Potentially Inappropriate Medication Utilization in the Emergency Department Visits by Older Adults: Analysis From a Nationally Representative Sample

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Abstract

Objectives: The objectives were to determine the frequency of administration of potentially inappropriate medications (PIMs) to older emergency department (ED) patients and to examine recent trends in the rates of PIM usage.

Methods: The data examined during the study were obtained from the National Hospital Ambulatory Medical Care Survey (NHAMCS). This study utilized the nationally representative ED data from 2000–2006 NHAMCS surveys. Our sample included older adults (age 65 years and greater) who were treated in the ED and discharged home. Estimated frequencies of PIM-associated ED visits were calculated. A multivariable logistic regression model was created to assess demographic, clinical, and hospital factors associated with PIM administration and to assess temporal trends.

Results: Approximately 19.5 million patients, or 16.8% (95% confidence interval [CI] = 16.1% to 17.4%) of eligible ED visits, were associated with one or more PIMs. The five most common PIMs were promethazine, ketorolac, propoxyphene, meperidine, and diphenhydramine. The total number of medications prescribed or administered during the ED visit was most strongly associated with PIM use. Other covariates associated with PIM use included rural location outside of the Northeast, being seen by a staff physician only (and not by a resident or intern), presenting with an injury, and the combination of female sex and age 65–74 years. There was a small but significant decrease in the proportion of visits associated with a PIM over the study period.

Conclusions: Potentially inappropriate medication administration in the ED remains common. Given rising concerns about preventable complications of medical care, this area may be of high priority for intervention. Substantial regional and hospital type (teaching versus nonteaching) variability appears to exist.

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Preventable medical complications related to medication utilization and prescription have gained growing national attention and are increasingly being targeted as areas for quality improvement.[1,2] An important group of patients in which these medical complications can have dire consequences are those

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individuals 65 years of age and older. Because many medications have prolonged half-lives in older adults, the adverse effects of these agents can pose problems long after patients have been discharged from the emergency department (ED).[3] Some medications disproportionately expose older adults to risk, as they lack efficacy relative to their inherent side effects.[4,5]

The ED has been identified as a high-risk environment for adverse medication events and potentially inappropriate medication (PIM) use in older adults, who comprise the largest and fastest growing age group of ED patients.[6–8] Older adults make up less than 15% of the U.S. population, but consume approximately one-third of all prescription medications.[9] This population is growing rapidly, as are the numbers of medications being prescribed to this age group. Previous research has shown that the rate of PIM use by older adults in ambulatory health settings is approximately 12.6%, which represents 16 million people annually.[10] Antihistamines and narcotics have accounted for the majority of inappropriate medications in prior studies. Several recent studies have found even higher rates of inappropriate medication administration.[8,11] The investigation of more recent national trends in PIM use in EDs has been limited and would provide meaningful information regarding the current scope of this problem.

The primary goal of this study was to determine the frequency of administration of PIMs to older adult ED patients who were discharged to home. The secondary objectives were to examine recent trends in the rates of PIM usage and explore which patient, hospital, and regional variables were associated with PIM utilization.

METHODS

Study Design

The National Hospital Ambulatory Medical Care Survey (NHAMCS) was designed by the National Center for Health Statistics (NCHS) and is administered by the U.S. Census Bureau to measure utilization and provision of ambulatory care services at U.S. hospitals. Using a four-stage probability sample design, NHAMCS collects a nationally representative sample of all visits to EDs based in noninstitutional general short-stay hospitals, excluding federal, military, and Veterans Administration hospitals. Detailed descriptions of the methods of NHAMCS have been previously published.[12,13] The University of Michigan Institutional Review Board approved this study.

