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Inappropriate Medication Prescriptions among Elders Surviving an Intensive Care Unit (ICU) Hospitalization

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Abstract

Background—Elderly patients admitted to intensive care units (ICU) are at risk of receiving potentially (PIMs) and actually inappropriate medications (AIMs).

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Objectives—To determine types of PIMs and AIMs, which PIMs are most likely to be considered AIMs, and risk factors for PIMs and AIMs at hospital discharge in elderly ICU survivors.

Design—Prospective cohort study

Setting—Tertiary care, academic medical center

Participants—120 patients 60 years old who survived an ICU hospitalization

Measurements—PIMs were defined according to published criteria; AIMs were adjudicated by a multidisciplinary panel. Medication lists were abstracted at the time of pre-admission, ward admission, Intensive Care Unit (ICU) admission, ICU discharge, and hospital discharge. Poisson regression was used to examine independent risk factors for hospital discharge PIMs and AIMs.

Results—Of 250 PIMs prescribed at discharge, the most common were opioids (28%), anticholinergics (24%), antidepressants (12%), and drugs causing orthostasis (8%). The three most common AIMs were anticholinergics (37%), non-benzodiazepine hypnotics (14%), and opioids (12%). Overall, 36% of discharge PIMs were classified as AIMs, but the percentage varied by drug type. Whereas only 16% of opioids, 23% of antidepressants, and 10% of drugs causing orthostasis were classified as AIMs; 55% of anticholinergics, 71% of atypical antipsychotics, 67% of non-benzodiazepine hypnotics and benzodiazepines, and 100% of muscle relaxants were deemed AIMs. The majority of PIMs and AIMs were first prescribed in the ICU. Pre-admission PIMs, discharge to somewhere other than home, and discharge from a surgical service predicted number of discharge PIMs, but none of the factors predicted AIMs at discharge.

Conclusions—Certain types of PIMs, which are commonly initiated in the ICU, are more frequently considered inappropriate upon clinical review. Efforts to reduce AIMs in elderly ICU survivors should target these specific classes of medications.

Keywords

potentially inappropriate medications; actually inappropriate medications; polypharmacy; ICU; older; risk factors; PIMs; AIMs

Introduction

Polypharmacy and inappropriate prescribing of medications are an increasing problem among the elderly. Drug-related admissions for people age 65 to 84 increased by 96% from 1997 to 2008,¹ and nearly half of adverse drug event-related hospitalizations occur among adults 80 years of age or older.² Inappropriate medications in the elderly can lead to confusion, falls, cognitive impairment, poorer health status, and higher mortality.³⁻⁷ The rapidly growing population among persons aged 65 or older⁸ will only magnify these hazards, unless more attention is focused on understanding and improving medication management and reconciliation.

In the lexicon of inappropriate prescribing, two important terms are potentially inappropriate medications (PIMs) and actually inappropriate medications (AIMs). PIMs are medications that—in light of their pharmacologic effects and prior research—are deemed potentially harmful to an elderly patient; when labeled a PIM, no consideration is given to a drug's potential benefits or the clinical circumstances surrounding its prescription for an individual patient. A PIM can, however, further be classified as an AIM if the risk of harm from the drug is judged to outweigh the potential clinical benefit after an individual patient's clinical circumstances are considered. Approximately 50% of hospitalized elders are discharged on at least one PIM, and about 80% of these patients are discharged on at least one AIM.⁹⁻¹²

Though PIMs and AIMs may be identified at the time of hospital discharge, the intensive care unit (ICU) is often where these medications are first prescribed. The fastest growing group of patients managed in the ICU is the elderly,¹³ a vulnerable population frequently given PIMs and AIMs in the hospital. We recently found that 85% of elderly ICU survivors were discharged from the hospital on at least one PIM, and 51% were discharged on at least one AIM.¹⁴ Among patients with one or more PIMs at hospital discharge, 59% had at least one AIM.¹⁴ Most of the PIMs (50%) and AIMs (59%) are first prescribed in the ICU.¹⁴

