Hospitalization Risk and Potentially Inappropriate Medications among Medicare Home Health Nursing Patients

Matthew C. Lohman, PhD[1,2], Brandi P. Cotton, PhD[1,2], Alexandra B. Zagaria, BA[3], Yuhua Bao, PhD[4,5], Rebecca L. Greenberg, MS[6], Karen L. Fortuna, PhD[1,2], and Martha L. Bruce, PhD[1,2]

[1]Department of Psychiatry, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA; [2]Dartmouth Centers for Health and Aging, Lebanon, NH, USA; [3]The Dartmouth Institute for Health Policy and Clinical Practice, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA; [4]Department of Healthcare Policy and Research, Weill Cornell Medical College, New York, NY, USA; [5]Department of Psychiatry, Weill Cornell Medical College, New York, NY, USA; [6]Institute of Geriatric Psychiatry, Weill Cornell Medical College, White Plains, NY, USA.

BACKGROUND: Hospitalizations and potentially inappropriate medication (PIM) use are significant and costly issues among older home health patients, yet little is known about the prevalence of PIM use in home health or the relationship between PIM use and hospitalization risk in this population.

OBJECTIVE: To describe the prevalence of PIM use and association with hospitalization among Medicare home health patients.

DESIGN: Cross-sectional analysis using data from 132 home health agencies in the US.

SUBJECTS: Medicare beneficiaries starting home health nursing services between 2013 and 2014 (n = 87,780).

MAIN MEASURES: Prevalence of individual and aggregate PIM use at start of care, measured using the 2012 Beers criteria. Relative risk (RR) of 30-day hospitalization or re-hospitalization associated with individual and aggregate PIM use, compared to no PIM use.

KEY RESULTS: In total, 30,168 (34.4%) patients were using at least one PIM, with 5969 (6.8%) taking at least two PIMs according to the Beers list. The most common types of PIMs were those affecting the brain or spinal cord, analgesics, and medications with anticholinergic properties. With the exception of nonsteroidal anti-inflammatory drugs (NSAIDs), PIM use across all classes was associated with elevated risk (10–33%) of hospitalization compared to non-use. Adjusting for demographic and clinical characteristics, patients using at least one PIM (excluding NSAIDs) had a 13% greater risk (RR = 1.13, 95% CI: 1.09, 1.17) of being hospitalized than patients using no PIMs, while patients using at least two PIMs had 21% greater risk (RR = 1.21, 95% CI: 1.12, 1.30). Similar associations were found between PIMs and re-hospitalization risk among patients referred to home health from a hospital.

CONCLUSIONS: Given the high prevalence of PIM use and the association between PIMs and hospitalization risk, home health episodes represent opportunities to substantially reduce PIM use among older adults and prevent adverse outcomes. Efforts to address medication use during home health episodes, hospitalizations, and care transitions are justified.

KEY WORDS: home care; pharmacoepidemiology; Medicare.
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INTRODUCTION

The use of Medicare home health (HH) nursing services in the US has grown significantly in the past decade, with approximately 3.5 million Medicare beneficiaries receiving HH services in 2013.[1] These include skilled nursing, rehabilitation, physical therapy, and other services provided to eligible homebound patients and paid for by Medicare, typically following discharge from a hospital or nursing facility.[1] HH recipients frequently begin care with substantial medical burden and functional limitation,[2] placing them at increased vulnerability for hospitalization and other adverse outcomes.[3] In addition, HH patients are often prescribed multiple medications, some of which may be inappropriate for older adults and may pose a greater risk of side effects, interactions, and hospitalizations.[4] The purpose of this study was to describe the prevalence of potentially inappropriate medications (PIMs) among a large national sample of Medicare HH patients and to estimate the association between PIMs and risk of subsequent hospitalization.

