Anti-osteoporosis Medication Use in a High Fracture-Risk Population: Contemporary Trends in Australian Residential Aged Care Facilities

Health Services Insights
Volume 12: 1–11

DOI: 10.1177/1178632919852111

Kimberly E Lind[1], Mikaela L Jorgensen[1], Leonard C Gray[2], Andrew Georgiou[1] and Johanna I Westbrook[1]

[1]Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Macquarie University, Sydney, NSW, Australia. [2]Centre for Health Services Research, Faculty of Medicine, The University of Queensland, Woolloongabba, QLD, Australia.

ABSTRACT: Osteoporotic fractures impose substantial morbidity and mortality among older adults. Undertreatment is an ongoing concern; treatment rates declined following reports of adverse effects of guideline-recommended bisphosphonates, but new antiresorptives have since become available. Our goal was to identify contemporary trends in osteoporosis treatment guideline adherence in a high fracture-risk population. We conducted a secondary data analysis using electronic health record data of adults aged ⩾65 years from 68 residential aged care facilities in Australia during 2014-2017 (n = 9094). Using medication administration data, we identified antiresorptive (bisphosphonates and denosumab) and vitamin D supplement use among residents with osteoporosis. Regression was used to evaluate temporal trends, and resident and facility characteristics associated with antiresorptive use and vitamin D use. In 2014, 34% of women and 42% of men with osteoporosis used antiresorptives; this decreased 8 percentage points by 2017. Antiresorptive use was higher among those with a history of fracture and lower in the last year of life. Denosumab use increased but did not substitute for the continued decline in bisphosphonate use. Vitamin D was consistently used by more than 60% of residents and was higher among those with fracture history. Greater attention to the treatment of osteoporosis treatment rates among this high fracture-risk population is warranted.

KEYWORDS: Osteoporosis, fracture prevention, bisphosphonate, denosumab, antiresorptive, vitamin D, residential aged care, long-term care

RECEIVED: January 30, 2019. **ACCEPTED:** April 25, 2019.

TYPE: Original Research

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship and/or publication of this article: Funding was provided by an Australian Research Council Linkage Grant (LP120200814).

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Kimberly E Lind, Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Macquarie University, Level 6, 75 Talavera Road, Macquarie University, NSW 2109, Australia. Email: Kim.Lind@mq.edu.au

Background

An estimated 86% of older adults in residential aged care facilities (RACFs, also called long-term care facilities) have osteoporosis, putting them at an increased risk of fractures of the hip, spine, and wrist.[1] Osteoporotic fractures impose a high degree of morbidity and mortality; excess mortality following hip fracture is estimated to be between 8% and 36%.[2] Fractures increase health care utilization and costs, and negatively affect the quality of life and functioning of older people, with many not returning to their prefracture health status.[2-4]

Medications commonly used for fracture prevention include a monoclonal antibody (denosumab), bisphosphonates, and vitamin D supplements. Recommendations from the Consensus Conference on Treatment of Osteoporosis in RACFs in Australia published in 2010 (update published in 2016) recommended vitamin D supplements paired with optimal calcium intake (supplementation as required) for all RACF residents and antiresorptives (bisphosphonates or denosumab) for residents at high risk of fracture.[5,6] Factors associated with fracture risk differ for people living in RACFs compared with those who are community-dwelling; RACF residents are regarded as having heighted risk of osteoporotic fractures if they have low bone mass, are female, are older aged, had a previous fracture, have low body weight, have postural instability, have low serum vitamin D, are incontinent (bowel or bladder), are cognitively impaired, have poor balance, or if they are ambulatory.[6,7] Although there are no published efficacy studies specifically in RACF populations, denosumab offers advantages over other antiresorptives, including convenience of administration with twice-yearly injections and a modest side effect profile.[8] In Australia, denosumab and bisphosphonates are subsidized (modest patient co-payment) through the Pharmaceutical Benefits Scheme (PBS) for (1) people 70 years or older who have a bone mineral density *T* score of −2.5 or less; (2) for people of any age who have had a minimal trauma fracture; and (3) for people of any age with corticoid-induced osteoporosis (minimum 3 months with at least 7.5 mg per day prednisolone or equivalent) with a bone mineral density *T* score of −1.5 or less, as long as they are not concomitantly using other subsidized antiresorptives.[9]

Despite subsidization of antiresorptives and increases in bone density testing, undertreatment of osteoporosis in Australia has been documented in community, inpatient, and RACF settings.[10] Undertreatment and even declining rates of pharmacological treatment for osteoporosis have been reported.[11,12] The total number of PBS claims for bisphosphonates dropped sharply after 2006,[13] when reports of rare adverse events associated with bisphosphonates use emerged.[14-18] Hip fracture rates that had been

declining since the introduction of bisphosphonates, parallel to trends in the United States,[19] began to increase.[20-22] Little is known about the current use of antiresorptives within the RACF population and whether treatment has stabilized now that denosumab is available. Studies in Australian RACFs found that use of vitamin D supplements ranged from 43% to 50% of residents,[23,24] and 8% used bisphosphonates.[25] However, those studies did not examine anti-osteoporosis medication use among people with osteoporosis specifically. In community-dwelling older men with osteoporosis, 10% used bisphosphonates and 7% used vitamin D supplements.[13] Among patients who presented with hip fracture between 2005 and 2009 at a hospital in Perth, anti-osteoporosis medication use was low and lower for rural-dwelling patients compared with urban-dwelling patients.[26]

Medication management is a leading quality concern in Australian RACFs,[27] but due to a lack of systematic monitoring, medication guideline adherence and subgroups at risk of suboptimal treatment remain unknown. Identifying factors that influence osteoporosis treatment rates in this high fracture-risk population is critical for determining subgroups at heightened risk of undertreatment and informing the design of targeted interventions or policy changes. Furthermore, evaluating trends in specific anti-osteoporosis medication use over time is important for understanding how the introduction and coverage of newer medications affect treatment rates and whether treatment recommendations are delivering the desired effects. No study to date has evaluated the use of medications for fracture prevention in older people according to osteoporosis status in Australian RACFs or examined resident and facility characteristics related to osteoporosis treatment. Finally, little is known about the uptake of denosumab and its impact on bisphosphonate use as it was only recently made available in Australia.

