The prevalence of osteoporosis in patients referred for DEXA scans at Helen Joseph hospital: A retrospective descriptive analysis.

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A research project submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Medicine (MMed) in Internal Medicine

9 October 2024

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Declaration: Students Contribution To Article(S) And Agreement Of Co-Author(S)

I, Karli Rachelle Anavi, student number 668976, declare that this research report is my own work. I have independently contributed adequately towards the research findings published in my article.

Signature of student  Date: 9 October 2024

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Declaration

I, Karli Rachelle Anavi declare that this research is my own, unaided work. It is being submitted for the Degree Master of Medicine (MMed) in Internal Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before any degree or examination at any other University.

Karli Anavi

Signed on this day of 9th October 2024 in Johannesburg

Dedication

I dedicate this work to my family for their unwavering support and encouragement.

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I express my sincere thanks to my supervisors:

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Chapter 2: Manuscript

The prevalence of osteoporosis in patients referred for DEXA scans at Helen Joseph Hospital: A retrospective descriptive analysis

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Abstract

Purpose: Osteoporosis and fragility fractures are expected to rise in a rapidly aging South African population. However, there is limited prevalence and fracture data currently available.

Methods: We assessed the prevalence of osteoporosis from all Dual-energy X-ray absorptiometry (DXA) scans done on referral at Helen Joseph Hospital in Johannesburg, Gauteng. All DXA scans between 01 January 2006 and 31 December 2021 were analysed. The World Health Organization (WHO) criteria were used to diagnose osteoporosis. Demographics, body parameters, and DXA measurements were collected.

Results: Out of 2266 DXA scans analysed, 880 were osteoporotic (females 96.4%; males 3.6%). Overall, the prevalence of osteoporosis was 38.8% (CI 38.6-40.8). The incidence increased with age. Bone mineral density (BMD) T - scores were lower in subjects with lower body mass index (BMI). The vertebral body with the greatest prevalence of fractures was thoracic level T12. Wedge deformities occurred more often at the levels of T12, T8, and T7, compared to biconcave deformities which were seen in lower lumbar vertebrae L1- L3 levels. There were no significant differences when comparing T scores by various bony regions between males and females above age 50.

Conclusion: Prevalence amongst those referred for DXA scans in this study was high however a true prevalence could not be appreciated due to the nature of the sampling. Further studies identifying the indications and risk factors in these patients will aid in understanding the epidemiology of osteoporosis in our context. Vertebral fracture prevalence varied at different vertebral body levels with the highest prevalence occurring at the level of T12. Underweight patients had more severe osteoporosis. Screening programs need emphasis and integration into routine clinical services. Further research, data capturing, and a fracture liaison service are needed to improve bone health in South Africa.

Keywords:

bone mineral density (BMD); dual-energy X-ray absorptiometry (DXA); osteoporosis

Introduction

Osteoporosis is the most common skeletal disorder seen in adults. It is characterized by low bone mass which predisposes to fragility fractures.(1) Osteoporosis is becoming an important public health concern as the population continues to grow with higher life expectancy rates worldwide.(1) It has recently been labeled as "the silent epidemic", as bone loss generally develops without any signs or symptoms.(2) For decades osteoporosis was assumed to be rare in sub-Saharan Africa (SSA), however, data is limited in this region.(3) Healthcare in SSA is further complicated by scarce resources and poor social infrastructure.(4)

Osteoporosis often goes undetected until there is a complication, typically a fracture.(1) Fractures hugely impact patients' quality of life and have significant cost implications on both the patients and the public health care system.(5) Hip fractures have devastating outcomes in South Africa (SA) with high one-year post fracture mortality rates of approximately 30% compared to international rates of 20%. (6,17) More than 50% of patients do not return to pre-fracture levels of independence and 15-29% are admitted into frail care. (6) Despite its consequences, osteoporosis remains a neglected disease.(7) A lack of awareness from both healthcare workers and the general population further conceals the extent of the condition.(7)

SA is a multi-ethnic population with a two-tiered health care system (both private and public services), and the use of facilities varies by socioeconomic status (3). Furthermore, within the public sector, there is poor availability of imaging techniques outside of tertiary institutions. (8) Specific risk factors identified in South African studies include having more than three pregnancies, low physical exercise, socioeconomic factors, type of contraceptive use, calcium and fat intake, and differences in bone geometry and genetics (7). Importantly, there are marked ethnic differences in body weight and bone geometry and previous studies have noted higher bone mineral density (BMD) measurements in the black population correlating to weight (4).

A recent publication on aging trends by the United Nations (UN) noted that the older adult population in Africa will develop tremendously with an estimated rise of 235.1 million between 2020 and 2050.(8) In order to prevent complications, the South African healthcare system needs to screen and diagnose osteoporosis routinely. The World Health Organization(WHO) has too emphasised these efforts as a priority.(9)

According to the National Osteoporosis Foundation of South Africa (NOFSA) guidelines, women older than 65 and men older than 70 should be screened for osteoporosis, regardless of additional risk factors.(10) Other indications for screening include known secondary causes of osteoporosis, previous individual or family history of fragility fractures, or strong clinical predictors.(10) Early diagnosis is key since treatment can reverse the progression of the disease and is readily available.(1) Modifiable risk factors include smoking, alcohol use, low physical activity, nutritional status and low body mass index (BMI). (10)

Dual-energy X-ray absorptiometry (DXA) is the gold standard and most widely used approach to measure BMD which is used for diagnosing osteoporosis.(11) T scores are calculated from BMD values and a diagnosis is made by using the standard deviation (SD) from the mean reference population.(12) The reference population is data from the National Health and Nutrition Examination Survey (NHANES) for Caucasian females aged 20 – 29, using femoral neck BMD which is the recommended standard from the WHO.(13) T scores of less than -2.5 are diagnostic of osteoporosis.(14) The lowest BMD value obtained is used to make a diagnosis (10). T scores are used in post-menopausal women whilst Z scores are used in pre-menopausal women and men below the age of 50 years (10).

