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PHARMACOEPIDEMIOLOGY AND PRESCRIPTION

Potentially inappropriate medications in community-dwelling older adults undertaken as a comprehensive geriatric risk assessment

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Abstract

Purpose The prescription of potentially inappropriate medications (PIMs) is associated with an increase in adverse events, prescribing cascades, high health-care costs, morbidity, and mortality in the elderly. The overarching objective of this study is to examine the prevalence of PIMs in the elderly, applying the 2012 American Geriatrics Society Beers criteria for the study period 2012–2014, and the updated 2015 Beers criteria for 2015.

Methods The study population (N = 70,479) included a continuously recruited national cohort of community-dwelling older (aged ≥ 65 years) New Zealanders who had undertaken the International Resident Assessment Instrument-Home Care (interRAI-HC) assessments between September 2012 and October 2015. Exposure of PIMs 90 days before and after assessment, and 90–180 days after assessment are reported.

Results Exposure to PIMs was highest in individuals aged over 95 years and in males. The average number of PIMs prescribed 90 days before assessment during the period 2015 was marginally higher compared to 2012–2014 (0.19 versus 0.04), and a greater number of individuals were exposed to one or more PIMs in 2015 compared to 2012–2014 (7.13 versus 2.17%). The prevalence of PIMs 90 days before and after assessment was 2.17 and 6.92% for 2012–2014, and 7.13 and 24.7% for 2015, respectively. The percent change in PIMs in 2012–2014 and 2015 after 90 days of assessment were 4.70% (confidence interval (CI) 4.50%, 5.00%, $p < 0.001$) and 17.60% (95% CI 16.80%, 18.30%, $p < 0.001$), respectively. The majority of PIMs prescribed belonged to the therapeutic class of medications acting on the central nervous system and the gastrointestinal system.

Conclusion Geriatric risk assessments may provide a vital opportunity to review medication lists by multidisciplinary teams with a view to reducing PIMs and unnecessary polypharmacy in older adults. Comprehensive geriatric risk assessment has the potential to reduce adverse medication outcomes and costs associated with inappropriate prescribing in a vulnerable population of older adults.

Keywords Elderly · Inappropriate prescribing · New Zealand · International Resident Assessment Instrument-Home Care

Introduction

Optimal prescribing of medications in older adults poses a challenge, given that the approved doses of medications extrapolated from clinical trials may not be suitable for the geriatric population [1]. It is well recognized that several medications have to be prescribed with caution in the elderly due to alterations in their pharmacokinetics and pharmacodynamics [2]. Older adults are prescribed a greater number of medications due to the high prevalence of comorbidities [3]. The utilization of a greater number of medications is an independent risk factor for increase in adverse events, drug interactions, hospital admissions, emergency department visits, prescribing cascades, high health-care costs, morbidity, and mortality in older people [3, 4].

Potentially inappropriate medications (PIMs) are defined as medications where the risks outweigh clinical benefit, particularly when there is a safer or more effective alternate therapy for the same condition [5]. Therefore, identifying

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potentially inappropriate medications is important to mitigate pharmacotherapy-related hazards in older adults.

Several criteria have been developed for identifying PIMs. These criteria are either medication-based explicit criteria, like the Beers criteria, or patient-based implicit criteria, like the Medication Appropriateness Index [6]. The American Geriatric Society Beers criteria were the first set of explicit criteria used for identifying inappropriate medication use in the geriatric population, published in 1991 and subsequently updated in 1997, 2003, 2012, and 2015. The Beers criteria are derived from expert opinions, published reviews, and consensus techniques, and often do not require a clinical judgment for its application [7, 8]. The Beers criteria are among the most frequently utilized criteria for assessing the appropriateness of prescribing medications for older adults [9]. Studies that have used the Beers criteria have reported figures of 5.2% to over 85% of older adults exposed to at least one PIM [10, 11]. These criteria guide health-care professionals to improve the safety of prescribing medications for the elderly by reducing the risk associated with unnecessary polypharmacy, drug interactions, and adverse reactions [8].

A recent introduction to the 2015 Beers criteria are the lists of specific medications that should be avoided, or have their dose adjusted, based on the individual's kidney function. The medication interactions documented to be associated with potential complications in older adults have also been introduced in the updated 2015 Beers criteria [7].

