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Ethnic and gender-specific incidence rates for hip fractures in South Africa: A multi-centre study

S.S. Dela[a,*], F. Paruk[b], S.L. Brown[c], M. Lukhele[d], A.A. Kalla[e], J.D. Jordaan[f], M. Conradie[g], O. Mohamed[h], P. Chutterpaul[b], B. Cassim[i]

[a] Department of Internal Medicine, Edendale Hospital, School of Clinical Medicine (SCM), University of KwaZulu-Natal (UKZN), South Africa
[b] Division of Internal Medicine, SCM, College of Health Sciences, UKZN, South Africa
[c] Mahatma Gandhi Memorial Hospital, Durban, South Africa
[d] Department of Orthopaedics, University of Witwatersrand, South Africa
[e] Division of Rheumatology, Faculty of Health Sciences, University of Cape Town, South Africa
[f] Division of Orthopaedics, Stellenbosch University, South Africa
[g] Division of Endocrinology, Stellenbosch University, South Africa
[h] Discipline of Public Health Medicine, SCM, College of Health Sciences, UKZN, South Africa
[i] Department of Geriatrics, SCM, College of Health Sciences, UKZN, South Africa

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ABSTRACT

Background: Limited data exist on the incidence of hip fractures in South Africa (SA). We report gender and ethnic specific incidence rates of hip fractures in SA.

Methods: In a multicentre prospective study, conducted in geographically defined municipalities of three provinces in SA, a structured questionnaire was administered to all subjects aged 40 years and over, presenting with a new atraumatic hip fracture, from 1 April 2017 to 31 March 2018. Gender and ethnic specific incidence rates (IR) of hip fractures were calculated using population statistics from Statistics SA.

Findings: Of the 2767 subjects enrolled, 1914 (69·2%) were women and 853 (30·8%) were men. The majority of subjects were from the White population (40·9%) followed by those from the African (26·4%), Coloured (18·7%) and Indian (13·9%) populations.

Men with hip fractures were significantly younger than women in the total group (69 [IQR 59–79] versus 77 years [IQR 68–84], $p < 0{\cdot}001$) and in each ethnic group. White subjects were significantly older ($p < 0{\cdot}0001$) and Africans significantly younger ($p < 0{\cdot}0001$) than the other ethnic groups.

In women, the highest IR was noted in the White population (176·0 per 100,000), followed by that in the Indian (147·7 per 100,000), Coloured (73·2 per 100,000) and African populations (43·6 per 100,000). A similar pattern was seen in men albeit at lower rates, with the highest rate in White men at 76·5 per 100,000.

In the total study population and the African population, the IR was higher in men compared to women in subjects under 60 years. In the White population, the IR was higher in men compared to women in the 40–44 years age group. While in the Coloured and Indian populations the IR was higher in men compared to women in the 40–49 years and 45–54 years age groups, respectively.

There was an increase in the relative risk ratios with age in the total study population, and in all ethnic groups in both women and men.

Interpretation: Hip fractures occur in all ethnic groups in South Africa with higher IRs in the White and Indian populations compared to the Coloured and African populations. Consistent with the published literature, the overall hip fracture IR was higher in women than in men, except in the younger age groups, and increased with age.

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Abbreviations: GP, Gauteng Province; IR, incidence rate; HF, hip fracture; KZN, KwaZulu-Natal; LE, life expectancy; NCD, non-communicable diseases; REDCap, Research Electronic Data Capture; SA, South Africa; SSA, sub-Saharan Africa; WC, Western Cape

* Corresponding author at: 10A 26th Avenue, Umhlatuzana 4092, South Africa.
E-mail address: sapnadela@gmail.com (S.S. Dela).

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1. Introduction

South Africa (SA), in a state of epidemiologic transition, is characterized by a quadruple burden of disease [1]. Established as an endemic area for tuberculosis and the epicentre of the Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS) epidemic, it faces significant challenges with a high infant and maternal mortality and trauma and violence burden [1]. In addition, there is the emerging burden of non-communicable diseases (NCD) e.g. cardiovascular diseases which rank second to HIV as a cause of mortality. Adding complexity to the epidemiology is the multi-ethnic population, which differs in genetic background, socio-economic status, access to health care and disease profile [2]. The South African population has four major ethnic groups of which the African population which is indigenous to the region is the largest. The White population are predominantly descendants of Dutch, German, French Huguenots, English and other European settlers, while the Indian population are descendants from India. The Coloured population is a multiracial ethnic group native to SA with ancestry from more than one of the various populations in this region.

The unprecedented roll out of antiretroviral treatment in the last decade has resulted in an increase in average life expectancy (LE) in SA from 52.2 years in 1960 to 61.1 years in men and 67.3 years in women in 2018 with the proportion of persons aged 60 years and older increasing to 8,5% (4·89 million) [3]. This has been accompanied by a rise in the prevalence of NCDs such as hypertension, diabetes and cardiovascular diseases [4]. However, little data are available on the burden of osteoporosis and its consequences.

Osteoporotic hip fractures (HF) are a major cause of disability and death in developed countries. More than a third of patients die within a year of HF and a significant number of survivors are dependent on nursing care [5]. In high-income countries, there have been major advances over the preceding decades in the epidemiology of risk factors [6], risk prediction, and the treatment of osteoporosis and fragility fractures in an effort to reduce the burden of HFs. The Fracture Risk Assessment Tool (FRAX®) developed at the University of Sheffield, United Kingdom (UK), is used in over 50 countries worldwide, but none in Sub-Saharan Africa (SSA) [7].

Osteoporosis and fragility fractures remain a low priority in SSA and SA. Available published data, albeit limited, suggest that osteoporotic HFs are rare in Africans in SA and in SSA. A handful of studies in SSA from Cameroon, The Gambia and Nigeria, have confirmed the low incidence [8–10]. Furthermore, only two studies have reported HF incidence in SA over the last 50 years. Solomon in 1968 found a very low incidence of HFs in African men and women (4·2 per 100,000 and 4.6 per 100,000 respectively) in Johannesburg, but this study was limited by the small sample size and restricted to a single region [11]. More recently a ten-fold increase in HF incidence in Africans has been reported, in five regional hospitals in KwaZulu-Natal [12]. This study was limited to the public sector and thus did not truly reflect the multi-ethnic SA population. Differences in HF incidence rates between ethnic groups have been documented in other multi-ethnic populations [13–15].