South African studies few have highlighted a higher incidence of hip fractures in White and Indian populations compared to the Coloured and African populations (3). A recent study by Paruk et al., investigating the prevalence of hip fractures amongst black South Africans showed age-adjusted hip fracture rates of 69.2 per 100,000 per annum for women and 73.1 per 100,000 per annum for men (3). Vertebral fractures found on DXA scans may be the only sign of established osteoporosis and are important in predicting future fracture risks (10). In a study

by Conradie et al. vertebral fractures occurred at a similar percentage in black (9 %) and white (5.1 %) women (4).

There are few South African-specific osteoporosis prevalence studies. In the hopes of providing insight, this study aims to determine the prevalence of osteoporosis at a tertiary hospital in SA and the overall profile of vertebral deformities.

Methods

Study design and setting

A retrospective cross-sectional design was utilized in this study, which involved analysing data from all patients referred for DXA scans at Helen Joseph Hospital in Johannesburg, Gauteng between 1 January 2006 to 31 December 2021. Helen Joseph Hospital serves as a referral center for the greater central Johannesburg region. The study included both male and female patients above the age of 18 years who were referred for a DXA scan. Among them, those diagnosed with osteoporosis (postmenopausal females used a BMD T score of ≤ -2.5 on DXA, while pre-menopausal females and males under the age of 50 used a BMD Z score < 2.0 to highlight low bone density), underwent further sub-analysis. The exclusion criteria encompassed incomplete data records, a diagnosis of osteopenia (BMD T score between -1.0 and -2.5), and a diagnosis of normal bone density (BMD T score within 1 SD of 1.0). Patient consent was not required from patients since all information was extracted directly from DXA reports. The study protocol received approval from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (HREC ref R14/49) and by the research committee at Helen Joseph Hospital.

Data collection

DXA machine Hologic Discovery W, serial number 82016, with QDR System Software version 12.5 was used for all scan reports. The same machine was used throughout the 15-year period. All scans were performed by trained radiographers with daily quality control scans to ensure accuracy prior to formal scans. Data regarding demographic characteristics, including age, sex, weight, and height, were gathered. Weight was measured using a calibrated electronic scale, while height was measured using a stadiometer. The scan results for each variable are

calculated on a computerized system outlined by the manufacturer's user manual. Once an individualized radiation dose is given to patients based on their body parameters, the computerized system generates a report of the calculated T and Z scores at each bony region. It also performs a lateral vertebral assessment on individual vertebral bodies between T6-L4 to identify vertebral body deformities. Any duplicate scans for the same patient in the study period were removed, utilizing the first scan in the assessment.

Demographic information and data measurements were obtained from each scan report. Body mass index (BMI) was calculated using the metric system, dividing the weight in kilograms by the square of the height in meters (kg/m^2). BMI values were categorized based on the World Health Organization (WHO) classification: underweight ($\leq$18.49 kg/m^2), normal weight (18.5 - $\leq$24.99 kg/m^2), overweight (25 - $\leq$29.99 kg/m^2), and obese ($\geq$30 kg/m^2).(15) DXA scan parameters such as T scores and Z scores for each bony region including anteroposterior (AP) spine, left and right femoral necks, total hips and bilateral hip average were collected. Vertebral evaluations from T6-L4 were collected, and each vertebral level was characterized as normal or deformity. If a deformity was found, it was further classified by sub-type (wedge or biconcave) and by severity (mild or moderate or severe) adapted from Genant's vertebral fracture assessment.(16)

BMD measurements

For all the participants, computerized BMD values at various bony regions including the AP spine, the left and right femoral necks, total hip, and bilateral averages of total hip were measured and converted into T and Z scores based on their SD from the mean. T score is calculated by comparing the BMD to the reference healthy population of same sex while Z score is calculated by comparing the BMD to the average BMD of same age, sex and size. (10)

Criteria for diagnosing osteoporosis

Osteoporosis diagnosis followed the standard guidelines outlined by the WHO. (10) Osteoporosis was classified based on a T score of $\leq$ -2.5 standard deviations (SDs) from the reference mean value, with the most negative value selected from the accepted skeletal

sites.(12) Female participants who were post-menopausal and males over the age 50 with a T score ≤ -2.5 were diagnosed with osteoporosis. Female participants who were premenopausal and males under the age of 50 were considered to have low bone density for age with a Z score of < 2.0. Importantly no evidence-based recommendations can be made on the interpretation of BMD data in males over the age of 50 (10).

