



Hip fractures in Singapore: ethnic differences and temporal trends in the new millennium

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Received: 11 July 2018 / Accepted: 3 January 2019 / Published online: 23 January 2019
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Abstract

Summary Despite an increase in absolute numbers, the age-standardized incidence of hip fractures in Singapore declined in the period 2000 to 2017. Among the three major ethnic groups, Chinese women had the highest fracture rates but were the only group to show a temporal decline.

Introduction A study published in 2001 predicted a 30–50% increase in Singapore hip fracture incidence rates over the ensuing 30 years. To test that prediction, we examined the incidence of hip fracture in Singapore from 2000 to 2017.

Methods We carried out a population-based study of hip fractures among Singapore residents aged ≥ 50 years. National medical insurance claims data were used to identify admissions with a primary discharge diagnosis of hip fracture. Age-adjusted rates, based on the age distribution of the Singapore population of 2000, were analyzed separately by sex and ethnicity (Chinese, Malay, or Indian).

Results Over the 18-year study period, 36,082 first hip fractures were recorded. Total hip fracture admissions increased from 1487 to 2729 fractures/year in the years 2000 to 2017. Despite this absolute increase, age-adjusted fracture rates declined, with an average annual change of -4.3 (95% CI $-5.0, -3.5$) and -1.1 (95% CI $-1.7, -0.5$) fractures/100,000/year for women and men respectively. Chinese women had 1.4- and 1.9-fold higher age-adjusted rates than Malay and Indian women: 264 (95% CI 260, 267) versus 185 (95% CI 176, 193) and 141 (95% CI 132, 150) fractures/100,000/year, respectively. Despite their higher fracture rates, Chinese women were the only ethnic group exhibiting a decline, most evident in those ≥ 85 years, in age-adjusted fracture rate of -5.3 (95% CI $-6.0, -4.5$) fractures/100,000/year.

Conclusion Although the absolute number of fractures increased, steep drops in elderly Chinese women drove a reduction in overall age-adjusted hip fracture rates. Increases in the older population will lead to a rise in total number of hip fractures, requiring budgetary planning and new preventive strategies.

Keywords Ethnic differences · Hip fracture rates · Singapore

ELY and GG are joint first authors.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s00198-019-04839-5>) contains supplementary material, which is available to authorized users.

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Introduction

Hip fractures result in increased morbidity, disability, and mortality risks among the elderly and impose a significant economic burden for acute and long-term care. Previous studies have reported an increasing incidence in some countries, while others have observed a decline, some after an initial rise [1–3]. It is unknown whether such differences are driven by different data sources and methods, differences in health care, or ethnic differences.

Studying hip fracture trends among Singapore's multi-ethnic population of Chinese, Malays, and Indians enable a comparison of hip fracture incidence across three major Asian ethnic groups. Globally, over 2.6 billion people belong to these three ethnic groups [4]. With a low total fertility rate (1.16 births per woman in 2017) and increasing life expectancy (average lifespan of 83.1 years in 2017), Singapore has a rapidly aging population and is likely to face the financial and healthcare burden of rising numbers of hip fractures. A previous study from Singapore reported a steady increase in age-adjusted hip fracture rates of around 1–1.5% per year in both men and women from 1991 to 1998. Based on these trends, the authors predicted a further 30–50% increase in hip fracture incidence rates over the ensuing 30 years in Singapore [5]. To test that prediction, we examined the incidence of hip fracture in Singapore from 2000 to 2017 by age, sex, and ethnicity.

Methods

We carried out a population-based study of hip fractures among Singapore residents from 2000 to 2017. Data on hip fractures were obtained from the Singapore Ministry of Health Central Claims Processing System, which covers all hospitalizations in public and private acute hospitals in Singapore. Inpatient admissions of Singapore residents with a discharge diagnosis of fracture involving the neck or the intracapsular, upper epiphyseal, subcapital, cervical, trochanteric, or subtrochanteric areas were retrieved using the following diagnostic codes from the International Classification of Disease, Tenth revision, Australian version (ICD-10-AM): S7200, S7201–S7211, S722–S723 for the period 2012–2017; and from ICD-9-CM (Australian version): 820, 820.0, 820.2, 820.8 for the period 2000–2011. To focus on osteoporotic fractures, we restricted the study to men and women ≥ 50 years at the time of admission.

