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Use of potentially inappropriate psychotropic medicines among older adults in 23 residential aged care facilities in Australia: a retrospective cohort study

Narjis Batool[1*], Magdalena Z. Raban[1], Karla L. Seaman[1], Johanna I. Westbrook[1] and Nasir Wabe[1]

Abstract

Background Psychotropic medications are frequently utilised in residential aged care facilities (RACFs). Longitudinal medication administration data can offer crucial insights into the potential inappropriate use of psychotropic medicines (PIPMs), guiding future quality improvement initiatives. This study aimed to determine the prevalence and predictors of PIPMs use and assess variation in PIPMs use by facility for residents of RACFs.

Methods We conducted a retrospective longitudinal cohort study using routinely collected electronic health data (2020–2021) relating to 3064 residents from 23 RACFs in New South Wales, Australia. The study included permanent residents aged ≥ 65 years and median length of stay was 483 days. The prevalence of PIPMs use was estimated using updated Beers criteria 2023. The extent of exposure to PIPMs was measured using two metrics i.e., number of days residents were exposed to PIPMs and the proportion of days covered by PIPMs. We used logistic regression model to determine factors associated with PIPM use. Funnel plots to visualised variation in PIPMs use across facilities.

Results In total 40% ($n = 1224$) residents used at least one PIPM and 10% ($n = 302$) used ≥ 2. The most frequently used PIPMs categories were benzodiazepines and Z-drugs (27.4%), followed by first and second generation antipsychotics (17.2%). Certain diagnoses (dementia, pain, depression, anxiety, and endocrine disorders) were associated with the increased use of PIPMs. For example, residents with dementia were 1.94 times more likely to use ≥ 2 PIPMs (OR 1.94; 95% CI 1.50–2.51). The prevalence of at least one PIPM by residents in each facility ranged from 23.3 to 57.0% across facilities. The overall median number of days residents were exposed to PIPMs were 91 days (IQR 6-320) while the median proportion of days covered by at least one PIPM was 39.3% (IQR 2.6–86.6%).

Conclusions Residents in aged care facilities showed a high rate of PIPMs use with substantial variation across facilities. Quality improvement initiatives which target inappropriate psychotropic medication use are necessary, particularly considering the link between psychotropic drug use and adverse events such as falls.

Keywords Psychotropic medicines, Residential aged care, Older adults, Beers criteria

Background

According to World Health Organisation (WHO), around 14% of older adults live with a mental health condition such as depression, anxiety, sleep disturbance, dementia [1, 2], which are commonly treated with psychotropic medicines [3]. The main classes of psychotropics are

*Correspondence:
Narjis Batool
narjis.batool@students.mq.edu.au
[1] Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Macquarie University, Level 6, 75 Talavera Road, North Ryde, Sydney, NSW, Australia

antidepressants, antipsychotics, anxiolytics and hypnotics (mostly benzodiazepines). Psychotropic medicine use has increased among older adults [4] with 28·54 defined daily dose (DDD) per 1000 individuals per day in 2008 to 34·77 DDD per 1000 individuals per day in 2019, similar to an average increase of 4.08% annually [5]. A study of 559 nursing home residents in Netherland carried out in 2012 found 56% had prescribed at least one psychotropic medicine, in the seven month study period [6]. Another study of 4478 residents from 147 nursing homes in UK carried out in 2017 reported 63.5% of participants were prescribed at least one psychotropic medicine in one month [7].

In Australia, use of psychotropic medicines has been increasing over the past two decades [3, 8]. The use is high among older adults in residential aged care facilities (RACFs). A cross-sectional study of 541 residents from 17 RACFs showed 70.8% of the residents were prescribed at least one psychotropic medicine in the 100 day study period [9]. Moreover, a study of 11,368 residents from 150 RACFs reported that 61% of residents were prescribed psychotropic medicine regularly over a year [10].

The high use of psychotropic medicines among older adults has been associated with increased risk of falls injuries, hospitalisation and death [11, 12]. The use of psychotropic medicines by older adults, where the potential risks are greater than their desired benefits are known as potentially inappropriate psychotropic medicines (PIPMs) [13]. Various interventions have been developed to reduce the use of PIPMs such as RedUSe program comprising psychotropic medicines audit and feedback, staff education, and interdisciplinary case review [14, 15]. The Royal Commission into Aged Care Quality and Safety and the NDIS Quality and Safeguards Commission released a joint statement regarding their support for collaborative action such as training of disability support workers using educational intervention, on the inappropriate use of psychotropic medicines among older adults [16]. Despite all these strategies and regulations, inappropriate use of these medicines continues as a significant problem in RACFs [17]. A study of 559 older adults with dementia from 44 RACFs reported that only 10% of psychotropic medicine use was completely appropriate according to the appropriate psychotropic drug use in dementia (APID) index [18]. In addition to this, a study involving 5825 residents with dementia across 68 RACFs in Australia revealed that the annual use of antipsychotics ranged between 27.6% and 32.6% over a four-year period, with duration of use often longer than recommended [19].