Statistical Analysis

SPSS (Statistical Product and Service Solutions) software version 25 was utilized for statistical analysis. The study used descriptive statistics to summarize categorical variables (sex, age group, BMI categories, and vertebral evaluation) and continuous variables (age, T scores, height, and weight). Continuous variables were represented using mean ± SD. Prevalence rates were represented using percentages (%) with a 95% confidence interval (CI). Comparison of osteoporosis by skeletal region according to BMI and sex was performed using a chi-square independence test. To compare sex differences in continuous variables such as weight, height, and age, a t-test was employed. One-way analysis of variance compared mean values across multiple categories (e.g., BMI categories). Statistical significance was defined as a probability value (p) of < 0.05. Any absent or incomplete data from participants resulted in their exclusion from the analysis. With a desired 5% margin of error and a 95% CI, the estimated required sample size was approximately 384.16.

Results

DXA results of 2853 patients were analysed, 587 DXA scans were excluded as there was incomplete data. Of the remaining 2264 scans that were analysed, 2166 were of female patients and the remaining 98 were of male patients. 880 were osteoporotic based on having a T score of ≤ -2.5 in those who were postmenopausal, and men over the age of 50 and those that were pre-menopausal and men under the age of 50 a Z score of ≤ -2.0 was used. 944 were osteopenic and 442 had normal DXA scans (Figure 1). The overall prevalence of osteoporosis was 38.8% (95% CI 36- 40.8%). Of the 2166 women, the prevalence of osteoporosis was 39.1% (95% CI 37- 41.1%). The prevalence in the 98 men was 32.3% (95% CI 23.1- 41.5%). Only subjects with a diagnosis of osteoporosis were further analyzed.

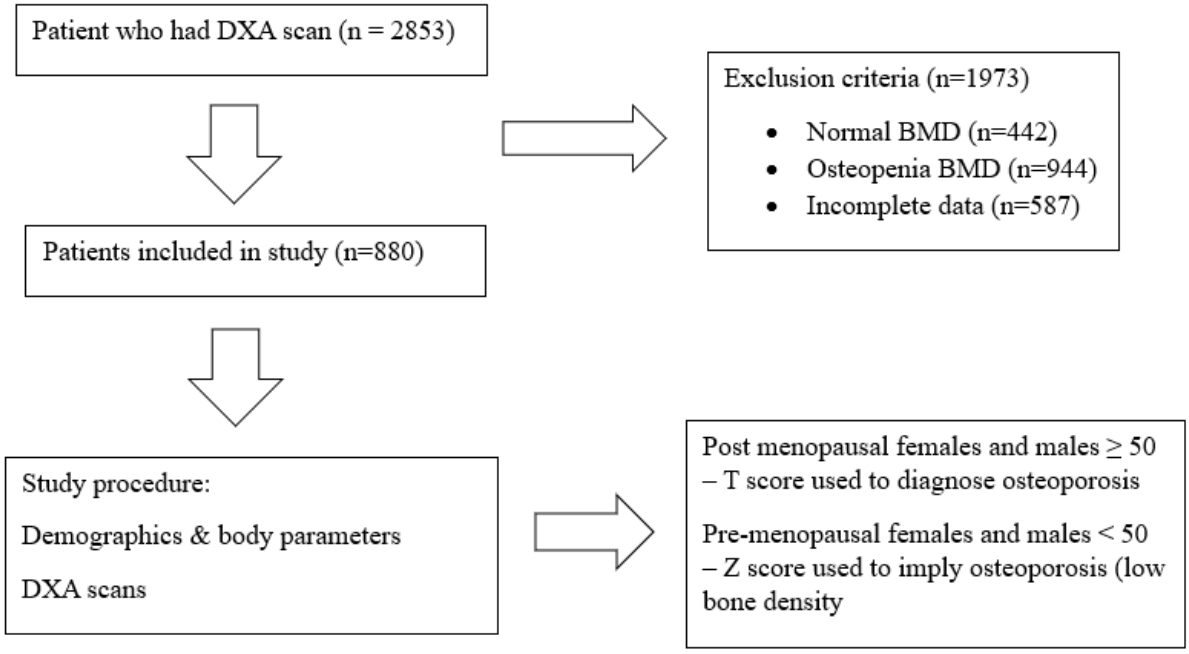

Figure 1: Flow chart of included subjects

A sub-analysis was conducted on 880 osteoporotic patients, consisting of 848 women (96.4%) and 32 men (3.6%). The overall mean age of the patients was 71.9 ± 12.5 years, with women having a mean age of 72.1 ± 12.4 years and men having a mean age of 66.4 ± 14.5 years. Among the sample, 792 patients (90%) were aged 50 years or older, and 609 patients (69.2%) were over the age of 60. As age increased, the prevalence of osteoporosis showed an increasing trend in both sexes ($p<0.003$). The average height for women was 1.5m ± 0.1m, while for men it was 1.6m ± 0.3m. Women had a mean weight of 64.6 kg ± 18.6 kg, whereas men had a mean weight of 76.2 kg ± 28.1 kg. Regardless of sex, more than half of the osteoporotic patients (56.3%) were categorized as overweight or obese. Additional findings can be found in Table 1.