Determining the incidence of HFs in SA is faced with several challenges. Firstly, SA has a unique multi-ethnic population, within which the incidence may differ considerably. Furthermore, the ethnic distribution varies significantly between provinces. Secondly, SA has a two-tiered health care system with both public and private sectors and the use of these facilities varies according to ethnicity and socio-economic status [4]. Lastly, there is no HF registry and electronic resources are largely unavailable in the public health sector.

In view of the limitations of the previously cited South-African HF studies, a multicentre study was conducted in both the public and private sectors, in defined geographical areas in three provinces, to provide a reliable estimate of gender specific incidence of HFs in the four major ethnic groups of SA and the age-dependent relative risk of hip fractures in SA.

2. Methodology

2.1. Approvals

Ethical approval was obtained from the Biomedical Ethics Research Committees of the Universities of KwaZulu-Natal, Cape Town, Stellenbosch and Witwatersrand and all study sites, including approval from the Regional, Provincial and National Departments of Health as well as private health care providers. The study was conducted according to the ethical guidelines and principles of the International Declaration of Helsinki and South African Guidelines for Good Clinical Practice.

In addition to the patients who were able to consent, ethical approval was obtained to record demographic data for individuals who did not or were unable to consent.

2.2. Study population and study design

South Africa's multi-ethnic population of over 50 million (51770561) comprises the African population (79·2%), Coloured population (8·92%), White population (8·86%), and Indian population (2·49%) spread across the nine provinces. The African population forms the majority in most provinces including Gauteng (GP), but not in the Western Cape (WC) where the Coloured population is in the majority at 48·8%. The largest population of Indian people (7·4%) resides in KwaZulu-Natal (KZN) [16]. To ensure adequate representation of all ethnic groups, these three provinces were selected for the study. In addition, these provinces are amongst the most populous representing over 55% of the total South African population [16], with a defined ethnic and gender breakdown, and a well-developed and accessible health care infrastructure. All public and private hospitals were identified through Department of Health websites and from a careful search of private hospital groups in these provinces.

The eight districts comprised eThekwini and Msunduzi municipalities in KZN, Johannesburg Metropolitan and Sedibeng municipalities in GP and the Cape Metropole plus the three surrounding municipal districts (West Coast, Cape Winelands and Overberg), in the WC. These districts were all urban. The total population aged 40 years and over in these eight municipal districts, 4,034,153 (Census 2011), representing 29·5% of the total SA population aged 40 years and over, served as the denominator for incidence calculation.

A prospective, observational study was conducted over 12 months from 1 April 2017 until 30 March 2018 in the 94 hospitals identified in the defined areas, 25 (26·6%) in the public sector and 69 (73·4%) private. All hospital managers and administrators were informed of the study and the investigators met with all orthopaedic surgeons affiliated to the selected hospitals as well as the admitting and nursing staff in these hospitals prior to the start of the study. The fieldworkers identified key personnel with whom regular contact was made. In addition, notices were placed in each hospital and staff requested to record all admissions with hip fractures.

All subjects aged ≥ 40 years, who presented to these hospitals with a fragility fracture of the hip, neck of femur or trochanter, residing within the designated geographical areas were enrolled into the study. Incident cases were identified through admission books, regular visits by trained fieldworkers, nurse informers and clinical records. Fragility fractures were defined as a fracture of the femur between the articular cartilage of the hip joint to 5 cm below the distal point of the lesser trochanter subsequent to a fall from a standing height or less, based on the AO classification and ICD-10 codes S72.141A, S72.142A, S72.001A, S72.002A, S72.21 and S72.22 [17]. High-velocity trauma HFs and periprosthetic fractures were excluded.

Trained fieldworkers administered a structured questionnaire to document demographic data. Age was determined from date of birth and ethnicity was self-reported.

2.3. Quality control

For quality assurance, a digital image of the hip radiograph was captured to confirm the presence of a HF. Further confirmation of the fracture was through review of the attending physician's records, ICD 10 codes and at interview. The fracture was confirmed initially from a photograph of the X-ray taken by the fieldworker and independently verified by the investigator at each site and centrally by the principal investigators (SD and BC). Where there was a disagreement, confirmation was obtained from the attending orthopaedic surgeon.

De-identified data encrypted by a number system were imported into a password-protected database, Research Electronic Data Capture (REDCap). The data were handled by the research team and were kept with the principal investigator until submission for data analysis. Only de-identified data were submitted for analysis. The team leader at each site and subsequently the central data manager verified the data to ensure accuracy. It was further confirmed that the index fracture was the first hip fracture reported for the participant, that this was not a readmission and that the fracture occurred within the time frame of the study.

2.4. Statistical analysis

Demographic data of the study population, age, gender and ethnicity, are expressed using descriptive statistics and frequency tables. For normally distributed data, continuous variables were expressed as means with standard deviations (SD) while medians and interquartile ranges (IQRs) were used for non-parametric data. Crude and age-standardised IRs for the study population and SA were calculated using the total African, Indian, White and Coloured populations aged ≥40 years, of the eight districts and SA, obtained from the 2011 census data [16]. Direct standardisation (actual number of fractures divided by the at-risk population) was used to calculate age-specific incidence rates. The relative risk ratio with 95% confidence intervals was calculated for each age group (5-year intervals), using the 40–44 year age group as the reference group, except in women in the White and Coloured populations in whom, since no fractures were recorded in the 40–44 year age group, the 45–49 year age group was used as the reference group. Age standardised IRs for the total population of SA were derived by multiplying the crude incidence by the proportion of the total SA population in five-year age bands.

3. Results

3.1. Demographic data

The demographic characteristics of the study population are presented in Table 1. A total of 2767 subjects with incident HFs were enrolled in the study period. The majority of subjects (1835, 66·3%) were admitted in the public sector.

White subjects made up the majority (1132, 40·9%), followed by Africans (730, 26·4%), Coloureds (518, 18·7%) and Indians (387, 13·9%).

More than two thirds of subjects were women (1914, 69·2%) in the total group and women also represented the majority of cases within each of the ethnic groups; the highest percentage of male HF subjects were noted in the African group.

Men with HF were significantly younger than women in the total group (69 years [IQR 59–79 years], versus 77 years [IQR 68–84 years]), $p < 0{\cdot}001$ and in each of the ethnic groups.

