Effect of a Collaborative Approach on the Quality of Prescribing for Geriatric Inpatients: A Randomized, Controlled Trial

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OBJECTIVES: To evaluate the effect of pharmaceutical care provided in addition to acute Geriatric Evaluation and Management (GEM) care on the appropriateness of prescribing.

DESIGN: Randomized, controlled trial, with the patient as unit of randomization.

SETTING: Acute GEM unit.

PARTICIPANTS: Two hundred three patients aged 70 and older.

INTERVENTION: Pharmaceutical care provided from admission to discharge by a specialist clinical pharmacist who had direct contacts with the GEM team and patients.

MEASUREMENTS: Appropriateness of prescribing on admission, at discharge, and 3 months after discharge, using the Medication Appropriateness Index (MAI), Beers criteria, and Assessing Care of Vulnerable Elders (ACOVE) underuse criteria and mortality, readmission, and emergency visits up to 12 months after discharge.

RESULTS: Intervention patients were significantly more likely than control patients to have an improvement in the MAI and in the ACOVE underuse criteria from admission to discharge (odds ratio (OR) = 9.1, 95% confidence interval (CI) = 4.2–21.6 and OR = 6.1, 95% CI = 2.2–17.0, respectively). The control and intervention groups had comparable improvements in the Beers criteria.

CONCLUSION: Pharmaceutical care provided in the context of acute GEM care improved the appropriate use of medicines during the hospital stay and after discharge. This is an important finding, because only limited data exist on the effect of various strategies to improve medication use in elderly inpatients. The present approach has the potential to minimize risk and improve patient outcomes. **J Am Geriatr Soc 55:658–665, 2007.**

Key words: drug therapy; appropriateness; randomized controlled trial; pharmaceutical care; acute geriatric care

Inappropriate use of medicines in elderly patients is of major concern to clinicians and public health authorities. Drug-related problems are implicated in 10% to 30% of hospital admissions in older people.[1–4] Moreover, adverse drug reactions occur during hospital stays in up to half of these patients.[3] A recent study found that 42% of elderly inpatients were prescribed at least one drug without valid indication and that dosage or duration was inadequate in about half of these patients.[5] Conversely, medicines for conditions such as heart failure or osteoporosis remain underused in 20% to 70% of patients.[6,7] Medication errors are also frequent during transition between acute and post-acute care, partly due to incomplete discharge instructions.[8]

Although geriatric evaluation and management (GEM) programs have been shown to decrease mortality and improve functional status in the hospital and around discharge,[9] their effect on the quality of drug use has been less studied. Early studies reported some effect on limited aspects of overuse or misuse.[10,11] A more-recent evaluation showed that inpatient geriatric care reduces suboptimal prescribing,[12] although improvements were only partially maintained after discharge, and the added value of clinical pharmacists in the GEM team was not evaluated.

Involving pharmacists in drug therapy is perceived as an effective means of improving patient care.[13] However most pharmacist-based intervention studies with elderly persons have been performed in primary care.[14] The few published studies with inpatients carry two limitations;

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outcome measures were incomplete with respect to overuse and misuse and did not include underuse,[11,15] and the intervention concerned limited aspects of pharmaceutical care, such as discharge planning,[10,15] or focused on a single class of drug.[16] In the present study, a prospective, randomized design was used to examine the effect of pharmaceutical care provided in addition to acute GEM care on the appropriateness of prescribing for elderly patients during admission and after discharge.

METHODS

Setting

The study was conducted at the acute GEM unit of a university teaching hospital (Mont-Godinne, Yvoir, Belgium). The unit has 27 beds and admits patients aged 70 and older who present with acute geriatric problems. A multidisciplinary team composed of two geriatricians (trained in geriatric pharmacotherapy), two residents (rotating twice a year), nurses, two physiotherapists, a social worker, a psychologist, and an occupational therapist care for patients. Medical care, rehabilitation, and discharge planning are provided.

Patients

All patients admitted to the unit between November 2003 and May 2004 were evaluated for eligibility. Exclusion criteria were terminal illness and a life expectancy of less than 3 months; refusal to participate; expected length of stay of 48 hours or less; pharmacist unable to perform an abstracted chart within 3 days of admission because of time constraints; patient transferred from another acute unit where he or she had been cared for by geriatrician(s); and inclusion during previous admission.

