Drugs - Real World Outcomes (2016) 3:13–24
DOI 10.1007/s40801-016-0065-6

SHORT COMMUNICATION

Medicines Management, Medication Errors and Adverse Medication Events in Older People Referred to a Community Nursing Service: A Retrospective Observational Study

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Published online: 15 March 2016

Abstract

Background Increasing numbers of older people are receiving support with medicines management from community nursing services (CNSs) to enable them to live in their own homes. Little is known about these people and the support they receive.

Objectives To explore the characteristics of older people referred for medicines management support, type of support provided, medication errors and adverse medication events (AMEs).

Methods A retrospective observational study of a random sample of 100 older people referred to a large non-profit CNS for medicines management support over a 3-month period was conducted. Measures were: demographics, referral source, current medical problems, medicines, medication aids, types of medication authorisations used by nurses, frequency of nurse visits and type of support provided, medication errors, AMEs and interdisciplinary teamwork among community nurses, general practitioners and pharmacists.

Results Older people (median 80 years) were referred for medicines support most often by hospitals (39 %). Other referrals were from families/carers, case-managers, palliative care services and general practitioners. Multiple health conditions (median 5) and medicines (median 10) were common; 66 % used ≥5 medicines; 48 % used ≥1 high-risk medicines—most commonly opiates, anticoagulants and insulin. Medication aids were frequently used, mostly multi-compartment dose administration aids (47 %). Most people received regular community nurse visits (≥4 per week) to administer medicines or monitor medicine-taking. Only 16 % had a medication administration chart; for other clients nurses used medicine lists or letters from doctors for medication authorisation. Medication errors occurred in 41 % of people and 13 % had ≥1 AME requiring medical consultation or hospitalisation; 9/13 (64 %) AMEs were potentially preventable. There was little evidence of interdisciplinary teamwork or medication review.

Conclusion CNS clients had multiple risk-factors for medication misadventure. Deficiencies in medicines management were identified, including low use of medication charts and interdisciplinary medication review. Strategies are needed to improve medicines management in the home-care setting.

Electronic supplementary material The online version of this article (doi:10.1007/s40801-016-0065-6) contains supplementary material, which is available to authorized users.

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Key Points

Older people referred to a community nursing service (CNS) for support with medicines management received intensive assistance, often over a prolonged period; they had multiple risk-factors for adverse medication events but interdisciplinary collaboration and medication review was uncommon.

Medication errors and adverse medication events requiring medical consultation occurred in 41 and 13 % of CNS clients respectively; a majority of adverse medication events were preventable.

There is a need to develop and test strategies to improve medication safety for CNS clients.

1 Introduction

The number of older Australians has increased by 65 % over the last 20 years [1]. Over the same period there has been a growing focus on supporting older people to remain living in their own homes for as long as possible [2], and an increase in the intensity of treatment for medical conditions that commonly affect older people (such as cardiovascular disease, diabetes, osteoporosis), leading to increased polypharmacy and medication regimen complexity [3]. Together these factors have led to increased demand for community nursing services (CNSs) to support older people with managing medicines at home [4]. A large Australian CNS recently reported that 56 % of its home nursing visits were primarily for the purpose of supporting medicines management [5]. Similar trends have been reported internationally [6].

There is evidence that older people receiving home nursing care are a group at high risk of medication-related problems and adverse medication events (AMEs) [7–10]. It has been suggested that the risk of medication-related problems among CNS clients may be greater than in other healthcare settings such as hospitals and residential aged-care facilities because of the unstructured environment and communication challenges in the home care setting [11]. For example, home care nurses have a less direct relationship and less contact with clients' medical practitioners and pharmacies. There may be multiple prescribers and multiple pharmacies involved in the client's care. Prescribers and pharmacists may not see the client regularly and may rely on the nurse to report medication-related problems. Home-care clients and their informal carers often participate in their own medicines management (by self-administering some medicines, attending medical appointments, purchasing over-the-counter medicines, etc.) which means there is potential for non-adherence and medication self-administration errors [11, 12].