Several criteria have been developed to identify potentially inappropriate medicines in older adults, which are broadly categorised as implicit and explicit criteria. Implicit criteria are patient-specific and contain questions to determine the appropriateness of medicines. Explicit criteria are non-patient specific and comprise a list of criteria to determine if a drug is inappropriate. Explicit criteria are mostly drug-oriented and/or disease-oriented and need little or no clinical information to be effectively applied [20]. The American Geriatric Society (AGS) Beers Criteria are widely used explicit criteria globally and include criteria for use of psychotropic medicines. Beers criteria were first published in 1991 and the latest version of the criteria were updated in 2023 [21]. The updated Beers criteria 2023 were modified to include additions, deletions, and revisions of potentially inappropriate medicines. The significant updates of Beers criteria 2023 for central nervous system (CNS) medicines are: (1) Beers criteria 2023 were organised into the same five general categories that were used in the Beers criteria 2019, (2) CNS medicines which were removed from the first category of Beers criteria 2023 were Protriptyline, Trimipramine, Amobarbital, Butobarbital, Mephobarbital, Pentobarbital, Secobarbital, Flurazepam, Quazepam. The potentially inappropriate medicines were removed due to low utilization or no longer available in the United States, (3) The Beers criteria 2023 has addition of potentially inappropriate anti-Parkinson's drugs which were absent in Beers criteria 2019, (4) The Beers criteria 2023 has modified and clarified some statements. For example, it clarified that the antidepressant criteria refer to antidepressants with strong anticholinergic activity. The Beers criteria can be applied to routinely collected electronic dataset in order to identify and monitor use of PIPMs, without the need for detailed chart review to identify PIPMs.

Various studies have investigated the use of psychotropic medicines [22, 23], but these have largely relied upon prescribed datasets and were mostly cross sectional or observational in design. This study utilised administered medications instead of prescribing medications and employed a longitudinal design to assess the PIPMs use. The primary objective of study was to determine the prevalence and types of PIPMs used, identify factors associated with the use of PIPMs. The secondary objective was to explore the facility variation in the prevalence of PIPMs use.

Methods

Study design and setting

We conducted a retrospective cohort study using routinely collected electronic health record (EHR) data from 23 RACFs managed by a large not-for-profit aged care provider in Sydney, New South Wales (NSW), Australia. Routinely collected data indicate information collected systematically and electronically by aged care providers

for clinical and administration purposes on a day-to-day basis. Routinely collected residential aged care provider data are more readily accessible, contain up-to-date information and can be linked to existing national or state-based administrative data sets, while providing more granular details about care delivered at the coalface [24]. The study received ethical approval from the Macquarie University Human Research Ethics Committee (reference no. 52019614412614).

Participants

We included all permanent residents aged ≥ 65 who were present in the RACFs at any time from 1st January 2020 to 31st December 2021. Non-permanent residents (interim or respite care residents) were excluded. The median length of stay was 483 days. The period in the hospital was excluded from the length of stay.

Data source

The data were taken from two sources: residential profile data and medication administration data. The residential profile data contain information about each resident's demographics characteristics (e.g., age, gender), health conditions (free text field with list of diagnoses such as hypertension, dementia, depression) and admission related information (e.g., patient ID, facility ID, entry, and departure dates).

Medication administration data contained details of each medicine administered, including product name, dosage form, route, whether the medicine was administered, and administration date and time. Medicine names were coded according to the World Health Organization's Anatomical Therapeutic Chemical (ATC) classification system [25].

The assessment of potentially inappropriate psychotropic medicines

In this study, the updated Beers criteria 2023 was used to assess PIPMs. Although several tools are available to determine the potentially inappropriate medicines, we used the Beers criteria because it is more suitable for our dataset, which lacks detailed clinical information over time. The Beers criteria are not disease-specific, making them ideal for situations where limited clinical details are available, particularly for conditions under the CNS category. The updated Beers criteria 2023 includes several modifications, such as the addition, deletion, and revision of certain potentially inappropriate medicines, further enhancing its applicability in our study.