The aims of this study were to identify trends in the use of antiresorptives (bisphosphonates and denosumab), which are recommended for high fracture-risk residents, and vitamin D supplements, which are recommended for all residents,[5,6] and assess associations between medication use and resident and facility characteristics.

Methods

We conducted a retrospective dynamic cohort study of people aged ⩾65 years living in RACFs in New South Wales and the Australian Capital Territory during 2014-2017. We included "permanent" (non–respite care) residents who had a length of stay of at least 2 weeks during the study period. This study forms part of a larger program of research examining medication use in RACFs.[28] This research was approved by our institution's Human Research Ethics Committee, and a waiver of consent was granted.

Data

We conducted a secondary data analysis using electronic health record (EHR) data from January 1, 2014, through September 30, 2017, using records from a large multisite, not-for-profit residential aged care provider. Analyses used a person-year file with 1 record per person per year they resided in a facility.

Dependent variables

Medication administration records from the EHR were used to identify relevant medication use. Antiresorptive use was defined as having at least one administration of a bisphosphonate or denosumab in a given year; this included oral and intravenous (IV) administrations. Vitamin D supplement use was defined in a parallel manner. We used this outcome because it most simply handled issues related to different dosing patterns for oral and IV medications, because of the dynamic nature of sample (ie, dynamic cohort which had people entering and leaving the cohort, and intermittent gaps in observation due to people being hospitalized and then coming back to the facility), it was most directly comparable to the outcome measures used in other Australian and international studies, and because we did not expect compliance with oral medications to be a substantial issue in this population (relative to community-dwelling populations) because RACF staff oversee and assist with medication administrations on a daily basis. Because guidelines recommend vitamin D supplements be paired with optimal calcium intake with supplementation as required,[5,6] we also created an indicator for vitamin D use with concurrent calcium supplement use for descriptive purposes (not as a main outcome) because some residents will have had sufficient calcium intake through their diet, but that proportion was unknown.

Independent variables

Osteoporosis and other chronic health conditions were identified using 3 sources in the EHR. First, health conditions reported on the Aged Care Funding Instrument (ACFI); the ACFI is an evaluation of health and functional status used by the Australian government to determine the level of aged care funding that will be provided to the RACF residents.[29] As providers are only required to report the 3 most impactful conditions in ACFI, we included conditions recorded in other places in residents' EHRs to obtain more complete reporting of conditions. Second, the residents' "special needs" notes in the EHR which include notes on diagnosed conditions were searched for relevant text strings. Third, using medication administration data we searched for medications that have specific indications and tend not to have off-label use (eg, antiresorptives were used to identify osteoporosis). We identified the first date that a given resident had the condition reported on their ACFI or EHR and included all time past that date (until discharge or death) as time with that condition (ie, we assumed that chronic conditions would persist). Condition criteria were developed by a team composed of a pharmacist, a physiotherapist specializing in geriatric care, and a chronic disease epidemiologist. The text strings used in the "special needs" notes were selected after all unique phrases appearing

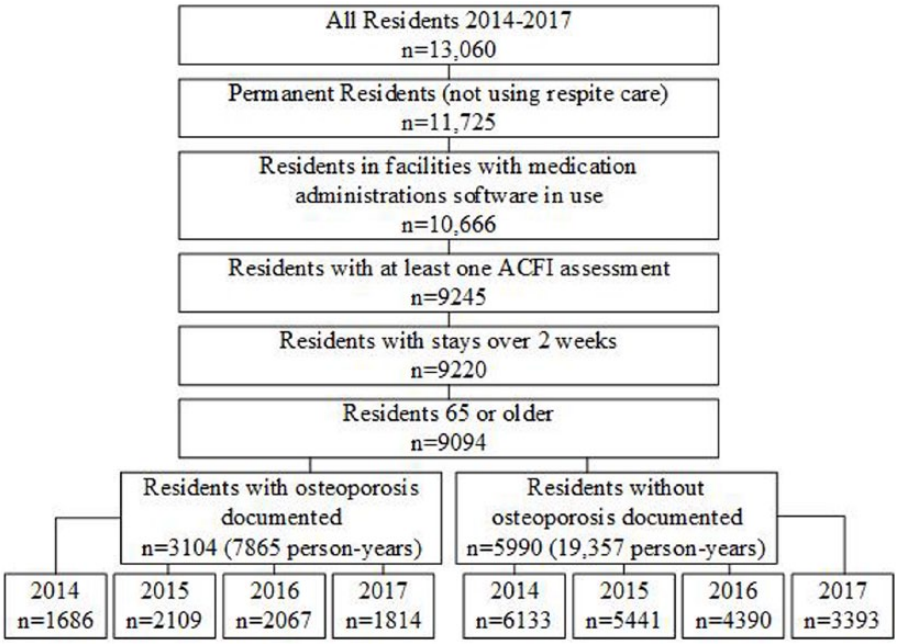

Figure 1. Sample size and exclusions. Residents of aged care facilities in Australia from a not-for-profit provider with 68 facilities.

in the notes had been parsed and categorized into disease categories; this ensured that we identified all relevant variations of text strings for a given condition, even if less common or outmoded terms were used or if there were misspellings or dialectical differences in spellings. Criteria for each chronic condition are presented in Supplemental Table 1.