Despite large numbers of people receiving CNS support, there has been little research focusing on this group [12, 13]. In Australia, Johnson et al. used a convenience sample of 111 CNS clients to develop medication risk assessment criteria and test a nurse-led intervention to improve medicine use [7, 14], and While et al. [15–17] conducted a series of qualitative studies exploring issues related to medicines management in CNS clients and their carers. Whilst these studies, and similar studies from other countries [9, 10, 12], highlighted complexities and problems related to medicines management, they did not recruit representative samples of CNS clients or report the frequency or type of medicines management support provided or the prevalence of medication errors and AMEs. Knowing more about people who receive medicines management support from CNSs, the types of support they receive and medication-related problems and AMEs encountered, may help with identifying areas for improvement and planning future care needs for home-care clients.

The aim of this study was to describe the characteristics of community-dwelling older people referred to an Australian CNS for support with medicines management, their medicines management and medication errors and adverse medication events.

2 Methods

2.1 Setting

The study was conducted at two metropolitan sites of a large, not-for profit CNS in Melbourne, Australia. The sites employed 120 registered nurses (degree-qualified nurses), nine enrolled nurses (diploma- or certificate-qualified nurses) and eight community care aides (non-nurse professional care workers).

2.2 Subjects

One hundred CNS clients were randomly selected (using a random number generator) from all people aged 50 years and over who were referred for medicines support between 16 July and 12 October 2012.

Table 1 Data collected and definitions

Data (definition)
Source of referral to the CNS
Reason for referral to the CNS
Current medical problems (active medical problems at the time of admission to the CNS)
Presence of cognitive impairment (documented dementia or mild cognitive impairment, Mini-Mental State Examination score <24 or Rowland Universal Dementia Assessment Scale score <23)
Medicines used at the time of CNS admission (medicines listed on the clients' first 'medication authorisation')
Use of medicines associated with heightened risk of an adverse medication event if taken or administered incorrectly (high risk: anticoagulants, chemotherapeutic agents excluding hormonal agents, immunosuppressant agents, insulins, lithium, opioids; moderate risk: antibiotics, anticonvulsants, antipsychotics, benzodiazepines, loop diuretics, oral corticosteroids, oral hypogylcaemics) [42]
Medication management aids used (e.g. dose administration/adherence aids)
CNS visits in the first and last weeks of the CNS admission[a]
Types of medication authorisations (medication administration charts or other medicine lists or instructions signed by a medical practitioner authorising the CNS to administer medicines or support clients' medicine self-administration) used during first and last weeks of admission[a]
Medication errors (deviations from the prescriber's instructions, whether or not they led to harm)
Adverse medication events (adverse drug reactions [ADRs] requiring medical consultation and unplanned medication-related hospital admissions)
Evidence of interdisciplinary teamwork (documented communication between CNS staff and prescribers or pharmacists, Home Medicines Reviews,[b] Team Care Arrangements,[c] Case Conferences[d])
Duration of CNS care (number of days from CNS admission to CNS discharge)[e]
Discharge location

CNS community nursing service

[a] For clients who had not been discharged from the CNS at the time of the audit, the last week of admission for the purpose of data collection was taken to be the last week of available data (at least six months after admission to the CNS)

[b] Home Medicines Review (HMR) is an Australian Government funded program that is available to patients in the community setting who are at risk of adverse medication events. A general practitioner can initiate an HMR by making a referral to an accredited consultant pharmacist

[c] Team Care Arrangement is an Australian Government funded (Medicare) service in which a general practitioner works with other health professionals involved in a patient's management to prepare and implement a multidisciplinary care plan

[d] Case conference is an Australian Government funded (Medicare) service in which a general practitioner organises, coordinates or participates in a meeting or discussion held to ensure that their patient's multidisciplinary care needs are met through a planned and coordinated approach

[e] CNS episodes of care that were temporarily interrupted by a period of residential respite or an acute hospitalisation were counted as one episode of care

2.3 Data Collection

Data were collected (May–December 2013) by retrospective review of clients' CNS records and telephone contact with clients' general practitioners (GPs) and pharmacies, using a pre-piloted data collection form. Data collected, and definitions, are provided in Table 1.