In this particularly complex patient population, many PIMs are reasonably appropriate given the patient's clinical conditions (i.e., the PIMs are not AIMs). Concordance or discordance of PIMs and AIMs has significant implications. For example, if drug class "A" accounts for a substantial proportion of PIMs among older ICU survivors but the majority of these PIMs are appropriately prescribed given the patients' circumstances, an intervention aimed at decreasing all PIMs will have the unintended consequence of reducing use of some appropriate medications. A more focused approach is to reduce exposure to AIMs by a) addressing the location in the hospital where AIMs are most commonly initiated, b) targeting classes of PIMs that are most often judged to be actually inappropriate after consideration of patient's circumstances, and c) targeting patients most likely to receive AIMs and providers most likely to prescribe them. The risk factors for prescription of AIMs among elderly patients surviving an ICU hospitalization are currently unknown.

In this study, we extend our previous work which described the prevalence of PIMs and AIMs in critically ill elderly patients.¹⁴ Here we explore 1) which specific PIM categories at hospital discharge were most often considered AIMs, 2) where specific AIM categories were most often initiated (i.e., pre-hospital, pre-ICU ward, ICU, or post-ICU ward), and 3) risk factors for PIMs and AIMs at hospital discharge. We hypothesized that 1) opiates, sedatives, and antipsychotics are the PIMs that are most often AIMs among older ICU survivors, and 2) older patients with delirium (which may prompt initiation of sedatives and/or antipsychotics) are at highest risk to be discharged from the hospital on PIMs and AIMs.

Methods

Study design and population

This prospective cohort study was nested in a larger long-term cohort study (NCT00392795), which enrolled critically ill patients admitted with respiratory failure or shock to the medical, surgical, or cardiovascular ICU at Vanderbilt University Hospital. Patients were excluded from the parent study if they were moribund, had respiratory failure or shock >72 hours prior to enrollment, were unable or unlikely to participate in cognitive testing during follow-up (due to blindness, deafness, inability to speak English, active substance abuse, or psychotic disorder), or were at high risk for severe cognitive impairment before the time of screening. The latter included patients admitted after cardiopulmonary arrest or with documented acute neurologic injury, those with chronic neurologic disease that prevented independent living, and those who underwent cardiac surgery in the 3 months before screening. For the current study, we included only those patients enrolled in the parent study who were older than 60 years of age and were discharged alive from the hospital. The age cutoff of 60 years was chosen, consistent with previous research,¹⁵ to include patients at higher risk for polypharmacy and inappropriate medication prescribing. Patients discharged to hospice were excluded due to common use of PIMs for symptom control (i.e., these PIMs are rarely AIMs in the hospice population). Informed consent was obtained from an available surrogate at enrollment into the parent study; patients themselves provided consent prior to hospital discharge, after their critical illness had improved and they were deemed competent to consent. The institutional review board at Vanderbilt University approved the study protocol.

Demographics and clinical characteristics

Demographics, APACHE II severity of illness score,¹⁶ ICU admission diagnoses, type of ICU, and comorbidities using the Charlson Comorbidity Index¹⁷ were recorded at study enrollment. Trained research personnel used the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU)¹⁸ to assess patients for delirium daily until hospital discharge or study day 30. Length of stay in the ICU and hospital, discharge location (home vs. other) and discharging hospital service (medical vs. surgical) were also recorded from the medical record.