Randomization

Patients were randomized to receive GEM care (control group) or pharmaceutical care in addition to GEM care (intervention group). Randomization was alternate and stratified for age (<85 vs ≥ 85), number of prescribed medicines (<5 vs ≥ 5), and identity of the resident in charge of the patient. A pharmacist external to the main study checked inclusion criteria and assigned participants to their groups. Because of the nature of the project, the physicians were not blinded to group assignment.

Ethical Considerations

The ethics committee of the institution approved the study protocol. Informed written consent was obtained from each participant (or from a relative if patient unable to give consent). The absence of pharmaceutical care in the control group was considered acceptable, because clinical pharmacy was not part of the standard of care in the institution.

Baseline Data Collection

The clinical pharmacist (AS, main investigator) performed a medical record review and an interview with each patient or caregiver to determine demographic characteristics, clinical status, and medications. The Charlson comorbidity score was calculated.[17] Cognitive impairment was defined as a diagnosis of dementia or the identification of cognitive problems without dementia. Patients without confusion or severe dementia were asked to rate their global health status on a 5-point Likert scale.

Intervention

The intervention consisted of a clinical pharmacist (AS) providing pharmaceutical care from admission to discharge according to a validated scheme described in detail elsewhere.[18] Pharmaceutical care involves the process through which a pharmacist cooperates with a patient and other professionals in designing, implementing, and monitoring a therapeutic plan that will produce specific therapeutic outcomes for the patient.[19] Briefly, the pharmacist was present on the unit 4 days per week, participated in medical and multidisciplinary rounds, had direct contact with patients and caregivers, and had access to patient medical records. For every patient, the pharmacist performed a medication history on admission and prepared a patient record with clinical and pharmaceutical data. The appropriateness of treatment was analyzed, and a pharmaceutical care plan was prepared. Whenever an opportunity for optimization was identified, the pharmacist discussed that opportunity with the prescriber, who could accept or reject the intervention. Furthermore, the pharmacist answered all questions that healthcare professionals asked about medications. At discharge, the pharmacist provided written and oral information on treatment changes to the patient or caregiver, as well as written information to the general practitioner. The intervention therefore involved a comprehensive pharmaceutical care approach that was not limited to applying the Medication Appropriateness Index (MAI), Beers criteria, and Assessing Care Of the Elderly (ACOVE) criteria (see below).

Primary Outcome Measure

Appropriateness of prescribing was measured on admission and at discharge. A combination of three measures that encompassed overuse, misuse, and underuse was used.

First, the MAI was selected, because it is currently the most comprehensive instrument to evaluate appropriateness. The MAI consists of 10 criteria. For each criterion, the index has operational definitions, explicit instructions, and examples, and the evaluator rates whether the particular medication is appropriate, marginally appropriate, or inappropriate.[20] The ratings generate weighted scores that serve as summary measures of prescribing appropriateness (0–18 per drug; higher scores indicate greater degrees of inappropriateness; the summated patient score can be obtained by summing up the MAI score of all drugs prescribed to an individual patient).[21] The instrument was tested before the study, and good interrater reliability was found after making minor modifications to improve clarity and understanding (overall kappa value = 0.84).[22] The main investigator evaluated the prescribing of all regularly scheduled medications at baseline (in a blinded way) and then at discharge. Discharge evaluations were unblinded because of the unavailability of a local clinical pharmacist unrelated to the study and with adequate knowledge and skills in geriatric pharmacotherapy, yet a comparison with ratings by a blinded Canadian clinical pharmacist (LM) for a sample of

Table 1. Patient Characteristics

Characteristic	Control (n = 90)	Intervention (n = 96)	*P*-value
Demographic			
Age, mean ± SD	81.9 ± 6.2	82.4 ± 6.9	.62
Female, %	66.7	71.9	.53
Community-dwelling, %	66.7	71.9	.53
Living alone, %	24.7	26.0	.87
Clinical and functional status			
Charlson comorbidity score, mean ± SD	2.0 ± 1.5	2.0 ± 1.6	.82
Cognitive impairment, %	46.7	43.8	.77
≥1 fall within previous 6 months, %	74.4	70.2	.61
≥1 hospital admissions within previous 6 months, %	31.1	36.5	.54
Need for support for ≥1 activities of daily living, %	56.7	59.4	.65
Self-rated health, %	(n = 61)	(n = 57)	
Good to excellent	32.8	42.1	.58
Fair	57.4	49.1	
Poor	9.8	8.8	
Pharmaceutical data, mean ± SD			
Prescribed drugs	7.3 ± 3.3	7.9 ± 3.5	.28
Daily administrations*	9.7 ± 4.8	10.0 ± 4.7	.71

* One administration was defined as the intake of one medicine at a given time during the day (e.g., 1 tablet of X in the morning and 2 tablets of Y in the evening = 2 daily administrations).
SD = standard deviation.