Sociodemographic data were abstracted from residents' records including age, sex, marital status, country of birth, and primary language spoken. We identified the mobility rating (higher values indicate higher level of assistance needed) from the ACFI that was conducted closest (temporally) to the year of medication use. We identified the date of death in the EHR for residents who died and created an indicator for having died within the year of observation as a proxy for limited life expectancy. Length of stay (LOS) was calculated as the time between residents' entry date and departure date if they left during the year of observation or the last day of observation for the study period if they were still alive. Using facility postcode, we linked area-level remoteness classification from the Australian Bureau of Statistics.[30]

Analysis strategy

To evaluate resident characteristics, facility characteristics, and temporal trends associated with anti-osteoporosis medication use, we used generalized estimating equations (GEE) probit regression to account for multiple years (ie, repeated measures) of observation for residents and included fixed effects for facilities (to account for repeated measures within facilities). We fit a model with the outcome of any antiresorptive medication use. As predictors we included age, sex, LOS, an indicator variable for English as the primary language spoken, country of birth (indicators for the most common countries of birth), marital status, health conditions, year, facility remoteness, an indicator for the last year of life, and the mobility rating from ACFI. Quadratic terms were included for age and LOS to allow curvilinear relationships. We then estimated marginal effects which can be interpreted as the change in probability of medication use associated with a change in the level of the independent variable relative to the reference group. The analysis for vitamin D use (regardless of calcium supplementation) was exactly parallel. We used a type I error rate of 0.05. Analyses were conducted using SAS 9.4 (SAS Institute, Cary, North Carolina) and Stata 15 (Stata Corp, College Station, Texas).

Results

The total sample comprised 9094 permanent RACF residents from 68 facilities; 3104 residents had osteoporosis documented (34.1%). Sample exclusions are presented in Figure 1. Sample characteristics are presented in Table 1, stratified by osteoporosis; among residents with osteoporosis, 84.2% were female and 43.0% had a history of fracture. Females were 3 years older than males (in both osteoporosis and no-osteoporosis groups), and compared with residents without osteoporosis, those with osteoporosis had median ages 3 years older.

The unadjusted proportions of residents who used anti-osteoporosis medications by medication type and sex by year are plotted in Figure 2. Bisphosphonate use was low (Figure 2, Panel A) and decreased over time from 30% to 18% for females and from 39% to 24% for males with osteoporosis during 2014-2017. Denosumab use was also low, but increased consistently during the study period from 5% to 15% for females with osteoporosis and from 4% to 16% for males with osteoporosis. Vitamin D supplements were used by more than 60% of residents with osteoporosis in each year, and approximately 20% of residents with osteoporosis used vitamin D with a calcium supplement (Figure 2, Panel B).

Table 1. Sample characteristics for residents by osteoporosis status (n = 9094).

VARIABLE	RESIDENTS WITH OSTEOPOROSIS (N = 3104)		RESIDENTS WITHOUT OSTEOPOROSIS (N = 5990)	
	FREQUENCY	COLUMN %	FREQUENCY	COLUMN %
Female	2612	84.15	3532	58.96
English primary language	2728	87.89	5238	87.45
Country of origin				
Australia	2147	69.17	4095	68.36
China	96	3.09	97	1.62
Italy	39	1.26	88	1.47
United Kingdom	293	9.44	541	9.03
Marital status				
Unknown	190	6.12	356	5.94
Single	230	7.41	607	10.13
Married	570	18.36	1567	26.16
Widowed	1838	59.21	2828	47.21
Divorced	242	7.80	530	8.85
Separated	34	1.10	102	1.70
Chronic conditions				
History of fracture	1336	43.04	698	11.65
Cerebrovascular disease	714	23.00	1056	17.63
Respiratory disease	949	30.57	1023	17.08
Renal disease	408	13.14	498	8.31
Myocardial infarction	133	4.28	222	3.71
Liver disease	56	1.80	57	0.95
Hypertension	1923	61.95	2211	36.91
Heart disease	992	31.96	1189	19.85
Dyslipidemia	1288	41.49	1550	25.88
Diabetes	595	19.17	1015	16.94
Heart failure	361	11.63	405	6.76
Neoplasms	745	24.00	777	12.97
Arthritis	1957	63.05	2027	33.84
Dementia	1692	54.51	2184	36.46
Died during study period	1467	47.26	2893	48.30
Mobility rating in ACFI (higher values indicate higher level of assistance needed)				
0	21	0.68	87	1.45
1	69	2.23	185	3.09
2	1393	44.92	2590	43.25
3	1618	52.18	3126	52.20
Facility remoteness category				
Major cities of Australia	2323	74.84	4226	70.55
Inner regional Australia	719	23.16	1640	27.38
Outer regional Australia	62	2.00	124	2.07

Table 1. (Continued)

VARIABLE	RESIDENTS WITH OSTEOPOROSIS (N = 3104)	RESIDENTS WITHOUT OSTEOPOROSIS (N = 5990)
	MEDIAN (IQR)	MEDIAN (IQR)
Age of females, y	89 (84-92)	86 (80-91)
Age of males, y	86 (80-90)	83 (76-88)
LOS of females, y	3.15 (1.50-5.46)	2.94 (1.22-5.52)
LOS of males, y	2.18 (1.08-4.43)	2.02 (0.80-4.22)

Abbreviations: ACFI = Aged Care Funding Instrument; IQR = interquartile range.
Aged care facility residents aged 65+ who had a length of stay (LOS) of at least 2 weeks during 2014-2017.

