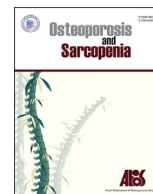




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Original article

An updated hip fracture projection in Asia: The Asian Federation of Osteoporosis Societies study

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ABSTRACT

Objectives: Hip fracture is a major public health problem. Earlier studies projected that the total number of hip fracture will increase dramatically by 2050, and most of the hip fracture will occur in Asia. To date, only a few studies provided the updated projection, and none of them focused on the hip fracture projection in Asia. Thus, it is essential to provide the most up to date prediction of hip fracture in Asia, and to evaluate the total direct medical cost of hip fracture in Asia.

Methods: We provide the updated projection of hip fracture in 9 Asian Federation of Osteoporosis Societies members using the most updated incidence rate and projected population size.

Results: We show that the number of hip fracture will increase from 1,124,060 in 2018 to 2,563,488 in 2050, a 2.28-fold increase. This increase is mainly due to the changes on the population demographics, especially in China and India, which have the largest population size. The direct cost of hip fracture will increase from 9.5 billion United State dollar (USD) in 2018 to 15 billion USD in 2050, resulting a 1.59-fold increase. A 2%–3% decrease in incidence rate of hip fracture annually is required to keep the total number of hip fracture constant over time.

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Conclusions: The results show that hip fracture remains a key public health issue in Asia, despite the available of better diagnosis, treatment, and prevention of fracture over the recent years. Healthcare policy in Asia should be aimed to reduce the burden of hip fracture.

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1. Introduction

Osteoporotic fracture is a major public health problem that is known to be associated with increased dependency, morbidity, and mortality. Among all osteoporotic fracture, hip fracture incurs the greatest morbidity, mortality, and costs. Studies by Cooper et al. [1] and Gullberg et al. [2] in 1990s projected that approximately 4.50–6.26 million of hip fractures will occur worldwide by 2050, where half of them will occur in Asia. Thus, a huge effort, including improve diagnosis and medications, various fracture prevention programmes, and research, has been undertaken to reduce the incidence of fracture worldwide.

Multiple studies have shown that incidence of hip fracture has been stabilized or reduced slightly in many countries or cities, such as Spain [3], Japan [4], United States [5], France [6], Taiwan [7], and Hong Kong [8]. However, this might not be the case for some countries, such as China [9,10] and Korea [11,12]. On the other hand, life expectancy worldwide has increased by 5 years in the last 15 years, according to the World Health Organization [13]. This implies that the total number of hip fracture may be continue to rise with the changing demographics, despite the decrease in the incidence of hip fracture reported in some countries. Therefore, we aim to provide the best estimate of hip fracture in Asia using the most updated information, and to evaluate the total direct medical cost of hip fracture in Asia.

2. Methods

2.1. Data sources

Data on incidence rate of hip fracture was obtained from 9 Asian Federation of Osteoporosis Societies (AFOS) members, including China [14,15], Hong Kong [16], India [17], Japan [18,19], Korea [20], Malaysia [21], Singapore [21], Taiwan [22,23], and Thailand [24] (Table 1). For Taiwan, we noted that a large difference in the incidence of hip fracture were estimated by two studies, due to Chie et al. [22] and Wang et al. [23] used International Classification of Diseases (ICD), 9th revision (ICD-9) of 820.XX (proximal femur fracture) and 820.XX to 821.XX (other femur fracture) to define hip fracture, respectively. To be conservative, we included both studies in the estimation of the total number of hip fracture. Only publications using nationwide or big databank that provided age-specific incidence of hip fracture between ages 50 and ≥ 80 years were included. Such decision provides a more accurate projection and accounts for a more realistic impact on total numbers of hip fractures due to change in the population demographics. Since 2 sets of hip fracture data were available for China, Japan, and Taiwan, the mean of the two estimates was used.

Similarly, direct costs of hip fracture were obtained from publications and available government data (Table 2) from China [25],

Table 1
Incidence rate of hip fractures in 9 Asian Federation of Osteoporosis Societies (AFOS) members.