In New Zealand (NZ), the International Resident Assessment Instrument-Home Care (interRAI-HC) assessment, a standardized and internationally validated tool, is mandated to assess geriatric patients living in the community with different levels of clinical complexity [12]. NZ is the only country where a standardized interRAI-HC has been implemented for the conduct of all community care assessments on older people needing publically funded long-term community services or entry to aged residential care [13].

Individuals are referred by a health practitioner to have their needs assessed by one of the trained interRAI-HC assessors. Assessors visit clients in their own residence to develop individualized care plans according to a standardized protocol. Participants are explicitly questioned if they consent to their de-identified interRAI-HC information being used for planning and research purposes. All data are directly entered into the electronic interRAI-HC database, maintained by New Zealand's Technical Advisory Services (TAS) (http://centraltas.co.nz). With approval, consented data are released by TAS, through the Ministry of Health [14].

Individual-level data that is available from the interRAI-HC suite include but are not limited to social demographics, medical conditions, frailty, cognitive function, and physical function [15]. The ubiquitous nature of the interRAI-HC assessment means that it accounts for numerous social, psychological, and clinical risk factors when examining health outcomes in an elderly population [15]. The interRAI-HC database can be linked to several NZ Ministry of Health national collections, including prescription use (Pharms database), hospital discharges (National Minimum Dataset), mortality data, and laboratory collections [15]. The NZ version of the interRAI-HC includes 236 individual questions, assessed over 20 domains, which generate 27 validated instrument scores that guide patient treatment [13].

Studies in NZ have shown that individuals over 65 years of age are the most frequent consumers of medications, and the prevalence of polypharmacy and hyperpolypharmacy is high and increasing in this vulnerable population [16].

Objectives

The overarching aim of this study is to identify PIM exposure, applying the 2012 and 2015 Beers criteria, in community-dwelling older adults who have undertaken a comprehensive geriatric risk assessment.

The specific objectives are as follows:

1. To examine the prevalence of exposure to PIMs, the most common PIMs prescribed, the prevalence of prescription of PIMs that may potentially exacerbate existing disease or syndrome in older New Zealanders, and medications to be used with caution, applying the 2012 and updated 2015 Beers criteria.
2. To examine the prevalence of potential clinically important non-anti-infective drug–drug interactions that should be avoided in the elderly, utilizing the updated 2015 Beers criteria.

Methods

The present study is approved by the Human Ethics Committee, University of Otago, NZ (ethical approval number 15/CEN/45/AM02).

Study population

Our retrospective study included 70,479 community-dwelling individuals, aged 65 years and older, living in NZ. The study population included all individuals who received at least one prescription medication between 2012 and 2015.

Data source

The following extracts were obtained from the Ministry of Health to undertake this study:

1. Pharmaceutical Claims Data Mart (Pharms) extract files (2012 to 2015): provided information on all the prescription claims made by community pharmacists funded by the Pharmaceutical Management Agency (PHARMAC). Each prescription record includes the sex, date of birth, prioritized ethnicity, and District Health Board of domicile of the patient; medication name; date of medication supplied; daily dose; frequency; and total quantity supplied for each National Health Index (NHI). The NHI is a unique identifier that is assigned to every person who uses health and disability support services in NZ [17].
2. interRAI-HC: individuals with their first interRAI-HC assessment undertaken between 1 September 2012 and 31 October 2015. The clinical assessments were sourced from cross-matched data from the interRAI-HC. The interRAI-HC assessments contained information on demographic (including ethnicity), social, and clinical diagnosis. The scales used in the interRAI-HC assessments are based on internationally validated performance scales. For example, the cognitive performance scale is based on the Minimum Data Set Cognitive Performance Scale [18].

PIM exposure

PIMs were identified using the 2012 and updated 2015 Beers criteria [7, 19]. Exposure to PIMs was considered if an individual was dispensed greater than or equal to one potentially inappropriate medication for any duration during the study period. A list of medications not available in NZ or not subsidized is given in ESM 1, and these were excluded from the study. The 2012 Beers criteria were applied to the data (N = 53,911) from July 2012 to December 2014, and the 2015 Beers criteria were applied to the data from January to October 2015 (N = 16,568). Data was digitized according to medications prescribed 90 days before assessment, 90 days after assessment, and 90 to 180 days after assessment, allowing for the time-varying effect of prescribing.