Singapore's resident population is composed of 75.0% Chinese, 13.7% Malays, and 8.7% Indians in 2007 [6]. In Singapore, an individual's race is determined by his or her father's race, which is self-declared at the time of birth. To calculate the age-specific incidence rates, demographic data were obtained from Department of Statistics of the Singapore resident population by sex, 45-year age-group, and race [6].

Identification of hip fracture cases (Fig. 1)

A total of 41,544 hospitalizations with a primary diagnosis of hip fracture for the period 2000–2017 were identified. To ensure that only first episodes of hip fracture were captured, persons with a hip fracture during the preceding 5 years (1995–1999) were excluded. In addition, 2335 hospitalizations of persons < 50 years of age and 2528 non-residents were also excluded. Of the remaining 36,108 first episodes within the study period, 26 were excluded because data on sex were missing. After these exclusions, the remaining 36,082 subjects with first hip fractures were analyzed.

Statistical analysis

Age-standardized incidence rates were calculated based on the age distribution of the Singapore population in 2000, and rates were analyzed separately in the two sexes and the three ethnic groups. Fracture rates are expressed per 100,000, with 95% confidence intervals (CI) estimated using Stata v13 software. Age- and sex-specific hip fracture incidence rates were calculated by dividing the respective hip fracture episodes by the corresponding populations. The average change in fracture rate per 100,000 per year was estimated using regression coefficients in a linear regression model, with incidence rate as the dependent variable and year as the independent variable. For comparisons with other cohorts globally, the annual percentage change (AAPC) and 95% CI were also calculated using the exponential method, based on linear regression of the natural logarithm of incidence rates with the year as independent variable, exponentiating to obtain the regression coefficient and its 95% CI [$\exp(\text{coefficient}) - 1$].

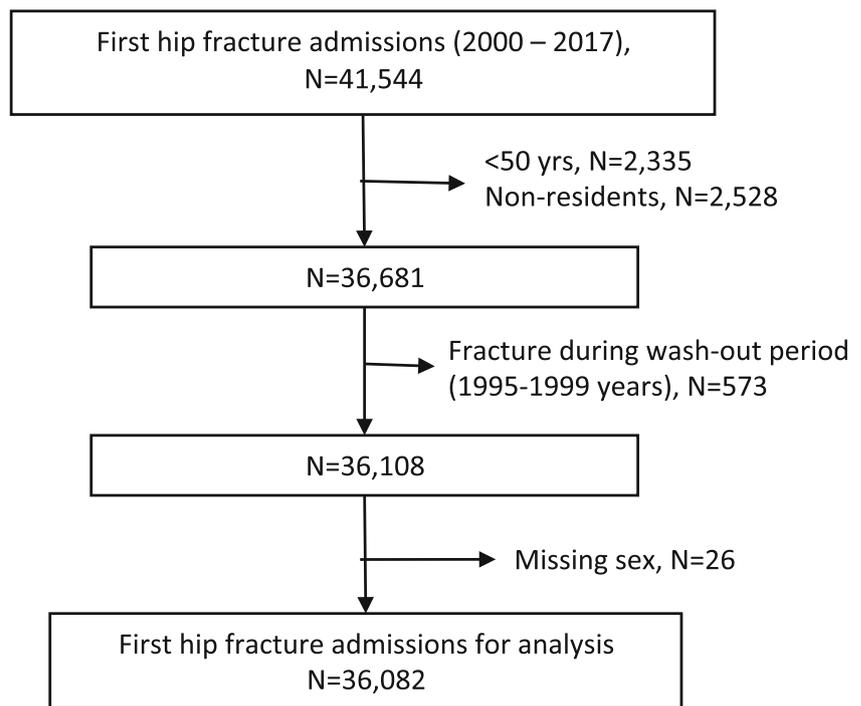
Ethics

This study was conducted using anonymized data de-identified by the Ministry of Health, and approved by the Domain Specific Review Board (DSRB) of National Healthcare Group.