AFOS members [reference]	Definition of hip fracture	Year of data ^a	Sex	Incidence in specific age group (per 100,000 person-years)							
				50–54	55–59	60–64	65–69	70–74	75–79	≥ 80	
China [15]	ICD-10: S72.002, S72.0052 for cervical fracture and S72.101, S72.1051, S72.1052, S72.2051 for trochanteric fracture. Subtrochanteric fractures (S72.2051) were included in the group of trochanteric fractures	2010	Male	44.0	48.0	46.0	65.0	126.0	237.0	557.4	
			Female	23.8	32.6	92.3	167.1	248.3	382.0	672.1	
China [14]	cervical fracture” or “trochanteric fracture	2015	Male	36.8	60.8	57.1	86.6	114.5	234.8	236.0	
			Female	23.8	32.6	92.3	167.1	248.3	382.0	416.5	
Hong Kong [16]	ICD-10: S72.0–S72.2 for fracture of femoral neck	2000–2004	Male	12.0	25.0	51.0	102.6	212.2	450.0	1210.8	
			Female	8.8	23.6	68.0	156.0	364.4	830.8	2174.3	
India [17]	ICD-10: S72.0–S72.2 for fracture of the proximal femur	2009	Male	79.0	83.0	72.0	90.0	101.0	338.0	447.4	
			Female	85.0	110.0	103.0	161.0	165.0	441.0	377.5	
Japan [19]	Not mentioned	2012	Male	22.3	22.3	50.3	50.3	168.8	168.8	723.0	
			Female	31.3	31.3	86.6	86.6	367.1	367.1	1860.8	
Japan [18]	All fractures were categorized as either neck or trochanteric (including subtrochanteric)	2015	Male	7.1	12.1	38.1	62.0	90.3	141.8	496.9	
			Female	28.6	33.9	61.3	62.6	165.6	308.4	1313.7	
Korea [20]	ICD-10: S72.0, S72.00 for fracture of the neck of the femur, S72.1, S72.10 for pertrochanteric fracture; N0601 for and hip fracture-related operation (open reduction & internal fixation), N0991 for closed reduction and percutaneous fixation, N0711 for total hip replacement, or N0715 for hip hemiarthroplasty	2002–2004	Male	8.0	19.0	41.1	69.4	125.7	211.4	405.2	
			Female	5.4	19.3	43.9	92.6	187.0	332.8	629.9	
Malaysia [21]	NA	1997–1998	Male	13.8	20.1	37.6	58.3	96.5	320.0	320.0	
			Female	9.2	26.5	48.2	103.0	230.0	644.0	644.0	
Singapore [21]	NA	1997–1998	Male	22.0	34.5	48.6	98.6	210.0	611.0	611.0	
			Female	14.1	34.0	81.1	195.0	408.0	1369.0	1369.0	
Taiwan [22]	ICD-9: 820	1996–2000	Male	36.0	50.0	87.0	149.0	284.0	542.0	1141.7	
			Female	22.0	45.0	93.0	215.0	459.0	934.0	1965.5	
Taiwan [23]	ICD-9: 820–821	2013	Male	182.0	182.0	324.0	324.0	838.0	838.0	2675.0	
			Female	167.0	167.0	428.0	428.0	1553.0	1553.0	4870.0	
Thailand [24]	Femoral neck or an intertrochanteric fracture	2006	Male	12.4	26.8	62.1	73.5	164.6	222.7	798.0	
			Female	25.9	32.7	83.2	158.1	388.8	793.4	1305.6	

^a Year of data indicates the year that the incidence data was estimated. It is not the year of publication.

Table 2
Projected direct medical cost of hip fracture in 2018 and 2050 by country.

AFOS members [reference]	Direct cost of each hip fracture (in USD)	Projected numbers of hip fractures		Projected direct cost of hip fractures (in million USD)	
		2018	2050	2018	2050
China [25]	3485.6	484,941	1,165,728	1690.3	4063.2
Hong Kong [26]	8831.9	9590	27,468	84.7	242.6
India [27]	772.0	331,898	792,334	256.2	611.7
Japan [28]	27,599.0	179,202	242,990	4945.8	6706.3
Korea [13]	3088.1	20,892	59,466	64.5	183.6
Malaysia [27]	6000.0	5880	20,893	35.3	125.4
Singapore [29]	6917.2	4477	15,806	31.0	109.3
Taiwan [30]	5776.0	45,063	121,131	260.3	699.7
Thailand [31]	2018.6	42,118	117,670	85.0	237.5
Total		1,124,060	2,563,488	9471.1	15,029.3

USD, United States dollar.

Hong Kong [26], India [27], Japan [28], Korea [13], Malaysia [27], Singapore [29], Taiwan [30], and Thailand [31]. The projection of direct medical cost was calculated assuming there was no secular change in incidence of hip fracture and unit cost.

