Trends in Prevalence and Determinants of Potentially Inappropriate Prescribing in the United States: 2007 to 2012

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OBJECTIVES: To estimate the prevalence and determinants of the use of potentially inappropriate medications (PIMs) in older U.S. adults using the 2012 Beers criteria.

DESIGN: Retrospective cohort study in a random national sample of Medicare beneficiaries.

SETTING: Fee-for-service Medicare beneficiaries from 2007 to 2012.

PARTICIPANTS: U.S. population aged 65 and older with Parts A, B, and D enrollment in at least 1 month during a calendar year (N = 38,250 individuals; 1,308,116 observations).

MEASUREMENTS: The 2012 Beers criteria were used to estimate the prevalence of the use of PIMs in each calendar month and over a 12-month period using data on diagnoses or conditions present in the previous 12 months. Generalized estimating equations were used to account for the dependence of multiple monthly observations of a single person when estimating 95% confidence intervals (CIs), and logistic regression was used to identify independent determinants of PIM use.

RESULTS: The point prevalence of the use of PIMs decreased from 37.6% (95% CI = 37.0–38.1) in 2007 to 34.2% (95% CI = 33.6–34.7) in 2012, with a statistically significant 2% (95% CI = 1–3%) decline per year assuming a linear trend. The 1-year period prevalence declined from 64.9% in 2007 to 56.6% in 2012. The strongest predictor of PIM use was the number of drugs dispensed. Individuals aged 70 and older and those seen by a geriatrician were less likely to receive a PIM.

CONCLUSION: From 2007 to 2012, the prevalence of PIM use in older U.S. adults decreased according to the 2012 Beers criteria, although it remains high, still affecting one-third each month and more than half over 12 months. The number of dispensed prescriptions could be used to target future interventions. **J Am Geriatr Soc 64:788–797, 2016.**

Key words: potentially inappropriate medications; Beers criteria; older adults; database study; pharmacoepidemiology; Medicare

Aging is associated with the development of multiple chronic diseases and with increasing use of long-term prescription medications to treat these conditions. Potentially inappropriate medications (PIMs) are drugs that have a high risk of adverse drug events (ADEs) relative to their potential benefit, particularly when safer or more-effective alternative therapies are available for the same condition.[1] Studies evaluating the consequences of PIM use in older adults have demonstrated that PIM use leads to risk of adverse clinical outcomes, jeopardizing the therapeutic objectives.[2–6] PIM use is considered a major public health problem, given its negative effect on health outcomes, hospitalizations, healthcare use, cost, and mortality.[2–6]

Increasing interest in safer, more-effective treatments in older adults has led to the development of prescribing guidelines that support clinical decisions when choosing therapies. Of these, the 2003 Beers criteria are arguably the most widely used in clinical practice and research.[1,7–9] Criticism of the 2003 Beers criteria led to a major revision in 2012.[10,11] The 2012 Beers criteria established an explicit list of unsafe drugs and drug combinations that should be avoided and includes a list of drug–disease interactions (DDIs), indicating that some drugs should be avoided in individuals with these diseases. The 2012 revision also included a list of drugs that should be used with caution in older adults.[10]

A recently published study using a subset of the 2012 Beers criteria documented an annual prevalence of PIM use of 42.6% in older community-dwelling U.S. adults.[12] To the knowledge of the authors of the current study, no

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DOI: 10.1111/jgs.14077

0002-8614/16/$15.00

studies examining the prevalence of PIM use using the complete version of the 2012 Beers criteria have been published. Therefore, the point prevalence and 12-month period prevalence of PIM use were examined in older adults using the 2012 Beers criteria, and time trends and factors associated with PIM use were determined.

METHODS

Using a random sample of Medicare fee-for-service claims and enrollment data, a cohort was constructed containing one record per Medicare beneficiary per month between 2007 and 2012 in which they used their Medicare Part D benefit and were continuously enrolled in Medicare Parts A and B for the prior 12 months.

Potentially inappropriate medication use was defined according to 2012 Beers criteria based on the list of medications and medication classes deemed to be inappropriate for use in older adults.[10] The operational definition of PIM use for this study used all categories of inappropriate prescribing (except for insulin dosed on a sliding scale) and the list of drugs to be used with caution included in the 2012 Beers criteria.

Drug classes were defined based on Anatomical Therapeutic Chemical codes and a list of generic names. An Anatomical Therapeutic Chemical to National Drug Code crosswalk was then used, and generic names were searched to identify all Part D claims for each drug class identified in the 2012 Beers criteria. Daily dose was estimated based on number of pills dispensed, strength, and days supplied and was used when the medication's inappropriate usage definition was defined according to excess dosage. Long-term use was defined as more than 1 month of use based on dispensing of a refill or prescriptions with a longer-than-30-day supply. Potential DDI was defined by examining diagnosis codes from Part A and B claims during the 12 months preceding the month of the prescription fill.

The point prevalence of PIM use was defined as the total number of older adults who filled one or more inappropriate prescriptions divided by the total number of older adults with at least one prescription during the calendar month (Figure 1). The 12-month period prevalence was defined as the number of older adults with PIM use in at least 1 month during the calendar year divided by the total number of adults with at least one prescription during the calendar year. To compare the most common PIMs according to the 2003 and 2012 Beers criteria, additional analyses were performed using the full list of drugs and conditions mentioned for each version.