Table 1: Demographics of the study subjects

		Total (n=880)	Women (n=848)	Men (n=32)	P value
		mean (SD), count (%)	mean (SD), count (%)	mean (SD), count (%)	
Age, year		71.9 (12.5)	72.1 (12.4)	66.4 (14.5)	0.036
Height, m		1.5 (0.1)	1.5 (0.1)	1.6 (0.3)	0.027
Weight, kg		65.0 (19.1)	64.6 (18.6)	76.2 (28.1)	0.001
Age Group	≤ 39	55 (6.3)	48 (5.7)	7 (21.9)	0.001
	40 - 49	33 (3.8)	29 (3.4)	4 (12.5)	
	50 - 59	183 (20.8)	175 (20.6)	8 (25)	
	60 - 69	298 (33.9)	290 (34.2)	8 (25)	
	70 - 79	233 (26.5)	230 (27.1)	3 (9.4)	
	≥ 80	78 (8.9)	76 (9)	2 (6.3)	
Menopause	Pre & peri (age<50)		77 (9.1)		
	Post (age≥60 ≥50)		771 (90.9)		
BMI Categories	Underweight	70 (8)	68 (8)	2 (6.3)	0.917
	Normal	315 (35.7)	302 (35.5)	13 (40.6)	
	Overweight	272 (30.9)	262 (31)	10 (31.3)	
	Obese	223 (25.4)	216 (25.5)	7 (21.9)	

T score analysis was only conducted on patients who were above the age of 50. 88 patients under the age of 50 were removed from the related statistical analysis. According to sex the mean BMD was analysed at each skeletal site (Table 2). Sex comparison revealed no statistically significant differences. The most severe T scores were noted in the AP spine region with mean T scores of -2.8 ±1.2 and -2.7 ±1.1 in women and men respectively. The bilateral hip average regions were equally affected in both women and men with no statistical significance.

Table 2: T scores of regions of osteoporotic subjects by sex

Bone region	Total (n=792) mean (SD)	Women (n=848) mean (SD)	Men (n=32) mean (SD)	P-value
AP spine	-2.8 (1.2)	-2.8 (1.2)	-2.7 (1.1)	0.594
Left femoral neck	-2.3 (1.2)	-2.3 (1.3)	-2.4 (0.6)	0.697
Right femoral neck	-2.4 (0.8)	-2.4 (0.8)	-2.3 (0.6)	0.428
Left total hip	-1.7 (1.5)	-1.7 (1.5)	-1.8 (0.7)	0.928
Right total hip	-1.9 (1.0)	-1.9 (1.0)	-1.6 (0.7)	0.280
Bilateral total average	-1.8 (1.1)	-1.8 (1.1)	-1.7 (0.7)	0.673

Overall, as BMI decreased toward the underweight category, the severity of osteoporosis increased, p-value <0.001 (Table 3). The underweight osteoporotic patients' most affected skeletal site was the AP spine followed by the total hip regions. Despite the majority of patients being overweight or obese, those who were underweight had more severe osteoporosis. The AP spine region was also the most affected area among the obese category of osteoporotic patients. The T scores of the AP spine region in the obese group were -2.5 ± 1.3, in the overweight group -2.8 ± 1, in the normal group -3.0 ± 1.2, and in the underweight group -3.2 ± 1.0.

Table 3: T scores of regions of osteoporotic subjects by weight category

Bone region	Total (n=879) mean (SD)	Underweight (n=70) mean (SD)	Normal (n=314) mean (SD)	Overweight (n=272) mean (SD)	Obese (n=223) mean (SD)	P-value
AP spine	-2.8 (1.2)	-3.2 (1.0)	-3.0 (1.2)	-2.8 (1.0)	-2.5 (1.3)	0.001
Left femoral neck	-2.3 (1.2)	-3.1 (0.9)	-2.6 (0.8)	-2.1 (1.6)	-2.0 (1.2)	0.001
Right femoral neck	-2.4 (0.8)	-3.1 (0.7)	-2.6 (0.7)	-2.3 (0.7)	-2.1 (0.9)	0.001
Left total hip	-1.7 (1.5)	-2.9 (0.7)	-2.1 (0.9)	-1.6 (1.8)	-1.1 (1.7)	0.001
Right total hip	-1.9 (1.0)	-2.9 (0.7)	-2.2 (0.9)	-1.7 (0.8)	-1.3 (1.0)	0.001
Bilateral total average	-1.8 (1.1)	-3.0 (0.7)	-2.2 (0.9)	-1.7 (1.1)	-1.2 (1.1)	0.001

The incidence of vertebral deformities varied among different vertebral levels. An exact prevalence rate could not be determined due to missing data, as not all osteoporotic patients had evaluations for vertebral deformities recorded at every level in the reports. An analysis of the available data is shown in Figure 2. The most affected vertebrae were the twelfth thoracic level with a total of 15.8% (118 of 747) and the first lumbar vertebrae with a total of 13.2% (99 of 751). The T12 level consisted of 118 fractures with 8.6% (64) wedge type and 7.2% (54) biconcave type. Wedge deformities occurred more often at the levels of T12, T8, and T7, compared to biconcave deformities which were seen in lower lumbar vertebrae L1- L3 levels. L1 had the most severe biconcave deformities at all levels 15.1% (15 of 99) fractures.