Medication abstraction and classification

We reviewed medical charts (including physician notes and medication administration records) to identify PIMs using the 2003 Beers criteria,¹⁹ which we supplemented with additional medications that we identified by reviewing the medication safety literature published since 2003,^{6,20-22} considering articles reporting the association between medication prescription, adverse events and medication safety in elderly patients. Though, we did not complete a formal review with the Delphi approach we did apply an evidence-based approach to the selection of these medications as suggested in the IOM standards for practice guidelines (<http://www.iom.edu/Reports/2011/Clinical-Practice-Guidelines-We-Can-Trust.aspx>) and as used in the recent Beers update.³⁵ Most of the medications we have included in our list have been added to the updated Beers Criteria.³⁵ All PIMs at hospital discharge were reviewed by a clinical panel comprised of a hospitalist (E.E.V.), geriatrician (L.S.), and clinical pharmacist (E.N.), to identify AIMs. Similar to the approach used by Gizzi et al.,¹⁵ the panel reviewed hospital discharge medications, patient medical history, and laboratory data to determine if each discharge PIM was actually inappropriate (i.e., an AIM) based on the clinical circumstances for an individual patient. A PIM was considered an AIM when at least two of the three panel members considered its risk-benefit profile to be unfavorable based on the patient's specific circumstances and criteria specified in the Medication Appropriateness Index,^{4,23} including indication, dosage, and likely effectiveness, as well as drug-drug interactions, drug-disease interactions, unnecessary duplication, and duration of treatment. Medications did not need to have caused harm in order to be considered an AIM. This approach was designed to mirror multidisciplinary clinical decision-making on rounds as opposed to independent assessments by individual clinicians; therefore, agreement between individual clinicians was not calculated.

Each PIM and AIM was classified into one of the following 12 mutually exclusive categories based on medication class and side effects: 1) Benzodiazepines, 2) Non-benzodiazepine sedatives, 3) Typical antipsychotics, 4) Atypical antipsychotics, 5) Opioids, 6) Anticholinergics, 7) Antidepressants, 8) Drugs causing orthostasis, 9) Nonsteroidal anti-inflammatory drugs, 10) Antiarrhythmics, 11) Muscle relaxants, or 12) Others. A complete list of medications reviewed, according to their classification, is available in the Appendix.1.

In order to determine where specific types of AIMs were initiated, we abstracted medications from the medical record at 5 distinct time points—pre-admission (i.e., outpatient medications recorded at the time of admission), ward admission (i.e., outpatient medications that were continued at admission plus newly prescribed inpatient medications), ICU admission, ICU discharge, and hospital discharge.

Statistical analysis

Patients' demographic and clinical variables were summarized using median and interquartile range (IQR) for continuous variables and proportions for categorical variables. We described PIMs and AIMs as the total number prescribed among all patients at different time points. For each discharge PIM category, we calculated the percentage of PIMs that

were determined to be AIMs and considered this the positive predictive value (PPV) for that PIM category; PIMs with higher PPVs could be useful when screening for possible AIMs (yielding more true positives), whereas PIMs with lower PPVs would yield more false positives (i.e., PIMs that were actually appropriately prescribed).

We used multivariable Poisson regression models with generalized estimating equations (GEE) to analyze risk factors for the number of PIMs and AIMs per patient at discharge. We analyzed PIMs and AIMs as the number prescribed per patient (continuous variables) rather than as present or absent (dichotomous variables) to preserve statistical power. We included in both models the following covariates, determined *a priori* according to prior publications^{9,24} and clinical relevance: age, number of pre-admission PIMs, Charlson comorbidity score, total days of delirium, hospital length of stay, discharge disposition (home or not home), and discharge service (medical or surgical). All covariates were included in both models, regardless of statistical significance.

We used R (version 2.11.1) for all statistical analyses. Two-sided $P < 0.05$ was considered statistically significant.

Results

We identified 135 patients who were enrolled in the parent study between May 2008 and 2010, who were older than 60 years of age and were discharged alive from the hospital. Of these, 11 were discharged to hospice, and 4 withdrew from the study prior to discharge. The remaining 120 patients were included in the current study and are described in Table 1. The cohort had a median age of 68 years, and nearly one in four patients was 75 years of age or older. A median APACHE score of 27 indicated a high severity of illness, and comorbid illness was common.

Categories of PIMs and AIMs: Frequency at Discharge and Time of Initiation

A total of 250 PIMs were prescribed at discharge. The four most common types of PIMs at discharge were opioids, anticholinergic medications, antidepressants, and drugs causing orthostasis (Table 2).

