Clinical and economic outcomes of pharmacist recommendations in a Veterans Affairs medical center

AUDREY J. LEE, MAUREEN S. BORO, KATHERINE K. KNAPP, JOY L. MEIER, and NANCY E. KORMAN

New drugs and increasingly complex drug regimens increase health care costs and the likelihood of medication misuse. The importance of medication misuse was underscored in 1999 when the Institute of Medicine (IOM) recommended that the reduction of medical errors be considered a national priority. In 2001, IOM emphasized the need to improve health care by adopting a team approach that crosses traditional boundaries of inpatient, outpatient, and nursing-home care. An improved system approach has also been recommended for pharmacy practice.

Pharmacists have an important role in decreasing medication misuse through collaborative drug therapy. This role is not new for pharmacists. Studies demonstrate that pharmacist recommendations can prevent medication errors and minimize adverse effects. Other studies have shown that pharmacist recommendations can decrease the cost of therapy and improve outcomes. However, many of these studies have been limited by the inability to capture information from a variety of practice settings or to capture both clinical and economic data.

The Veterans Affairs (VA) health...
The purpose of our study was to evaluate pharmacist recommendations in a VA medical center serving inpatients, outpatients, and nursing-home residents. The evaluation characterized the types and frequencies of recommendations and estimated the level of benefit or harm that would have occurred with and without them, as well as the economic and clinical consequences.

**Methods**

**Study site.** The study was conducted at a VA medical center that included a tertiary care teaching hospital (344 acute care beds and 18-bed surgical, medical, and coronary care unit), a 120-bed nursing home, and clinics with over 220,000 patient visits per year. At the time of the study, the medical center was providing care to approximately 25,000 veteran patients. The pharmacy service was staffed by 36 pharmacists and 5 pharmacy residents. Of the 36 pharmacists, 22 were staff pharmacists, 8 were pharmacist specialists, and 6 were administrators. Thirty of the pharmacists held the doctor of pharmacy degree, 6 held the bachelor of science degree, and 19 had completed residency training. These pharmacists had 2–40 years of experience each.

**Study design.** Our study was designed to evaluate the first 600 recommendations that met the study criteria, including 250 in the inpatient setting, 250 in the outpatient setting, and 100 in the nursing home. Data were collected from April 1998 through April 1999 at each practice setting until the goal for that setting was reached. A minimum of 100 recommendations for each setting were required to obtain a statistical power of 80% (a priori level of significance, 0.05).

We defined a recommendation as one made to a provider that involved application of the pharmacist’s knowledge to a specific patient or a physician order. A recommendation was included if it was adequately recorded in the electronic system for documenting recommendations, occurred during the study period, and involved a veteran patient who received care at the medical center during the study period. The electronic documentation system included 15 types of pharmacist recommendations derived from earlier studies and clinical experience (Table 1).

Recommendations were excluded if they were incomplete (lacking information necessary for classifying them), were duplicates, or involved an automatic therapeutic interchange or an order clarification. Recommendations were also excluded if they did not require the pharmacist to use clinical judgment or were not patient specific, such as the provision of standardized medication counseling and drug information or the routine ordering of laboratory tests. Recommendations for activities in which the pharmacist served as the patient’s provider were also excluded (e.g., protocol-driven warfarin dosage adjustments by anticoagulation pharmacists).

The data included recommendations by pharmacists, pharmacy residents, and pharmacy students, all of whom had access to the electronic medical record. Pharmacist preceptors reviewed all recommendations made by students. Before data were collected, all pharmacists and students participated in an orientation to the electronic system for documenting recommendations.

**Acceptance rates and clinical outcomes.** We determined acceptance rates for recommendations by chart review. A recommendation was considered to have been accepted if it was implemented within 3 days for inpatients and within 30 days for outpatients and nursing-home residents. For each patient for whom the pharmacist made a recommenda-

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**Table 1. Types of Pharmacist Recommendations**