15 patients showed that there was no bias toward more-favorable and -unfavorable ratings for intervention and control patients, respectively.

Second, the use of drugs that should be avoided in older people was assessed using the 1997 Beers criteria[23] and selecting eight (classes of) drugs from the original list based on their inclusion in the hospital formulary (amitriptyline, anticholinergic antihistamines, dipyridamole, ergot mesyloids, indomethacin, long-acting benzodiazepines, oxybutynin, and propoxyphene). This measure was selected in addition to the MAI to enable comparisons with published data. In addition, the use of benzodiazepines was examined in patients with at least one fall in the previous 6 months, as proposed in the most-recent criteria.[24]

Third, seven ACOVE criteria relative to underuse were selected, because the MAI does not detect underuse and because high levels of underuse were identified in previous studies.[6,7,25–28] The ACOVE criteria are process measures of quality of care for vulnerable older people.[29] Underuse indicators are expressed as follows; if there is a certain condition, then the patient should receive a certain drug, unless contraindicated. Additional instructions were developed on the contraindications (available upon request). These were based on previous publications[30–32] and on minor adaptations related to local considerations. An inappropriate rating was given if the patient had the condition of interest and no contraindication to receiving the medication, but did not receive it, or the patient had the condition and received the medication but had a contraindication to receiving the drug. Two blinded pharmacists (GC and CG) who were not involved in patient care independently performed all Beers and ACOVE measures. When ratings differed, they reexamined and discussed the data to reach a consensus. They also recorded whether medication improvements made during admission were maintained after discharge (see below).

Secondary Outcome Measures

Because polymedication is not a valid measure of appropriate prescribing, a measure of unnecessary drug use was used instead (defined as patients who received an inappropriate rating for indication, efficacy, or therapeutic duplication with the MAI).[33] Prevalence was evaluated on admission and at discharge.

Additional outcome measures were collected after discharge. All patients were followed up 1 month, 3 months, and 1 year postdischarge through telephone calls performed by two trained hospital pharmacists (SA and SB) who were blinded to group assignment and not involved in patient care. One of these two pharmacists (SA) and the main investigator (AS) developed the questionnaire. Data, which the person preparing the medications (patient or caregiver) provided, included the following: mortality, readmission or visit to an emergency department (double-checked with the hospital record when applicable), medications taken, and satisfaction with the information received on medications during admission (1-month post-discharge, using the following scale: satisfied, moderately satisfied, not satisfied).

Contamination (Educational Bias)

Because the same physicians were caring for control and intervention patients, contamination of control patients was possible. To assess this bias, two investigators (GC and CG) applied the Beers and ACOVE criteria to a random sample of 90 patients admitted to the unit 1 year before the study (November 2002 to May 2003). This sample is called here the "historical control group." The MAI could not be applied because of insufficient data in the medical record. Patients were excluded if a discharge letter was lacking, if information was missing about the drugs taken, or if the patient died before discharge.

Statistical Analysis

A sample size of 90 patients per group was required to have 80% power to detect a 20% absolute improvement in ACOVE and Beers criteria at a two-sided .05 significance level and assuming a response rate of 0.2 in the control group. Twenty-eight patients per group would provide 90% power to detect an effect size of 0.9 on the MAI.[34] The sample size was finally set to 100 patients per group to account for loss of participants due to dropout and death.

Study groups at baseline were compared using chi-square or Fisher exact tests for categorical variables, the Student *t* test for normally distributed continuous variables, and the Wilcoxon rank sum test for nonnormally distributed variables. Baseline and discharge ratings were compared within groups, using nonparametric related-sample tests. A Pearson chi-square test was used to detect a significant difference between the probabilities of improvement of the MAI score in the control and intervention groups. When conditioning on a baseline categorical covariate was required, the Cochran-Mantel-Haenszel test was used, and the homogeneity of the (log) odds ratios across strata was checked using the Breslow-Day test. These procedures were applied to detect an improvement in the Beers criteria conditionally on an age indicator and the ACOVE criteria conditionally on the number of conditions with omitted drug on admission. When necessary, a Fisher exact test was preferred to the Pearson chi-square test in sparse contingency tables. Similar results were obtained using singular logistic regression (to compare the proportion of patients with at least one improvement) and the *t* test and Wilcoxon rank-sum test (to compare mean differences on admission vs discharge between control and intervention groups). In each test, statistical significance was considered to be .05. Statistical analyses were performed using SPSS Statistical Software 13.0 (SPSS Inc., Chicago, IL).