Beers criteria 2023 has five categories: 1 (potentially inappropriate medicines in older adults), 2 (potentially inappropriate medicines in older adults with various diseases or syndrome), 3 (medicines used with specific caution), 4 (potentially inappropriate drug-drug interactions), 5 (medicines dosage should be adjusted based on kidney function). To examine PIPMs, first category of Beers criteria was considered. First category of Beers criteria has various drug classes, but the drugs listed under the CNS drug class were used, which were identified using ATC codes (Table 1).

Since medical condition data were limited, criteria were applied to the available information in the EHR data. The recommendation for potentially inappropriate antipsychotics in Beers criteria was: "Avoid, except in FDA-approved indications such as schizophrenia, bipolar disorder, Parkinson disease psychosis, adjunctive treatment of major depressive disorder, or for short-term use as an antiemetic". This clinical information for antipsychotic medicines was applied to indications such as schizophrenia and bipolar disorders due to our data limitations.

Outcome measures

The outcome measures were the proportion of residents using at least one PIPM; and those using two or more unique PIPMs at any time during the study period. We measured the extent of exposure to PIPMs throughout the study period using number of days residents were exposed to PIPMs and the proportion of days covered by PIPMs. Number of days residents were exposed to PIPMs represent the total number of days residents received a specific PIPM during their stay, while proportion of days covered by PIPMs is the ratio of number of days residents were exposed to PIPMs to the resident's length of stay. Proportion of days covered indicates the proportion of time residents were exposed to the PIPM during their stay in RACFs. Both metrics were calculated for overall PIPM usage as well as for different PIPM classes.

Statistical methods

Descriptive statistics were used to summarise the use of PIPMs in RACFs. We used logistic regression model to examine the factors associated with both outcome measures (e.g., PIPM use, yes/no). We adjusted the analysis for the following potential confounders: socio-demographics (age, sex); and health conditions (i.e., arthritis, dementia, circulatory conditions, pain, depression, endocrine disorder, fracture, anxiety, osteoporosis and visual impairment) [26, 27].

To explore variation in the use of PIPMs by facility, we generated two sets of funnel plots: (i) the proportion of residents in each facility that used at least one PIPM and (ii) the proportion of residents using two or more PIPMs. Both funnel plots were adjusted for potential confounders. Funnel plots had the facility size on x-axis and the 95% and 99.8% control limits were superimposed on each

Table 1 Beers criteria (2023) for potentially inappropriate psychotropic medicines (PIPMs)

Drug class	Specific medications considered	Recommendation	ATC codes
Antidepressants with strong anticholinergic activity	Amitriptyline Amoxapine Clomipramine Desipramine Doxepin Imipramine Nortriptyline Paroxetine	Avoid	N06A
Antiparkinsonian agents with strong anticholinergic activity	Benztropine Trihexyphenidyl	Avoid	N04A
Antipsychotics first- (typical) and second- (atypical) generation	Amisulpride Aripiprazole Brexpiprazole Cariprazine Chlorpromazine Clozapine Flupenthixol Fluphenazine Haloperidol Levomepromazine Lurasidone Olanzapine Paliperidone Pericyazine Perphenazine Pimavanserin Prochlorperazine Quetiapine Risperidone Ziprasidone Zuclopenthixol	Avoid, except in FDA-approved indications such as schizophrenia, bipolar disorder.	N05A
Barbiturates	Butalbital Phenobarbital Primidone	Avoid	N03A
Benzodiazepines	Alprazolam Chlordiazepoxide Clobazam Clonazepam Clorazepate Diazepam Estazolam Lorazepam Midazolam Oxazepam Temazepam Triazolam	Avoid	N05B
Nonbenzodiazepine benzodiazepine receptor agonist hypnotics ("Z-drugs")	Eszopiclone Zaleplon Zolpidem	Avoid	N05C

ATC Anatomical Therapeutic Chemical

plot [28]. The 95% control limit was considered as an alarm limit and 99.8% as an action limit. Facilities lying above the 99.8% control limits were regarded as extreme outliers.

Results

Participants

A total of 3064 residents were included in the study. The median age of residents was 86 (IQR 80–90) years, and two thirds (66.7%) were females. The most common health conditions were circulatory (87.1%); arthritis (55.7%); dementia (51.3%); pain (49.5%); and depression (44.8%). Nearly half of all residents (49.4%) were taking 9 or more medicines. Table 2 describes the baseline characteristics of the residents.

