Multiple medication use in older patients in post-acute transitional care: a prospective cohort study

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Background: Older adults with a range of comorbidities are often prescribed multiple medications, which may impact on their function and cognition and increase the potential for drug interactions and adverse events.

Aims: This study investigated the extent of polypharmacy and potentially inappropriate medications in patients receiving post-discharge transitional home care and explored the associations of polypharmacy with patient characteristics, functional outcomes, and frailty.

Methods: A prospective observational study was conducted of 351 patients discharged home from hospital with support from six Transition Care Program (TCP) sites in two states of Australia. A comprehensive geriatric assessment was conducted at TCP admission and discharge using the interRAI Home Care assessment tool, with frailty measured using an index of 57 accumulated deficits. Medications from hospital discharge summaries were coded using the World Health Organization Anatomical Therapeutic Chemical Classification System.

Results: Polypharmacy (5–9 drugs) was observed in 46.7% and hyperpolypharmacy (≥10 drugs) in 39.2% of patients. Increasing numbers of medications were associated with greater number of comorbid conditions, a higher prevalence of diabetes mellitus, coronary heart disease, chronic obstructive pulmonary disease, dizziness, and dyspnea and increased frailty. At discharge from the program, the non-polypharmacy group (<5 drugs) had improved outcomes in Activities of Daily Living, Instrumental Activities of Daily Living and fewer falls, which was mediated because of lower levels of frailty. The commonest drugs were analgesics (56.8%) and antiulcer drugs (52.7%). The commonest potentially inappropriate medications were tertiary tricyclic antidepressants.

Conclusion: Polypharmacy is common in older patients discharged from hospital. It is associated with frailty, falls, and poor functional outcomes. Efforts should be made to encourage regular medication reviews and rationalization of medications as part of discharge planning. Whether careful deprescribing improves outcomes in frail patients should be the focus of randomized trials.

Keywords: polypharmacy, older people, post-acute care, functional outcomes

Introduction

Background

Older adults with a range of comorbidities are often prescribed multiple medications, some of which may impact on their function and cognition, and many have a potential for drug interactions.1,2 Studies showing evidence of benefit from pharmacotherapy have mostly been conducted in younger patients, and it is unclear how this translates to frail older patients. These patients are often excluded from drug trials; yet they are the largest consumers of medications.1,2 Several studies have found current use of five or more drugs in well over a quarter of older community dwelling adults,2,4 with higher prevalence in frail older populations and in hospitalized patients.5,6
The assessment of frailty using various methods, including the Frailty Index, is being incorporated in recent studies of older adults and provides an insight into their accumulated deficits and reduced reserve.7,8 The increased number of comorbidities requiring medications makes these patients prone to polypharmacy, yet their frailty status, together with the pharmacokinetic and pharmacodynamic changes that occur with aging, places them at risk of adverse events. The risks of polypharmacy include non-adherence, adverse drug reactions, drug–drug interactions, falls, fractures, poor nutrition, and mortality,9–14 as well as increased exposure to potentially inappropriate medications (PIMs).5,15 However, few studies have reported on the association of polypharmacy with functional outcomes in older patients.

**Aims**

The aims of the study were to

1. Explore the extent of polypharmacy in a cohort of older patients discharged from hospital to a home care program;

2. Assess the relationship between polypharmacy and patient characteristics, functional outcomes, and frailty; and

3. Describe the prevalence of the most common medications in this cohort, with particular emphasis on PIMs.

**Methods**

**Study design, setting, and participants**

A prospective observational cohort study of older persons discharged from hospital to a community-based Transition Care Program was conducted at six sites in two Australian states, Queensland and South Australia. The Transition Care Program (TCP) is designed to facilitate transitions from hospital to home for older people (aged 70 years and over or 50 years and over for the indigenous population), offering those with high care needs additional support during convalescence.16 The program is therapy focused, providing a package of services which includes home help and personal care, physiotherapy and occupational therapy, nursing care, and case management over a maximum period of 12 weeks (average 7 weeks) post-discharge from hospital.16 The provision of primary medical care to a Transition Care recipient is undertaken by their general practitioner.16

Consecutive patients entering the TCP during the period from November 2009 to September 2010, who gave informed consent to participate, were eligible for the study. Recruitment details for the study, originally designed to examine the functional recovery trajectories of patients with high care needs, have previously been published.17 Ethics approval was given by the University of Queensland Human Research Ethics Committee (HREC) as well as HRECs responsible for governance at each of the TCP sites.

