a population above 65 years with hip fractures, the average direct cost was € 9690 for females and € 9019 for males [45]. In the present study, in addition to 25.79% of direct costs, hip fractures accounted for approximately 9.4% of the total economic burden directly due to the cost of long-term care of patients with hip fractures.

The costs and consequences of fractures are drastically high for public health [1]. The massive global burden of osteoporosis suggests that fracture risk assessment should be considered by health policy-makers [5]. According to the IOF recommendation, to support the effective management of osteoporotic fractures, health systems should prioritize prevention, provision of standard care, and financing [39]. Likewise, prioritizing bone health and supporting programs, such as fracture liaison services, are necessary to reduce this burden [43].

Fracture liaison service (FLS) is an accepted approach to reduce the incidence of osteoporotic fractures [46]. FLS care, in addition to cost-efficiency, significantly reduces the risk of subsequent fracture and post fracture mortality,

especially in patients with hip fractures [12]. Although cost-efficacy studies report that the implementation of FLS is beneficial to patients and health care systems [47], further research is still needed to evaluate the clinical efficacy and cost-effectiveness of strategies for finding osteoporotic cases and assessment of risk worldwide [5].

According to the available evidence, population aging is one of the most important factors affecting the incidence of osteoporosis, so with an increase in the elderly population, the medical and socio-economic consequences of osteoporosis drastically increase [1, 2]. Iran is also moving toward population aging due to reduced fertility, reduced mortality, and increased life expectancy [15]; therefore, osteoporosis and its outcomes would be a critical public health problem in Iran shortly. It should seriously be considered by policy-makers who plan for the disease prevention and control programs [9].

In this study, we attempted for the first time to provide a comprehensive estimate of the economic impact of osteoporosis in Iran, a middle-income country. However, to do so, we had to make several assumptions due to data limitations. To estimate the incidence of osteoporotic fractures (excluding hip), the ratio of the incidence of osteoporotic fractures (including vertebral, forearm, and “other” fractures) to hip fractures in Iran was assumed to be similar to that in Sweden for each age and sex. In addition, because the incidence of the femur, pelvis, humerus, rib, clavicle, scapula, and sternum fractures was only available in complete form for Sweden, it was not possible to estimate the incidence of these fractures by fracture type for Iran. However, these fractures accounted for more than 50% of all estimated fractures and were responsible for a significant proportion of the economic burden of osteoporosis.

In some cases, vertebral fractures may be asymptomatic or not be correctly diagnosed. Although asymptomatic vertebral fractures can reduce QoL and impose costs, the study did not consider asymptomatic cases, so the estimates of vertebral fractures may be undercounted.

Conclusion

According to the results of the study, osteoporosis is an important health problem in Iran, and its economic burden is significant. Interventions to prevent osteoporosis and especially associated fractures, such as screening and prophylaxis, can reduce the cost of the disease and improve patients' quality of life. Further studies are needed to identify cost-effective and feasible interventions in Iran.

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Declarations

Ethics approval and consent to participate This study was approved by the ethics committee of the Deputy of Research and Technology of the Tehran University of Medical Sciences (IR.TUMS.EMRI.REC.1396.0016). All authors confirm and declare that this study was conducted in compliance with the Declaration of Helsinki. The participants were assured that their information would remain confidential. Informed consent was obtained from all individual participants included in the study.

Conflicts of interest None.

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