Referral details, medical problems, cognitive function and use of medication aids were obtained from referral documents, CNS admission notes and care plans. Medicines used by clients were obtained from medication authorisations.

CNS home visits, medication errors, AMEs and discharge location were identified by reviewing CNS progress notes and discharge records. Evidence of interdisciplinary teamwork was identified from CNS records and telephone calls to clients' GPs and/or community pharmacies.

2.4 Data Analysis

Age-adjusted Charlson Co-morbidity Index scores were calculated (a score of ≥ 5 indicates at high risk of mortality) [18]. The use of medicines associated with heightened risk of adverse events was determined by a pharmacist researcher, who compared clients' medicine lists against a pre-defined list of 'risk' medicines (Table 1).

Potential AMEs were reviewed by an expert panel to determine causality, preventability and contribution to hospital admission, using modified Hallas criteria [19, 20]. The panel comprised three clinical pharmacists and two registered nurses, each with over 15 years of experience encompassing hospital and community aged care. Panel members assessed each case independently. When there was disagreement, the case was discussed until consensus was reached. Severity was assessed using Pearson criteria

[21], and the primary underlying cause of the AME was classified using Hepler and Strand's classification [22]. The AME assessment criteria are provided in Supplementary File 1.

Data were analysed using SPSS (version 21, IBM Corporation, USA). Analyses were carried out using descriptive tests, with results reported as frequency and proportion for categorical variables and median and interquartile range (IQR) for discrete and non-normally distributed continuous variables.

3 Results

One hundred and ninety-seven people aged 50 years or over were referred for medicines support. The characteristics of the 100 clients selected for the study, and their reasons for referral, are summarised in Table 2. CNS clients were visited a median of four to five days a week. In the first week of care the most common reason for medicines support visits was to administer medicines; in the last week it was to monitor medicine-taking (Table 3).

A minority of clients ($n = 16$) had a medication administration chart during the first week of their CNS admission; 14 of these were handwritten by a hospital doctor and two were printed or handwritten by a GP. The remaining 84 clients' treatment authorisations were printed or handwritten medicine lists provided by the client's GP ($n = 48$), hospital doctor ($n = 27$), specialist ($n = 1$) or unknown source ($n = 8$). Use of medication administration charts remained low, with only 15 clients having one at the time of discharge. Twenty-two clients had more than one medication authorisation used concurrently (e.g. a GP medicine list plus a letter from a GP or specialist indicating a medicine change) during either the first or last week of their CNS admission.

Medication authorisations for 85 clients included all of their medicines. The other 15 clients' authorisations included a partial list only (usually parenteral medicines, because the CNS was involved in administering those medicines only). The 85 clients with a complete medicine list used a median of ten medicines (IQR 6–13, range 2–26), and 66 % used five or more. The median number of regular, long-term medicines (excluding 'when required' and short-term medicines) was eight (IQR 4–11, range 1–21). Forty-eight clients used one or more high risk medicines, most commonly opiates (28 % clients), anticoagulants (17 % clients) and insulins (14 % clients).

One hundred and thirty-seven medication errors were identified, affecting 41 (41 %) clients (Table 4). Twenty-three (23 %) clients had an unplanned hospital admission—after expert panel review 9/23 (39.1 %) of these were deemed to have been possibly medication-related (Table 5). Five clients had an ADR that required medical consultation without hospital admission. One client had both a medication-related hospital admission and an ADR without admission, so overall there were 13 (13 %) clients with one or more AME requiring medical consultation or hospitalisation (Table 5). Nine (64 %) AMEs were considered to have been potentially preventable. Eight clients died at home; all were receiving end-of-life care for a terminal illness prior to their death.

There was little evidence of interdisciplinary teamwork. CNS nurses recorded contact with the clients' GP or pharmacy for only eight clients in the first week of care and one in the final week. No client had a multidisciplinary case conference documented at any time during their CNS admission, and only one client had a Team Care Arrangement. One client had a Home Medicines Review (HMR) recorded in their CNS record; a further four had received an HMR according to their GP or community pharmacist.