Study Sample

We restricted our population of interest to ED patients from 2000 to 2006, aged 65 years and older, who were discharged to home. Patients who were admitted to the hospital, died in the ED, or left prior to examination or against medical advice were not included. The survey included a field for medications associated with the ED visit. Although the current survey has data on up to eight medications, surveys before 2003 only included up to six, so this study concentrated on the first six medication fields. Each medication in the database was assigned an identification number in accordance to a system designed by the NCHS.[14] In addition, an indicator was added in the later years of the study period to distinguish between medications that were simply prescribed, versus those that were actually administered during the visit. As this indicator was not available for all years, we did not utilize it as part of our analysis.

The Beers criteria were used to define PIMs and are given in Appendix 1 (see Data Supplement S1, available as supporting information in the online version of this paper).[5] Medications that were inappropriate only in certain dosages, duration of administration, or comorbid conditions were not included in this study because this information is not identifiable in NHAMCS-ED. Therefore, the PIMs that were considered in our analysis were medications that have been listed on the Beers criteria independent of diagnosis or condition. We applied the 2002 criteria to all years, although nifedipine, clonidine, and ketorolac were added in that revision. Database management was conducted using SAS Version 9.1.2 (SAS Institute, Inc., Cary, NC), and data analysis was performed using STATA Version 10 (StataCorp LP, College Station, TX).

Statistical Methods

Using the complex survey design of NHAMCS, estimates of the proportion of subjects in the population of interest (subpopulation) meeting the inclusion criteria were calculated using sampling weights. To examine the associations between demographic, hospital, provider, and visit characteristics we conducted bivariate analyses using PIM association with an ED visit as a dichotomous outcome (0/1). Chi-square tests of this association were conducted for categorical variables. Logistic regression was performed for continuous variables. We then conducted a multivariate analysis using Hosmer and Lemeshow[15] methodology. Continuous variables that did not exhibit a linear relationship with the logit were dichotomized. In addition, region of the country was dichotomized for the models to facilitate the investigation of interaction terms involving region and urbanity. Year was considered as a continuous variable to assess for temporal trends. Briefly, covariates with a $p < 0.25$ were all entered into a preliminary main effects model, all other covariates (those with $p > 0.25$ on bivariate analysis) were considered using forward selection, and a priori considered interaction terms were entered using forward selection to the previously constructed model to produce the final model. Details of the procedures and rationale utilized in model building are provided in Appendix 2 (see Data Supplement S2, available as supporting information in the online version of this paper). Model fit was assessed using the svylogitgof function for complex survey data as described by Archer and Lemeshow.[16]

Sensitivity Analyses

To assess whether considering the number of PIMs associated with the visit as the outcome instead of the dichotomous outcome used above substantially changed the predictive model, we performed zero inflated Poisson regression using the same final model created using binary logistic regression. We also examined the rates of the three medications added to the Beers criteria list in 2002 over the time period of this study.

RESULTS

Between 2000 and 2006, the NHAMCS survey captured a total of approximately 470,000 ED and outpatient clinic visits, corresponding to a national estimate of about 1.5 billion total ambulatory visits. Of these visits, 35,000 met our selection criteria of being 65 or older, presenting to the ED, and being discharged to home at the end of the visit. This provides a population estimate of about 116 million ED visits from 2000 to 2006 for the sample of interest, whose characteristics are given in Table 1. Nearly 75% (95% confidence interval [CI] = 70.8% to 78.4%) of the sample of interest were administered or prescribed at least one medication in the ED.

Table 1
Characteristics of Target Population (Discharged ED Patients Age 65 Years and Older)