**Data collection**

A comprehensive geriatric assessment using the interRAI Home Care instrument was conducted at TCP admission and discharge. The interRAI instruments comprise a suite of assessment tools to support assessment and care planning of persons with chronic illness, frailty, and disability across care settings,18 with substantial reliability on core items in common.19 The interRAI Home Care assessment collects data on multiple domains including sociodemographics, medical conditions, medications, physical and mental function, nutrition, and symptoms and syndromes such as mood, behavior, and continence. A number of scales embedded in the interRAI instruments combine single items belonging to a domain, such as activities of daily living (ADL), instrumental ADL (IADL), and cognition, which can be used to describe the presence and extent of deficits in that domain.17,20,21 Trained assessors gathered data from multiple sources including from the patient, carers, medical and allied health staff, and hospital records. Medications from hospital discharge summaries were coded by pharmacy students using the World Health Organization Anatomical Therapeutic Chemical (ATC) Classification System and reviewed by a pharmacist and a geriatrician.

**Measures**

**Medication exposure**

There is no universally accepted definition of polypharmacy in the literature. Some studies define it as use of five or more medications.2–11 This has been supported in a recent study investigating polypharmacy cutoff points and risks of adverse outcome.22 Moreover, recent studies have defined the use of ten or more medications as excessive polypharmacy or hyperpolypharmacy.23 Inclusion of over-the-counter medications and medications not consumed on a regular basis is also variable. In our study, polypharmacy status was categorized into three groups – non-polypharmacy (0–4 drugs), polypharmacy (5–9 drugs), and hyperpolypharmacy (≥10 drugs) – based on regular medications. Drugs, vitamins, and mineral supplements administered on a regular basis through any recognized drug-delivery method were included in the analysis. Supplements without ATC codes, such as cranberry juice and primrose oil, were excluded.
The American Geriatrics Society 2012 Beers Criteria was used to identify PIMs with a recommendation to avoid, regardless of patients’ comorbidities. We included as PIMs those medications where the recommendation to avoid was strong and the quality of evidence was classified as moderate or high, also taking into account exposure to drugs above recommended maximum daily dose.\textsuperscript{25} Table S1 lists the PIMs meeting these criteria.

**Frailty**

The frailty index (FI) was calculated using a well described methodology,\textsuperscript{26} based on accumulated health deficits such as symptoms, signs, disabilities, and diseases measured in the interRAI Home Care assessment. Disability in ADL and IADL, impairments in general cognition and mobility, number of comorbidities, incontinence, and depressed mood were included as deficits. For each patient, deficits were added and divided by the total counted, here 57, to calculate an individual index score. Polypharmacy was excluded from the deficit count. The higher the score, the greater the number of deficits, and the more likely the patient is to be frail. In community-dwelling older people, 0.25 has been proposed as the cutoff between “fit” and “frail,” with scores of \( \geq 0.40 \) associated with dependence on others for activities of daily living.\textsuperscript{27}

**Analysis**

To describe characteristics across polypharmacy groups, comparison of means (analysis of variance) or medians (Kruskal–Wallis test) for continuous variables was used, depending on distribution of the data. For categorical variables, chi-square or Fisher’s exact test (where cell numbers are less than five) was performed. An exploratory analysis using logistic regression models tested the association between polypharmacy, frailty status, and functional outcomes. For the purpose of interpreting odds ratios, \( \text{FI} \) was multiplied by 10 so that the per-unit change was 0.1.\textsuperscript{8} Patients with missing data were excluded from the relevant analysis, and percentages were reported as proportions of patients with available data. Significance level was set at \( P\)-value of \( <0.05 \). The SPSS IBM version 22 was used for analysis.

**Results**

Of the 351 TCP clients enrolled in the study, four cases had missing medication data. The remaining 347 cases were included in the analysis. The mean age (standard deviation [SD]) was 78.9 (±8.8) years, and 65.7% were females. The majority of patients discharged to the TCP needed ongoing support after hospitalization for orthopedic conditions (50.7%), including fractures (37.5%), medical conditions resulting in deconditioning (23.6%), and stroke (14.6%). The median length of stay in the TCP was 54 days (interquartile range 37–73 days).

