

## Current and Future Burden of Hip and Vertebral Fractures in Asia

Hiroshi Hagino\*

\*School of Health Science, Faculty of Medicine, Tottori University, Yonago 683-8503, Japan

### ABSTRACT

The increase in the incidence of hip fractures over time disappeared in Northern European and North American Caucasians after 2000, while an increase was observed in Asian countries including Japan until 2010. However, a decrease in the incidence was observed after 2010. The prevalence of vertebral fractures in Asians, Europeans, and American Caucasians is similar, and the incidences of clinical and morphometric vertebral fractures are higher in Asians compared with European Caucasians. The decrease in the incidence of vertebral fractures over time has been observed in Japan. Although the stabilization or decrease over time in the incidence of hip and vertebral fractures have been observed, the number of patients with these fractures is expected to increase rapidly with increases in the elderly population. Multidisciplinary measures to prevent fragility fractures are an urgent issue in Asia at this time. This narrative review outlines the recent trends in incidence and future burdens of hip fracture and vertebral fracture in Asia.

**Key words** clinical fracture; incidence; morphometric fractures; mortality; prevalence

In many countries, the oldest old are now the fastest growing segment of the total population. Globally, the population aged  $\geq 85$  years is projected to increase 351% between 2010 and 2050, compared with a 188% increase for the population aged  $\geq 65$  years and a 22% increase for the population aged  $< 65$  years.<sup>1</sup> As the population becomes older, more people will develop fragility fractures. Japan is currently the most aged country in the world, with 29% of the population aged  $\geq 65$  years and 5% aged  $\geq 85$  years in 2020.<sup>2</sup> As the population of the very elderly continues to expand, extending healthy life expectancy is an urgent issue.

The frequency of fragility fractures increases with age. The incidence of fragility fractures is an indicator of osteoporosis in the population. In addition, the cost of fracture treatment has been increasing over the years. Trends in fracture incidence and predicted number of

patients are important data for policy makers. Among fragility fractures, hip and vertebral fractures are known to cause declines in mobility and other physical functions in the elderly as well as lower life expectancy and higher treatment costs. In contrast to hip fracture, which results in inability to walk and requires hospitalization and surgical treatment, vertebral fracture is treated conservatively in most cases, with a limited number of fractures receiving medical attention. Therefore, the incidence of hip fractures is easy to determine, and epidemiological studies have been conducted in many countries around the world. On the other hand, the incidence of vertebral fractures is difficult to ascertain, and few studies have been reported. The age-specific and gender-specific incidence of hip fractures is lower in Asians compared to Northern Europeans and North American Caucasians. On the other hand, the prevalence and incidence of vertebral fractures are the same or higher in Asians compared with those in North Europeans or North American Caucasians. This manuscript provides a narrative review of recent epidemiological findings about hip and vertebral fractures in Asia.

### HIP FRACTURE Burden

Hip fracture is caused by a fall from standing height in 80% of cases.<sup>3</sup> Most patients have difficulty moving immediately after the injury, and surgery is performed in 95% of cases. Among patients who were ambulatory and living in the community before a hip fracture, half do not return to their pre-fracture level of mobility.<sup>4</sup> A critical review reported that between 40% and 60% of patients with hip fractures returned to their pre-fracture level of mobility and ability to perform instrumental activities of daily living.<sup>5</sup> Among people who independently performed self-care before the fracture, 20–60% required assistance for various tasks at 1 and 2 years after fracture. As a result, 10–20% of patients with hip fracture are institutionalized following fracture.

The mean overall 1-year mortality rate associated hip fractures was 22.0% (range, 2.4–34.8%) based on a system review of studies from 36 different countries.<sup>6</sup> In this systematic review mean 1-year mortality rate was 17.9% reported from Asian countries (range, 2.4–30.4%). It has also been reported that the risk of mortality after