Due to changes in pharmacodynamics and pharmacokinetics common in aging, older adults are at greater risk of side effects, adverse reactions, and other complications from medications compared to younger adults.[5–7] In response to this issue, the Beers Criteria were established, providing a systematic cataloging of PIMs—medications posing distinct risks for side effects and adverse events among older adults—to guide healthcare providers' prescribing practices.[4] The use of PIMs has been linked to increased risk of adverse drug reactions,[8] falls,[9–12] emergency department visits,[13] and hospitalizations;[14] nevertheless, a substantial number of older adults still use them.[15] The estimated prevalence of PIMs received during ambulatory care visits is 8–13%;[16,17] among older adults in long-term nursing facilities it is as high as

50%.[18] Likewise, HH patients frequently have complex medication regimes and high rates of medication use.[19–21] A previous study of nationally representative HH recipients found that 21% were taking 15 or more prescription medications at start of care (SOC), and 38% were taking at least one PIM according to the 2003 Beers criteria.[15] Subsequent updates to the Beers criteria and health care reforms aimed at reducing negative patient outcomes have created a need for renewed attention to PIM use in HH.

Approximately 16% of Medicare HH patients are hospitalized during the first 30 days of care,[22] with 17% re-hospitalized after referral to HH from a hospital.[23] Hospitalizations negatively impact patient health, quality of life, and functioning, and are a major source of rising healthcare costs.[3,24,25] Furthermore, a high incidence of hospitalization and re-hospitalization within 30 days of HH initiation may lead to lower Medicare payments for hospitals and poor quality ratings for HH agencies.[26–28] Initiatives to prevent hospitalization in HH have focused on transition planning and care coordination,[29–31] but few include explicit strategies to avoid or eliminate PIMs.[32] Despite the increased risk of adverse reactions associated with PIMs,[14] their potential contribution to hospitalization risk in HH is unclear.

This study had two primary objectives. First, we aimed to describe the prevalence and types of PIM use at SOC among a large sample of patients receiving HH nursing services, using Beers criteria recommendations. Our second aim was to estimate the association between PIM use at SOC and subsequent hospitalization within the first 30 days of HH. We hypothesized that 1) PIM prevalence among HH patients would be greater than that for older adults living in the community or receiving ambulatory care, and 2) the risk of hospitalization and re-hospitalization would be greater for patients using PIMs than for their counterparts not using PIMs.

METHODS

Sample

Data were obtained from Medicare-mandated Outcome Assessment and Information Set (OASIS) evaluations[33] from 132 HH agencies. All agencies subscribed to web-based technology services through a software company, Brightree, LLC, which stored clinical data in a centralized database for tracking, referral, and care planning. Electronic health records were obtained in the context of an implementation trial that offered all agencies access to web-based resources to support their clinicians' use of a depression care management protocol. The protocol was integrated into the standard clinical software and available to all HH clinicians. Participating HH agencies were located across 32 states and provided care for an average of 333 patients per year. Agency characteristics and patient sociodemographic characteristics were similar to national statistics.[34,35]

Medicare patients (age ≥ 65) who received a SOC OASIS evaluation between January 1, 2013, and December 31, 2014, were included in the sample. Patients who started HH more than once over the study period (n = 13,357) were included, but analysis was limited to the first episode, resulting in a total sample of 87,780 unique patient episodes. This study was approved by the institutional review boards of Weill Cornell Medical College and Dartmouth College.

Measures

Potentially Inappropriate Medications. PIMs were defined using the 2012 Beers criteria,[4] the current version at the time of data collection. We included only medications that were recommended to be avoided, irrespective of indication, specific diseases, or syndromes, as information about patient disease status and medication indication were not consistently available in the sample data. We identified patient medications using American Hospital Formulary Service (AHFS) codes and medication names recorded during SOC OASIS assessments. Patients were considered to be taking a PIM if their medication list included a qualifying medication at or within 3 days of SOC. For medications that were classified as PIMs only when exceeding a recommended daily intake, we calculated individual daily dosage by multiplying prescribed dosage by number of daily doses. Table 1 describes sample prevalence and classifications of PIMs. In secondary analyses, patients taking medications from two or more PIM categories (Table 1) were distinguished from patients taking one PIM.

Hospitalization. We defined hospitalization as any acute care hospitalization occurring within 30 days of HH initiation or upon discharge from HH. Re-hospitalization was defined as any hospitalization within 30 days of HH initiation occurring among the subset of patients referred to HH from an acute or long-term hospitalization.

