The cost of osteoporosis, osteopenia and associated fractures in Australia in 2017

G. Tatangelo[1], J. Watts[2], K. Lim[1], C. Connaughton[1], J. Abimanyi-Ochom[2], F. Borgström[3], G. C. Nicholson[4,5], C. Shore-Lorenti[4, 12], A. L. Stuart[6], S. Iuliano[7], E. Seeman[1,7], R. Prince[8], L. March[9], M. Cross[9], T. Winzenberg[10], L. L. Laslett[10], G. Duque[4,11], P. R. Ebeling[4, 12], K. M. Sanders[1, 4]

[1]Institute for Health and Ageing, Australian Catholic University, Melbourne, Victoria 3000, Australia

[2]Deakin Health Economics, Centre for Population Health Research, Deakin University, Geelong, VIC, Australia

[3]LIME/MMC, Karolinska Institutet, Solna, Sweden

[4]Department of Medicine, The University of Melbourne and Western Health, Sunshine hospital, Melbourne, VIC, Australia

[5]Rural Clinical School, The University of Queensland, Toowoomba, QLD, Australia

[6]School of Medicine, Deakin University, Geelong, VIC, Australia

[7]Department of Medicine, Austin Health, The University of Melbourne, Melbourne, VIC, Australia

[8]School of Medicine and Dentistry, University of Western Australia, Department of Endocrinology and Diabetes, Sir Charles Gairdner Hospital, Perth, WA, Australia

[9]Institute of Bone and Joint Research, University of Sydney—Royal North Shore Hospital, Sydney, NSW, Australia

[10]Menzies Research Institute Tasmania, University of Tasmania, Tasmania, TAS, Australia

[11]Ageing Bone Research Program, Sydney Medical School, Nepean Hospital, University of Sydney, Sydney, NSW, Australia

[12]Department of Medicine, School of Clinical Sciences, Monash University, Melbourne, VIC, Australia

*Corresponding author. Address for correspondence: Kerrie Sanders, Australian Institute of Musculoskeletal Science (AIMSS), The University of Melbourne, Sunshine hospital, Furlong Rd, Victoria 3000, Australia; e-mail: ksanders@unimelb.edu.au

Abstract

Introduction: Osteoporosis and osteopenia are increasingly prevalent conditions among older adults. Not only do the fractures associated with poor bone health have significant health consequences for the individual, but their economic impact is placing increasing financial burden on governments and society in general. The aim of this study was to determine the economic cost of osteoporosis, osteopenia and fractures among Australians aged 50 years and over in 2017.

Method: This burden of disease study uses previous Australian data on the incidence and prevalence of osteoporosis and osteopenia together with recent Australian data on health service utilisation following fracture, to provide an estimate of the economic burden of osteoporosis. A 'bottom-up' approach was taken to overcome the methodological limitations of previous estimates and provide an accurate and detailed account of the current direct economic costs.

Results: The total direct cost of osteoporosis in Australia in 2017 was estimated to be $3.44 billion (AUD 2017, USD 2.77 billion). The treatment of fractures accounted for 68% of total direct costs and the non-fracture management of osteoporosis accounted for 32%. Hip fractures accounted for the highest proportion (43%) of the total direct cost of fractures, although fractures at 'other' sites accounted for 38.5% of the cost of fractures. Fractures among individuals aged 70 years and over accounted for 74% of the direct costs of fractures (55% and 19% in women and men, respectively). Fracture costs in those with osteopenia accounted for 50% of direct fracture treatment costs. **Conclusions:** This up-to-date cost analysis estimated that costs in 2017 were three times higher than in 2007. These estimates will aid clinicians, government policy makers,

researchers and health care organisations to acknowledge the economic importance of reducing osteoporosis-related fractures and associated costs. This provides a strong public health case to promote bone health that will assist in reducing future fracture related costs.

Keywords: Osteoporosis, health economics, health services research, practice/policy-related issues; general population studies.

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The Australian healthcare system is one of the most accessible and high quality systems in the world [1]. However, accurate data on the current incidence, prevalence and associated healthcare costs of some age-related conditions such as osteoporosis and related fractures are not readily accessible. With a steadily increasing number of older adults in our population, Australian healthcare, like healthcare systems in many other developed countries, must adapt to the changing needs of a rapidly ageing population [2]. Osteoporosis and osteopenia are increasingly prevalent conditions that have significant health consequences for individuals who sustain fractures [3, 4]. In 2012, estimates showed 4.74 million Australians over 50 years of age (66% of people over 50) had osteoporosis or osteopenia. This number is expected to increase by 31% in 2022, equating to 6.2 million Australians over the age of 50 [4]. In addition to the significant physical and psychological burden fracture(s) impose on individuals, the economic impact of osteoporosis and fractures places a significant and ever increasing financial burden on governments and other health funders [4]. In order for steps to be taken to reduce society-wide burden, an accurate estimate of the cost attributable to osteoporosis, osteopenia and associated fractures in Australia is critical.

An important gap in the estimation of the cost of osteoporosis is the lack of information available for site-specific fractures other than hip fractures. The most common fracture sites associated with osteoporosis and osteopenia are hip, wrist, spine, humerus and pelvis, although other skeletal sites are also affected [5]. International estimates indicate that fractures at sites other than the hip or vertebrae collectively account for approximately 60% of all fractures and contribute a significant portion of the costs [6, 7]. However, the costs associated with fractures at sites other than hip have not been quantified for a large Australian sample. In addition it is unclear what proportion of total costs associated with poor bone health is attributable to the direct health-related costs of fracture treatment, and what proportion is attributable to non-fracture management of osteoporosis and osteopenia and fracture-prevention [8, 9]. Without this information, the ability to develop a targeted plan for an economically sustainable prevention and management approach is limited.