The number of regular medications taken ranged from 0 to 24, with a mean (SD) of 8.5 (±3.6). For “as needed” pro re nata (PRN) medications, the mean (SD) was 0.8 (±1.1). Only 14.1% of patients took \( <5 \) regular medications (non-polypharmacy). Polypharmacy (5–9 drugs) was observed in 46.7% and hyperpolypharmacy (\( \geq 10 \) drugs) in 39.2%. The majority in the hyperpolypharmacy group (n=131; 96.3%) were taking between 10 and 15 regular medications, with five taking more than 15 regular medications.

Table 1 shows the characteristics of patients according to polypharmacy categories at admission to the TCP. Patients with polypharmacy and hyperpolypharmacy had more comorbidities than the non-polypharmacy group and were more likely to have diabetes mellitus, coronary heart disease, chronic obstructive pulmonary disease (COPD), or depression. They were also more likely to have symptoms of pain, dizziness, and dyspnea. There was no significant association between polypharmacy categories and stroke, congestive heart disease, Parkinson’s disease, or cancer. Considering frailty status and geriatric syndromes (including history of falls in the previous 90 days, impaired cognition, dependence in basic and instrumental ADL, and bladder incontinence), only the FI had a significant association with polypharmacy.

Table 2 shows outcomes at discharge from the TCP according to polypharmacy status. The majority of patients continued living in the community (85.6%), 12.4% were readmitted to hospital, 0.9% were discharged to residential aged care facilities (RACF), and 1.2% died. Patients in the polypharmacy and hyperpolypharmacy groups were more likely than the non-polypharmacy group to fail to improve in ADL and IADL and were more likely to fall over the duration of the TCP.

Multivariate models of functional outcomes (failure to improve ADL or IADL or falls over the TCP), with FI and polypharmacy groups as covariates, show that frailty status mediates the effects of polypharmacy. The odds ratios of ADL and IADL functional decline and falls for a 0.1 increase in FI are shown in Table 3.

Table 4 shows the most common drug categories by polypharmacy group. The most commonly used drugs were analgesics (56.8%). Non-opioid drugs were prescribed more
Table 1 Characteristics of patients on admission to the TCP according to polypharmacy status

<table>
<thead>
<tr>
<th>Demographics</th>
<th>All n=347</th>
<th>Non-polypharmacy &lt;5 drugs n=49 (14.1%)</th>
<th>Polypharmacy 5–9 drugs n=162 (46.7%)</th>
<th>Hyperpolypharmacy ≥10 drugs n=136 (39.2%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD</td>
<td>78.9±9.8</td>
<td>78.7±9.6</td>
<td>78.5±8.6</td>
<td>79.4±8.7</td>
<td>0.696</td>
</tr>
<tr>
<td>Female</td>
<td>228 (65.7)</td>
<td>30 (61.2)</td>
<td>104 (64.2)</td>
<td>94 (69.1)</td>
<td>0.521</td>
</tr>
<tr>
<td>Medications</td>
<td>Regular, mean ± SD</td>
<td>8.5±3.6</td>
<td>2.8±1.2</td>
<td>7.2±1.3</td>
<td>12.2±2.0</td>
</tr>
<tr>
<td></td>
<td>PRN, mean ± SD</td>
<td>0.8±1.1</td>
<td>0.9±1.1</td>
<td>0.7±0.9</td>
<td>0.9±1.2</td>
</tr>
<tr>
<td>Comorbidities</td>
<td>No of comorbidities, mean ± SD</td>
<td>6.0±3.0</td>
<td>3.9±2.5</td>
<td>5.8±2.7</td>
<td>7.0±3.1</td>
</tr>
<tr>
<td>Diabetes</td>
<td>89 (26.3)</td>
<td>6 (12.6)</td>
<td>39 (25.2)</td>
<td>44 (32.4)</td>
<td>0.029</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>116 (34.1)</td>
<td>7 (14.9)</td>
<td>57 (35.8)</td>
<td>52 (38.8)</td>
<td>0.010</td>
</tr>
<tr>
<td>COPD</td>
<td>44 (13.1)</td>
<td>2 (4.3)</td>
<td>15 (9.7)</td>
<td>27 (20.1)</td>
<td>0.006</td>
</tr>
<tr>
<td>Depression</td>
<td>72 (21.4)</td>
<td>3 (6.4)</td>
<td>38 (24.5)</td>
<td>31 (23.0)</td>
<td>0.015</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Pain – moderate/severe</td>
<td>179 (52.0)</td>
<td>24 (50.0)</td>
<td>69 (43.1)</td>
<td>86 (63.2)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>84 (24.5)</td>
<td>8 (16.7)</td>
<td>30 (19.9)</td>
<td>46 (33.8)</td>
<td>0.005</td>
</tr>
<tr>
<td>Dyspea</td>
<td>132 (38.3)</td>
<td>9 (18.8)</td>
<td>62 (38.5)</td>
<td>61 (44.9)</td>
<td>0.006</td>
</tr>
<tr>
<td>Fatigue – moderate/severe</td>
<td>148 (42.9)</td>
<td>19 (40.4)</td>
<td>65 (40.1)</td>
<td>64 (47.1)</td>
<td>0.452</td>
</tr>
<tr>
<td>Constipation</td>
<td>65 (18.8)</td>
<td>7 (14.6)</td>
<td>28 (17.4)</td>
<td>30 (22.1)</td>
<td>0.425</td>
</tr>
</tbody>
</table>

