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Health Outcomes Associated With Potentially Inappropriate Medication Use in Older Adults

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Abstract

The purpose of this study was to examine the prevalence of potentially inappropriate medication use (PIMs) among community-dwelling older adults and the association between PIMs and health care outcomes. Participants were 17,971 individuals age 65 years and older. PIM use was defined by the Beers criteria. Drug-related problems (DRPs) were defined using ICD-9 codes. Forty percent of the 17,971 individuals filled at least 1 PIM prescription, and 13% filled 2 or more PIM prescriptions. Overall DRP prevalence among those with at least 1 PIM prescription was 14.3% compared to 4.7% in the non-PIM group ($p < .001$). In conclusion, preventing PIM use may be important for decreasing medication-related problems, which are increasingly being recognized as requiring an integrated interdisciplinary approach.

Keywords

medications; healthcare costs; geriatrics; adverse drug events

Drug-related problems (DRPs) are prevalent in the older adult population and pose a major patient safety concern. DRPs arise because of the increasing number of medications required by this age group, fragmented systems of care, pre-existing health conditions, and the pharmacokinetic and pharmacodynamic changes that occur with aging (Bigos, Bies, & Pollock, 2006; Cusack, 2004; Gurwitz, 2004; Hajjar et al., 2003; Turnheim, 2004, 2005). Avoiding use of high-risk drugs is an important strategy in reducing DRPs. The purpose of this study was to examine both the prevalence of potentially inappropriate medication (PIMs) use among community-dwelling older adults and the association between PIMs and health care outcomes.

One method promoted to identify high-risk medications is the use of an explicit list of PIMs. PIMs were first devised and publicized by Beers et al. for nursing home residents and subsequently expanded to include older adults in all settings (Beers, 1997). PIMs are medications identified through expert panel review as having risks that outweigh benefits (Beers et al., 1991). Since the early 1990s, the prevalence of PIMs has been examined in a

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number of long-term care (Lau, Kasper, Potter, & Lyles, 2004), outpatient (Aparasu & Sitzman, 1999; Curtis et al., 2004), acute care (Onder et al., 2005), and community settings (Zhan et al., 2001). For research purposes, use of explicit criteria is generally preferred over the use of implicit criteria applied by expert reviewers.

The clinical validity of using a list of medications based on expert panel review and explicit criteria has been questioned as being overly simplistic and not including all the common drugs causing problems in older adults (Crownover & Unwin, 2005; Shorr, 2004). Moreover, despite the numerous reports of the prevalence of PIMs, only a few investigators (Fu, Liu, & Christensen, 2004; Thapa, Gideon, Cost, Milam, & Ray, 1998) have examined whether PIMs are associated with adverse clinical outcomes. Therefore, we investigated the outcomes associated with PIM use in a population of community-dwelling older adults.

The Beers criteria have been revised recently; hence, the current prevalence of PIMs in managed care populations is unreported. In this study, the prevalence of PIMs was examined using the most currently revised list (Fick et al., 2003) with community-dwelling older adults in a managed care organization (MCO). Additionally, the association between PIMs and selected health care outcomes and DRPs was examined to determine the clinical usefulness of the PIMs criteria. The specific aims were to: (a) describe the prevalence and characteristics of medication use in a community-dwelling managed care population aged 65 and older, (b) compare the use of healthcare services and costs among older adults on PIMs to those who were not on PIMs, and (c) describe the prevalence of DRPs in persons with and without PIMs.

METHOD

Design

In this retrospective cohort study, an administrative database from a large MCO located in the Southeast United States was used to examine medication use in patients aged 65 and older. Lines of service included the Medicare+Choice product line only. Approval for this study was received from the University Institutional Review Board for human subjects research.

Sample and Procedures

We identified 17,971 individuals aged 65 years and older who were continuously enrolled for a 6-month period from January 1, 2000 through June 30, 2000. All claims filed for these individuals during this 6-month time period were extracted. PIM use was defined by the Beers criteria, and any participant using at least one such drug was defined to be in the PIM group.

To determine the prevalence of PIMs, all individuals were included in the analyses. To determine cost, utilization, and DRPs, 1,094 individuals were excluded because they had no professional or facility claims by which to define these variables; the final sample was 16,877. There were 6,875 participants in the PIM group with at least one use of health services and 10,002 in the comparison group. Sixty-one percent of the 16,877 individuals were female, and the mean age was 73.33 years (*SD*=6.47; Table 1). There were no differences between the two groups on age, but there were more women in the PIM group (Table 1).