The following potential risk factors for PIM use were also defined based on individual characteristics (age, sex, race, region, medical conditions mentioned in Charlson Comorbidity Index) and healthcare use (number of distinct generic drugs filled each month and number of emergency department (ED) visits, outpatient visits, hospital admissions and specialty physician visits during the previous 12 months).

Logistic models and generalized estimating equations (GEE) with an independent correlation structure were used to account for the dependence of multiple monthly observations of a single person to estimate 95% confidence intervals (CIs). Bivariable and multivariable models were then fit to examine independent determinants of PIM use, as measured using point prevalence. All analyses were performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC).

The institutional review board of the Gillings School of Global Public Health, University of North Carolina at Chapel Hill, approved the study protocol.

RESULTS

The study sample included 1,308,116 observations from 38,250 individuals. The mean age ± SD was 77.5 ± 7.8 (38.2% aged ≥80), 65.9% were female, and 84.9% were white (Table 1). The most common comorbidities during the previous 12 months were chronic pulmonary disease (35.5%) and diabetes mellitus without complications (35.0%). Polypharmacy use of ≥5 drugs) was found in 38.6% of individuals, and 8.6% were taking 10 or more drugs (mean 4.2 ± 3.6). During the previous 12 months, 34.3% had one or more ED visits, and 23.4% required hospitalization.

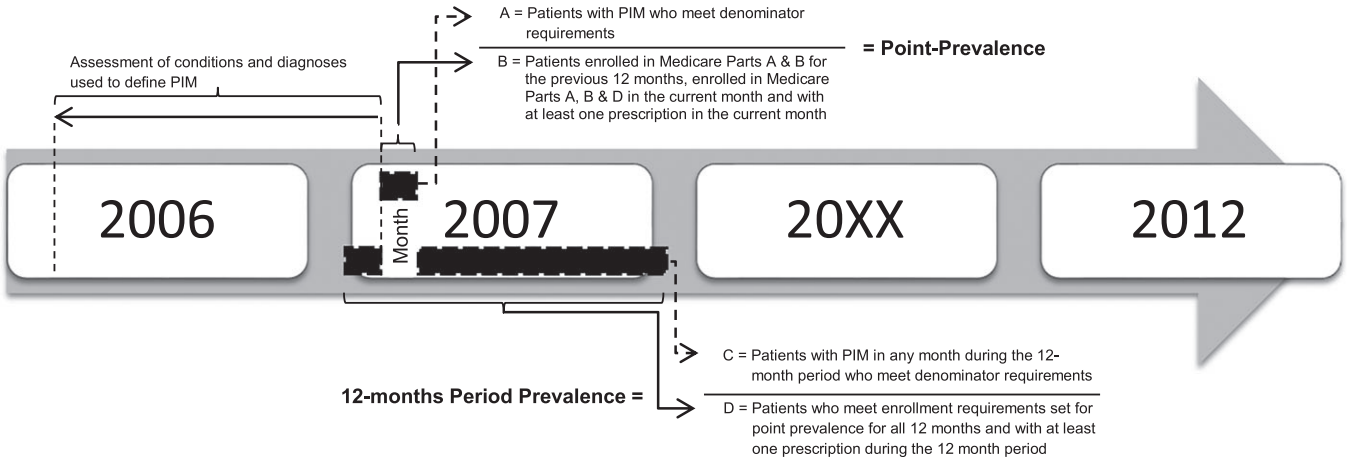

Figure 1. Study design.