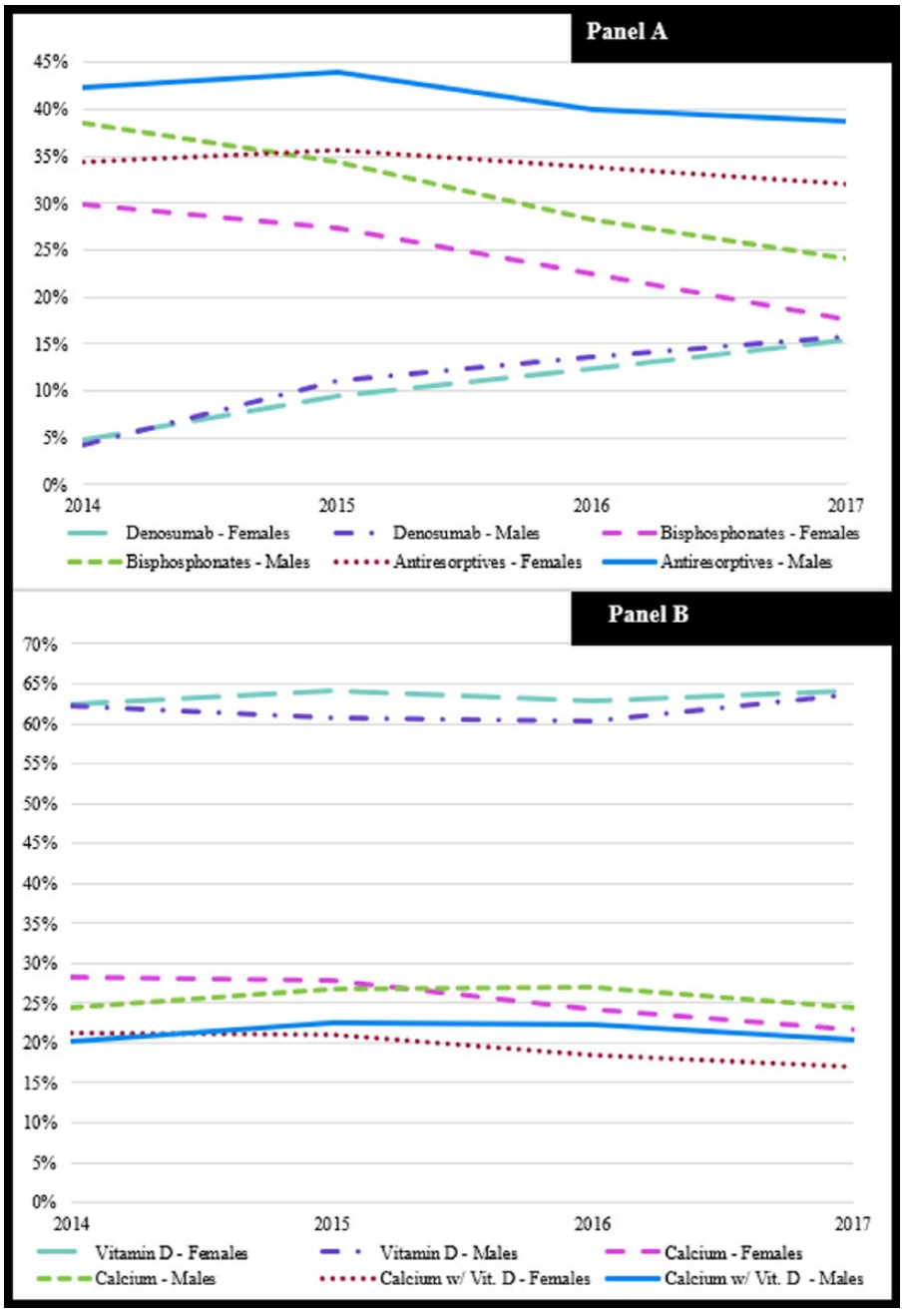

Figure 2. Unadjusted proportion of residents who used osteoporosis medications by sex and osteoporosis diagnosis, 2014-2017. N = 3104 permanent aged care facility residents aged 65 and older with documented osteoporosis. (Panel A) Antiresorptive use and (Panel B) vitamin D use.

Table 2. Generalized estimating equations regression marginal effects—outcome is any antiresorptive medication use.

INDEPENDENT VARIABLE	ESTIMATE (SE)	95% CI	*P* VALUE
Male	0.06 (0.02)	0.02 to 0.11	.01
Age	0.01 (0.004)	0.002 to 0.02	.02
Age^2, decades	−0.004 (0.001)	−0.01 to −0.002	<.001
English primary language	−0.04 (0.04)	−0.11 to 0.04	.33
Marital status (ref. group is married)			
Unknown	0.08 (0.04)	0.003 to 0.15	.04
Single	0.08 (0.04)	0.01 to 0.15	.02
Widowed	0.06 (0.02)	0.01 to 0.10	.01
Divorced	0.10 (0.03)	0.03 to 0.16	.01
Separated	0.08 (0.07)	−0.07 to 0.22	.32
Country of origin (ref. group is all other countries)			
Australia	−0.01 (0.03)	−0.06 to 0.04	.69
China	−0.08 (0.06)	−0.19 to 0.04	.20
Italy	−0.11 (0.06)	−0.23 to 0.01	.07
United Kingdom	0.001 (0.03)	−0.07 to 0.07	.98
Comorbidities (ref. group is absence of disease)			
History of fracture	0.07 (0.02)	0.04 to 0.10	<.001
Cerebrovascular disease	0.01 (0.02)	−0.02 to 0.05	.52
Respiratory disease	0.04 (0.01)	0.01 to 0.06	.01
Renal disease	−0.04 (0.02)	−0.08 to 0.01	.09
Myocardial infarction	−0.001 (0.04)	−0.07 to 0.07	.99
Liver disease	−0.13 (0.05)	−0.23 to −0.04	.01
Hypertension	−0.02 (0.02)	−0.05 to 0.01	.29
Heart disease	0.01 (0.02)	−0.02 to 0.04	.67
Dyslipidemia	0.05 (0.02)	0.02 to 0.08	.001
Diabetes	−0.05 (0.02)	−0.09 to −0.01	.01
Heart failure	0.03 (0.02)	−0.02 to 0.07	.25
Cancer	0.01 (0.02)	−0.02 to 0.04	.63
Arthritis	0.02 (0.01)	−0.01 to 0.05	.11
Dementia	−0.02 (0.02)	−0.04 to 0.01	.31
Died during year of observation	−0.05 (0.02)	−0.08 to −0.02	.001
Mobility rating (ref. group is 0)			
1	0.12 (0.09)	−0.05 to 0.30	.16
2	0.10 (0.08)	−0.06 to 0.26	.20
3	0.08 (0.08)	−0.07 to 0.24	.30
Length of stay, y	−0.01 (0.01)	−0.02 to 0.003	.17
Length of stay, y^2	0.003 (0.003)	−0.004 to 0.01	.44