Measures

Demographics and co-morbidity—ICD-9 codes taken from the discharge diagnosis listing (up to 10 per patient) were used to determine medical diagnoses. Comorbidity was measured using the Deyo-adapted Charlson Comorbidity Index (Deyo, Cherkin, & Ciol, 1992). The Deyo version was designed for use with administrative databases and has proven reliability and validity across multiple populations. Comorbid conditions were identified using ICD-9 codes, then assigned a weighting that takes into account both the number and seriousness

of comorbidities. The Charlson index contains 18 categories of comorbidity: the higher the score, the more severe the burden of comorbidity. Age was calculated based on birth date, as of January 1, 2000. Payor status was the Medicare+ Choice product line only.

Potentially inappropriate medications (PIMs)—PIMs consensus criteria (Fick et al., 2003) identify specific medications that should be avoided in the elderly regardless of diagnosis. We used the medications or medication classes from pages 2,719 to 2,720 in the 2003 update of the list that *should generally be avoided* in persons aged 65 or older because they are either ineffective or because they pose unnecessarily high risk for older persons and a safer alternative is available. Also included were all those that were dose dependent (such as digoxin and the short-acting benzodiazepines). When a criterion applied only to excessive dose, data on dose were used to assure accurate analysis. All modifications from the 2003 update, including the exclusion of extended-release oxybutynin, were incorporated. Beers medications from Table 2 of the article that considered diagnosis or condition were not included in our analyses, as information about diagnoses is likely to be incomplete and unreliable in this type of administrative database.

Potential drug-related problems—DRPs were defined using ICD-9 codes for principal and secondary diagnoses. The ICD-9 codes were selected based on review of the literature and previous studies on potential DRPs in older adults (Budnitz et al., 2005; Chan, Nicklason, & Vial, 2001; Hanlon et al., 1997). These codes and the method have been described previously (Kolanowski, Fick, Waller, & Ahern, 2006). They represent a conservative assessment of DRPs. Codes were selected that represent plausible adverse effect links with drugs included in the Beers criteria. For example, an individual prescribed a benzodiazepine or tricyclic antidepressant may subsequently develop a problem with falling or acute confusion (Budnitz et al., 2005; Chan et al., 2001; Hanlon et al., 1997). Codes were examined the same way in both the PIM and comparison groups. To be considered a potential DRP, these coded medical conditions had to occur within 30 days after a new prescription was dispensed. New prescription refills were those not in the database at the time of enrollment. Refills were not considered new prescriptions. New prescriptions were defined the same in both the cases and comparison group. Both groups had only unique prescriptions (no refills) considered in the analysis of costs and DRPs. This method considers both the temporal relationship between the drug and DRP, as well as events that are a known effect of the drug exposure (biologic plausibility).

Health care utilization and costs—Health care costs were defined based on the MCO claims data for payments in U.S. dollars (year 2000) made directly to the provider. Medical claims data were used for services performed in every setting. There were three types of medical services from an insurance/payment standpoint (i.e., facility, which are billed on UB-92 forms; professional, which are billed on HCFA 1500 forms; and pharmacy). Places of treatment included inpatient, Outpatients (OP; including OP surgeries, radiology, OP clinics affiliated with hospitals, emergency room, homecare, and physician office visits). Costs included total, facility, provider, and prescription components. Subjects were community dwelling at baseline, and any nursing home claims were for short-stay, skilled nursing home visits. None of the patients was in the nursing home at baseline. Utilization included prescriptions in both inpatient and OP settings. Filled prescriptions were defined as total numbers, and included refills. Refills were not included in the calculation of unique prescriptions. All numbers presented are for a 6-month period.

Statistical Analyses

Statistical significance was assessed with an alpha level of .05. Prevalence for each individual PIM and use of any PIM were determined for the full sample of 17,971. Basic chi-square and

t-tests were performed to examine differences between those who had been prescribed a PIM and those who had not been prescribed a PIM. Also examined were differences in rates of demographic characteristics and proxy DRPs between the PIM and comparison groups. Odds ratios and 95% confidence intervals (CI) for the DRPs were determined to show the magnitude of the association. Chi-square tests were performed, and when the cell sizes were too small to conduct a valid chi-square test, a Fisher's exact test was performed. Likewise, the percent of individuals on each PIM and a distribution of the number of PIMs per individual were determined.