Table 1. Sample Characteristics of U.S. Older Adults: 2007–2012

Characteristic	2007 N = 210,878 (23,000 beneficiaries)	2008 N = 212,813 (23,188 beneficiaries)	2009 N = 213,759 (23,214 beneficiaries)	2010 N = 214,356 (23,469 beneficiaries)	2011 N = 221,730 (24,420 beneficiaries)	2012 N = 234,580 (26,062 beneficiaries)	Overall N = 1,308,116 (38,250 beneficiaries)
Male, %	32.5	33.0	33.7	34.5	34.9	35.8	34.1
Age, mean ± SD	77.6 ± 7.7	77.6 ± 7.8	77.6 ± 7.9	77.5 ± 7.9	77.4 ± 7.9	77.3 ± 7.8	77.5 ± 7.8
Age, %							
66–69	18.0	17.6	18.1	18.1	18.6	18.7	18.2
70–74	22.4	23.1	23.2	23.8	24.2	25.0	23.6
75–79	21.2	20.3	19.9	19.4	19.4	19.6	20.0
80–84	18.1	18.5	17.9	17.7	17.2	16.3	17.6
≥85	20.3	20.5	20.9	21.0	20.7	20.3	20.6
Race, %							
White	84.8	85.0	85.0	84.9	84.7	84.8	84,9
Black	8.8	8.2	8.2	8.2	8.4	8.4	8.4
Asian	2.3	2.4	2.4	2.6	2.5	2.4	2.4
Hispanic	2.6	2.6	2.6	2.6	2.5	2.3	2.5
Other	1.1	1.3	1.3	1.3	1.4	1.4	1.3
North American Native	0.4	0.4	0.4	0.4	0.3	0.3	0.4
Unknown	0.1	0.1	0.1	0.1	0.2	0.3	0.1
Region, %							
South	39.5	39.3	39.3	39.3	39.3	39.1	39.3
North central	25.3	24.8	24.6	24.5	24.4	23.9	24.6
Northeast	18.4	18.8	18.6	18.5	18.4	19.3	18.7
West	16.5	16.8	17.2	17.5	17.6	17.4	17.2
Unknown	0.3	0.3	0.3	0.2	0.2	0.2	0.3
Comorbidities in previous 12 months, %							
Chronic pulmonary disease	35.0	35.0	35.4	35.8	36.1	35.7	35.5
Diabetes mellitus without complications	33.4	33.9	34.7	35.5	36.0	36.1	35.0
Peripheral vascular disease	21.6	21.4	22.0	22.6	22.4	22.0	22.0
Cerebrovascular disease	19.5	19.4	19.6	19.9	19.5	19.2	19.5
Congestive heart failure	19.9	19.0	18.8	18.7	18.3	17.4	18.7
Cancer	14.0	13.9	14.1	14.7	14.9	14.9	14.4
Renal disease	9.7	10.2	11.4	12.8	13.9	14.5	12.2
Diabetes mellitus with chronic complications	10.2	10.6	11.2	11.8	11.9	12.3	11.3
Dementia	8.4	8.4	8.7	8.7	8.5	8.3	8.5
Myocardial infarction	6.2	5.9	5.9	6.1	6.1	6.3	6.1
Connective tissue or rheumatic disease	5.1	5.3	5.7	5.6	5.7	5.8	5.5
Mild liver disease	4.4	4.6	4.7	4.8	5.0	4.9	4.7
Peptic ulcer disease	2.7	2.4	2.3	2.3	2.3	2.1	2.3
Metastatic carcinoma	1.8	1.7	1.6	1.7	1.8	1.8	1.7
Paraplegia or hemiplegia	0.7	0.7	0.7	0.7	0.7	0.6	0.7
Moderate or severe liver disease	0.3	0.3	0.4	0.3	0.5	0.4	0.4
Acquired immunodeficiency syndrome or human immunodeficiency virus	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Healthcare use in previous 12 months							
Prescription drug use in the current month, %							
Polypharmacy (≥ 5 drugs)	39.8	39.8	39.3	38.9	37.9	36.7	38.6

(Continued)

Table 1 (Contd.)

Characteristic	2007 N = 210,878 (23,000 beneficiaries)	2008 N = 212,813 (23,188 beneficiaries)	2009 N = 213,759 (23,214 beneficiaries)	2010 N = 214,356 (23,469 beneficiaries)	2011 N = 221,730 (24,420 beneficiaries)	2012 N = 234,580 (26,062 beneficiaries)	Overall N = 1,308,116 (38,250 beneficiaries)
Number of prescription fills per month							
1–2	32.7	33.1	33.8	34.3	35.2	36.6	34.3
3–4	27.5	27.1	26.9	26.8	26.8	26.7	27.1
5–9	31.1	31.0	30.6	30.2	29.4	28.6	30.0
≥10	8.7	8.8	8.8	8.7	8.5	8.1	8.6
Number of prescription fills, mean ± SD	4.3 ± 3.6	4.2 ± 3.6	4.1 ± 3.6	4.1 ± 3.6	4.0 ± 3.6	3.9 ± 3.6	4.2 ± 3.6
Any outpatient office visits, %	92.9	92.8	93.0	93.6	93.9	93.8	93.3
Number of outpatient office visits, mean ± SD	8.4 ± 7.3	8.3 ± 7.4	8.5 ± 7.4	8.9 ± 7.7	9.2 ± 7.9	9.1 ± 7.9	8.8 ± 7.6
Any emergency visit	34.6	33.5	34.3	34.2	34.5	34.7	34.3
Number of emergency visits, mean ± SD	0.7 ± 1.5	0.7 ± 1.5	0.7 ± 1.5	0.7 ± 1.6	0.7 ± 1.6	0.7 ± 1.6	0.7 ± 1.5
Any hospital admission	24.8	23.5	23.9	23.2	23.0	22.0	23.4
Number of hospital admissions, mean ± SD	0.5 ± 1.3	0.5 ± 1.2	0.5 ± 1.2	0.5 ± 1.2	0.5 ± 1.2	0.5 ± 1.1	0.5 ± 1.2
Number of prescribers, mean ± SD	1.6 ± 0.9	1.6 ± 0.9	1.6 ± 0.9	1.6 ± 0.9	1.6 ± 0.9	1.6 ± 0.9	1.6 ± 0.9
Number of prescribers per month							
1	58.7	58.4	57.9	57.6	57.1	56.5	57.7
2	27.1	27.0	27.3	27.4	27.6	27.7	27.4
≥3	14.2	14.5	14.8	15.0	15.3	15.9	15.0
Number of prescriber specialties, mean ± SD	1.4 ± 0.7	1.4 ± 0.7	1.4 ± 0.7	1.4 ± 0.7	1.4 ± 0.7	1.4 ± 0.7	1.4 ± 0.7
Number of prescribers specialties per month							
1	65.3	65.1	64.7	64.7	64.0	63.6	64.5
2	27.0	27.2	27.7	27.8	28.4	28.7	27.8
≥3	7.7	7.8	7.6	7.5	7.7	7.7	7.7
Prescriber specialty in previous 12 months							
General practitioner, family practitioner, internist	81.1	81.1	83.0	84.4	85.5	85.7	83.6
Geriatrician	1.5	2.4	2.4	2.4	2.3	2.4	2.4
Other	42.9	44.5	48.2	49.8	52.4	55.0	49.0

SD = standard deviation.