This burden of disease study brings together data from multiple Australian sources on health service utilisation, community service utilisation and morbidity. The Geelong Osteoporosis Study (GOS) [10] is an Australian prospective longitudinal cohort study that has provided an accumulating picture of the prevalence of osteoporosis and the incidence of fractures in Australia. The AusICUROS prospective cohort study provides data on health and community service utilisation associated with low energy fractures [3, 11]. These data are brought together in a novel approach that aims to overcome the limitations of previous cost estimates by using a 'bottom up' (resource use at the patient level) costing economic approach to determine the costs associated with fracture treatment. Epidemiological data and a 'top down' costing approach (using health administrative data) are used to determine costs associated with management of

osteoporosis and fracture prevention. Combined, these two major data components are modelled to determine the total direct costs of osteoporosis.

The aim of this study was to use the best available Australian data on incidence, prevalence and health and community service utilisation to estimate the 2017 cost burden of disease relating to osteoporosis and fractures (prevention and management) in the Australian population aged 50 years and over. Importantly, this study provides a separate cost of fractures associated with osteoporosis and osteopenia by site (hip, wrist, vertebral, and other types of fractures).

Methods

Overview

There are two major components to the method to determine costs in this study: the data sources that have been used as a basis for the population rates of osteoporosis, osteopenia and fractures; and the methods used to analyse the cost data. The prevalence of osteoporosis and osteopenia and the incidence of fractures were taken from existing Australian data sources. These data sources, together with population data from the Australian Bureau of Statistics (ABS), were used to estimate the prevalence of osteoporosis, osteopenia and the incidence of fractures within the Australian population aged over 50 years. The same method was used to estimate costs for each Australian state that were based on population estimates from the ABS [12]. A bottom-up costing approach was used to determine the average direct health care and non-health care total costs of a fracture, as well as the average community health service costs of managing someone with osteoporosis or osteopenia. This method has been described in a previous Report [4].

Fracture treatment costs were determined from AusICUROS study. This study collected service utilisation data at predetermined intervals from Australians with recent low trauma fracture. Data from AusICUROS included patient hospital records and self-reported questionnaires about health and non-health service use associated with treatment of the fractures and any related side-effects. As per the previous Report, the number of fractures was projected using the Australian Bureau of Statistics (ABS) population estimates for 2017 [12]. Cost data were based on 2012 estimates and adjusted by Consumer Price Index (CPI) for 2017 dollars. All costs are presented in 2017 Australian dollars (AUD).

Data sources

Incidence/prevalence data for osteoporosis, osteopenia and fractures

ABS population data were used from the estimated resident population for each state and territory for 2017 [12]. Population data by sex and 5-year age bands from aged 50 years and over were used to generate population estimates for men and women in two age groups (50-69 years and 70+ years). To determine the proportion of the population with osteoporosis and osteopenia, the 5-year age interval data from the GOS [13] were used. This study recruited an age-stratified random sample of the region's population [2]. The 5-year rates were then applied to the 5-year population cohorts from the ABS to determine the weighted average proportions (by population) for osteoporosis and osteopenia for men and women in two age groups (50-69 years and 70+ years).

The GOS cohort [10] was followed prospectively for approximately five years after baseline for fracture ascertainment [14, 15]. Fracture cases were categorized according to their bone mineral density (BMD) scores at baseline (categorised as normal, osteopenia and osteoporosis). The proportion of all fractures in each BMD category was used to estimate the population-standardised number of fractures for each category over a 5-year period. The fractures arising from those with BMD in the normal category (BMD above a t-score of -1) were not attributed to osteoporosis and not included in the analysis of cost and burden of osteoporosis.

The number of fractures at each site (hip, wrist, vertebral and 'other'), by sex and five-year age groups were determined by data from Sanders et al. [5]. Subsequently Crisp et al. [16] found declining incidence of hip fracture rates by 20% and 13% in women and men, respectively. To account for these changes, the proportion of hip fractures observed by Sanders et al. [5] was reduced in each 5-year cohort by 20% for females and by 13% for males. Since there was no evidence for the reduction in total fracture rates, the proportion of non-hip fractures was then increased so that the overall number of fractures remained the same [14]. Although fracture rates were different between those with osteoporosis and osteopenia, the distribution according to fracture site was assumed to be the same. 'Other' fractures included humerus, ankle, lower limb, rib, pelvic, forearm (not classified as wrist), patella, foot and hand fractures [5]. Skull, facial, finger and toe fractures were not included.

Burden of fractures

For each fracture type (hip, vertebral, wrist, 'other'), a clinical pathway was modelled by sex, age (50-69 years, 70+ years) and BMD category (osteoporosis, osteopenia) [3]. In total, 32 clinical pathways were modelled to estimate the burden from fractures. Data from the

AusICUROS fracture cohort were used to estimate health and community service utilisation data following a fracture. From this study, complete fracture-related service utilisation for 12 months were available for 505 adults with low trauma fracture from eight Australian study sites. The distribution of fracture site sustained by AusICUROS participants is detailed elsewhere [4].