4 Discussion

Community nursing services play a vital role in helping frail older people to remain living in their own homes. This is the first study to quantify and describe medicines management support and medication-related problems in a representative sample of older people referred to a CNS. It found that CNS clients had a very high prevalence of risk-factors for medication-related problems, including multiple co-morbidities, cognitive impairment, polypharmacy and use of medicines associated with heightened risk. CNS clients used a median of ten medicines, which is higher than the average for community-dwelling older people [23].

In the first week of care most clients were visited on at least 5 days, mainly to administer medicines. In the last week of care, the number of visits was slightly lower and the most common form of support was monitoring medicine-taking. This may reflect the fact that some clients regained independence or semi-independence, or that some of the sickest and frailest individuals, with intensive care needs, were discharged to residential care or died.

The most common form of medication authorisation used by the CNS was medicine lists provided by GPs (usually summaries printed from GPs' electronic patient records). Medication administration charts were infrequently used, and in some cases multiple medication authorisations were used concurrently. Reliance on GP medicine lists, letters from GPs and specialists and multiple medication authorisations stems from difficulty accessing GPs to obtain and maintain medication charts in the community setting. However, use of these types of

Table 2 Client characteristics and medicines management ($n = 100$ clients)

Variable	Data *n* (%) or median (IQR); range
Age, years	80 (73–87); 55–97
Gender female, *n* (%)	60 (60 %)
No. of current medical conditions	5 (3–7); 1–22
Type of medical conditions[a]	
Cancer, leukemia, lymphoma (excluding skin cancer)	32 (32 %)
Diabetes	32 (32 %)
Respiratory disease	17 (17 %)
Dementia or Alzheimer's disease	16 (16 %)
Myocardial infarction	15 (15 %)
Cerebrovascular accident	14 (14 %)
Renal disease	11 (11 %)
Congestive heart failure	8 (8 %)
Others	8 (8 %)
Age-adjusted Charlson Comorbidity Index score	6 (5–8); 1–13
Charlson score ≥5 (higher risk of mortality)	77 (77 %)
Cognitive impairment[b]	30 (30 %)
Number of medicines[c]	10 (6–13); 2–26
Reason for referral to CNS	
Medicines management ONLY[d]	81 (81 %)
Medicines management plus OTHER care[e]	19 (19 %)
Source of referral to CNS	
Hospital	39 (39 %)
Family or informal carer	12 (12 %)
Palliative care service	12 (12 %)
Case manager	11 (11 %)
General practitioner	10 (10 %)
Aged Care Assessment Team	6 (6 %)
Medical specialist	3 (3 %)
Community health service	2 (2 %)
Self	1 (1 %)
Unknown	4
Duration of care (length of stay) with CNS	
1–7 days	25 (25 %)
8–30 days	29 (29 %)
31–60 days	21 (21 %)
>60 days	25 (25 %)
Discharge location	
Home	56 (56 %)
With self-care or informal care	41
Client terminated care	4
With other formal care	2
Ongoing care not documented	9
Acute hospital	20 (20 %)
Subacute or palliative care hospital	5 (5 %)
Residential care	9 (9 %)
Died at home	8 (8 %)
Unknown	2 (2 %)

Table 2 continued

Variable	Data *n* (%) or median (IQR); range
Multi-compartment dose administration aid (DAA)	47 (47 %)[f]
DAA packed by	
Community pharmacy	42
Client/carer/family member	2
Not documented	3
Single-compartment DAA used by CNS for setting out evening doses when nurse visited in the morning	12 (12 %)
Locked box used by CNS to store medicines	17 (17 %)[g]

CNS community nursing service, *DAA* Dose Administration Aid

[a] Conditions included in the Charlson Comorbidity Index

[b] Likely to be an underestimate, because only 36 % clients had a MMSE or RUDAS score documented

[c] Number of medicines at the time of admission to RDNS (includes regular and when required medicines; when combination products were used the individual active ingredients were counted as separate medicines). Data not available for 15 clients

[d] Monitoring medicine-taking, administering medicines, medicines prompting and assisting with self-administration

[e] Wound care ($n = 14$), personal care such as hygiene or mobility assistance ($n = 7$), clinical monitoring such as blood pressure, weight, bowel function, pain, fluids ($n = 7$)