Characteristics	Mean	95% CI
Age (yr)	77.3	77.26–77.51
Sex		
Female	68,266,450 (58.9)	58.2–59.6
Male	47,623,239 (41.1)	40.4–41.8
Race/ethnicity		
White, non-Hispanic	80,044,665 (69.1)	66.7–71.4
African American, non-Hispanic	13,664,783 (11.8)	10.6–12.9
Hispanic	19,366,269 (16.7)	14.6–18.8
Asian	2,004,111 (1.7)	1.2–2.3
Other	809,861 (0.7)	0.5–0.9
Health insurance		
Medicare	86,745,631 (78.0)	76.8–79.1
Medicaid	8,139,515 (7.3)	6.5–8.1
Private	13501858 (12.1)	11.2–13.1
Self-pay	2,094,559 (1.9)	1.6–2.2
Other	787,334 (0.7)	0.6–0.9
Region		
Northeast	25,182,718 (21.7)	19.4–24.0
Midwest	28,362,215 (24.5)	21.3–27.7
South	40,621,098 (35.1)	31.5–38.6
West	21,723,658 (18.8)	16.3–21.2
MSA	90,889,491 (78.4)	72.0–84.9
Non-MSA	25,000,198 (21.6)	15.1–28.0
Hospital ownership		
Voluntary, nonprofit	89,031,694 (76.8)	73.8–79.8
Government, non-Federal	16,809,855 (14.5)	11.8–17.2
Proprietary	10,048,140 (8.7)	6.6–10.8
Seen by attending only	90,497,459 (78.1)	76.3–79.9
Seen by resident	10,429,755 (9.0)	7.8–10.2
Seen by midlevel provider	7,720,371 (6.7)	5.7–7.6
Immediacy		
Immediate/no triage	19,631,809 (16.9)	14.9–19.0
Less than 15 minutes	31,049,887 (26.8)	25.0–28.5
15–60 minutes	42,201,238 (36.4)	34.8–38.0
>1–2 hours	16,025,846 (13.8)	12.7–15.0
>2–24 hours	6,980,909 (6.0)	5.3–6.8
Injury related visit	32,603,307 (28.1)	27.4–28.9
Total number of visit medications		
0	29,407,762 (25.4)	24.3–26.5
1	29,424,573 (25.4)	24.6–26.2
2	21,774,332 (18.8)	18.2–19.4
3	12,936,491 (11.2)	10.7–11.6
4	7,845,784 (6.8)	6.3–7.2
5	4,586,968 (4.0)	3.6–4.3
6	9,913,779 (8.6)	7.4–9.7

Data are reported as mean or number (%). Estimates of means and proportions of hospital, visit, and demographic characteristics for all target population ED visits in U.S. from 2000–2006.
MSA = metropolitan statistical area.

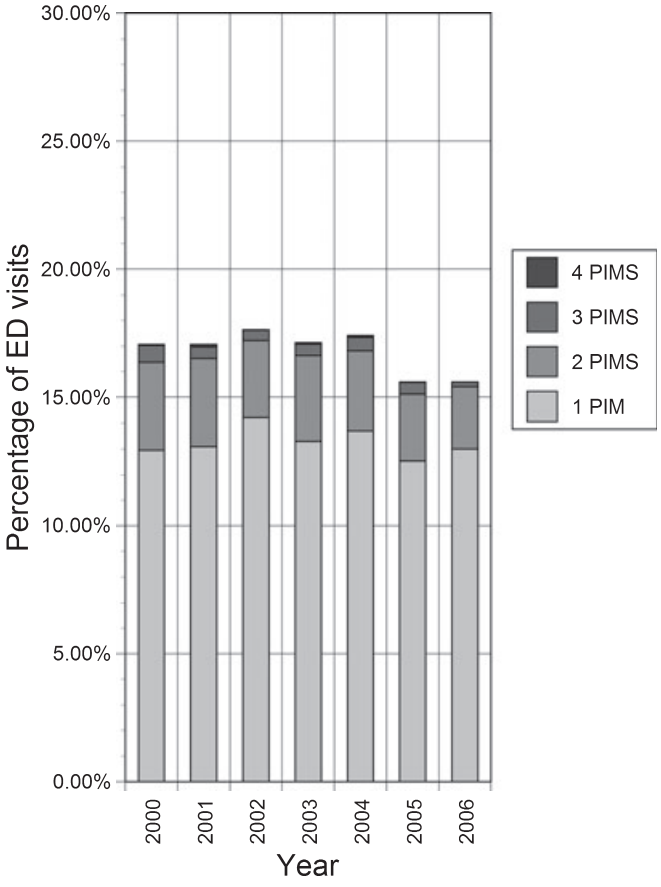

Figure 1. Weighted proportion of target population receiving potentially inappropriate medications (PIMs) by year.