Notes: Unless otherwise stated, columns represent n (%). “Based on the CPS, which ranges from 0 (intact cognition) to 6 (very severe cognitive impairment);”c cognitively impaired patients were defined as CPS scores ≥2, corresponding to a mean Mini Mental State Examination score of <24. d Based on ADL scale (long form), which assesses independence in seven ADL items (personal hygiene, dressing upper body and lower body, locomotion, toilet use, bed mobility, and eating). The scale has a range from 0 to 28, with higher scores indicating greater dependence. e The IADL scale summarizes the performance on seven IADL items (meal preparation, housework, finances, medication management, phone use, shopping, and transport). The scale has a range from 0 to 42, with higher scores indicating greater dependence.

Abbreviations: ADL, activities of daily living; COPD, chronic obstructive pulmonary disease; CPS, cognitive performance scale; IADL, instrumental ADL; IQR, interquartile range; PRN, pro re nata; sD, standard deviation; TCP, Transition Care Program.

frequently than opioids (46.1% and 27.1%, respectively). Anti-ulcer drugs (52.7%), statins (44.1%), aspirin, and anti-aggregates (43.2%) followed. Cardiovascular drugs were also commonly used. Beta blockers and angiotensin converting enzyme inhibitors were each prescribed in about a third of patients, while diuretics, calcium channel blockers, and angiotensin receptor blockers were each prescribed in about a quarter of the patients. Vitamin D and analogues

Table 2 Outcomes at discharge from the TCP according to polypharmacy status

<table>
<thead>
<tr>
<th>Discharge destination</th>
<th>All n=347</th>
<th>Non-polypharmacy &lt;5 drugs n=49 (14.1%)</th>
<th>Polypharmacy 5–9 drugs n=162 (46.7%)</th>
<th>Hyperpolypharmacy ≥10 drugs n=136 (39.2%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community</td>
<td>297 (85.6)</td>
<td>44 (89.8)</td>
<td>139 (85.8)</td>
<td>114 (83.8)</td>
<td>0.200</td>
</tr>
<tr>
<td>Hospital</td>
<td>43 (12.4)</td>
<td>3 (6.1)</td>
<td>20 (12.3)</td>
<td>20 (14.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RACF</td>
<td>3 (0.9)</td>
<td>2 (4.1)</td>
<td>1 (0.6)</td>
<td>0 (0.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Died</td>
<td>4 (1.2)</td>
<td>0 (0.0)</td>
<td>2 (1.2)</td>
<td>2 (1.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of stay (days) median (IQR)</td>
<td>54 (37–73)</td>
<td>57 (38.5–80)</td>
<td>54 (38.75–69.25)</td>
<td>48.5 (31.25–73)</td>
<td>0.199</td>
</tr>
<tr>
<td>Failure to improve in ADL</td>
<td>42 (12.6)</td>
<td>2 (4.1)</td>
<td>15 (9.8)</td>
<td>25 (18.9)</td>
<td>0.011</td>
</tr>
<tr>
<td>Failure to improve in IADL</td>
<td>63 (19.0)</td>
<td>4 (8.3)</td>
<td>23 (14.9)</td>
<td>36 (27.7)</td>
<td>0.003</td>
</tr>
<tr>
<td>Falls while in the TCP</td>
<td>48 (15.3)</td>
<td>2 (4.5)</td>
<td>30 (20.4)</td>
<td>16 (13.0)</td>
<td>0.023</td>
</tr>
</tbody>
</table>

Notes: Unless otherwise stated, columns represent n (%). “Failure to improve in ADL was defined as having a worse (higher) ADL scale score at discharge than at admission or maintaining their score for those with some impairment on admission.” Failure to improve in IADL was defined as having a worse (higher) IADL scale score at discharge than at admission or maintaining their score for those with some impairment on admission.