The point prevalence of PIM use decreased from 37.6% (95% CI = 37.0–38.1) in 2007 to 34.2% (95% CI = 33.6–34.7) in 2012 (Figure 2), a statistically significant 2% (95% CI = 1–3%) decline per year from 2007 through 2012 assuming a linear trend. The 12-month period prevalence of PIM use decreased from 64.9% (95% CI = 64.1–65.8) in 2007 to 56.6% (95% CI = 55.9–57.4) in 2012. In 2012, DDIs accounted for 16.4% of the point prevalence of PIM use and 30.9% of the 12-month prevalence.

The most frequently prescribed PIMs according to the 2012 Beers criteria based on drug choice or dosing were digoxin in doses greater than 0.125 mg/d (5.0%), glyburide (2.8%), and estrogen (2.6%) (Table 2). The most frequent DDIs were medications inducing or worsening delirium (5.4%), followed by drugs inducing falls and fractures (4.9%), such as anticholinergics and sedatives. In contrast, using the 2003 Beers criteria, the most commonly prescribe PIMs based on drug choice or dosing criteria

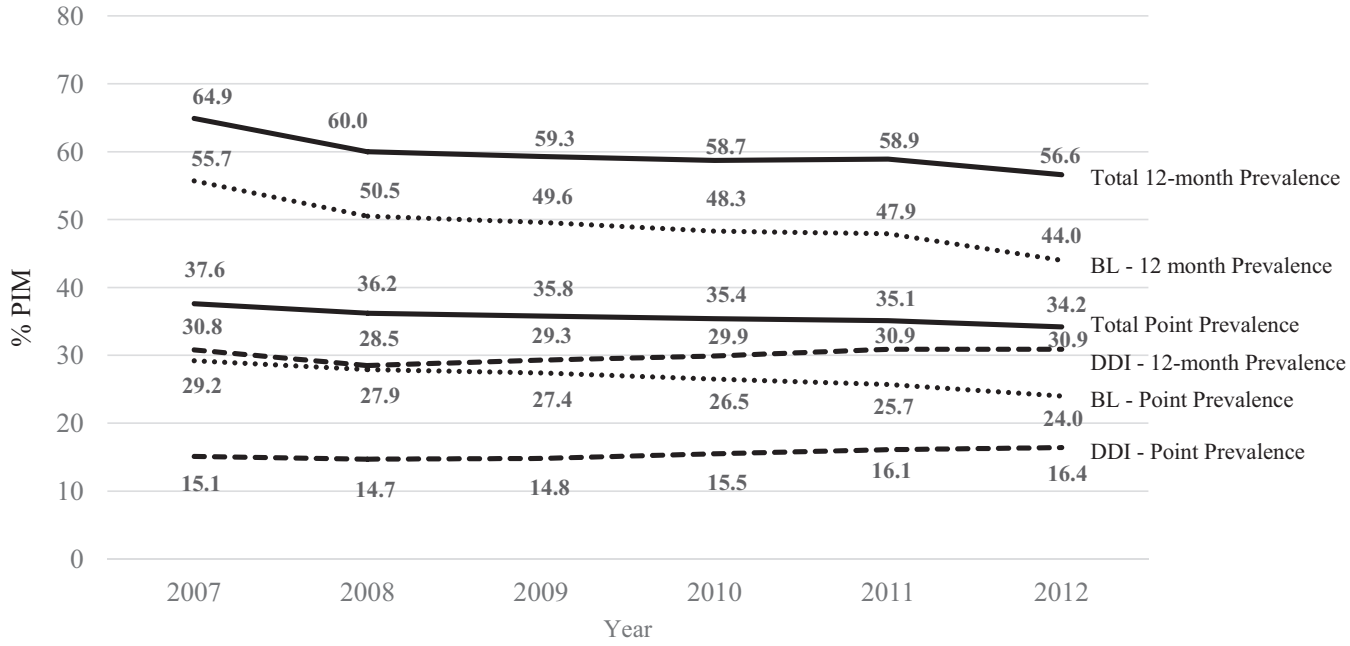

Figure 2. Point prevalence (in current month) and 12-month prevalence of potentially inappropriate medication (PIM) use in older Medicare beneficiaries between 2007 and 2012 according to the 2012 Beers criteria. BL = Beers List (potentially inappropriate prescriptions based on drug choice, dosage, or duration of use); DDI = drug-disease interaction (potentially inappropriate prescriptions based on drug–disease interactions. Precision (95% confidence interval) of all estimates within ±1 percentage point.

Table 2. The 10 Most Common Potentially Inappropriate Medications Based on Drug Choice or Dosing and Drug-Disease Interaction Detected Between 2007 and 2012 According to the Beers Criteria 2003 and 2012