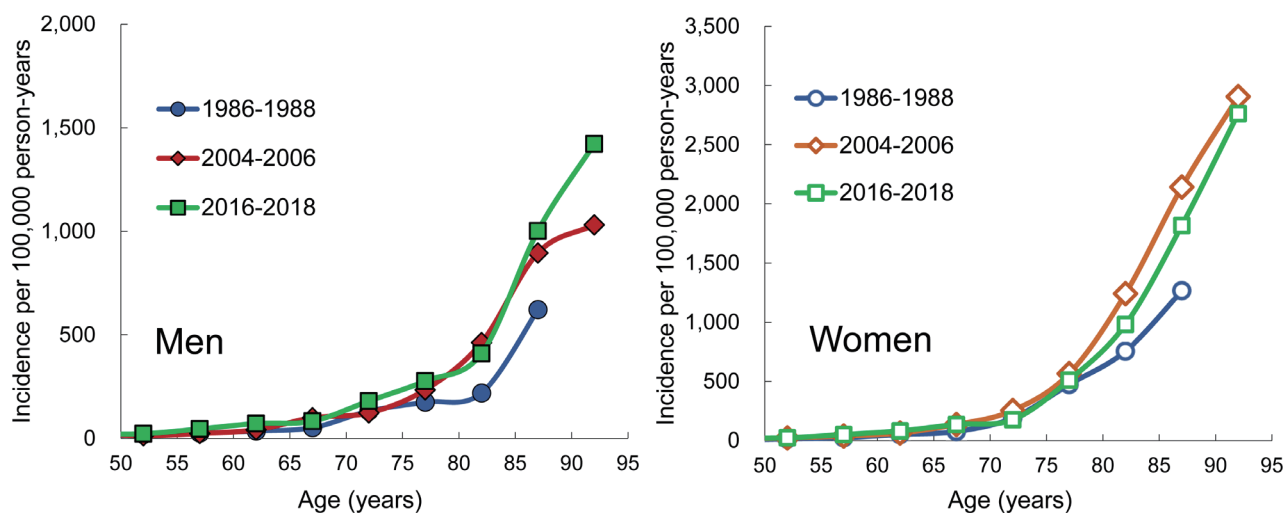
Corresponding author: Hiroshi Hagino, MD, PhD

hagino@tottori-u.ac.jp

Received 2021 February 15

Accepted 2021 February 17

Online published 2021 March 22



**Fig. 1.** Age group-specific and gender-specific incidence of hip fractures in Tottori Prefecture, Japan. Data are from references 10, 12, and 13.

hip fracture is significantly greater in patients who also have vertebral fractures compared to patients without vertebral fractures.<sup>7</sup>

#### Incidence in Asia

After 2000, the increase in the incidence of hip fractures over time disappeared in Northern Europe and North American Caucasians, while an increase was observed in Japan.<sup>8</sup> Incidence changed subsequently in Japan as well. Hip fracture incidence studies in Japan were conducted in Niigata Prefecture in 2015<sup>9</sup> and Tottori Prefecture in 2018,<sup>10</sup> in addition to a nationwide sampling survey in 2017.<sup>11</sup> The incidence in Tottori Prefecture during 1986–1988, 2004–2006, and 2016–2018 is shown in Fig. 1. Compared with the 1986–1988 survey,<sup>12</sup> incidence was higher in the 2004–2006 survey<sup>13</sup> for both sexes and all age groups. The incidence in 2016–2018 did not show any increases over time when compared with the incidence in 2004–2006, except for males aged  $\geq 90$  years. In other parts of Japan, trends in the 2017 nationwide sampling survey<sup>11</sup> and the 2015 survey in Niigata Prefecture<sup>9</sup> were similar (Table 1). In addition, the results of a study that estimated incidence using data from the National Database of Health Insurance Claims in Japan also showed no change in incidence among women between 2012 and 2015.<sup>14</sup> For men, an increase in incidence was observed until 2018, except for the results of a survey in Niigata Prefecture from 2012–2015. An increase in incidence in men aged  $\geq 90$  years was observed in Tottori Prefecture, but in the Niigata Prefecture survey, incidence was calculated for a group aged  $\geq 85$  years; therefore, it was not possible

to evaluate for a change in incidence among individuals aged  $\geq 90$  years in Niigata Prefecture.

The trends in hip fracture incidence in Asian countries other than Japan in recent years have also changed (Table 1). In China, an increase in the incidence was observed before 2010.<sup>15</sup> After 2010, a decrease in incidence was observed in a nationwide survey from 2012 to 2016.<sup>16</sup> However, in Tangshan, China, an increase in incidence was observed from 2010 to 2015.<sup>17</sup> In Taiwan,<sup>18, 19</sup> Hong Kong,<sup>20</sup> and Singapore,<sup>21</sup> a decline in incidence has been reported since early 2000. A study in South Korea found a sustained increase in incidence from 2008 to 2012<sup>22</sup>; however, a decrease was observed from 2010 to 2015.<sup>23</sup> A systematic review from South Korea showed that the age-adjusted incidence of hip fractures was stable among men and women.<sup>24</sup> In Thailand, a increase in incidence was observed during 1997–2006<sup>25</sup>; there have been no more recent reports. In addition, there is no information on incidence trends since 2010 in countries and regions other than those in Asia mentioned above.