RESULTS

Patient Characteristics

Figure 1 summarizes the flow of patients entered into the study and analyzed for the primary and secondary outcome measures. No significant differences were present in the characteristics of patients at baseline (Table 1). The percentages of patients for whom data were available after discharge were as follows: at 1 month, 98% (88/90) of control and 99% (95/96) of intervention patients for clinical data and 84% (72/86 patients alive) of control and 83% (79/95 patients alive) of intervention patients for

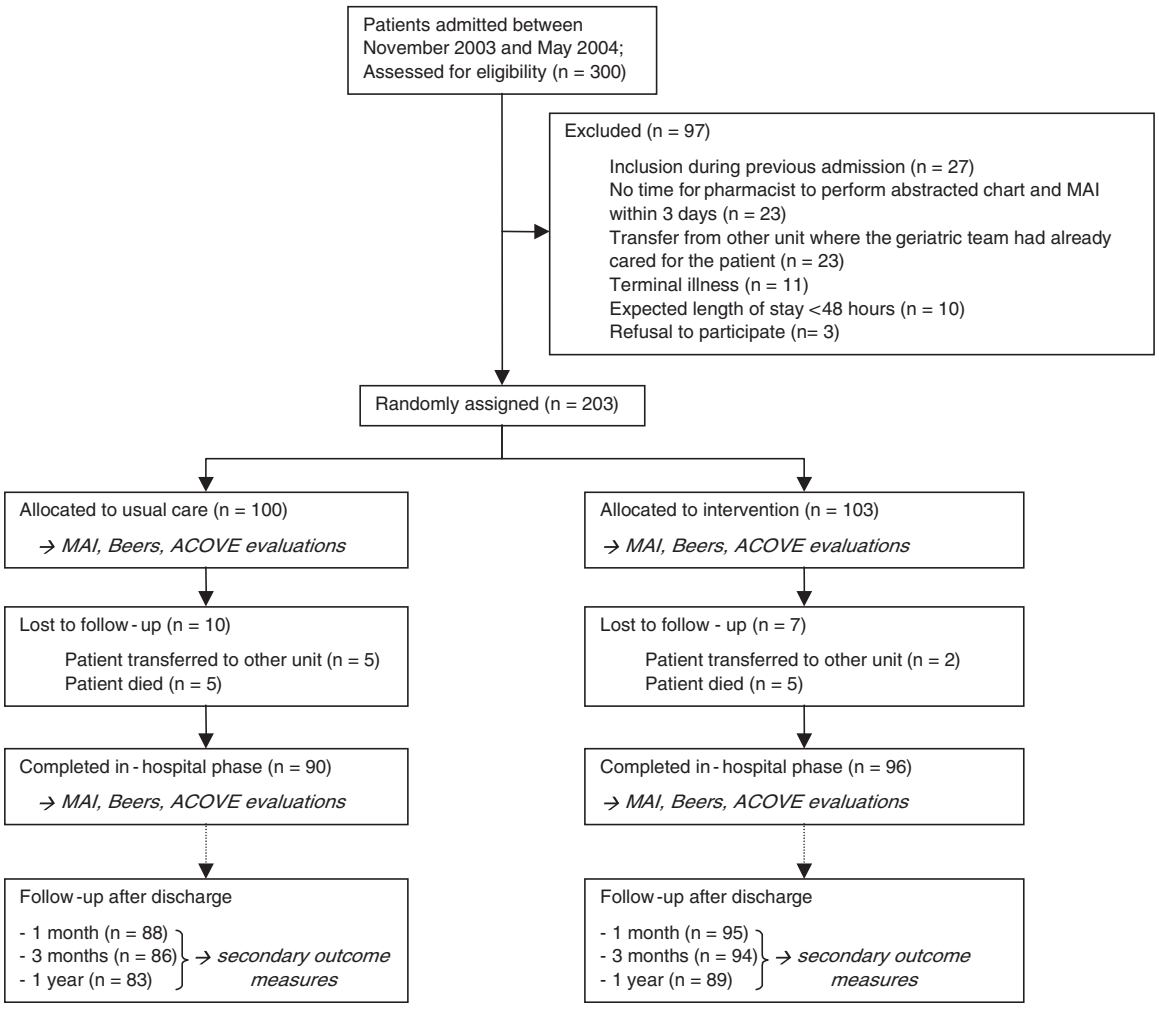

Figure 1. Flow of patients through the trial. Dotted arrows followed by italics refer to the evaluations performed (primary and secondary outcome measures). ACOVE = Assessing Care of the Vulnerable Elderly; MAI = Medication Appropriateness Index.