Prevalence of PIPMs use according to the Beers criteria

Of the 3064 residents, 40% ($n=1224$) used at least one PIPM and 10% ($n=302$) used two or more PIPMs. The most frequently used PIPMs categories were benzodiazepines and Z-drugs (27.4%), followed by antipsychotics first and second generation (17.2%) and antidepressants with strong anticholinergic activity (5.22%). The most frequently used PIPMs were midazolam (13.1%), quetiapine (5.91%), amitriptyline (3.62%), benztropine (0.52%), primidone (0.16%), and zolpidem (0.16%) (Supplementary Table S1).

Exposure of residents to PIPMs

Figure 1 displays the number of days residents were exposed to PIPMs and the proportion of days covered by PIPMs. The overall median number of days residents were exposed to PIPMs were 91 days (IQR 6-320). The highest median number of days using a PIPM was for antidepressants at 169 days. The median proportion of days covered by at least one PIPM was 39.3% (IQR 2.6–86.6%) indicating that half of the residents received PIPM for 2 out of 5 days. The median proportion of days covered across the PIPM classes ranged from 5.7% (benzodiazepines and Z drugs) to 63.1% (antidepressants) (Fig. 1B).

Factors associated with the use of PIPMs

Table 3 presents the results of logistic regression model, showing factors associated with the use of PIPMs. Residents with dementia, pain, depression, anxiety, and endocrine disorders showed significant associations with the use of PIPMs as identified in the literature [26]. Residents with dementia were 1.94 times more likely to use two or more PIPMs (OR 1.94; 95% CI 1.50–2.51) after adjusting

Table 2 Baseline characteristics of residents of 23 residential aged care homes

Characteristics, n (%)	Total (*n* = 3064)	2020 (*n* = 2407)	2021 (*n* = 2476)
Sex, *n*			
Male	1019 (33.3)	754 (31.3)	792 (31.9)
Female	2045 (66.7)	1653 (68.7)	1684 (68)
Age, median (IQR)	86 (80–90)	86 (79–90)	86 (80–91)
Age category in years, n (%)			
65–74	380 (12.4)	316 (13.1)	333 (13.5)
75–84	979 (31.9)	767 (31.9)	805 (32.5)
85–94	1445 (47.2)	1127 (46.8)	1142 (46.1)
≥ 95	260 (8.48)	197 (8.18)	196 (7.92)
No. of medicines, n (%)			
1–4	487 (15.9)	370 (15.4)	356 (14.4)
5–8	1064 (34.7)	829 (34.4)	850 (34.3)
>=9	1513 (49.4)	1208 (50.2)	1270 (51.3)
Health conditions, n (%)			
Circulatory	2668 (87.1)	2095 (87.0)	2143 (86.6)
Arthritis	1708 (55.7)	1399 (58.1)	1365 (55.1)
Dementia	1572 (51.3)	1284 (53.3)	1260 (50.9)
Pain	1517 (49.5)	1280 (53.2)	1214 (49.0)
Depression	1374 (44.8)	1145 (47.6))	1114 (45)
Endocrine disorder	1149 (37.5)	871 (36.2)	942 (38.1)
Fracture	1071 (34.9)	907 (37.7)	869 (35.1)
Anxiety	1023 (33.4)	868 (36.1)	833 (33.6)
Osteoporosis	865 (28.2)	699 (29.0)	699 (28.2)
Visual impairment	540 (17.6)	468 (19.4)	420 (17)

for the confounders. Residents using >=9 medicines were two times more likely to use a PIPM compared to those using < 5 medicines (OR 2.09; 95% CI 1.66–2.65) after adjusting for confounders (Table 3). Socio-demographic factors including sex and age were not significantly associated with the use of PIPMs.

Variation in the pattern of PIPMs use by facility

Variation in the prevalence of PIPMs use by facility is shown in Fig. 2a and b. The adjusted percentage of residents on at least one PIPM ranged from 23.3 to 57.0% (Fig. 2a) and from 3.4 to 21% for the use of two or more PIPMs (Fig. 2b) across the 23 facilities. The adjusted percentage of residents using at least one PIPM had three facilities outside the control limits. Two facilities had a prevalence of use below the lower 99.8% control limit while one facility was above the upper 99.8% control limit. The adjusted percentage of residents using two or more PIPMs was within the control limits across all facilities, except for one facility which exceeded the upper 99.8% control limit, indicating an outlier rate warranting further investigation.