Several hypotheses have been proposed as to why the age-adjusted incidence of hip fractures has declined over time. Changes in the incidence of hip fractures over 4 decades were analyzed to elucidate the cause of changes using data from the Framingham Heart Study, a population-based cohort study in the United States.<sup>26</sup> Adjusted for age, the incidence of hip fractures decreased by 4.4% per year from 1970 to 2010. The authors found that the decrease in hip fracture incidence occurred along with decreases in smoking and heavy drinking. Other risk factors for hip fracture, such as

**Table 1. Recent changes in the incidence of hip fractures in Asians countries**

Region (country)	Observation period	Annual change (%)		Author (year)
		Men	Women	
Tangshan (China)	2010–2015	–1.01	+3.67	Tian (2017) <sup>17</sup>
China	2012–2016	–4.66	–0.50	Zhang (2020) <sup>16</sup>
Hong Kong	2001–2009	–1.31	–2.20	Chau (2013) <sup>20</sup>
Taiwan	1996–2010	–0.94	–1.18	Wu (2017) <sup>18</sup>
Taiwan	2001–2012	–1.39	–1.55	Chen (2017) <sup>19</sup>
South Korea	2010–2015	–1.70	–0.47	Hong (2019) <sup>23</sup>
South Korea	2008–2012	+2.73	+3.95	Ha (2016) <sup>22</sup>
Singapore	2000–2017	–0.9	–1.7	Yong (2019) <sup>21</sup>
Chiang Mai (Thailand)	1997–2006	+1.39	+2.29	Wongtriratanachai (2013) <sup>25</sup>
Niigata (Japan)	2010–2015	–1.76	–1.88	Imai (2018) <sup>9</sup>
Japan	2012–2015	+1.6	–0.07	Tamaki (2019) <sup>14</sup>
Japan	2012–2017	+0.71	–1.07	Takusari (2020) <sup>11</sup>
Tottori (Japan)	2010–2018	+1.21	–0.39	Hagino (2020) <sup>10</sup>

underweight, obesity, and early menopause, were stable over the study period. However, since these changes in fracture risk over time were found in a study conducted in the United States, it is unclear whether these factors are reasons for the decline in incidence in Asia.

It has been reported that the incidence of hip fractures is higher in more urbanized areas.<sup>27</sup> Although there is no clear explanation for a higher incidence of hip fractures in urban versus rural areas, it has been suggested that dietary habits, lifestyle, environmental factors, or genetic factors may account for geographic differences in fracture incidence.<sup>27</sup> As hip fracture rates were highest in countries with the highest gross national income per capita, such as those of Europe and North America, Cauley et al.<sup>28</sup> found that indicators of socioeconomic status, life expectancy, health status, and degree of urbanization are implicated in differences in the incidence of hip fractures across countries around the world. Asia was experiencing a more rapid change in socioeconomic status than Europe and North America until 2010. For example, car ownership increased 4.9-fold in China between 2000 and 2010. Westernization and changes in socioeconomic status may have slowed after 2010, causing incidence to plateau. Improvements in nutritional intake, including calcium intake, and improvements in physical function in the elderly may have also influenced changes in fracture incidence.<sup>10</sup>

Improvement in osteoporosis treatment for fracture prevention is another possible explanation for the decrease in hip fracture incidence. Hip fracture incidence decreased with the start of bisphosphonate use, and the

impact of pharmacotherapy on fracture incidence was estimated to be as high as 40%.<sup>29</sup> Alendronate, the first nitrogen-containing bisphosphonate with effects on hip fracture prevention, was approved to treat osteoporosis in 2001 in Japan, 7 years after alendronate treatment began in Western countries. The delay in the start of bisphosphonate treatment nearly matches the lag in hip fracture incidence stabilization between Western countries and Japan.