Abbreviations: ADL, activities of daily living; IADL, instrumental ADL; IQR, interquartile range; RACF, residential aged care facilities; TCP, Transition Care Program.
were prescribed in 27.1%, while anti-resorptives and calcium were taken by 22.5% and 24.5%, respectively. A high proportion was prescribed antidepressants (30.8%) and laxatives (28%). Only nine patients were on antipsychotics and four patients on anti-dementia drugs. In all but a few drug categories (anticoagulants, oral hypoglycemics, anti-emetics, anti-Parkinson, antipsychotics, and anti-dementia drugs) the prevalence of each drug class increased significantly across the polypharmacy groups, with the hyperpolypharmacy group having the highest prevalence.

The number of TCP patients taking at least one PIM was 41 (11.8%), with two persons taking two PIMs. Of

<table>
<thead>
<tr>
<th>Drug</th>
<th>All n=347</th>
<th>Non-polypharmacy ≤5 drugs n=49 (14.1%)</th>
<th>Polypharmacy 5–9 drugs n=162 (46.7%)</th>
<th>Hyperpolypharmacy ≥10 drugs n=136 (39.2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analgesics</td>
<td>197 (58.6)</td>
<td>15 (30.6)</td>
<td>84 (51.9)</td>
<td>98 (72.1)</td>
</tr>
<tr>
<td>– Non-opioids</td>
<td>160 (46.1)</td>
<td>9 (18.4)</td>
<td>73 (45.1)</td>
<td>78 (57.4)</td>
</tr>
<tr>
<td>– Opioids</td>
<td>94 (27.1)</td>
<td>8 (16.3)</td>
<td>31 (19.1)</td>
<td>55 (40.4)</td>
</tr>
<tr>
<td>Antiacid</td>
<td>183 (52.7)</td>
<td>12 (24.5)</td>
<td>80 (49.4)</td>
<td>91 (66.9)</td>
</tr>
<tr>
<td>Statis</td>
<td>153 (44.1)</td>
<td>11 (22.4)</td>
<td>64 (39.5)</td>
<td>78 (57.4)</td>
</tr>
<tr>
<td>Aspirin and anti-aggrs</td>
<td>150 (43.2)</td>
<td>9 (18.4)</td>
<td>64 (39.5)</td>
<td>77 (56.6)</td>
</tr>
<tr>
<td>Beta blockers</td>
<td>119 (34.3)</td>
<td>7 (14.3)</td>
<td>53 (32.7)</td>
<td>59 (43.4)</td>
</tr>
<tr>
<td>Angiotensin converting enzyme inhibitors</td>
<td>109 (31.4)</td>
<td>9 (18.4)</td>
<td>47 (28.0)</td>
<td>53 (39.0)</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>107 (30.8)</td>
<td>1 (2.0)</td>
<td>51 (31.5)</td>
<td>55 (40.4)</td>
</tr>
<tr>
<td>- Tricyclics</td>
<td>33 (9.5)</td>
<td>1 (2.0)</td>
<td>13 (8.0)</td>
<td>19 (14.0)</td>
</tr>
<tr>
<td>- SSRIs</td>
<td>47 (13.5)</td>
<td>0 (0.0)</td>
<td>23 (14.2)</td>
<td>24 (17.6)</td>
</tr>
<tr>
<td>- MAO inhibitors</td>
<td>1 (0.3)</td>
<td>0 (0.0)</td>
<td>1 (0.6)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>- Other (eg, SNRIs)</td>
<td>30 (8.6)</td>
<td>0 (0.0)</td>
<td>15 (9.3)</td>
<td>15 (11.0)</td>
</tr>
<tr>
<td>Laxatives</td>
<td>97 (29.0)</td>
<td>6 (12.2)</td>
<td>32 (19.8)</td>
<td>59 (43.4)</td>
</tr>
<tr>
<td>Vitamin D and analogues</td>
<td>94 (27.1)</td>
<td>3 (6.1)</td>
<td>41 (25.3)</td>