Of the 250 discharge PIMs, 90 (36%) were classified as AIMs with the three most common types being anticholinergics, non-benzodiazepine hypnotics (e.g., zolpidem), and opioids (Table 2). Of the anticholinergic AIMs, the H₂ blockers (61%) and promethazine (15%) were the most common. Three of the four most commonly prescribed discharge PIM categories had low PPVs (i.e., these PIMs were infrequently classified as AIMs). Specifically, only 16% of opioids, 23% of antidepressants, and 10% of drugs causing orthostasis were found to be actually inappropriate after the patient's circumstances were considered. Discharge PIM categories with the highest PPV for AIMs included the anticholinergics (55%), non-benzodiazepine hypnotics (67%), benzodiazepines (67%), atypical antipsychotics (71%), and muscle relaxants (100%) (Table 2). The Appendix.2 Table shows the distribution of PIMs and AIMs categories at the patient level.

Of the AIMs most often prescribed at hospital discharge, 67% of anticholinergic AIMs were initiated in the ICU, 21% were started on the wards, and only 12% were present prior to admission. Of the non-benzodiazepine hypnotic AIMs, 46% were initiated in the ICU, 23% on the wards, and 31% were present at pre-admission. Of the opioids determined to be AIMs, 73% were initiated in the ICU, 18% on the wards, and 9% were pre-admission medications. Four of every five atypical antipsychotics classified as AIMs were started in the ICU, 20% were initiated on the ward, and none were present at pre-admission. Certain offending medications were initiated almost exclusively in the hospital. For example, only

1% (1 out of 120 patients) were receiving an atypical antipsychotic before admission and strikingly 12% (14 out of 120 patients) were discharged from the hospital on an atypical antipsychotic.

PIMs and AIMs: Risk-Factors for Number at Discharge

In a multivariable analysis, the number of pre-admission PIMs ($P<.001$), discharge to somewhere other than home ($P=.03$), and discharge from a surgical service ($P<.001$) were found to be significant independent predictors of the number of PIMs prescribed to a patient at hospital discharge (Table 3). None of the factors examined, however, were associated with the number of AIMs at hospital discharge. Neither age ($P=.90$), number of pre-admission PIMs ($P=.49$), Charlson comorbidity score ($P=.96$), delirium duration ($P=.68$), hospital length of stay ($P=.15$), discharge disposition ($P=.72$), nor discharge service ($P=.08$) predicted number of discharge AIMs.

Discussion

Medications are the primary cause of adverse events for elderly patients following hospital discharge.^{6,20} Significant attention has been focused on reducing prescription of PIMs, but some of these medications are appropriately prescribed to complicated patients who are likely to benefit from them. Thus, attention should be directed specifically towards reducing AIMs. In this study, we found that three of the most commonly prescribed types of PIMs (opioids, antidepressants, and drugs causing orthostasis) were often judged to be appropriate after considering the individual patient's clinical condition (e.g., post-operative pain control, a new diagnosis of major depressive disorder, etc.). These PIM categories, therefore, had low PPV for detecting AIMs in older survivors of critical illness. In addition, we found that the risk factors for being prescribed a PIM at discharge were not necessarily risk factors for being prescribed an AIM. Our study, the first to specifically evaluate ICU survivors for receipt of PIMs and AIMs, suggests that published lists of PIMs may not be an efficient screening tool for identifying and thereby reducing prescription of AIMs to older patients after critical illness. Instead, a more refined list of PIMs with high PPV is needed, as is knowledge regarding risk factors for receipt of AIMs after critical illness.

A critical feature of our investigation was a thorough evaluation of the actual appropriateness of each PIM based on the clinical circumstances. Mattison et al.²⁵ recently emphasized that studies of PIMs should determine scenarios in which it is appropriate to prescribe PIMs, moving beyond simply labeling some medications as “potentially inappropriate,” since some PIMs are appropriately prescribed in specific clinical situations. Clinicians caring for older patients, especially at the end of a complex hospital stay, must determine which PIMs should be discontinued prior to hospital discharge vs. those that are appropriately prescribed.