Statistical analyses

The "STrengthening the Reporting of OBservational studies in Epidemiology" (STROBE) guidelines (www.strobe-statement.org) were followed to report the analysis (ESM 2) [20]. Age was stratified into four age bands: 65–74 years, 75–84 years, 85–94 years, and over 95 years. All descriptive statistical analyses were conducted using IBM SPSS version 24. $p < 0.05$ was regarded as statistically significant. The Wilson method for calculating confidence intervals for proportions [21] was employed to compare the PIM exposure as a time-varying exposure, digitized into 90 days, at a significance of $p < 0.001$. The chi-square test was used to analyze nominal/categorical data.

Results

The study used data extracted from the matched interRAI-Pharms dataset, for the time period 2012 to 2015, to identify the prevalence of exposure to PIMs in older New Zealanders. A total of 70,479 individuals aged 65 years and older were studied, of which females constituted 61.3% in 2012–2014 and 60.1% in 2015. The mean age of the individuals was 83.7 (± 7.4) years in 2012–2014 and 82.35 (± 7.6) years in 2015. The prevalence of PIMs 90 days before and after treatment was 2.17 and 6.92% for 2012–2014, and 7.13 and 24.7% for 2015, respectively. The percent change in PIMs in 2012–2014 and 2015 after 90 days of assessment was 4.70% (confidence interval (CI) 4.50%, 5.00%, $p < 0.001$) and 17.60% (95% CI 16.80%, 18.30%, $p < 0.001$), respectively (ESM 5). The average number of medications dispensed was 2.47 in 2012–2014, and 2.41 in 2015, evaluated 90 days before assessment. The sociodemographic characteristics of the study population are depicted in Table 1. As illustrated in Tables 2, 3, and 4, the exposure to PIMs 90 days before assessment was highest in individuals aged 95 years and over (3.2% in 2012–2014, and 8.7% in 2015) and was higher in males (2.8% in 2012–2014, and 7.3% in 2015). Data analysis was carried out on all ethnicities; however, the data on New Zealand Europeans and Māori are specifically reported as they constitute the largest ethnicities in NZ [22]. In 2012–2014, 2.2% of NZ Europeans and 2% of the Māori population were prescribed PIMs. In 2015, 7% of NZ Europeans and 9.5% of the Māori ethnicity were prescribed PIMs (Tables 2, 3, and 4).

The summary findings of the study are depicted in Tables 2, 3, and 4. The average number of PIMs for an individual 90 days before assessment was 0.04 in the period 2012–2014 and 0.19 in 2015. A total of 2.17% individuals were prescribed PIMs in the period 2012–2014, and 7.13% in 2015, 90 days before assessment. The maximum number of PIMs was prescribed 90 days after assessment in 2012–2014, most of which belonged to the therapeutic class of the central nervous system (CNS) and gastrointestinal (GI) system (ESM 3). A majority of those exposed to PIMs in 2012–2014 had two PIMs. There were more PIMs prescribed in the time slices after assessment for the year 2015, and the maximum PIMs prescribed belonged to the therapeutic class of the CNS and GI system (ESM 4). Also, a majority of those exposed to PIMs in 2012–2014 had two to three PIMs in 2015. There has been a decline in the prevalence of PIMs in 2012–2014 in the time period of 90–180 days after assessment (4.4%) as compared to 90 days after assessments (6.92%). However, the prevalence of PIMs in 2015 remained unchanged after 90 and 90–180 days of assessments (24.6%).