Fracture-related costs included the direct health-related costs and the non-health services. Direct health-related costs included ambulance, hospitalisation, emergency department, imaging, medical services, pharmaceuticals, rehabilitation and community health. Non-health services included community support services (such as 'meals on wheels', home help and formal and informal care) and residential care [3]. Costs attributed to residential care were calculated based on the proportion of fracture participants in AusICUROS study who changed their permanent dwelling after the fracture from community to a residential aged care facility (RACF). An assumption was made that the average stay in RACF was 6 months in this first year.

The perspective taken is that of a limited societal perspective with direct costs of fracture management and osteoporosis management included, as well as informal care. Costs associated with productivity loss have not been included in this analysis.

Costs associated with the ongoing management of osteoporosis (excluding any fracture treatment)

Non-fracture-related costs included routine medical (GP visits) and pathology (including Vitamin D) tests, dual-energy X-ray absorptiometry (DXA), and pharmaceuticals for bone health. To determine the total utilisation of anti-osteoporosis medications, the volume of dispensed prescriptions from the Pharmaceutical Benefits Scheme (PBS) and Repatriation

Pharmaceutical Benefits Scheme (RPBS) using the Item Reports from Medicare Australia [17] were used for the 2011/2012 financial year. All medications where osteoporosis was listed under the authority restriction were included. To determine the total annual cost, the reported number of prescriptions from the PBS and RPBS were multiplied by the schedule fee for each drug and inflated to $AUD 2017.

Other services were included based on recommended follow-up investigations for the management of osteoporosis/osteopenia. It was assumed that everyone with a new fracture would have one DXA in the year of the fracture, and that the rest of the population with osteoporosis or osteopenia would have one DXA every three years (an annual rate of 0.33) [18]. The total cost of DXA was determined from the MBS expenditure data. Pathology tests for Vitamin D were assumed once every 2 years for the population with osteoporosis or osteopenia, and other relevant routine pathology tests for renal function and serum calcium were based on the assumption of two tests annually [4]. General practitioner visits were assumed at a rate of 2.4 visits annually for the population with osteoporosis or osteopenia irrespective of fracture.

Itemised tables by category of resource with average resource utilisation rate for the fracture population and the unit cost for each resource can be found in the report by Watts and colleagues [4]. For more details, specific assumptions made for each rate and cost, as well as the source of the data, can also be found in the Report [4].

Results

Total cost of osteoporosis, osteopenia and associated fractures in Australia in 2017 (Table 1)

The total direct cost of osteoporosis, osteopenia and associated fractures in Australia in 2017 was estimated to be AUD $3.44 billion (USD 2.77 billion). The treatment of fractures

accounted for 68% of the total direct costs (including informal care) of osteoporosis. Of this, hip fractures accounted for the highest proportion (43%) although the direct treatment cost of fractures at 'other' sites accounted for 39% of the cost of all fractures. Treatment costs of vertebral fracture accounted for 11%, and wrist fracture accounted for 7% of the cost of all fractures. The cost for informal care, which includes non-health costs for home care, accounted for 5.3% of the total direct cost of treating fractures. The analysis demonstrates the total cost of treating all fractures in adults with osteopenia is estimated to comprise 50% of the total cost of treating fragility fractures in Australia (Table 7a & supplementary table 7b).

The non-fracture management of osteoporosis (fracture prevention) accounted for 32% of the total direct costs associated with osteoporosis. This includes the use of anti-osteoporosis medications, supplements of calcium and vitamin D, but does not include costs associated with exercise therapy or other lifestyle interventions. Routine medical and pathology accounted for 72% of the cost for non-fractures. DXA scans and anti-osteoporosis pharmaceuticals accounted for 4% and 24% of the total non-fracture costs, respectively.

Total cost of all fractures by sex, age group and cost category (Table 2)

Fractures among those aged 70 years and over accounted for 74% of the total direct costs of fracture treatment. Twenty-seven per cent of total direct costs of fracture treatment were attributable to men.

Almost 70% of the total direct cost of all fractures was for hospital care with half of this cost attributable to fractures among women aged 70 years and over. Rehabilitation (inpatient and

outpatient combined) accounted for the second highest component of direct costs (14%) with almost three-quarters of this cost attributable to women 70 years and over.

Cost by fracture type, sex, age group and cost category

Tables 3 to 6 provide cost estimates for hip, wrist, vertebral and 'other' fracture sites (grouped). The direct total cost for fractures includes all health care and community services (directly related to fracture care), as well as costs attributable to residential aged care.

The total direct cost of hip fractures was $1.01 billion of which hospital care contributed 65.5% (Table 3). Forty three per cent of hospital costs were attributable to women aged 70 years and over, and 16.5% to men aged 70 years and over. Rehabilitation represented 19% of direct costs for hip fractures, of which 14% of costs were for women aged 70 years and over, and 4% were attributable to men aged 70 years and over.

The total cost of wrist fractures was $164 million, of which hospital care contributed 69%. Ninety per cent of these hospital costs were attributable to women (Table 4). Rehabilitation represented 16% of direct costs for wrist fractures, of which the majority was attributable to women aged 70 years and over (95%).

The total cost of vertebral fractures represented 7% of the total direct costs of treating all fractures ($267 million; Table 5). Hospital care represented 53% of which more than half (56%) was attributable to women aged 70 years and over. Rehabilitation represented 14% of direct costs for vertebral fractures. The cost associated with informal care was $38 million, representing 14% of the cost of vertebral fractures.