3.2. Incidence of hip fractures in the total study population

The IR for hip fractures was 68·6 per 100,000 for the total population and 87·5 and 46·2 per 100,000 for women and men, respectively (Table 2). In both women and men, there was a progressive increase in the relative risk of hip fractures with age, with the highest incidence in subjects aged 85 years and over, 1276·7 per 100,000 in women and 649·4 per 100,000 in men (Table 2 and Fig. 1).

In the age groups below 60 years, the IR of hip fractures was higher in men than in women (Table 2 and Fig. 1).

3.3. Ethnicity and gender specific incidence of hip fractures

The IR was highest in the White (129·9 per 100,000) and Indian populations (111·7 per 100,000) and lower in the Coloured (58·2 per 100,000) and African populations (37·9 per 100,000). White women had the highest IR, 176·0 per 100,000 compared to Indian (147·7 per 100,000), Coloured (73·2 per 100,000) and African women (43·6 per 100,000). A similar pattern was seen in men, with IRs of 76·5, 69·2, 39·7, and 31·1 per 100,000, in White, Indian, Coloured and African men, respectively.

In the younger age groups, the IR was higher in men than in women. The IR was higher in men compared to women in the 40–59 years age group in the African population, 40–44 years group in the White population, the 40–49 years group in the Coloured population in the 45–54 years age group in the Indian population (Table 3).

In both sexes and in all ethnic groups, the IR increased with age (Table 3).

4. Discussion

This is the first study to report HF incidence in both men and women in the four major ethnic groups in SA. Based on differences in HF incidence in other multi-ethnic populations [13–15], and the ethnic differences in bone mineral density (BMD) in SA [18–20], this study sought to determine ethnic and gender specific IRs of hip fractures. The study was undertaken in designated municipalities in three provinces, in which the population aged 40 and above represented 29·5% of the total South African population above the age of 40 years.

In this study, white men and women with HFs were significantly older than men and women with HFs in the other ethnic groups. This is a reflection of the LE in SA which is highest in the White population, with 14·2% of the White population being older than 65 years, compared to 4·4%, 4·7% and 6·9% in Black African, Coloured and Indian populations, respectively [21]. Other possibilities include differences in risk factor profile. The highest IR of HFs was seen in White women (176·0 per 100,000) and Indian women at 147·7 per 100,000 with lower rates in the Coloured and African populations. A similar pattern was seen in men.

While osteoporosis and its consequences occur in all populations, there is extensive literature to show that fracture rates vary significantly in adults from different ethnic groups in both high-income and low-income countries [13–15]. Both genetic factors and the environment play a role in determining BMD and fracture risk in various ethnic groups. Little is known about the traditional risk factors for HF in SA, nor the contribution of BMD to fracture risk. A single study reports a significantly higher fall risk in urbanized White versus Coloured and African populations in SA [22] and limited studies of a lower BMD at the hip [19] and longer hip axis length (HAL) in White compared to African women [23] have been reported. It is possible that differences in genetics, socio-economic circumstances, lifestyle and mortality rates may differentially affect fracture risk amongst the different ethnic groups. South Africa's high level of income inequality [24] has resulted in up to 50% of the population being below the poverty line [25] with high levels of communicable diseases, such as HIV/AIDS, and protein calorie malnutrition especially in the indigent populations [26–28]. In addition, the daily calcium intake in SA is suboptimal and amongst the lowest in the world [29]. Furthermore, SA is an endemic area for HIV/AIDS, which impacts negatively on bone health and increases fracture risk. A number of reasons have been postulated including the effect of low body mass index and malnutrition, concomitant opportunistic infections and anti-retroviral therapy (ART), especially protease inhibitors which have been shown to increase bone loss [30]. Mortality rates are also higher in young African adults, especially in men from

Table 1
Demographic characteristics of the study population.

	Total study population	Women	Men	W:M ratio	*p* value
Total population n (%)	2767 (100)	1914 (69·2)	853 (30·8)	2·24:1	
Median age (IQR) in years	75 (64–83)	77 (68–84)	69 (59–79)		< 0·001[a]
Ethnic groups n (%)					
White population	1132 (40·9)	824 (72·7)	308 (27·2)	2·67:1	
African population	730 (26·4)	454 (62·2)	276 (37·8)	1·64:1	
Coloured population	518 (18·7)	359 (69·3)	159 (30·7)	2·26:1	
Indian population	387 (14·0)	277 (71·6)	110 (28·4)	2·52:1	
Median age (IQR) in years					
White population	79 (72–86)	80 (73–87)	77 (68–84)		< 0·001[a]
African population	67 (57–78)	71 (61–81)	66 (58–75)		< 0·001[a]
Coloured population	74 (64–81)	75 (67–83)	61 (51–70)		< 0·001[a]
Indian population	72 (63–80)	76 (67–82)	67 (57–75)		< 0·001[a]

IQR: interquartile range.
[a] Mann-Whitney *U* test

Table 2
Age standardised incidence rates (IRs) of hip fractures in five-year age bands for the overall population stratified by sex.