[f] 20/47 (42.6 %) clients using a multi-compartment DAA received CNS visits 7 days a week

[g] 11/47 (23.4 %) clients using a multi-compartment DAA had a locked box used to store the medicines

authorisation and multiple authorisations is associated with risk of medication errors. It has been reported in several studies that GP medicine lists have a high rate of errors and discrepancies, for a variety of reasons including that the GP is often not the only prescriber and because patient records are not always updated when there are dose-changes and medicines ceased [9, 24, 25]. There were 26 medication errors related to discrepancies between medication authorisations and clients' medicines (usually pharmacy-packed dose administration aids [DAAs]), which may reflect inaccurate medication authorisations and/or deficiencies in interdisciplinary communication (e.g. GP or other prescriber failing to notify the pharmacy of a medicine change for a DAA client, or GP being unaware of a medicine change initiated by another prescriber).

Multi-compartment DAAs were used by nearly 50 % of CNS clients. Whilst these may simplify medicines management for some older people, they can also increase the cost and complexity of medicines management and there is evidence that they are sometimes used unnecessarily [12, 26]. In this study almost half of the clients who used a DAA were receiving CNS visits 7 days a week, and almost one quarter had their DAA stored in a locked box. It is likely that some of these clients could have been managed without a DAA since they were not self-administering their medicines.

Medication errors were prevalent, with 41 % clients having one or more error identified. Almost three quarters resulted from clients (or carers) missing doses or taking medicines incorrectly. It is not surprising that client/carer errors were common given that CNS clients were older people with functional and/or cognitive decline who were referred for medicines management support, and many continued to have some involvement in taking their medicines (since the CNS could usually visit only once a day and medicines often needed to be taken at other times). However, it is also possible that healthcare providers and their systems contributed to some of the errors attributed to clients. For example, failure to simplify unnecessarily complex medication regimens or to choose the simplest dose-forms sometimes contributed to client errors. It is common practice for CNS nurses to set out the evening doses for clients when they visit in the morning, in order to avoid multiple daily visits, and this practice was sometimes associated with missed doses when the client forgot to take those medicines.

Medication errors caused by CNS staff were uncommon, however this is likely to be an underestimate because these were difficult to detect using retrospective methodology (which was largely reliant on CNS staff identifying and documenting such errors) and with low usage of medication administration charts. In hospitals and residential care settings, using medication chart audits and direct observation of staff administering medicines, much higher error rates have been reported [27, 28].

Missing the occasional dose of a medicine is unlikely to be clinically significant for most medicines, so whilst

Table 3 Community nursing service (CNS) visits

	First week of care (100 clients) *n* (%) clients	Last week of care (71 clients)[a] *n* (%) clients
No. of days per week that CNS visited clients		
1 to 2	19 (19.0 %)	28 (39.4 %)
3 to 4	23 (23.0 %)	8 (11.2 %)
5 to 6	19 (19.0 %)	14 (19.8 %)
7	39 (39.0 %)	21 (29.6 %)
Median	5 (IQR 3–7, range 1–7)	4 (IQR 2–7, range 1–7)
No. of times CNS visited per day		
1	87 (87.0 %)	64 (90.1 %)
2	9 (9.0 %)	5 (7.0 %)
3	4 (4.0 %)	2 (2.8 %)
Primary reason for CNS medicines support visits (as per care plan)		
Administering medicines	44 (44 %)	27 (38.0 %)
Monitoring medicine-taking	32 (32 %)[b]	28 (39.4 %)
Assisting with medicine-taking	16 (16 %)	7 (9.9 %)
Prompting medicine-taking	8 (8.0 %)	6 (8.5 %)
Other	–	3 (4.2 %)[c]
Type of medicine support provided by CNS (as per progress notes)[d]		
Assessment of medicines management	14 (14 %)	1 (1.4 %)
Administering medicines	52 (52 %)	32 (45.1 %)
Monitoring medicine-taking	55 (55 %)	39 (54.9 %)
Assisting with medicine-taking	32 (32 %)	19 (26.8 %)
Prompting medicine-taking	16 (16 %)	12 (16.9 %)
Education about medicines management	20 (20 %)	3 (4.2 %)
Liaising with community pharmacy or doctors about clients' medicines	8 (8 %)	1 (1.4 %)
Medicines support provided for		
All prescribed medicines	50 (50 %)	40 (56.3 %)
Selected medicines[e]	48 (48 %)	26 (36.6 %)
Not documented	2 (2.0 %)	5 (5.0 %)