A series of analyses of covariance models corresponding to the four types of paid costs (total, provider, facility, and prescription) and four types of utilization (inpatient stays, OP visits, office visits, and ER visits) were used to assess whether costs and utilization were different among those using no PIMs, those prescribed one PIM, and those prescribed two or more PIMs. Potential covariates included sex, age, and the Charlson Comorbidity Index. Due to the non-normality of the cost and utilization data and the large variability, the natural log transformation of the cost or utilization variable was used in the ANCOVA models. Post hoc differences were performed using a Bonferroni correction to the overall alpha level. Logistic regression for each of the four types of utilization was used to determine the odds of having a visit among those with a PIM versus the odds of having a visit among the comparison group, controlling for sex, age, and the Charlson Comorbidity Index.

RESULTS

Prevalence of PIMs

Table 2 displays the distribution and range of PIMs. Of the 16,877 individuals with at least one use of health services, 6,875 (40.7%) filled at least one PIM prescription and 2,326 (13.8%) filled more than one. Table 2 also displays the prevalence of each unique PIM among all 17,971 individuals. Where there is an overlap in individual drugs and classes, an individual drug was counted in only one category (immediate release oxybutynin, flurazepam, amitriptyline, etc.). The most frequently prescribed PIMs in descending order were estrogens only (i.e., without progesterones), propoxyphene, benzodiazepines, digoxin >.125 mg/d, non-steroidal anti-inflammatory drugs (NSAIDS), anticholinergics, muscle relaxants, and amitriptyline.

PIM Use and Drug-Related Problems

The overall prevalence of a DRP occurring within 30 days of a new prescription among those with at least one PIM prescription was 14.3% (Table 3). The prevalence of any DRP in the comparison group was only 4.7% ($p < .01$). For each type of DRP, the prevalence was higher for the majority of DRPs among those having a PIM versus the comparison group. Overall, the prevalence of any DRP was significantly higher among those with a PIM than the comparison group.

PIM Use, Co-Morbidity, Cost, and Utilization

Among those in the PIM group, the mean Charlson Comorbidity Index (Deyo et al., 1992) was .84 (*SD*=1.38). Among those in the comparison group, the mean Charlson Comorbidity Index was .60 (*SD*=1.08). All costs (total, facility, provider, and prescription) had significant correlations with the number of PIMs used, after controlling for sex, age, and the Charlson Comorbidity Index. The Tukey–Kramer post hoc tests indicated that the adjusted least square means were all significantly different from one another for all types of costs (total, facility, provider, and prescription), with two or more PIM having the highest costs, followed by the one PIM group, and then the comparison group (Table 4). Also, the number of inpatient, OP, office, and emergency room visits increased significantly in those using PIMs: two or more

PIM group had the highest utilization, followed by the one PIM group, and then the comparison group, after controlling for sex, age, and the Charlson Comorbidity Index.

Those prescribed one or more PIMs as compared to those prescribed no PIMs had increased inpatient visits (OR 1.99, 95% CI: 1.76–2.26); increased OP visits (OR 1.53, 95% CI: 1.43–1.63); increased office visits (OR 1.89, 95% CI: 1.55–2.30); and increased emergency room visits (OR 1.98; CI: 1.77–2.20). Even after adjusting for increasing age, being female, and higher comorbidity scores, the presence of PIMs increased the risk of health care utilization 1.5–2 times that of the non-PIM comparison group.

DISCUSSION

In this study, the researchers examined the prevalence of PIMs among community-dwelling older adults and the association between new onset DRPs with new prescriptions among those receiving PIMs compared to those not receiving PIMs. In this group of community-dwelling managed-care elderly, 40% of older adults were using PIMs as defined by the updated Beers criteria (Fick et al., 2003). This prevalence rate is higher than reported in studies of community-dwelling older adults using the previous criteria, which indicated a prevalence of 25–30% (Stuart et al., 2003; Zhan et al., 2001). Because 9.6% of our study population was on estrogens only, the increase in overall prevalence seems related in large part to this addition to the revised Beers criteria.

We also found that PIM use as defined by the updated Beers criteria is associated with increased likelihood of potential DRPs and resulted in higher healthcare costs and utilization compared to persons not on PIMs. This finding is important because some investigators have questioned the validity of using expert panels to determine PIMs (Crownover & Unwin, 2005; Rask et al., 2005; Shorr, 2004). In a study of 211 Medicare enrollees, Rask et al. (2005) found that PIMs were not associated with DRP; indeed, the majority of DRPs in this study occurred in persons prescribed non-PIMs. Researchers in several recent controlled studies, however, have begun to show a link with the Beers criteria and poorer patient outcomes (Klarin, Wimo, & Fastbom, 2005; Lau et al., 2004). Lau et al. found PIM use was associated with increased risk of hospitalization and increased risk of deaths among NH residents. Klarin et al. found an increased risk of hospitalization with inappropriate medication use in the community-dwelling elderly (derived from the Beers and Canadian criteria) after controlling for age, sex, race, co-morbidity, functional level, smoking, and body mass index. The recent Institute of Medicine (IOM) report *Preventing Medication Errors* addressed the use of inappropriate medications in the section on prescribing and ordering, and cites previous interventions on inappropriate medication using the Beer's criteria as an example of strategies for weighing the use of non-pharmacological approaches with the risks and benefits of medications in older adults (Committee on Identifying and Preventing Medication Errors, Aspden, Wolcott, Bootman, & Cronenwett [CIPME 2007], p. 71). On the other hand, the authors also concluded that there are not enough rigorous studies on outcomes using these criteria to currently endorse their widespread use.