Age bands in years	Number of fractures	At risk population	Incidence rate per 100·000	Relative risk ratio (95% CI)	SA overall population	Age standardised incidence rate per 100·000 for SA
Total population						
40–44	48	929,807	5·2		2,931,394	1·1
45–49	84	795,738	10·6	2·0 (1·44–2·92)	2,607,406	2·0
50–54	112	664,521	16·9	3·3 (2·33–4·58)	2,207,783	2·7
55–59	182	528,376	34·4	6·7 (4·85–9·17)	1,789,277	4·5
60–64	239	403,441	59·2	11·5 (8·41–15·63)	1,379,343	6·0
65–69	279	264,019	105·7	20·5 (15·06–27·8)	952,931	7·4
70–74	358	192,705	185·8	35·9 (26·60–48·50)	744,681	10·1
75–79	454	122,282	371·3	71·7 (53·20–96·50)	479,025	13·0
80–84	391	75,623	517·0	99·6 (73·90–134·40)	321,651	12·2
> 85	620	57,641	1075·6	206·0 (153·70–176·40)	254,539	20·0
Total	2767	4,034,153	68·6		13,668,030	
Total women						
40–44	17	470,668	3·6		1,539,840	0·7
45–49	29	424,033	6·8	1·9 (1·04–3·45)	1,419,001	1·3
50–54	59	356,371	16·6	4·6 (2·67–7·86)	1,202,221	2·6
55–59	98	286,816	34·2	9·5 (5·65–15·82)	981,649	4·4
60–64	134	221,459	60·5	16·7 (10·11–27·70)	770,314	6·1
65–69	180	148,003	121·6	33·6 (20·46–55·30)	553,732	8·8
70–74	255	113,915	223·9	61·8 (37·86–101·0)	453,013	13·3
75–79	331	76,546	432·4	119·2 (73·20–194·0)	314,805	17·8
80–84	311	49,740	625·3	172·0 (105·60–280·0)	221,496	18·1
> 85	500	39,163	1276·7	349·0 (215·30–566·0)	179,403	30·0
Total	1914	2,186,714	87·5		7,635,474	
Total men						
40–44	31	459,139	6·8		1,391,554	1·6
45–49	55	371,705	14·8	2·1 (1·37–3·28)	1,188,405	2·9
50–54	53	308,150	17·2	2·5 (1·59–3·83)	1,005,562	2·9
55–59	84	241,560	34·8	5·0 (3·32–7·50)	807,628	4·7
60–64	105	181,982	57·7	8·3 (5·57–12·30)	609,029	5·8
65–69	99	116,016	85·3	12·2 (8·21–18·22)	399,199	5·6
70–74	103	78,790	130·7	18·7 (12·60–27·85)	291,668	6·3
75–79	123	45,736	268·9	38·5 (26·10–56·80)	164,220	7·3
80–84	80	25,883	309·1	44·2 (29·36–66·60)	100,155	5·1
> 85	120	18,478	649·4	92·6 (62·70–136·70)	75,136	8·1
Total	853	1,847,439	46·2		6,032,556	

CI: confidence interval; SA: South Africa.
Direct standardisation (actual number of fractures divided by the at-risk population) was used to calculate age-specific incidence rates based on the age and sex structure of the total study group. The relative risk ratio of fracture with 95% confidence intervals was calculated for women and men in 5-year intervals, using the 40–44 year age group as the reference group.

HIV/AIDS and other infectious diseases and trauma. It is therefore possible that a healthy survivor bias may explain the lower IR of hip fractures in the older African population [31].

In contrast, lifestyle factors may account for the higher IR in the White women who are more likely to smoke and consume alcohol than African and Indian women (15%, 3% and 3% for smoking and 36%, 18%, and 1% for alcohol consumption, respectively) [21].

The lower IR of hip fractures in the South African White population (129·9 per 100,000) compared to their European counterparts e.g. in the United Kingdom (349 per 100,000) [32] and Netherlands (246 per 100,000) [33] may be due to genetic and environmental factors. The White population in SA originates from Europeans, mostly men, who immigrated to SA > 300 years ago and the current population reflects a wider genetic diversity with admixtures from other ethnic groups [34].

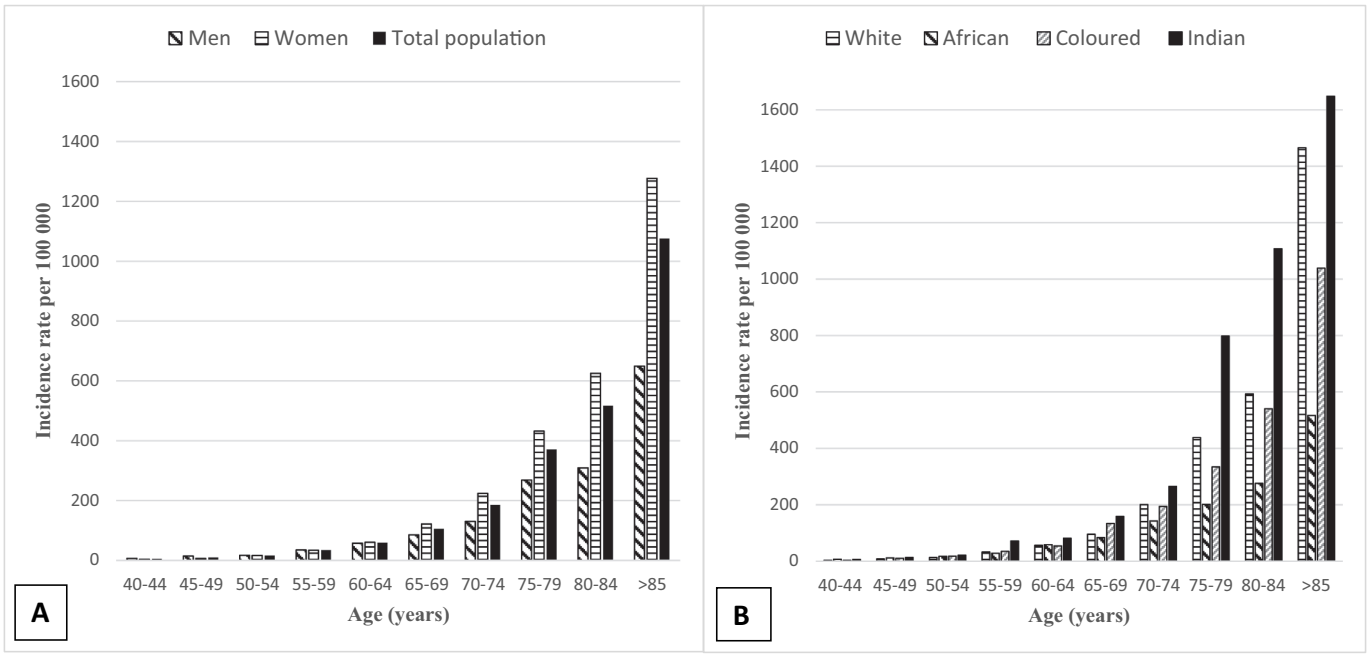

Fig. 1. Age standardised incidence rates for South African men and women (A) and ethnic groups (B).
Results presented in 5 year age bands

In addition, the warmer sub-tropical climate may result in lifestyle differences with more exposure to sunlight, higher vitamin D levels and a lower fall risk compared to their European counterparts. An increase in falls and hip fractures has been reported with increasing latitude in Sweden [35] and latitude is a significant risk factor for vitamin D deficiency [36]. In addition, genetic factors may play a role.

