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Prevalence of Potentially Inappropriate Medication Use in Older Adults Using the 2012 Beers Criteria

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Abstract

Background—The Beers list of potentially inappropriate medications (PIMs) provides a key indicator of medication prescribing quality. The criteria were updated in 2012, adding new drugs and assessing evidence strength.

Objectives—To use the most recently available population-based data to estimate PIM prevalence under the 2012 update and to provide a benchmark from which to measure future changes.

Design and Setting—Retrospective cohort study using nationally representative data from the 2006–2010 Medical Expenditure Panel Survey (MEPS).

Participants—Community-dwelling sample of US older adults (n = 18,475).

Measurements—We operationalized the updated Beers criteria, generating a “broad” PIM definition that incorporated form, route or dose restrictions where clearly specified and a “qualified” definition that applied specific exceptions where mentioned in the rationale associated

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Author Contributions

Amy Davidoff, Nicole Brandt and Donna Fick conceived the study design. Edward Miller, Eric Sarpong and Eunice Yang constructed and analyzed the data. Amy Davidoff took the lead and Eric Sarpong and Edward Miller contributed to drafting of the article. Nicole Brandt, Donna Fick and Eunice Yang made critical revisions that affected intellectual content. All authors approved the final version of the paper.

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with each drug category. Bivariate analyses described PIM prevalence, comparing the two operational definitions, and examined time trends.

Results—Among older adults with prescription medications, 42.6% had at least one medication fill that met the broad definition, with non-steroidal anti-inflammatory drugs (NSAIDs) having the highest (10.9%) prevalence. The rate declined from 45.5% in 2006–2007 to 40.8% in 2009–2010. The categories with the largest absolute decline were NSAIDs, selected sulfonylureas, and estrogens. PIM prevalence was 30.7% using the qualified definition.

Conclusion—Despite the overall high use of PIMs, there has been a decline observed in recent years. Future studies should test the effect of educational and clinical interventions on changes in PIM use and patient outcomes. The current study results can aid in targeting these interventions.

Keywords

inappropriate; Beers criteria; older adults; medication; MEPS

INTRODUCTION

The Beers list of potentially inappropriate medications (PIMs) is a key indicator of medication prescribing quality, as well as an important educational tool for clinicians. Initially developed in 1991 with a focus on medication use in nursing home residents,[1] the list was updated and expanded to include all geriatric care settings in 1997 and again in 2003.[2,3] In 2012, an expert panel was convened in collaboration with the American Geriatrics Society to update the Beers criteria.[4] The panel was charged with both updating the Beers list and rating the quality of evidence which supported the panel's recommendations. To accomplish this, the panel systematically reviewed the literature, entertained public comment and graded the published evidence during an open period, per the Institute of Medicine standards. This approach ensured transparency and rigor. A modified Delphi method was used to achieve consensus on the panel's recommendations.

PIMs continue to be prescribed to older adults, despite evidence of poor outcomes and adverse events.[5–9] Prevalence of PIMs has been assessed in a variety of studies, in different settings and subpopulations, including several U.S. population-based. For example, estimates by Zhan et al.,[10] based on the 1996 Medical Expenditure Panel Survey (MEPS), indicate that over one-fifth of community-dwelling adults aged 65 years and over received at least one of 33 PIMs. PIM exposure was more common in older adults with poor health and a larger number of prescriptions. Trends from 1987 to 1996 indicated a reduction in PIM use for some drug groups. Decreased PIM exposures, and a higher risk of PIM exposures associated with poor health was confirmed in a study by Stuart et al.[11] using the 1995 and 1999 Medicare Current Beneficiary Survey. A more recent study by Zhang et al.[12] used the 2007 MEPS and operationalized the same 33 PIM recommendations from prior studies, found a dramatic decline in PIM exposure for older adults from 21.3% in 1996 to 13.8% in 2007.

With ongoing changes in medications available in the market, changing indications, and a heightened emphasis on medication safety, PIM use is a moving target, and estimates need

to be updated regularly. Prior estimates of PIM exposure reflect both earlier time periods and earlier versions of the Beers criteria. Furthermore, most prior estimates of PIM exposure selected drugs from the Beers list that should be avoided in all or most cases, but did not apply specific qualifying criteria such as dose, duration, and reason for use. To help fill the gap in the literature, and to provide a benchmark from which to observe future changes, we used the most recently available MEPS data to update PIM prevalence estimates that incorporate recent changes to the Beers criteria. Our study illustrates how operationalizing additional details of the Beers panel's recommendations alters the estimates of PIM prevalence, and provides a more clinically relevant estimate of PIMs. We also use the new system of evidence ratings in the Beers criteria to distinguish those PIM exposures supported by stronger evidence.

METHODS

Data and Cohort

We used data from the 2006–2010 MEPS, an on-going overlapping panel survey sponsored by the Agency for Healthcare Research and Quality (AHRQ) that collects detailed and nationally representative information on health care utilization and expenditures, insurance coverage, sources of payment, health status, and socio-demographic variables for the U.S. civilian, non-institutionalized population.[13,14] Each year a new panel of households is sampled and interviewed in five survey rounds over two-and-a-half years to obtain annual data reflecting a two year reference period. In each interview round, the MEPS collects information concerning new prescription fills. Respondents commonly use medicine bottles and receipts when providing this information, hence respondents tend to report chronic condition medication use accurately.[15] Additional details about medications, including quantity or days supplied, are obtained from dispensing pharmacies. The MEPS Prescribed Medicines files are linked to the Multum Lexicon database, a product of Cerner Multum, Inc., which facilitated identification of relevant drugs. The study also used the MEPS Condition files and Full-Year Consolidated files, which contain information on individuals' demographic, socio-economic and health characteristics. We limited our sample to adults aged 65 years and above.

Criteria Selection

The 2012 update of the Beers' criteria identified 38categories of drugs that should be avoided by older adults, as well as criteria specific to older adults with selected chronic conditions, and a smaller set of criteria associated with medications that should be used with caution. We focused on the first set of criteria, as they are applied most broadly, and scrutinized the criteria to determine which ones could be operationalized with greatest reliability using self-reported prescription drug and medical condition data reported in the MEPS. We selected 36 of the 38 categories, excluding insulin dosed on a sliding scale, as the MEPS did not provide a mechanism to distinguish a fixed from a flexible dosing schedule. We also excluded mineral oil, which we expected to be purchased over-the-counter, and thus, poorly documented within the MEPS.