In 2012–2014, the medications which were contraindicated in patients presenting with urinary incontinence, constipation,

Table 1 Characteristics of the study population ($N = 70,479$)

	Total	Percent
Age		
65–74	12,151	17.2
75–84	28,976	41.1
85–94	27,022	38.3
95+	2330	3.3
Sex		
Female	43,008	61
Male	27,467	39
Ethnicity		
NZ European	62,340	88.5
Māori	3801	5.4
Other	4338	6.2
Marital status		
Married	27,375	38.8
Other	43,104	61.2
Living arrangements		
Alone	34,931	49.6
Spouse only	22,328	31.7
Others	13,220	18.8
Cognitive impairment		
None/minimal	37,007	52.5
Mild	21,884	31.1
Moderate	7544	10.7
Severe	4042	5.7
Dementia		
No	60,374	85.7
Yes	10,105	14.3
Depression		
No	61,745	87.6
Yes	8732	12.4
Schizophrenia		
No	69,966	99.3
Yes	511	0.7
Parkinson's disease		
No	67,789	96.2
Yes	2688	3.8
Heart failure		
No	58,106	82.4
Yes	12,371	17.6
Cancer		
No	59,872	85
Yes	10,605	15
Stroke		
No	58,170	82.5
Yes	12,309	17.5
Chronic obstructive pulmonary disease		
No	59,174	84
Yes	11,305	16
Diabetes		
No	55,925	79.3
Yes	14,554	20.7
Coronary heart disease		
No	47,989	68.1
Yes	22,490	31.9
Hemiplegia		
No	67,970	96.4
Yes	2509	3.6
Hip fracture		
No	69,173	98.1
Yes	1303	1.8

and falls featured commonly among the medications to be avoided for older adults with specific diseases or syndromes, as depicted in ESM 3. In 2015, the medications which were contraindicated in falls and dementia were among the most commonly prescribed medications to be avoided for older adults with specific diseases or syndromes, as shown in ESM 4. Among the medications to be used with caution in the elderly, antipsychotics, selective serotonin reuptake inhibitors (SSRIs), and tricyclic antidepressants (TCAs) were prescribed most often in 2012–2014 (ESM 3). In 2015, among the medications which were to be used with caution in the elderly, diuretics, antipsychotics, TCAs, and SSRIs were commonly prescribed (ESM 4). Of the potentially clinically important non-anti-infective drug–drug interactions to be avoided in the elderly, the maximum interactions were observed when opioid drugs were prescribed with more than two CNS-active medications, when more than one anticholinergic drug were prescribed to the same patient, and when benzodiazepines were prescribed with more than two CNS-active medications (ESM 4).

Discussion

Older people represent a significant proportion of the population in NZ [23]. A majority of them have multiple chronic medical conditions, and the number of medications continues to rise in this vulnerable population [24]. Previous studies in NZ have shown a significant increase in polypharmacy and hyperpolypharmacy in the past decade [16]. Consequent to the increase in polypharmacy, the number of PIMs has shown to increase over time [25]. Our unique study examines the prevalence of PIMs for the first time in NZ in a high-risk population who has undertaken a comprehensive geriatric risk assessment. The prevalence of PIMs was 2.17% in 2012–2014, and 7.13% in 2015, when evaluated 90 days before assessment. Exposure to PIMs was highest in individuals aged over 95 years and in males. The average number of PIMs for each patient was 0.04 in the period 2012–2014, and 0.19 in 2015. The majority of PIMs prescribed belonged to the therapeutic class of the CNS and the GI system.

In a study conducted in a community-dwelling cohort of older people in NZ [26], 42.7% were prescribed at least one PIM according to the 2012 Beers criteria, which is much higher than the PIMs detected using the interRAI-HC dataset (mean value of 0.04 in 2012–2014, and 1.9 in 2015, 90 days before assessment). A primary reason for the difference could be that the geriatric risk assessments are conducted in older individuals living in the community requiring complex care needs, whereas the study conducted by Nishtala et al. ($N = 316$) identified PIMs in a surveyed population of older adults living in the community [26]. For this study, we have only considered a 90-day period to estimate the prevalence of

Table 2 Summary of the findings in the interRAI-HC dataset according to the 2012 and 2015 Beers criteria (90 days before assessment)