The total cost of fractures at other sites represented almost 40% of the cost of treating all fractures ($903 million; Table 6). Hospital care represented 73% of direct costs for 'other' fractures. Hospital care for women aged 50-69 years represented 24% of total cost of 'other' fractures, the same proportion of costs as hospital care for women as in the age group 70 years and over. For men aged 70 years and over, the cost of hospital care represented 13% of the total costs for 'other' fractures. Rehabilitation represented 9% of direct costs for 'other' fractures and informal care was almost $90 million, representing another 10% of the cost of 'other' fractures.

Figure 1 shows the cost of osteoporosis, osteopenia and associated fractures across Australian states in 2017 for people aged 50 years and over. Also displayed is the proportion of cost in each state that was attributable to people aged 70 and over. Thirty four per cent of the total national cost of fracture was from NSW (including ACT), this equates to $809 million. Victoria accounted for 25% of the total national costs ($589 million). Queensland, Western Australia, South Australia, Tasmania and the Northern Territory accounted for 19%, 10%, 8%, 3%, and 0.5% of the total national costs respectively. The total cost within each state and territory were largely driven by the cost associated with osteoporosis and fractures among people aged 70 and over. For example, 74% of the total cost of fractures in NSW and the ACT were attributable to osteoporosis and fractures among people aged 70 and over.

Discussion

The total direct cost associated with osteoporosis, osteopenia and fractures among Australians aged 50 years and over in 2017 was estimated to be AUD 3.44 billion. This indicates that the economic costs associated with osteoporosis are significant and had previously

been underestimated [4, 19, 20]. By using Australian data on fracture incidence and prevalence of osteoporosis, together with a bottom-up costing approach to estimate resource utilisation, our research provided a more accurate and detailed account of the direct costs. The findings show the distribution of the cost burden of this disease across the cost categories of fracture treatment and the clinical management of osteoporosis. In contrast to previous estimates, our findings demonstrated the majority of cost was attributable to fracture treatment, rather than non-fracture management of osteoporosis. In addition, this is the first Australian study to provide a detailed breakdown of the costs associated with specific fracture sites (hip, wrist, vertebral and 'other'). These new estimates also demonstrated that men accounted for 27.5% of costs, and show that the burden of osteoporosis is not only attributable to women. Using the derived mean cost of fracture by site, age group and sex, the direct cost of fractures in adults with osteopenia (T score between 1 and 2.49) is estimated to be equal to the cost burden of those with osteoporosis (T score $\leq$2.5).

No previous Australian burden of illness study had used a 'bottom-up' approach to capturing actual resource utilisation in a large number of adults followed for 18-months following a fracture. Prior to this study, the direct health cost of osteoporosis was estimated to be $1.9 billion in 2007 [8] based only on the cost of hospitalised fracture cases in adults aged 20 years and over, classified as low trauma and without consideration of bone density. This new research, in line with other international burden of disease studies, targeted adults from 50 years and older studies [6, 7, 16, 21-23]. The current study also used Australian epidemiologic and cost data to confine the burden of osteoporosis to adults with low bone density and included direct costs from both hospitalised and non-hospitalised fractures.

The large burden of disease attributable to osteoporosis was predominantly due to fractures, with fractures representing 68% of total direct costs. This cost estimate does not include indirect costs such as productivity loss and the impact on disability and quality of life. Thirty-two per cent of the burden of disease attributable to osteoporosis is due to the cost of management and prevention of further bone loss in Australians with either osteoporosis or osteopenia. In contrast, Access Economics [8] found that the cost of non-fracture management of osteoporosis and osteopenia outweighed the cost of fractures. However, as previously discussed, this earlier study is likely to have significantly underestimated the total fracture cost, as the estimates were based on hospitalised fractures only. The current finding provide evidence to support that efforts to reduce the prevalence of fractures may significantly reduce the economic burden across the healthcare system [24]. In the majority of countries, population screening approaches targeted to the prevention of osteoporosis-related fractures have not been adopted due to the perception of cost inefficiency [25]. However, recent research has demonstrated the efficacy of screening approaches in reducing the incidence of fractures among community-dwelling older people [26]. There is substantial evidence including Australian data that demonstrates the mid-to-long term cost efficiencies of fracture liaison services [27, 28]. These services that aim to ‘capture’ adults when they are seeking treatment for recent fracture and offer assessment and referral to existing bone health services, have been shown to be effective in reducing the rate of subsequent fracture among fracture patients by up to 80% [29].

In line with previous studies [6, 7], treatment and management of hip fractures had the highest cost, representing 43% of the direct cost of all fractures in the current Australian study. In Canada, hip fractures accounted for 53% of acute care costs and represented 50% of

hospitalisations attributable to osteoporotic fractures [7] while in the USA, hip fractures have been estimated to account for 72% of total hospital costs but represented only 14% of all fractures [6]. Although hip, wrist (7%) and vertebral fractures (11%) together accounted for 61.5% of the direct costs of fracture treatment, the economic burden of osteoporosis would be significantly underestimated by not including the 38.5% of direct costs used in the treatment and management of 'other' (non-hip, non-wrist and non-vertebral) fractures. In Canada, Burge and colleagues [6] found that 'other" fractures represented 40% of all fractures and Tarride and colleagues [7] reported these 'other' fractures accounted for almost 20% of direct costs in the USA. As such, there is a growing evidence for the importance of prevention, treatment, and education that is concentrated on skeletal fracture sites other than hip, vertebral and wrist [6] that have traditionally been the focus of osteoporosis reports.