Our finding that some common PIMs were rarely AIMs has significant implications. If one views a list of PIMs as a screening tool, any given item (i.e., medication class) on the list has 100% sensitivity for detecting an AIM in that medication class and 100% negative predictive value (NPV) for ruling out AIMs in that class. (In general, the negative predictive value is defined as the percentage of subjects with a negative test result who are correctly diagnosed.) Unfortunately, some items on the screening tool will have low PPV for the identification of an AIM (opiates was an example in our cohort), whereas others will have high PPV (such as atypical antipsychotics in our cohort). Our study shows that the PPV depends on the drug type. Thus, when developing a screening system, one cannot be concerned only with high NPV, one must consider PPV as well. Screening tools that include medication classes with low PPV will generate false positive “flags” or warnings, which could lead to misguided clinical decisions or alert fatigue.²⁶ In our cohort, for example, if

clinicians were alerted to each opiate prescription at the time of discharge, this may have led to a) inappropriate discontinuation of an appropriate medicine needed for pain control, b) change to a potentially more harmful alternative, and c) a decrease of the impact of such alerts regarding PIMs that have much higher PPVs for being AIMs. Electronic warning systems will likely be valuable in reducing AIMs after critical illness, but the systems that rely on PIMs as screening tools should only include those with the highest PPV, which in our study were the atypical antipsychotics (71%), non-benzodiazepine hypnotics (67%), benzodiazepines (67%), the anticholinergics (55%), and muscle relaxants (100%)

The fact that many PIMs are not AIMs also reveals the value of using a multidisciplinary team to identify AIMs from lists of PIMs generated when discharge medication lists are screened. In our investigation, we created a team with a geriatrician, internist, and pharmacist, all of which are often involved in the care of elderly hospitalized patients.²⁷ Whereas a computer-based decision support system can easily identify PIMs using structured data,²⁸ evaluating the clinical context is far more complicated, especially for older ICU survivors. Thus, a multidisciplinary team is needed to consider the clinical context to distinguish PIMs from AIMs. Of course, such a team is not available in some settings; when resources are limited, knowledge of which PIMs are most likely AIMs (i.e., have high PPVs) could guide the development of computer-based decision support systems or other surveillance approaches that are efficient in that particular setting.

Interventions designed to reduce AIMs need not be implemented solely at the time of hospital discharge. We found that nearly two out of every three AIMs were first prescribed in the ICU, a period of the patient's course when the medication may have been appropriately given. For example, non-benzodiazepine sedatives (e.g., zolpidem, choral hydrate) and atypical antipsychotics are frequently used in the ICU because delirium and sleep cycle alteration are common complications of critical illness.^{29,30} Even though these and other PIMs may be appropriate early in the ICU course, the indications for their use are usually temporary. Failing to discontinue such medications before hospital discharge is potentially harmful to patients in the long-term.^{31,32} Thus, clinicians should seek to identify and discontinue AIMs at three important transitions during a critically ill elderly patient's hospital course. First, clinicians should review medications appropriateness at the time of hospital or ICU admission. Second, another evaluation should be carried out at the time of ICU discharge. Finally, medications should be screened for PIMs at hospital discharge and the patient's clinical situation should be reviewed, ideally by a multidisciplinary team of clinicians, to judge the appropriateness of each PIM. Electronic health records could be leveraged to alert clinicians at each of these time points to the presence of PIMs, particularly those with high PPV for being AIMs.

Strategies designed to reduce AIMs would be more focused if the specific patients most likely to receive AIMs or the providers most likely to prescribe them were known. Unfortunately, in this relatively small study, we were unable to demonstrate significant risk factors associated with the number of AIMs at discharge; thus, additional research is needed to target AIM-reducing interventions. Though we found no risk factors for AIMs, we found that a high number of pre-admission PIMs, discharge to a location other than home, and discharge from a surgical service were all predictive of a high number of PIMs at discharge. These risk factors were found in other studies as well.^{9,24,33} The fact that PIM risk factors were not associated with AIMs highlights, once again, that interventions tailored towards identifying PIMs will not always efficiently identify AIMs. Some of the factors that independently predicted PIMs in our study (e.g., discharge from a surgical service) may have been driven by a particular PIM category (e.g., opioids), which the clinical panel usually deemed appropriate given the clinical circumstances (e.g., treatment of post-operative pain). In these situations, the PIM risk factors are likely associated with the