The IR of hip fractures in Africans (43·6 per 100,000 in women and 31·1 per 100,000 in men, respectively), is substantially higher than that originally reported by Solomon in the 1960's (4·3 per 100,000 in women, 6·9 per 100,000 in men) [11]. The rate when calculated for subjects aged 60 years and over is also substantially higher (96 per 100,000) than that reported by Paruk et al., (63·7 per 100,000) [12]. Several studies have reported a lower HF incidence in Africans and African Americans compared to the White population [9,13,19]. Higher BMD at the proximal femur [19], a shorter HAL, intrinsic differences in trabecular and cortical bone histomorphometry [37], genetic, environmental, and nutritional factors as well as higher mortality rates in developing countries [38] may be contributing factors to the low incidence in Africans. Importantly though, Africans constitute the largest proportion of the SA population [16] and despite the lowest rate of fractures, had the second highest number of fractures in absolute terms.

In this study Coloured population subjects had a lower incidence of HFs than did White and Indian subjects, despite highest rates of smoking (38% in women and 49.3% in men) [21]. This community is heterogeneous with a diverse genetic background and it is possible that the IR will vary within the group dependent on genetic factors. In our study subjects self-identified as Coloureds. Data on bone health in the SA Coloured population are limited. A single study suggested similar BMD in Coloured and White women [20].

Although data on hip fracture incidence in Indian women are sparse, the current IR of 147·7 per 100,000 in South African Indian women compares to a regional study from the Rohtak district, North India (159 per 100,000) as does the exponential rise in HF incidence in the 7th, 8th and 9th decades [39]. The IR is however significantly lower compared to Singaporean Indian women (361 per 100,000) [14], alluding to geographic and environmental influences. The Indian population has been in SA for nearly 160 years and has adopted the local culture, including a more westernized diet compared to the traditional fibre-rich diet and low calcium diet of Indians on the subcontinent [40].

The hip fracture IRs for the White and Indian populations in this study are is very similar (Table 2). The IR for the Indian population is second highest throughout the age bands, with Indian women have the highest hip fracture IR from the age of 50 years onwards (Fig. 2). Similarly, Indian men also have the highest IR above the age of 50 years with the exception of a higher IR in white men in the over 85-year age band (Fig. 2). This suggests that the fracture risk is highest in the Indian ethnic group in both adult women and men older than 50 years with the exception of a higher risk in much older white men.

Incidence rates for men in this study followed the same ethnic pattern as for women, with White men having the highest incidence (76·5 per 100,000) followed by Indian (69·2 per 100,000), Coloured (39·7 per 100,000) and African subjects (31·1 per 100,000). The IR in older men, in keeping with global trends, was lower than in older women. This is thought to be due to genetically determined higher peak bone mass in men, absence of accelerated menopause-associated bone loss, less propensity to fall and reduced LE in men compared to women, despite the higher prevalence of alcohol intake and smoking in men [41]. The higher IR of hip fractures in younger men in this study is in accordance with data from Cameroon [8] and global trends. Possible reasons for this include differences in lifestyle, especially smoking and alcohol consumption, trauma rates and the effect of HIV/AIDS.

Age adjusted IRs are consistently higher in females after the age of 60 years with an exponential increase in both genders with ageing. Near half of all HFs (42%, 811/1914) occurred in females ≥80 years, thus highlighting the major contribution of age to HF risk especially in females. The average age at fracture for women and men in this study is lower than that in developed countries, and will influence local screening and treatment guidelines.

5. Limitations

The strengths of this study are the large sample size, which includes participants from all ethnic groups, and the care taken to include all private and public health facilities in the study sites. There are, however, limitations. The study was conducted in urban areas within three provinces and it is possible that the IR may differ in the rural populations. Some patients with HFs may not have been able to access hospital care due to lack of transport and financial support, and thus not

Table 3
Age standardised incidence rates of hip fractures in five-year age bands for South African men and women stratified by ethnicity.

