Research in Social and Administrative Pharmacy xxx (xxxx) xxx

Contents lists available at ScienceDirect

Research in Social and Administrative Pharmacy

journal homepage: www.elsevier.com/locate/rsap

# Trajectories of *pro re nata* (PRN) medication prescribing and administration in long-term care facilities

Monica Sharma [a], Xin Yee Wong [a], J Simon Bell [b,c], Megan Corlis [d], Michelle Hogan [e], Janet K. Sluggett [b,d,f,*]

[a] University of South Australia, UniSA Clinical and Health Sciences, Adelaide, South Australia, Australia
[b] Centre for Medicine Use and Safety, Faculty of Pharmacy and Pharmaceutical Sciences, Monash University, Parkville, Victoria, Australia
[c] Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
[d] University of South Australia, UniSA Allied Health and Human Performance, Adelaide, South Australia, Australia
[e] Helping Hand Aged Care, North Adelaide, South Australia, Australia
[f] Registry of Senior Australians (ROSA), Health Ageing Research Consortium, South Australian Health and Medical Research Institute, Adelaide, South Australia, Australia

ARTICLE INFO

*Keywords:*
Pro re nata
Nursing homes
Long-term care
Residential aged care
Medication administration
Medication management

ABSTRACT

*Background:* Little is known about changes in *pro re nata* (PRN) medication prescribing and administration in residential aged care facilities (RACFs) over time.
*Objective:* To determine the prevalence and factors associated with PRN medication administration in RACFs and examine changes over 12-months.
*Methods:* Secondary analyses utilizing data from the SIMPLER randomized controlled trial (n = 242 residents, 8 RACFs) was undertaken. PRN medication data were extracted from RACF medication charts. Factors associated with PRN medication administration in the preceding week were explored using multivariable logistic regression.
*Results:* At baseline, 211 residents (87.2%) were prescribed ≥1 PRN medication, with 77 (36.5%) administered PRN medication in the preceding week. PRN administration was more likely in non-metropolitan areas, and less likely among residents with more severe dementia symptoms and greater dependence with activities of daily living. No significant differences in overall PRN prescribing or administration in 162 residents alive at 12-month follow-up were observed.
*Conclusions:* Despite being frequently prescribed, the contribution of PRNs to overall medication use in RACFs is small. PRN prescribing and administration was relatively static over 12-months despite likely changes in resident health status over this period, suggesting further exploration of PRN prescribing in relation to resident care needs may be warranted.

## Introduction

*Pro re nata* (PRN or as needed) medications comprise one-third to one-half of all medications prescribed in residential aged care facilities (RACFs) and are administered in response to acute episodes (e.g. chest pain) or for conditions with fluctuating symptoms (e.g. constipation).[1–3] A recent systematic review reported 48.4%–97.4% of residents are prescribed PRN medication (n = 7 studies).[2] However, most existing studies were published >20 years ago and largely focus on PRN prescribing,[2] with the frequency of administration not extensively researched. Evidence from one study suggested 28% of residents are administered PRN medication each week, while another study reported an average of 5.85 PRN administrations per person-month.[4,5]

Improved understanding of the frequency of PRN medication administration is needed as RACF nurses often make the decision to administer PRNs that are prescribed by general medical practitioners (GPs). When prescribed and administered appropriately, PRN medications provide residents with timely access to medications for symptom management. However, safety concerns have been raised about recognition and management of possible adverse events post-administration

* Corresponding author. Senior Research Fellow, UniSA Allied Health and Human Performance, University of South Australia, GPO Box 2471, Adelaide, South Australia, 5001, Australia.
*E-mail address:* janet.sluggett@unisa.edu.au (J.K. Sluggett).

https://doi.org/10.1016/j.sapharm.2020.11.003
Received 1 November 2020; Accepted 2 November 2020
Available online 10 November 2020

and the risk of exceeding the maximum recommended dose when the same medication is given PRN and regularly.[3–6] Although existing studies suggest it is rare to exceed the maximum daily dose for this reason,[4,5] nervous system medications that are commonly administered PRN may pose safety concerns at high doses.