<table>
<thead>
<tr>
<th>Type of Recommendation</th>
<th>Inpatient Setting (n = 250)</th>
<th>Outpatient Setting (n = 250)</th>
<th>Nursing-Home Setting (n = 100)</th>
<th>All Settings (n = 600)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust dosage or frequency</td>
<td>129 (51.6)</td>
<td>83 (33.2)</td>
<td>44 (44)</td>
<td>256 (42.7)</td>
</tr>
<tr>
<td>Drug not indicated</td>
<td>32 (12.8)</td>
<td>31 (12.4)</td>
<td>16 (16)</td>
<td>79 (13.2)</td>
</tr>
<tr>
<td>Drug interaction</td>
<td>17 (6.8)</td>
<td>47 (18.8)</td>
<td>2 (2)</td>
<td>66 (11.0)</td>
</tr>
<tr>
<td>Prevent or manage adverse drug event</td>
<td>26 (10.4)</td>
<td>21 (8.4)</td>
<td>5 (5)</td>
<td>52 (8.7)</td>
</tr>
<tr>
<td>Untreated diagnosis</td>
<td>14 (5.6)</td>
<td>22 (8.8)</td>
<td>14 (14)</td>
<td>50 (8.3)</td>
</tr>
<tr>
<td>Prevent or manage drug allergy</td>
<td>15 (6)</td>
<td>9 (3.6)</td>
<td>5 (5)</td>
<td>29 (4.8)</td>
</tr>
<tr>
<td>Duplication of therapy</td>
<td>5 (2)</td>
<td>16 (6.4)</td>
<td>4 (4)</td>
<td>25 (4.2)</td>
</tr>
<tr>
<td>Other*</td>
<td>7 (2.8)</td>
<td>14 (5.6)</td>
<td>1 (1)</td>
<td>22 (3.6)</td>
</tr>
<tr>
<td>Duration of therapy</td>
<td>2 (0.8)</td>
<td>5 (2.0)</td>
<td>5 (5)</td>
<td>12 (2.0)</td>
</tr>
<tr>
<td>Evaluate response</td>
<td>2 (0.8)</td>
<td>2 (0.8)</td>
<td>3 (3)</td>
<td>7 (1.2)</td>
</tr>
<tr>
<td>Switch from i.v. to p.o. route</td>
<td>1 (0.4)</td>
<td>0 (0)</td>
<td>1 (1)</td>
<td>2 (0.3)</td>
</tr>
</tbody>
</table>

*Some examples of other recommendations included pharmacist recommendations to improve patient compliance and to prevent abuse of narcotics.
tion, a review of electronic progress notes and laboratory test results was performed to evaluate outcomes related to the patient's medical problem. Clinical outcomes were classified as resolution, improvement, no change, or worsening of the medical problem. In addition, we determined if adverse outcomes could be attributed to the recommendation.

Independent review process. The process for reviewing recommendations was similar to that of an earlier study. Each recommendation was reviewed for the potential to prevent or cause harm by two independent evaluators, a board-certified physician internist and a pharmacist with a Pharm.D. degree and two years of postgraduate residency training. In cases of disagreement, a board-certified internist acted as a tiebreaker. All evaluators had at least five years of practice experience, including work experience at a VA medical center. All evaluators were provided with electronic health summaries to allow patient-specific evaluation of the recommendations and were blinded with respect to the pharmacist making the recommendation, the patient, and the physician.

If an evaluator judged that harm could have occurred, the evaluator estimated the probability on a scale from 0 to 1.0, with 0 defined as completely unlikely, 0.5 as neither likely nor unlikely, and 1.0 as very likely. The evaluator then identified the health care resources needed to treat the harmful event, such as medications, laboratory and diagnostic procedures, clinic visits, and hospitalization.

We determined the percentage of cases in which the evaluators agreed that harm could have occurred with and without the recommendation and calculated the average probability of harm predicted by each evaluator for each health care setting. The kappa statistic was calculated to measure interrater reliability. Paired t tests were used to compare the evaluators' estimates of the probability of harm. The a priori level of significance was set at 0.05.

Cost analysis. The cost analysis looked at the cost of the original therapy (the therapy before a change was recommended), the cost of the recommended therapy, and cost avoidance. We estimated the cost of the original and recommended therapy for each of the 600 recommendations by multiplying the national VA drug acquisition cost by the duration of therapy and adding the associated cost for a pharmacist to process and fill the order (Appendix A). The duration of therapy was based on the guidelines listed in Appendix A. The labor cost was calculated by multiplying the local hourly wage for a VA pharmacist by the average time spent processing and filling orders (based on a national VA workload report)31. The local labor cost for a pharmacist to make a recommendation was included (Appendix A). These methods were modified from an earlier study.