White men							White women					
Age bands in years	Number of fractures	At risk population	IR per 100·000	Relative risk ratio (95% CI)	SA overall population	ASR per 100·000 for SA	Number of fractures	At risk population	IR per 100·000	Relative risk ratio (95% CI)	SA overall population	ASR per 100·000 for SA
40–44	4	65,318	6·1	Referent	171,997	1·0	0	69,371	0·00		179,477	0·0
45–49	3	59,018	5·1	0·8 (0·19–3·71)	156,902	0·8	7	65,207	10·7	Referent	168,283	1·5
50–54	6	59,261	10·1	1·7 (0·47–5·85)	157,248	1·5	10	64,798	15·4	1·4 (0·55–3·78)	167,291	2·2
55–59	16	54,057	29·6	4·8 (1·67–14·45)	141,607	4·0	21	60,192	34·9	3·3 (1·39–7·64)	153,989	4·6
60–64	25	51,573	48·5	7·9 (2·75–22·7)	130,050	6·1	36	57,119	63·0	5·9 (2·61–13·18)	143,607	7·7
65–69	25	42,320	59·1	9·6 (3·36–27·7)	106,772	6·1	61	47,643	128·0	11·9 (5·45–26·03)	120,536	13·1
70–74	41	31,723	129·2	21·1 (7·55–58·8)	78,970	9·8	99	38,055	260·2	24·2 (11·24–52·00)	94,464	20·8
75–79	63	20,274	310·7	50·6 (18·42–139)	49,839	14·9	147	27,673	531·2	49·2 (23·07–105·00)	67,083	30·2
80–84	49	12,607	388·7	63·2 (22·83–175)	29,264	10·9	149	20,801	716·3	66·3 (31·07–141·30)	47,809	29·0
> 85	77	7942	969·5	156·8 (57·4–428)	17,238	16·1	294	17,375	1692·1	155·0 (73·30–328·00)	37,711	54·1
Total	309	404,093	76·5		1,039,887		824	468,234	175·9		1,180,250	
African men							African women					
40–44	21	266,057	7·9	Referent	1,021,704	1·9	14	258,565	5·4	Referent	1,143,034	1·1
45–49	34	196,582	17·3	2·2 (1·27–3·77)	854,749	3·6	13	223,477	5·8	1·1 (0·51–2·29)	1,047,384	1·1
50–54	32	149,935	21·3	2·1 (4·56–4·69)	698,391	3·6	24	175,333	13·7	2·5 (1·31–4·89)	861,535	2·2
55–59	34	112,414	30·3	3·8 (2·22–6·60)	551,836	4·0	35	134,817	26·0	4·8 (2·58–8·90)	690,365	3·3
60–64	41	73,363	55·9	7·1 (4·18–11·97)	393,074	5·3	56	92,423	60·6	11·2 (6·23–20·10)	520,367	5·8
65–69	30	37,203	80·6	10·2 (5·85–17·82)	237,856	4·6	47	55,371	84·9	15·7 (8·63–28·44)	363,204	5·7
70–74	26	23,774	109·4	13·8 (7·79–24·60)	177,401	4·7	68	42,230	161·0	29·7 (16·7–52·80)	308,451	9·1
75–79	26	12,898	201·6	25·5 (14·35–45·30)	95,293	4·6	55	27,287	201·6	37·2 (20·67–66·80)	215,415	8·0
80–84	12	7414	161·9	20·5 (10·08–41·60)	61,937	2·4	56	17,262	324·4	59·7 (33·3–107·20)	156,208	9·3
> 85	20	6803	294·0	37·1 (20·15–68·50)	51,746	3·7	86	13,711	627·2	115·1 (65·5–202·40)	128,774	14·9
Total	276	886,443	31·1		4,143,987		454	1,040,476	43·6		5,434,737	
Coloured men							Coloured women					
40–44	5	93,895	5·3	Referent	149,805	1·3	0	107,522	0·0		169,473	0·0
45–49	12	86,502	13·9	2·8 (0·82–5·78)	135,644	2·9	7	101,936	6·9	Referent	158,823	1·4
50–54	8	72,584	11·0	1·7 (0·60–4·97)	113,879	1·9	20	86,211	23·2	3·4 (1·43–7·98)	133,656	4·0
55–59	19	52,941	35·9	5·6 (2·24–14·05)	84,224	4·8	22	65,002	33·9	4·9 (2·11–11·53)	101,924	4·5
60–64	26	38,028	68·4	10·7 (4·4–25·97)	60,552	6·6	21	49,013	42·9	6·2 (2·65–14·66)	76,499	4·3
65–69	23	23,646	97·3	15·2 (6·2–37·3)	37,411	5·8	47	28,774	163·3	23·8 (10·74–52·50)	48,875	10·4
70–74	23	15,402	149·3	23·3 (9·5–57·3)	24,668	5·8	51	22,656	225·1	32·7 (14·85–72·00)	35,643	10·4
75–79	17	8501	199·9	31·2 (12·32–79·2)	13,698	4·3	62	15,123	409·9	59·5 (27·23–129·80)	23,743	12·6
80–84	11	3961	277·7	43·3 (16·04–117)	6371	2·8	55	8251	666·6	96·4 (43·95–211·60)	12,907	11·2
> 85	14	2529	553·6	86·2 (33·15–224)	4531	3·9	74	5944	1244·9	179·0 (82·60–388·40)	10,060	16·2
Total	158	397,989	39·7		630,783		359	490,432	73·2		771,603	
Indian men							Indian women					
40–44	1	33,869	2·9	Referent	48,048	0·7	3	35,210	8·5	Referent	47,856	1·6
45–49	6	29,603	20·3	6·9 (0·83–57)	41,110	3·8	2	33,413	5·9	0·7 (0·12–4·20)	44,511	1·1
50–54	7	26,370	26·6	8·9 (1·11–73)	36,044	4·4	5	30,029	16·7	1·9 (0·467–8·17)	39,739	2·7
55–59	15	22,148	67·7	22·9 (3·03–173·40)	29,961	9·3	20	26,805	74·6	8·8 (2·6–29·43)	35,371	10·6
60–64	13	19,018	68·4	23·1 (3·03–176·70)	25,353	7·9	21	22,904	91·7	1·75 (3·21–36)	29,841	10·9
65–69	21	12,847	16·5	55·3 (7·44–410·50)	17,160	1·9	25	16,215	154·2	18·07 (5·46–59·80)	21,117	13·1
70–74	13	7891	164·7	55·7 (7·3–43)	10,629	8·0	37	10,974	337·2	39·44 (12·17–127·80)	14,455	19·6
75–79	17	4063	418·4	141 (18·8–1·06)	5390	10·4	67	6463	1036·7	120·4 (37·9–382·60)	8564	35·7
80–84	8	1901	420·8	142 (17·78–1·13)	2583	4·9	51	3426	1488·6	172 (53·8–55)	4572	27·4
> 85	9	1204	747·5	251·3 (31·9–1·98)	1621	5·6	46	2133	2156·6	248 (77·2–80)	2858	24·8
Total	110	158,914	69·2		217,899		277	187,572	147·7		248,884	

ASR: age standardised rate; CI: confidence interval; IR: incidence rate; SA: South Africa.
Direct standardisation (actual number of fractures divided by the at-risk population) was used to calculate age-specific incidence rates based on the age structure of each ethnic group. The relative risk ratio of fracture with 95% confidence intervals was calculated for each ethnic group in 5-year intervals, using the reference group indicated.