The IOM report (CIPME, 2007) also clearly pointed to the need to design studies by persons not associated with the pharmaceutical industry to describe and explore DRPs in older adults. Currently, there is no organized national approach for the investigation and prevention of DRPs in older adults (Fick, 2007). Randomized controlled trials of DRPs are often not feasible or ethical and are rarely funded by the industry post market. Our research lends further evidence that the Beers criteria should be part of a multi-component strategy for investigating and preventing DRPs among community-dwelling older adults because they are related to adverse outcomes and cost.

In our study, a proxy method was employed for identifying potential DRPs using ICD-9 codes for principal and secondary diagnoses known to occur as a DRP. This method is based on a review of the literature and previous studies on DRPs and adverse drug events in older adults, and has been previously published (Kolanowski et al., 2006). For example, falls are known to occur at a higher rate with benzodiazepine and anti-depressant use (Thapa et al., 1998). Given the retrospective nature of the study, our measures for DRPs are limited in their ability to imply causality and will require further testing in a prospective study. Using administrative data, documenting causality is always somewhat limiting. Nonetheless, the method we used in both groups to determine that medications were not refills along with their timely relationship to the development of adverse outcomes that are logically connected to those drugs, provides strong evidence for avoiding these drugs in older adults. We considered key aspects of the Narnajo algorithm such as temporal relationship and biologic plausibility (Naranjo et al., 1981) for determining the relationship between the start of a new drug and onset of a new DRP. Coupled with finding that the occurrence of DRPs was almost threefold greater in the PIMs group versus the non-PIMs group, this lends credence to this approach to using administrative data.

The other limitations of this study are similar to those of others using administrative data: problems with coding, changing reimbursements, high patient turnover, and the limits of the available economic and clinical data. By selecting only individuals with prescription coverage (our variable of interest), selection bias may have been introduced. This type of design and analysis also lacks specificity on the probability that a change in clinical status is the result of a DRP (Michel & Knodel, 1986; Naranjo et al., 1981). The nature of available data and the non-experimental design of the study limit the causal inferences that can be made. Despite these caveats—the results demonstrate that the use of administrative data to identify DRPs is a feasible way to illustrate association and an important tool for practice improvement. Previous researchers also have documented the robustness of claims data for drug assessment (Strom, 2001; Walker, 2001; Wang, Schneeweiss, Glynn, Mogun, & Avorn, 2004).

Nursing Implications

Drug use in older adults is increasingly recognized as a complex problem that requires an integrated interdisciplinary approach. Behavioral problems and clinical conditions requiring the use of multiple medications and their associated effects in older adults are among the most challenging issues facing healthcare in the next decade—yet America lacks any national approach for prevention of DRPs. Nurses, working together with patients, families, pharmacists, physicians, insurers, other therapists, and policy makers, may be able to identify barriers to obtaining high quality evidence that can guide medication use, and ultimately to build and implement strategies to reduce PIM.

This information may be helpful to nurses, who are often on the front line of monitoring medication use in older adults, including reporting adverse events and assessing symptoms and patient verbalizations regarding pain, confusion, and other needs. Nurses also are often the first to notify a physician or other provider about the need for a medication or to report a DRP. Many of the medications shown to be related to PIMs in our findings are central nervous system active medications and are used as the first line of treatment for behavioral problems, despite their side effects and off-label use. The use of PIMs information may provide an opportunity for nurses to lead the way in the implementation and testing of non-pharmacological interventions for behavior problems in vulnerable older adults. For example, benzodiazepines have been found in previous studies to be an independent risk factor for delirium (Pandharipande et al., 2006). Simon and Ludman (2006) recently found that benzodiazepines were prescribed to older adults in primary care for sleep and anxiety problems without clear indication for use and were continued long term without improvements in symptoms. Many

non-pharmacological approaches for pain, sleep, and behavior problems are nurse led (Horgas & Elliott, 2004; Kolanowski, Litaker, & Buettner, 2005; McDowell, Mion, Lydon, & Inouye, 1998; Richards, Beck, O'Sullivan, & Shue, 2005).