Age group comparison shown in Figure 3 showed that vertebral fracture frequency increased with age. Level T7 was significant as there is a higher proportion of deformities in the ≥ 80 age group (19.8%), compared to other groups ($p<0.009$). There was a statistically significant proportion of deformities among those that were ≤ 39 years compared to other age groups at levels L1 and L4 with 23.8% and 21.1% respectively. However, the small sample size in age group < 39 years old must be considered.

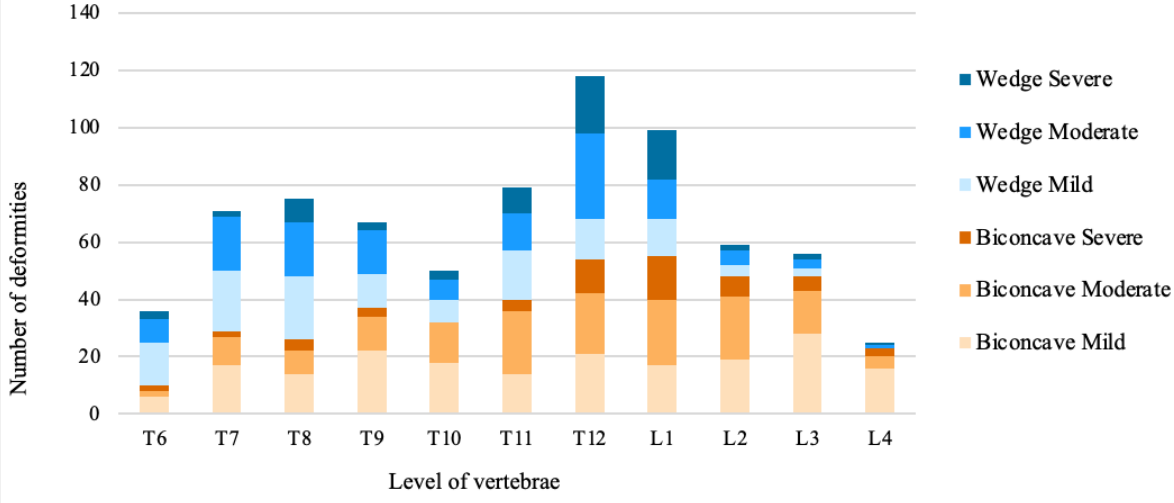

Figure 2: Vertebral deformity types amongst osteoporotic subjects

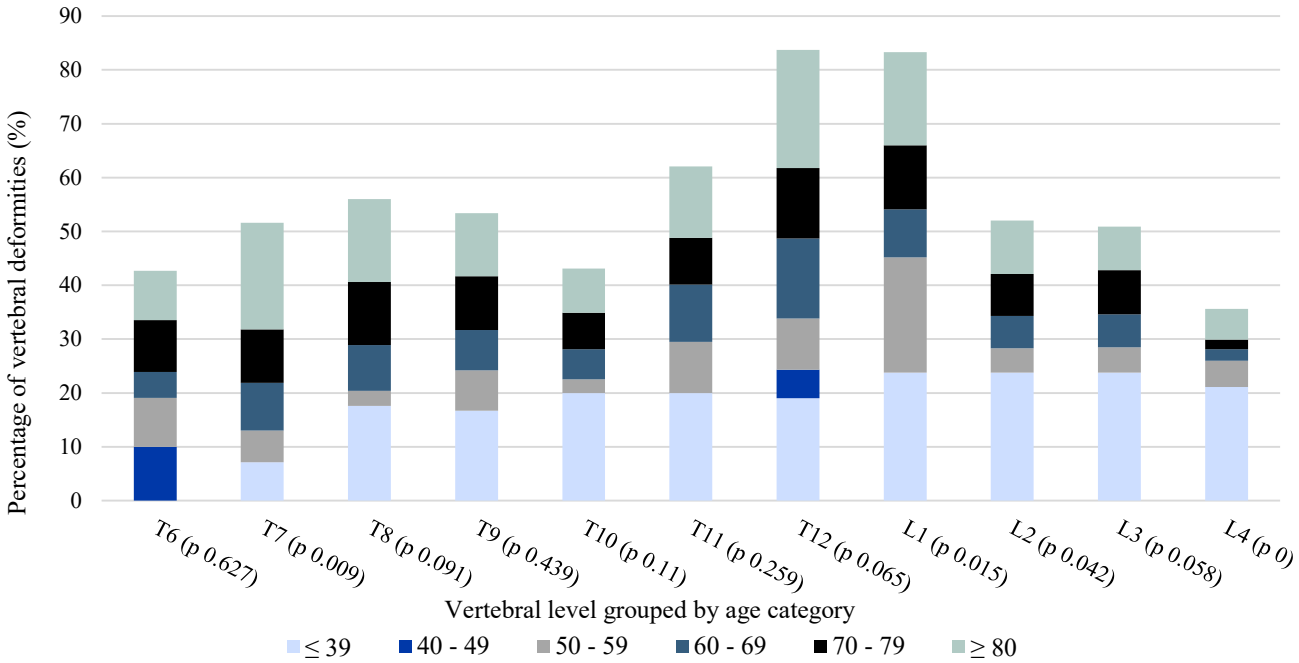

Figure 3: Analysis of vertebral deformities by age group among osteoporotic subjects

Discussion

This study had a large sample of referred patients for DXA scans and reveals a prevalence of 38.8% of osteoporosis. The larger sample size contributed to a reduced margin of error of 2.1%, which is considered highly favorable. The global prevalence is estimated at 19.7% based on a recent meta-analysis by Xiao et al. which covers 6 continents, and 37 countries. (17) The highest continent prevalence was in Africa at 26.9%.(17) Similarly, Salari et al. meta-analysis showed a world prevalence of 18.3 %.(18) Our prevalence rate must be viewed with caution. It cannot be compared to global rates as it is only the inferred prevalence rate in those patients referred for DXA scans and thus cannot be extrapolated to the general population. The limitation with the overall prevalence is that the indications for the DXA scans could not be elicited due to the nature of the data being collected directly from scan reports.