	2012–2014	2015
Average number of medications for each patient	2.47	2.41
Average number of PIMs	0.04	0.19
Classification of most common PIMs prescribed		
Medications of the central nervous system (%)	1.45	3.70
Medications of the gastrointestinal system (%)	0.79	5.20
Medications prescribed for pain (%)	0.76	3.44
Syndromes/diseases where the PIMs prescribed may exacerbate the drug-disease interactions		
Falls (%)	1.97	6.90
Incontinence (%)	5.60	1.47
Heart failure (%)	0.80	3.18
Constipation (%)	2.30	NA
Dementia (%)	1.35	3.60
Medications to be used with caution in the elderly		
Antipsychotics (%)	0.68	1.97
Tricyclic antidepressants (%)	0.47	1.69
Selective serotonin reuptake inhibitors (%)	0.44	1.37
Potentially important non-anti-infective drug–drug interactions that should be avoided in older adults		
Opioid receptor agonist analgesics and more than 2 CNS-active medications (%)	Not applicable (NA)	4.96
More than 1 anticholinergic drug prescribed to a patient (%)	NA	3.25
Benzodiazepines and non-benzodiazepines, benzodiazepine r eceptor agonist hypnotics, and more than 2 CNS-active medications (%)	NA	2.77

PIMs. The annual prevalence could be much higher and comparable to other studies that have examined the prevalence of PIMs in the general population.

The prevalence of PIMs was 40.9% in a similar population-level study (N = 537,387) conducted in the elderly in NZ, utilizing the 2012 Beers criteria [27]. The study used data extracted from the matched National Minimum Dataset (NMDS)-Pharms dataset for the year 2011. The most common PIMs dispensed to their study population were medications belonging to the CNS, a finding analogous to our study [26, 27]. The primary reason could be a dramatic increase in the number of CNS-active medications prescribed for older adults in the past decade [28]. In a recent study conducted in NZ, it was observed that there is a high rate of prescription of medications acting on the CNS among older adults [29].

In the current study exposure to PIMs was observed to be highest in individuals aged over 95 years, similar to the findings of the study by San-José et al., in which the majority of PIMs were prescribed in the oldest old patients. The high prevalence of PIMs could be attributed to the significant multimorbidity in this cohort requiring complex care [30]. Males were exposed to a higher number of PIMs in our study, in contrast to the observations of the research by Narayan and Nishtala, where the PIMs were more prevalent in females [27]. The disparity could be due to the differences in the co-morbidities captured in the datasets. The older New Zealand Europeans and Māori were prescribed a higher percentage of PIMs in 2015 compared to 2012–2014, 90 days before assessment. A similar study by Narayan and Nishtala [27] has reported a higher prevalence of PIMs in the European

Table 3 Classification of PIMs according to gender and ethnicity (90 days before assessment)

	Males (%)	Females (%)	NZ European (%)	Māori (%)
2012–2014				
Total	20,864 (38.70)	33,044 (61.30)	47,701 (88.40)	2844 (5.27)
Exposure to PIMs	589 (2.80)	582 (1.70)	1046 (2.20)	57 (2.00)
2015				
Total	6603 (39.8)	9964 (60.1)	14,639 (88.30)	957 (5.80)
Exposure to PIMs	485 (7.30)	697 (7.00)	1021 (7.00)	91 (9.50)

Table 4 Classification of PIMs according to age of the patients

	65–74 years (%)	75–84 years (%)	85–94 years (%)	95+ years (95%)
2012–2014				
Total	9103 (16.9)	22,200 (41.2)	20,830 (38.6)	1778 (3.3)
Exposure to PIMs	209 (2.29)	459 (2.06)	446 (2.14)	57 (3.21)
2015				
Total	3048 (18.40)	6776 (40.90)	6192 (37.40)	552 (3.30)
Exposure to PIMs	230 (7.54)	479 (7.07)	425 (6.86)	48 (8.69)

population of New Zealand. Nishtala and Salahudeen have reported that the prevalence of PIMs is high and increasing over recent years in Māori but is less compared to NZ Europeans [16]. There is also evidence to show that Māori received fewer prescriptions compared to non-Māori [31].