PRN prescribing might change during an individual's RACF stay. Reduced mobility and functional decline over time may increase pain and impact utilization of regular and/or PRN opioids and laxatives.[7] Medications targeted for deprescribing in RACFs may be prescribed PRN for short periods,[8] while PRN medications that are administered frequently may be re-charted for regular administration. Death is the most common reason for exiting an RACF[9] and administration of PRN opioids, benzodiazepines and antiemetics is noted to be increased at end-of-life.[4,10] Conducting longitudinal studies to determine medication use trajectories is an international priority area for geriatric pharmacotherapy research.[11] Despite this, little is known about changes in PRN medication prescribing and administration in RACFs over time.

This study examined the prevalence and resident characteristics associated with the administration of PRN medications and explored changes in PRN prescribing and administration over 12-months.

## Methods

### *Design, setting and participants*

Secondary analyses of baseline and 12-month follow-up data from the SImplification of Medications Prescribed to Long-tErm care Residents (SIMPLER) cluster randomized controlled trial were conducted. SIMPLER received ethical approval from Monash University Human Research Ethics Committee and has been described elsewhere.[12,13] Briefly, English-speaking permanent residents who took ≥1 medication regularly were recruited from 8 South Australian RACFs in 2017. Similar to long-term care facilities, RACFs provide accommodation and personal care for individuals who can no longer stay at home.[1] Residents anticipated to live for <3 months were excluded from participating at baseline. Of the 720 residents screened, 631 were invited to participate and informed consent was obtained for 242 individuals.

### *Medication data*

Exposures of interest were the prevalence of PRN prescribing and administration at baseline and follow-up, and PRN administrations in the previous 24-h and 7 days. Details for all prescription and non-prescription medications (e.g. multivitamins, complementary and alternative medications) were extracted from paper-based medication charts and coded using the World Health Organization Anatomical Therapeutic Chemical (ATC) Classification System.[14] Nurse-initiated medications, telephone orders, medications prescribed on the short-term section (e.g. antibiotics) and non-medications (e.g. bandages) were excluded. Prescriptions for different formulations of the same medication were considered as separate prescriptions. For all medications prescribed PRN, we determined the total number of doses of the same medications administered regularly over the preceding week and calculated the proportion of administrations that were for PRN medications. Among residents who were administered a PRN medication in the 24-h pre-study entry, we reviewed regularly prescribed medications and calculated the total dose administered over that 24-h period and compared to the maximum recommended dose.[15,16]

### *Covariates*

Research nurses collected baseline demographic information and administered the following scales: the Katz activities of daily living (ADL),[17] FRAIL-NH,[18] Dementia Severity Rating Scale (DSRS)[19] and Mini Nutritional Assessment Short Form.[20] Disease burden was characterized using the Charlson Comorbidity Index.[21] Loss to follow-up was recorded over 12-months.

### *Analysis*

Resident characteristics associated with PRN medication administration among individuals charted ≥1 PRN medication at baseline were examined using logistic regression. Variables with a p-value of ≤0.25 in the univariate models were eligible for inclusion in a backward stepwise multivariate logistic regression analysis.

Wilcoxon signed rank and McNemar's tests were used to investigate prescribing changes at 12-months. Residents from both SIMPLER study arms were included because the intervention delivered in SIMPLER aimed to consolidate administration times for regular medications and did not target deprescribing nor PRN medications.[12,13] Data were analyzed using SAS v 9.4 (SAS Institute, Cary, NC).

## Results

Baseline characteristics of the 242 residents are summarized in Table 1. At baseline, 2280 medications were prescribed for regular administration and 1090 for PRN administration. This included 29 PRN medications prescribed for resident self-administration. Residents were prescribed a median of 4 (IQR 2–6) PRN medications. There were 211 (87.2%) residents prescribed PRN medication, although considerable intra-facility variation in prescribing was observed, ranging from 33.3% to 97.3% across the 8 RACFs (Fig. 1). The distribution of medications prescribed regularly, regularly and PRN, and only PRN across each therapeutic class is summarized in Fig. 2 and Table 2. The most prevalent PRN medications prescribed were paracetamol (54.1% of residents), docusate and sennosides (40.9%) and metoclopramide (26.8%).