Many African studies are heterogeneous making them difficult to compare and there are no large population-based studies.(19) Local prevalence data is lacking and there is no hip fracture registry (3). SA is a multi-ethnic population, and our study also lacked any ethnic data which

could be an important area of further research. Data comparing post-hip fracture mortality rates show higher levels in SA compared to international countries (20). It is plausible that the reason that SA hip fracture mortality rates are higher than international rates is due to restricted resources for diagnosis and delayed operation of fractures.(20)

Our study site, Helen Joseph Hospital is a tertiary academic hospital in Johannesburg, Gauteng catering to a vast drainage area. Statistics SA estimates that out of a total population of 60.6 million people, 16,1(26,6%) million reside in Gauteng.(21) Most of our study population was above the age of 60 years (69.2%) with an average of 71.9 years. There was an observed rise in the prevalence of osteoporosis as age advanced. Age is widely acknowledged as a significant risk factor for osteoporosis. 8.9% of the patients included in the study were over the age of 80, emphasising age as a risk factor and the likelihood of the elderly being referred for DXA scans. There is a need for South African-specific prevalence rates and screening programs, particularly targeting patients aged 60 years and older.(22)

In our study, the prevalence of osteoporosis amongst women was 39.1%. The majority of women 771 of 848 (90.9%) were above 50 years old (post-menopausal age range). This is in keeping with the literature demonstrating post-menopausal women as the highest-risk group. The global prevalence found osteoporosis in 24.8% of women, and 27.4% of postmenopausal women.(17) Menopause occurs at approximately 51 years old in developed societies.(23) A WHO technical report suggests the average age of post-menopausal women is about 62 in SSA.(24) Whilst women have a physiologically higher risk for osteoporosis development, both sexes are affected.

There is a lower reported global prevalence in men, however, most research is heavily focused on women. In the current study, a male prevalence of 32.3% was found which is markedly high despite fewer male patients in the sample. Perhaps, the smaller sample of males is due to their seemingly lower health-seeking behaviours. The global prevalence of osteoporosis among men is estimated at 11.7%.(18) Our study demonstrates a much higher level probably due to a selection bias as men with suspected disease are more likely to be referred for DXA scans. Other studies have highlighted the rise in male osteoporosis rates in SSA. A study of 51

Zimbabwean men found osteoporosis with prevalence of 24% in the lumbar region and 6% in the femoral region using DXA.(7) A South African study by Siwela et al. reported that 18.5% of men had osteoporosis using opportunistic CT scans to analyse BMD.(25)

Our study is in line with former studies documenting the impact of low BMI (<18.5) on osteoporosis risk and its increased severity.(17) Moreover, Paruk et al. found compelling evidence of a notable negative association between osteoporosis and body mass index (BMI) across both sexes.(7) Excessive leanness is an established risk factor for hip fractures reported in a meta-analysis.(10) Interestingly, most of our study sample were either classified as overweight or obese (>56.3%) which is an unusual finding.

Developing countries have significantly higher osteoporosis prevalence rates than developed countries. Several factors contribute such as socioeconomic status, levels of healthcare infrastructure, and education playing a role in the South African context.(17) The exact prevalence of osteoporosis in SA remains unclear. In 1994, Kalla et al. provided local reference BMD values for fracture risk assessment and highlighted that American data are inappropriate for use in the SA population.(26) A misconception also exists that osteoporosis is a disease of elder Caucasian women; however, studies have found that black women have similar bone densities and rates of vertebral fractures.(22) The works of Conradie et al. and Kruger et al. have supported this notion.(4,11) Our study did not have ethnic data to assess. This could be an area for future research. Knowledge of ethnicity and socioeconomic status would provide a more comprehensive understanding of osteoporosis epidemiology.

In our study, vertebral fracture analysis among osteoporotic patients was a secondary outcome. Vertebral fractures are clinically silent and are often not included in the differential diagnosis of back pain.(18,19) Under-diagnosis of more than 50% is observed in many regions globally.(19) Vertebral fractures found on DXA scans may be the only sign of established osteoporosis and are important in predicting future fracture risks.(10,27) The vertebral evaluation on DXA scans has a sensitivity of 68% in comparison to X-ray interpretation.(29)

We found that most fractures occur at the twelfth thoracic level with an prevalence rate of 15.8% followed by the first lumbar level (13.2%). Similarly, an South African study by Esaadi et al. in KZN (Kwa-Zulu Natal) found frequent fractures at levels T11, T12, and L1 with an overall fracture rate of 20.8%.(28) Our estimated prevalence rate varied at each vertebral level lowest at 8% and the highest at 15.8%. Age group analysis showed a higher incidence of vertebral deformities with increasing age at all vertebral levels. The seventh thoracic level was significant as there is a higher proportion of deformities in the ≥ 80 age group (19.8%) compared to other age groups. Additionally, those ≤ 39 years of age had a higher proportion of deformities at level L1 with 23.9% as well as L4 with 21.1% compared to other groups. This finding may reflect the low sample size of patients in the age category of <39 years old. Despite the elevated prevalence of osteoporosis observed in this study, most patients did not exhibit vertebral deformities.