There are some important limitations to the study that should be noted. Both the prevalence of osteoporosis and osteopenia, and fracture incidence were taken from one large region located in south-eastern Victoria. Although the analysis specifically used age and sex-specific fracture rates in adults with osteoporosis and osteopenia, the fracture site distribution was assumed to be the same for all adults irrespective of bone density. Our estimates incorporated an observed decline in hip fracture rates of 20% in women and 13% in men [16]. While some data suggested the decline is restricted to hip fracture incidence there are no recent international studies published that use reliable data for incidence of non-hip fractures [30, 31]. However recent Canadian data suggested there may also be a decline in other major osteoporotic fracture sites [24]. There are no published Australian data to identify changes in fractures occurring at other sites. Furthermore the cost burden of 'other' fractures could be overestimated

since AusICUROS recruitment was through a combination of emergency department, inpatient wards and some public hospital medical imaging services. Fractures of a less serious nature may have been managed without visiting an emergency department and confirmed using private radiology services not included in our recruitment procedures. It is very likely that there are differences in fracture rates among Indigenous Australians consistent with racial differences identified between individuals of First Nations and Caucasian Canadians [32] and in the USA between Black Americans, Hispanic and Caucasian Americans [33]. However there were no reliable published Australian data available to incorporate such differences into the analysis. The Australian Indigenous population accounts for less than 1.2% of Australian adults aged 50 years and over [8]. Service utilisation collected from a 'bottom-up' approach using individual patient records and self-reported questionnaire may underestimate health services attributable to other medical conditions that may be associated with the fracture. Kilgore and colleagues (2013) have reported increases in fracture-related expenditure when using a cost modelling approach that compared healthcare utilisation following the fracture with the period 6-month prior to fracture. These 'attributable' expenditures included incremental changes in recorded conditions such as pneumonia, aftercare, joint pain, pressure ulcers and other musculoskeletal conditions (ref: Kilgore et al BMR 2013). Finally the cost related to change of residence to an aged care facility following the fracture are likely to be underestimated. The AusICUROS study participants may have a healthy volunteer bias since individuals who sustained a fracture at more than one site and/or those who sustained another fracture during the 12-month post-fracture period, were excluded.

Our estimate of a 50% cost burden of treating fractures among adults with osteopenia relative to that of adults with osteoporosis, is novel and highlights the economic cost-benefit of promoting strategies to promote bone health in those who are classified as osteopenia rather than osteoporotic.

This up-to-date information on the costs of osteoporosis in Australia will aid clinicians, government policy makers, researchers and health care organisations and funding bodies to assess the economic importance of reducing both osteoporosis-related fractures and associated costs, promoting bone health and identifying further resource needs. This will be particularly important in planning for a healthcare system capable of addressing the needs of an increasing number of older Australians who will be at significant risk of fracture. The comparison of attributable fracture costs across the seven Australian states and Northern Territory demonstrated the cost burden of treating fractures was largely driven by the proportion of the women aged 70 years and over. However, although hip fractures accounted for the largest proportion of the burden of osteoporosis and osteopenia, fractures at other sites accounted for a significant proportion of the cost for all fractures and should not be ignored in future planning of resource needs. People with fracture at skeletal sites other than hip represent a group at high risk of subsequent fracture including hip fracture [34]. With appropriate assessment of falls risk and bone health these people may benefit from implementation of osteoporosis prevention and management. The current study also highlights the need for greater awareness that osteoporosis is not only a condition affecting women; men account for about 30% of all fractures and their associated costs.

Competing interests

No competing interests

Authors' contributions

GT drafted the manuscript. KS, JW and FB conceived of the study, contributed to its design, collected data and helped to draft the manuscript. KL, JA and CC conducted the data analyses. JA, FB, GN, CS-L, AS, SI, ES, RP, LM, MC, TW, LL, GD and PE contributed to the study design, conducted the AusICUROS study site data collection. All authors participated in interpretation of the findings and read and approved of the final manuscript.

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Tables and Figures

Table 1: Total costs in AUD millions of osteoporosis and osteopenia[(1)], and fractures in 2017

Component one: Fracture Treatment Costs	**Direct Cost[(2)]**	**Informal care**	**% Direct Fracture Cost**	**Total cost and %**
Hip fractures	962.55	49.20	43.1%	
Wrist fractures	154.88	9.43	7.0%	
Vertebral fractures	229.33	37.66	11.4%	
Other fractures	816.05	86.98	38.5%	
Total Direct Fracture Cost *(including informal care)*	*2,168.3*	*183.3*	*100%*	**2,346.08**
Proportion of total overall costs				**68.2%**

Component two:			
Non-Fracture/Prevention Cost[1]			
Routine medical and pathology	792.46	72.3%	
DXA	42.83	3.9%	
Pharmaceuticals- bone health	260.96	23.8%	
Non-Fracture/Prevention Cost[1]	*1,096.3*	*100%*	**1,096.25**
Proportion of total overall costs			**31.8%**
Total Overall Costs		**100.0%**	**3,442.33**

(1) Refers to fracture prevention including anti-osteoporosis pharmaceuticals, doctor visits for prescription of these drugs, DXA scans, calcium and vitamin D supplements. **(2)** *Refers to direct costs not including informal care (number of hours of care given by family and friends [4] etc which has been costed at the rate of community service 'home help' in Australia [35])*

Table 2: Total cost in AUD of all fractures by gender, age group and sector in Australia for 2017