Of the 211 residents prescribed PRN medication, 25 (11.8%) were administered ≥1 PRN medication in the 24-h before study entry (n = 32 administrations) and in these individuals there were no instances where the maximum daily dose recommended for that medication was exceeded. Additionally, 77 (36.5%) residents were administered ≥1 PRN medication in the week before study entry, with administration rates of 22.2%–88.9% across the RACFs (Fig. 1). Among these 77 residents, the median number of PRN medications administered in the week pre-study entry was 1 (IQR 1–2) and the median number of administrations was 2 (IQR 1–3). Laxatives and opioids were the most commonly administered PRNs (Table 2). PRN administrations accounted for 0.9% of all medication administrations.

In the final multivariable model, PRN administration was more likely among individuals residing in a regional area and less likely among individuals with higher DSRS and Katz ADL scores (Table 1).

Among the 162 residents alive at follow-up, no significant change in the total number of medications prescribed at baseline and follow-up was observed for medications prescribed regularly (median 9 (IQR 7–12) vs. 9 (IQR 6–12), p = 0.055) or PRN (4 (IQR 2–6) vs. 4 (IQR 2–7), p = 0.216). No significant changes in overall prevalence of PRN prescribing were observed at follow-up (87.7% vs. 93.2%, p = 0.095) although small increases in PRN antipsychotic prescribing occurred (Supplementary Table 1). The proportion of residents administered PRN medication in the preceding week was similar at follow-up (32.4% vs. 28.5%).

## Discussion

The main study findings were that almost 9 in every 10 residents were prescribed PRN medication, with nervous system and alimentary tract and metabolism medications frequently prescribed. Administration was less common, with 37% receiving PRN medication over a 7-day period and a median of 2 PRN doses administered, although facility-level variation was observed. PRN administration was more likely in non-metropolitan locations and less likely among individuals with more

**Table 1**
Characteristics of all participating residents (n = 242) and those associated with *pro re nata* (PRN) medication administration in the week prior to study entry among residents prescribed PRN medication (n = 211).

| Characteristic | Median (IQR) or N (%) at study entry (n = 242 residents) | Univariate analysis[a] | | Multivariate analysis[a,b] | |
|---|---|---|---|---|---|
| | | Odds ratio (95% CI) | p-value | Adjusted odds ratio (95% CI) | p-value |
| Age in years | 87.0 (81.0–92.0) | 1.01 (0.97–1.04) | 0.805 | | |
| Female | 179 (74.0%) | 0.93 (0.49–1.77) | 0.828 | | |
| Rural location | 48 (19.8%) | 2.93 (1.28–6.70) | 0.011 | 3.01 (1.26–7.19) | 0.013 |
| Length of RACF stay (years) | 2.5 (1.0–4.7) | 1.03 (0.94–1.13) | 0.499 | | |
| Charlson Comorbidity Index score | 2.0 (2.0–3.0) | 1.05 (0.88–1.27) | 0.549 | | |
| Dementia diagnosis | 131 (54.1%) | 0.56 (0.32–0.99) | 0.046 | | |
| Dementia Severity Rating Scale score[c] | 21.0 (11.5–38.5) | 0.99 (0.97–1.01) | 0.239 | 0.95 (0.93–0.98) | <0.001 |
| Mini Nutritional Assessment Short Form (MNA-SF) | 9.5 (8.0–11.0) | 0.93 (0.83–1.04) | 0.197 | | |
| Katz Activities of Daily Living score | 1.0 (1.0–3.0) | 0.84 (0.71–0.98) | 0.029 | 0.65 (0.52–0.81) | <0.001 |
| Frailty in Nursing Homes (FRAIL-NH) score[c] | 7.0 (3.0–10.0) | 1.10 (1.02–1.18) | 0.010 | | |
| No. of medications charted for regular administration | 9.0 (6.0–12.0) | 1.08 (1.01–1.15) | 0.020 | | |

CI confidence interval; IQR interquartile range; RACF residential aged care facility.
[a] Among residents prescribed at least one PRN medication at baseline.
[b] Hosmer and Lemeshow goodness-of-fit test p = 0.626.
[c] Not recorded for n = 2 residents.

severe symptoms of dementia or greater dependence with ADLs. The overall number of medications prescribed did not change considerably over time.