Medications that could have potentially exacerbated the existing disease or syndrome were classically given for the treatment of incontinence (5.6%) and constipation (2.3%) for 2012–2014 (90 days before assessment); these are similar results to those of the study conducted by Narayan and Nishtala, in which a greater proportion of PIMs were observed for the treatment of incontinence and constipation [27]. Furthermore, in the year 2015 (90 days before assessment), medications that could have potentially exacerbated the existing disease or syndromes were classically the medications given for the treatment of falls (6.9%) and dementia (3.6%), similar to the findings of a study conducted in Pennsylvania in 2015 [32]. There is a proportionately increased incidence of incontinence, constipation, falls, and dementia as one ages [33–36].

In a recent study conducted in the USA, it was observed that almost one third (30.9%) of older adults were prescribed at least one PIM [37]. Two Brazilian studies conducted in a community of older adults found a prevalence of 42.1 and 50% in PIM use and the mean number of medications per patient as 4.46, as compared to 2.17% (2012–2014) and 7.13% (2015) prevalence in our study, and the mean number of medications of 2.47 and 2.41 in 2012–2014 and 2015, respectively, 90 days before assessment [38, 39]. Various studies detected a high prevalence of PIM use in hospitalized, aged, and recipients of home health-care services in Nigeria, Taiwan, and India, according to the Beers criteria of 2012 [38]. A study conducted in Sweden based on a register of elderly patients observed a mean of 5.4 medications per patient and a 17% prevalence of potentially inappropriate medication use [38]. A study conducted in Spain, a year before and after the intervention of an educational seminar on Beers criteria, showed no significant difference in the potentially inappropriate prescriptions [40].

The prevalence of PIMs in our population is mainly influenced by our study population, which included older people with complex care needs, compared to the general population of the elderly in the other international studies. We digitized the PIM exposure in 90-day slices, and hence, this may not reflect the cumulative PIM exposure during the study period. The variability in PIM exposure between studies can be attributed to the research designs (retrospective or prospective cohort, cross-sectional designs, reporting of point prevalence, or annual PIM prevalence), different versions of the Beers criteria applied, prescribing patterns based on cost and locally recommended guidelines and formularies, and characteristics of the study population and settings (primary care, secondary care, continuing care) [27].

A number of initiatives have been proposed in NZ to reduce the prescription of PIMs, such as the involvement of pharmacists in pharmaceutical care and strategies focusing on deprescribing [41, 42]. Individualized assessment that comprises a review of the necessity for continuing each medication helps in simplifying treatment regimens and reduces the potential for harm. While withdrawing a prescribed medication, several factors must be considered, such as clinical indication and benefit of the treatment, appropriateness of the regimen, duration of use, patient adherence, and the prescribing cascade [42]. The review and modification of a patient's medication regimen should be conducted by a multidisciplinary team comprising a pharmacist, physician, and nurse. There is also an overwhelming need for efficient education in geriatric prescribing through an integrated approach involving the physician, pharmacologist, pharmacist, and patient [43].

The 2015 Beers criteria appear to be a more comprehensive guide to medication safety in older adults, as compared to the 2012 Beers criteria, since the modifications have been made according to current clinical prescribing practices. The results are reflected in our study, noting that the updated 2015 Beers criteria have captured more PIMs (7.13%), compared to the 2012 Beers criteria (2.17%). For example, there has been an addition of desmopressin for the treatment of nocturia or nocturnal polyuria because of the high risk of hyponatremia; avoidance of the use of proton-pump inhibitors beyond 8 weeks without justification; the addition of non-benzodiazepine, benzodiazepine receptor agonist hypnotics to the list of medications to avoid in individuals with dementia or cognitive impairment; the addition of opioids to the list of CNS medications that should be avoided in individuals with a history of falls or fractures; and avoidance of antipsychotics as a first-

line treatment of delirium [7]. The 2015 Beers criteria use a more widespread systematic review and grading of evidence, since they eliminate many medications that are no longer used in clinical practice [44]. A separate guidance on avoiding 13 combinations of medications known to cause harmful drug–drug interactions has also been added to the 2015 Beers criteria [45].

The interRAI-HC assessment is an international collaborative to improve the quality of life of vulnerable persons through a seamless comprehensive geriatric assessment system. The interRAI-HC instruments have been adopted around the world, bringing a standard level of care to geriatric populations. It is a collaborative network of researchers in over 30 countries, committed to improving care for persons who are disabled or medically complex [46, 47]. The interRAI-HC assessments provide a unique opportunity to re-evaluate prescribing in this high-risk population to reduce PIMs and polypharmacy.