Results

Over the 18-year study period (2000 to 2017), 36,082 first hip fractures were recorded among Singapore residents (Fig. 1). During the same period, the population of Singapore increased from 4.0 to 5.6 million, with the median age increasing from 34.0 to 41.3 years [6]. In residents aged ≥ 50 years, women had a twofold higher age-adjusted rate of hip fractures than men (253 [95% CI, 250, 256] versus 125 [95% CI 122, 127] per 100,000).

The absolute number of hip fracture admissions to Singapore hospitals increased from 1487 to 2729 fractures/

Fig. 1 Case selection, identification, and exclusions

year in the years 2000 to 2017, an average of 72 (95% CI 65, 79) additional fractures per 100,000 per year. This represents an average annual percentage change (AAPC) of 3.5% (95% CI 3.3, 3.8). As shown in Fig. 2 (upper panel), this absolute increase was observed in both women [average increase 46.3 (95% CI 41, 52) fractures/year; AAPC 3.3% (95% CI 3.0, 3.6)] and men [average increase 25 (95% CI 23, 28) fractures/year; AAPC 4.1% (95% CI 3.7, 4.4)].

Owing to increases in the Singapore population, however, these increases in absolute numbers were not reflected in hip fracture rates per 100,000 population, which declined by -1.6 (95% CI $-2.2, -1.0$) per 100,000 per year [AAPC -0.8 (95% CI $-1.1, -0.5$)]. As shown in the middle panel of Fig. 2, this decline was observed both in women [-2.7 (95% CI $-3.7, -1.7$)] per 100,000 per year; AAPC -1.0% (95% CI $-1.4, -0.6$) and men [-0.4 (95% CI $-0.9, -0.2$) per 100,000 per year; AAPC -0.3% (95% CI $-0.7, -0.1$)].

Because of the aging Singapore population, age-adjusted fractures rates declined to an even greater extent than the overall rates: -2.8 (95% CI $-3.3, -2.3$) per 100,000 per year; AAPC -1.4% (95% CI $-1.7, -1.2$). As shown in the lower panel of Fig. 2, that decline was observed both in women [-4.3 (95% CI $-5.1, -3.5$) per 100,000 per year; AAPC -1.7% (95% CI $-2.0, -1.4$)] and men [-1.1 (95% CI $-1.7, -0.6$) per 100,000 per year; AAPC -0.9% (95% CI $-1.3, -0.5$)].

Because of the higher rates in women, the remainder of the analysis was restricted to that sex. Marked differences were observed among the three ethnic groups. Chinese women had 1.4- and 1.9-fold higher rates than Malay and Indian women, respectively: 264 (95% CI 260, 267) versus 185 (95% CI 176,

193) and 141 (95% CI 132, 150) per 100,000 per year (Table 1). As shown in Fig. 3, Chinese women had a steady decline in age-adjusted annual hip fracture rates, from 304 (95% CI 296, 311) per 100,000 in 2000–2005 to 240 (95% CI 235, 245) per 100,000 per year in 2011–2017, representing a 21% decline over the three time periods (5–7 years each), an annual decrease of -5.3 (95% CI $-6.0, -4.6$) per 100,000; AAPC -2.0% (95% CI $-2.3, -1.7$). As shown in Fig. 4 and Supplementary Table 1, this decline was most evident in Chinese women ≥ 85 years: -62.2 (95% CI $-75.7, -48.8$) fractures/100,000/year; AAPC -2.6% (95% CI $-3.1, -2.0$). Significant declines were also observed among the 80–84, 75–79, and 70–74 year groups: -27.7 (95% CI $-36.5, -18.9$) fractures/100,000/year; AAPC -2.1% (95% CI $-2.8, -1.4$); -11.1 (95% CI $-16.4, -5.9$) fractures/100,000/year; AAPC -1.5% (95% CI $-2.3, -0.8$); and -6.5 (95% CI $-9.2, -3.8$) fractures/100,000/year; AAPC -1.8% (95% CI $-2.5, -1.0$), respectively. In contrast, no significant changes in hip fracture rates were observed in Malay or Indian women: 0.8 (95% CI $-1.7, 3.2$) fractures/100,000/year; AAPC 0.5% (95% CI $-1.0, 1.9$); and -0.4 (95% CI $-2.5, 1.6$) fractures/100,000/year; AAPC -0.4% (95% CI $-1.8, 1.1$), respectively (Fig. 3).