This high prevalence of PRN prescribing is consistent with existing evidence suggesting 48–97% of residents are prescribed PRN medication.[2,4,5,22] This may reflect anticipatory prescribing to optimize resident care and limit unnecessary hospitalizations in accordance with current guidelines[23] and/or the model of primary care delivery in the RACF. In Australia, GPs visit RACFs periodically but are often based off-site[24] and PRNs may be prescribed to ensure residents and staff have timely access to medications for symptom management. Factors impacting the high PRN prescribing rates observed could be further explored among stakeholders using a qualitative approach. The PRN administration rates observed in this study are consistent with a previous South Australian study that reported 28% of residents were administered a PRN medication over 7 days, with administration more likely among residents with a greater dependence with ADLs and taking more medications regularly.[5] Associations between greater dementia severity and PRN medication administration in the present study may reflect difficulty in communicating symptoms but requires further exploration to identify whether differences in regular medication prescribing also exist. Our findings contrast with another Australian study which reported a three-fold variation in PRN administration rates was observed across RACFs over 12-months that was not explained by

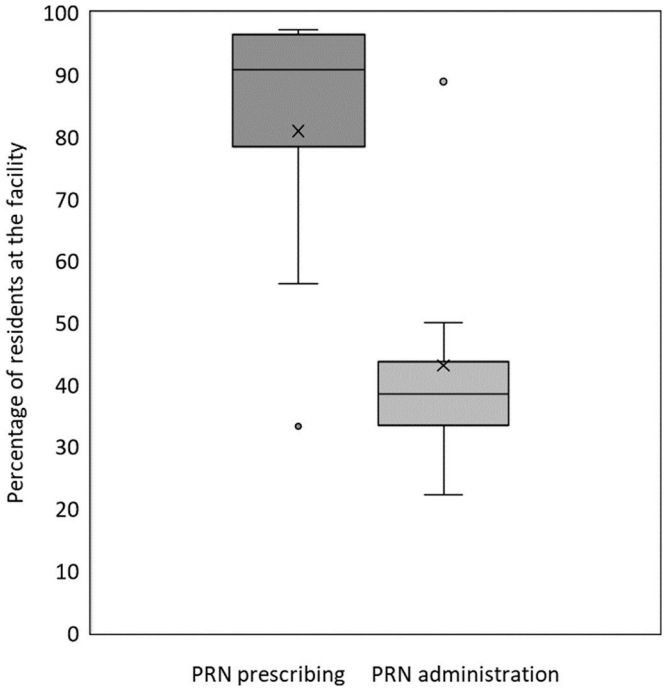


**Fig. 1.** Boxplot of facility-level variation in *pro re nata* (PRN) medication prescribing and administration (n = 8 facilities).