From this sample of 35,000 visits, it was found that 5,926 visits were associated with at least one PIM. This corresponds to a population estimate of 19,423,635 visits, or 16.8% (95% CI = 16.1% to 17.4%), associated with at least one PIM between 2000 and 2006. The frequency of PIM-associated visits by year is depicted in Figure 1. Between 2000 and 2006, 13.25% (95% CI = 12.66% to 13.84%) received one PIM, 3.03% (95% CI = 2.76% to 3.30%) received two PIMs, 0.45% (95% CI = 0.35% to 0.55%) received three PIMs, and 0.04% (95% CI = 0.02% to 0.06%) received four PIMs. No visit was associated with more than four PIMs. While the rate of PIM-associated visits fluctuated from year to year, the rate remained above 15% throughout the study period. Table 2 lists the 10 most frequent PIMs identified. The percentages reflect the total number of PIMs administered to the population of interest as the denominator, as some subjects received multiple PIMs.

The bivariate associations between variables of interest and PIM use are reported in Table 3. The final logistic regression model provides adjusted odds ratios (ORs) for variables included in the model in Table 4. The relationships between covariates involved in interaction terms included in the final model are given in Figure 2. Younger women were more likely to have a

Table 2
Ten Most Commonly Administered Potentially Inappropriate Medications in Sample of Interest

Medication	Estimated Number	Percentage of Visits	95% CI
Promethazine	5,889,976	5.08	4.87–5.29
Ketorolac	3,696,537	3.19	3.03–3.35
Propoxyphene	3,043,306	2.63	2.50–2.75
Meperidine	2,785,735	2.40	2.26–2.55
Diphenhydramine	1,360,910	1.17	1.10–1.25
Clonidine	1,293,805	1.16	1.08–1.25
Hydroxyzine	930,219	0.82	0.76–0.88
Diazepam	898,733	0.78	0.72–0.84
Cyclobenzaprine	601,431	0.52	0.47–0.57
Nifedipine	405,871	0.35	0.31–0.39

Weighted estimate for total number (and percentage) of visits associated with most common prescribed/administered PIMs in the target population from 2000–2006.

Table 3
Bivariate Associations Between Patient, Hospital, and Visit Variables and Use of PIMs

Variable	OR	95% CI
Demographic variables		
Age (75 and older vs. 65–74 yr)	1.30	1.23–1.37
Female (versus male)	1.39	1.31–1.48
Race/ethnicity (referent: white, non-Hispanic)		
Asian	0.85	0.68–1.05
Black/African American	1.08	0.99–1.18
Hispanic	1.06	0.96–1.17
Other	0.88	0.60–1.28
Payer (referent: Medicare)		
Medicaid	0.98	0.87–1.11
Other	0.96	0.67–1.37
Private insurance	1.09	0.99–1.20
Self-pay	0.92	0.73–1.17
Hospital variables		
Non-MSA vs. MSA	1.27	1.13–1.43
Region (referent: Northeast)		
Midwest	1.35	1.19–1.54
South	1.92	1.73–2.14
West	1.51	1.35–1.69
Hospital owner (referent voluntary/nonprofit)		
Proprietary	1.32	1.18–1.49
Government, non-Federal	1.17	1.03–1.33
Provider variables		
Attending only	1.30	1.20–1.42
Resident present	0.69	0.61–0.78
Midlevel provider	1.00	0.88–1.14
Visit variables		
Injury related visit	1.25	1.18–1.34
Year (1-yr change, i.e., 2002 vs. 2001)	0.98	0.96–1.00
Triage (referent: immediate/ no triage)		
Below 15 minutes	0.97	0.87–1.09
15–60 minutes	1.23	1.11–1.37
1–2 hours	1.37	1.21–1.56
2–24 hours	1.33	1.15–1.54
Prescribed or administered two or more medications	6.62	6.15–7.14

MSA = metropolitan statistical area; PIM = potentially inappropriate medication.
The results of the individual bivariate associations between clinical, demographic, provider, and hospital level variables and prescription/administration of PIMs.