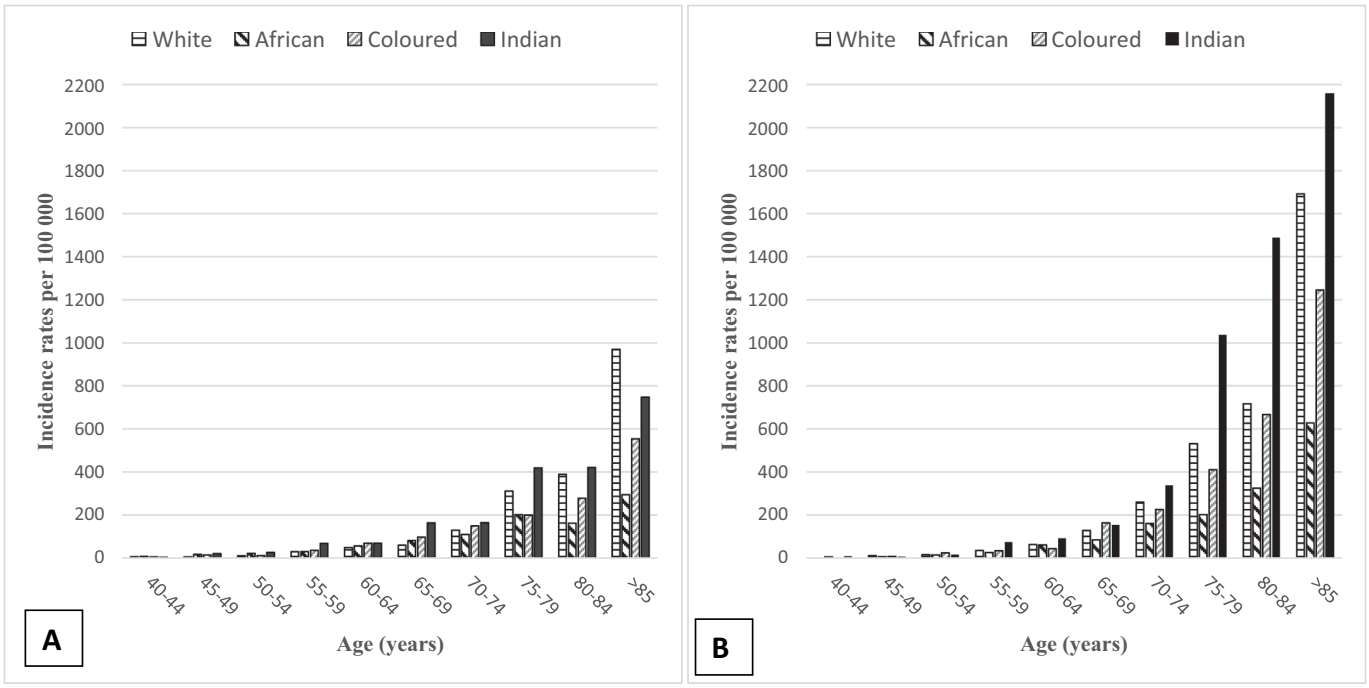

Fig. 2. Age standardised incidence rates according to ethnicity in South African men (A) and women (B).

included in the study population. Census data were obtained from 2011, this was the last available census data at the start of the study. Current estimates project an increase in the population to around 58 million, largely due to migration. However, the ethnic breakdown of the population has not changed substantially, and incidence rates are unlikely to be affected.

6. Conclusion

This study, the first to investigate hip fracture incidence rates in the major ethnic groups in SA, confirms the ethnic differences in HF incidence rates in SA, as shown in other multi-ethnic populations. Hip fracture IRs were highest in White and Indian populations compared to the Coloured and African populations. Consistent with the published literature, the overall hip fracture IR was higher in women than in men, except in the younger age groups, and increased with age. Further studies are required to determine risk factors for hip fractures in the different ethnic groups. Together with health economic analyses, these incidence data will influence the calibration and intervention thresholds for FRAX® models for SA. There is a dearth of HF incidence data from the rest of the countries in SSA, and these data may be used as proxy data for developing risk assessment models for countries with similar ethnic populations.

Declaration of competing interest

Professor B Cassim received local travel grant from Servier Laboratories South Africa (Pty) Ltd.

All other authors report no conflict of interests.

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Appendix A. Supplementary data

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References

[1] D. Bradshaw, M. Schneider, R. Dorrington, D.E. Bourne, R. Laubscher, South African cause-of-death profile in transition - 1996 and future trends, S. Afr. Med. J. 92 (2002) 618–623.
[2] H. Coovadia, R. Jewkes, P. Barron, D. Sanders, D. McIntyre, The health and health system of South Africa: historical roots of current public health challenges, Lancet 374 (2009) 817–834, https://doi.org/10.1016/S01406736(09)60951-X.
[3] Statistics South Africa. Mid-year population estimates, Available online at www.statssa.gov.za, (2018) Accessed on 29 January 2019.
[4] B. Nojilana, D. Bradshaw, V. Pillay-van Wyk, et al., Emerging trends in non-communicable disease mortality in South Africa. 1997–2010, S. Afr. Med. J. 106 (2016) 477–484, https://doi.org/10.7196/SAMJ.2016.v106i4.10674.
[5] S.R. Cummings, L.J. Melton, Epidemiology and outcomes of osteoporotic fractures, Lancet 359 (2002) 1761–1767, https://doi.org/10.1016/S0140-6736(02)08657-9.
[6] J.A. Kanis, A. Oden, O. Johnell, et al., The use of clinical risk factors enhances the performance of BMD in the prediction of hip and osteoporotic fractures in men and women, Osteoporos. Int. 18 (2007) 1033–1046, https://doi.org/10.1007/s00198-007-0343-y.
[7] WHO Collaborating Centre for Metabolic Bone Diseases, University of Sheffield Medical School, FRAX® fracture risk assessment tool, Available online at https://www.sheffield.ac.uk.
[8] R.M. Zebaze, E. Seeman, Epidemiology of hip and wrist fractures in Cameroon, Africa, Osteoporos. Int. 14 (2003) 301–305, https://doi.org/10.1007/s00198-002-1356-1.
[9] T.J. Aspray, A. Prentice, T.J. Cole, Y. Sawo, J. Reeve, R.M. Francis, Low bone mineral content is common but osteoporotic fractures are rare in elderly rural Gambian women, J. Bone Miner. Res. 11 (1996) 1019–1025, https://doi.org/10.1002/jbmr.5650110720 Jul.
[10] E. Jervas, C.K. Onwukamuche, G.E. Anyanwu, A.I. Ugochukwu, Incidence of fall related hip fractures among the elderly persons in Owerri, Nigeria, Asian J. Med. Sci. 3 (2011) 110–114.
[11] L. Solomon, Osteoporosis and fracture of the femoral neck in the South African Bantu, J. Bone Joint Surg. (Br.) 50 (1968) 2–13 (PMID: 5641595).
[12] F. Paruk, G. Matthews, B. Cassim, Osteoporotic hip fractures in Black South Africans: a regional study, Arch. Osteoporos. 12 (2017) 107, https://doi.org/10.1007/s11657-017-0409-1.
[13] S.L. Silverman, R.E. Madison, Decreased incidence of hip fracture in Hispanics, Asians and Blacks: California hospital discharge data, Am. J. Public Health 78