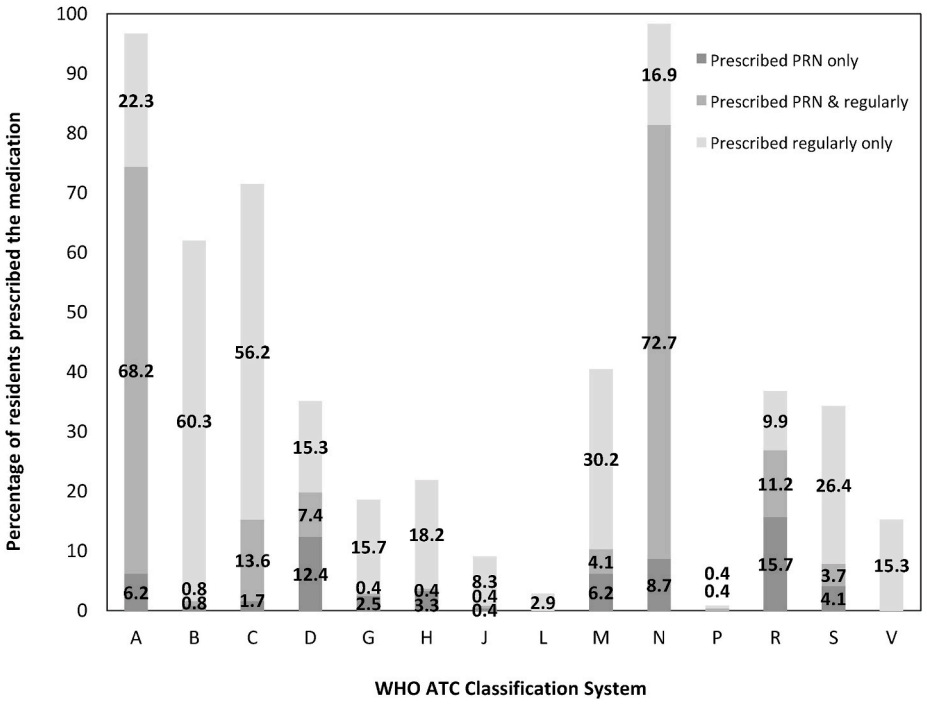


**Fig. 2.** Prevalence of prescribing of *pro re nata* (PRN) and regular medications at study entry
A = alimentary tract and metabolism; B = blood and blood forming organs; C = cardiovascular system, D = dermatologicals; G = genito-urinary system and sex hormones; H = systemic hormonal preparations, excluding sex hormones and insulins; J = anti-infectives for systemic use; L = antineoplastic and immunomodulating agents; M = musculoskeletal system; N = nervous system; P = antiparasitic products, insecticides and repellents; R = respiratory system; S = sensory organs; V = various.

resident age nor dementia diagnosis.[4]

Alimentary tract or nervous system medications were often prescribed for both regular and PRN administration, and PRN administration was generally sparse. This suggests a preference to treat conditions such as pain and constipation using medications administered regularly rather than PRN. Australian guidelines recommend regular administration of paracetamol as a first-line analgesic and routine prescription of laxatives when prescribing opioids.[15,23] Although residents were often prescribed medications from the same class both regularly and PRN, there was no evidence that maximum doses were exceeded when a PRN medication was administered. This is an encouraging finding because supratherapeutic doses can occur when the same medications are prescribed regularly and PRN.[3,6]

Overall, PRN prescribing or administration did not change considerably over time. This finding may have been influenced by baseline length of stay, the modest sample size or because residents who died during follow-up were excluded. Previous cross-sectional studies have reported conflicting associations between length of stay and number of PRN medications prescribed.[2,4,5,22,25] Changes in PRN prescribing and administration might be more prevalent at RACF entry or end-of-life. A recent study reported PRN medications were administered more frequently to residents who died during 12-month follow-up compared to those alive (mean 8.0 versus 5.0 administrations per person-month).[4]

Small increases in PRN antipsychotic prescribing were observed at follow-up, despite Australian guideline recommendations for antipsychotics prescribed for behavioral and psychological symptoms in residents with dementia to be reviewed within three months.[23,26] Factors such as the model of primary care delivery and regular medication reviews could impact use of high-risk medications for extended durations. Decreases in PRN and regular opioid and benzodiazepine prescribing were observed post-collaborative medication review in Norwegian RACFs,[27] while the presence of an in-house GP facilitated a reduction in the mean percentage of residents prescribed a PRN (75%–68%, $p < 0.001$) in a recent Australian trial.[28]

While frequently prescribed, PRN medications accounted for only 7% of opioid and 5% of anxiolytic administrations. The inability to discern between medications dispensed for regular and/or PRN use is a common limitation of RACF pharmacoepidemiological studies using pharmacy claims data to determine medication exposure. Our finding that PRNs comprised <1% of all administrations over 7-days, and that prescribing and administration did not change considerably during follow-up, provides further reassurance that the contribution of PRN medications to total medication exposure in RACF-based studies is likely to be small.