In a recent study of anti-psychotic use in persons with dementia, researchers (Schneider et al., 2006) indicated the need to be cautious with off-label use of medications that are not evaluated for that use and are not supported by data from well-conducted studies. Our findings and those of other recent studies may be helpful in creating interventions to decrease the use of PIMS and indicate the need to study which drugs listed in the Beers criteria cause the most problems. This will require a larger prospective study.

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References

Aparasu RR, Sitzman SJ. Inappropriate prescribing for elderly outpatients. American Journal of Health-System Pharmacy 1999;56:433–439. [PubMed: 10096703]

Beers MH. Explicit criteria for determining potentially inappropriate medication use by the elderly. An update. Archives of Internal Medicine 1997;157:1531–1536. [PubMed: 9236554]

Beers MH, Ouslander JG, Rollingher I, Reuben DB, Brooks J, Beck JC. Explicit criteria for determining inappropriate medication use in nursing home residents. UCLA Division of Geriatric Medicine. Archives of Internal Medicine 1991;151:1825–1832. [PubMed: 1888249]

Bigos KL, Bies RR, Pollock BG. Population pharmacokinetics in geriatric psychiatry. American Journal of Geriatric Psychiatry 2006;14:993–1003. [PubMed: 17138806]

Budnitz DS, Pollock DA, Mendelsohn AB, Weidenbach KN, McDonald AK, Annest JL. Emergency department visits for outpatient adverse drug events: Demonstration for a national surveillance system. Annals of Emergency Medicine 2005;45:197–206. [PubMed: 15671977]

Chan M, Nicklason F, Vial JH. Adverse drug events as a cause of hospital admission in the elderly. Internal Medicine Journal 2001;31:199–205. [PubMed: 11456032]

Aspden, P.; Wolcott, J.; Bootman, JL.; Cronenwett, LR., editors. Committee on Identifying and Preventing Medication Errors. Preventing medication errors: Quality chasm series. Washington, DC: The National Academies Press; 2007.

Crownover BK, Unwin BK. Implementation of the Beers criteria: Sticks and stones—or throw me a bone. Journal of Managed Care Pharmacy 2005;11:416–417. [PubMed: 15934801]

Curtis LH, Ostbye T, Sendersky V, Hutchison S, Dans PE, Wright A, et al. Inappropriate prescribing for elderly Americans in a large outpatient population. Archives of Internal Medicine 2004;164:1621–1625. [PubMed: 15302631]

Cusack BJ. Pharmacokinetics in older persons. American Journal of Geriatric Pharmacotherapy 2004;2:274–302. [PubMed: 15903286]

Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. Journal of Clinical Epidemiology 1992;45:613–619. [PubMed: 1607900]

Fick D. Commentary on the Laroche et al. study. The Brown University Geriatric Psychopharmacology Update 2007;11:5.

Fick D, Cooper JW, Wade WE, Waller JL, Maclean JR, Beers MH. Updating the Beers criteria for potentially inappropriate medication use in older adults: Results of a US consensus panel of experts. Archives of Internal Medicine 2003;163:2716–2724. [PubMed: 14662625]

Fu AZ, Liu GG, Christensen DB. Inappropriate medication use and health outcomes in the elderly. Journal of the American Geriatric Society 2004;52:1934–1939.

Gurwitz JH. Polypharmacy: A new paradigm for quality drug therapy in the elderly? Archives of Internal Medicine 2004;164:1957–1959. [PubMed: 15477428]

Hajjar ER, Hanlon JT, Artz MB, Lindblad CI, Pieper CF, Sloane RJ, et al. Adverse drug reaction risk factors in older outpatients. American Journal of Geriatric Pharmacotherapy 2003;1:82–89. [PubMed: 15555470]

Hanlon JT, Schmader KE, Koronkowski MJ, Weinberger M, Landsman PB, Samsa GP, et al. Adverse drug events in high risk older outpatients. Journal of the American Geriatric Society 1997;45:945–948.