Discussion

We observed several important trends in the occurrence of hip fractures in Singapore. During the period 2000–2017, absolute numbers of hip fractures continued to increase, with a mean annual increase of 72 fractures per 100,000 and an

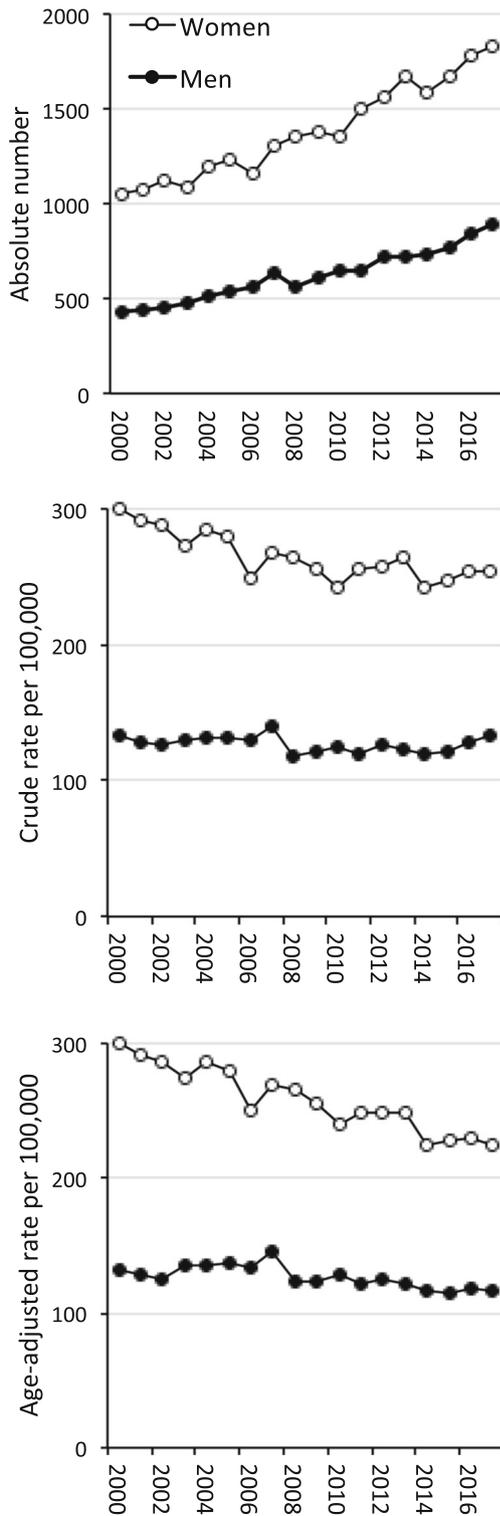


Fig. 2 Temporal trends in hip fractures in Singapore, 2000 to 2017. Upper panel: Crude annual numbers of hip fractures. Middle panel: crude incidence rates per 100,000 population. Lower panel: Age-adjusted incidence rates per 100,000 population. Age was adjusted to the year 2000 population

AAPC of 3.6% (95% CI 3.3, 3.8). Nevertheless, the crude fracture rate per 100,000 declined in both men and a woman,

Table 1 Hip fracture rates in women by age and ethnicity (2000–2017)