Operational Definitions of PIM Use

Generating the operational definitions of PIM use involved a three-step process. In Step 1 we used the updated Beers' criteria to identify relevant medication names or therapeutic classes and the specific restrictions or exceptions related to dose, route, duration, and medical condition, as well as the ratings of evidence quality and recommendation strength. We merged this information onto the prescription medication files by drug name (including combination products) or therapeutic class so that each medication fill record had the relevant criteria to assess whether it qualified as a PIM. In Step 2 we used the data elements in the MEPS medication file to compute the parameters (e.g. dose), needed to assess whether the fill met the operational definitions for PIM use. The MEPS Prescribed Medication files include information on drug name, therapeutic class, dose form, route of administration, strength, quantity, and reasons for use (medical condition for which the drug was used). Medication fills from 2009 and 2010 also included days supplied, which we used to calculate daily quantity (fill quantity/days supplied). We used the information on daily quantity from fills in 2009–2010 to logically impute days supplied values for each drug/quantity combination in the 2006–2008 data. Information on quantity, strength and days supplied was used to calculate daily dose (quantity × strength/days). Finally, days supplied for each drug were summed across fills for each person to get annual days supplied, which was used to measure therapy duration. The reasons for use were based on self-report and coded to International Classification of Diseases, 9th revision, clinical modification (ICD-9-CM). We searched the medication fills for specific conditions mentioned in the Beers criteria. In sensitivity analyses, we linked and applied information about conditions of interest reported for each respondent but that were not reported to be the reason for using a specific drug. This broader group of conditions may have been reported as the reason for using other healthcare services, or because they caused lost work/school or bed days. Detailed information about the operational definitions for each drug category is provided in Appendix Table 1.

To develop an indicator that a fill met the criteria for a PIM (Step 3), we compared information from the Beers criteria (Step 1) to the medication and person-level information on each medication record developed during Step 2. We developed two operational definitions. A "broad" definition that assigned PIM status based on use of a specified drug, applying only those criteria related to form, route or dose restrictions where clearly specified. A "qualified" definition applied selected exceptions mentioned in the rationale associated with each drug category. These exceptions usually related to requirements for a minimum duration or therapy, or the presence of a medical condition, making the qualified definition more restrictive. Person-level PIM exposure measures were generated by summing the medication fill level PIM measures within each of the 36 drug categories, and then generating an indicator of PIM use that cut across the 36 categories.

Analytic Approach

We quantified the number and proportion of prescription medication fills that met the definition for PIM use, and the number and proportion of older adults with PIM use overall and by drug category. To characterize the difference between the two estimates, we measured the proportion of individuals whose PIM status was affected by duration and

condition restrictions. We used sampling weights to generate nationally representative, average annual estimates overall for 2006–2010. To assess changes in prevalence over time, we compared the person-level estimates for the periods 2006–2007 and 2009–2010. Estimated standard errors and t-tests of the significance of changes over time accounted for the complex design of the MEPS. Analyses were conducted using SAS version 9.2 (Cary, NC) and Stata12 (College Station, TX).

RESULTS

The study cohort included 18,475 person-years, accounting for an annual average of 39.58 million older adults, and 35.93 million older adults with at least one prescription medication. Over half (52.1%, S.E. 0.81%) were aged 65–74 years of age, four-fifths were white non-Hispanic, and 57% (S.E. 0.41%) were female. Detailed information about the characteristics of our older adult sample is provided in Appendix Table 2.

Table 1 presents PIM prevalence estimates. Among older adults with prescription medication use, 15.3 million, or 42.6% had at least one prescription medication fill that met the broad definition for a PIM (left side of table), accounting for 106.0 million PIM fills. The prevalence of PIM use by drug category ranged from a negligible quantity (for example, chloral hydrate or ergot mesylates) to a high of 10.9% for non-steroidal anti-inflammatory drugs (NSAIDs) and 9.3% for benzodiazepines. These drug categories affected 25.7% and 21.7%, respectively, of older adults with PIM fills. The average number of prescription fills per person that met the broad definition for a PIM ranged from a low of 2.6 for nitrofurantoin to a high of 6.4 for selected sulfonylureas and tricyclic antidepressants.

The overall prevalence using the qualified definition was 30.7% of older adults with drug use. The most prevalent individual categories continued to include NSAIDs, although the rate dropped to 4.7%, and selected sulfonylureas were used by 4.1%. The proportion with potentially inappropriate benzodiazepine use was much lower under the qualified definition at 0.9% of older adult medication users.

Only 9.2% of individual prescription fills could be classified as PIMs using the broad definition, with 6.6% under the qualified definition. Tables describing the distribution by drug category are provided in Appendix Table 3.

Figure 1 presents information about the distribution of additional criteria that were met under the qualified definition. Among older adults with any PIM under the qualified definition, 6.8% had a PIM that met specific dose criteria, while 27.7% had a PIM that met duration criteria and 19.5% had a PIM that met restrictions based on reasons for use. Nearly two-thirds (63.1%) had at least one fill for a drug that should always be avoided.

Figure 2 reports the distribution of adults by the quality of evidence used to characterize PIM status. Using the broad definition, over half (22% of 42.6%) of adults with a PIM had at least one medication for which the evidence quality was deemed to be high. When the qualified definition was applied, that proportion was slightly less than half (14.0% of 30.7%). We found that almost all adults with PIMs had at least one drug category where the recommendation was considered to be strong (data not shown).

Table 2 shows trends in the proportion of persons with PIM fills using the broad definition, comparing the periods from 2006–2007 to 2009–2010. Overall the rate declined from 45.5% in 2006–2007 to 40.8% in 2009–2010, representing a 10.3% decrease from the baseline ($p<0.01$). The categories with the largest absolute decline were NSAIDs, selected sulfonylureas, and estrogens, while use of skeletal muscle relaxants increased during this period. Parallel results using the qualified definition are provided as Appendix Table 4.