2.2. Statistical analysis

For ease of comparison, we provided the incidences of hip fracture based on the following stratified age groups: 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, and ≥ 80 years. In cases where published data included incidence of hip fracture for age groups beyond 80 years (e.g., 80–84, 85–89, and ≥ 90 years), the incidence of hip fracture for the group ≥ 80 years was estimated based on the population structure of the study populations in the study year.

Projections for hip fractures was done in the year of 2025, 2030, 2035, 2040, 2045, and 2050 based on the most recent available sex- and age-specific incidence of hip fracture and the predicted population size in these years by the Worldbank (available at <http://www.worldbank.org/>), except the predicted population size of Taiwan was from the United Nations (<http://data.un.org/Default.aspx>), since such data was unavailable in the Worldbank. We multiplied the incidence of hip fracture for each of the 5-year age groups for each sex by the predicted number of population in each group to calculate the projected total numbers of hip fractures. The same method was used to calculate the projected direct medical cost. The projected total number of hip fracture was further estimated assuming 1%, 2%, and 3% increase or decrease of incidence rate in involved AFOS members since the study year of the published data in the respective country or region.

3. Results

We identified hip fracture incidence in 9 AFOS members that were suitable for analysis. The total population of 9 AFOS members in 2018 was 3.19 billion, which accounts for 70.3% and 42.0% of the Asia and World population, respectively.

Table 1 shows the incidences of hip fracture based on previously published data in 9 AFOS members, graph showing the difference in hip fracture incidence between the countries is provided as Fig. 1. Assuming there was no substantial change in hip fracture incidence since the study year, the projected number of hip fracture in the study areas will be 1.12 million in 2018, and it will reach 2.56 million by 2050 (Table 3), equivalent to 2.28-fold increase when compared to 2018. Malaysia and Japan are projected to have the highest (3.55 fold) and the lowest (1.36 fold) increase in the total number of hip fractures by 2050, respectively. The absolute number increase in projected hip fracture in 2050 will be 0.515 million in

male, 0.925 million in female, and 1.44 million in overall population for all AFOS members. The increase will be mainly contributed by China (0.681 millions) and India (0.460 millions), which explains 79% of the total increase.

Assuming there is a 1%, 2%, and 3% increase in hip fracture incidence annually calculated from the study year, the total numbers of hip fractures are expected to reach 3.8, 5.6, and 8.3 million in 2050, respectively (Table 4). On the other hand, if there were a 1%, 2%, and 3% decrease in hip fracture incidence annually since the study year, the total number of hip fractures will then be 1.7, 1.2, and 0.77 million, respectively (Table 5).

For the direct medical cost of hip fractures, the projected cost in 2018 will be USD 9.5 billion, and the projected cost increasing to USD 15 billion by 2050.

4. Discussion

The current study projected that the total number of hip fractures in the studied Asian countries or geographic regions will increase from 1.12 million in 2018 to 2.56 million in 2050. Similarly, the direct medical cost will increase from USD 9.5 billion in 2018 to USD 15 billion in 2050.

Cooper et al. [1] and Gullberg et al. [2] projected that the total numbers of hip fractures in Asia by 2050 will be 3.25 million and 2.02 million (45% of the total numbers of hip fractures), respectively. Thus, Asia has long been regarded as a “high risk” region with the highest increase in hip fracture number. The projections made by Cooper and Gullberg were only based on incidence data obtained from 1 to 3 countries in Asia and had been outdated since over 20 years had passed after the article had been published. Using the most updated incidence rate and projected population size, our estimation shows that the total number of hip fracture in 9 Asian countries or regions would reach 2.56 million. Notably, this number will be greater if the whole Asia is included in the projection. For instance, if the hip fracture incidence rate for remaining parts of Asia is assumed to be similar to that in 9 AFOS member countries or regions, the total number of hip fracture occurrences would be estimated to about 3.66 million, which is more than that projected by Cooper and Gullberg.

The increase in total number of hip fracture is expected to be highest in Malaysia and the lowest in Japan. According to the data from United Nations (<http://data.un.org/>), the median age in Malaysia and Japan is 26.99 years and 45.53 years in 2012. Thus, the prevalence of hip fracture in Malaysia is expected to be lower than that in Japan. This also explains the greatest increase in total number of hip fracture is in Malaysia, while the lowest increase is expected to be in Japan, a country with the highest proportion of elderly citizens. China and India contribute to the highest absolute