pharmaceutical data; at 3 months, these percentages were 96% (86/90) and 98% (94/96) and 86% (68/79 patients alive) and 85% (75/88 patients alive), respectively; and at 12 months, 92% (83/90) and 93% (89/96) for clinical data, respectively.

Appropriateness of Prescribing

Medication Appropriateness Index

Almost 60% of prescriptions for all patients included in the study (N = 186) had at least one inappropriate rating at baseline. Intervention patients were significantly more likely to have an improvement in their summated MAI score than were control patients (odds ratio (OR) = 9.1, 95% confidence interval (CI) = 4.2–21.6, Table 2). Intervention patients had highly significant improvements in MAI scores (Table 2), as well as important improvements in each individual criterion (Table 3). In contrast, for control patients, improvements were smaller, and two individual criteria (modalities practical, and cost) did not improve (Table 3).

Drugs to Avoid in Older People

Approximately 30% of all patients included in the study were taking at least one drug to avoid at admission. Long-acting benzodiazepines and dipyridamole accounted for 65% of cases (of inappropriate prescribing). Both groups had similar improvement from admission to discharge (OR = 0.6, 95% CI = 0.3–1.1, Table 3). For the benzodiazepines-fall criteria, there was a higher absolute decrease in prescribing for intervention patients (although the difference between groups was not significant). This was secondary to an increase in new users in the control group (3.4% intervention patients, 12.7% of control patients, $P = .10$), whereas discontinuation was similar in both groups (15.5% vs 15.9%).

ACOVE Criteria of Underuse

Seventy-eight percent of patients were eligible for at least one indicator. More than half of patients had at least one inappropriate rating at baseline. When controlling for the baseline level of underuse, intervention patients were six times as likely as control patients to have at least one improvement (OR = 6.1, 95% = CI 2.2–17.0, Table 3). Table 4 summarizes, for each individual criterion, the baseline level of inappropriateness, as well as the improvements from admission to discharge.

Persistence of Improvements After Discharge

Of patients with an improvement in the Beers or ACOVE criteria at discharge, 3 months after discharge, there was no difference in persistence of improvements between the control and intervention groups, although the study was not powered to detect a difference. Nevertheless, a trend toward higher maintenance rates was detected in the intervention group for two criteria: Beers drugs (improvement maintained in 94% of intervention vs 86% of control cases) and benzodiazepines in patients with previous fall (86% vs 56%, respectively). The differences were not significant.

Table 2. Changes in Appropriateness of Prescribing from Admission to Discharge

Measure of Appropriateness of Prescribing	Historical Control Group (n = 90)			Control Group (n = 90)			Intervention Group (n = 96)			OR (95% Confidence Interval)*
	Baseline	Discharge	*P*-value†	Baseline	Discharge	*P*-value†	Baseline	Discharge	*P*-value†	
MAI (range 0–18), mean ± SD										
Per drug‡	NE	NE		3.2 ± 2.1	2.7 ± 1.6	.02	3.2 ± 2.1	0.9 ± 1.0	<.001	
Summated patient score	NE	NE		21.2 ± 14.3	19.3 ± 12.5	.36	24.1 ± 17.0	7.1 ± 7.5	<.001	9.1 (4.2–21.6)
Drug to avoid (Beers criteria)										
Inappropriate drugs per patient, mean ± SD	0.38 ± 0.53	0.13 ± 0.37	<.001	0.44 ± 0.69	0.04 ± 0.21	<.001	0.29 ± 0.56	0.03 ± 0.17	<.001	0.6 (0.3–1.1)
Patients taking ≥1 inappropriate drug, %	35.6	12.2	<.001	34.4	4.4	<.001	25.0	3.1	<.001	
Patients taking a benzodiazepine of patients with previous fall, %	NE	NE		65.1	60.3	.63	58.6	44.8	.02	
Underuse (Assessing Care of Vulnerable Elders criteria)										
Inappropriate ratings per patient, mean ± SD	0.76 ± 0.87	0.57 ± 0.78	.002	0.92 ± 0.95	0.63 ± 0.81	.002	0.75 ± 0.89	0.17 ± 0.43	<.001	6.1 (2.2–17.0)§
Patients with ≥1 inappropriate rating, %	55.6	43.3	.007	58.9	44.4	.02	50.0	14.6	<.001	