Discussion

Statement of principal findings

This longitudinal, multi-facility study of over 3000 older adults in RACFs revealed that 40% of residents were using at least one PIPM and 10% using two or more during the two-year study period. These residents are likely to have been at increased risk of falls, fracture, psychomotor and cognitive impairment [29]. The most frequently used PIPMs were benzodiazepines and Z-drugs (27.4%). We found substantial variation in the percentage of residents using PIPMs by facility, ranging from 23.3 to 57.0%.

Interpretation within the context of the wider literature

Our study specifically focuses on the use of potentially inappropriate medicines related to CNS medications, using the updated Beers criteria 2023. Comparisons with prior studies that may have used the Beers criteria 2019 remain valid because the changes regarding CNS medications in the latest version do not significantly affect the findings in our population. The CNS medications removed from the 2023 version (e.g., protriptyline, trimipramine, amobarbital) were already not being used in our study population (2020–2021), so they do not affect the extent of potentially inappropriate medicines use in this context. While the Beers criteria 2023 introduced potentially inappropriate medicines for certain anti-Parkinson's drugs that were not included in the 2019 version, the contribution of these drugs to potentially inappropriate medicines in our study was minimal. Therefore, this change does not substantially impact the overall proportion of potentially inappropriate medicines in our population, regardless of whether the 2019 or 2023 criteria were applied.

The prevalence of PIPMs observed in this study is lower than found in previous studies conducted globally. Two cross sectional studies used the Beers Criteria 2019 to assess PIPM use. One study among 2555 residents from 27 nursing homes in Italy found that 63.2% used at least one PIPM [30]. A second study of 456 individuals in India found 91.2% of older adults used at least one PIPMs [31]. But these studies did not explore the extent of exposure to PIPMs. However, our findings align with a systematic review of global studies that reported the use of CNS medicines including psychotropic medicines among RACF residents. The review reported the lowest use of psychotropic medicines (56.9%, 95% CI, 52.2–61.4%) from studies of Australian RACFs as compared to other countries, with the highest rates of use reported in Europe (72.2%, 95% CI, 67.1–77.1%) [32]. The low use of

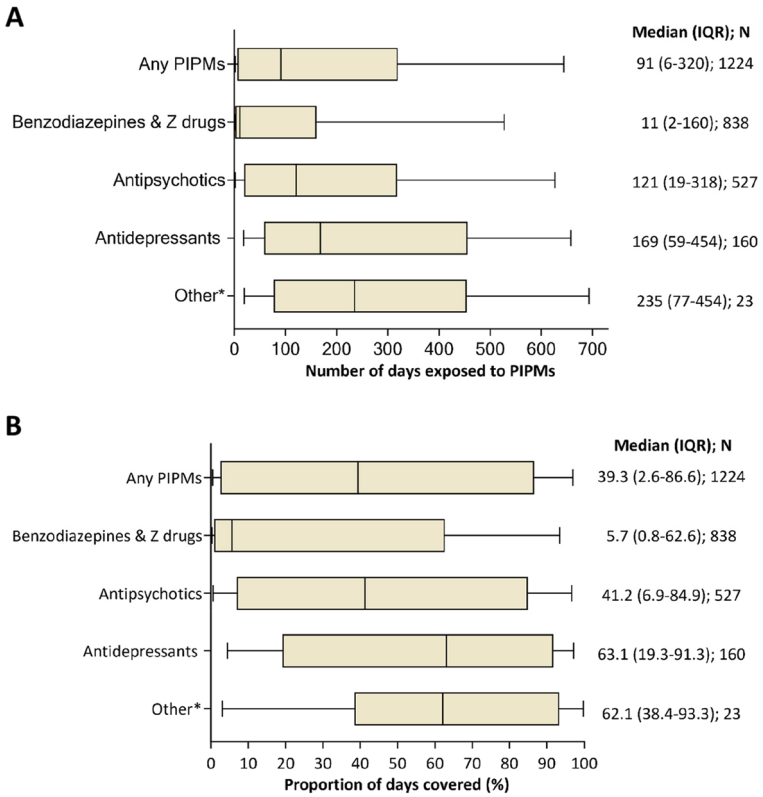

Fig. 1 The number of days residents were exposed to PIPMs and proportion of days covered by PIPMs *Includes antiparkinsonian agents ($n=17$) and barbiturates ($n=6$). Boxes in the figure represent the IQR with the median value within the boxes and the capped bars represent the 10th and 90th percentiles

psychotropic medicines in Australia may be due to adapting more proactive approach, which is used to control behavioural symptoms and pain by timely tapering the dose without return of symptoms [33]. Various interventions have been developed to optimise the medication use such as, medication reviews, staff education, multidisciplinary case-conferencing, and clinical decision support systems [34]. In Australia, various studies have seen the impact of these interventions on psychotropic medicines use and observed reduction in the inappropriate use of psychotropic medicines for residents of RACF [35, 36]. According to National aged care quality indicator program, strategies such as person-centered care planning and managing the use of psychotropic medicines can prevent the inappropriate use of psychotropic medicines [27]. There are clinical practice guidelines for the appropriate use of psychotropic medicines among people with dementia and living in RACFs to support the evidence based use of psychotropic medicines [37].