	2012 Beers Criteria	2003 Beers Criteria
Potentially inappropriate medication choice or dose		
First	Digoxin dose >0.125 mg/d (5.0%)	Propoxyphene (2.4%)
Second	Glyburide (2.8%)	Estrogen oral (2.1%)
Third	Estrogen with or without progestins (2.6%)	Clonidine (2.1%)
Fourth	Spironolactone >25 mg/d (2.4%)	Amitriptyline (1.7%)
Fifth	Amitriptyline (1.8%)	Doxazosin (1.6%)
Drug–disease interaction		
First	Delirium—all TCAs, anticholinergics, benzodiazepines, chlorpromazine, corticosteroids, histamine-receptor antagonists, meperidine, sedative hypnotics, thioridazine (5.4%)	Cognitive impairment—barbiturates, anticholinergics, antispasmodics and muscle relaxants, central nervous system stimulants (2.0%)
Second	History of falls or fractures—anticonvulsants, antipsychotics, benzodiazepines, non- benzodiazepine hypnotics, TCAs, selective serotonin reuptake inhibitors (4.9%)	Chronic constipation—CCBs, anticholinergics, TCAs (1.1%)
Third	Dementia and cognitive impairment—anticholinergics, benzodiazepines, histamine-receptor antagonists, zolpidem, antipsychotics, chronic and as-needed use (4.2%)	Blood clotting disorders or receiving anticoagulant therapy—NSAIDs, aspirin, dipyridamole, ticlopidine, clopidogrel (1.0%)
Fourth	Heart failure—NSAIDs and cyclooxygenase-2 inhibitors, nondihydropyridine CCBs (diltiazem, verapamil), pioglitazone, rosiglitazone, cilostazol, dronedarone (3.3%)	Stress urinary incontinence—alpha blockers, anticholinergics, TCAs, long-acting benzodiazepines (0.6%)
Fifth	Syncope—acetylcholinesterase inhibitors, peripheral alpha-blockers (doxazosin, prazosin, terazosin), tertiary TCAs, chlorpromazine, thioridazine, olanzapine (2.1%)	Arrhythmias—TCAs (0.4%)

TCA = tricyclic antidepressant; CCB = calcium channel blocker; NSAID = nonsteroidal anti-inflammatory drug.

were propoxyphene (2.4%), oral estrogen (2.1%), and clonidine (2.1%); similar to the 2012 Beers criteria, anticholinergic and psychotropic drug use in individuals with cognitive impairment were the most-frequent DDI criteria detected.

Several factors were associated with PIM use in multivariable analyses (Table 3). The factor most strongly associated with PIM use was number of drugs (OR = 7.51, 95% CI = 7.09–7.94 for ≥10 drugs vs 1–2). Other independent predictors of PIM use included characteristics

Table 3. Factors Associated with Potentially Inappropriate Medication (PIM) Use in Older Medicare Beneficiaries According to the 2012 Beers Criteria

Characteristic	N	With PIM Use, %	Odds Ratio (95% Confidence Interval)	
			Crude	Adjusted
Year				
2007	210,878	37.6	1	1
2008	212,813	36.2	0.94 (0.93–0.96)	0.94 (0.93–0.96)
2009	213,759	35.7	0.92 (0.90–0.95)	0.92 (0.90–0.95)
2010	214,356	35.4	0.91 (0.89–0.93)	0.91 (0.89–0.94)
2011	221,730	35.1	0.90 (0.88–0.93)	0.92 (0.89–0.94)
2012	234,580	34.2	0.86 (0.84–0.89)	0.90 (0.87–0.93)
Participant characteristic				
Age				
66–69	237,936	33.4	1	1
70–74	309,311	32.1	0.94 (0.90–0.98)	0.90 (0.86–0.94)
75–79	261,074	34.4	1.04 (0.99–1.10)	0.89 (0.84–0.94)
80–84	230,185	37.2	1.18 (1.12–1.25)	0.92 (0.87–0.97)
≥85	269,610	41.7	1.42 (1.35–1.50)	0.94 (0.89–1.00)
Sex				
Male	446,165	32.9	1	1
Female	861,951	37.1	1.21 (1.16–1.26)	1.12 (1.07–1.17)
Race and ethnicity				
White	1,110,223	35.3	1	1
African American	109,337	39.5	1.19 (1.12–1.27)	0.93 (0.86–1.00)
Hispanic	33,035	38.1	1.13 (1.01–1.26)	0.83 (0.74–0.93)
Asian	31,875	33.8	0.93 (0.83–1.04)	0.83 (0.74–0.94)
North American Native	4,713	38.1	1.13 (0.85–1.50)	0.85 (0.64–1.13)
Other	17,160	32.6	0.88 (0.74–1.06)	0.92 (0.76–1.11)
Unknown	1,773	33.6	0.93 (0.60–1.44)	0.75 (0.45–1.23)
Region				
Northeast	244,361	34.1	1	1
South	514,112	37.2	1.14 (1.08–1.20)	1.17 (1.10–1.24)
West	224,873	36.7	1.12 (1.05–1.19)	1.28 (1.20–1.37)
North central	321,371	33.9	0.99 (0.93–1.05)	1.03 (0.97–1.10)
Comorbidities				
Myocardial infarction				
No	1,228,373	35.1	1	1
Yes	79,743	44.9	1.51 (1.43–1.59)	0.77 (0.72–0.81)
Congestive heart failure				
No	1,063,952	30.7	1	1
Yes	244,164	57.5	3.07 (2.95–3.18)	1.96 (1.88–2.04)
Peripheral vascular disease				
No	1,020,341	33.2	1	1
Yes	287,775	44.3	1.60 (1.54–1.65)	0.98 (0.94–1.02)
Cerebrovascular disease				
No	1,052,687	33.3	1	1
Yes	255,429	45.4	1.67 (1.61–1.72)	1.05 (1.01–1.09)
Dementia				
No	1,196,587	33.5	1	1
Yes	111,529	58.8	2.83 (2.70–2.97)	1.77 (1.68–1.87)
Chronic pulmonary disease				
No	843,744	31.9	1	1
Yes	464,372	42.5	1.58 (1.53–1.63)	0.97 (0.94–1.01)
Connective tissue or rheumatic disease				
No	1,235,615	35.3	1	1
Yes	72,501	42.5	1.36 (1.27–1.45)	1.04 (0.97–1.11)
Peptic ulcer disease				
No	1,277,442	35.4	1	1
Yes	30,674	48.7	1.74 (1.62–1.86)	1.23 (1.14–1.33)
Mild liver disease				
No	1,246,407	35.3	1	1
Yes	61,709	42.2	1.34 (1.26–1.42)	1.05 (0.99–1.12)

(Continued)

Table 3 (Contd.)