### *Strengths and limitations*

This study utilized comprehensive data from RACFs maintained by the same not-for-profit provider. Participants were similar to all individuals receiving residential care from this provider and the wider Australian RACF population in terms of age, sex and dementia diagnosis.[12,29] However, study findings may not reflect practices in all RACFs or end-of-life care. Provision of non-pharmacological interventions, discussions about PRN use with the prescriber, and/or resident outcomes post-PRN administration are unknown. Administration among 10 residents self-administering may be underestimated as no PRN administrations were recorded for those individuals. We were also unable to determine the appropriateness of prescribing or whether PRN medications were under-administered.

## Conclusions

Approximately one third of residents are administered a PRN medication each week. There is little variation in PRN prescribing or administration over time and the overall contribution to total medication use in RACFs is small. Further exploration of PRN prescribing in relation to changing resident care needs may be warranted, along with future research to understand non-pharmacological interventions undertaken before PRN administration and utilization in specific situations such as end-of-life care.

## Declaration of competing interest

JKS was an embedded researcher within Helping Hand Aged Care during 2017–19. MC and MH report employment by Helping Hand Aged Care in the last 36 months. JSB and JKS report grant funding from

**Table 2**
*Pro re nata* (PRN) medication prescribing and administration at baseline (n=242 residents)

| Medication name/class (ATC code) | Medications prescribed (n, %) | | PRN medication administered in the previous 7 days | | Percentage of all administrations in the previous week that were PRN |
|---|---|---|---|---|---|
| | Prescribed PRN (n, %) | Prescribed for administration regularly (n, %) | N (%) | No. of PRN administrations, median (IQR) | |
| Alimentary tract and metabolism (A) | 180 (74.4) | 219 (90.5) | 37 (20.6) | 1.0 (1.0-1.0) | 1.6 |
| Blood and blood forming organs (B) | 4 (1.7) | 148 (61.2) | - | - | - |
| Cardiovascular system (C) | 37 (15.3) | 169 (69.8) | 2 (5.4) | 1.0 (1.0-1.0) | 0.1 |
| Dermatologicals (D) | 48 (19.8) | 55 (22.7) | 2 (4.2) | 3.5 (1.0-6.0) | 0.7 |
| Genito Urinary System (G) | 7 (2.9) | 39 (16.1) | - | - | - |
| Systemic Hormonal Preparations (H) | 9 (3.7) | 45 (18.6) | - | - | - |
| Antiinfectives (J) | 1 (0.4) | 20 (8.3) | - | - | - |
| Musculo-skeletal system (M) | 25 (10.3) | 82 (33.9) | 3 (12.0) | 1.0 (1.0-1.0) | 0.4 |
| Nervous System (N) | 197 (81.4) | 217 (89.7) | 42 (21.3) | 2.0 (1.0-3.0) | 1.5 |
| Respiratory System (R) | 65 (26.9) | 51 (21.1) | 6 (9.2) | 2.0 (1.0-3.0) | 1.6 |
| Sensory Organs (S) | 19 (7.9) | 73 (30.2) | 1 (5.3) | - | 0.2 |
| *Specific medication classes* | | | | | |
| Antacids (A02A) | 26 (10.7) | 4 (1.6) | 1 (3.8) | 1.0 (1.0-1.0) | 1.8 |
| Propulsives (A03FA) | 67 (27.7) | 3 (1.2) | 1 (1.5) | 1.0 (1.0-1.0) | 2.3 |
| Laxatives (A06) | 166 (68.6) | 124 (51.2) | 33 (19.9) | 1.0 (1.0-2.0) | 3.7 |
| Loperamide (A07DA03) | 31 (12.8) | 1 (0.4) | 1 (3.2) | 12 (12.0-12.0) | 77.4 |
| Organic nitrates (C01DA) | 27 (11.1) | 16 (6.6) | - | - | - |
| Dermatological corticosteroids (D07) | 42 (17.3) | 16 (6.6) | 2 (4.8) | 3.5 (1.0-6.0) | 3.6 |
| Opioids (N02A) | 90 (37.2) | 73 (30.2) | 20 (22.2) | 2.0 (1.0-2.5) | 7.1 |
| Paracetamol (N02BE01, N02AJ06) | 131 (54.1) | 156 (64.5) | 9 (6.9) | 3.0 (2.0-4.0) | 0.9 |
| Antipsychotics (N05A*) | 23 (9.5) | 55 (22.7) | 2 (8.7) | 2.5 (2.0-3.0) | 0.8 |
| Anxiolytics (N05B) | 64 (26.4) | 34 (14.0) | 9 (14.1) | 1.0 (1.0-2.0) | 4.9 |
| Hypnotics & Sedatives (N05C) | 34 (14.1) | 27 (11.2) | 4 (11.8) | 1.0 (1.0-1.50) | 2.6 |
| Salbutamol (R03AC02) | 51 (21.1) | 12 (5.0) | 2 (3.9) | 1.0 (1.0-1.0) | 0.9 |