DISCUSSION

PIM use has been examined over the past three decades using previously published Beers criteria, in different settings and subpopulations, and in both the U.S. and internationally.[4,10–12] Given the changing landscape of available drugs, it is important to present updated information about the prevalence of PIM exposure. This is the first study to use nationally representative data for the U.S. community-based population to estimate prevalence of PIMs using the 2012 update to the Beers criteria. In this study we developed and applied two operational definitions, broad and qualified, to capture PIM use. Since the updated criteria included clinical caveats that are often important but hard to clearly define with administrative data, our approach is innovative and reveals important new information for research, education and practice. The most compelling finding shows that a high percentage (42%) of older adults received PIMs, but that a portion of them were used in cases where the duration was not particularly long, for patients who lacked specific medical conditions identified as problematic, or who had diagnoses for which use was justified. Even with these qualifications in the definition, almost one third (30.7%) of community-dwelling older adults were prescribed drugs, some of which are known to be associated with falls, delirium, declines in cognitive and physical functioning and other potentially serious health outcomes.[5,6,16] While the proportion of older adults with PIM use is large, these prescriptions make up a much smaller proportion of total prescription fills, suggesting that most prescribing is not problematic with respect to the dimensions captured by the Beers criteria. The analysis does not address adherence to guidelines nor cost of chosen therapy, dimensions that may also be relevant as quality and/or value indicators.

The updated 2012 American Geriatrics Society Beers Criteria continues to highlight the use of PIMs in older adults. We applied the updated criteria to the 2006–2010 MEPS, which was the most recent population-based data available when we conducted our study. These data pre-date the new guidelines, hence, they do not reflect potential changes in prescribing that may result from their dissemination. However, the evidence base used to update the criteria was developed over time, with some of the information available to clinicians during the study period. In an environment with evolving availability of both new and old drugs, and evidence on their effectiveness and safety, this study provides a useful snapshot and an important benchmark to assess the impact of the updated criteria over time.

Our analysis suggests that PIM use is decreasing, yet with the addition of new medication categories such as non-benzodiazepine sedatives, continued intervention and surveillance are needed.[4] Furthermore, PIM use has been operationalized as a marker of quality prescribing through various metrics and indicators.[17–19] Therefore, it is helpful to target key drug categories that have the highest prevalence in this study, namely first generation

antihistamines, antispasmodics, nonselective alpha1 blockers, non-benzodiazepine hypnotics, estrogens, selected sulfonylureas, NSAIDs and skeletal-muscle relaxants. Benzodiazepine use was also highly prevalent using the broad definition, although much less common when applying the qualified definition. Despite the continued prevalence in some categories, it is encouraging to note that the use of agents such as selected sulfonylureas, and digoxin, which have limited efficacy as well as increased adverse effects in older adults, appear to be declining.

Our estimates of PIM exposure are similar to estimates from selected subgroups of community-based older adults enrolled in managed care organizations (40.7%)[6] or receiving home care (38%),[20] yet substantially higher than those of other general community-based population estimates, for example the estimated 13.8% of older adults with PIM use in 2007.[12]The study by Zhang et al. applied the same criteria published in an earlier study by Zhan et al.[10]to permit comparison of trends over time. But while this approach may document discontinuation of older drugs, it does notincorporate newly available drugs, or drugs for which there is new evidence of harm, and will under-estimate the extent of problematic drug prescribing. Another key difference is that other studies only operationalized the subset of criteria where the drug was to be avoided in all cases. Our results indicate that among all adults with PIMs, only 63% of older adults had used PIMs that should be avoided universally.

There are limitations to this analysis. Some of the Beers' criteria could not be fully implemented, for example, the MEPS lacks information on the exact timing of medication use, so it was not possible to assess concurrent medication use or the timing of medication use relative to condition diagnosis. The MEPS drug use data may be subject to under-reporting. A recent comparison between drug use reported in the MEPS by Medicare beneficiaries, compared with Part D claims suggested that the MEPS underreports medication use for acute conditions, but to a lesser extent for chronic use.[21] Underreporting, therefore, is likely to affect our results for nitrofurantoin, but should be less important for the majority of other PIMs, which are primarily used to treat chronic conditions. Subsequent improvements to procedures for editing drug quantity in the MEPS were applied to these data, and are expected to reduce underreporting.[15,22] An additional limitation is that the reason for use of each drug was based upon self-report. Older adults taking many medications, especially off-label, may not be aware of the correct indication. As a result, certain diagnoses may be under-reported as the reason for using a drug. For example, antipsychotics are contraindicated for treatment of behavioral problems of dementia. We observed very few prescription records where the specific ICD-9 code was consistent with that criterion. We expanded our search to include dementia more broadly (without requiring the behavioral problems), but still found relatively few prescriptions reported as treatment related to dementia. We finally considered antipsychotic use among older adults with a diagnosis of dementia related to non-drug utilization or disability. As a result there is a large difference between PIM prevalence estimates using the broad definition (that did not require a diagnosis of dementia) and the qualified definition (that required the dementia diagnosis) associated with antipsychotics. We consider these to be upper and lower bound estimates, where the true estimate lies is unclear.

Despite these caveats, this study has several important strengths including the large sample size and transparent methods for determining PIM use with the AGS updated Beers criteria. This is also the first study to operationalize the clinical definition of PIMS in both a broad and qualified manner. This study has clear practice implications and the results illustrate that interventions to decrease PIM use are still greatly needed. Several interventions have been found to decrease PIM use if done before the point of ordering.[23] Several studies have used interruptive alerts when PIMs are prescribed to recommend alternative medications or non-drug approaches,[24] reduced dose and frequency, or no medication.[25,26] These types of alerts are most effective as they require an action from the provider or prescriber of the PIM before proceeding.

PIM exposure is a key element of quality. Because prescription drug availability changes over time, it is important to continually update the criteria used and add new drugs or eliminate drugs that are no longer on the market. In a related study, we examine characteristics of older adults who are more likely to experience PIMs, as well as selected characteristics of providers, and the association of PIM receipt with other dimensions of quality. Future studies should test interventions to decrease PIM use and evaluate the impact on clinical and patient outcomes. To have the largest return on investment, interventions to reduce PIMs should also focus on the most common PIMs such as NSAIDs and short-acting benzodiazepines. Ongoing studies utilizing the updated criteria are important to advancing the quality initiative for the prevention of adverse medication events in older adults.