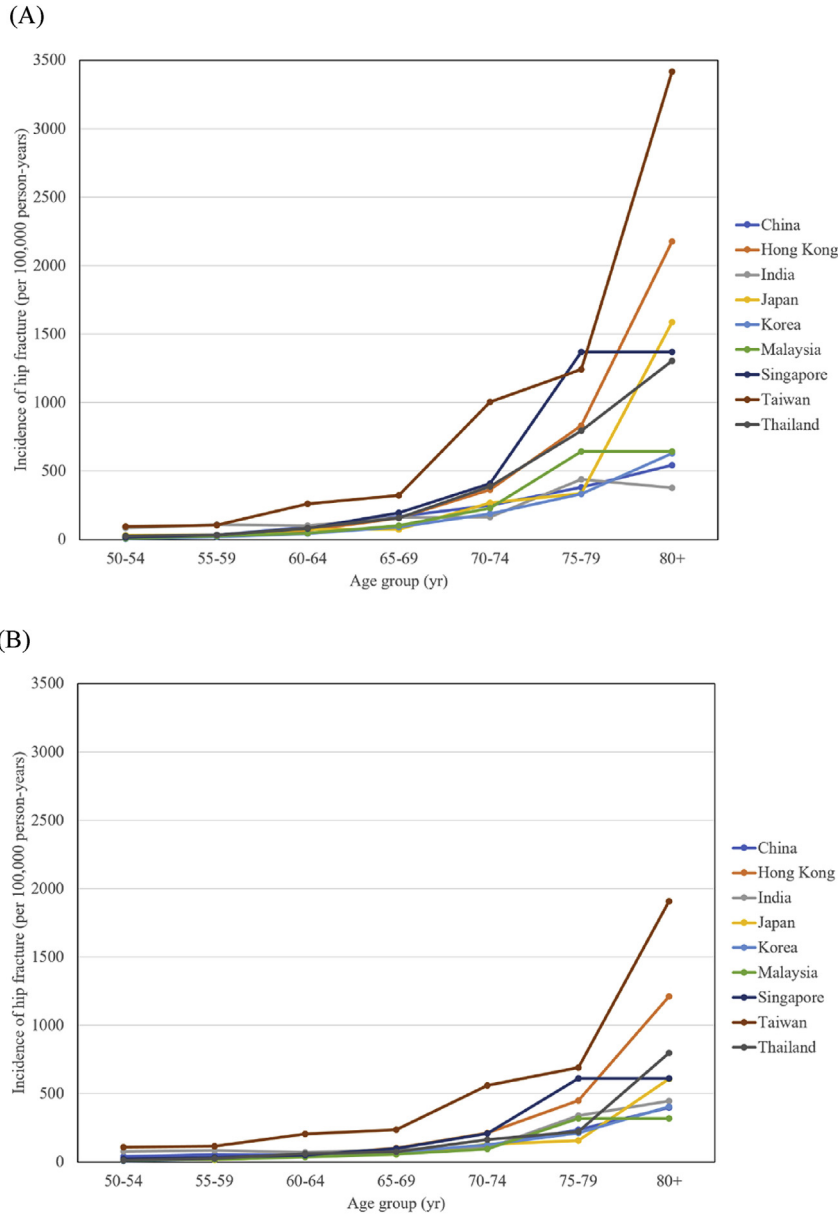


Fig. 1. Incidence of hip fracture in female (A) and male (B) in 9 studied countries/regions. Mean incidence rate was used for China, Japan, and Taiwan (see Methods section in main text).

number increase in hip fracture, because these 2 countries have the highest population size. Indeed, these 2 countries constitute approximately 37% of the world population. Thus, hip fracture is expected to be a huge burden for Asia.

Hip fracture is not only a personal medical issue, but it affects the family, the whole community and by extension the whole nation. The current study estimated that the direct medical cost in 2018 reaches USD 9.5 billion, and the cost will escalate to USD 15 billion by 2050. The increase in direct medical cost in 2050 (1.59 fold) is lower than the increase in number of hip fractures in 2050 (2.28 fold; Table 3). This is due to the direct medical costs of hip fracture for the countries with the highest increase in the number of hip fracture (China and India) are generally lower (Table 2); whereas Japan, the country with the highest direct medical cost, has the lowest increment in the number of hip fractures by 2050 (Table 3). It should be noted that given the burgeoning economic development in China and India, it is expected that the direct

medical cost will increase over time. Thus, the projected direct cost from these countries would be underestimated.