Horgas AL, Elliott AF. Pain assessment and management in persons with dementia. Nursing Clinics of North America 2004;39:593–606. [PubMed: 15331304]

Klarin I, Wimo A, Fastbom J. The association of inappropriate drug use with hospitalisation and mortality: A population-based study of the very old. Drugs & Aging 2005;22:69–82. [PubMed: 15663350]

Kolanowski A, Fick D, Waller JL, Ahern F. Outcomes of antipsychotic drug use in community-dwelling elders with dementia. Archives of Psychiatric Nursing 2006;20:217–225. [PubMed: 17010825]

Kolanowski AM, Litaker M, Buettner L. Efficacy of theory-based activities for behavioral symptoms of dementia. Nursing Research 2005;54:219–228. [PubMed: 16027564]

Lau DT, Kasper JD, Potter DE, Lyles A. Potentially inappropriate medication prescriptions among elderly nursing home residents: Their scope and associated resident and facility characteristics. Health Services Research 2004;39:1257–1276. [PubMed: 15333108]

McDowell JA, Mion LC, Lydon TJ, Inouye SK. A nonpharmacologic sleep protocol for hospitalized older patients. Journal of the American Geriatric Society 1998;46:700–705.

Michel DJ, Knodel LC. Comparison of three algorithms used to evaluate adverse drug reactions. American Journal of Hospital Pharmacy 1986;43:1709–1714. [PubMed: 3752106]

Naranjo CA, Busto U, Sellers EM, Sandor P, Ruiz I, Roberts EA, et al. A method for estimating the probability of adverse drug reactions. Clinical Pharmacology and Therapeutics 1981;30:239–245. [PubMed: 7249508]

Onder G, Landi F, Liperoti R, Fialova D, Gambassi G, Bernabei R. Impact of inappropriate drug use among hospitalized older adults. European Journal of Clinical Pharmacology 2005;61:453–459. [PubMed: 15912391]

Pandharipande P, Shintani A, Peterson J, Pun BT, Wilkinson GR, Dittus RS, et al. Lorazepam is an independent risk factor for transitioning to delirium in intensive care unit patients. Anesthesiology 2006;104:21–26. [PubMed: 16394685]

Rask KJ, Wells KJ, Teitel GS, Hawley JN, Richards C, Gazmararian JA. Can an algorithm for appropriate prescribing predict adverse drug events? American Journal of Managed Care 2005;11:145–151. [PubMed: 15786853]

Richards KC, Beck C, O'Sullivan PS, Shue VM. Effect of individualized social activity on sleep in nursing home residents with dementia. Journal of the American Geriatric Society 2005;53:1510–1517.

Schneider LS, Tariot PN, Dagerman KS, Davis SM, Hsiao JK, Ismail MS, et al. Effectiveness of atypical antipsychotic drugs in patients with Alzheimer's disease. New England Journal of Medicine 2006;355:1525–1538. [PubMed: 17035647]

Shorr RI. Interpreting interventions to improve drug use using administrative databases. Journal of the American Geriatric Society 2004;52:1018–1019.

Simon GE, Ludman EJ. Outcome of new benzodiazepine prescriptions to older adults in primary care. General Hospital Psychiatry 2006;28:374–378. [PubMed: 16950371]

Strom BL. Data validity issues in using claims data. Pharmacoepidemiology and Drug Safety 2001;10:389–392. [PubMed: 11802582]

Stuart B, Kamal-Bahl S, Briesacher B, Lee E, Doshi J, Zuckerman IH, et al. Trends in the prescription of inappropriate drugs for the elderly between 1995 and 1999. American Journal of Geriatric Pharmacotherapy 2003;1:61–74. [PubMed: 15555468]

Thapa PB, Gideon P, Cost TW, Milam AB, Ray WA. Antidepressants and the risk of falls among nursing home residents. New England Journal of Medicine 1998;339:875–882. [PubMed: 9744971]

Turnheim K. Drug therapy in the elderly. Experimental Gerontology 2004;39:1731–1738. [PubMed: 15582289]

Turnheim K. Pharmacokinetic dosage guidelines for elderly subjects. Expert Opinion on Drug Metabolism & Toxicology 2005;1:33–48. [PubMed: 16922651]

Walker AM. Pattern recognition in health insurance claims databases. Pharmacoepidemiology and Drug Safety 2001;10:393–397. [PubMed: 11802583]

Wang PS, Schneeweiss S, Glynn RJ, Mogun H, Avorn J. Use of the case-crossover design to study prolonged drug exposures and insidious outcomes. Annals of Epidemiology 2004;14:296–303. [PubMed: 15066610]

Zhan C, Sangl J, Bierman AS, Miller MR, Friedman B, Wickizer SW, et al. Potentially inappropriate medication use in the community-dwelling elderly: Findings from the 1996 Medical Expenditure Panel Survey. Journal of the American Medical Association 2001;286:2823–2829. [PubMed: 11735757]