PIM-associated visit, as were rural visits outside of the Northeast. Several variables were associated with PIM administration, the strongest association of which was receiving or being prescribed two or more medications during an ED visit. Race and ethnicity were not associated with PIMs. Other visit characteristics associated with PIM use included presenting with an injury or a nonurgent complaint. Insurance status was not shown to have a significant association with PIM use. Visits occurring at for-profit hospitals were more likely to be associated with a PIM. Having a resident or intern involved in the visit was associated with a lower likelihood of receiving a PIM. In the final model controlling for the other covariates, the odds of receiving a PIM decreased slightly for each additional year compared to 2000 with an OR of 0.98 (95% CI = 0.95 to 0.997).

For the first sensitivity analysis, the model was repeated using zero-inflated Poisson regression. There was no substantial change (i.e., the incidence rate ratios did not differ from the logistic regression ORs by more than 10%), and therefore only the results for the logistic model are presented. When considering the utilization of the three medications added to the Beers list in 2003 over our study period, no substantial change was observed over time with a stable rate around 0.7% (see Data Supplement S3, available as supporting information in the online version of this paper).

DISCUSSION

Using a national sample of U.S. ED visits, we found that a large proportion (nearly one in six visits) of older adults discharged from the ED receive PIMs. Despite the increased national attention to drug-related medical complications, the total number of older adults receiving PIMs has been stable for over 6 years. This means that almost 3 million ED visits by older adults each year are estimated to be associated with PIM administration or prescription. Our study found that older adults who presented to EDs outside the Northeast, in nonacademic hospitals, with an injury and with a less urgent complaint were significantly more likely to receive a PIM. The variability that exists between regions and academic versus nonacademic hospitals is interesting. It suggests that improvements may be occurring, although with the persistently high rates of PIM usage acceleration, wider implementation of efforts is likely to be necessary.

Medications are a significant source of potential morbidity and mortality in older patients. This is due to physiologic changes that occur with aging, polypharmacy, and burden of chronic illnesses. Potentially inappropriate but commonly prescribed medications can contribute to falls, altered mentation, and gastrointestinal bleeding. Medication-induced complications in older adults account for 7% to 11% of their visits to the ED, and contribute to 12% to 17% of their hospital admissions.[12,17–21] These PIMs may negatively affect a patient's quality of life, as well as add unnecessary health care costs to an already struggling U. S. health care system.

Although the applicability of the Beers Criteria to the ED has previously been questioned because they were

Table 4
Final Logistic Regression Model of Impact of Patient, Hospital, and Visit Characteristics

Parameter	OR	95% CI	Estimated Beta	Standard Error	p-value
Intercept			−4.59	0.215	<0.001
Demographic covariates					
Age less than 75 yr*	1.67	1.35–2.07	0.51	0.109	<0.001
Sex (female vs. male)*	1.56	1.39–1.75	0.45	0.059	<0.001
Hospital covariates					
Region (rest of United States vs. Northeast)*	2.05	1.45–2.91	0.72	0.178	<0.001
Non-MSA vs. MSA*	1.35	1.17–1.57	0.30	0.075	<0.001
For profit hospital (vs. nonprofit or government)	1.19	1.03–1.38	0.17	0.074	0.017
Provider covariates					
Seen with resident or intern involvement	0.65	0.55–0.76	−0.43	0.081	<0.001
Visit covariates					
Visit due to injury	1.52	1.40–1.66	0.42	0.043	<0.001
Immediacy which should be seen (greater than 1 hour vs. immediate)	1.44	1.29–1.61	0.37	0.055	<0.001
Received/prescribed two or more medications	6.99	6.31–7.73	1.94	0.052	<0.001
Timing					
Year of visit (vs. 2000 per additional year)	0.98	0.95–0.997	−0.03	0.011	0.028
Interaction terms					
Age × Sex interaction			0.16	0.077	0.037
Northeast × Urban interaction			0.23	0.151	0.119