[a] Last week data only includes clients whose length of stay with CNS was ≥14 days

[b] Sometimes combined with education (e.g. education and monitoring for clients newly commenced on insulin)

[c] No longer needing medicines management support in final week of care, but still receiving other care (monitoring blood sugar level $n = 1$; wound care $n = 2$)

[d] Most clients had more than one type of medicines support documented

[e] Some clients self-administered most of their medicines but required support with particular medicines such as injectable medicines, warfarin, eye drops

missed doses were the most common error, many were of minimal clinical importance. However, some errors had potential to cause harm, such as clients double-dosing, often due to confusion associated with the use of DAAs, clients taking an incorrect dose (including cases involving insulin, warfarin and prednisolone), clients potentially receiving incorrect medicines or doses as a result of inaccurate medicine lists, inter-professional communication failures, prescribing errors or dispensing errors and running out of medicines. One-third of errors involved medicines associated with moderate or high risk of AMEs if administered incorrectly.

AMEs requiring medical attention were identified in 13 % of CNS clients, including medication-related hospital admissions in 9 % of clients. This may be an underestimate, as identification of AMEs relied on CNS documentation. It is possible that some AMEs were not recognised or documented by CNS nurses. A majority of AMEs were considered to be potentially preventable, which is consistent with studies in other populations [29, 30].

The most common cause of AMEs was prescribing problems (Table 5). This, plus the high number of medication errors, and in particular errors related to discrepancies between medication authorisations and pharmacy-

Table 4 Medication errors ($n = 100$ clients)

Variable	Data *n* (%) or median (IQR); range
Clients with one or more medication error	41 (41 %)
Number of errors identified	137
No. of medication errors per client	
1	14
2	10
3 or more	17
Type of medication errors	
Missed dose	67 (48.9 %)
Discrepancy between medication authorisation and client's medicines	26 (19.0 %)[a]
Wrong dose taken/given	13 (9.5 %)
Medicine taken from wrong compartment of DAA	12 (8.8 %)
Extra dose taken/given	15 (10.9 %)
Wrong administration method	2 (1.5 %)
Wrong route of administration	1 (0.7 %)
Wrong dose time	1 (0.7 %)
Errors involving high-risk medicines	
Opiates	10
Insulins	5
Anticoagulants	3
Immunosuppressants	3
Lithium	1
Total	22/137 (16.1 %)
Errors involving moderate-risk medicines	
Oral hypogylcaemics	6
Benzodiazepines	6
Loop diuretics	4
Anticonvulsants	4
Antipsychotics	3
Oral corticosteroids	2
Antibiotics	1
Total	23 (16.8 %)
Causes of error(s)	
Client/carer[b]	101 (73.7 %)
Healthcare provider/system[c]	36 (26.3 %)

DAA dose administration aid

[a] In 22 cases the discrepancy involved a pharmacy-packed DAA

[b] Client/carer errors (e.g. forgot to take medicine, accidentally took wrong dose, dropped tablet on the floor) or deliberate non-adherence (e.g. chose not to take a medicine or varied the dose). It was not possible to accurately quantify what proportion were unintended errors versus deliberate non-adherence using retrospective methodology; however, a large majority appeared to be errors

[c] Errors caused by general practitioners and other prescribers, pharmacists and nurses. This includes prescribing errors, dispensing errors, administration errors and communication failures. The number of errors attributed to each of these categories could not be accurately quantified retrospectively, because often the specific cause could not be determined. For example, when there was a discrepancy between the medication authorisation and the client's medicines ($n = 26$), it was not possible to determine whether this was due to an error on the authorisation, a dispensing/DAA packing error, or lack of communication between members of the healthcare team following a medicine change. Other provider/system errors were: medicines not available (not re-ordered or not delivered by pharmacy) ($n = 3$), multiple DAAs delivered resulting in client confusion and error ($n = 3$), patch not removed when new one applied ($n = 1$), problem with syringe driver ($n = 1$), delayed nurse visit ($n = 1$)