<td>50 (36.8)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>94 (27.1)</td>
<td>3 (6.1)</td>
<td>35 (21.6)</td>
<td>56 (41.2)</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>90 (25.9)</td>
<td>3 (6.1)</td>
<td>39 (24.1)</td>
<td>48 (35.3)</td>
</tr>
<tr>
<td>Calcium</td>
<td>85 (24.5)</td>
<td>3 (6.1)</td>
<td>36 (22.2)</td>
<td>46 (33.8)</td>
</tr>
<tr>
<td>Angiotensin receptor blockers</td>
<td>78 (22.5)</td>
<td>4 (8.2)</td>
<td>31 (19.1)</td>
<td>43 (31.6)</td>
</tr>
<tr>
<td>Osteoporosis/anti-resorptives</td>
<td>78 (22.5)</td>
<td>4 (8.2)</td>
<td>31 (19.1)</td>
<td>43 (31.6)</td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>59 (17.0)</td>
<td>7 (14.3)</td>
<td>32 (19.8)</td>
<td>20 (14.7)</td>
</tr>
<tr>
<td>– Heparin</td>
<td>15 (4.3)</td>
<td>3 (6.1)</td>
<td>7 (4.3)</td>
<td>5 (3.7)</td>
</tr>
<tr>
<td>– Warfarin</td>
<td>46 (13.3)</td>
<td>4 (8.2)</td>
<td>26 (16.6)</td>
<td>16 (11.7)</td>
</tr>
<tr>
<td>Oral hypoglycemis</td>
<td>57 (16.4)</td>
<td>4 (8.2)</td>
<td>25 (15.4)</td>
<td>28 (20.6)</td>
</tr>
<tr>
<td>Eye medications</td>
<td>50 (14.4)</td>
<td>2 (4.1)</td>
<td>17 (10.5)</td>
<td>31 (22.8)</td>
</tr>
<tr>
<td>Thyroid medications</td>
<td>48 (13.8)</td>
<td>3 (6.1)</td>
<td>14 (8.6)</td>
<td>31 (22.8)</td>
</tr>
<tr>
<td>COPD/asthma medications</td>
<td>48 (13.8)</td>
<td>1 (2.0)</td>
<td>16 (9.9)</td>
<td>31 (22.8)</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>46 (13.3)</td>
<td>1 (2.2)</td>
<td>16 (9.9)</td>
<td>29 (21.3)</td>
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<tr>
<td>Benzoiazepines</td>
<td>44 (12.7)</td>
<td>3 (6.1)</td>
<td>12 (7.3)</td>
<td>29 (21.3)</td>
</tr>
<tr>
<td>Antibacterials</td>
<td>44 (12.7)</td>
<td>1 (2.0)</td>
<td>18 (11.1)</td>
<td>25 (18.4)</td>
</tr>
<tr>
<td>Nitrates</td>
<td>37 (10.7)</td>
<td>0 (0.0)</td>
<td>10 (6.2)</td>
<td>27 (19.9)</td>
</tr>
<tr>
<td>Digoxin</td>
<td>30 (8.6)</td>
<td>1 (2.0)</td>
<td>10 (6.2)</td>
<td>19 (14.0)</td>
</tr>
<tr>
<td>Insulin</td>
<td>20 (5.8)</td>
<td>0 (0.0)</td>
<td>3 (1.9)</td>
<td>17 (12.5)</td>
</tr>
<tr>
<td>Anti-emetics</td>
<td>15 (4.3)</td>
<td>1 (2.0)</td>
<td>5 (3.1)</td>
<td>9 (6.6)</td>
</tr>
<tr>
<td>Anti-Parkinson</td>
<td>12 (3.5)</td>
<td>2 (4.1)</td>
<td>4 (2.5)</td>
<td>6 (4.4)</td>
</tr>
<tr>
<td>Antipsychotics</td>
<td>9 (2.6)</td>
<td>1 (2.0)</td>
<td>5 (3.1)</td>
<td>3 (2.2)</td>
</tr>
<tr>
<td>Anti-dementia drugs</td>
<td>4 (1.2)</td>
<td>0 (0.0)</td>
<td>3 (1.9)</td>
<td>1 (0.7)</td>
</tr>
</tbody>
</table>

**Abbreviations:** COPD, chronic obstructive pulmonary disease; MAO, monoamine oxidase; SNRIs, serotonin norepinephrine reuptake inhibitor; SSRIs, selective serotonin reuptake inhibitor; TCP, Transition Care Program.

