Guided Prescription of Psychotropic Medications for Geriatric Inpatients

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Background: Inappropriate use or excessive dosing of psychotropic medications in the elderly is common and can lead to a variety of adverse drug events including falls, oversedation, and cognitive impairment.

Methods: We developed a database of psychotropic medication dosing and selection guidelines for elderly inpatients. We displayed these recommendations to physicians through a computerized order entry system at a tertiary care academic hospital. The system was activated for 2 of 4 six-week study periods in an off-on-off-on pattern. Main outcome measures were agreement with the recommended daily dose for the initial drug order, incidence of dosing at least 10-fold greater than the recommended daily dose, prescription of nonrecommended drugs, inpatient falls, altered mental status as measured by a brief nursing assessment, and hospital length of stay.

Results: A total of 7456 initial orders for psychotropic medications were prescribed for 3718 hospitalized elderly patients with a mean±SD age of 74.7±6.7 years. The intervention increased the prescription of the recommended daily dose (29% vs 19%; P<.001), reduced the incidence of 10-fold dosing (2.8% vs 5.0%; P<.001), and reduced the prescription of nonrecommended drugs (10.8% vs 7.6% of total orders; P<.001). Patients in the intervention cohort had a lower in-hospital fall rate (0.28 vs 0.64 falls per 100 patient-days; P=.001). No effect on hospital length of stay or days of altered mental status was found.

Conclusion: A geriatric decision support system for psychotropic medications increased the prescription of recommended doses, reduced the prescription of nonrecommended drugs, and was associated with fewer inpatient falls.

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PSYCHOTROPIC MEDICATIONS have been implicated in a variety of adverse drug events (ADEs), including falls, hip fractures, delirium, and oversedation.14 Vulnerable geriatric patients may experience disproportionate injury from psychotropic medications because of increased frequency of use, slower metabolic clearance, or reduced physiologic reserve.10,11 The hospitalized elderly, who experience 4 times as many preventable ADEs than do younger patients,12 are potentially most vulnerable because of acute-onset illness and high prevalence of frailty.13 Efforts to reduce ADEs in the elderly due to psychotropic medications have focused on reduced drug dosing and improved drug selection.14-20 "Geriatric dosing," or a reduced recommended initial dose for elderly patients, is endorsed by the Food and Drug Administration (FDA).21,22 The FDA mandates that drug manufacturers state a recommended geriatric dose for all medications evaluated in a significant number of patients older than 65 years. Additional guidelines for psychotropic prescribing are available as part of the Beers criteria and the Assessing Care Of Vulnerable Elders (ACOVE) quality indicators, which were developed to achieve consensus on appropriate geriatric drug use and dosing.23-25 Adherence to the Beers criteria has been found to be suboptimal in a variety of health care settings.26,27

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We developed an automated medication decision support system for patients 65 years or older to deliver evidence-based prescribing recommendations and expert geriatric knowledge at the point of care. We aimed to encourage more conservative initial dosing and better psychotropic drug selection among hospitalized elderly patients. The application was not designed to advise physicians on the subsequent titration of these agents in response to patients’ response to the initial dose, although this might also be beneficial. We hypothesized that closer adherence to the recommendations in our system would lead to reductions in altered mental status, inpatient falls, and hospital length of stay.
DESCRIPTION OF INTERVENTION

Guided dosing of psychotropic medications was integrated into the Brigham Integrated Computer System (BICS) order entry application, which serves Brigham and Women's Hospital, a 720-bed tertiary care hospital in Boston, Mass. House staff physicians directly enter more than 90% of inpatient orders into BICS, including medication, laboratory, and radiology orders. The remainder of orders, including verbal orders, are entered by nurses or medical students and cosigned by physicians. When ordering a medication, after choosing the name of a drug from a coded list, the health care provider is presented with a list of potential doses; one is highlighted as the most commonly used (or “default”) dose (Figure 1). The default dose is selected if the physician presses the “enter” key; other doses on the list are selectable by moving the cursor keys up and down. The frequency of drug administration is also selected from a list of possibilities, one of which is highlighted as the default. The offered lists of doses and frequencies are intended to provide general guidance and be appropriate for most clinical circumstances in which the drug is used.