	Total Cost for Women $AUD (%)		**Total Cost for Men $AUD (%)**		**Total $AUD (%)**
ALL FRACTURES	Age 50 - 69 years	Age 70+ years	Age 50 - 69 years	Age 70+ years	Age 50+ years
Hospital Total	322,171,823 (13.7)	790,200,737 (33.7)	150,038,191 (6.4)	311,999,675 (13.3)	1,574,410,425 (67.1)
Ambulance	13,799,492 (0.6)	33,225,817 (1.4)	7,650,458 (0.3)	14,097,776 (0.6)	68,773,542 (2.9)
Community Fracture Mgt.	11,188,565 (0.5)	15,864,557 (0.7)	5,424,421 (0.2)	6,919,843 (0.3)	39,397,386 (1.7)

Rehabilitation	27,540,242 (1.2)	235,534,461 (10.0)	9,005,572 (0.4)	63,673,123 (2.7)	335,753,398 (14.3)
Nursing home	0	61,981,786 (2.6)	0	20,504,990 (0.9)	82,486,776 (3.5)
Community Services	9,449,127 (0.4)	41,573,333 (1.8)	210,425 (0.0)	10,758,147 (0.5)	61,991,032 (2.6)
Informal care	38,811,884 (1.7)	99,343,875 (4.2)	20,897,734 (0.9)	24,215,432 (1.0)	183,268,925 (7.8)
Total Direct Cost	**422,961,132 (18.0)**	**1,277,724,566 (54.5)**	**193,226,800 (8.2)**	**452,168,986 (19.3)**	**2,346,081,485 (100.0)**

Note: Fracture Management includes GP, Physio, Med Spec, x-ray, Pharmaceutical, Supplements. Total Direct Cost includes informal care.

Table 3: Total cost in AUD of hip fractures by sex, age group and cost category in Australia for 2017

	Total Cost for Women $AUD (%)		**Total Cost for Men $AUD (%)**		**Total $AUD (%)**
HIP FRACTURES	Age 50 - 69 years	Age 70+ years	Age 50 - 69 years	Age 70+ years	Age 50+ years
Hospital Total	34,036,336 (3.4)	435,139,563 (43.0)	26,549,016 (2.6)	167,430,327 (16.5)	663,155,242 (65.5)
Ambulance	1,177,140 (0.1)	12,465,618 (1.2)	951,506 (0.1)	5,095,523 (0.5)	19,689,788 (1.9)
Community Fracture Mgt.	843,311 (0.1)	4,849,128 (0.5)	625,767 (0.1)	3,065,488 (0.3)	9,383,693 (0.9)
Rehabilitation	6,566,198 (0.6)	140,630,408 (13.9)	7,600,995 (0.8)	40,297,927 (4.0)	195,095,528 (19.3)

Nursing home	0	40,203,163 (4.0)	0	19,861,292 (2.0)	60,064,455 (5.9)
Community Services	94,606	11,567,781 (1.1)	0	3,501,348 (0.3)	15,163,735 (1.5)
Informal care	239,352	46,155,736 (4.6)	70,359	2,732,960 (0.3)	49,198,407 (4.9)
Total Direct Cost	**42,956,943 (4.2)**	**691,011,397 (68.3)**	**35,797,644 (3.5)**	**241,984,865 (23.9)**	**1,011,750,848 (100)**
Percentage of total direct cost for all fractures	**1.8**	**29.5**	**1.5**	**10.3**	**43.1**

Note: Fracture Management includes GP, Physio, Med Spec, x-ray, Pharmaceutical (pain relief etc), Supplements. Total Direct Cost includes informal care.

Table 4: Total cost in AUD of wrist fractures by sex, age group and cost category in Australia for 2017

	Total Cost for Women $AUD (%)		**Total Cost for Men $AUD (%)**		**Total $AUD (%)**
WRIST FRACTURES	Age 50 - 69 years	Age 70+ years	Age 50 - 69 years	Age 70+ years	Age 50+ years
Hospital Total	40,295,819 (24.5)	61,532,004 (37.4)	5,238,007 (3.2)	5,913,400 (3.6)	112,979,230 (68.8)
Ambulance	1,215,013 (0.7)	2,419,943 (1.5)	177,952 (0.1)	409,797 (0.2)	4,222,705 (2.6)
Community Fracture Mgt.	1,910,265 (1.2)	2,472,267 (1.5)	211,847 (0.1)	234,520 (0.1)	4,828,900 (2.9)
Rehabilitation	3,468,462 (2.1)	20,877,942 (12.7)	74,070	1,288,985 (0.8)	25,709,459 (15.6)
Nursing home	0	4,791,079 (2.9)	0	35,496	4,826,575 (2.9)
Community Services	133,016 (0.1)	2,139,423 (1.3)	0	38,156	2,310,595 (1.4)
Informal care	3,306,264 (2.0)	6,091,947 (3.7)	31,558	0	9,429,769 (5.7)
Total Direct Cost	**50,328,839 (30.6)**	**100,324,607 (61.1)**	**5,733,433 (3.5)**	**7,920,354 (4.8)**	**164,307,233 (100)**
Percentage of total direct cost for all fractures	**2.1**	**4.3**	**0.2**	**0.3**	**7.0**

Note: Fracture Management includes GP, Physio, Med Spec, Xray, Pharmaceutical (pain relief etc), Supplements. Total Direct Cost includes informal care.