Two assumptions were made when calculating the cost of original and recommended therapy. The cost of original therapy was assumed to be zero if the recommendation involved starting a medication for a previously untreated medical problem, such as initiating lipid-lowering therapy for previously untreated hyperlipidemia. If the recommended therapy involved withholding or discontinuing the medication, then it was assumed that the cost of the recommended therapy was only the cost of the pharmacist making the recommendation.

The average cost avoidance was calculated when the evaluators (including input from the tiebreaker) agreed that the recommendation prevented harm or caused harm (Appendix A). For each recommendation, the type of care identified by the two evaluators was used to calculate the corresponding cost of care. If the evaluators indicated that the cost of care would have increased the length of hospitalization, then the local VA International Classification of Disease (ICD-9)-specific bed-day cost associated with the recommendation was used. If the ICD-9-specific bed-day cost was not available, then the local VA average intensive care, surgical, or medical service-specific bed-day cost was used. Service-specific and ICD-9-specific costs were all-inclusive. If a recommendation did not involve a longer hospital or nursing-home stay, then local VA costs were used for laboratory tests, diagnostic procedures, medications, telephone care, clinic visits, and emergency-room visits whenever indicated. The cost of self-care was assumed to be zero.

Cost avoidance was calculated by multiplying the cost of care associated with a recommendation by the corresponding probability of harm estimated by the evaluator. The higher of the two cost-avoidance figures for each recommendation was defined as the maximum cost and the lower cost figure as the minimum. The two costs were then averaged to determine the mean cost avoidance per recommendation. The maximum cost-avoidance figures for each recommendation were then added together to determine the total maximum cost-avoidance figure. The total minimum cost-avoidance figure was calculated by using the same method.

Stratification of recommendations. We integrated data about the frequency of recommendations by type, likelihood of causing harm, and cost avoidance for each practice setting. Overall cost avoidance was determined by multiplying recommendation frequency by mean cost avoidance. We then identified the types of recommendations that were most common, most likely to cause harm, and most costly to the health care system. The stratification included recommendations for which the two evaluators agreed that harm was prevented or occurred.

Results

A total of 1511 pharmacist recom-
recommendations were screened sequentially to reach the study goal of 250 inpatient, 250 outpatient, and 100 nursing-home recommendations. A total of 911 recommendations were excluded because they were incomplete (38.5%), involved routine activities that did not require the pharmacist to use clinical judgment or to provide a patient-specific recommendation (17.7%), were therapeutic interchanges (15%), were entered by a pharmacist who was the patient’s provider (14.2%), were order clarifications (10.2%), or were duplicate entries (4.4%). Of the 600 recommendations that met the study’s criteria, 303 (50.5%) were made by clinical pharmacists, 172 (28.7%) by staff pharmacists, 64 (10.7%) by pharmacy residents, and 61 (10.2%) by pharmacy students.

Types of recommendations. Table 1 shows the distribution of the 600 recommendations by type. Rank ordering indicated that adjusting the dosage or frequency of administration accounted for over 40% of the recommendations. This type of recommendation was the most common in all practice settings. The second most frequent type of recommendation was discontinuing a drug that was not indicated for the patient’s medical problem. This type of recommendation ranked second in the inpatient and nursing-home settings and third in the outpatient setting.

Acceptance rates. Of the 600 recommendations, 31 could not be evaluated for acceptance because of insufficient documentation. Of the remaining 569 recommendations, 92.4% were accepted by providers. By practice setting, acceptance was 97.9% for inpatients, 92.8% for outpatients, and 78.8% for nursing-home patients.

Clinical outcomes. Table 2 shows the clinical outcomes related to 487 patients’ medical problems (representing 81% of all the recommendations). For the remaining 113 recommendations, the documentation needed to evaluate clinical outcomes was insufficient. For over 30% of the cases in each setting, the medical problem associated with the recommendation either improved or was resolved. For example, patients who required antimicrobials subsequently showed improvement in their infection. For approximately 40% of the cases in each setting, there was no change in the medical problem associated with the recommendation. For example, when the pharmacist recommended the elimination of unnecessary medication, the patient’s medical condition did not worsen. Only 1 (0.2%) of 487 patients had an adverse event related to a recommendation.

Acceptance of recommendations. Table 1 shows the acceptance rates by practice setting. Of the remaining 569 recommendations, 31 could not be evaluated for acceptance because of insufficient documentation. Of the remaining 569 recommendations, 92.4% were accepted by providers. By practice setting, acceptance was 97.9% for inpatients, 92.8% for outpatients, and 78.8% for nursing-home patients.