Table 2. (Continued)

INDEPENDENT VARIABLE	ESTIMATE (SE)	95% CI	*P* VALUE
Facility remoteness category (ref. group is major city)			
Inner regional[a]	−0.64 (0.26)	−1.15 to −0.13	.01
Outer regional[a]	−1.43 (0.28)	−1.99 to −0.88	<.001
Time (y, ref. group is 2014)			
2015	−0.003 (0.01)	−0.02 to 0.02	.76
2016	−0.04 (0.01)	−0.06 to −0.02	<.001
2017	−0.08 (0.01)	−0.10 to −0.06	<.001

Abbreviations: CI = confidence interval; SE = standard error.
Outcome of antiresorptive medication use is defined as at least one administration of a bisphosphonate or denosumab in a given year. N = 3104 aged care facility residents with osteoporosis from 68 facilities. Age is scaled to years past 65.
[a]Marginal effects not estimable, parameter estimate reported.

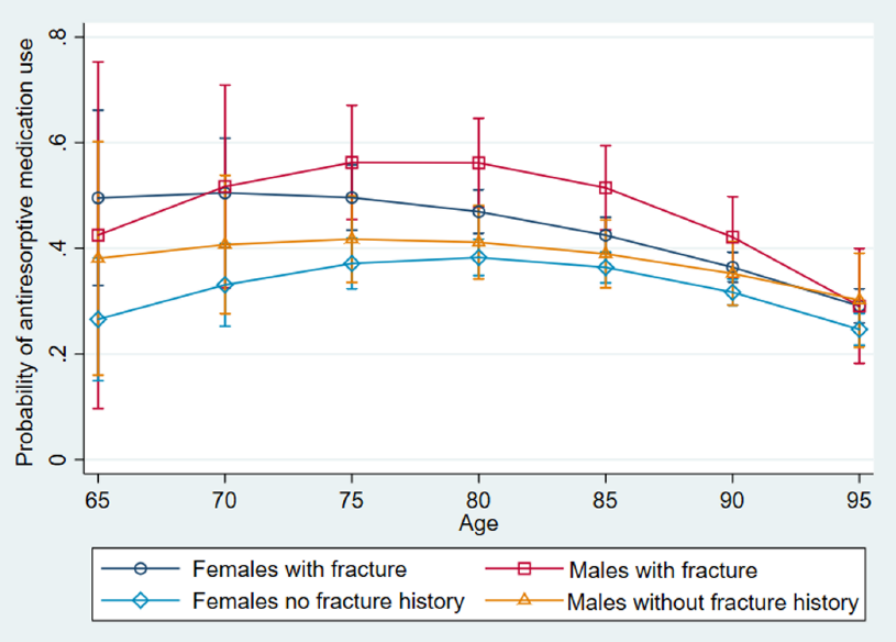

Figure 3. Model-based estimates of antiresorptive use by age, sex and facture history.

The GEE regression found that for residents with osteoporosis, antiresorptive use varied by sex, age, health status, last year of life, and time (Table 2, Figure 3). Older age was associated with higher bisphosphonate use, although the increase was smaller at older ages (negative quadratic term for age). Antiresorptive use was 13 points lower for residents with liver disease compared with those without ($P = .01$), 5 points lower for residents with diabetes ($P = .01$), and 5 points lower for residents who died during the year ($P = .001$). Antiresorptive use was higher for residents who had a history of fracture (7 points; $P < .001$), had chronic lower respiratory disease (4 points; $P = .01$), had dyslipidemia (5 points; $P = .001$), or were men (6 points; $P = .01$). Antiresorptive use decreased over time; relative to 2014, decreases were significant in 2016 (4 points lower; $P < .001$) and 2017 (8 points lower; $P < .001$).

Vitamin D supplement use varied by age and health status (Table 3, Figure 4). Age had a curvilinear trend where compared with younger residents, older residents were more likely to use vitamin D supplements, but at older ages this difference tapered off. Vitamin D use was 5 points higher among residents with a history of fracture ($P < .001$) and 4 points higher among residents with dyslipidemia ($P = .01$).

Discussion

This study found both encouraging and concerning trends in osteoporosis treatment for residents in RACFs. Antiresorptive use declined during 2014-2017; despite increasing use of denosumab, antiresorptive use continued to fall. Bisphosphonate use decreased during the study period, consistent with studies reporting declining bisphosphonate use after concerns about rare but serious side effects were reported in 2006.[13] Antiresorptive use varied by other factors such as sociodemographic characteristics and facility characteristics, indicating that clinical characteristics specified by treatment guidelines

Table 3. Generalized estimating equation regression marginal effects—outcome is any vitamin D use.