Characteristic	N	With PIM Use, %	Odds Ratio (95% Confidence Interval)	
			Crude	Adjusted
Diabetes mellitus without complications				
No	850,741	31.8	1	1
Yes	457,375	42.8	1.60 (1.55–1.66)	1.12 (1.07–1.16)
Paraplegia and hemiplegia				
No	1,298,889	35.5	1	1
Yes	9,227	54.4	2.16 (1.88–2.48)	1.20 (1.03–1.40)
Renal disease				
No	1,149,109	34.2	1	1
Yes	159,007	46.4	1.66 (1.59–1.74)	0.90 (0.86–0.95)
Diabetes mellitus with chronic complications				
No	1,159,769	34.1	1	1
Yes	148,347	48.1	1.79 (1.71–1.88)	1.02 (0.96–1.08)
Cancer				
No	1,119,446	35.9	1	1
Yes	188,670	34.1	0.92 (0.88–0.97)	0.89 (0.85–0.94)
Moderate or severe liver disease				
No	1,303,360	35.6	1	1
Yes	4,756	55.7	2.27 (1.86–2.78)	1.43 (1.16–1.78)
Metastatic carcinoma				
No	1,285,287	35.6	1	1
Yes	22,829	37.6	1.09 (1.00–1.19)	0.96 (0.87–1.05)
Acquired immunodeficiency syndrome, human immunodeficiency virus				
No	1,306,918	35.7	1	1
Yes	1,198	40.3	1.22 (0.80–1.85)	0.90 (0.60–1.36)
Healthcare use				
Prescription drug use				
Number of prescription fills per month				
1–2	440,632	18.4	1	1
3–4	348,296	30.2	1.92 (1.87–1.96)	1.76 (1.71–1.81)
5–9	401,440	48.6	4.18 (4.05–4.32)	3.38 (3.25–3.50)
≥10	117,748	72.4	11.59 (11.01–12.21)	7.51 (7.09–7.94)
Polypharmacy (≥5 drugs)				
No	788,928	23.6	1	-
Yes	519,188	54.0	3.79 (3.69–3.90)	-
Any outpatient office visits				
No	87,134	42.4	1	
Yes	1,220,982	35.2	0.74 (0.70–0.78)	*
Number of outpatient office visits				
0	87,134	42.4	1	1
1–6	529,284	31.0	0.61 (0.58–0.65)	0.98 (0.92–1.04)
7–12	388,015	34.4	0.71 (0.67–0.76)	1.00 (0.93–1.06)
≥13	303,683	43.4	1.04 (0.98–1.11)	1.13 (1.05–1.63)
Any emergency visits				
No	859,550	30.3	1	
Yes	448,566	45.9	1.95 (1.90–2.00)	*
Number of emergency visits				
0	859,550	30.3	1	1
1	240,605	40.3	1.55 (1.51–1.59)	1.15 (1.12–1.19)
2–5	186,957	51.2	2.41 (2.33–2.49)	1.33 (1.28–1.38)
≥6	21,004	63.9	4.07 (3.76–4.41)	1.48 (1.35–1.63)
Any hospital admission				
No	1,002,331	31.6	1	1
Yes	305,785	49.1	2.09 (2.03–2.14)	0.97 (0.87–1.09)
Number of prescribers per month				
1	754,195	30.2	1	1
2	358,150	38.8	1.46 (1.43–1.50)	1.07 (1.03–1.12)
≥3	195,771	50.9	2.39 (2.31–2.47)	1.06 (1.00–1.12)
Number of prescriber specialties per month				
1	844,217	31.3	1	1
2	363,642	41.0	1.53 (1.49–1.56)	0.96 (0.91–1.01)
≥3	100,257	53.4	2.52 (2.42–2.63)	1.00 (0.92–1.08)

(Continued)

Table 3 (Contd.)

Characteristic	N	With PIM Use, %	Odds Ratio (95% Confidence Interval)	
			Crude	Adjusted
Prescriber				
Geriatrician				
No	1,276,492	35.5	1	1
Yes	31,624	43.5	1.40 (1.27–1.54)	0.89 (0.79–0.99)
General practitioner, family practitioner, internist				
No	284,470	31.5	1	1
Yes	1,023,646	36.8	1.27 (1.22–1.31)	0.99 (0.95–1.04)
Other specialty				
No	749,063	33.2	1	1
Yes	559,053	39.0	1.28 (1.25–1.32)	1.08 (1.03–1.12)

*Not included in multivariable model.

such as female sex (OR = 1.12, 95% CI = 1.07–1.17), residence in the western and southern regions of the country, and medical conditions such as congestive heart failure (OR = 1.96, 95% CI = 1.88–2.04) and dementia (OR = 1.77, 95% CI = 1.68–1.87). Having one or more ED visits during the previous 12 months (OR = 1.23, 95% CI = 1.19–1.26) and having more than 1 prescriber in a given month (OR = 1.09, 95% CI = 1.03–1.16 for ≥3 prescribers vs 1) were also associated with greater risk of PIM use. Greater risk of PIM use was seen in older adults with more ED and outpatient office visits during the previous 12 months and more prescriptions filled and prescribers in a given month.