We developed a decision support tool that altered the default dose and the default frequency for psychotropic medications for patients 65 years and older. Patient age was calculated from the birth date stored in the registration database. For intervention patients, the system displayed the geriatric-specific dosing suggestions and displayed the alert “Default for 65 or older patients” (Figure 1). For example, the dose list for oral lorazepam highlighted 1 mg for adult patients younger than 65 years and 0.5 mg for patients 65 years and older.

A second function of the intervention suggested a substitution when the physician ordered one of 12 psychotropic medications known to be poorly tolerated or higher risk in elderly patients (Figure 2). As an example, intravenous morphine sulfate was recommended in place of intravenous meperidine. When possible, the suggested substitutions had similar analgesic or sedating potency. If physicians elected not to accept the substitution, the system still highlighted a reduced dose or frequency for the nonrecommended agent.

KNOWLEDGE BASE

Three medication classes were targeted for the intervention: benzodiazepines, opiates, and neuroleptics. The literature was reviewed to determine which psychotropic medications should be dose-adjusted or possibly not prescribed at all when the patient is older than 65 years. A list of 72 medications with specific recommendations was created from published literature and drug monographs. A panel of clinicians including a geriatrician (J.A.), a geriatric psychiatrist, a pharmacist (C.S.), 2 internists (J.F.P. and D.W.B.), and an anesthesiologist specializing in pain management modified the knowledge base according to their clinical expertise.

The intervention was developed to interoperate with decision support modules already alerting physicians to recommended drug dosing for renal failure and drug interactions.28 Many of the medications in the knowledge base were affected by both the geriatric and renal decision support rules. To resolve these conflicts, the system was designed to deliver the more conservative recommendation. For most psychotropic agents, the presence of severely impaired creatinine clearance generated a lower dose recommendation than did advanced age.

STUDY DESIGN

The performance of the decision support application was measured during 4 consecutive 6-week study periods. The first and third study periods were control periods consisting of usual computerized order entry. During control periods, a highlighted dose and frequency was standard for all adult patients, and dose recommendations for impaired renal function were active. The decision support application was activated for the second and fourth periods. All orders for psychotropic medications in the knowledge base on eligible patients were recorded in a log file at the time of ordering. Only initial orders were analyzed as subsequent dose titrations were expected to be based on a patient’s response to the initial dose. Approval for the study design was obtained from the institutional research board of the participating hospital.

POPULATION

All patients 65 years or older prescribed a medication in the knowledge base and admitted to any of the medical, surgical, neurology, and gynecology services from October 8, 2001, through May 16, 2002, were evaluated. General ward and intensive care patients were eligible for analysis. Only those patients whose admission was entirely contained within 1 of the 6-week study periods were included. The age, sex, and race for each patient were drawn from the registration database for the hospital.
The incidence of “greater than 10-fold orders” was calculated by identifying orders whose average daily dose was at least 10-fold higher than the recommended daily dose. A 10-fold cutoff was chosen because it has been reported in other populations to be an important indicator of error.\(^3\)

Three patient outcomes were measured using administrative data collected in the course of standard patient care. Length of stay was measured by subtracting the date of admission recorded in the electronic medical record from the date of discharge. Falls were identified through the hospital incident reporting system. A hospital-wide program to report all patient falls was in place during all study periods, and quality managers review all fall incident reports, following up with the care team to help ensure accuracy of the report. We reported on all falls during control and intervention periods and calculated the proportion of falls that were preceded by a psychotropic medication order. Fall injuries were documented on the standardized computerized incident report form by a nurse or physician caring for the patient.

Altered mental status was measured as part of routine care by the patient’s nurse who performed a commercial 23-item assessment (Medicus acuity score; Quadramed, Reston, Va) to estimate staffing needs. One item on the scale consisted of the yes/no question “Does the patient have altered mental status?” By convention and hospital policy, nursing staff recorded the assessment electronically at noon daily.