Potential for harm without the pharmacist recommendations. Overall, two of the three evaluators responded that patient harm would have occurred had the pharmacist not intervened in 540 of the 600 cases (90%). The kappa statistic based on the primary evaluators’ responses was 0.18, suggesting a low level of interrater reliability. However, the observed level of agreement between the primary evaluators was 80.4% across all health care settings. This observed agreement was a significant improvement over the level of agreement that would have been expected on the basis of chance alone (76.0%, t = 5.02, p < 0.001).

In particular, the physician primary evaluator indicated that harm could have occurred without the recommendation for 485 (81%) of 600 cases, compared with 92% for the pharmacist primary evaluator. The primary evaluators agreed that harm was avoided in 199 (80%) of the 250 inpatient cases, 192 (77%) of the 250 outpatient cases, and 78.8% for nursing-home patients.

Table 2. Evaluable Clinical Outcomes by Setting*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Inpatient Setting (n = 242)</th>
<th>Outpatient Setting (n = 164)</th>
<th>Nursing-Home Setting (n = 81)</th>
<th>All Settings (n = 487)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem associated with recommendation resolved</td>
<td>71 (29.3)</td>
<td>7 (4.3)</td>
<td>9 (11.1)</td>
<td>87 (17.9)</td>
</tr>
<tr>
<td>Problem associated with recommendation improved</td>
<td>37 (15.3)</td>
<td>49 (29.9)</td>
<td>18 (22.2)</td>
<td>104 (21.3)</td>
</tr>
<tr>
<td>Problem associated with recommendation unchanged</td>
<td>100 (41.3)</td>
<td>96 (58.5)</td>
<td>44 (54.3)</td>
<td>240 (49.3)</td>
</tr>
<tr>
<td>Problem associated with recommendation worsened</td>
<td>12 (5)</td>
<td>11 (6.7)</td>
<td>7 (8.6)</td>
<td>30 (6.2)</td>
</tr>
<tr>
<td>Patient had adverse effects related to recommendation</td>
<td>0</td>
<td>1 (0.6)</td>
<td>0</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Patient died for reason unrelated to recommendation</td>
<td>22 (9.1)</td>
<td>0</td>
<td>3 (3.7)</td>
<td>25 (5.1)</td>
</tr>
</tbody>
</table>

*Outcomes were not evaluable in 113 of 600 cases (inpatient, 8 cases; outpatient, 86 cases; and nursing home, 19 cases) because of insufficient information.
outpatient cases, and 69 (69%) of the 100 nursing-home cases.

The physician tiebreaker evaluated 118 cases in which the primary evaluators did not agree about the potential for harm. The tiebreaker indicated that harm could have occurred without the pharmacist recommendation in 80 (68%) of these cases. The tiebreaker agreed more with the pharmacist primary evaluator (65% of cases) than with the physician primary evaluator (35%).

**Potential for harm as a consequence of the pharmacist recommendations.** In only 4 (<1%) of the 600 cases, two of the three evaluators agreed that harm could have resulted from the pharmacist recommendations. All of these cases involved the outpatient setting. The physician primary evaluator indicated that patient harm could have occurred for 2 cases (0.3%), compared with 25 cases (4%) for the pharmacist evaluator. The level of agreement between the primary evaluators across all health care settings was 0.96.

The tiebreaker evaluated the 25 cases in which the primary evaluators could not agree whether the pharmacist recommendations resulted in harm. The tiebreaker indicated that harm could have occurred in 3 (12%) of these 25 cases.

**Probability of harm.** The overall average probability of harm was 0.45 and did not differ significantly by setting. Estimates of the probability of harm did not differ significantly between the primary evaluators for any setting. The tiebreaker reported a lower probability of harm than both primary evaluators (0.26). Finally, for the four recommendations that the evaluators agreed could have resulted in harm, the overall average probability of harm was 0.18.

**Economic analysis.** Table 3 summarizes the cost of therapy and cost avoidance across all settings. Overall, the recommendations reduced the cost of therapy by 20%. The mean saving per recommendation by setting ranged from $19 to $41, with the greatest saving occurring in the nursing-home setting. The overall mean cost avoidance per recommendation was $700. Cost avoidance ranged from $325 per recommendation in the outpatient setting to $1,057 in the inpatient setting. The mean total cost avoidance across all settings was $420,155 (minimum, $154,949; maximum, $685,362).