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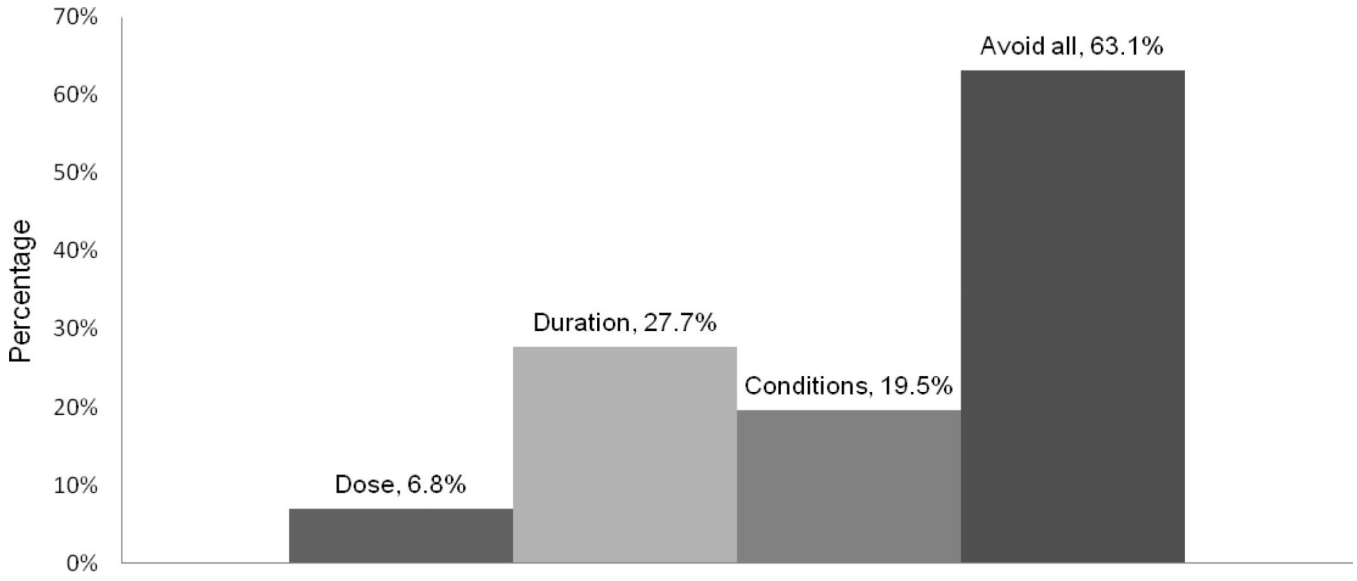

FIGURE 1.

Source: Medical Expenditure Panel Survey, Household Component, Consolidated files, 2006–2010.

Note: Individuals may have potentially inappropriate medication use (PIMs) in more than one category.

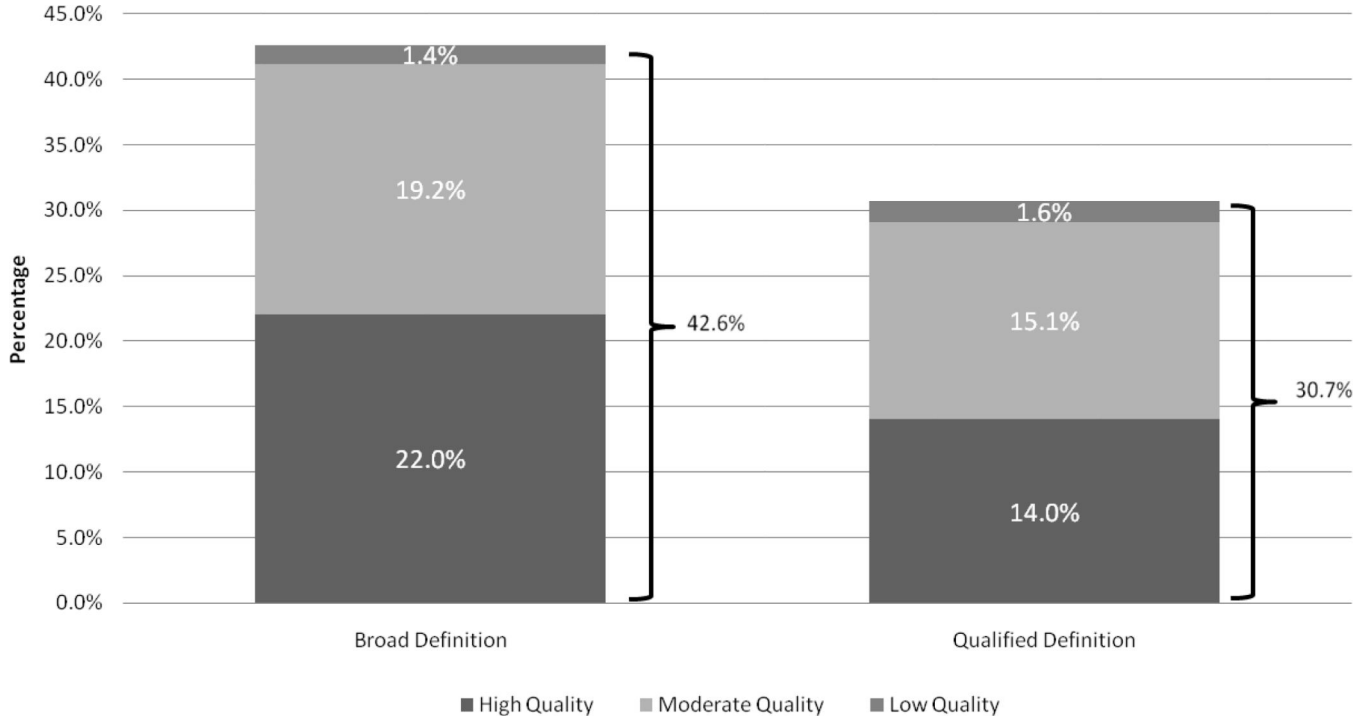

FIGURE 2.

Source: Medical Expenditure Panel Survey, Household Component, Consolidated files, 2006–2010.

Note: Individuals with multiple potentially inappropriate medications (PIMs) are categorized according the PIM with the highest level of evidence.

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Table 1

Potentially Inappropriate Medication Receipt among Older Adults, by Detailed Categories, Broad and Qualified Definitions, 2006–2010