Older age and Asian or Hispanic race or ethnicity were associated with lower rates of PIM use in adjusted analyses. People with at least one prescription from a geriatrician were less likely to have received a PIM (OR = 0.89, 95% CI = 0.79–0.99).

DISCUSSION

This study provides evidence that PIM use is common in older adults in the United States. Every month, one in three older adults who filled at least one prescription in the month received a drug for which the potential harms outweigh the potential benefits. Only a small reduction in PIM use has occurred since 2007. It was also found that more than 50% of older U.S. adults being treated with prescription medication received at least one PIM during a calendar year. This highlights the importance of a clear definition of the prevalence of PIM use for interpretation in pharmacoepidemiological studies and the cumulative nature of this risk to older adults.

This study is the first to apply the complete version of the 2012 Beers criteria to a nationally representative population. A recent systematic review of PIM use reported 19 studies conducted in five countries, none of which used the 2012 Beers criteria.[13] Furthermore, most previously published studies have modified the 2003 Beers criteria to exclude items that depend on dosage, use frequency, or diagnosis[14] or have used subsets of the 2012 criteria.[12,15,16]

The current estimates of the prevalence of PIM use using the 2012 Beers criteria are generally higher than those of previously published studies, which have reported inappropriate medication use in 14% to 45.5% of older community-dwelling U.S. adults.[12–14] In addition, the risk of receiving a PIM decreases with age. Thus, the current findings are in contrast to those of most previous studies on community-dwelling older people, which suggested that PIM use increases with advancing age.[13] The inclusion of DDI in the current study definition of PIM use or different Medicare drug coverage and drug availability during the study period may explain this difference. The current findings are consistent with those of previous studies in the United States suggesting that individuals in the west and the south are more likely to receive a PIM.[17]

A recent study[12] using the Medical Expenditure Panel Survey (MEPS) estimated the annual prevalence of PIM use based on a subset of the 2012 Beers criteria (36 medication classes that older adults should avoid). The prevalence of PIM use ranged from 46% in 2006–07 to 41% in 2009–10, lower than the estimates for the same subset of medication classes of 56% in 2007 to 48% in 2010 reported in the current study. These discrepant estimates may be due to differing methods of prescription medication capture. The MEPS relies on self-report of medication use in interviews using medicine bottles and receipts, whereas the current analyses drew on prescription dispensing records, which are not subject to the same potential for underreporting.[9] In addition to the subset of 34 medication classes evaluated previously,[12] the prevalence of inappropriate medications use in older adults due to DDIs was also examined, providing the first complete evaluation of the 2012 Beers criteria using 52 medication classes.

This study is consistent with other data showing a trend of PIM use decreasing over time,[18,19] although PIM users continue to take a large number of drugs and use of anticholinergic and psychotropic drugs. Therefore, strategies to improve quality of care in older adults should focus on strategies to reduce the total number of medications prescribed,[20] as well as anticholinergic burden and the use of psychotropic medications specifically.[21] It is likely that pharmacogeriatric training would be an important component of successful practice change. Geriatricians were less likely to prescribe PIMs, and they are better trained in pharmacogeriatrics and the consequences of PIM use. The

current study also found that a previous ED visit was a predictor of PIM use, although special considerations should be taken into account in the emergency setting; in light of the risk of ADEs after the emergency attention, conducting a comprehensive medication reconciliation process and selecting safer alternatives during the ED visit may enhance the quality and safety of health care and reduce the incidence of ADEs.

The current study found a lower prevalence of PIM use according to the 2003 Beers criteria than with the 2012 Beers criteria, mainly because the older version of the Beers criteria included a shorter list of drugs and DDIs that should be avoided in older adults than did the 2012 Beers criteria. A lower prevalence of PIM use was also found according to the 2003 Beers criteria in 2011 and 2012 than in previous years, which can be explained by the removal of propoxyphene and its combinations from the U.S. market in 2010 (Tables S1–S4).

It is not surprising that the prevalence of PIM use varied depending on the definition of PIM use that was used and the clinical setting. For instance, the medical literature rarely distinguishes between point prevalence (e.g., in a given month) and 12-month period prevalence (over a 12-month period). Consistent study methods across pharmacoepidemiological prevalence studies have the potential to enhance the value of research on PIM use by allowing direct comparison of research findings. Future interventions to improve the health of older adults might focus on the list of common PIMs, such as high-dose digoxin, glyburide, anticholinergics, psychotropics, and older medications such as propoxyphene, doxazosin, and amitriptyline.

Given the consistency of findings across time and criteria used, the evidence already available of the ADEs listed in these criteria is insufficient to change clinical practice towards safer, better-tolerated pharmacotherapy in older adults. Therefore, additional studies evaluating the consequences of PIM use will be needed to educate physicians and healthcare providers about the risk of PIM use and treatment alternatives.