It is alarming that the projected number of hip fracture remains very high, even though a great effort in diagnosis, fracture prevention, and research has been undertaken. With the estimation in Table 5, the main target in Asia is to reduce the annual incidence of hip fracture by 2%–3% each year, in order to stabilize the total number of hip fracture over time. To achieve this goal, various stakeholders, including patients, patient families, healthcare professionals, and governments, need to be actively involved. There could be 10 recommendations for the goal-attaining strategy. First, Asian governments should make more resources available for the management of osteoporosis. AFOS has published a declaration on osteoporosis in Asia [32], which is a big step forward to galvanise the stakeholders to focus on the size of osteoporotic fracture and its impact on the populations. This would not only raise the awareness for the health professionals, but also national health policy makers

Table 3
Projected number of hip fracture by country, sex, and year.

AFOS members	Sex	Projected numbers of hip fractures by year							Fold change (2050/2018)
		2018	2025	2030	2035	2040	2045	2050	
China	Male	188,616	235,537	272,220	312,110	357,430	401,465	431,336	2.29
	Female	296,325	381,587	459,679	542,672	617,468	683,327	734,392	2.48
	All	484,941	617,124	731,898	854,783	974,898	1,084,792	1,165,728	2.40
Hong Kong	Male	2944	3583	4424	5363	6268	6764	6771	2.30
	Female	6646	8114	10,268	13,019	16,066	18,851	20,697	3.11
	All	9590	11,697	14,692	18,382	22,333	25,615	27,468	2.86
India	Male	142,106	173,208	201,846	233,860	266,396	298,689	332,144	2.34
	Female	189,791	234,644	274,701	318,114	363,940	410,854	460,190	2.42
	All	331,898	407,852	476,547	551,974	630,336	709,544	792,334	2.39
Japan	Male	38,106	44,191	49,014	50,810	50,589	51,544	53,601	1.41
	Female	141,096	162,852	180,046	186,234	184,417	184,841	189,390	1.34
	All	179,202	207,043	229,060	237,044	235,007	236,386	242,990	1.36
Korea	Male	6646	9261	11,464	13,839	16,324	18,246	19,526	2.94
	Female	14,247	18,815	22,805	27,539	32,753	36,996	39,940	2.80
	All	20,892	28,076	34,269	41,378	49,077	55,242	59,466	2.85
Malaysia	Male	1972	2679	3307	4044	4859	5686	6629	3.36
	Female	3908	5504	6940	8583	10,329	12,230	14,264	3.65
	All	5880	8183	10,248	12,628	15,188	17,916	20,893	3.55
Singapore	Male	1278	1947	2542	3151	3680	4062	4344	3.40
	Female	3199	4771	6219	7803	9268	10,465	11,462	3.58
	All	4477	6717	8761	10,953	12,948	14,527	15,806	3.53
Taiwan	Male	15,852	19,262	22,852	27,910	32,562	36,242	38,674	2.44
	Female	29,211	38,197	46,363	57,668	68,206	76,563	82,458	2.82
	All	45,063	57,459	69,216	85,578	100,769	112,805	121,131	2.69
Thailand	Male	11,558	14,724	17,575	21,051	24,888	28,249	30,905	2.67
	Female	30,560	40,139	49,079	59,627	70,558	80,054	86,765	2.84
	All	42,118	54,862	66,653	80,679	95,446	108,303	117,670	2.79
Total	Male	409,076	504,393	585,243	672,138	76,2997	850,948	923,930	2.26
	Female	714,984	894,622	1,056,100	1,221,259	1,373,005	1,514,182	1,639,558	2.29
	All	1,124,060	1,399,015	1,641,343	1,893,397	2,136,001	2,365,130	2,563,488	2.28

AFOS, Asian Federation of Osteoporosis Societies.

Table 4
Estimated number of hip fracture by sex and year based on modelling for a 1%, 2%, and 3% increase in hip fracture incidence.

Year	No change			1% Increase annually			2% Increase annually			3% Increase annually		
	Men	Women	All	Men	Women	All	Men	Women	All	Men	Women	All
2018	409,076	714,984	1,124,060	440,334	768,135	1,208,469	474,120	825,602	1,299,722	510,652	887,773	1,398,425
2025	504,393	894,622	1,399,015	582,267	1,030,943	1,61,3211	671,921	1,187,792	1,859,713	775,112	1,368,262	2,143,374
2030	585,243	1,056,100	1,641,343	710,444	1,279,744	1,990,188	861,706	1,549,708	2,411,415	1,044,332	1,875,433	2,919,766
2035	672,138	1,221,259	1,893,397	858,335	1,556,754	2,415,090	1,094,659	1,982,153	3,076,812	1,394,255	2,521,042	3,915,296
2040	762,997	1,373,005	2,136,001	1,024,633	1,841,175	2,865,809	1,373,493	2,465,005	3,838,499	1,837,888	3,295,076	5,132,964
2045	850,948	1,514,182	2,365,130	1,201,496	2,135,734	3,337,230	1,692,529	3,006,103	4,698,633	2,378,873	4,222,578	6,601,450
2050	923,930	1,639,558	2,563,488	1,371,889	2,432,097	3,803,986	2,031,281	3,598,361	5,629,642	2,999,317	5,310,458	8,309,775
Fold change (2050/2018)	2.26	2.29	2.28	3.12	3.17	3.15	4.28	4.36	4.33	5.87	5.98	5.94