	Broad Definition			Qualified Definition		
	Persons with PIMs as % of Older Adults with		Annual PIM Fills per Person/ Category	Persons with PIMs as % of Older Adults with		Annual PIM fills per person/ category
	Any Drug Use[1]	Any PIMs		Any Drug Use	Any PIMs	
Prevalence of PIMS, Any	42.6%	100.0%	6.9	30.7%	100.0%	6.9
By Category/ SubcategoryAnticholinergics						
First generation antihistamines	3.8%	8.8%	2.7	3.6%	11.6%	2.8
Antiparkinson	0.1%	0.3%	ns	0.1%	0.4%	ns
Antispasmodics	2.8%	6.6%	3.6	2.8%	9.1%	3.6
Antithrombotics						
Dipyridamole	rse	rse	ns	rse	rse	ns
Ticlopidine	rse	rse	ns	rse	rse	ns
Anti-infective						
Nitrofurantoin	1.3%	3.0%	2.6	0.6%	1.9%	ns
Cardiovascular						
Alpha1 blockers	4.3%	10.0%	5.3	3.7%	12.1%	5.3
Alpha agonists	2.2%	5.2%	6.1	2.2%	6.8%	6.1
Antiarrhythmics	2.4%	5.7%	6.1	1.0%	3.4%	5.1
Disopyramide	rse	rse	ns	rse	rse	ns
Dronedarone	rse	rse	ns	rse	rse	ns
Digoxin	1.8%	4.2%	6.0	1.8%	5.8%	6.0
Nifedipine, immediate release	0.2%	0.4%	ns	0.2%	0.6%	ns
Spironolactone	0.4%	1.0%	ns	rse	rse	ns
Central Nervous System						
Tricyclic antidepressants	2.3%	5.4%	6.4	2.3%	7.4%	6.4
Antipsychotics	1.8%	4.1%	6.1	0.3%	0.9%	ns
Thioridazine, Mesoridazine	rse	rse	ns	rse	rse	ns
Barbiturates	0.4%	1.0%	ns	0.4%	1.5%	ns

	Broad Definition			Qualified Definition		
	Persons with PIMs as % of Older Adults with		Annual PIM Fills per Person/ Category	Persons with PIMs as % of Older Adults with		Annual PIM fills per person/ category
	Any Drug Use[1]	Any PIMs		Any Drug Use	Any PIMs	
Benzodiazepines (all)	9.3%	21.7%	5.6	0.9%	2.9%	7.1
Short acting	6.7%	15.7%	5.6	0.6%	1.8%	6.9
Long acting	2.8%	6.7%	5.3	0.4%	1.2%	ns
Chloral hydrate	0.0%	0.0%	ns	0.0%	0.0%	ns
Meprobamate	rse	rse	ns	rse	rse	ns
Non-benzodiazepine hypnotics	3.3%	7.8%	4.7	1.7%	5.5%	7.3
Ergot mesylates	0.0%	0.0%	ns	0.0%	0.0%	ns
Endocrine						
Androgens	0.3%	0.8%	ns	0.2%	0.7%	ns
Dessicated thyroid	0.6%	1.5%	ns	0.6%	2.1%	ns
Estrogens with or without progestins	3.6%	8.4%	5.2	3.6%	11.6%	5.2
Growth hormone	rse	rse	ns	rse	rse	ns
Megestrol	0.3%	0.8%	ns	0.3%	1.1%	ns
Sulfonylureas	4.1%	9.6%	6.4	4.1%	13.3%	6.4
Gastrointestinal						
Metoclopramide	1.0%	2.4%	5.4	1.0%	3.3%	5.4
Trimethobenzamide	rse	rse	ns	rse	rse	ns
Pain						
Meperidine	0.1%	0.2%	ns	0.1%	0.3%	ns
Non-COX-selective NSAIDs	10.9%	25.7%	4.0	4.7%	15.2%	6.9
Indomethacine, Ketorolac	0.6%	1.5%	2.9	0.6%	2.1%	2.9
Pentazocine	rse	rse	ns	rse	rse	ns
Skeletal muscle relaxants	3.0%	7.1%	3.5	3.0%	9.9%	3.5

Source: Medical Expenditure Panel Survey Household Component, 2006–2010

Notes:

[1] Person purchased, or otherwise acquired, at least one outpatient prescription drug during the year.

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ns = insufficient sample to support reliable estimate; rse = relative standard error > 0.3.

Table 2

Change in Percent of Older Adults with Potentially Inappropriate Medication Receipt, Broad Definition, 2006/07 versus 2009/10

	Percentage of older adults with a PIM in		Percentage Point Change		Percent Change
PIM categories	**2006/07**	**2009/10**			
All PIMs	45.5%	40.8%	−4.7%	**	−10.3%
Anticholinergics					
First generation antihistamines	4.2%	3.4%	−0.8%	*	−19.3%
Antiparkinson	rse	rse			
Antispasmodics	2.9%	3.0%	0.1%		5.2%
Antithrombotics					
Dipyridamole	rse	rse			
Ticlopidine	rse	rse			
Anti-infective					
Nitrofurantoin	1.5%	1.3%	−0.3%		−18.0%
Cardiovascular					
Alpha1 blockers	4.5%	3.9%	−0.6%		−12.8%
Alpha agonists	2.4%	2.2%	−0.3%		−11.5%
Antiarrhythmics	2.3%	2.6%	0.2%		9.3%
Disopyramide	rse	rse			
Dronedarone	0.0%	rse			
Digoxin	2.0%	1.4%	−0.6%	*	−30.3%
Nifedipine, immediate release	0.3%	rse			
Spironolactone	0.4%	0.6%	0.2%		58.3%
Central Nervous System					
Tricyclic antidepressants	2.5%	2.1%	−0.4%		−16.5%
Antipsychotics	2.0%	1.7%	−0.3%		−15.4%
Thioridazine, Mesoridazine	rse	0.0%			
Barbiturates	0.5%	0.4%	−0.1%		−23.2%
Benzodiazepines (all)	9.5%	9.0%	−0.6%		−5.9%
Short acting	7.1%	6.3%	−0.8%		−11.3%

	Percentage of older adults with a PIM in		Percentage Point Change		Percent Change
PIM categories	**2006/07**	**2009/10**			
Long acting	2.8%	2.9%	0.2%		6.0%
Chloral hydrate	0.0%	0.0%			
Meprobamate	rse	rse			
Non-benzodiazepine hypnotics	3.3%	3.5%	0.1%		4.5%
Ergot mesylates	0.0%	0.0%			
Endocrine					
Androgens	0.4%	0.4%	0.0%		6.2%
Dessicated thyroid	0.9%	0.4%	−0.5%	**	−56.5%
Estrogens with or without progestins	4.3%	3.2%	−1.1%	**	−26.6%
Growth hormone	rse	0.0%			
Megestrol	0.4%	0.3%	−0.1%		−16.5%
Sulfonylureas	4.5%	3.5%	−1.0%	**	−22.4%
Gastrointestinal					
Metoclopramide	1.1%	0.9%	−0.2%		−14.0%
Trimethobenzamide	rse	rse			
Pain					
Meperidine	rse	rse			
Non-COX-selective NSAIDs	11.7%	10.4%	−1.4%	*	−11.7%
Indomethacine, Ketorolac	0.6%	0.6%	0.0%		6.2%
Pentazocine	rse	0.0%			
Skeletal muscle relaxants	3.0%	3.3%	0.3%		10.2%