Results of final logistic regression model that provide adjusted ORs for associations between variables of interest and PIM prescription/administration. Main effects were considered for entry into the model if $p < 0.25$ and interaction terms were included using forward selection with a criteria of $p < 0.05$ (see Data Supplement S2 for details). Total medications and age were initially considered as continuous variables but did not have a linear relationship with the logit and were dichotomized. *ORs for covariates involved in interactions are estimated assuming all other covariates are at the referent level. The Archer-Lemeshow goodness-of-fit statistic was 0.69 ($p = 0.71$).
MSA = metropolitan statistical area.

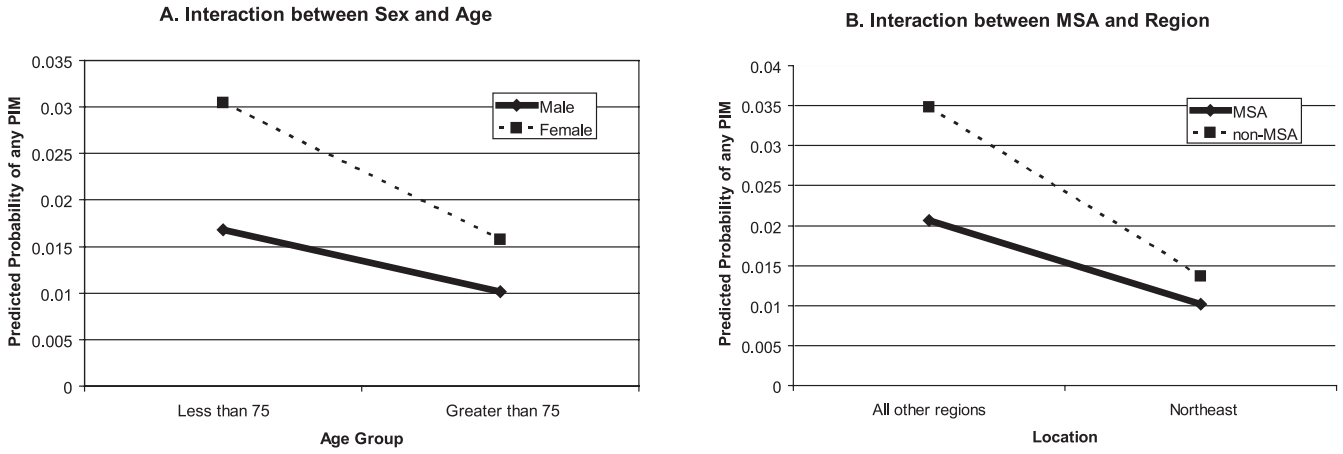

Figure 2. Predicted probabilities of potentially inappropriate medication (PIM) administration for covariates with interaction ([A] sex and Age [yr]; [B] MSA and region) derived from final logistic regression model. All other covariates are considered to be at referent level and year 2000. MSA = metropolitan statistical area; PIM = potentially inappropriate medication.

initially constructed for other clinical settings (i.e., extended care facilities), the general principles of the criteria are broadly applicable.[22] The medications on the list pose an unfavorable risk-to-benefit ratio in older adults, and there are usually safer, more efficacious medication alternatives available. Additionally, these medications can potentially interact with routine medications being taken by older adults, compounding the frequent administration of multiple medications during a single ED visit.[19,23,24] This study design did not explore the possibility of medication interaction. This may suggest we are currently underestimating the potential harm. An argument that could be made is that a single dose of a medication given in the ED is unlikely to have a long-term deleterious effect. This may be the case for certain medications such as ketorolac; however, for medications that affect cognition and balance, a patient could experience a fall or respiratory arrest after being sent home, and clearly such events could be life-altering. While each PIM may not be inappropriate in every administration or prescription to an older adult sent home from the ED, given that alternatives

exist, it is likely that our method provides a reasonable estimation of the scope of the problem using the existing criteria previously published by experts.