This study has some limitations. First, if individuals have alternative sources of prescription coverage or over-the-counter drug use (e.g., some antihistamines, nonsteroidal antiinflammatory drugs), these findings might underestimate the real burden of PIM use. Several categories of medications are excluded from Medicare Part D coverage, such as benzodiazepines and barbiturates, some of which are listed in the Beers criteria. Second, although claims data overcome problems of recall bias and provide nearly complete information on prescription drug use, medical status and healthcare use can be underrepresented in a database, thereby underestimating the prevalence of PIM use. Finally, and most importantly, there are no data on why specific clinicians made certain prescription choices for specific patients. Not all PIMs can be avoided; sometimes the benefits of a medication outweigh the risks. Moreover, it could not be confirmed that the drugs prescribed and dispensed were actually consumed. In addition, the Beers criteria address only potential overprescribing while not addressing potential underprescribing or use of duplicate drug classes,[10,11] which may underestimate the prevalence of PIM use.

Despite these limitations, these prevalence data improve on prior research. Previous studies rarely contained information on drug dosage or disease conditions and thus more often underestimated PIM use related to underlying disease and failed to report excessive dosage or duration.[9,12,13] In contrast, the current study included diseases or conditions and doses and duration of medication use, allowing better estimation of the prevalence of PIM use.

Screening tools such as the 2012 Beers criteria may be used to detect potential risks and support medical decision-making in clinical practice. This is a tool for continued improvement in safety when used in quality improvement interventions for geriatric prescribing. This tool also permits comprehensive understanding of the epidemiology of drug-related problems for broader public health purposes. Prescribing guidelines are not meant to supersede the clinical judgment of prescribers and are not intended as absolute contraindications. The Beers criteria are intended to serve as guidance to reduce risk and prevent harm when using medications in older adults, allowing the quality of prescribing in clinical practice to be assessed at the population level.[11]

In conclusion, one in three older adults monthly and one in two older adults yearly are exposed to PIM use in the United States according to the 2012 Beers criteria, with a slight decrease in the prevalence of PIM use between 2007 and 2012. Factors associated with PIM use, such as individual characteristics (≥3 prescriptions filled in a given month, female sex, western and southern regions) and healthcare use (ED during the previous 12 months), provide clues as to how to improve the quality of drug prescribing in older adults. These factors also allow individuals at highest risk of PIM use to be identified. Further research is needed to quantify the effects of PIM use on the risk of ADEs such as delirium, falls and fractures, healthcare cost, and frailty.

ACKNOWLEDGMENTS

The database infrastructure used for this project was funded by the Pharmacoepidemiology Gillings Innovation Lab for the Population-Based Evaluation of Drug Benefits and Harms in Older U.S. Adults (GIL 200811.0010), the Center for Pharmacoepidemiology, Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina (UNC); the CER Strategic Initiative, UNC Clinical Translational Science Award (UL1TR001111); the Cecil G. Sheps Center for Health Services Research, UNC; and the UNC School of Medicine. Funding was also received from MECESUP UCH0811 Chile and the National Institute on Aging (NIA; R01 AG023178).

Conflict of Interest: TS receives investigator-initiated research funding and support as principal investigator (R01 AG023178) and co-investigator (R01 AG042845) from the NIA, as co-investigator (R01 CA174453) from the National Cancer Institute, National Institutes of Health (NIH), and as principal investigator from the Patient-Centered Outcomes Research Institute (PCORI). Dr. Stürmer receives salary support from the Center for Pharmacoepidemiology (current members: GlaxoSmithKline, UCB BioSciences, Merck) and research support from pharmaceutical companies (Amgen, Merck, AstraZeneca) to the Department of Epidemiology, UNC. Dr. Jonsson Funk receives investigator-initiated research funding and salary support as princi-

pal investigator from the Agency for Healthcare Research and Quality (K02 HS017950) and NIH, National Heart Lung and Blood Institute (R01 HL118255); as a co-investigator on grant awards from the NIA, NIH (R01 AG023178), the NIH National Center for Advancing Translational Sciences (NCATS, 1UL1TR001111) and co-investigator of a pilot project from the PCORI (1IP2PI000075). Dr. Jonsson Funk receives salary support from the Center for Pharmacoepidemiology (current members: GlaxoSmithKline, UCB BioSciences, Merck) and salary and research support from AstraZeneca to the Department of Epidemiology, UNC. Dr. Lund receives salary support and research support from the PhRMA Foundation for a Research Starter Award to the Department of Epidemiology, University of North Carolina at Chapel Hill.

Author Contributions: Dr. Jirón and V. Pate had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Jirón, Stürmer: study concept and design. Stürmer, Jonsson Funk: acquisition of data. Pate, Jirón, Stürmer, Hanson, Jonsson Funk, Lund: analysis and interpretation of data. Jirón: drafting of the manuscript. Jirón, Hanson, Stürmer, Jonsson Funk, Pate, Lund: critical revision of the manuscript for important intellectual content. Pate: statistical analysis. Stürmer: obtained funding. Jirón, Pate, Stürmer: administrative, technical, or material support. Stürmer: study supervision.

Sponsor's Role: The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the Agency for Healthcare Research and Quality.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. Inappropriate Medications and Classes to Avoid in Older Adults, as Defined by Expert Panel Criteria

Table S2. Diagnoses or Conditions Considered in Inappropriate Medications to Avoid in Older Adults, as Defined by Expert Panel Criteria

Table S3. Point-Prevalence and 12-Month Prevalence of Potentially Inappropriate Prescribing among US Medicare Older Adults between 2007 and 2012 According to 2003 Beers Criteria

Table S4. Factors Associated with Potentially Inappropriate Prescribing among US Medicare Older Adults According to 2003 Beers Criteria

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