Covariates. Potential confounding factors included sociodemographic, clinical, and functional variables derived from OASIS assessments, completed by trained clinical staff. Sociodemographic variables included age (65–74, 75–84, and 85+ years), ethnicity (Hispanic vs. non-Hispanic), race (white, black, Asian, and other), HH referral source, and dual Medicaid/Medicare eligibility. Environmental variables included rural vs. metropolitan location, agency auspices, and whether agencies were freestanding or hospital-based.

Clinical covariates included variables related to patients' physical, mental, and functional health status. Using the International Statistical Classification of Diseases and Related Health Problems ninth revision (ICD-9) diagnostic codes, we created indicator variables for the ten most common primary diagnoses[3] and the principal conditions or reasons for receiving HH services, including type 2 diabetes, heart disease, chronic obstructive pulmonary disease (COPD), skin ulcers or wounds, stroke, osteoarthritis, neurocognitive disorders,

Table 1 Prevalence of Potentially Inappropriate Medications by Effect and Class among the Total Sample (N = 87,780)

Medication effect category	Class	Names	Sample prevalence
Anticholinergic	Antihistamines	Brompheniramine, carbinoxamine, chlorpheniramine, clemastine, cyproheptadine, dexbrompheniramine, dexchlorpheniramine, diphenhydramine (oral), doxylamine, hydroxyzine, promethazine, triprolidine	2308 (2.6%)
	Antiparkinson	Benztropine (oral) Trihexyphenidyl	226 (0.3%)
	Antispasmodic	Belladonna alkaloids, clidinium-chlordiazepoxide, dicyclomine, hyoscyamine, propantheline, scopolamine	606 (0.7%)
Antithrombotic		Dipyridamole (short-acting oral form) Ticlopidine	113 (0.1%)
Anti-infective		Nitrofurantoin	360 (0.4%)
Cardiovascular		Guanabenz, guanfacine, methyldopa, disopyramide, digoxin (> 0.125 mg/day), nifedipine	3687 (4.2%)
Drugs affecting brain and spinal cord	Tertiary tricyclic antidepressants	Amitriptyline, chlordiazepoxide-amitriptyline, clomipramine, doxepin (> 6 mg/day), imipramine, perphenazine-amitriptyline, trimipramine	1695 (1.9%)
	Antipsychotic	Thioridazine Mesoridazine	21 (0.02%)
	Barbiturates	Amobarbital, butabarbital, butalbital, mephobarbital, pentobarbital, phenobarbital, secobarbital	264 (0.3%)
	Benzodiazepines	Short-acting: alprazolam, estazolam, lorazepam, oxazepam, temazepam, triazolam Long-acting: clorazepate, chlordiazepoxide, chlordiazepoxide-amitriptyline, clidinium-chlordiazepoxide, clonazepam, diazepam, flurazepam, quazepam	15,248 (17.4%)
	Anxiolytic	Meprobamate	13 (0.01%)
Drugs affecting glands that produce/secrete hormones		Estrogens (pill or skin patch)	77 (0.09%
		Megestrol	426 (0.5%)
	Sulfonylureas	Chlorpropamide Glyburide	1278 (1.5%)
Gastrointestinal		Metoclopramide (except with diagnosis of gastroparesis)	450 (0.5%)
		Mineral oil (oral)	43 (0.05%)
		Trimethobenzamide	4 (<0.01%)
Pain medications		Meperidine	18 (0.02%)
	Daily non-COX-selective nonsteroidal anti-inflammatory drugs (NSAIDs)—excluded if taking concurrent proton pump inhibitor	Aspirin (> 325 mg/day)diclofenac, etodolac, fenoprofen, ibuprofen, ketoprofen, meclofenamate, mefenamic acid, meloxicam, nabumetone, naproxen, oxaprozin, piroxicam, sulindac, tolmetin	7340 (8.4%)
	Other NSAIDs	Indomethacin Ketorolac	265 (0.3%)
	Other analgesic	Pentazocine	4 (<0.01%)
	Skeletal muscle relaxants	Carisoprodol, chlorzoxazone, cyclobenzaprine, metaxalone, methocarbamol, orphenadrine	2640 (3.0%)

pneumonia, urinary tract infections, and surgical aftercare. As a measure of comorbidity, we summed the number of patients' primary and secondary ICD-9 diagnoses.