A subgroup analysis of the cost-avoidance data found significant differences between the primary evaluators’ mean predicted cost consequences. In all three settings, the physician’s cost estimates were significantly lower than the pharmacist’s: for the inpatient setting, physician mean, $836 (range, $0–$18,196), versus pharmacist mean, $1,562 ($0–$29,412) (p = 0.005); for the outpatient setting, physician mean, $266 ($0–$8,829), versus pharmacist mean, $489 ($0–$24,889) (p = 0.05); and for the nursing-home setting, physician mean, $545 ($0–$14,289), versus pharmacist mean, $1,412 ($0–$28,578) (p = 0.02).

**Stratification of recommendations.** Table 4 provides integrated data on the seven most common types of recommendations for which harm was prevented. Recommendations performed to prevent or manage drug allergies were associated with the highest average probability of harm (0.65) across all the health care settings. Recommendations involving management of a drug interaction were associated with the second highest average probability of harm for the nursing-home (0.60) and inpatient (0.54) settings but not the outpatient setting.

Cost avoidance by type of recommendation was greatest for recommendations related to drug interactions in the inpatient setting ($1647), while recommendations to initiate a medication regimen for an untreated diagnosis contributed to the highest cost avoidance for the outpatient and nursing-home settings ($1479 and $2306, respectively).
Table 4. Most Frequent Types of Recommendations Judged To Prevent Harm

<table>
<thead>
<tr>
<th>Setting</th>
<th>Type of Recommendation</th>
<th>n</th>
<th>Average Cost Avoided per Recommendation ($)</th>
<th>Average Probability of Harm</th>
<th>Probability of Harm (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient Setting</td>
<td>Drug interaction</td>
<td>17</td>
<td>0.54</td>
<td>0.36</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Prevent or manage drug allergy</td>
<td>15</td>
<td>0.65</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>Adjust dosage of frequency</td>
<td>12</td>
<td>0.47</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Prevent or manage adverse drug event</td>
<td>12</td>
<td>0.47</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Drug not indicated</td>
<td>12</td>
<td>0.47</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Duplication of therapy</td>
<td>5</td>
<td>0.36</td>
<td>0.36</td>
<td>0.36</td>
</tr>
<tr>
<td>Outpatient Setting</td>
<td>Drug interaction</td>
<td>64</td>
<td>1.65</td>
<td>1.65</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td>Prevent or manage drug allergy</td>
<td>18</td>
<td>1.88</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td></td>
<td>Adjust dosage of frequency</td>
<td>18</td>
<td>1.88</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td></td>
<td>Prevent or manage adverse drug event</td>
<td>18</td>
<td>1.88</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td></td>
<td>Drug not indicated</td>
<td>18</td>
<td>1.88</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td></td>
<td>Duplication of therapy</td>
<td>18</td>
<td>1.88</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td>Nursing-Home Setting</td>
<td>Drug interaction</td>
<td>650</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>Prevent or manage drug allergy</td>
<td>640</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>Adjust dosage of frequency</td>
<td>640</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>Prevent or manage adverse drug event</td>
<td>640</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>Drug not indicated</td>
<td>640</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>Duplication of therapy</td>
<td>640</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
</tr>
</tbody>
</table>

The mean probability of harm and the added costs associated with recommendations predicted to cause harm were low. Three of the recommendations involved stopping a drug that was not indicated. These recommendations were associated with a mean probability of harm of 0.17 and an added cost of $31. The remaining type of recommendation involved a dosage or frequency adjustment and was associated with a probability of harm of 0.20 and an added cost of $25.

Table 5 integrates frequency and cost-avoidance data to show the overall impact of pharmacist recommendations. The analysis included the seven most common types of recommendations, which accounted for 83% of the mean total cost avoidance. The probability of harm was considered in this analysis because the cost-avoidance calculation included this factor as a multiplier. The greatest cost avoidance was due to dosage or frequency adjustments, accounting for 46% of the mean total cost avoidance. Most of the cost avoidance due to this type of recommendation occurred in the inpatient setting. For the outpatient and nursing-home settings, the greatest saving was due to initiating a drug regimen for an untreated diagnosis.