indications that led to appropriate prescription and continuation of the PIMs. Risk factors specific to AIMs rather than PIMs are therefore needed to shape efficient interventions. A smaller sample size of AIMs may have hampered our ability to identify risk factors, since statistical power was reduced. Larger, multi-center investigations may therefore still identify risk factors for AIMs. Until such factors are known, efforts to reduce AIMs should focus on the PIMs categories that are almost always inappropriate at discharge (i.e., those with high PPVs), such as atypical antipsychotics, non-benzodiazepine hypnotics, benzodiazepines, anticholinergics, and muscle relaxants.

We had hypothesized an association between delirium days, PIMs, and AIMs. The lack of such a relationship can potentially be explained by the nature of the statistical analysis, which examined potential predictors of PIMs and AIMs overall. Delirium duration might indeed be associated with greater prescription of specific PIMs or AIMs, such as antipsychotics or benzodiazepines, but we lacked sufficient sample size to examine predictors of specific PIM or AIM types. Future studies with larger samples should evaluate this issue further.

One limitation of our study is that we did not evaluate the short- and long-term adverse clinical outcomes (e.g., functional and cognitive status, rehospitalization, institutionalization) related to AIMs prescription. Ultimately, development of an evidence base that specifies the likelihood of harm associated with different medications, under different clinical circumstances, would provide detailed guidance to providers about the relative risks and benefits of particular agents in the elderly. Such a knowledge base could be incorporated into computerized order entry systems and drug safety surveillance programs. Further studies are needed to link PIMs and AIMs to adverse events so such systems can be developed.

Our study has several other limitations. First, we only examined prescribed medications and did not examine the cohort for inappropriate underprescribing, or medication discontinuation, any of which can expose patients to risk, as recently highlighted by Bell et al.³⁴ Second, the single-center nature of this study limits generalizability of our results to populations similar to the one studied. Third, this study was carried out before the 2012 Beers update was published.³⁵ The majority of the medications we added to the 2003 Beers criteria based on our own review of the medication safety literature^{6,20,21} have been also included in the 2012 update, supporting our approach, but some of the medications may require further deliberation before widely being considered PIMs. Fourth, owing to the multidisciplinary adjudication process that we employed, we did not assess agreement between individual clinicians in the panel regarding their determination of AIMs. It is possible that biases within the panel (e.g., personality or hierarchical relationships) influenced determinations, though we tried to minimize this by the selection of individuals (who were approximately the same age and did not have dominating personalities) and requirement for agreement between at least two out of three adjudicators. Fifth, we did not specifically evaluate the effect of each clinical discipline (e.g. cardiology, nephrology, orthopedics, etc.) on the risk of prescribing PIMs and AIMs; this should be further evaluated.

In summary, we found that PIMs (i.e., medications often associated with adverse effects) prescribed to elderly patients at hospital discharge were common and most often initiated during their ICU stay. Most of these PIMs were considered appropriate upon clinical review, which may explain why risk factors were identified for PIMs at discharge but not for AIMs. That many PIMs were not AIMs highlights the importance of clinical context in assessing the safety of medications at discharge. If medication safety programs focus on reducing AIMs rather than PIMs, e.g., by screening primarily those PIMs with high PPV for AIMs,

they may save time and money by avoiding unnecessary scrutiny of medications that are appropriately prescribed and focusing attention on higher risk medications.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Demographics and Clinical Characteristics of Elderly Survivors of Critical Illness^a