Studies describing vertebral fractures are heterogenous. In Mexico, a prevalence rate of 19.35% was found in females over the age of 50.(19) In Ethiopia, prevalence rates of 8.9% among women, 9.5% among men.(8) Conradie et al. found a similar prevalence among older South African women of 9.1% and 5% in black and white women respectively.(30) It was difficult to compare our results with other studies due to considerable discrepancies.

The current study has several limitations. Firstly, there is a sample bias as the data was collected from patients referred for DXA scans at a tertiary hospital, where the likelihood of suspected disease is high, potentially impacting the generalizability of the findings. Moreover, the study was conducted at a single site in the urban Johannesburg area, and the analysis did not include an assessment of ethnic differences due to insufficient data, further limiting the extrapolation of the results to the broader population. The indications for DXA and risk factors for osteoporosis in this specific population cannot be fully appreciated since the data was collected solely from DXA reports.

Another limitation was the exclusion of patients with osteopenia on DXA who also had a vertebral fracture and would have been classified as osteoporotic. This omission missed the opportunity to obtain a more accurate prevalence rate among those referred for DXA scans.

Furthermore, incomplete data sets were encountered as not all scan reports evaluated every vertebral level, which posed challenges in assessing the prevalence accurately.

Strengths include consistency in body parameters and measurements with the same DXA machine making data standardized. This cross-sectional study was large and had an adequate sample size with an error rate of 2.1% at 95% CI which falls within the acceptable range of less than 5% for research studies.

Conclusion

In conclusion, prevalence amongst those referred for DXA scans in this study was high however a true prevalence could not be appreciated due to the nature of the sampling. Further studies identifying the indications and risk factors in these patients will aid in understanding the epidemiology of osteoporosis in our context. Vertebral fracture prevalence varied at different vertebral body levels with the highest prevalence occurring at the level of T12. Underweight patients had more severe osteoporosis Utilizing DXA scans to make a diagnosis should be encouraged as a screening tool. Focused studies examining the prevalence and ethnic differences of osteoporosis in the general South African community and improving overall awareness will further help establish patterns and insights. Future research endeavors should prioritize fracture prevention in order to minimize the potential morbidity and mortality associated with osteoporosis.

Statements and Declarations

Author Contributions

The final manuscript was read and approved by all authors.

Data availability

The datasets used in this study are available upon request from the corresponding author.

Conflicts of interest

The authors declare that they have no conflicts of interest regarding the research, authorship, and publication of this study.

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Supplementary materials

Table 4 and Table 5 contain datasets for the analysis of vertebral evaluation by sex and by deformity types among osteoporotic subjects respectively.

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Supplementary materials:

Table 4: Vertebral level evaluation by sex

		Total (n=880) n (%)	Women (n=848) n (%)	Men (n=32) n (%)	P value
T6	Deformity	36 (8)	34 (7.7)	2 (20)	0.185
	Normal	417 (92)	409 (92.3)	8 (80)	
T7	Deformity	71 (12)	69 (12)	2 (11.1)	1
	Normal	522 (88)	506 (88)	16 (88.9)	
T8	Deformity	75 (11.3)	73 (11.4)	2 (9.5)	1
	Normal	586 (88.7)	567 (88.6)	19 (90.5)	
T9	Deformity	67 (9.6)	65 (9.6)	2 (8.7)	1
	Normal	631 (90.4)	6109 (90.4)	21 (91.3)	
T10	Deformity	50 (6.8)	49 (6.9)	1 (4.3)	1
	Normal	682 (93.2)	660 (93.1)	22 (95.7)	
T11	Deformity	79 (10.6)	76 (10.6)	3 (13)	0.727
	Normal	663(89.4)	643 (89.4)	20 (87)	
T12	Deformity	118 (15.8)	114 (15.7)	4 (17.4)	0.774
	Normal	629 (84.2)	610 (84.3)	19 (82.6)	
L1	Deformity	99 (13.2)	92 (12.6)	7 (30.4)	0.023
	Normal	652 (86.8)	636 (87.3)	16 (69.6)	
L2	Deformity	59 (8)	58 (8.1)	1 (4.5)	1
	Normal	681 (92)	6609 (91.9)	21 (95.5)	
L3	Deformity	56 (7.6)	53 (7.4)	3 (13)	0.409
	Normal	680 (92.4)	6609 (92.6)	20 (87)	
L4	Deformity	25 (3.6)	22 (3.3)	3 (13.6)	0.042
	Normal	6660 (96.4)	641 (96.7)	19 (86.4)	

Table 5: Analysis of vertebral evaluation and fractures among osteoporotic subjects