INDEPENDENT VARIABLE	ESTIMATE (SE)	95% CI	*P* VALUE
Male	−0.01 (0.02)	−0.05 to 0.03	.59
Age	0.01 (0.004)	0.003 to 0.02	.01
Age^2, decades	−0.003 (0.001)	−0.01 to −0.001	.002
English primary language	0.01 (0.04)	−0.06 to 0.08	.73
Marital status (ref. group is married)			
Unknown	0.05 (0.03)	−0.01 to 0.12	.12
Single	0.06 (0.03)	−0.003 to 0.12	.06
Widowed	0.02 (0.02)	−0.02 to 0.07	.26
Divorced	0.01 (0.03)	−0.05 to 0.07	.73
Separated	−0.12 (0.07)	−0.26 to 0.03	.12
Country of origin (ref. group is all other countries)			
Australia	0.02 (0.03)	−0.03 to 0.08	.35
China	0.05 (0.06)	−0.07 to 0.17	.40
Italy	−0.07 (0.07)	−0.21 to 0.08	.36
United Kingdom	0.004 (0.03)	−0.06 to 0.07	.91
Comorbidities (ref. group is absence of disease)			
History of fracture	0.05 (0.01)	0.03 to 0.08	<.001
Cerebrovascular disease	−0.03 (0.02)	−0.06 to 0.01	.15
Respiratory disease	0.01 (0.01)	−0.02 to 0.04	.43
Renal disease	−0.03 (0.02)	−0.08 to 0.01	.12
Myocardial infarction	0.06 (0.03)	−0.01 to 0.13	.08
Liver disease	0.01 (0.05)	−0.09 to 0.12	.79
Hypertension	−0.001 (0.02)	−0.03 to 0.03	.95
Heart disease	0.02 (0.02)	−0.01 to 0.05	.18
Dyslipidemia	0.04 (0.02)	0.01 to 0.07	.01
Diabetes	0.03 (0.02)	−0.01 to 0.07	.09
Heart failure	−0.002 (0.02)	−0.05 to 0.04	.91
Cancer	0.004 (0.02)	−0.03 to 0.04	.79
Arthritis	−0.01 (0.01)	−0.03 to 0.02	.67
Dementia	0.01 (0.01)	−0.02 to 0.04	.42
Died during year of observation	−0.03 (0.02)	−0.06 to 0.002	.06
Mobility rating (ref. group is 0)			
1	0.16 (0.10)	−0.03 to 0.36	.10
2	0.08 (0.09)	−0.10 to 0.26	.38
3	0.06 (0.09)	−0.12 to 0.24	.53
Length of stay, y	0.01 (0.01)	−0.001 to 0.02	.09
Length of stay, y^2	−0.005 (0.003)	−0.01 to 0.002	.14

Table 3. (Continued)

INDEPENDENT VARIABLE	ESTIMATE (SE)	95% CI	*P* VALUE
Facility remoteness category (ref. group is major city)			
Inner regional[a]	0.25 (0.26)	−0.26 to 0.75	.34
Outer regional[a]	−0.29 (0.26)	−0.80 to 0.22	.27
Time (y, ref. group is 2014)			
2015	0.02 (0.01)	−0.001 to 0.04	.07
2016	0.01 (0.01)	−0.01 to 0.03	.40
2017	0.02 (0.01)	−0.004 to 0.04	.10

Abbreviation: CI = confidence interval; SE = standard error.
Outcome of any vitamin D supplement use is defined as at least one administration of vitamin D in a given year. N = 3104 aged care facility residents with osteoporosis from 68 facilities. Age is scaled to years past 65.
[a]Marginal effects not estimable, parameter estimate reported.

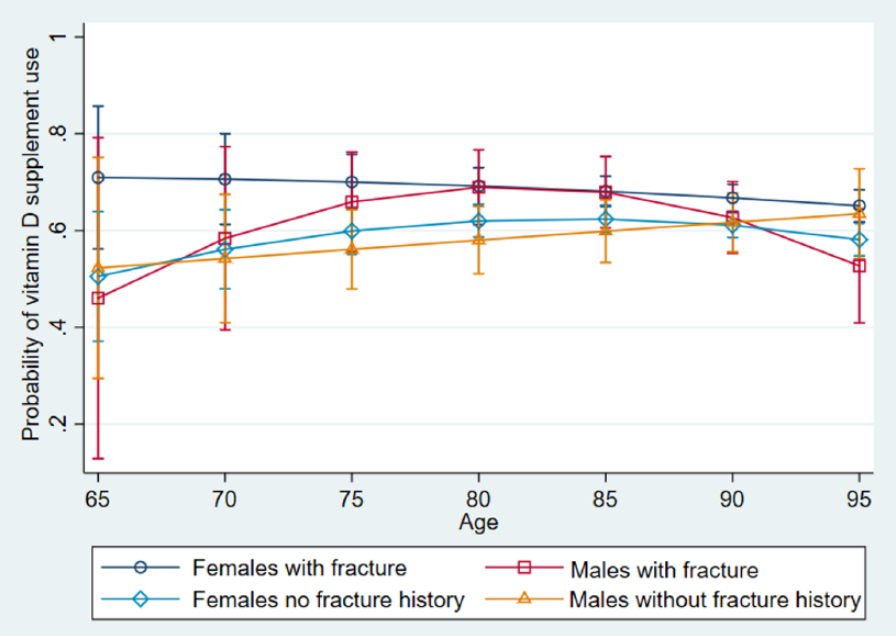

Figure 4. Model-based estimates of vitamin D supplement use by age, sex, and fracture history.

are not the sole driver of antiresorptive use. These findings are countered by some positive trends in anti-osteoporosis medication use that indicated treatment consistent with guidelines. First, vitamin D supplement use was high and remained stable during the study period. Unlike antiresorptives, vitamin D use was mostly unvaried by sociodemographic and facility characteristics, which we interpret as an encouraging finding. Another positive finding was that residents in their last year of life (as a proxy for limited life expectancy) had lower antiresorptive utilization rates—consistent with recommendations.[5,6]