Strengths of the study

Because of the wide prescription coverage in this population, selection bias may have been eliminated. A major strength of the study is that, for the first time, a nationwide database of a comprehensive geriatric assessment was set up to capture a suite of clinical and sociodemographic data. The interRAI-HC assessment allows for comparing data on residents with similar needs within a facility or within a chain of facilities, so a standardized *best practice* approach to providing care can be used. The availability of diagnosis in the interRAI-HC assessments enabled the accurate identification of PIMs according to the 2012 and 2015 Beers criteria.

Limitations

Not all medications listed in the Beers criteria were available in NZ or funded by PHARMAC. Further limitations were the unavailability of laboratory data, such as creatinine clearance (CrCl) values, due to which the medications that should have been avoided or have their dosage reduced to varying levels of kidney function in older adults according to the 2015 Beers criteria have not been considered in the study. The study might not be applicable to other countries because of variances in health systems, prescribing guidelines, and the cost of medications, as they influence prescribing patterns. Also, the population under study is a high-risk population requiring complex care needs, different from other study populations. The updated criteria were applied retrospectively, and it is possible that certain aspects of the criteria might not have been applicable and/or considered by prescribers during the study period. It was hard to ascertain if aspirin was prescribed for primary prevention of cardiac events, and hence, aspirin was not considered as one of the medications to be used with caution for our study. We excluded the list of non-anti-infective medications that should be avoided or have their dosage reduced with varying levels of kidney function in older adults (Beers 2015 criteria), since serum creatinine values were not available to estimate renal function.

Since data was unavailable to identify the exact number of individuals prescribed PIMs based on CrCl, individuals were stratified into age groups, assuming individuals > 85 years would have a lower CrCl for nitrofurantoin and spironolactone [27]. The dispensing of antipsychotics for short-term use as antiemetic or for behavioral problems of dementia could not be ascertained, and these were excluded from the analysis. Additionally, diagnoses including atrial fibrillation, recently decompensated heart failure, hypogonadism, removal of the pituitary gland, gastroparesis, Barrett's esophagitis, pathological hypersecretory condition, agitation, delirium, peptic ulcers, chronic kidney disease, lower urinary tract symptoms, benign prostatic hypertrophy, and epilepsy could not be identified from the interRAI-HC assessments, and were excluded from the analysis. Furthermore, we could not identify a diagnosis of hypertension from the interRAI-HC assessments; hence, the indication for clonidine or peripheral alpha blockers as antihypertensive agents could not be confirmed. In addition, data was unavailable to identify specific conditions for prescriptions with estrogens.

Conclusion

The diligent use of the Beers criteria can alert clinicians to the potential for improving prescribing in this high-risk population vulnerable to adverse events. However, it is important to note that in spite of their widespread applicability across countries and settings since 1991, prescribing of PIMs continues to pose a challenge in the elderly. Despite these limitations, incorporation of the Beers criteria as an indicator to assess the quality of prescribing in older adults has the potential to reduce adverse outcomes and costs associated with inappropriate prescribing. The high prevalence of PIMs in our population with complex care needs may suggest that a comprehensive medication review may not be a focus of these geriatric assessments. The primary focus of these assessments is on functional, cognitive, and quality of life domains. Our findings highlight that interRAI-HC assessments provide a significant opportunity to re-evaluate prescribing in a cohort of vulnerable older adults requiring complex care needs. In this study, the prevalence of PIMs was examined at the first geriatric assessment. Further studies are warranted to examine the impact of repeated geriatric assessments on the prevalence of PIMs.

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Author's contributions Author S.B had full access to all the data in the study, and takes reponsibility for the integrity of the data and the accuracy of data analysis. P. N. designed the study. S. N. and S. B. performed the research. S. N. analyzed the data. P. N. contributed to the new methods or models. S. B. wrote the paper. All authors contributed to the data interpretation, critically commented on the manuscript for intellectual content, and approved the final manuscript.

Compliance with ethical standards Statement of human rights Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants For this type of study, formal consent is not required, since complete anonymity is maintained.

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