Table 5: Total cost in AUD of vertebral fractures by sex, age group and cost category in Australia for 2017

	Total Cost for Women $AUD (%)		**Total Cost for Men $AUD (%)**		**Total $AUD (%)**
VERTEBRAL FRACTURES	Age 50 - 69 years	Age 70+ years	Age 50 - 69 years	Age 70+ years	Age 50+ years
Hospital Total	28,264,433 (10.6)	79,584,211 (29.8)	10,495,679 (3.9)	22,538,470 (8.4)	140,882,793 (52.8)
Ambulance	2,894,108 (1.1)	8,457,902 (3.2)	1,178,742 (0.4)	1,360,241 (0.5)	13,890,993 (5.2)
Community Fracture Mgt.	1,775,868 (0.7)	3,131,270 (1.2)	559,766 (0.2)	764,523 (0.3)	6,231,427 (2.3)
Rehabilitation	2,767,765 (1.0)	28,731,990 (10.8)	168,147 (0.1)	5,460,229 (2.0)	37,128,131 (13.9)
Nursing home	0 (0.0)	6,593,429 (2.5)	0	150,362 (0.1)	6,743,791 (2.5)
Community Services	3,236,925 (1.2)	20,935,673 (7.8)	0	284,994 (0.1)	24,457,591 (9.2)
Informal care	9,429,901 (3.5)	21,361,595 (8.0)	4,522,230 (1.7)	2,348,322 (0.9)	37,662,049 (14.1)
Total Direct Cost	**48,369,000 (18.1)**	**168,796,070 (63.2)**	**16,924,563 (6.3)**	**32,907,141 (12.3)**	**266,996,774 (100)**
Percentage of total direct cost for all fractures	**2.1**	**7.2**	**0.7**	**1.4**	**11.4**

Note: Fracture Management includes GP, Physio, Med Spec, Xray, Pharmaceutical (pain relief etc), Supplements. Total Direct Cost includes informal care.

Table 6: Total cost in AUD of other fractures by sex, age group and cost category in Australia for 2017

	Total Cost for Women $AUD (%)		**Total Cost for Men $AUD (%)**		**Total $AUD (%)**
OTHER FRACTURES	Age 50 - 69 years	Age 70+ years	Age 50 - 69 years	Age 70+ years	Age 50+ years
Hospital Total	219,575,234 (24.3)	213,944,958 (23.7)	107,755,489 (11.9)	116,117,478 (12.9)	657,393,160 (72.8)
Ambulance	8,513,230 (0.9)	9,882,354 (1.1)	5,342,258 (0.6)	7,232,215 (0.8)	30,970,057 (3.4)
Community Fracture Mgt.	6,659,121 (0.7)	5,411,892 (0.6)	4,027,041 (0.4)	2,855,312 (0.3)	18,953,366 (2.1)
Rehabilitation	14,737,816 (1.6)	45,294,121 (5.0)	1,162,359 (0.1)	16,625,982 (1.8)	77,820,279 (8.6)
Nursing home	0	10,394,115 (1.2)	0	457,841 (0.1)	10,851,955 (1.2)
Community Services	5,984,580 (0.7)	6,930,456 (0.8)	210,425	6,933,649 (0.8)	20,059,111 (2.2)
Informal care	25,836,367 (2.9)	25,734,596 (2.8)	16,273,587 (1.8)	19,134,150 (2.1)	86,978,701 (9.6)
Total Direct Cost	**281,306,350 (31.2)**	**317,592,493 (35.2)**	**134,771,160 (14.9)**	**169,356,626 (18.8)**	**903,026,630 (100)**
Percentage of total direct cost for all fractures	**12.0**	**13.5**	**5.7**	**7.2**	**38.5**

Note: Fracture Management includes GP, Physio, Med Spec, Xray, Pharmaceutical (pain relief etc), Supplements. Total Direct Cost includes informal care.

Table 7: Mean individual and total cost in AUD ($millions) of fractures by BMD category, sex, age group and cost category in Australia for 2017

Fracture	Women				Total All women	Men				Total All men	ALL Total
	50-69 years		70+ years			50-69 years		70+ years			
	Osteoporosis	Osteopenia	Osteoporosis	Osteopenia		Osteoporosis	Osteopenia	Osteoporosis	Osteopenia		
Hip											
Number of fractures	*759*	*1,039*	*10,807*	*6,827*	*19,431*	*448*	*956*	*2,292*	*4,536*	*8,233*	*27,665*
Mean cost per patient	***$23,893***		***$39,192***			***$25,482***		***$35,444***			
Total direct cost	$18.14	$24.82	$423.54	$267.55	$734.05	$11.43	$24.37	$81.25	$160.78	$277.83	$1,011.88
% Cost – osteoporosis [1]					**60.2%**					**33.4%**	**52.8%**
Wrist											
Number of fractures	*4,010*	*5,487*	*6,952*	*4,392*	*20,841*	*397*	*847*	*457*	*904*	*2,606*	*23,447*
Mean cost per patient	***$5,299***		***$8,736***			***$4,607***		***$5,818***			
Total direct cost	$21.25	$29.08	$60.73	$38.37	$149.42	$1.83	$3.90	$2.66	$5.3	$13.7	$163.1
% Cost – osteoporosis [1]					**54.9%**					**32.9%**	**53.0%**
Vertebral											
Number of fractures	*3,069*	*4,199*	*9,829*	*6,209*	*23,307*	*796*	*1,698*	*1,449*	*2,868*	*6,812*	*30,118*
Mean cost per patient	***$6,666***		***$10,500***			***$6,807***		***$7,637***			
Total direct cost	$20.46	$28.00	$103.20	$65.19	$216.85	$5,418.46	$11.56	$11.07	$21.91	$49.5	$266.80
% Cost – osteoporosis [1]					**57.0%**					**33.0%**	**52.5%**
Other											
Number of fractures	*12,569*	*17,200*	*14,378*	*9,083*	*53,231*	*5,962*	*12,718*	*3,983*	*7,882*	*30,545*	*83,776*
Mean cost per patient	***$9,449***		***$13,544***			***$7,214***		***$14,274***			
Total direct cost	$118.77	$162.53	$194.74	$123.02	$599.06	$43.01	$91.75	$56.85	$112.50	$304.12	$903.17