Age	Chinese		Malay		Indian	
	Rate*	95% CI	Rate*	95% CI	Rate*	95% CI
50–54	11	9, 13	9	6, 12	8	3, 14
55–59	29	27, 32	24	16, 31	22	15, 29
60–64	76	71, 82	68	52, 85	77	54, 99
65–69	163	154, 172	173	143, 204	164	133, 194
70–74	365	343, 386	396	342, 450	346	302, 391
75–79	738	698, 777	722	643, 800	632	536, 729
80–84	1326	1240, 1411	1235	1077, 1394	1216	1030, 1403
≥ 85	2409	2231, 2588	1699	1423, 1975	1825	1486, 2165
≥ 50 [#]	264	260, 267	185	176, 193	141	132, 150

*Per 100,000 women

[#] Age-adjusted to Singapore 2000 population

indicating that the increase in absolute number of hip fractures was due to an increase in the number of women and men at risk for hip fracture. When crude rates per 100,000 were age-adjusted, fracture trends declined even more steeply, indicating the contribution of the aging Singapore population to the increase in total number of fractures. Marked ethnic differences were observed, with Chinese women having 1.4- and 1.9-fold higher fracture rates than Malay and Indian women, respectively. However, Chinese women had a steady decline in their age-standardized fracture rates during the 18-year study period, a trend limited to women ≥ 70 years. In contrast,

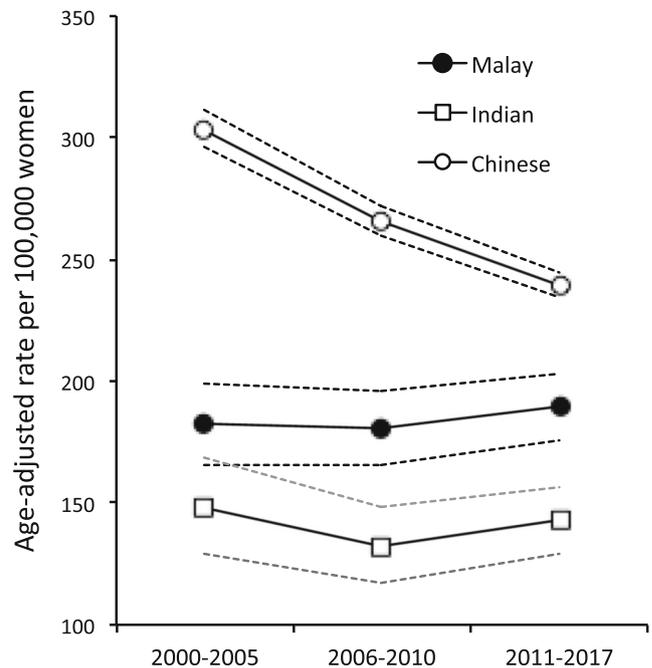
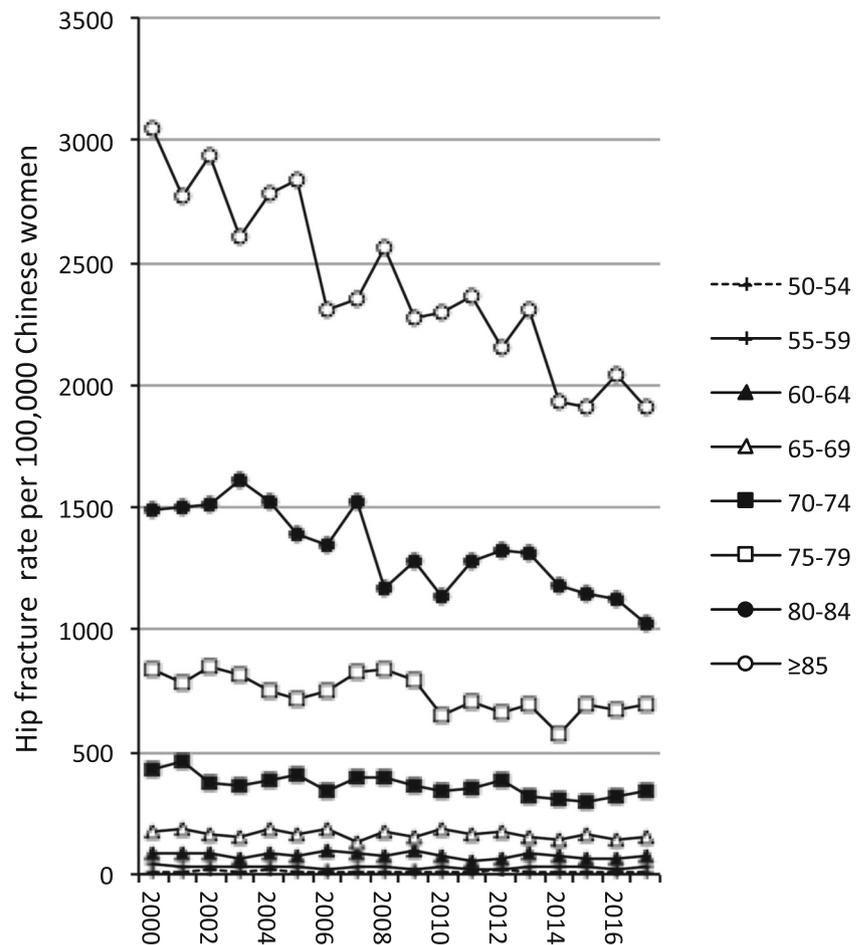