Underutilization of bisphosphonates is not unique to Australia; recent commentary has highlighted the need for physicians to address patient concerns about bisphosphonates.[31] Low antiresorptive use during the study period may be a response to concerns about adverse side effects,[14-18] but may also be a consequence of the guidelines for PBS subsidization of antiresorptives. People living in RACFs may experience barriers to accessing dual-energy x-ray absorptiometry (DEXA) scans, and thus may have difficulties meeting the coverage criteria for antiresorptives without having a fracture. These barriers may be compounded for those residing in more remote areas; we found that remoteness was associated with lower medication use, consistent with prior research.[26] Our data only include facilities located in the 3 most urban categories, and these differences may be greater in the most remote areas of Australia. Our data reflect treatment provided well after concerns about atypical fractures as an adverse (but rare) effect of bisphosphonates were highlighted; thus, it is unclear the degree to which these reports explain recent bisphosphonate trends and what part of the reduction in bisphosphonate use is attributable to prescribers choosing denosumab instead of bisphosphonates. Compared with other Australian studies, we observed higher

rates of bisphosphonate use (other studies: 8%-20%, our study: 18%-39%), but this could plausibly be explained by those studies using larger denominators (all older adults vs our use of just people with documented osteoporosis). We found somewhat higher vitamin D supplement use (other studies: 8%-50%, our study: 60%-64%).[13,23-26] An unexpected finding was that antiresorptive use (mostly bisphosphonate use) was higher in men than in women. We cannot conclusively identify why this difference occurred, but we suspect that it is an artifact of higher diagnosis rates in women. If men are less likely to have their osteoporosis diagnosed and documented and the cases that are diagnosed represent more severe cases, these cases may be more likely to use antiresorptives. In other words, this would make the denominator of men with osteoporosis smaller than it should be, which generates an upward bias in the antiresorptive treatment rate.

The greatest limitation of this study is likely underidentification of osteoporosis; we found that approximately one-third of residents had osteoporosis documented in their EHR, well below the expected prevalence based on prior research that has suggested that osteoporosis may affect 86% of people in the RACF setting.[1] If this is the case, our estimates of antiresorptive use may overestimate the true treatment rates. The residents identified as having osteoporosis could represent those with more severe osteoporosis and/or with less complex and less severe comorbidities. If this is the case, then our results may overestimate osteoporosis treatment rates, assuming that residents with more severe osteoporosis are more likely to receive treatment. Our estimates of treatment rates are also likely conservative because we used a simple measure of annual medication use (any use within the calendar year) that did not address whether or not residents had used sufficient amounts of the medications for them to be effective. However, we may have underascertained intravenous antiresorptives if residents received infusions outside of the RACF. Another limitation is that we lacked information on the severity of osteoporosis or details of contraindications for antiresorptives or supplements; thus, we could not determine eligibility for antiresorptive coverage or medication appropriateness. We also lacked information on dietary calcium intake and thus do not know whether most vitamin D users were receiving adequate calcium.

The strengths of this study come from our use of a large and recent longitudinal sample of residents within Australia's most populous region, our regression approach which corrected for repeated measurements, and use of medication administration data that are not subjected to measurement error from noncompliance. Our findings should be generalizable to the Australian RACF population as our sample is demographically similar.[28] We demonstrated the potential value of EHR data from RACFs as a tool for examining quality of care issues, particularly medication use, which is a leading quality concern in Australian RACFs. Little is known about the quality and safety of care in Australian RACFs as Australia lacks a systematic, evidence-based, public reporting system for the aged care sector. As a consequence, compliance with treatment guidelines for common geriatric conditions such as osteoporosis remains largely unmeasured and unreported. This study sheds new light on this issue and indicates areas for targeting treatment. Future research should build on our use of RACF EHR data by linking data from general practice and hospitalizations, which could improve the ability to identify cases of osteoporosis and provide the data necessary for evaluating important outcomes such as incident fractures. Future research should also examine longitudinal trends in anti-osteoporosis medication use across settings and how medication use changes as older adults transition across different settings of care.

Conclusions

This study found aged care facility residents with documented osteoporosis had high use of vitamin D supplements, but use of antiresorptives was low and declining over time. Effective strategies for improving osteoporosis treatment rates in the residential setting are available,[32,33] and fracture prevention within the most vulnerable population can be improved. Current undertreatment of osteoporosis may translate into a substantial number of fractures and hospitalizations that could be prevented. Quality monitoring in RACFs for treatment of common chronic conditions may be achieved using data collected routinely, such as medication administration.

Author Contributions

KEL: study concept and design, analysis and interpretation of data, preparation of manuscript. MLJ: study design, interpretation of data, preparation of manuscript. LCG: study design, interpretation of data, preparation of manuscript. AG: interpretation of data, preparation of manuscript. JIW: interpretation of data, preparation of manuscript.

Supplemental Material

Supplemental material for this article is available online.

ORCID iD

Kimberly E Lind https://orcid.org/0000-0002-8850-1576

REFERENCES

1. Zimmerman SI, Girman CJ, Buie VC, et al. The prevalence of osteoporosis in nursing home residents. *Osteoporos Int*. 1999;9:151–157.
2. Abrahamsen B, van Staa T, Ariely R, Olson M, Cooper C. Excess mortality following hip fracture: a systematic epidemiological review. *Osteoporos Int*. 2009;20:1633–1650.
3. Harvey N, Dennison E, Cooper C. Osteoporosis: impact on health and economics. *Nat Rev Rheumatol*. 2010;6:99–105.
4. Peeters CM, Visser E, Van de Ree CL, Gosens T, Den Oudsten BL, De Vries J. Quality of life after hip fracture in the elderly: a systematic literature review. *Injury*. 2016;47:1369–1382.
5. Duque G, Close JJ, Jager D, et al. Treatment for osteoporosis in Australian residential aged care facilities: consensus recommendations for fracture prevention. *Med J Aust*. 2010;193:173–179.
6. Duque G, Lord SR, Mak J, et al. Treatment of osteoporosis in Australian residential aged care facilities: update on consensus recommendations for fracture prevention. *J Am Med Dir Assoc*. 2016;17:852–859.