Variables	(N =120)
Age	68 (64-74)
Men, No. (%)	64 (53%)
Race, No. (%)	
- Caucasian	115 (96%)
- African American	5 (4%)
Charlson Index at enrollment	2 (1.0-4.0)
Intensive care unit type at admission, No. (%)	
- Medical intensive care unit	57 (48%)
- Surgical intensive care unit	63 (52%)
APACHE II score	27 (20-32)
Admission diagnosis, No. (%):	
- Surgery ^b	39 (32%)
- Sepsis/Acute respiratory distress syndrome	23 (19%)
- Cardiogenic shock/Myocardial Infarction/CHF	22 (18%)
- Airway protection	17 (14%)
- ARDS without infection	9 (7%)
- Other ^c	10 (9%)
Hospital length of stay, days	10 (6-16)
Delirium duration, days	3 (1-6)
Discharging service, No. (%)	
- Surgical	64 (53%)
- Medical	56 (47%)
Discharge disposition, No. (%)	
- Home	56 (47%)
- Rehabilitation	36 (30%)
- Long term acute care	17 (14%)
- Nursing Home	11 (9%)

^aMedian (interquartile range) unless otherwise noted.

^bSurgery: abdominal, urological, cardio-vascular, transplant, orthopedic, ear-nose-throat.

^cOther: cirrhosis/hepatic failure, hemorrhagic shock, arrhythmia, gastrointestinal bleed.

Abbreviations: APACHE-II, Acute Physiology and Chronic Health Evaluation-II; ARDS, acute respiratory distress syndrome; CHF, congestive heart failure.

Table 2
Categories of Potentially Inappropriate Medications (PIMs) Pre-admission, and Categories of PIMs and Actually Inappropriate Medications (AIMs) at Discharge

PIMs categories ^a	Pre-admission PIMs, N (%) ^b (N=157) ^c	Discharge PIMs, N (%) ^b (N=250) ^d	Discharge AIMs, N (%) ^b (N=90) ^e	Positive Predictive Value (PPV) ^f
-Opioids	21 (13%)	69 (28%)	11 (12%)	16%
-Anticholinergics	39 (25%)	60 (24%)	33 (37%)	55%
-Antidepressants	32 (20%)	30 (12%)	7 (8%)	23%
-Drugs causing orthostasis	14 (9%)	20 (8%)	2 (2%)	10%
-Non-benzodiazepine hypnotics	14 (9%)	18 (7%)	13 (14%)	67%
-Benzodiazepines	8 (5%)	12 (5%)	8 (9%)	67%
-Atypical antipsychotics	1 (1%)	14 (6%)	10 (11%)	71%
-Antiarrhythmics	8 (5%)	13 (5%)	1 (1%)	8%
-Typical antipsychotics	0 (0%)	2 (1%)	0 (0%)	0%
-Muscle relaxants	4 (3%)	3 (1%)	3 (3%)	100%
-NSAIDS	6 (4%)	0 (0%)	0 (0%)	n/a
-Others ^g	10 (6%)	9 (4%)	2 (2%)	22%

Abbreviations: NSAIDS, non-steroidal-anti-inflammatory drugs

^a Although some medications may exhibit multiple properties, the medications have been classified to be mutually exclusive as described in the methods. The specific medications evaluated, according to their category, are listed in the appendix.

^b Percentages in these columns show the proportion of total PIMs or AIMs that were accounted for by individual PIMs categories.

^c A total of 157 PIMs were prescribed to 79 patients prior to admission.

^d A total of 250 PIMs were prescribed to 103 patients at hospital discharge.

^e A total of 90 AIMs were prescribed to 61 patients at hospital discharge.

^f PPV indicates the proportion of PIMs in each PIM category that were considered actually inappropriate medications (AIMs) at hospital discharge.

^g Others included digoxin, ferrous sulfate, furosemide, nitrofurantoin, and toremide.

Table 3
Risk Factors for Potentially Inappropriate Medications (PIMs) at Hospital Discharge

Risk Factor	Rate Ratio	95% Confidence Interval	P
Age	1.00	0.99-1.02	.72
Number of pre-admission PIMs	1.16	1.08-1.25	<.001
Charlson comorbidity score	1.03	0.97-1.08	.37
Days of delirium	1.00	0.97-1.03	.93
Hospital length of stay	1.02	1.00-1.04	.08
Discharge service (surgical vs. medical)	1.45	1.20-1.69	<.01
Discharge disposition (not home vs. home)	1.38	1.10-1.66	.03