Fig. 3 Hip fracture incidence trends in Singapore women, stratified by ethnicity. Data shown are mean age-adjusted rates per 100,000 for the periods indicated. Dotted lines are 95% CI. Based on data in Supplementary Table

Fig. 4 Temporal trends in age-specific hip fracture incidence rates per 100,000 Chinese women (2000–2017)



no decline was observed among women of Malay or Indian ethnicity.

A previous Singapore study reported a threefold increase in age- and sex-adjusted hip fracture rates from 1958 to 1998 among residents aged ≥ 50 years [5]. In contrast, we observed a reversal of the trend in the years 2000–2017 among residents of both sexes, with an overall age-adjusted decline of -2.7 (95% CI $-3.2, -2.2$) fractures per 100,000 per year; AAPC -1.4% (95% CI $-1.6, -1.1$). This decline is consistent with those reported from Chinese populations in Hong Kong [7] and Taiwan [8], and from economically advanced populations in Sweden [9], France [10], Denmark, Switzerland, Canada [11], and the USA [3, 12]. Such declines are not universal. In Tangshan, a city in Northern China with a population similar to Singapore's, increases of 85% and 306% were observed in hip fracture incidence in men and women, respectively, from 1994 to 2010 [13]. In Beijing, hip fractures rates increased 58% in women and 49% in men from 1990 to 1992 to 2002–2006 [14]. In Spain, an annual decline of 2.2% was reported for women 65–74 years of age but a 0.6% annual increase was observed for those over 85 years [15]. In Singapore, the median length of stay in hospital for hip fractures undergoing surgery is 12 days [16]. As in other rapidly

aging Asian societies [17], the absolute increase in number of fractures (due to aging and increase of the Singapore population) ensures that the heavy burden for inpatient care of hip fractures will continue to rise.

Consistent with the previous survey [5], we found that hip fractures were highest in Chinese women. Disturbingly, Chinese women were the only ethnic group with a significant decline in hip fracture rates. The reasons for these ethnic-specific features of hip fracture epidemiology are unclear. One key risk factor for hip fracture is low bone mineral density, which can lead to osteoporosis. We therefore consulted recent population trends in known risk factors for low bone mineral density, including body weight, smoking, alcohol consumption, physical activity, and diabetes [3, 18]. National trends in the prevalence of these risk factors are summarized in Table 2 [19]. Although the prevalence of obesity (BMI > 30.0 kg/m²) in all races increased from 6.3% (95% CI 5.6, 6.7) in 1998 to 10.8% (95% CI 9.8, 11.8) in 2010, obesity prevalence among the Chinese was two- to fivefold lower than for Indians or Malays (Table 2). Low body fat is associated with lower bone mineral density [20], and obesity protects against hip fractures. A lower prevalence of obesity may have contributed to the higher rates of hip fractures observed in