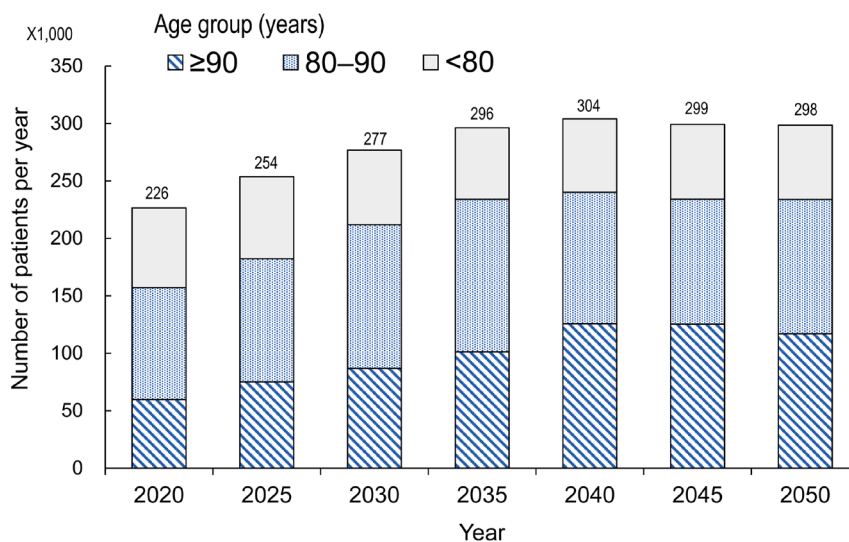
#### Estimated number of future patients

Based on the incidence of hip fractures by gender and age group in Tottori Prefecture in 2016–2018<sup>10</sup> and published future population estimates,<sup>2</sup> the projected number of hip fractures in Japan was 226,000 in 2020, 277,000 in 2030, and 304,000 in 2040, with the number of patients plateauing by 2040 (Fig. 2). The number of hip fractures in Asia is expected to increase the most in the future compared to other parts of the world. It is estimated that 1.66 million hip fractures occurred worldwide in 1990; this figure is expected to increase to 3.94 million by 2025 and 6.26 million by 2050.<sup>30</sup>

## VERTEBRAL FRACTURE

### Burden

Vertebral fracture is the most common type of fragility fracture. A recent prospective study elucidated that women with moderate or severe vertebral fractures continued to have lower physical ability at 5 years and had an almost three-fold reduction in time spent walking compared to women without vertebral fractures.<sup>31</sup>

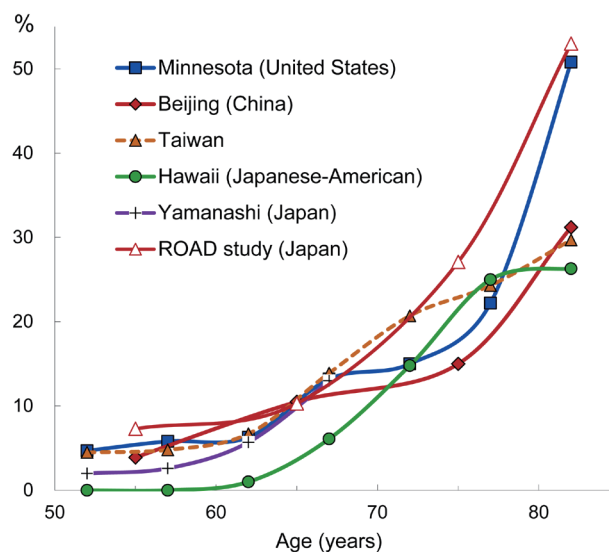


**Fig. 2.** Estimates of the number of future patients with hip fractures in Japan. Based on age group-specific incidence in Tottori Prefecture (2016–2018)<sup>10</sup> and future population estimates for Japan.<sup>2</sup>

Age-adjusted mortality rates in patients with vertebral fractures compared with the general population were 1.82 for women and 2.12 for men in the Dubbo Osteoporosis Epidemiology Study in Australia.<sup>32</sup> The 10-year survival rates for participants with and without vertebral fractures were 69% and 86%, respectively. The survival rate was lower in those with more vertebral fractures in a Japanese study.<sup>33</sup> According to data from the Health Insurance Review Assessment Service in South Korea, the overall mortality rate in patients with new vertebral fractures at 3 months, 6 months, 1 year, and 2 years after vertebral fracture were 5.56%, 9.41%, 14.60%, and 20.61% in men, and 2.41%, 4.36%, 7.16%, and 10.48% in women, respectively.<sup>34</sup> The standardized mortality ratio was highest during the first 3 months and gradually declined to 2.53 in men and 1.86 in women over the 2-year period.