**Table 4 Prevalence of drug use in TCP patients by medication class**
those taking at least one PIM, 2 (4.1%) were in the non-
polypharmacy group; 17 (10.5%) were in the polypharmacy
and 22 (16.2%) in the hyperpolypharmacy group. This
distribution failed to reach statistical significance (P=0.066;
Fisher’s exact test). The commonest PIMs prescribed were
tertiary tricyclic antidepressants (9.5%), particularly amitriptiline. Digoxin at a dose of >125 µg was prescribed in
less than 2% of patients. Dipyridamol, promethazine,
glibenclamide, and oral estrogens were each prescribed in
only one or two patients. None of the patients was prescribed
potent non-steroidal anti-inflammatory drugs which increase
the risk of gastrointestinal bleeding and peptic ulceration.
There were no patients on barbiturates or the antiparkinsonian
agent, benztropine.

Discussion
The findings of this study showed that polypharmacy was
significantly associated with frailty and poor functional out-
comes. However, multivariate models of functional outcomes
(failure to improve ADL or IADL or falls over the TCP), with
FI and polypharmacy groups as covariates, show that frailty
status mediates the effects of polypharmacy. This accords
with previous findings which indicate that older adults who
are frail are more likely to be exposed to multiple medications
associated with increases in number of comorbidities. Con-
versely, multiple medications may exacerbate frailty.24 While
the association of polypharmacy with frailty and adverse
outcomes has been shown in studies of community-dwelling
older adults,22,24,28 there have been few studies which have
shown this relationship in the post-acute care setting.

The majority of patients in our study (86%) were pre-
scribed five or more medications per day. The mean number
of drugs of 8.5 is higher than that reported in other studies of
nursing home patients, community-dwellers, and day hospital
patients, which report values of 3.7–7.9.5,10,29–31 The definition
of polypharmacy and inclusion of vitamins, minerals,
and over-the-counter medications was variable in these other
studies, making comparison difficult.

Similar to previous reports,23,32 prevalence of diabetes
mellitus, coronary heart disease, COPD, and depression were
lower in the non-polypharmacy group, as were symptoms
of dizziness and dyspnea. In contrast to a previous study,23
measures of ADL, IADL, and cognition were not associated
with polypharmacy at admission to the TCP. However, better
functional outcomes in ADL and IADL were achieved with
TCP rehabilitation for those on fewer medications. This was
most likely because of their lower levels of frailty, which is a
predictor of functional gain in rehabilitation patients.5 Those
with fewer medications were less likely to fall over the dura-
tion of the TCP, which is consistent with studies showing
a relationship between polypharmacy and risk of falls.33
A strong association between cognitive impairment and
reduced rates of excessive polypharmacy has recently been
described in nursing-home residents.23 In contrast, our study
did not find such an association, most likely due to the small
number of patients with severe cognitive impairment.

Analgesics were the most commonly prescribed class of
medications, which may reflect the fact that the majority of
patients had been hospitalized with fractures or for orthopedic
procedures. While fractures were the commonest reason for
hospitalization in patients admitted to the TCP, this was not
mirrored by the use of anti-resorptives and vitamin D and analogues,
which was lower than expected, given the importance of these
medications in the prevention of osteoporotic fractures.34,35

Though analgesic use was high, no patients were pre-
scribed potent non-steroidal anti-inflammatory drugs, which
are listed as PIMs under the Beers Criteria,23 due to greater
propensity for gastrointestinal side effects. The majority of
PIMs that met Beers criteria were not prescribed for any of
the patients in our study.

The difficulties comparing our study with other published
polypharmacy studies, due to different patient selection and
polypharmacy definitions, are acknowledged. Our study has
prospectively collected data on functional outcomes in a cohort of patients often excluded from clinical studies
– frail elderly patients residing in the community but meeting
criteria for residential aged care. This is an important
group of patients in which interventions can delay or avoid
institutionalization.17 Considerations should be given to
enabling regular medication reviews and rationalization in
patients enrolled in community rehabilitation and Transition
Care Programs, by encouraging regular pharmacist and medi-
ical input. These interventions have been shown to improve
appropriate prescribing and reduce drug-related adverse
events, though results on number of medications prescribed
have been variable.5,36–39

The strengths of our study are that the cohort is character-
istic of older people eligible for post-discharge home-based
care and representative of TCP recipients in particular, having
been recruited across multiple sites in both rural and metro-
politan communities. Few studies have explored associations
of polypharmacy with functional outcomes after a period of
longitudinal follow up. A study limitation is that the medication
lists were documented by the interRAI assessors who tran-
scribed or photocopied the patients’ drug charts from hospital
discharge summaries. It is acknowledged that this method of

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collecting medication data is not the current gold standard. To achieve complete medication reconciliation, multiple sources of information (including patient interview, general practitioner’s letter, and dispensing history from the pharmacy) should be accessed. A further limitation is that the indications for each medication prescribed could not be determined.