The current study found that 10 medications accounted for 86.5% of PIMs used in the ED, of which almost 40% was due to two medications—promethazine and ketorolac. Thus, taking measures that concentrate on eliminating the use of only a small number of medications could be very beneficial. The most frequently identified PIMs fall into similar categories including antihistamines, nonsteroidal anti-inflammatory drugs, narcotics, and antihypertensives.

The problem of PIM use should be solvable at the system level. Incorporating more safety measures such as computer reviews or formulaic approaches, in addition to informing practitioners about the Beers criteria, may dramatically decrease PIM administration to older adults in the ED. The use of computer-aided real-time decision support was effective in reducing PIM use in a recent trial.[25] In addition, updates of the Beers criteria with the involvement of emergency physicians, or development of new criteria specifically designed for emergency medicine, could potentially be avenues for future initiatives. Despite a lack of prior substantial emergency medicine input and other limitations, the Beers criteria certainly represent an important starting point and are the most useful list of this sort that currently exists.[22]

LIMITATIONS

Although there are circumstances in which medications appearing on the Beers criteria are justified, more often than not, the medications are still given at inappropriate times. In one example, only an estimated 13% of visits in which diazepam was administered were for sprain, strain, fracture, or dislocation, which would represent potentially appropriate uses of the medication.[10] As the number of potential indications for medications is quite large, we did not attempt to relate the reason for visit (except for injury) or diagnosis to the medication use. This is a limitation in NHAMCS, given that relatively few sampled visits are occurring for each medication. We also could not identify whether a medication was given in the ED or if it was prescribed for the patient to take at home. However, because NHAMCS has changed its data collection process, future analyses of these data starting in 2003 will be able to separate out medication administration in the ED versus prescription. An additional limitation is the restriction of our analysis to the first six medication fields to ensure consistency throughout our analysis. This would tend to lead to an underestimation of PIM associated visits. A further limitation of this study is that the NHAMCS survey does not provide any information regarding whether the PIM actually led to an adverse event. However, prior work has shown compelling associations between PIM use and medication-related problems and hospitalizations in older adults.[18,21,26–28] It is reasonable to conclude that while PIMs are not inevitably going to cause problems for each individual patient, they place the patient at a higher risk for having an adverse event, and that risk-to-benefit ratio becomes unfavorable to an older adult when there are alternative medications. Finally, other adverse events associated with medications and medication interactions are not addressed by this study design, but would be useful areas for further study.

CONCLUSIONS

Approximately 3 million older adults in the United States each year are receiving or being prescribed at least one potentially inappropriate medication in the ED. This high number demonstrates that the abundant literature expressing the risks of prescribing older adults certain medications has not translated into reductions in the large numbers of older adults receiving potentially inappropriate medications in the ED. It is necessary to encourage ED caregivers to review the safety concerns associated with potentially inappropriate medication prescription and administration, especially when polypharmacy is involved. Eliminating the use of the top two drugs alone would reduce the amount of potentially inappropriate medication administration by 40%. As preventable errors and complications of medical care are increasingly becoming intolerable to payers and society, reducing the use of certain medications in older adults should be a focus in the efforts to optimize patient outcomes.

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Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. 2002 criteria for potentially inappropriate medication use in older adults: independent of diagnoses or conditions.

Data Supplement S2. Details of the procedures and rationale utilized in model building.

Data Supplement S3. Visits associated with medications added to Beers in 2002.

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