Table 5 Adverse medication events (AMEs)

Patient	AME	Medicine(s)	Underlying cause of AME	Causality	Preventability	Severity	Contribution to hospital admission
Events requiring medical consultation but no hospital admission							
72 years female with dementia	Nausea and vomiting	Donpezil 5 mg daily (recently commenced)	Idiosyncratic response	Probable	Not preventable	Mild	–
88 years male with dementia	Fatigue	Rivastigmine 9 mg patch daily (recently commenced)	Idiosyncratic response	Possible	Not preventable	Mild	–
86 years female with deep vein thrombosis	Bruising	Warfarin 3 mg daily (recently commenced; 5 mg taken by client inadvertently on one occasion). Also on aspirin 100 mg daily	Patient-related/ Prescribing issue	Probable	Possibly preventable	Mild	–
92 years female with atrial fibrillation, congestive cardiac failure and renal impairment	Bradycardia	Digoxin 187.5 μg daily	Prescribing issue	Probable	Definitely preventable	Moderate	–
80 years male with type 2 diabetes, discharged from hospital on a short course of prednisolone	Hypoglycaemia	Lantus (insulin) 22 units daily (recently commenced in hospital), gliclazide MR 120 mg daily, weaning prednisolone dose	Prescribing issue	Definite	Definitely preventable	Moderate	–
Events that contributed to an unplanned hospital admission							
68 years female with breast cancer	Erythema multiforme	Docetaxel (administered in hospital, but reaction occurred at home)	Idiosyncratic response	Definite	Not preventable	Moderate	Dominant
77 years female with recent major abdominal surgery	Urethral bleed	Enoxaparin 40 mg subcut daily	Idiosyncratic response	Probable	Not preventable	Moderate	Partly contributing
89 years female with multiple co-morbidities	Fall, fractured neck of femur	Polypharmacy (15 regular medicines), including fall-risk increasing medicines (diazepam 5 mg at night, cyproheptadine 4 mg daily, amlodipine 10 mg daily, irbesartan 300 mg/ hydrochlorothiazide 12.5 mg daily, atenolol 50 mg daily, carbamazepine 200 mg at night)	Prescribing issue	Possible	Possibly preventable	Severe	Dominant
74 years female with anxiety disorder discharged from hospital psychiatric unit	Exacerbation of anxiety disorder	Abrupt cessation of quetiapine 75 mg/day (ceased by general practitioner).	Prescribing issue	Probable	Possibly preventable	Moderate	Dominant

Table 5 continued

Patient	AME	Medicine(s)	Underlying cause of AME	Causality	Preventability	Severity	Contribution to hospital admission
89 years female with multiple co-morbidities	Fall, fractured neck of femur	Polypharmacy (5 regular medicines), including fall-risk increasing medicines (citalopram 20 mg daily, dipyridamole SR 200 mg daily, amlodipine 5 mg daily, trandolapril 1 mg daily)	Prescribing issue	Possible	Possibly preventable	Severe	Dominant
92 years female with atrial fibrillation and congestive cardiac failure	Severe peripheral oedema and skin tear	Frusemide 20 mg/day (no dose increase despite increasing oedema). Digoxin recently ceased. Also on bisoprolol 2.5 mg daily, telmisartan 80 mg daily	Prescribing issue	Possible	Possibly preventable	Moderate	Partly contributing
68 years female with metastatic breast cancer	Pain crisis	Suspected non-adherence to oral analgesia	Patient-related issue	Probable	Definitely preventable	Moderate	Dominant
87 years female with metastatic adenocarcinoma	Pain/end of life care	Morphine 5–10 mg, midazolam 0.5–2.0 mg and metoclopramide 10–40 mg subcut infusion (faulty syringe driver resulting in inadequate therapy)	Delivery issue	Probable	Possibly preventable	Moderate	Dominant
91 years female with hypertension	Dehydration and hyponatraemia	Irbesartan with hydrochlorothiazide 300 mg/12.5 mg daily	Idiosyncratic response	Possible	Not preventable	Moderate	Dominant