Functional status variables were created to indicate level and sources of functional limitation. Activities of daily living (ADLs) and instrumental activities of daily living (IADLs) were measured as the sum of nine ADLs (grooming, dressing upper body, dressing lower body, bathing, toilet transferring, toilet hygiene, transferring, ambulation, and feeding) and three IADLs (preparing light meals, using the telephone, and managing oral medications), respectively;[33] higher scores represented greater functional dependence. Pain interference, cognitive limitation, and dyspnea severity were each measured on a four-point scale ranging from 0 (no limitation) to 4 (severe or dependent). Elevated depressive symptoms were defined as a score ≥ 3 on the two-item Patient Health Questionnaire (PHQ-2) depression screen.[36] We also considered several independent risk factors found to be predictive of hospitalizations in previous studies,[3,34,37] including multiple previous hospitalizations, fall history, frailty, current smoking, obesity, alcohol dependence, and drug dependence.

Analyses

We generated summary descriptive statistics for demographic and health-related variables and compared these across medication effect categories (Table 1) using t-tests for continuous variables and chi-square tests for categorical variables.

Log-binomial generalized linear models were used to calculate the relative risk of hospitalization associated with PIM categories, both individually and in aggregate. Potential confounding factors were selected for inclusion in analytic models based on prior literature and a change-in-estimate procedure.[38] Factors producing a 10% or greater change in the bivariate association between PIM use and hospitalization were included for adjustment in final models. In separate analyses, we estimated the relative risk of 30-day re-hospitalization within the subsample of patients referred to HH from a hospital.

All statistical analyses were performed using Stata statistical software, version 14.0 (StataCorp LP, College Station, TX).

RESULTS

The sample included 87,780 Medicare beneficiaries initiating home health HH services, among whom 30,168 (34.4%) were taking at least one PIM at or within the first 3 days of SOC. Table 2 compares demographic and health characteristics of patients using at least one PIM to patients without PIM. Compared to patients with no PIMs, patients using PIMs were younger on average (mean = 78.8 years [8.4] vs. mean = 80.5 years [8.5]), were more likely to be female, white, to be dually eligible for Medicaid and Medicare, and to live in a rural location. Rates of individual ICD-9 primary diagnoses were similar by PIM status; however, patients with PIM had a greater number of comorbid diagnoses than patients without PIM (5.44 [1.03] vs. 5.36 [1.09]) and a greater number of baseline risk factors for hospitalization.

Table 3 compares the frequency of use and characteristics of patients taking different classes of PIMs. The most common PIMs were benzodiazepines, followed by medications with analgesic, cardiovascular, and anticholinergic effects. Patients taking cardiovascular medications or other less common PIMs (i.e., antithrombotic, anti-infective, glandular, and gastrointestinal medications) were older on average than patients taking other PIM classes and had a greater number of comorbid conditions. Women were more likely to be using anticholinergic medications or medications affecting the brain or spinal cord. Patients taking anticholinergic medications, benzodiazepines, and cardiovascular medications had the greatest mean number of hospitalization risk factors.

Overall, 11,457 (13.1%) patients were hospitalized within 30 days of starting HH care. Among patients taking at least one PIM, 4130 (13.7%) were hospitalized, compared to 7327

Table 2 Patient Characteristics by Potentially Inappropriate Medication (PIM) Use