Conclusion
Polypharmacy is common in older patients discharged from hospital to home-based care. It is associated with frailty, falls, and poor functional outcomes. Efforts should be made to encourage regular medication reviews and rationalization of medications by pharmacists and geriatricians in these frail patients with reduced physiological reserves. Use of medications associated with functional decline such as benzodiazepines and anticholinergics as well as other PIMs should be minimized.

Acknowledgments
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Disclosure
The authors declare that there are no conflicts of interest.

References


Table S1 Potentially inappropriate medications Beers Criteria 2012

<table>
<thead>
<tr>
<th>Potentially inappropriate medications</th>
<th>ATC code for drug as a single agent</th>
<th>ATC code(s) for drug in combination with other agents</th>
</tr>
</thead>
</table>

**Anticholinergics**

**Antihistamines**
(as single agent or as part of combination products)
- Brompheniramine: R06AB01, R06AB51
- Carboxamine: R06AA08
- Chlorpheniramine: R06AB04, R06AB54
- Clemastine: R06AA04, R06AA54
- Cyproheptadine: R06AX02
- Dexbrompheniramine: R06AB06, R06AB56
- Dexchlorpheniramine: R06AB02, R06AB52
- Diphenhydramine (oral): R06AA02, R06AA52
- Doxylamine: R06AA09, R06AA59
- Hydroxyzine: N05BB01, N05BB51
- Promethazine: R06AD02, R06AD52
- Triprolidine: R06AX07

**Antiparkinson agents**
- Benztropine (oral): N04AC01
- Trihexyphenidyl: N04AA01

**Antithrombotics**
- Dipyridamole, oral short acting*: B01AC07
  (does not apply to extended release combination with aspirin)
- Ticlopidine*: B01AC05

**Anti-arrhythmics**
- Digoxin: C01AA05

**Tertiary TCAs, alone or in combination**
- Amitriptyline: N06AA09, N06CA01
- Chlordiazepoxide-amitriptyline
- Clomipramine: N06AA04
- Doxepin: N06AA12, N06AA02
- Imipramine: N06AA02, N06AA03
- Perphenazine-amitriptyline: N06CA01
- Trimipramine: N06AA06

**Barbiturates**
- Amobarbital*: N05CA02
- Butobarbital*: None
- Butalbital: None
- Mepobarbital*: N03AA01
- Pentobarbital*: N05CA01
- Phenobarbital: N03AA02
- Secobarbital*: N05CA06
- Meprobamate: N05BC01, N05BC51

**Sulfonylureas, long duration**
- Chlorpropamide: A10BB02
- Glyburide (glibenclamide): A10BB01

**Analgesics**
- Meperidine: N02AB02
- Indomethacin: M01AB01
- Ketorolac: M01AB15
- Pentazocine*: N02AD01

**Antipsychotics**
- Thioridazine: N05AC02
- Mesoridazine: N05AC03

(Continued)
### Table S1 (Continued)

<table>
<thead>
<tr>
<th>Potentially inappropriate medications</th>
<th>ATC code for drug as a single agent</th>
<th>ATC code(s) for drug in combination with other agents</th>
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<tbody>
<tr>
<td>Meprobamate</td>
<td>N05BC01</td>
<td>N05BC51</td>
</tr>
<tr>
<td>Ergot mesylates*</td>
<td>C04AE51</td>
<td></td>
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<tr>
<td>Isoxsuprine*</td>
<td></td>
<td></td>
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<tr>
<td><strong>Endocrine</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ergot mesylates*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isoxsuprine*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estrogens with or without progestins (oral and patch)</td>
<td>G03</td>
<td></td>
</tr>
<tr>
<td>Megestrol</td>
<td>G03AC05 G03DB02 L02AB01</td>
<td>G03FA08 G03FB04</td>
</tr>
<tr>
<td><strong>Skeletal muscle relaxants</strong></td>
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<td></td>
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<tr>
<td>Carisoprodol</td>
<td>M03BA02</td>
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<td>Metaxalone</td>
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<tr>
<td>Methocarbamol</td>
<td>M03BA03</td>
<td></td>
</tr>
<tr>
<td>Orphenadrine</td>
<td>N04AB02</td>
<td>M03BC01 M03BC51</td>
</tr>
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</table>

**Note:** *Infrequently used drugs.*

**Abbreviations:** ATC, anatomical therapeutic chemical; TCA, tricyclic antidepressants.