Source: Medical Expenditure Panel Survey, Household Component, 2006–2010

Notes:

**(*) indicates $p < .05(.10)$ for the percentage point change; rse = relative standard error > 0.3.

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Appendix Table 1

Operationalizing Broad and Qualified Definitions of Potentially Inappropriate Medication Use in the Medical Expenditure Panel Survey, 2006–2010

		Broad definition		Qualified definition	
Category/subcategory	**Conditions/exceptions**	**Detailed notes**		**Conditions/exceptions**	**Detailed notes**
Anticholinergics (excluding) TCA)					
First generation antihistamines	1	Avoid all, except for single agent diphenhydramine with route of administration other than oral.	Administration route for diphenhydramine was almost always oral.	Oral diphenhydramine excepted (not a PIM) if duration < 1 month	For single agent diphenhydramine, we assessed duration and exempted use <=1month as a proxy for acute use to treat severe allergic reactions.
Antiparkinson agents	2	Avoid all, except benztropine with route of administration other than oral.		Same as Broad definition	
Antispasmodics	3	Avoid all, no exceptions		Same as Broad definition	
Antithrombotics					
Dipyridamole	4	Avoid only oral short acting version	Avoid If dose form is **not** extended release tablet, extended release capsule, or delayed release capsule.	Same as Broad definition	
Ticlopidine	5	Avoid all, no exceptions		Same as Broad definition	
Anti-infectives					
Nitrofurantoin	6	Avoid all, no exceptions		Avoid for long-term use, avoid in patients with creatinine clearance < 60 mL/min	Long term use defined as > 30 days, measured by days supplied. Could not operationalize creatinine clearance measure. Instead searched for any reported health service use to treat chronic kidney disease (ICD9 codes 403, 404, or 585) as a proxy for poor creatinine clearance.
Cardiovascular					
Alpha1 blockers	7	Avoid doxazosin, prazosin and terazosin.		Avoid for treatment of hypertension and most other uses; exception if drug is used to increase urinary flow in men with benign prostatic hypertrophy (BPH)	Excepted if BPH (ICD9 code 600) was reported as the condition alpha1 blockers were intended to treat.
Alpha agonists, central	8	Avoid all, no exceptions		Avoid clonidine as first line antihypertensive	Could not operationalize therapy lines in MEPS.

		Broad definition		Qualified definition	
Category/subcategory	**Conditions/exceptions**	**Detailed notes**		**Conditions/exceptions**	**Detailed notes**
Antiarrhythmic drugs (Class la, 1c, III)	9	Avoid all, no exceptions		Avoid use for atrial fibrillation. All other conditions excepted.	Categorized as PIM if atrial fibrillation (ICD9 codes 427.3*, 427.89 or 427.9) was reported as the condition antiarrhythmic drugs were intended to treat.
Disopyramide	10	Avoid all, no exceptions		Same as Broad definition	
Dronedarone	11	Avoid all, no exceptions		Avoid if patient has atrial fibrillation or congestive heart failure (CHF)	Searched for any health services use to treat atrial fibrillation ICD9 codes (427.31, 427.32, 427.89, 427.9) or CHFICD9 (code 428).
Digoxin	12	Avoid if dose > 125 microgram/day	Assigned if digoxin strength is 250 mcg.	Same as Broad definition	
Nifedipine, immediate release	13	Avoid if not extended release	Exception if dose form is extended release tablet, extended release capsule, or delayed release capsule.	Same as Broad definition	
Spironolactone	14	Avoid if dose > 25 mg/day	Assigned if spironolactone strength is 50 mg or 100 mg.	Avoid if dose > 25 mg/day and if patient has CHF or with creatinine clearance < 30 mL/min	Could not operationalize creatinine clearance criterion. Instead used CKD diagnosis. Assigned if spironolactone strength is 50 mg or 100 mg, and if patient has any reported health service use to treat CHF (ICD9 code 428) or CKD (403, 404, 585).
Central Nervous System					
Tricyclic antidepressants (TCA)	15	Avoid if doxepin > 6 mg/ day; avoid all others		Same as Broad definition	
Antipsychotics (conventional & atypical)	16	Avoid all, no exceptions		Avoid use for behavioral problems of dementia.	Limited use of codes for behavioral problems of dementia, so we used broader set of dementia codes (ICD9 290, 294 and 331) reported as the condition antipsychotics were intended to treat. Due to concerns about under-reporting of dementia as a reason for drug use, we assigned as PIM if the patient reported any health service use to treat dementia.
Thioridazine, Mesoridazine	17	Avoid all, no exceptions		Same as Broad definition	
Barbiturates	18	Avoid all, no exceptions		Same as Broad definition	

		Broad definition		Qualified definition	
Category/subcategory	**Conditions/exceptions**	**Detailed notes**		**Conditions/exceptions**	**Detailed notes**
Benzodiazepine - short acting	19	Avoid all, no exceptions		Avoid if used to treat delirium, insomnia, or agitation.	Categorized as PIM if delirium (290, 780.1), or insomnia (780.5, 780.9, 327) were reported as the condition benzodiazepines were intended to treat. Due to concerns about under-reporting of dementia (underlying reason for agitation diagnosis) as a reason for drug use, we assigned as PIM if the patient reported any health service use for dementia.
Benzodiazepine-long acting	19	Avoid all, no exceptions			
Chloral hydrate	20	Avoid all, no exceptions		Same as Broad definition	
Meprobamate	21	Avoid all, no exceptions		Same as Broad definition	
Non-benzodiazepine hypnotics	22	Avoid all, no exceptions		Avoid chronic use (> 90 days supplied during year)	Duration of therapy measured based on days supplied.
Ergot mesylates: isoxsuprine	23	Avoid all, no exceptions		Same as Broad definition	
Endocrine					
Androgens	24	Avoid all, no exceptions		Avoid except for use for hypogonadism	Excepted if hypogonadism (ICD9 code 257) was reported as the condition androgens were intended to treat.
Dessicated thyroid	25	Avoid all, no exceptions		Same as Broad definition	
Estrogens w/ or w/o progestins	26	Avoid oral or transdermal, except vaginal		Same as Broad definition	
Growth hormone	27	Avoid all, no exceptions		Same as Broad definition	
Insulin, sliding scale	28	Not implemented	MEPS did not provide a mechanism to distinguish a fixed from a flexible dosing schedule.	Same as Broad definition	
Megestrol	29	Avoid all, no exceptions		Same as Broad definition	
Sulfonylureas	30	Avoid chlorpropamide and glyburide, no exceptions		Same as Broad definition	
Gastrointestinal					
Metoclopramide	31	Avoid all, no exceptions		Avoid except for use for gastroparesis.	Unable to implement exception because of under-reporting of gastroparesis.