	Total	Any PIM	No PIM	
	(*n* = 87,780)	(*n* = 30,168)	(*n* = 57,612)	
Characteristic	Frequency (%)			*p*-value*
Age, mean (SD), years	79.9 (8.5)	78.8 (8.4)	80.5 (8.5)	<0.001
65–74	26,364 (30.0)	10,542 (34.9)	15,822 (27.5)	
75–84	32,259 (36.7)	11,137 (36.9)	21,122 (36.7)	
85+	29,157 (33.2)	8489 (28.1)	20,668 (35.9)	
Gender				<0.001
Male	32,181 (36.7)	10,032 (33.3)	22,149 (38.4)	
Female	55,599 (63.3)	20,136 (66.7)	35,463 (61.6)	
Race				<0.001
White	76,847 (87.5)	26,957 (89.4)	49,890 (86.6)	<0.001
Black	9697 (11.0)	2883 (9.6)	6814 (11.8)	<0.001
Asian	672 (0.8)	155 (0.5)	517 (0.9)	<0.001
Other	563 (0.6)	172 (0.6)	391 (0.7)	0.056
Hispanic ethnicity				0.072
Non-Hispanic	86,083 (98.1)	29,619 (98.2)	56,464 (98.0)	
Hispanic	1696 (1.9)	548 (1.8)	1148 (2.0)	
Referral source				<0.001
Skilled nursing facility	18,141 (20.7)	5931 (19.7)	12,210 (21.2)	<0.001
Hospital	35,638 (40.6)	12,552 (41.6)	23,086 (40.1)	<0.001
Rehab	5740 (6.5)	1914 (6.3)	3826 (6.6)	0.092
Other	640 (0.7)	248 (0.8)	392 (0.7)	0.019
Community	27,619 (31.5)	9522 (31.6)	18,097 (31.4)	0.645
Insurance				<0.001
Medicare only	84,802 (96.6)	29,040 (96.3)	55,762 (96.8)	
Medicare/Medicaid	2978 (3.4)	1128 (3.7)	1850 (3.2)	
Agency location				<0.001
Metropolitan	70,575 (80.5)	23,578 (78.3)	46,997 (81.7)	
Rural	17,061 (19.5)	6552 (21.7)	10,509 (18.3)	
Common primary diagnoses				
Diabetes	2025 (2.3)	666 (2.2)	1359 (2.4)	0.156
Heart failure	6789 (7.7)	2257 (7.5)	4532 (7.9)	0.043
COPD	2943 (3.4)	1245 (4.1)	1698 (2.9)	<0.001
Stroke	3173 (3.6)	1099 (3.6)	2074 (3.6)	0.746
Osteoarthritis	1635 (1.9)	608 (2.0)	1027 (1.8)	0.015
Hypertension	2029 (2.3)	679 (2.3)	1350 (2.3)	0.386
Hospitalization risk factors				
Total factors, mean (SD)	2.35 (1.2)	2.47 (1.2)	2.29 (1.2)	<0.001
Previous hospitalizations	25,557 (29.1)	9278 (30.8)	16,279 (28.3)	<0.001
Frailty indicators	29,516 (33.6)	10,512 (34.8)	19,004 (33.0)	<0.001
Smoker	11,468 (13.1)	4546 (15.1)	6922 (12.0)	<0.001
Obese	14,189 (16.2)	5234 (17.3)	8955 (15.5)	<0.001
High fall risk	8254 (9.4)	2652 (8.8)	5602 (9.7)	<0.001
Severe dyspnea	37,048 (42.2)	13,687 (45.4)	23,361 (40.6)	<0.001
Depressive symptoms	3520 (4.12)	1577 (5.4)	1943 (3.5)	<0.001

**p-values from t-test (continuous) and χ^2 (categorical) comparing patients using PIMs to patients not using PIMs*

Table 3 Demographic and Health Characteristics by Type of Potentially Inappropriate Medication (PIM) Use (*n* = 30,168)

	Anticholinergic	Brain/Spinal	Cardiovascular	Analgesic*	Other PIM†
	(*n* = 3072)	(*n* = 16,600)	(*n* = 3687)	(*n* = 9904)	(*n* = 2699)
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Age (years)					
65–74	1270 (41.3)	6024 (36.3)	876 (23.8)	3857 (38.9)	879 (32.6)
75–84	1080 (35.2)	6176 (37.2)	1474 (40.0)	3456 (34.9)	1031 (38.2)
85+	722 (23.5)	4400 (26.5)	1337 (36.3)	2591 (26.2)	789 (29.2)
Gender					
Male	938 (30.5)	4780 (28.8)	1470 (39.9)	3560 (35.9)	1001 (37.1)
Female	2134 (69.5)	11,820 (71.2)	2217 (60.1)	6344 (64.1)	1698 (62.9)
Race					
White	2656 (86.5)	15,307 (92.2)	3187 (86.4)	8753 (88.4)	2271 (84.1)
Black	369 (12.0)	1162 (7.0)	440 (11.9)	1055 (10.7)	381 (14.1)
Asian	24 (0.8)	51 (0.3)	32 (0.9)	46 (0.5)	17 (0.6)
Other	22 (0.7)	79 (0.5)	28 (0.8)	50 (0.5)	30 (1.1)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Comorbidity‡	5.50 (1.0)	5.48 (1.0)	5.53 (1.0)	5.37 (1.1)	5.52 (1.0)
Hospitalization risk§	2.59 (1.3)	2.57 (1.2)	2.57 (1.2)	2.31 (1.3)	2.54 (1.2)
Cognitive limitation	0.76 (0.9)	0.81 (0.9)	0.74 (0.8)	0.64 (0.8)	0.78 (0.9)
Pain interference	2.43 (1.3)	2.33 (1.4)	2.04 (1.4)	2.48 (1.3)	2.14 (1.4)