Table 2 Prevalence of risk factors for hip fracture

	1998	2004	2010
Obesity (BMI > 30 kg/m ²)			
All races	6.3 (5.6, 7.0)	6.8 (6.0, 7.5)	10.8 (9.8, 11.8)
Chinese	4.0 (3.4, 4.6)	4.2 (3.5, 4.9)	7.9 (6.5, 9.3)
Malay	18.0 (14.9, 21.1)	20.0 (16.6, 23.5)	24.0 (21.9, 26.1)
Indian	12.6 (9.1, 16.1)	13.2 (9.5, 16.8)	16.9 (14.3, 19.5)
Daily smoking			
All races	15.1 (14.1, 16.1)	12.3 (11.3, 13.4)	14.3 (13.2, 15.4)
Chinese	13.8 (12.7, 14.9)	11.5 (10.4, 12.6)	12.8 (11.1, 14.5)
Malay	22.1 (18.7, 25.4)	17.7 (14.4, 21.0)	26.5 (24.3, 28.7)
Indian	16.3 (12.5, 20.2)	11.8 (8.3, 15.30)	10.1 (8.0, 12.2)
Regular alcohol consumption			
All races	2.8 (2.4, 3.3)	3.3 (2.8, 3.9)	2.6 (2.1, 3.1)
Chinese	3.1 (2.6, 3.7)	3.7 (3.0, 4.3)	2.9 (2.0, 3.8)
Malay	0.6 (0.0, 1.2)	0.7 (0.0, 1.4)	0.6 (0.2, 1.0)
Indian	3.3 (1.4, 5.1)	3.5 (1.5, 5.5)	3.3 (2.1, 4.5)
Regular exercise			
All races	17.7 (16.7, 18.8)	16.9 (15.8, 18.1)	19.0 (17.7, 20.3)
Chinese	16.9 (15.7, 18.1)	16.6 (15.3, 17.9)	19.2 (17.3, 21.3)
Malay	18.4 (15.3, 21.5)	18.0 (14.7, 21.3)	15.3 (13.3, 16.9)
Indian	24.3 (19.8, 28.8)	17.0 (12.9, 21.0)	21.7 (18.8, 24.6)
Diabetes			
All races	11.3 (10.4, 12.2)	9.0 (8.1, 9.9)	11.3 (10.3, 12.3)
Chinese	10.0 (9.0, 10.9)	7.5 (6.6, 8.5)	9.7 (8.2, 11.2)
Malay	15.8 (12.9, 18.7)	13.2 (10.2, 16.1)	16.6 (14.7, 18.5)
Indian	20.2 (16.0, 24.4)	18.1 (13.9, 22.2)	17.2 (14.6, 19.8)

Risk factors were obtained for Singapore residents (men and women) aged 18–69 years from National Health Surveys 1998, 2004, and 2010. Data expressed as percentage (95% CI) of residents in that ethnic group. National health surveys use a consistent methodology based on stratified random sampling of over 4000 subjects/survey. The ethnic composition of each survey was 30% Chinese, 30% Indians, and 30% Malays. Minority groups (Malays and Indians) were oversampled to ensure reliable prevalence estimates

Chinese. Interestingly, differences in obesity rates narrowed from 3.1-fold and 4.5-fold higher in Chinese versus Indians and Malays, respectively, in 1998 to 2.1-fold and 3.0-fold higher in 2010, congruent with the convergence in hip fracture rates shown in Fig. 3. Despite having the highest obesity rates, however, Malay women had higher fracture rates than Indian women, who in turn had intermediate obesity rates, but the lowest fracture rates, among the three ethnic groups. These data suggest that although a lower obesity prevalence may contribute to the higher fracture rates in Chinese women, it does not entirely account for the differences across ethnicities.