### Incidence in Asia

The prevalence of vertebral fractures and the incidence of vertebral deformities increase with age and vary by geographic area. Approximately 65–75% of new vertebral fractures are clinically silent and only 30–40% of patients visit a medical institution.<sup>35, 36</sup> Since vertebral deformities after fracture persist throughout life, vertebral fractures have been investigated and analyzed separately in terms of the prevalence of vertebral deformities and the incidence of new fracture. Incidence is divided into incidence of fractures with pain that result in a visit to a medical institution (clinical fractures) and incidence of all new vertebral fractures (morphometric fractures)

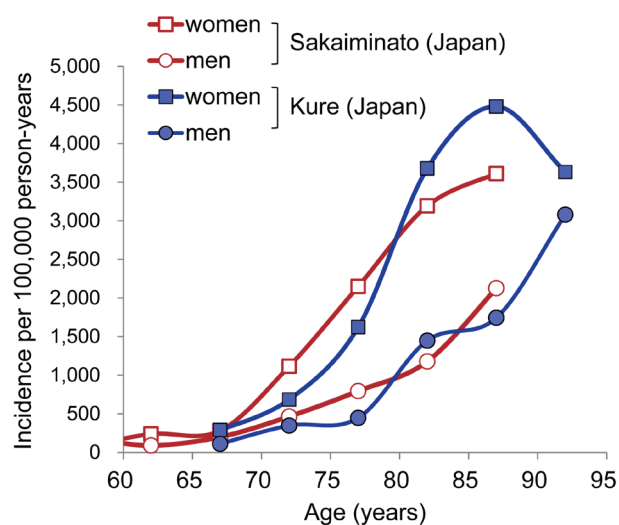


**Fig. 3.** Age group-specific prevalence of vertebral fractures in women among different geographic regions. Data from Minnesota (United States) and Hawaii (United States),<sup>40</sup> Beijing (China),<sup>43</sup> Taiwan,<sup>39</sup> Yamanashi (Japan),<sup>41</sup> and the ROAD study (Japan)<sup>42</sup> are shown.

based on the frequency of new vertebral deformities on radiographs, which includes fractures that do not result in a visit to a medical institution.

The prevalence of vertebral fractures in Asians is the same or slightly higher than that among Western Caucasians<sup>37–43</sup> (Fig. 3). Wong and Seeman found no differences in the prevalence of vertebral fractures among Asians and Caucasians.<sup>44</sup> The prevalence of





**Fig. 4.** Age-specific and gender-specific incidence of clinical vertebral fractures in Japan. Data are from references 47 and 48.

vertebral fractures in residents of Japan is reported to be higher than the prevalence in residents of Hong Kong, Thailand, or Indonesia.<sup>45, 46</sup>

The incidences of clinical vertebral fractures have been reported in Tottori<sup>47</sup> and Hiroshima<sup>48</sup> Prefectures in Japan. Age-specific incidence is similar in both locations (Fig. 4). Table 2 shows the incidence of clinical vertebral fractures adjusted for the Japanese population structure for age  $\geq 65$  years in 2020 based on published incidence by gender and age. Incidence for both genders was highest in South Korea,<sup>34</sup> followed by Japan<sup>47, 48</sup> and Hong Kong.<sup>49</sup> Swedish individuals<sup>50</sup> and American Caucasians<sup>51</sup> had lower incidence than Asians.<sup>46</sup> The incidence of morphometric vertebral fractures, which are diagnosed based on a decrease in vertebral height on routine radiographic imaging of the spine in Hiroshima study,<sup>52</sup> was approximately 3,000/100,000 person-years for women in their 70s and 8,000/100,000 person-years

for women in their 80s. Those rates are higher than those reported in Rotterdam study.<sup>53</sup>