7. Chen JS, Simpson JM, March LM, et al. Fracture risk assessment in frail older people using clinical risk factors. *Age Ageing*. 2008;37:536–541.
8. Silva-Fernández L, Rosario MP, Martínez-López JA, Carmona L, Loza E. Denosumab for the treatment of osteoporosis: a systematic literature review. *Reumatol Clin*. 2013;9:42–52.
9. NPS MedicineWise. *Decision Pathway for PBS-Listed Treatment Selection: Management of Confirmed Osteoporosis*. NPS MedicineWise. https://www.nps.org.au/professionals/osteoporosis/decision-pathway-for-pbs-listed-treatment-selection-management-of-confirmed-osteoporosis. Accessed May 11, 2019.
10. Australian Bureau of Statistics. *Health Service Usage and Health Related Actions, Australia, 2014–15*. Australian Bureau of Statistics. http://www.abs.gov.au/ausstats/abs@.nsf/0/CD8DB1EFA25F665DCA257B39000F371A?Opendocument. Up-dated March 27, 2017. Accessed December 19, 2017.
11. Khosla S, Hofbauer LC. Osteoporosis treatment: recent developments and ongoing challenges. *Lancet Diabetes Endocrinol*. 2017;5:898–907.
12. Parikh S, Avorn J, Solomon DH. Pharmacological management of osteoporosis in nursing home populations: a systematic review. *J Am Geriatr Soc*. 2009;57:327–334.
13. Bleicher K, Naganathan V, Cumming RG, et al. Prevalence and treatment of osteoporosis in older Australian men: findings from the CHAMP study. *Med J Aust*. 2010;193:387–391.
14. Schneider JP. Should bisphosphonates be continued indefinitely? an unusual fracture in a healthy woman on long-term alendronate. *Geriatrics*. 2006;61:31–33.
15. Armamento-Villareal R, Napoli N, Panwar V, Novack D. Suppressed bone turnover during alendronate therapy for high-turnover osteoporosis. *N Engl J Med*. 2006;355:2048–2050.
16. Goh S-K, Yang KY, Koh JSB, et al. Subtrochanteric insufficiency fractures in patients on alendronate therapy: a caution. *J Bone Joint Surg Br*. 2007;89:349–353.
17. Kwek EB, Goh SK, Koh JS, Png MA, Howe TS. An emerging pattern of subtrochanteric stress fractures: a long-term complication of alendronate therapy? *Injury*. 2008;39:224–231.
18. Lenart BA, Lorich DG, Lane JM. Atypical fractures of the femoral diaphysis in postmenopausal women taking alendronate. *N Engl J Med*. 2008;358:1304–1306.
19. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. *JAMA*. 2009;302:1573–1579.
20. Crisp A, Dixon T, Jones G, et al. Declining incidence of osteoporotic hip fracture in Australia. *Arch Osteoporos*. 2012;7:179–185.
21. Clout A, Narayanasamy N, Harris I. Trends in the incidence of atypical femoral fractures and bisphosphonate therapy. *J Orthop Surg (Hong Kong)*. 2016;24:36–40.
22. Fisher A, Martin J, Srikusalanukul W, Davis M. Bisphosphonate use and hip fracture epidemiology: ecologic proof from the contrary. *Clin Interv Aging*. 2010;5:355–362.
23. Walker P, Miller Amberber A, Kurrle S, Kifley A, Cameron ID. Prevalence of vitamin D supplement use in Australian residential aged care facilities in November 2014. *BMC Res Notes*. 2017;10:385.
24. Curtain CM, Williams M, Cousins JM, Peterson GM, Winzenberg T. Vitamin D supplementation in Tasmanian nursing home residents. *Drugs Aging*. 2016;33:747–754.
25. Taxis K, Kochen S, Wouters H, et al. Cross-national comparison of medication use in Australian and Dutch nursing homes. *Age Ageing*. 2017;46:320–323.
26. Lai MM, Ang WM, McGuiness M, Larke AB. Undertreatment of osteoporosis in regional Western Australia. *Australas J Ageing*. 2012;31:110–114.
27. Australian Government AgedCare Complaints Commissioner. *Aged Care ComplaintsCommissioner: Annual Report2017-18*. Melbourne VIC Australia: Australian Government AgedCare Commissioner. https://www.agedcarequality.gov.au/sites/default/files/media/Aged%20Care%20Complaints%20Commissioner%20%E2%80%93%20Annual%20Report%202017%E2%80%9318.pdf. Up-dated 2018. Accessed January 30, 2019.
28. Pont LG, Raban MZ, Jorgensen ML, Georgiou A, Westbrook JI. Leveraging new information technology to monitor medicine use in 71 residential aged care facilities: variation in polypharmacy and antipsychotic use. *Int J Qual Health Care*. 2018;30:810–816.
29. Australian Government Department of Human Services. *Aged Care Funding Instrument*. Australian Government Department of Human Services. https://www.humanservices.gov.au/organisations/health-professionals/services/aged-care-funding-instrument. Up-dated November 23, 2017. Accessed May 23, 2018.
30. Australian Bureau of Statistics. *Australian Statistical Geography Standard (ASGS)*. Australian Bureau of Statistics. http://www.abs.gov.au/ausstats/abs@.nsf/0/D964E42C5DF5B6D4CA257B03000D7ECB?Opendocument. Up-dated January 31, 2013. Accessed March 12, 2018.
31. Abbasi J. Amid osteoporosis treatment crisis, experts suggest addressing patients' bisphosphonate concerns. *JAMA*. 2018;319:2464–2466.
32. Walker P, Kifley A, Cameron ID. *Focus on the Implementation of Vitamin D Supplements in Australian Residential Aged Care Facilities (RACFs)*. Sydney, NSW, Australia: The University of Sydney. https://sydney.edu.au/medicine/cdpc/documents/resources/Implementation-of-Vitamin-D-in-Residential-Aged-Care-Facilities-Summary-Report.pdf. Up-dated 2018. Accessed June 28, 2018.
33. Kennedy CC, Ioannidis G, Thabane L, et al. Successful knowledge translation intervention in long-term care: final results from the vitamin D and osteoporosis study (ViDOS) pilot cluster randomized controlled trial. *Trials*. 2015;16:214.