Discussion

Our study indicates that pharmacist recommendations in an integrated health care system can prevent harm in inpatients, outpatients, and nursing-home patients. In absence of the pharmacist recommendations, the evaluators agreed that patient harm would have resulted in 90% of cases.

Two comparable studies have demonstrated the value of pharmacist recommendations for inpatients and outpatients.9,15 In the previous inpatient study, evaluators’ rate of agreement in predicting the avoidance of harm (87% [52 of 60 cases]) was similar to that in our study (80% [199 of 250]). The rates of agreement that the recommendations could have caused harm were also similar (1.7% [1 of 60] versus 0% [0 of 250]). In the outpatient study, evaluators were less likely to agree that the recommendations avoided harm than in our study (21% [126 of 623] versus 78% [195 of 250], respectively).9 In addition, the mean probability of harm was higher than in our study (0.783 versus 0.445). The differences may be due to variations in patient populations, practice settings, and evaluators’ perspectives on the likelihood of harm. Because the previous study in outpatients did not report whether the recommendations may have caused harm, no direct comparison with our study could be made.

In our study, providers strongly agreed that the pharmacist recommendations for inpatients and outpatients were appropriate, as evidenced by a greater than 90% rate of acceptance. Other studies have demonstrated a high acceptance rate.5,12,22,26 The recommendations for nursing-home patients in our study had a lower acceptance rate (79%). Many of the unaccepted recommendations in this setting were made to reduce polypharmacy. Providers may have rejected some of these recommendations because they believed that their patients still needed these medications to be available, even if they had not been recently administered.

Our findings indicate that pharmacist recommendations for drug therapy significantly decrease health care costs. Our study focused on recommendations involving pharmacists’ clinical judgment and excluded therapeutic interchanges and drug conversions. Despite the exclusion of these recommendations, direct cost savings were demonstrated for all three health care settings. These savings were small, however, compared with the cost avoidance realized in health care resources. As anticipated, the mean cost avoidance per recom-
mendation was greatest for the inpatient setting, followed by the nursing-home and outpatient settings. Cost avoidance for inpatients was highest because many recommendations were projected to avoid longer hospital stays. Recommendations for nursing-home patients produced the second highest cost avoidance because of projected avoidance of increased nursing-home stays, hospital admissions, and emergency-room visits.

While the primary evaluators agreed that the recommendations prevented harm, they disagreed about the types of health care resources used to treat the harm. For example, there was less agreement concerning the length of nursing-home or hospital stays. As a result, there were significant differences in the predicted cost consequences among all three settings. Previous studies also found disagreement among evaluators concerning the utilization of health care resources.

While this study demonstrated that pharmacist recommendations can decrease health care costs, it also showed that these recommendations can improve patient outcomes and are unlikely to cause harm. Other studies support these findings.12,20,23 For the 31 cases with negative outcomes (worsening of the medical problem or development of an adverse effect), the evaluators did not predict that harm or negative outcomes would have resulted from the recommendations. Most of these patients had multiple comorbidities accompanying a clinical condition that increased the likelihood of a negative outcome. For example, one pharmacist recommended increasing the dosage of an antimicrobial, but the patient died of complications related to the infection.

We stratified our cost-avoidance data to identify the types of recommendations associated with the highest probability of harm and cost avoidance. Identifying these recommendations could enable pharmacists to make the best use of limited pharmacy resources. Recommendations made to prevent or manage drug allergies had the highest average probability of harm for all health care settings, while the cost avoidance per recommendation was highest for drug interaction-related recommendations and recommendations to start a drug regimen for an untreated diagnosis. Furthermore, after recommendation-frequency data were integrated with cost-avoidance data (Table 5), the recommendations involving adjustment of dosage or frequency had the highest overall cost impact. The latter recommendations had the highest cost impact primarily because they were the most frequent. This finding is supported by other studies.12,20,23

Our study was limited by its retrospective design. Also, the assessment of the recommendations for potential benefits and risks was subjective. The local VA ICD-9-specific bed-day cost was not available in each case; for these cases, we used the potentially less precise local VA average service-specific bed-day cost. As a result, our cost-avoidance figures are probably underestimates, since the ICD-9-specific bed-day cost was usually higher than the average service-specific bed-day cost. Our analysis was further limited by the use of individual reviewers instead of a panel of reviewers. In addition, clinical endpoints for evaluating the outcomes could not be clearly defined or predetermined because the recommendations were associated with a variety of medical problems. Finally, the study was conducted at a VA facility, so care should be taken in extrapolating the results to other health care systems.