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		Broad definition		Qualified definition	
Category/subcategory	**Conditions/exceptions**	**Detailed notes**		**Conditions/exceptions**	**Detailed notes**
Mineral oil, oral	32	Not implemented	OTC purchases poorly documented in MEPS	Not implemented	
Trimethobenzamide	33	Avoid all, no exceptions		Same as Broad definition	
Pain					
Meperidine	34	Avoid all, no exceptions		Same as Broad definition	
Aspirin	35	Avoid if daily dose>325 mg	Assigned if aspirin strength was 600 mg or 770 mg.	Avoid chronic NSAID use	Assigned if aspirin strength was 600 mg or 770 mg and days supplied > 90.
Non-Cox selective NSAIDs, oral	35	Avoid all, no exceptions		Avoid chronic NSAID use	Assigned if days supplied > 90.
Indomethacin	36	Avoid all, no exceptions		Same as Broad definition	
Ketorolac, oral & parenteral	36	Avoid all, no exceptions		Same as Broad definition	
Pentazocine	37	Avoid all, no exceptions		Same as Broad definition	
Skeletal muscle relaxants	38	Avoid all, no exceptions		Same as Broad definition	

Appendix Table 2

Characteristics of U.S. Community-Dwelling Older Adults, 2006–2010

	Total Number of Older adults :			Percent Distribution of Older adults[1]	
Adult characteristics	**Unweighted**	**Average Annual Total (1,000s)**	**Std Error**	**Percent**	**Std Error**
Age					
65–74	9,912	20,603	558	52.1%	0.8%
75–84	6,241	13,738	429	34.7%	0.6%
85 and older	2,322	5,241	238	13.2%	0.5%
Race/ethnicity					
White, non-Hispanic	11,748	31,507	875	79.6%	0.8%
Black, non-Hispanic	3,063	3,386	170	8.6%	0.4%
Hispanic	2,326	2,784	174	7.0%	0.5%
Other	1,338	1,906	214	4.8%	0.5%
Sex					
Male	7,897	17,066	456	43.1%	0.4%
Female	10,578	22,517	549	56.9%	0.4%
Marital Status					
Currently married	9,654	21,359	655	54.0%	0.8%
Formerly married	8,063	16,776	450	42.4%	0.7%
Never married	757	1,446	97	3.7%	0.2%
Education					
Less than High School	5,822	9,375	277	23.7%	0.6%
High School graduate	5,905	13,719	433	34.7%	0.7%
Some college (1–3 years)	3,003	7,218	264	18.2%	0.5%
College graduate (4 yrs)	1,906	4,730	231	12.0%	0.5%
Post graduate (5+ yrs)	1,533	4,053	203	10.2%	0.4%
Income relative to FPL					
Poor (< 100% FPL)	2,926	3,902	146	9.9%	0.3%
Low income (100–<200%)	4,847	10,068	288	25.4%	0.5%
Middle income (200–<400%)	5,411	11,674	364	29.5%	0.6%

Adult characteristics	Total Number of Older adults : Unweighted	Average Annual Total (1,000s)	Std Error	Percent Distribution of Older adults[1] Percent	Std Error
High income (>=400%)	5,291	13,938	471	35.2%	0.7%
Supplemental Insurance					
Private group with drug coverage	6,287	15,057	465	38.0%	0.7%
Private non-group with drug coverage	2,894	3,953	152	10.0%	0.4%
Medicaid with drug coverage	1,648	4,080	179	10.3%	0.4%
Medicare managed care with drug coverage	3,775	8,055	361	20.3%	0.7%
No medical supplement, drug coverage	1,669	3,535	189	8.9%	0.4%
Private or public supplemental without drug coverage	694	1,778	130	4.5%	0.3%
No medical or drug supplemental coverage	1,508	3,124	158	7.9%	0.4%
General health status					
Excellent/Very Good	4,203	10,456	350	26.4%	0.5%
Good	6,516	14,460	420	36.5%	0.5%
Fair/Poor	7,581	14,295	377	36.1%	0.6%
Body Mass Index					
Less than 25	6,040	13,105	392	33.1%	0.6%
25 to 30	6,572	14,181	420	35.8%	0.5%
More than 30	4,647	9,675	292	24.4%	0.5%
ADL limits					
Yes	2,000	3,720	190	9.4%	0.4%
No	15,867	34,346	857	86.8%	0.4%
IADL limits					
Yes	3,556	6,884	251	17.4%	0.5%
No	14,311	31,181	809	78.8%	0.5%
Census Region					
Northeast	3,067	7,864	355	19.9%	0.8%
Midwest	3,911	8,789	461	22.2%	1.0%
South	7,231	14,634	566	37.0%	1.1%
West	4,266	8,295	360	21.0%	0.8%
MSA status					

Adult characteristics	Total Number of Older adults : Unweighted	Average Annual Total (1,000s)	Std Error	Percent Distribution of Older adults[1] Percent	Std Error
MSA	14,629	31,907	870	80.6%	1.40%
Non-MSA	3,846	7,675	610	19.4%	1.40%
Has usual source of care?					
Yes	16,350	35,259	875	89.1%	0.33%
No	1,342	2,513	124	6.3%	0.29%
More likely than others to take risks					
No / uncertain	13,509	28,918	703	73.1%	0.44%
Yes	2,687	5,828	204	14.7%	0.35%
Smoke					
No	14,851	32,002	810	80.8%	0.41%
Yes	1,670	3,367	130	8.5%	0.30%

Source: Medical Expenditure Panel Survey Household Component, Consolidated Files 2006–2010

Notes:

[1] Due to rounding and missing values, percentages do not always sum to 100%.

FPL = Federal poverty line; ADL = activities of daily living; IADL = instrumental activities of daily living; MSA = metropolitan statistical area.

The following variables have some missing values: education, health status, BMI, ADL, IADL, usual source of care, more likely to take risks and smoking status.