Vitamin D deficiency is associated with increased muscle weakness, higher bone turnover, and risk of falls and hip fractures in older adults [21]. In Singapore, vitamin D deficiency (≤ 20 ng/ml of 25(OH) vitamin D) has been observed in 18% of patients referred to an osteoporosis clinic [22] and 57% in patients hospitalized for hip fractures [23]. Intriguingly, hypovitaminosis D is significantly higher in persons of Malay ethnic origin: 90.5% in Malay patients with hip fracture

compared to 55% of Chinese and 61.1% Indians [23]. These differences are thought to be related to the cover-all Malay dress code, including long sleeves and headdress for Muslim-Malay women. Low Vitamin D may have contributed to the higher hip fracture rates observed in Malay compared to Indian women. If vitamin D deficiency in Malay women is validated in future studies, an ethnic-based approach to Vitamin D evaluation and supplementation may reduce the risk of hip fracture in in this ethnic group.

Malays have the highest smoking rates among the three ethnic groups, whereas alcohol consumption in Singapore is low in all three ethnic groups (Table 2), and that prevalence has also declined over time. No major differences are observed in regular exercise or in the prevalence of diabetes among the ethnic groups. The contribution of smoking and other factors to ethnic differences in fracture rates should be explored in future studies. Among Singaporeans, greater genetic heterogeneity has been observed between Indians and Chinese than between Chinese and Malays in Singapore

[24]. Chinese women have been reported to have significantly longer hip axis length compared to either Malay or Indian women, which may contribute to higher hip fracture rates in the Chinese [25]. Whether ethnic-specific genetic variants contribute to differences in hip geometry [26] and bone mineral density and risk of fracture [27] are worthy of future study.

Although having the highest fracture rates, Chinese women were the only ethnic group to show a temporal decline. Hip fracture rates were highest in Chinese women aged ≥ 85 years and this demographic also exhibited the steepest temporal decline in fracture rates. Several factors may be associated with this decline. Since a previous study revealed that a large fraction (42%) of Chinese women were not aware of the relationship of osteoporosis to hip fractures [28], various initiatives to increase awareness have been implemented. A Singapore Ministry of Health clinical practice guideline [29] and editorials in local medical journals [30, 31] have been published. The Singapore Health Promotion Board and Osteoporosis Society of Singapore has held public forums with extensive press coverage to emphasize the scale of the problem [32]. The OPTIMAL secondary fracture prevention program, which is clinician champion-driven and case manager-run, was established in public hospitals in Singapore in 2008 [33]. Anti-osteoporosis drugs such as bisphosphonates are increasingly prescribed and consumed, as costs have fallen with the introduction of generic medications [34]. Currently, more than half of Singapore hospitals have implemented fracture liaison services [16], resulting in good compliance with osteoporosis medications. Intriguingly, a recent US study reported a reversal in the last few years of the earlier age-adjusted declines in hip fracture incidence [12]. Factors postulated to contribute to that reversal include a decline in DXA measurement (due to changes in health care funding), as well as a reduction in bisphosphonate therapy for osteoporosis due to fear of rare adverse effects, such as atypical femoral fractures and osteonecrosis of the jaw [35]. Whether awareness of these adverse events will lead to similar reductions in bisphosphonate use in Singapore, with subsequent flattening of declining fracture rates, should be examined in future studies.

Our study has a number of strengths. We used a large database that includes all Singaporean residents so our results should be generalizable to Singapore. We included a large number of subjects over an 18-year period and studied both women and men and three ethnic groups of women. However, our study has several limitations. Some degree of misclassification of diagnoses and coding errors is likely when using administrative databases. In addition, age-specific analyses of temporal trends for Malay and Indian women had limited statistical power due to their smaller populations and lower rates of hip fractures.

Despite declining age- and population-adjusted fracture rates, absolute numbers of hip fractures increased an average annual rise of 3.6% in Singapore. This increase was partly due

to population growth of those over 70 years, and especially of those aged ≥ 85 years. Globally, the number of people aged 80 years or over is growing even faster than the number of older persons overall. Projections indicate that the number of people aged 80 or over worldwide will increase more than threefold between 2017 and 2050, rising from 137 million to 425 million [36]. Our study predicts a mean annual increase of 72 hip fractures per 100,000 population in Singapore. This increase must be factored into hospital and health manpower and expenditure planning.

Funding This study was partially funded by a Singapore National Medical Research Council Grant (Number CSAS16May007) to ELY.

Compliance with ethical standards

Conflicts of interest None.

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