### Conclusion
Pharmacist recommendations improved clinical outcomes and saved money at a VA medical center.

### References

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**Table 5.**

<table>
<thead>
<tr>
<th>Type of Recommendation</th>
<th>Inpatient Total Cost Avoidance</th>
<th>Outpatient Total Cost Avoidance</th>
<th>Nursing-Home Total Cost Avoidance</th>
<th>Total Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust dosage or frequency</td>
<td>146,000 (55.2)</td>
<td>21,663 (26.7)</td>
<td>25,349 (34.0)</td>
<td>193,012 (45.9)</td>
</tr>
<tr>
<td>Untreated diagnosis</td>
<td>6,199 (2.3)</td>
<td>28,102 (34.6)</td>
<td>29,978 (40.2)</td>
<td>64,279 (15.3)</td>
</tr>
<tr>
<td>Drug interaction</td>
<td>14,976 (5.7)</td>
<td>13,967 (17.2)</td>
<td>2,874 (3.9)</td>
<td>31,817 (7.6)</td>
</tr>
<tr>
<td>Prevent or manage drug allergy</td>
<td>13,469 (5.1)</td>
<td>2,070 (2.5)</td>
<td>3,198 (4.3)</td>
<td>18,737 (4.5)</td>
</tr>
<tr>
<td>Prevent or manage adverse drug event</td>
<td>11,600 (4.4)</td>
<td>10,711 (13.2)</td>
<td>200 (0.3)</td>
<td>22,511 (5.4)</td>
</tr>
<tr>
<td>Drug not indicated</td>
<td>9,703 (3.7)</td>
<td>1,614 (2.0)</td>
<td>6,646 (8.9)</td>
<td>17,963 (4.3)</td>
</tr>
<tr>
<td>Duplication of therapy</td>
<td>296 (0.1)</td>
<td>1,891 (2.3)</td>
<td>8 (0.01)</td>
<td>2,195 (0.5)</td>
</tr>
</tbody>
</table>

*Percentage of total for indicated setting, calculated from the mean total cost-avoidance figures by setting in Table 3.*

Appendix A—Sample calculations for determining cost of original and recommended therapy and cost avoidance

I. Cost of original therapy

A. Data for outpatient recommendation

Original therapy = trimethoprim-sulfamethoxazole double-strength 1 tablet p.o. b.i.d. for 5 days

Acquisition cost = $0.062 per tablet

Labor cost for filling and processing order = $2.92

B. Calculations

Cost of original therapy = (daily drug acquisition cost × duration of therapy) + (labor cost)

Cost of original therapy = ($0.062 per tablet × 2 tablets per day × 5 days) + $2.92 = $3.54

II. Cost of recommended therapy

A. Data for outpatient recommendation

Recommended therapy = doxycycline 100 mg p.o. b.i.d. for 5 days

Acquisition cost = $0.06 per tablet

Labor cost for filling and processing order = $2.92

Average cost of making recommendation = $4.71

B. Calculations

Cost of recommended therapy = (drug acquisition cost × duration of therapy) + (labor cost) + (average cost of making recommendation)

Cost of recommended therapy = ($0.06 per tablet × 2 tablets per day × 5 days) + ($2.92) + ($4.71) = $8.23

III. Calculation of cost avoidance

A. Data for inpatient cost avoidance = probability of harm associated with inpatient recommendation × number of hospital days × International Classification of Diseases-specific bed-cost per day

B. Calculations

1. Physician evaluator: Minimum cost avoidance = 0.7 × 7 hospital days × $1058.60 per day = $5187.14

2. Pharmacist evaluator: Maximum cost avoidance = 0.9 × 10 hospital days × $1058.60 per day = $9527.40

Appendix B—Guidelines for determining duration of therapy when calculating cost of original and recommended therapy

Scheduled medications

1. Long-term medications taken daily: 365 days

2. Long-term medications taken intermittently: known duration or (number of tablets per prescription/number of potential doses per day) × (1 + number of refills)

3. Short-term outpatient or discharge medications: known duration excluding refills

4. Short-term hospital medications: known duration or bed-specific average length of stay

5. Medication changes from i.v. to p.o. route: known duration or 2 days

Unscheduled medications

1. Outpatient or hospital medications: known duration

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