**STATISTICAL ANALYSIS**

All statistical analyses were conducted using the SAS statistical system (SAS Institute Inc, Cary, NC). Continuous data were represented as means with standard deviations or medians with interquartile ranges and evaluated with an unpaired \(t\) test and Wilcoxon rank sum for normal and skewed data, respectively. Categorical data were presented as proportions and compared with a \(\chi^2\) test.

Multivariable logistic regression was performed to determine the effect of the intervention on falls adjusted for age, sex, race, and a variable coding the number of days since the beginning of the study. The time-based variable was included to evaluate whether a linear secular effect was contributing to the differences in outcomes.

**RESULTS**

**PATIENTS**

Altogether, 3718 patients 65 years or older and whose admission was wholly contained within 1 of the 4 six-week study periods were evaluated. In the 2 control periods, 1925 patients were admitted for 9479 days, while 1793 patients were admitted for 8661 days within the 2 intervention periods. Fewer patients were enrolled during the first intervention period because of reduced admissions during the last 2 weeks of December compared with similar intervals in the other 3 study periods. Age, sex, and race were similar between the 2 cohorts (Table 1).

**DRUG ORDERS**

In all, 3908 initial psychotropic drug orders were prescribed for eligible patients in the control periods, compared with 3525 orders in the intervention period. The number of orders per admission was similar in the 2 cohorts (median, 2; interquartile range, 1-3; \(P\geq.20\)). The percentage of drug orders written “to be given as needed” was 89% overall, with fewer in the intervention periods compared with control periods (82% vs 95%; \(P<.001\)).

Prescriptions for every class of psychotropic drugs agreed with the system recommendations more frequently during the intervention periods (overall, 29.3% vs 19.4%; \(P<.001\)). The agreement rate for both of the 2 control periods was lower than the agreement rate for both of the 2 intervention periods (Figure 3). The agreement with suggested neuroleptic dosing was higher than for opiates and benzodiazepines (Table 2).

The overall incidence of 10-fold orders decreased from 5.0% to 2.8% during the intervention periods. In addition, nonrecommended drug orders decreased from 10.8% to 7.6% (\(P<.001\)). Of the decrease in nonrecommended drug use, 97% was attributable to reduced prescribing of meperidine in both intramuscular and intravenous forms.

**Table 1. Patient Characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Admissions (n = 1925)</th>
<th>Intervention Admissions (n = 1793)</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admitting service, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiology</td>
<td>17.4</td>
<td>19.4</td>
<td>.11</td>
</tr>
<tr>
<td>General medicine</td>
<td>19.3</td>
<td>20.6</td>
<td>.34</td>
</tr>
<tr>
<td>Oncology</td>
<td>8.5</td>
<td>7.6</td>
<td>.35</td>
</tr>
<tr>
<td>Other</td>
<td>54.9</td>
<td>52.4</td>
<td>.78</td>
</tr>
<tr>
<td>Race, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>85.7</td>
<td>85.5</td>
<td>.89</td>
</tr>
<tr>
<td>Black</td>
<td>7.1</td>
<td>7.6</td>
<td>.54</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3.2</td>
<td>2.7</td>
<td>.33</td>
</tr>
<tr>
<td>Other</td>
<td>3.3</td>
<td>3.3</td>
<td>.95</td>
</tr>
<tr>
<td>Female, %</td>
<td>52.7</td>
<td>52.9</td>
<td>.90</td>
</tr>
<tr>
<td>Age, mean ± SD, y</td>
<td>74.6 ± 6.8</td>
<td>74.8 ± 6.9</td>
<td>.39</td>
</tr>
</tbody>
</table>

**Figure 3. Agreement with application recommendations by study period.** Data are percentage of total orders in each drug class that agree with dosing recommendations delivered by the physician order entry application.
PATIENT OUTCOMES

Altered Mental Status

During the four 6-week study periods, 15792 nursing assessments of mental status were recorded representing evaluations for 87% of all patient-days. Of the responses to the Medicus survey, 3375 (21%) indicated altered mental status. Patients in the intervention group were scored as having a similar number of altered mental status days compared with control patients (20.9 vs 21.9 per 100 patient-days; \( P = .17 \)).