Level of vertebrae	Deformity (n)	Biconcave deformity n (%)				Wedge deformity n (%)			
		Total	Mild	Moderate	Severe	Total	Mild	Moderate	Severe
T6	36(8)	10 (2.2)	6 (1.3)	2 (0.4)	2 (0.4)	26 (5.8)	15 (3.3)	8 (1.8)	3 (0.7)
T7	71(12)	29 (4.9)	17 (2.9)	10 (1.7)	2 (0.3)	42 (7.1)	21 (3.5)	19 (3.2)	2 (0.3)
T8	75(11.3)	26 (3.9)	14 (2.1)	8 (1.2)	4 (0.6)	49 (7.4)	22 (3.3)	19 (2.9)	8 (1.2)
T9	67(9.6)	37 (5.3)	22 (3.2)	12 (1.7)	3 (0.4)	30 (4.3)	12 (1.7)	15 (2.2)	3 (0.4)
T10	50(6.9)	32 (4.4)	18 (2.5)	14 (1.9)	0 (0)	18 (2.5)	8 (1.1)	7 (1)	3 (0.4)
T11	79(10.7)	40 (5.4)	14 (1.9)	22 (3)	4 (0.5)	39 (5.3)	17 (2.3)	13 (1.8)	9 (1.2)
T12	118(15.8)	54 (7.2)	21 (2.8)	21 (2.8)	12 (1.6)	64 (8.6)	14 (1.9)	30 (4)	20 (2.7)
L1	99(13.2)	55 (7.3)	17 (2.3)	23 (3.1)	15 (2)	44 (5.9)	13 (1.7)	14 (1.9)	17 (2.3)
L2	59(8)	48 (6.5)	19 (2.6)	22 (3)	7 (0.9)	11 (1.5)	4 (0.5)	5 (0.7)	2 (0.3)
L3	56(7.6)	48 (6.5)	28 (3.8)	15 (2)	5 (0.7)	8 (1.1)	3 (0.4)	3 (0.4)	2 (0.3)
L4	25(3.5)	23 (3.3)	16 (2.3)	4 (0.6)	3 (0.4)	2 (0.2)	0 (0)	1 (0.1)	1 (0.1)

Appendix A: Ethical Clearance - Human Research Ethics Committee (Medical)

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research and Innovation)

TO:	Dr KR Anavi School of Clinical Medicine Department of Medicine Division of Internal Medicine - Endocrinology and Metabolism Medical School, University E-mail: karli.anavi.21@gmail.com
CC:	Supervisor: Drs R Daya and Z Bayat <reyna.daya13@gmail.com> and <HREC-Medical Research Office@wits.ac.za>
FROM:	Mr Iain Burns Human Research Ethics Committee (Medical) Tel: 011 717 1252 E-mail: Iain.Burns@wits.ac.za
DATE:	2022/04/01
REF:	R14/49
PROTOCOL NO:	**M220279** (This is your ethics application reference number. Please quote it in all enquiries, oral or written, relating to this study.)
PROJECT TITLE:	*The prevalence of osteoporosis at a tertiary academic hospital: a retrospective descriptive analysis*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Dr KR Anavi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M220279

NAME: (Principal Investigator) Dr KR Anavi

DEPARTMENT: School of Clinical Medicine
Department of Medicine
Division of Internal Medicine - Endocrinology and Metabolism
Medical School, University

PROJECT TITLE: *The prevalence of osteoporosis at a tertiary academic hospital: a retrospective descriptive analysis*

DATE CONSIDERED: 2022/02/25

DECISION: Approved unconditionally

CONDITIONS:

NOTE: If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>

SUPERVISOR: Drs R Daya and Z Bayat

APPROVED BY: Dr CB Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 2022/04/01

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **February** and therefore reports and re-certification will be due in the month of **February** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

4 April 2022
Date

Appendix B: Ethical Clearance – Helen Joseph Hospital

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Gauteng Department of Health
Helen Joseph Hospital
Enquiries: Dr. M. Mukansi
Research Committee: Chairperson
Tel :(011) 489-0306/1087
Fax :(011) 489 1038
E mail:Murimisi.mukansi@wits.ac.za

25 January 2022

To whom it may concern

Subject: HELEN JOSEPH HOSPITAL RESEARCH COMMITTEE APPLICATION

PROTOCOL TITLE: The prevalence of osteoporosis at a tertiary academic hospital: A retrospective descriptive analysis.

Principal Investigator: Dr. Karli Rachelle Anavi

Ethics Clearance: Pending

Co- investigator: Dr. Karli Rachelle Anavi

Department: Helen Joseph Hospital

Committee Recommendations
The Committee is giving you Conditional access while awaiting the final ethical clearance certificate from the University of Witwatersrand.

It is the duty of the researcher to collect the data to the relevant department after the Research Committee approved the study.

Dr. M. Mukansi
Chairperson of HJH Ethic and Research Committee

Appendix C: Faculty Approval Letter Of Title Change

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

21 April 2022
Person No: 668976
PAG

Dr KR Anavi
18 Angela Heights
hathway road cresswold
Barlow Park
2090
South Africa

Dear Dr Karli Anavi

Master of Medicine in Internal Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *The prevalence of osteoporosis in patients referred for DEXA scans at Helen Joseph hospital: A retrospective descriptive analysis* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

100 1922 2022

Appendix E: Plagiarism Declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Karli Rachelle Anavi (Student number: 668976) am a student registered for the degree of Master of medicine Internal medicine (MMed) in the academic year 2024.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature:  Date: 9 October 2024