Table 1

Characteristics of the Study Sample, Medication Use, and Overall Costs

	PIMs (*n*=6,875)		Comparisons (*n*=10,002)			
	Mean	***SD***	**Mean**	***SD***	***t*-test or x^2**	***p*-value**
Female sex (n, %)	4,882	71.01	5,436	54.36	476.06	<.01
Age	73.48	6.53	73.23	6.45	−2.47	<.01
Co-morbidity index	.84	1.38	.60	1.08	−12.00	<.01
Total paid costs	$2,257.37	6,260.54	$1,119.51	5,080.77	−12.50	<.01
Facility paid costs	$1,663.60	5,610.45	$783.40	4,659.33	−10.71	<.01
Provider paid costs	$401.17	1,082.57	$221.04	1,083.73	−10.61	<.01
Prescription costs	$192.59	186.39	$115.07	151.79	−28.58	<.01
Inpatient visits	.18	.61	.08	.37	−12.67	<.01
Outpatient visits	.88	1.38	.53	.99	−18.26	<.01
Office visits	6.55	6.55	4.45	4.77	−22.73	<.01
ER visits	.17	.49	.08	.31	−13.41	<.01
Total prescriptions (including refills)	14.55	9.77	6.18	6.53	−62.15	<.01
Total prescription types	6.26	3.58	2.76	2.56	−69.65	<.01
Total PIMs (including refills)	3.71	2.99				
Total unique PIM types	1.48	.79				

PIMs, potentially inappropriate medications, ER, emergency room.

Table 2

Distribution of Each Potentially Inappropriate Medication (n=17,971)*

Inappropriate Medication	*n*	Percent
Estrogens only	1,718	9.56
Propoxyphene and combination products	1,333	7.42
Doses of short acting benzodiazepines‡	1,327	7.38
Digoxin, when exceeding >.125 mg/d	846	4.71
Long-term use of full dosage longer half-life non-Cox selective NSAIDS agents*	832	4.63
Anticholinergics and antihistamines*	689	3.83
Muscle relaxants and antispasmodics* (oxybutynin)	577	3.21
Doxazosin	427	2.38
Amitriptyline (elavil, limbitrol, or triavil)	407	2.26
Macrodantin	229	1.27
Long-acting benzodiazepines*	329	1.83
Clonidine	274	1.52
Short-acting nifedipine	239	1.33
Gastrointestinal antispasmotics*	245	1.36
Daily fluoxetine	216	1.20
Indomethacin	139	.77
Cimetidine	103	.57
Ketorolac	97	.54
Barbiturates (except phenobarbital)	95	.53
Amiodarone	77	.43
Doxepin	88	.49
Desiccated thyroid	30	.17
Short-acting dipyridamole	46	.26
Methyldopa	28	.16
Flurazepam (dalmane)	27	.15
Ticlopidine	27	.15
Orphenadrine	22	.12
Meperidine	19	.11
Trimethobenzamide (tigan)	14	.08
Thioridazine	14	.08
Meprobamate	12	.07
Disopyramide (norpace)	10	.06
Reserpine at doses >.25 mg	12	.07
Pentazocine (talwin)	5	.03
Ferrous sulfate > 325 mg daily	3	.02
Chlorpropamide (diabenese)	2	.01
Ethacrynic acid	1	.01
Isoxsuprine	1	.01
Methyltestosterone	1	.01

NSAIDS, non-steroidal anti-inflammatory drugs.

*Individual drugs and drugs in each class as defined by the updated Beers criteria Table 1 (Fick et al., 2003, pp. 2,719–2,720).

‡Doses > lorazepam 3 mg, oxazepam 60 mg, alprazolam 2 mg, temazepam 15 mg, triazolam .25 mg.

Table 3

Chi-Square or Fisher's Exact Tests Between Individuals With Potentially Inappropriate Medications and Comparison Individuals for Prevalence of Drug-related Problems (DRPs)Within 30 Days of a Prescription