(1988) 1482–1483, https://doi.org/10.2105/AJPH.78.11.1482.
[14] L.K. Koh, S.M. Saw, J.J. Lee, K.H. Leong, J. Lee, National working committee on osteoporosis. Hip fracture incidence rates in Singapore 1991–1998, Osteoporos. Int. 12 (2001) 311–318 (PMID: 11420781).
[15] D.S. Lauderdale, S.J. Jacobsen, S.E. Furner, P.S. Levy, J.A. Brody, J. Goldberg, Hip fracture incidence among elderly Hispanics, Am. J. Public Health 88 (1998) 1245–1247, https://doi.org/10.2105/ajph.88.8.1245.
[16] Statistics South Africa. Census, Available online at www.statssa.gov.za, (2011) Accessed 14 June 2017.
[17] J.P. Brown, R.G. Josse, Clinical practice guidelines for the diagnosis and management of osteoporosis in Canada, CMAJ 167 (2002) S1–34 (PMID: 12427685).
[18] E.D. Daniels, J.M. Pettifor, C.M. Schnitzler, S.W. Russell, D.N. Patel, Ethnic differences in bone density in female South African nurses, J. Bone Miner. Res. 10 (1995) 359–367.
[19] M. Conradie, M.M. Conradie, M. Kidd, S. Hough, Bone density in black and white South African women: contribution of ethnicity, body weight and lifestyle, Arch. Osteoporos. 9 (2014) 193, https://doi.org/10.1007/s11657-014-0193-0 (becomes 23).
[20] A.A. Kalla, A.B. Fataar, L. Bewerunge, Age-related loss of bone in South African females by means of the Hologic QDR 1000 system, S. Afr. Med. J. 84 (7) (1994) 398–405 (becomes 34).
[21] South African Demographic and Health Survey, Key indicators report, Available online at, 2016. https://www.statssa.gov.za/publications.
[22] S.Z. Kalula, M. Ferreira, G.H. Swingler, M. Badri, Risk factors for falls in older adults in a South African Urban Community, BMC Geriatr. 16 (2016) 51, https://doi.org/10.1186/s12877-016-0212-7.
[23] E.D. Daniels, J.M. Pettifor, C.M. Schnitzler, G.P. Moodley, D. Zachen, Differences in mineral homeostasis, volumetric bone mass and femoral neck axis length in black and white South African women, Osteoporos. Int. 7 (1997) 105–112.
[24] World Bank, GINI index (World Bank estimate), http://data.worldbank.org/indicator/SI.POV.GINI/countries, (2015) Accessed 27 November 2019.
[25] M. Aliber, Chronic poverty in South Africa: incidence, causes and policies, World Dev. 31 (3) (March 2003) 473–490, https://doi.org/10.1016/S0305-750X(02)00219-X.
[26] M. Chopra, S. Drimie, C. Witten, Combating Malnutrition in South Africa. Global Alliance for Improved Nutrition, Global Alliance for Improved Nutrition (GAIN), 2009 (Working Paper Series).
[27] E. Van Tonder, L. Gardner, S. Cressey, R. Tydeman-Edwards, K. Gerber, Adult malnutrition: prevalence and use of nutrition-related quality indicators in South African public-sector hospitals, South African J. Clin. Nutr. 32 (1) (2019) 1–7, https://doi.org/10.1080/16070658.2017.1410003.
[28] D. Evans, M. Maskew, I. Sanne, Increased risk of mortality and loss to follow-up among HIV-positive patients with oropharyngeal candidiasis and malnutrition before antiretroviral therapy initiation: a retrospective analysis from a large urban cohort in Johannesburg, South Africa, Oral Surg. Oral Med. Oral Pathol. Oral Radiol. 113 (3) (2012) 362–372, https://doi.org/10.1016/j.oooo.2011.09.004 Mar.
[29] E.M. Balk, G.P. Adam, V.N. Langberg, A. Earley, P. Clark, P.R. Ebeling, et al., Global dietary calcium intake among adults: a systematic review, Osteoporos. Int. 28 (2017) 3315–3324, https://doi.org/10.1007/s00198-017-4230-x.
[30] J. Compston, Osteoporosis and fracture risk associated with HIV infection and treatment, Endocrinol. Metab. Clin. N. Am. 43 (2014) 769–780, https://doi.org/10.1016/j.ecl.2014.05.001.
[31] R.L. McGraw, J.E. Riggs, Osteoporosis, sedentary lifestyle, and increasing hip fractures: pathogenic relationship or differential survival bias, Calcif. Tissue Int. 55 (2) (1994) 87–89. Aug.
[32] B.R. Singer, G.J. McLauchlan, C.M. Robinson, J. Christie, Epidemiology of fractures in 15,000 adults. The influence of age and gender, J. Bone Joint Surg. 80 (1998) 243–248 (PMID: 9546453).
[33] A. Lalmohamed, P.M.J. Welsing, W.F. Lems, et al., Calibration of FRAX ® 3.1 to the Dutch population with data on the epidemiology of hip fractures, Osteoporos. Int. 23 (2012) 861–869, https://doi.org/10.1007/s00198-011-1852-2.
[34] Erasmus JC, Klingenberg A, Greeff JM. Allele frequencies of AVPR1A and MAOA in the Afrikaner population. S. Afr. J. Sci. 2015;111(7/8), Art. #2015-0074, 6 pages. doi:10.17159/sajs.2015/20150074.
[35] A. Odén, J.A. Kanis, E.V. McCloskey, H. Johansson, The effect of latitude on the risk and seasonal variation in hip fracture in Sweden, J. Bone Miner. Res. 29 (10) (2014) 2217–2223, https://doi.org/10.1002/jbmr.2250 October.
[36] P.F. Leary, I. Zamfirova, J. Au, W.H. McCracken, Effect of latitude on vitamin D levels, J. Am. Osteopath. Assoc. 117 (7) (2017) 433–439 July.
[37] C.M. Schnitzler, J.M. Mesquita, Cortical bone histomorphometry of the iliac crest in normal black and white South African adults, Calcif. Tissue Int. 79 (2006) 373–382, https://doi.org/10.1007/s00223-006-0053-z.
[38] World Bank open data, Available online at https://data.worldbank.org/indicator/.
[39] D.K. Dhanwal, R. Siwach, V. Dixit, A. Mithal, K. Jameson, C. Cooper, Incidence of hip fracture in Rohtak district, North India, Arch. Osteoporos. 8 (135) (2013), https://doi.org/10.1007/s11657-013-0135-2.
[40] A.V. Khadilkar, R.M. Mandlik, Epidemiology and treatment of osteoporosis in women: an Indian perspective, Int. J. Women's Health (7) (2015) 841–850, https://doi.org/10.2147/IJWH.S54623.
[41] J.A. Cauley, P.M. Cawthon, K.E. Peters, et al., Osteoporotic fractures in men (MrOS) Study Research Group. Risk factors for hip fracture in older men: the Osteoporotic Fractures in Men Study (MrOS), J. Bone Miner. Res. 31 (2016) 1810–1819, https://doi.org/10.1002/jbmr.2836.