In our study, benzodiazepines emerged as the most frequently used PIPM (27.4%). A study among 1111 residents from 24 nursing homes in Netherland also found frequent use of benzodiazepines (39.2%) [38]. The high use of benzodiazepines in RACFs could be due to their common use in older adults for sleep disorders, anxiety, and depression. We found high prevalence of benzodiazepine use by residents, however the median proportion of days covered when residents used a benzodiazepine was low at 5.7% (0.8–62.6) of their length of stay. Based on clinical practice guidelines for psychotropic medicines, routine use of benzodiazepines is not recommended for people living with dementia, sleep disorders or those living in residential aged care [39]. This suggest that our results are broadly fitting the guidelines, as these are not being used routinely and may not be considered as inappropriate.

Antipsychotics were the second most used PIPMs (17.2%) in our study. This may be due to the common behavioural and psychological symptoms of dementia among residents in RACFs. The median proportion of days covered by antipsychotic was 41.2% (6.9–84.9), showing residents were exposed to antipsychotic for 2 out of every 5 days. This means almost half of their time spent in RACF, they were exposed to antipsychotics. According to clinical practice guidelines, antipsychotics should be used based on risk benefit ratio of individuals

Table 3 Factors associated with the use of potentially inappropriate psychotropic medicines in older adults living in residential aged care

Logistic regression				
	At least one PIPM		**Two or more PIPMs**	
Characteristics	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex				
Female vs. Male	1.12 (0.96–1.31)	0.97 (0.82–1.15)	1.10 (0.85–1.41)	0.94 (0.71–1.24)
Age [Ref = 65–74 years]				
75–84	0.96 (0.76–1.22)	0.95 (0.74–1.22)	0.95 (0.65–1.38)	0.90 (0.61–1.33)
85–94	0.95 (0.75–1.19)	0.97 (0.76–1.25)	0.84 (0.58–1.22)	0.84 (0.57–1.24)
≥ 95	0.80 (0.58–1.11)	0.96 (0.67–1.36)	0.67 (0.38–1.17)	0.83 (0.46–1.49)
No. of medicines [Ref = 1–4]				
5–8	1.39 (1.10–1.76)*	1.33 (1.04–1.69)*	1.84 (1.15–2.95)*	1.69 (1.05–2.73)*
>=9	2.18 (1.75–2.72)*	2.09 (1.66–2.65)*	2.90 (1.86–4.52)*	2.59 (1.64–4.10)*
Health status				
Circulatory	0.99 (0.80–1.23)	0.89 (0.71–1.12)	1.38 (0.94–2.05)	1.29 (0.86–1.94)
Arthritis	1.08 (0.93–1.25)	0.95 (0.81–1.11)	1.07 (0.84–1.36)	0.93 (0.72–1.20)
Dementia	1.26 (1.09–1.46)*	1.41 (1.21–1.64)*	1.69 (1.33–2.16)*	1.94 (1.50–2.51)*
Pain	1.32 (1.14–1.53)*	1.18 (1.01–1.37)*	1.53 (1.20–1.94)*	1.40 (1.09–1.81)*
Depression	1.79 (1.55–2.08)*	1.38 (1.18–1.62)*	2.23 (1.74–2.84)*	1.71 (1.31–2.22)*
Endocrine disorder	0.86 (0.74-1.00)	0.83 (0.71–0.97)*	0.94 (0.73–1.20)	0.89 (0.69–1.14)
Fracture	1.13 (0.98–1.32)	1.04 (0.88–1.22)	1.26 (0.98–1.60)	1.17 (0.90–1.51)
Anxiety	2.29 (1.96–2.67)*	2.01 (1.71–2.38)*	2.04 (1.61–2.59)*	1.66 (1.29–2.15)*
Osteoporosis	1.15 (0.98–1.34)	1.03 (0.87–1.23)	1.15 (0.89–1.48)	1.00 (0.76–1.32)
Visual impairment	1.12 (0.93–1.35)	0.97 (0.80–1.19)	1.15 (0.85–1.56)	0.99 (0.72–1.35)

and treatment should be time-limited and regularly reviewed [40–42]. This suggest that antipsychotics use may be considered as inappropriate.