Medication classes are not mutually exclusive
**Includes nonsteroidal anti-inflammatory drugs taken without concurrent proton pump inhibitor*
†Includes antithrombotic, anti-infective, glandular/hormonal, and gastrointestinal medications
‡Sum of ICD-9 diagnoses (0–6)
§Sum of hospitalization risk factors (see Table 1)

(12.7%) patients not using a PIM. Among patients referred to HH from a hospital setting (*n* = 35,638), 5205 (14.6%) were re-hospitalized, including 1897 (36.4%) who were taking a PIM. Table 4 presents estimates, from unadjusted and adjusted models, of the relative risk (RR) of hospitalization and re-hospitalization associated with PIM use. Compared with patients not taking PIMs, those taking at least one PIM had an approximately 6% greater risk of 30-day hospitalization (RR = 1.06, 95% CI: 1.03, 1.10) when controlling for key confounding variables.

Table 4 Relative Risk of Hospitalization by Medication Class

	30-Day hospitalization		30-Day re-hospitalization†	
	(*n* = 87,780)		(*n* = 35,638)	
	Crude RR (95% CI)	Adjusted RR* (95% CI)	Crude RR (95% CI)	Adjusted RR‡ (95% CI)
Any PIM	1.08 (1.04, 1.12)	1.06 (1.03, 1.10)	1.05 (1.00, 1.11)	1.05 (1.00, 1.11)
Any PIM (excluding NSAIDs)	1.17 (1.13, 1.21)	1.13 (1.09, 1.17)	1.17 (1.11, 1.23)	1.13 (1.07, 1.19)
Anticholinergic	1.13 (1.03, 1.23)	1.10 (1.01, 1.20)	1.12 (0.99, 1.27)	1.08 (0.95, 1.22)
Neurological				
Benzodiazepines	1.17 (1.12, 1.22)	1.12 (1.07, 1.17)	1.18 (1.11, 1.25)	1.13 (1.06, 1.21)
Other	1.08 (0.97, 1.21)	1.09 (0.98, 1.22)	1.00 (0.84, 1.18)	1.01 (0.85, 1.19)
Cardiovascular	1.20 (1.11, 1.29)	1.13 (1.04, 1.22)	1.28 (1.15, 1.43)	1.19 (1.07, 1.33)
Analgesics				
NSAID	0.76 (0.71, 0.81)	0.81 (0.75, 0.87)	0.70 (0.63, 0.77)	0.77 (0.70, 0.86)
Other	1.05 (0.95, 1.15)	1.05 (0.96, 1.15)	1.03 (0.91, 1.18)	1.09 (0.95, 1.24)
Gland/hormone	1.20 (1.08, 1.34)	1.17 (1.04, 1.30)	1.22 (1.04, 1.43)	1.17 (1.00, 1.37)
Other (less common) PIM				
Antithrombotic	1.29 (0.85, 1.94)	1.29 (0.86, 1.93)	1.22 (0.70, 2.15)	1.24 (0.72, 2.13)
Anti-infective	1.28 (1.01, 1.61)	1.29 (1.02, 1.62)	1.45 (1.05, 2.02)	1.48 (1.06, 2.05)
Gastrointestinal	1.57 (1.31, 1.86)	1.33 (1.12, 1.58)	1.60 (1.27, 2.03)	1.33 (1.05, 1.68)
No. of PIMs				
0 (*n* = 57,612)	(Reference)	(Reference)	(Reference)	(Reference)
1 (*n* = 24,199)§	1.06 (1.02, 1.10)	1.05 (1.01, 1.09)	1.03 (0.97, 1.09)	1.03 (0.97, 1.09)
2+ (*n* = 5969)§	1.14 (1.07, 1.22)	1.10 (1.03, 1.18)	1.16 (1.06, 1.28)	1.14 (1.03, 1.25)
No. of PIMs (excluding NSAIDs)				
0 (*n* = 62,759)	(Reference)	(Reference)	(Reference)	(Reference)
1 (*n* = 20,903)	1.14 (1.10, 1.19)	1.11 (1.07, 1.16)	1.13 (1.06, 1.20)	1.10 (1.04, 1.17)
2+ (*n* = 4118)	1.30 (1.20, 1.39)	1.21 (1.12, 1.30)	1.36 (1.23, 1.51)	1.27 (1.14, 1.41)