The criteria used to determine adverse medication event causality, preventability, severity and contribution to hospital admission are provided in Supplementary File 1

packed DAAs, suggests that CNS clients could benefit from better interdisciplinary collaboration. Interdisciplinary collaboration is needed to enable a 'best possible medication history' and medication reconciliation [31] to occur on admission to the CNS (in order to ensure that the correct medicine regimen is implemented and all members of the healthcare team have access to the same medicine list) [6, 12], to increase the use of medication administration charts (which enable clear documentation of medication administration and improve medication safety), and to facilitate interdisciplinary medication reviews. Despite CNS clients' high risk of AMEs, and eligibility for government-funded interdisciplinary care services, there was little evidence of formal interdisciplinary collaboration in relation to medicines management.

Interdisciplinary medication reviews such as HMR have been shown to identify and address medicine discrepancies, medication-related problems and inappropriate prescribing, simplify medication regimens and reduce the risk of AMEs [6, 11, 32–35]. The CNS involved in this study, like most CNSs, does not employ its own pharmacists or medical practitioners, so the only way for an interdisciplinary medication review to occur is if the clients' GP initiates an HMR (nurses are not able to initiate government-funded HMRs). The low use of HMR in this cohort is consistent with previous Australian studies in high-risk groups such as people referred to Aged Care Assessment Teams or residing in supported accommodation [34, 36]. Efforts to increase the uptake of HMRs, even in high-risk groups such as CNS clients, have had limited success [34, 37], suggesting that alternative methods to facilitate interdisciplinary medicines management are needed. One option is for the CNS to employ clinical pharmacists to work with its nurses to undertake medication reconciliation and medicines reviews, and liaise with clients' GPs and community pharmacists. A pilot study exploring the role of clinical pharmacists in a CNS is currently underway [38].

A limitation of our study was that it included only one metropolitan CNS. Further studies are warranted to determine the extent to which these findings are generalisable to other CNSs, in particular in rural and regional areas. Retrospective methodology may have led to underestimation of medicine use, medication errors, AMEs and interdisciplinary teamwork. A strength of the study was random

selection of subjects to obtain a sample representative of the older people referred for medicines support. Another strength was review of clients' complete CNS records, including nursing progress notes, to extract data, which is likely to have improved detection of errors and ADRs compared with reliance on spontaneous voluntary reporting by nurses.

Although there has been little previous Australian research in the home nursing setting, research conducted internationally suggests that many of these issues are not unique to Australia. Studies from other countries (mainly the USA) have reported that home nursing clients often have multiple medicines-related risk factors (including polypharmacy, multiple healthcare providers, poor communication between providers and outdated medicine lists) leading to medication errors and AMEs [8–10, 39–41]. No Australian or international study has previously recruited a similar random sample and reported the type of medicines management support provided, so it is not possible to compare this data with other studies.

5 Conclusion

Older people referred to a CNS for medicines management support were a frail group of people with multiple risk-factors for AMEs. They received intensive medicines management support, often over a prolonged period. There was minimal formal interdisciplinary collaboration and infrequent medication review. Medication errors and AMEs were common. There is a need to develop and test strategies to improve medication safety for CNS clients.

Acknowledgments The authors thank Ms Kira Harvey, Ms Ann Johnson, A/Prof Susan Koch, Ms Denise van den Bosch, Ms Barbara Petrie and Mr Neil Petrie for their assistance with this study.

Author contributions RAE, CB and CYL conceived and designed the study. All authors contributed to data collection. CYL and RAE performed the data analyses, with input from all authors. RAE and CYL prepared the manuscript. All authors reviewed drafts and approved the final manuscript.

Compliance with Ethical Standards

Ethical approval The study was approved by the Royal District Nursing Service and Monash University Human Research Ethics Committees.

Conflict of interest Rohan Elliott, Cik Yin Lee, Christine Beanland, Krishna Vakil and Dianne Goeman declare that they have no conflicts of interest.

Funding No financial assistance was received for the conduct of the study or preparation of the manuscript.

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