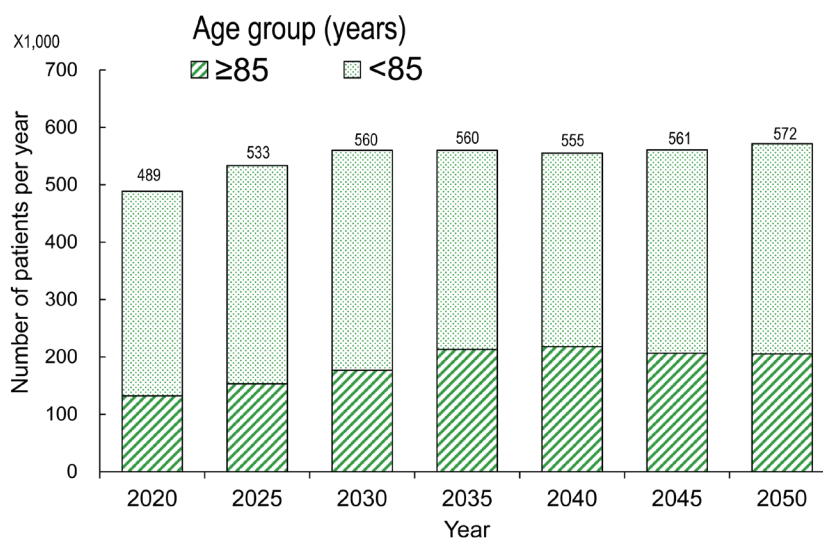
Thus, the prevalence of vertebral fractures in Asians, Europeans, and American Caucasians is similar. The incidences of clinical and morphometric vertebral fractures are higher in Asians compared with European Caucasians, in sharp contrast to the higher incidence of hip fractures in Sweden than in Asian countries. Although it is not clear why the racial differences in the incidence between these two fractures are reversed, one possibility is that vertebral fracture risk mainly depends on bone strength, whereas hip fracture risk depends on fall risk as well as bone strength, since 92% of hip fractures are attributed to falls.<sup>54</sup> The fact that Asians have a lower risk of falling than Caucasians<sup>55</sup> may account for differences in incidence between these two fracture types.

In the United States, the incidence of vertebral fractures in Rochester (Minnesota) based on file review and radiology reports was reported to be stable in men and women aged 35–69 years between 1965 and 1989.<sup>56</sup> A population-based cohort study from Iceland revealed a trend toward a decline in the incidence of vertebral fractures in both genders from 1989 to 2008.<sup>46, 57</sup> The incidence of thoracic vertebral fractures in a Japanese population from Hiroshima and Nagasaki, Japan, was observed from 1958 to 1986.<sup>58</sup> Incidence was significantly lower in the younger birth cohorts for both sexes. Incidence declined by a factor of 0.5 in males and 0.6 in females for each 10-year decrease in birth year. The incidence of vertebral fractures decreased significantly among individuals age  $\geq 50$  years from 2004 to 2015 in Sado, Japan.<sup>59</sup> The decrease in the incidence of vertebral fractures over time is thought to be due to improvements in diet, as well as changes in body size and age at menarche and menopause.

**Table 2. Population structure-adjusted incidence of clinical vertebral fractures**

Country or geographic region	Observation period	Incidence in men	Incidence in women	Overall incidence	Author (year)
Malmö (Sweden)	1993–1994	606.1	1010.4	1616.5	Kanis (2000) <sup>50</sup>
Rochester, Minnesota (United States)	1985–1989	398.1	865.4	1263.5	Cooper, C (1992) <sup>51</sup>
Hong Kong	1995	380.8	1443.0	1823.8	Bow (2012) <sup>49</sup>
Nationwide (South Korea)	2008	1093.7	3130.8	4224.5	Lee (2012) <sup>34</sup>
Kure (Japan)	2015	690.7	1958.0	2648.7	Hamasaki (2020) <sup>48</sup>
Sakaiminato (Japan)	2010–2012	772.4	1980.8	2753.1	Tsukutani (2015) <sup>47</sup>

Incidence (number of patients / 100,000 person-years) was adjusted to the population structure of persons aged  $\geq 65$  years in 2020 in Japan.



**Fig. 5.** Estimates of the future number of patients with vertebral fractures in Japan. Based on age group-specific incidence in the city of Sakaiminato in Tottori Prefecture, Japan<sup>47</sup> and future population estimates for Japan.<sup>2</sup>

### Estimated number of future patients

Figure 5 shows the estimated number of future patients with clinical vertebral fractures in Japan based on the incidence by gender and age group in Sakaiminato, Japan.<sup>47</sup> The number of patients with fracture will continue to increase until 2030–2035, but there will be no increases thereafter. However, while the incidence of vertebral fractures in the 90–99 and 100+ age groups is not fully known, the number of patients in these age groups will need to be monitored as the population grows in the future. It should also be noted that there are twice as many fractures with no or mild symptoms that do not come to medical attention.

### CONCLUSION

Compared with Western Caucasians, Asians have a lower incidence of hip fractures and a higher incidence of vertebral fractures. Since the number of patients with fragility fractures is expected to increase rapidly with increases in the elderly population, multidisciplinary measures to prevent fragility fractures are an urgent issue in Asia.

*The author declares no conflict of interest.*

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