**RR = relative risk*
†Re-hospitalization was analyzed among subset of patients referred to HH from a hospital (n = 35,638)
‡Models adjusted for age, race, gender, number of chronic medical conditions, number of hospitalization risk factors, rural location, and limitations with ADLs
§Subset of patients prescribed at least one PIM (n = 30,168)

We found similar levels of risk associated with nearly all individual PIMs (Table 4). In descending order of magnitude, patients taking gastrointestinal, anti-infective, glandular, benzodiazepines, or anticholinergic medications had between 33% and 10% greater risk of hospitalization than patients not taking PIMs in those respective classes. Only NSAID use was associated with significantly lower risk of hospitalization (RR = 0.81 95% CI: 0.75, 0.87). When NSAIDs were excluded, the association between overall PIM use and hospitalization was twice as strong (RR = 1.13, 95% CI: 1.09, 1.17). As shown in the lower half of Table 4, risk of hospitalization was also positively associated with the number of PIM medications. Relative to no PIM use, patients taking one PIM (RR = 1.11, 95% CI: 1.07, 1.16) and patients taking two or more PIMs (RR = 1.21, 95% CI: 1.12, 1.30) had increased risk of hospitalization, and this association was consistent when including NSAIDs. Model results for re-hospitalization risk, estimated in the subset of 35,638 HH patients referred to HH from a hospital, were similar in both direction and magnitude, and taking a greater number of PIMs was also associated with greater re-hospitalization risk (Table 4).

DISCUSSION

This study demonstrates that the prevalence of PIM use among Medicare HH patients remains high (34.4%), despite recommendations to avoid them. Furthermore, use of PIMs was associated with significantly greater risk of hospitalization within 30 days of SOC, after adjusting for factors related to baseline risk of hospitalization. Together, these findings suggest that adequate consideration and management of medications remain important elements of care for medically vulnerable older adults, and represent potential targets for efforts to reduce hospitalizations.

The high prevalence of PIM use in this sample (34.4%) is consistent with studies using prior versions of Beers criteria, which reported that between 31 and 38% of HH patients were using at least one PIM.[15,39] Moreover, the prevalence of PIMs in this sample was greater than previous estimates among community-dwelling older adults,[40] and more than twice as high as that for patients in ambulatory care.[16,17] Several factors likely drive continued high rates of PIM use in HH. First, HH patients frequently require services from multiple health care providers and settings, creating the potential for medication errors through poor provider communication or insufficient transition planning. Second, the Beers criteria include medications which are *potentially* but not *necessarily* inappropriate. Given few alternatives or concerns about withdrawal effects, providers may choose to continue patients on PIMs, weighing clinical judgment against recommendations. Third, some common PIMs (e.g., NSAIDs and antihistamines) are available without prescription.

Not surprisingly, patients using PIMs had greater comorbidity and baseline risk of hospitalization. Patients with greater medical burden are more likely to see multiple care providers, to have recent hospitalizations, and have more complex health needs, all of which may lead to PIM prescription. In contrast, the finding that patients using PIMs were significantly younger on average than patients not using PIMs is counterintuitive. Potential reasons include closer scrutiny of medications for older patients, a need for higher-level care than home health (e.g., nursing home care), or greater risk of mortality among older patients using PIMs.