Length of Stay

No difference in length of stay was detected between control and intervention periods, with identical median and interquartile range at 4 days and 2 to 6 days, respectively (\( P = .43 \)).

In-Hospital Falls

Fewer falls occurred during intervention periods compared with control periods (Table 3). When corrected for differences in total patient-days of observation in each group, the rate of falls continued to be significantly less (0.28 vs 0.64 falls per 100 patient-days; \( P = .001 \)). The proportion of patients who were prescribed a psychotropic medication prior to a fall was similar in both intervention and control cohorts (83.3% for each). A logistic regression model confirmed that patients in the intervention group had a reduced risk of falling (odds ratio, 0.50; 95% confidence interval, 0.30-0.82), and no other tested covariates, including age, sex, race, and time since study initiation, were significantly correlated with falls. The corresponding rate of fall-related injuries trended lower in the intervention group (0.06 vs 0.17 per 100 patient-days; \( P = .09 \)).

COMMENT

We designed, implemented, and evaluated a system of guided prescribing for hospitalized elderly patients receiving psychotropic medications. The system successfully increased the rate of initial prescriptions that agreed with an expert panel's recommended dosing and drug selection. The system also reduced more aggressive dosing, defined as 10-fold higher than the consensus recommendation. Aggressive dosing of psychotropics can be necessary in the acute-care setting, with examples being sedation of critically ill patients and unremitting pain or agitation, but it also raises the greatest safety concerns. Overall, our data show that a reduced default dose in the context of a physician order entry application can lower the initial dose ultimately chosen across a broad spectrum of possible dosing strategies for psychotropic agents.

Computerized physician order entry reduces serious medication error rates, even with limited decision support. However, computerized physician order entry has had more impact on near misses than on errors that cause injuries. We have hypothesized that more sophisticated decision support such as renal and geriatric dosing may be required to have a greater impact. Our application demonstrated incremental benefit over a system of guided prescribing for renal impairment, which was active during both the intervention and control periods and which featured a similar interface and operation. Because the renal dosing suggestions were in place for the control and the intervention periods, our estimates of the benefits of geriatric dosing are more conservative than would be expected if renal dosing suggestions were not in place. As in this previous study, a large number of the medication orders we evaluated did not agree with the decision support suggestion, even in the intervention group. Physician unwillingness to accept computerized dosing guidance is probably an important factor in the low rate of agreement. Another likely explanation is that a single recommended dose does not pertain to specialized indications such as prophylaxis for alcohol withdrawal or sedation for an invasive procedure. Additional clinical factors such as a medical history of long-term psychotropic use.

### Table 2. Initial Orders for Psychotropic Medications

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Admissions</th>
<th>Intervention Admissions</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total orders, No.</td>
<td>3908</td>
<td>3548</td>
<td></td>
</tr>
<tr>
<td>Orders per admission, median (IQR)</td>
<td>2 (1-3)</td>
<td>2 (1-3)</td>
<td>.73</td>
</tr>
<tr>
<td>PRN orders, %</td>
<td>95.1</td>
<td>82.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Agreement with recommendation (% of total orders in class)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All classes (n = 7456)</td>
<td>18.6</td>
<td>29.3</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Benzodiazepines (n = 3023)</td>
<td>20.8</td>
<td>28.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Opiates (n = 3976)</td>
<td>16.6</td>
<td>29.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Neuroleptics (n = 457)</td>
<td>22.5</td>
<td>38.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Orders with 10-fold dosing (% of total orders in class)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All classes</td>
<td>5.0</td>
<td>2.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>3.5</td>
<td>2.0</td>
<td>.01</td>
</tr>
<tr>
<td>Opiates</td>
<td>5.5</td>
<td>2.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Neuroleptics</td>
<td>10.0</td>
<td>7.5</td>
<td>.35</td>
</tr>
<tr>
<td>Orders for nonrecommended drugs* (% of total orders)</td>
<td>10.8</td>
<td>7.6</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

**Abbreviations:** IQR, interquartile range; PRN, to be given as needed.

*Nonrecommended drugs included chloridiazepoxide, diazepam, estazolam, flurazepam, triazolam, carisoprodol, meperidine, pentazocine, propoxyphene, chlorpromazine, and fluphenazine.