% Cost – osteoporosis [1]					**52.3%**				**32.8%**	**45.8%**
Cost of fracture (Total)	**$178,616.52**	**$244,421.53**	**$782,217.81**	**$494,127.98**	**$1,699,383.84**	**$61,684.59**	**$131,587.45**	**$151,822.41**	**$300,454.94**	**$645,549.39**	**$2,344,933.23**
% Cost – osteoporosis [1]					**56.5%**					**33.1%**	**50.1%**

[1] *Refers to the percentage of costs relating to fracture treatment/ management that occur in adults aged 50 years and over with osteoporosis at the total hip and/or lumbar spine (defined as bone mineral density T score equal to or less than negative 2.5).*

Table 7a: Mean individual and total cost in AUD ($millions) of fractures by BMD category, sex, age group and cost category in Australia for 2017

	Women					**Men**					
	50-69 years		**70+ years**		**Total**	**50-69 years**		**70+ years**			
Fracture	**O/porosis**	**O/penia**	**O/porosis**	**O/penia**	**All women**	**O/porosis**	**O/penia**	**O/porosis**	**O/penia**	**Total All men**	**ALL Total**
Hip											
Number of fractures	*759*	*1,039*	*10,807*	*6,827*	*19,431*	*448*	*956*	*2,292*	*4,536*	*8,233*	*27,665*
Mean cost per patient	***$23,893***		***$39,192***			***$25,482***		***$35,444***			
Total direct cost	$18.14	$24.82	$423.54	$267.55	$734.05	$11.43	$24.37	$81.25	$160.78	$277.83	$1,011.88
% Cost – osteoporosis [1]					**60.2%**					**33.4%**	**52.8%**
Wrist											
Number of fractures	*4,010*	*5,487*	*6,952*	*4,392*	*20,841*	*397*	*847*	*457*	*904*	*2,606*	*23,447*
Mean cost per patient	***$5,299***		***$8,736***			***$4,607***		***$5,818***			
Total direct cost	$21.25	$29.08	$60.73	$38.37	$149.42	$1.83	$3.90	$2.66	$5.3	$13.7	$163.1
% Cost – osteoporosis [1]					**54.9%**					**32.9%**	**53.0%**
Vertebral											
Number of fractures	*3,069*	*4,199*	*9,829*	*6,209*	*23,307*	*796*	*1,698*	*1,449*	*2,868*	*6,812*	*30,118*

Mean cost per patient	***$6,666***		***$10,500***			***$6,807***		***$7,637***			
Total direct cost	$20.46	$28.00	$103.20	$65.19	$216.85	$5,418.46	$11.56	$11.07	$21.91	$49.5	$266.80
% Cost – osteoporosis [1]					**57.0%**					**33.0%**	**52.5%**
Other											
Number of fractures	*12,569*	*17,200*	*14,378*	*9,083*	*53,231*	*5,962*	*12,718*	*3,983*	*7,882*	*30,545*	*83,776*
Mean cost per patient	***$9,449***		***$13,544***			***$7,214***		***$14,274***			
Total direct cost	$118.77	$162.53	$194.74	$123.02	$599.06	$43.01	$91.75	$56.85	$112.50	$304.12	$903.17
% Cost – osteoporosis [1]					**52.3%**					**32.8%**	**45.8%**
Cost of fracture (Total)	**$178,616.52**	**$244,421.53**	**$782,217.81**	**$494,127.98**	**$1,699,383.84**	**$61,684.59**	**$131,587.45**	**$151,822.41**	**$300,454.94**	**$645,549.39**	**$2,344,933.23**
% Cost – osteoporosis [1]					**56.5%**					**33.1%**	**50.1%**

[1] *Refers to the percentage of costs relating to fracture treatment/ management that occur in adults aged 50 years and over with osteoporosis at the hip and/or lumbar spine (defined as bone mineral density T score equal to or less than negative 2.5). The entire analysis only includes adults with either osteoporosis or osteopenia (defined as T score at hip and/or lumbar spine between negative 1 and negative 2.5). Therefore the treatment costs of fractures in adults with osteopenia is estimated to be 49.9% of the total cost of treating fragility fractures.*

Supplementary Table 7b: Assumptions relating to cost distribution between osteoporosis and osteopenia[1]

	Women		Men	
Fracture type	50-69 years	70+ years	50-69 years	70+ years
Hip	4%	26%	6%	28%
Wrist	20%	17%	5%	6%
Vertebral	15%	23%	10%	18%
Other	62%	34%	78%	49%
	100%	100%	100%	100%

[1] Assumes fracture site distribution was the same between adults with osteoporosis and osteopenia.

Fracture site distribution is taken from fracture ascertainment in a population in south eastern Australia –

1. Sanders, K.M., et al., *Age- and gender-specific rate of fractures in Australia: A population-based study.* Osteoporosis International, 1999. **10**(3): p. 240-247.

Figure 1. Total costs of osteoporosis, osteopenia and fractures in 2017 by State