* excluding lithium and prochlorperazine

Resthaven Inc. and the Australian Government Aged Care Quality Agency in the last 36 months.

## Acknowledgements

The investigators thank the Helping Hand Aged Care management team and RACF staff, clinicians, and residents and families for their valuable support and participation in the SImplification of Medications Prescribed to Long-tErm care Residents (SIMPLER) randomized controlled trial.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sapharm.2020.11.003.

## Funding sources

JKS is supported by a National Health and Medical Research Council (NHMRC) Early Career Fellowship (grant number APP1156439). JSB is supported by an NHMRC Boosting Dementia Research Leadership Fellowship (grant number APP1140298). This study utilized data from the SIMPLER study, which was funded by the NHMRC Cognitive Decline Partnership Centre (CDPC). The CDPC received support from the NHMRC and funding partners including Helping Hand Aged Care, HammondCare, Brightwater and Dementia Australia.

## References

1. Sluggett JK, Ilomäki J, Seaman K, et al. Medication management policy, practice and research in Australian residential aged care: current and future directions. *Pharmacol Res*. 2017;116:20–28.
2. Dörks M, Allers K, Hoffmann F. Pro re nata drug use in nursing home residents: a systematic review. *J Am Med Dir Assoc*. 2019;20:287–293. e287.
3. Vaismoradi M, Vizcaya Moreno F, Sletvold H, et al. PRN medicines management for psychotropic medicines in long-term care settings: a systematic review. *Pharmacy (Basel)*. 2019;7:157.
4. Picton L, Ilomäki J, Keen CS, et al. Rates of PRN medication administration in Australian residential aged care. *J Am Med Dir Assoc*. 2020. https://doi.org/10.1016/j.jamda.2020.04.033.
5. Stasinopoulos J, Bell JS, Ryan-Atwood TE, et al. Frequency of and factors related to pro re nata (PRN) medication use in aged care services. *Res Soc Adm Pharm*. 2018;14:964–967.
6. Haw C, Wolstencroft L. A study of the prescription and administration of sedative PRN medication to older adults at a secure hospital. *Int Psychogeriatr*. 2014;26:943–951.
7. Blekken LE, Nakrem S, Vinsnes AG, et al. Constipation and laxative use among nursing home patients: prevalence and associations derived from the Residents Assessment Instrument for Long-Term Care Facilities (interRAI LTCF). *Gastroenterol Res Pract*. 2016:1215746.
8. Potter K, Flicker L, Page A, et al. Deprescribing in frail older people: a randomised controlled trial. *PloS One*. 2016;11, e0149984.
9. Australian Institute of Health and Welfare (AIHW). *GEN Fact Sheet 2017–18: People Leaving Aged Care*. Canberra: AIHW; 2019.
10. Russell BJ, Rowett D, Currow DC. Pro re nata prescribing in a population receiving palliative care: a prospective consecutive case note review. *J Am Geriatr Soc*. 2014;62:1736–1740.
11. Tan ECK, Sluggett JK, Johnell K, et al. Research priorities for optimizing geriatric pharmacotherapy: an international consensus. *J Am Med Dir Assoc*. 2018;19:193–199.