### Table 3. Patient Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Admissions</th>
<th>Intervention Admissions</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altered mental status days per 100 patient-days</td>
<td>20.9</td>
<td>21.9</td>
<td>.17</td>
</tr>
<tr>
<td>Hospital length of stay, median (IQR)</td>
<td>4 (2-6)</td>
<td>4 (2-6)</td>
<td>.43</td>
</tr>
<tr>
<td>Total falls per 100 patient-days, rate (No.)</td>
<td>0.64 (60)</td>
<td>0.28 (24)</td>
<td>.001</td>
</tr>
<tr>
<td>Fall injuries per 100 patient-days, rate (No.)</td>
<td>0.17 (13)</td>
<td>0.06 (5)</td>
<td>.09</td>
</tr>
</tbody>
</table>

**Abbreviation:** IQR, interquartile range.
were unavailable to the order entry system and may have appropriately led to a higher initial dose than the one suggested by the application. Our guided prescribing application was deliberately designed to deliver dosing recommendations without interrupting or slowing the ordering process, and thus there was no barrier to choosing a higher value on the dose list. More sophisticated dose recommendation engines could attempt to capture indication or clinical assessments of dementia and frailty to improve the specificity of the suggestion and to incorporate stronger warnings against overdosage when necessary.

Few data are available regarding implementation of geriatric prescribing suggestions in computerized physician order entry applications. Geriatric consultations, which provide more detailed, individualized recommendations, have been variably effective at improving patient outcomes. Educational interventions to reduce psychotropic use are also effective and have shown improvements in drug-related cognitive impairment. One successful multicomponent intervention to reduce delirium by Inouye et al included standardized psychotropic recommendations and implemented educational efforts to reduce inappropriate psychotropic use. The system presented here differs from these efforts by delivering the recommendation at the point of care in real-time. The knowledge represented in the application is available to all physicians at all times, including many physicians in specialties with little exposure to geriatric prescribing principles.

In-hospital falls have multiple causes, and few interventions have been successful for preventing falls. Psychotropic medication use is a common precipitant, and many of the identified risk factors for falls in the hospital such as frailty and incontinence are difficult to modify, the selection and dosing of psychotropic medications can more readily influenced in the acute-care setting. The results of this trial suggest that guided prescribing of psychotropic medication may be an important tool for reducing the fall risk of an entire hospitalized population. The intervention periods were associated with a greater than 50% drop in inpatient falls, and none of the available demographics confounded the association. Several potential confounders including the presence of motor and sensory deficits could not be measured but were expected to be evenly distributed between control and intervention periods.

Neither hospital length of stay nor rate of altered mental status was significantly altered by the intervention. Altered mental status is typically correlated with use of psychoactive medications. However, the brief nursing report of mental status in the Medicus survey may not be sensitive enough to detect oversedation and hypoactive delirium, especially since only 1 daily assessment was performed. These states are also commonly missed by health care providers during the course of hospital care, and future evaluation of guided psychotropic dosing should include standardized delirium and sedation assessments.

This study has several limitations. It was not randomized, and secular trends in hospitalized patients that matched the timing of the intervention may have influenced the outcomes and confounded our results. Second, most psychotropic medication orders were written “to be given as needed,” and we could not verify the actual administration of medication ordered. Third, we were not able to use standardized geriatric assessment instruments, but the high enrollment enabled the capture of multiple falls, which are uncommon but potentially severe. Fourth, admissions crossing the boundaries of a study period were not included in the analysis, which excludes patients with a longer hospital course. Finally, house staff are the primary users of the order entry application, and the findings in this report may not generalize to community and other nonteaching environments.

In summary, decision support software to guide prescribing of psychotropic medications significantly increased recommended drug selection and dosing and was associated with fewer inpatient falls. As hospitals and health care systems struggle to provide a safer prescribing environment for a rapidly aging population, providing guidance and expert geriatric advice at the point of decision making will be a critical component of quality care.

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REFERENCES

9. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a sys-


22. Knapp D, Erwin G. *Screening Criteria for Outpatient Drug Use Review: Final Re*