The overall use of antidepressants is less than other PIPMs (5.22%). This could be due to the reason that we only look at the antidepressants with strong anticholinergic activity. However, antidepressants showed highest median proportion of days covered among all PIPMs. The median proportion of days covered by antidepressants was 63.1% (19.3–91.3), covering 3 out of 5 days of resident's time in RACFs. This may be result of increase depressive and anxiety disorders among older adults [43]. According to clinical guidelines, antidepressants should not be used regularly for treating minor depressive symptoms or mild to major depression [44]. Psychological therapies should be considered for mild to severe major depression such as cognitive behaviour therapy, supportive psychotherapy, behavioural therapy, interpersonal psychotherapy etc [45, 46]. Antidepressants should be considered for severe depression only if the potential benefit effects are more than harmful effects [47]. Hence, identified antidepressants may be considered as inappropriate.

The indications such as dementia, pain, depression, and anxiety showed association with the increased use of PIPMs. The high use of benzodiazepines may increase the risk of falls, fracture, anxiety disorders, pneumonia and dementia [48–50]. The possible risks of using inappropriate antipsychotics can be pneumonia, venous thromboembolism and cerebrovascular events [51, 52]. However, inappropriate antidepressants may increase the risk for cognitive deficit [53].

Variation in the prevalence of PIPMs use by facility was also observed. However, two out of 23 facilities had percentage of residents using PIPM outside the control limits showing less use of PIPM. The low use of PIPMs could be due to statistical variation or the residents at this facility were using more appropriate substances by adapting the interventions and guidelines regarding the safe and appropriate use of medicines. One facility out of 23 showed high use of PIPM by the residents. It means risk of adverse events such falls, fracture, cognitive impairment could be more likely in this facility. The potential factors contributing the variation between the facilities in the use of PIPMs could be attributed to several factors, both related to the facilities themselves and

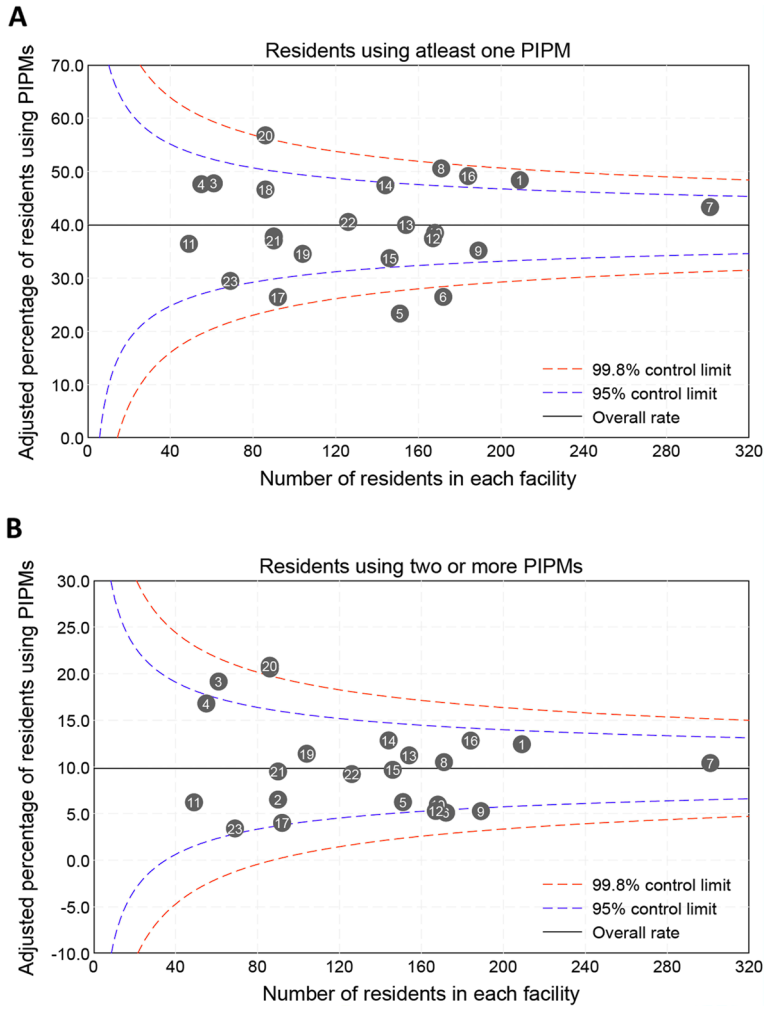

Fig. 2 Funnel plots of the percentage of residents on (**a**) at least one PIPM (**b**) two or more PIPMs in each facility, adjusted for resident characteristics. The circles represent facilities, and the solid line shows the mean prevalence of PIPM use. Covariates used in calculating the risk–adjusted prevalence included age, sex, and health status, as shown in Table 2.