Appendix Table 3

Potentially Inappropriate Prescription Medication Fills Among Older Adults, by Detailed Categories, 2006–2010

	Broad Definition		Qualified Definition	
	PIM fills as a percentage of:		PIM fills as a percentage of:	
PIM categories	**All Drug Purchases**	**All PIM Fills**	**All Drug Purchases**	**All PIM Fills**
All PIM fills	9.2%	100.0%	6.6%	100.0%
Anticholinergics				
First generation antihistamines	0.3%	3.5%	0.3%	4.7%
Antiparkinson	0.0%	0.3%	0.0%	0.4%
Antispasmodics	0.3%	3.4%	0.3%	4.8%
Antithrombotics				
Dipyridamole	rse	rse	0.0%	rse
Ticlopidine	rse	rse	0.0%	rse
Anti-infective				
Nitrofurantoin	0.1%	1.2%	0.1%	1.2%
Cardiovascular				
Alpha1 blockers	0.7%	7.7%	0.6%	9.3%
Alpha agonists	0.4%	4.6%	0.4%	6.3%
Antiarrhythmics	0.5%	5.0%	0.2%	2.5%
Disopyramide	rse	rse	rse	rse
Dronedarone	rse	rse	rse	rse
Digoxin	0.3%	3.6%	0.3%	5.0%
Nifedipine, immediate release	0.0%	0.3%	0.0%	0.4%
Spironolactone	0.1%	0.8%	0.0%	rse
Central Nervous System				
Tricyclic antidepressants	0.5%	5.0%	0.5%	6.9%
Antipsychotics	0.3%	3.6%	0.0%	0.6%
Thioridazine, Mesoridazine	rse	rse	rse	rse
Barbiturates	0.1%	0.7%	0.1%	0.9%
Benzodiazepines (all)	1.6%	17.7%	0.2%	3.0%
Short acting	1.2%	12.6%	0.1%	1.8%
Long acting	0.5%	5.1%	0.1%	1.1%
Chloral hydrate	0.0%	0.0%	0.0%	0.0%
Meprobamate	rse	rse	rse	rse
Non-benzodiazepine hypnotics	0.5%	5.3%	0.4%	5.9%
Ergot mesylates	0.0%	0.0%	0.0%	0.0%
Endocrine				
Androgens	0.0%	0.5%	0.0%	0.4%
Dessicated thyroid	0.1%	1.3%	0.1%	1.8%
Estrogens with or without progestins	0.6%	6.3%	0.6%	8.8%

	Broad Definition		Qualified Definition	
	PIM fills as a percentage of:		PIM fills as a percentage of:	
PIM categories	**All Drug Purchases**	**All PIM Fills**	**All Drug Purchases**	**All PIM Fills**
Growth hormone	rse	rse	0.0%	rse
Megestrol	0.0%	0.4%	0.0%	0.5%
Sulfonylureas	0.8%	8.8%	0.8%	12.3%
Gastrointestinal				
Metoclopramide	0.2%	1.9%	0.2%	2.6%
Trimethobenzamide	rse	rse	0.0%	rse
Pain				
Meperidine	rse	rse	0.0%	rse
Non-COX-selective NSAIDs	1.4%	14.7%	1.0%	15.3%
Indomethacine, Ketorolac	0.1%	0.6%	0.1%	0.9%
Pentazocine	rse	rse	0.0%	rse
Skeletal muscle relaxants	0.3%	3.6%	0.3%	5.1%

Source: Medical Expenditure Panel Survey Household Component, 2006–2010

Notes:

ns = insufficient sample to support reliable estimate; rse = relative standard error > 0.3.

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Appendix Table 4

Change in Percent of Older Adults with Potentially Inappropriate Medication Receipt, Qualified Definition, 2006/07 versus 2009/10

	Percentage of older adults with a PIM in		Percentage Point Change		Percent Change
PIM categories	**2006/07**	**2009/10**			
Any PIM	33.1%	29.3%	−3.8%	**	−11.5%
Anticholinergics					
First generation antihistamines	4.0%	3.2%	−0.8%	*	−19.3%
Antiparkinson	rse	rse			0.0%
Antispasmodics	2.9%	3.0%	0.1%		5.2%
Antithrombotics					
Dipyridamole	rse	rse			
Ticlopidine	rse	rse			
Anti-infective					
Nitrofurantoin	0.7%	0.5%	−0.2%		−29.5%
Cardiovascular					
Alpha1 blockers	3.8%	3.5%	−0.3%		−7.6%
Alpha agonists	2.4%	2.2%	−0.3%		−11.5%
Antiarrhythmics	1.0%	1.2%	0.2%		19.9%
Disopyramide	rse	rse			
Dronedarone	0.0%	0.0%	0.0%		
Digoxin	2.0%	1.4%	−0.6%	*	−30.3%
Nifedipine, immediate release	0.3%	rse			
Spironolactone	0.0%	rse			
Central Nervous System					
Tricyclic antidepressants	2.5%	2.1%	−0.4%		−16.5%
Antipsychotics	0.2%	0.3%	0.1%		36.4%
Thioridazine, Mesoridazine	rse	0.0%			
Barbiturates	0.5%	0.4%	−0.1%		−23.2%
Benzodiazepines (all)	0.9%	0.9%	0.0%		2.9%
Short acting	0.7%	0.6%	−0.1%		−15.3%

	Percentage of older adults with a PIM in		Percentage Point Change		Percent Change
PIM categories	**2006/07**	**2009/10**			
Long acting	0.3%	0.4%	0.1%		30.1%
Chloral hydrate	0.0%	0.0%	0.0%		
Meprobamate	rse	rse			
Non-benzodiazepine hypnotics	1.5%	2.0%	0.5%		30.0%
Ergot mesylates	0.0%	0.0%	0.0%		
Endocrine					
Androgens	rse	0.2%			
Dessicated thyroid	0.9%	0.4%	−0.5%	**	−56.5%
Estrogens with or without progestins	4.3%	3.2%	−1.1%	**	−26.6%
Growth hormone	rse	0.0%			
Megestrol	0.4%	0.3%	−0.1%		−16.5%
Sulfonylureas	4.5%	3.5%	−1.0%	**	−22.4%
Gastrointestinal					
Metoclopramide	1.1%	0.9%	−0.2%		−14.0%
Trimethobenzamide	rse	rse			
Pain					
Meperidine	rse	rse			
Non-COX-selective NSAIDs	4.9%	4.7%	−0.2%		−3.8%
Indomethacine, Ketorolac	0.6%	0.6%	0.0%		6.2%
Pentazocine	rse	0.0%			
Skeletal muscle relaxants	3.0%	3.3%	0.3%		10.2%

Source: Medical Expenditure Panel Survey Household Component, Consolidated Files 2006–2010

Notes:

**(*)indicates p < .05(.10) for the percentage point change; rse = relative standard error > 0.3.