12. Sluggett JK, Chen EY, Ilomäki J, et al. Reducing the burden of complex medication regimens: SImplification of Medications Prescribed to Long-tErm care Residents (SIMPLER) cluster randomized controlled trial. *J Am Med Dir Assoc*. 2020;21:1114–1120.e4.
13. Sluggett JK, Chen EYH, Ilomäki J, et al. SImplification of Medications Prescribed to Long-tErm care Residents (SIMPLER): study protocol for a cluster randomised controlled trial. *Trials*. 2018;19:37.
14. WHO Collaborating Centre for Drug Statistics Methodology. ATC classification index with DDDs. http://www.whocc.no/atc_ddd_index/; 2020. Accessed 2020.10.30.
15. Australian Medicines Handbook. Adelaide: Australian Medicines Handbook Pty Ltd; 2020 (online) https://amhonline.amh.net.au/. Accessed 2020.10.30.
16. Faculty of Pain Medicine. *Australian and New Zealand College of Anaesthetists (FPM ANZCA)*. Opioid calculator; 2019. http://www.opioidcalculator.com.au/. Accessed 2020.10.30.
17. Katz S, Ford AB, Moskowitz RW, et al. Studies of illness in the aged. The index of ADL: a standardized measure of biological and psychosocial function. *J Am Med Assoc*. 1963;185:914–919.
18. Kaehr E, Visvanathan R, Malmstrom TK, et al. Frailty in nursing homes: the FRAIL-NH scale. *J Am Med Dir Assoc*. 2015;16:87–89.
19. Clark CM, Ewbank DC. Performance of the dementia severity rating scale: a caregiver questionnaire for rating severity in Alzheimer disease. *Alzheimer Dis Assoc Disord*. 1996;10:31–39.
20. Kaiser MJ, Bauer JM, Ramsch C, et al. Validation of the Mini Nutritional Assessment short-form (MNA®-SF): a practical tool for identification of nutritional status. *J Nutr Health Aging*. 2009;13:782.
21. Quan H, Li B, Couris CM, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am J Epidemiol*. 2011;173:676–682.
22. Dörks M, Schmiemann G, Hoffmann F. Pro re nata (as needed) medication in nursing homes: the longer you stay, the more you get? *Eur J Clin Pharmacol*. 2016;72:995–1001.
23. The Royal Australian College of General Practitioners. *RACGP Aged Care Clinical Guide (Silver Book)*. fifth ed. Melbourne: RACGP; 2019.
24. Reed R. Models of general practitioner services in residential aged care facilities. *Aust Fam Physician*. 2015;44:176–179.
25. Stokes JA, Purdie DM, Roberts MS. Factors influencing PRN medication use in nursing homes. *Pharm World Sci*. 2004;26:148–154.
26. Australian Commission on Safety and Quality in Health. Care (ACSQHC) and Australian Institute of health and Welfare. In: *The Third Australian Atlas of Healthcare Variation*. Sydney: ACSQHC; 2018.
27. Fog AF, Kvalvaag G, Engedal K, et al. Drug-related problems and changes in drug utilization after medication reviews in nursing homes in Oslo, Norway. *Scand J Prim Health Care*. 2017;35:329–335.
28. Haines TP, Palmer AJ, Tierney P, et al. A new model of care and in-house general practitioners for residential aged care facilities: a stepped wedge, cluster randomised trial. *Med J Aust*. 2020;212:409–415.
29. Chen EY, Bell JS, Ilomäki J, et al. Medication regimen complexity in 8 Australian residential aged care facilities: impact of age, length of stay, comorbidity, frailty, and dependence in activities of daily living. *Clin Interv Aging*. 2019;14:1783.