the populations they care for. Differences in facility characteristics, such as the organisation of care teams, availability of physician time, and staff expertise (particularly in managing behavioural and mental health conditions), are likely contributors. Facilities that focus more heavily on residents with complex mental health needs may have higher rates of PIPM use due to the nature of care required for these residents. In addition to facility characteristics, the specific characteristics of the resident population may also play a role in the observed variation. Although we adjusted for key patient-level factors in our analysis (e.g., age, sex, and comorbidities), there may still be unmeasured confounders (e.g., disease severity) contributing to differences in prescribing patterns. As outlined by the Australian Commission on Safety and Quality in Health Care, several strategies could potentially reduce such healthcare variation, including: (1) policy initiatives aimed at promoting consistent standards of care, (2) increased engagement of clinicians in adhering to best practice guidelines, (3) fostering shared decision-making between residents (and their families) and healthcare providers, and (4) conducting more research into the underlying factors contributing to these variations and their impact on outcomes [54].

Implications for practice and policy

The study has important implication for ensuring safe medicines use among older adults in RACFs. Psychotropic medicines are commonly used in RACFs to manage behavioural and psychological symptoms of dementia, and our results showed high use of PIPMs in RACFs. This high use of PIPMs can be resulted into adverse events such as falls or related injuries, therefore medication management reviews are required. It is

encouraged to use nonpharmacological strategies such as physical activity, cognitive behavioural therapy, music therapy and psychosocial interventions and other sensory simulation as first line treatment to manage behavioural and psychological symptoms of dementia and psychotropic medicines should be deprescribe where possible [55]. According to guidelines, medicines should be regularly reviewed in RACFs at least once annually and every 6 months in frail residents [56].

Strengths and limitation

This study investigated the prevalence of PIPMs among older adults in Australian RACFs by using routinely collected electronic aged care data which enable us to identify PIPMs without the need for primary data collection or chart reviews. This allowed us to efficiently conduct a multicentre design, involving 3064 residents from 23 RACFs. We used the most recent Beers criteria 2023 which was not used previously in any study in Australia. A particular contribution of this study was the inclusion of measure of the extent of exposure to PIPMs by measuring number of days residents were exposed to PIPMs and proportion of days covered by PIPMs, which has not previously been reported in any Australian studies.

The study has some limitations. First, the results of study focus on RACFs from one provider and therefore may not be representative of all RACFs in Australia. Second, the data on demographic variables such as country of birth, ethnicity, language, and education status were missing, and these factors may be further potential confounders for PIPMs. We also did not have any information about the reasons of PIPM use from residents' perspectives. Third, our assessment of medication appropriateness was based solely on the Beers criteria, and it is important to emphasize that our analysis cannot definitively confirm whether the medications were actually inappropriate. We only evaluated medications flagged as potentially inappropriate, but without detailed clinical context, it is not possible to assess whether they were indeed misused.

Conclusion

The present study provides a comprehensive examination of PIPM use in RACFs using large longitudinal data. The study revealed a high rate of PIPMs use with substantial variation across facilities and dementia, pain, depression, and anxiety disorders were risk factors for the high use of PIPMs. Quality improvement initiatives which target inappropriate psychotropic medication use are necessary, particularly considering the link between psychotropic use and adverse events such as falls.

Supplementary Information

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Supplementary Material 1.

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Not applicable.

Authors' contributions
N.W., M.Z.R., K.L.S. and J.I.W were involved in the conception and design of the study; N.B. was involved in the data analysis with input from other team members; N.B. was involved in the initial manuscript drafting; all authors were involved in the data interpretation, the critical revision and the final approval for publication.

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Data availability
The data that support the findings of this study are not publicly available. Data are however available from the authors upon reasonable request and with permission of the data custodian.

Declarations

Ethics approval and consent to participate
The study has received ethical approval from the Macquarie University Human Research Ethics Committee (reference no. 52019614412614). The ethics committee granted us a waiver of consent since the study utilized de-identified retrospective data, and obtaining consent from the participants was deemed impracticable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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