Importantly, this study found that medications included in the Beers criteria, both individually and in aggregate, are associated with significantly elevated risk (10–33%) of hospitalization and re-hospitalization when adjusting for other health factors. With the implementation of the Hospital Readmissions Reduction Program in 2012[26] and public reporting on the quality of HH agencies,[27] hospitals and HH agencies are incentivized to partner with each other to reduce the risk of hospitalization for HH patients. While several previous studies have questioned the practical benefits of Beers criteria in predicting negative outcomes,[41,42] the current findings suggest that medication use is an important element in identifying vulnerable patients.

Another interesting finding is that NSAIDs without concurrent proton pump inhibitors, which are among the most common PIMs, were associated with reduced risk of hospitalization. This finding may reflect potential cardiovascular benefits of some NSAIDs in low doses, or their use by healthier individuals to treat minor pains and inflammation. Potential negative consequences of NSAIDs may occur outside of brief HH episodes and are typically associated with regular use;[4] however, NSAIDs are commonly taken without prescription, and the regularity of their use compared to prescription medications is unclear. Because of this greater potential for measurement error with NSAIDs, we repeated analyses while excluding NSAIDs as PIMs, and found a stronger relationship between PIM use and hospitalization. Similar considerations are warranted for future studies investigating both prescription and non-prescription medications.

The association between PIMs and hospitalization risk highlights the shared role of hospitals and HH agencies in reducing medication-related issues. As most PIM use originated prior to HH, our findings suggest that reducing PIM prescribing in hospitals is an important step toward reducing their prevalence in HH. The Joint Commission on Accreditation of Healthcare Organizations has outlined priority goals for improving medication safety.[43] These include correct labeling of medication, accurate transcribing upon admission and discharge, and review of medication regimens. Still, research indicates that older adults taking a PIM upon hospital admission are likely to continue taking PIMs at discharge,[44] suggesting that opportunities for medication reconciliation are often missed. In a study of 770 patients referred from hospitals to HH, 100% of patient medication lists had at least one error, including inappropriate medications and dosing errors.[45] A similar study found discrepancies between home nurse medication review and admission information in 88.4% of HH patients.[46]

Given the present findings, HH nurses may serve a critical role in improving communication between hospitals, HH agencies, and other providers. For instance, HH nurses may assist in documenting and communicating the rationale for certain medications.[44] Home-based medication reconciliation programs have been shown to reduce the risk of death and hospitalization in care transition periods.[47–49] In comparison, there is limited evidence for the effectiveness of medication interventions among current HH patients. One notable randomized controlled trial conducted by Zillich and colleagues (2014) evaluated the effectiveness of telephonic medication therapy management (MTM) and found that development of medication-related action plans reduced hospitalization risk, but only among patients with low baseline risk.[32] Further research is needed to evaluate the effectiveness of similar medication-focused efforts in HH toward reducing hospitalizations.

The results of the present study should be interpreted considering certain limitations. First, because retrospective data were used, the reasons for hospitalization were unknown. Therefore, we were unable to determine whether medication-related events (e.g., falls, toxicity) contributed to hospitalization. The consistency in hospitalization risk across PIM categories and the proportionally greater risk of hospitalization associated with a higher number of concurrent PIMs suggest that medications played a role in at least some hospitalizations. Second, we were unable to determine whether patients were receiving end-of-life (EOL) or palliative care, which may justify the use of certain PIMs;[50] however, only 1.8% of patients were eventually discharged to hospice or died during home care, and less than half (41.4%) of these patients were taking a PIM. Finally, although models were adjusted for baseline risk of hospitalization, unmeasured confounding by indication may have influenced the estimated associations. Nevertheless, despite limitations, the study has notable strengths that bolster its relevance, including a large, diverse sample, use of administrative data with little missing information, and a focus on hospitalization risk.

PIM usage is high among HH patients. While in many cases the use of PIMs may be justified, they contribute significantly to greater risk of hospitalization, suggesting the need for efforts to limit their use. Hospitalizations, HH episodes, and care transitions represent opportunities for reducing PIM use and mitigating the risk of hospitalization.

Corresponding Author: *Matthew C. Lohman, PhD; Department of PsychiatryGeisel School of Medicine at Dartmouth, Lebanon, NH, USA (e-mail: lohmanm@mailbox.sc.edu).*

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