	PIMS (*n*=6,875)		Comparisons (*n*=10,002)					
Variable	***n***	**Percent**	***n***	**Percent**	**Odds Ratio**	**95% CI**	χ^2	***p*-value**
Alteration of consciousness	35	.51	14	.14	3.65	1.96–6.79	19.18	<.01
Syncope	246	3.58	122	1.22	3.01	2.41–3.74	106.25	<.01
Sleep disturbances	102	1.48	42	.42	3.57	2.49–5.12	54.50	<.01
Malaise and fatigue	237	3.45	106	1.06	3.33	2.65–4.20	116.64	<.01
Retention of urine	52	.76	26	.26	2.92	1.82–4.69	21.83	<.01
Urinary incontinence	61	.89	24	.24	3.72	2.32–5.97	34.07	<.01
Adverse effect	21	.31	12	.12	2.55	1.25–5.19	7.18	.01
Bradycardia	50	.73	25	.25	2.92	1.81–4.72	20.98	<.01
Dehydration	126	1.83	44	.44	4.23	2.99–5.96	79.27	<.01
Acute depression	16	.23	3	.03	7.77	2.26–26.69	14.89	<.01
Falls	25	.36	9	.09	4.05	1.89–8.69	15.18	<.01
Hemorrhage bowel	49	.71	18	.18	3.98	2.32–6.84	29.25	<.01
Gastritis	17	.25	8	.08	3.10	1.34–7.18	7.71	.01
Hypoglycemia	15	.22	13	.13	1.68	.80–3.53	1.91	.17
Hypotension	20	.29	8	.08	3.64	1.60–8.28	10.94	.01
Hip fracture	34	.49	16	.16	3.10	1.71–5.62	15.44	<.01
Femur fracture	14	.20	3	.03	6.80	1.95–23.67	12.21	<.01
Confusion	17	.25	11	.11	2.25	1.05–4.81	4.64	.03
Dementia	61	.89	28	.28	3.18	2.04–4.99	28.65	<.01
Delirium	32	.47	14	.14	3.34	1.78–6.26	15.88	<.01
Any cognitive impairment	100	1.45	51	.51	2.88	2.05–4.04	41.00	<.01
Any proxy DRP	981	14.27	468	4.68	3.39	3.02–3.80	477.44	<.01

Table 4

ANCOVA of Potentially Inappropriate Medication (PIM) Status on Log of the Cost or Utilization Variable Controlling for Sex, Age, Charlson Comorbidity Index (CCI); total Number of Prescription Types

Model	R^2	Back Transformed Adjusted Mean	*SE*	*F-value*	*p-value*
Total paid costs	.21				
Female sex				21.18	<.01
Age				2.68	.10
CCI				2,761.93	<.01
PIM status				522.19	<.01
0 PIMs (*n*=10,002)		174.94	1.02		
1 PIM (*n*=4,549)		381.36	1.03		
2+ PIMs (*n*=2,326)		635.36	1.04		
Facility paid costs	.16				
Female sex				73.15	<.01
Age				.02	.89
CCI				2,235.74	<.01
PIM status				232.78	<.01
0 PIMs (*n*=10,002)		11.84	1.03		
1 PIM (*n*=4,549)		23.15	1.05		
2+ PIMs (*n*=2,326)		52.45	1.07		
Provider paid costs	.17				
Female sex				28.63	<.01
Age				1.38	.23
CCI				2,569.81	<.01
PIM status				219.52	<.01
0 PIMs (*n*=10,002)		30.80	1.02		
1 PIM (*n*=4,549)		51.01	1.03		
2+ PIMs (*n*=2,326)		85.62	1.05		
Prescription paid costs	.12				
Female sex				7.75	.01
Age				.57	.45
CCI				476.67	<.01
PIM status				744.38	<.01
0 PIMs (*n*=10,002)		25.49	1.02		
1 PIM (*n*=4,549)		73.42	1.03		
2+ PIMs (*n*=2,326)		121.51	1.04		
Inpatient visits	.09				
Female sex				7.24	.01
Age				3.29	.07
CCI				1,438.39	<.01
PIM status				34.48	<.01
0 PIMs (*n*=10,002)		1.02	1.00		
1 PIM (*n*=4,549)		1.03	1.00		
2+ PIMs (*n*=2,326)		1.04	1.00		
Outpatient visits	.10				
Female sex				56.48	<.01
Age				39.28	<.01
CCI				1,455.36	<.01
PIM status				106.66	<.01
0 PIMs (*n*=10,002)		1.12	1.00		
1 PIM (*n*=4,549)		1.18	1.01		
2+ PIMs (*n*=2,326)		1.26	1.01		
Office visits	.18				
Female sex				5.06	.03
Age				15.96	<.01

Model	R^2	Back Transformed Adjusted Mean	*SE*	*F-value*	*p-value*
CCI				2,298.24	<.01
PIM status				438.46	<.01
0 PIMs (*n*=10,002)		3.29	1.01		
1 PIM (*n*=4,549)		4.23	1.01		
2+ PIMs (*n*=2,326)		5.36	1.02		
Emergency room visits	.02				
Female sex				1.24	.27
Age				21.34	<.01
CCI				112.77	<.01
PIM status				65.48	<.01
0 PIMs (*n*=10,002)		1.01	1.00		
1 PIM (*n*=4,549)		1.01	1.00		
2+ PIMs (*n*=2,326)		1.04	1.00		

CCI, Charlson co-morbidity index, PIM, potentially inappropriate medication.