Predicted change in population demographics are included in the calculations, with the number of hip fracture estimated based on the increase in each of the age group for the different countries.

Table 5
Estimated number of hip fracture by sex and year based on modelling for a 1%, 2%, and 3% decrease in hip fracture incidence.

Year	No change			1% Decrease annually			2% Decrease annually			3% Decrease annually		
	Men	Women	All	Men	Women	All	Men	Women	All	Men	Women	All
2018	409,076	714,984	1,124,060	380,147	665,797	1,045,944	353,366	620,254	973,620	328,565	578,063	906,628
2025	504,393	894,622	1,399,015	436,767	776,145	1,212,913	378,056	673,184	1,051,240	327,101	583,713	910,814
2030	585,243	1,056,100	1,641,343	481,688	870,920	1,352,608	396,101	717,673	1,113,774	325,421	590,926	916,347
2035	672,138	1,221,259	1,893,397	525,613	956,927	1,482,540	410,452	748,880	1,159,332	320,059	585,311	905,370
2040	762,997	1,373,005	2,136,001	567,109	1,022,169	1,589,279	420,706	759,665	1,180,371	311,485	563,565	875,051
2045	850,948	1,514,182	2,365,130	601,246	1,071,190	1,672,436	423,783	756,107	1,179,890	297,954	532,474	830,428
2050	923,930	1,639,558	2,563,488	620,439	1,102,323	1,722,762	415,402	739,082	1,154,483	277,278	494,132	771,411
Fold change (2050/2018)	2.26	2.29	2.28	1.63	1.66	1.65	1.18	1.19	1.19	0.84	0.85	0.85

Predicted change in population demographics are included in the calculations, with the number of hip fracture estimated based on the increase in each of the age group for the different countries.

for resource allocation and effective programs to reduce future fractures. Second, increase public awareness of osteoporosis and

reduce primary osteoporotic fracture. Third, fall prevention by improving public awareness of its risk factor, such as sarcopenia.

Fourth, reducing re-fracture rate by promoting fracture liaison services (FLSs) [33]. Fifth, early detection of osteoporosis by bone densitometry screening under the trained professionals. Sixth, promote the proper use of antiosteoporosis drug with adequate adherence, which is currently underuse. Seventh, use of generic drug as the first line regimen if considering the cost of treatment. Eighth, nationwide reimbursement of FLS should be encouraged. Ninth, supportive patient group and volunteer in promoting osteoporosis prevention and treatment. Tenth, international cooperation should be enhanced to advance the osteoporosis management.

There are several strengths in the study. The last projection or modelling for the number of hip fractures in Asia was more than 20 years ago, thus, using the recent available information of age- and sex-specific incidence of hip fractures provide a more accurate estimate. Second, the study was conducted by the investigators from the 11 Asian regions or countries (members of the AFOS), thus the study represented the current situation and perspective from these Asian regions. Nevertheless, there are limitations. There were only a point incidence of fractures, therefore secular changes in incidence of hip fracture were not accounted for in the current study, and the changes in the total number of fractures are merely based on the changes in population demographics. In addition, the predicted medical cost was estimated based on data published years ago, therefore it was not accounted for the changes in medical cost as well. However, a recent Korean study [13] showing that the average treatment cost decreased slightly by 2% from 2007 (USD 1520.7) to 2011 (USD 1490.1). Therefore, it is expected that the medical cost should not have big changes over time in developed countries.

In conclusion, the number of hip fracture is expected to increase substantially between 2018 and 2050 based on predicted changes in population demographics in Asian countries. Furthermore, more than USD 10 billion will be spent on the direct medical cost of hip fracture each year in Asia by 2050, assuming the cost of hip fracture treatment is unchanged. These data should make reduction of hip fracture being considered as a top health priority in Asian countries, so as to reduce the burden to the individual and healthcare system.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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