* Odds ratio (OR) for having at least one improvement from admission to discharge in the intervention group compared with the control group.
† Two-sided *P*-values comparing baseline and discharge scores using the Wilcoxon signed ranks test for continuous data and the McNemar test for categorical data.
‡ The average Medication Appropriateness Index (MAI) score per drug on admission or discharge was obtained by dividing total score on admission or discharge by the number of drugs evaluated on admission or discharge.
§ Conditionally on the number of conditions with omitted drug on admission.
NE = not evaluated because lack of data to perform the MAI or unreliable data on previous falls; SD = standard deviation.

Table 3. Percentage of Drugs with Inappropriate Ratings on Admission and at Discharge Using the Medication Appropriateness Index (MAI)

	Control		Intervention	
	Baseline (n = 633)	Discharge (n = 654)	Baseline (n = 728)	Discharge (n = 766)
MAI Criterion	%			
Indication	9.8	7.5	12.1	2.6
Choice	23.2	18.5	25.4	6.1
Dosage	28.0	25.1	26.5	6.8
Modalities correct	19.3	17.9	17.6	8.1
Modalities practical	15.0	16.8	17.3	3.3
Drug-drug interactions	7.4	6.7	7.3	1.3
Drug-disease interactions	18.8	15.4	18.1	4.6
Duplication	3.0	2.3	5.2	1.0
Duration	16.7	13.8	20.5	6.1
Cost	23.2	25.8	23.1	10.7
Overall*	59.9	64.5	59.8	27.3

* Inappropriate rating in at least 1 of the 10 criteria.

Secondary Outcome Measures

At least one unnecessary drug was prescribed to 84.4% of control and intervention patients on admission. At discharge, unnecessary drug use was still detected in 77.8% of control patients, in contrast to 37.5% of intervention patients.

One year after discharge, the rate of death and emergency visits was lower in the intervention group than in the control group (22.5% of intervention vs 30.1% of control patients, $P = .30$; and 7.9% vs 12.0%, respectively, $P = .45$), but none of the differences were statistically significant. Readmission rates were similar (32.6% vs 33.7%, respectively, $P = 1.0$). One month after discharge, satisfaction with information received on medicines was higher in the intervention group (80.0% of intervention patients vs 60.9% of control patients were satisfied, $P = .10$), but again this difference was not statistically significant.

Assessment of Educational Bias

The baseline characteristics of the historical control group did not differ significantly from that of study patients. There was no difference in improvements in the control and the historical control group for Beers criteria ($P = .41$, Table 4). However, when the analysis was restricted to patients with at least one Beers' drug on admission (n = 63), improvements were significantly higher in the control than in the intervention group ($P = .04$). There was no evidence of contamination for the ACOVE criteria.

DISCUSSION

This study demonstrates that adding pharmaceutical care to a GEM program substantially reduces overuse, misuse, and underuse of medicines in elderly inpatients. The robustness of the data stems from the use of a randomized, controlled design; the combination of three validated instruments to document overuse, misuse, and underuse; and the limited loss to follow-up.

The most significant finding is that pharmaceutical care led to marked improvements in the MAI and the ACOVE underuse scores. The reasons underlying the success of the intervention are probably that a structured and comprehensive approach toward treatment review was taken, the intervention addressed several factors responsible for inappropriateness,[35] and there was direct contact between the pharmacist and the multidisciplinary team, with the pharmacist present when prescribing decisions were made. The last is consistent with previous studies that reported

Table 4. Improvements in Seven Underuse Assessing Care of Vulnerable Elders (ACOVE) Criteria from Admission to Discharge

Underuse ACOVE Criteria Condition (number of patients in the three groups with the condition of interest)	Drug	Patients with Inappropriate Rating on Admission n (%)	Improvement from Admission to Discharge* %		
			Historical Control	Control	Intervention
Osteoporosis/fracture (125)	Bisphosphonate, calcium, vitamin D	90 (72.0)	32.0	48.7	86.0
Atrial fibrillation (84)	Anticoagulant/aspirin	33 (39.2)	9.0	20.5	62.7
Ischemic heart disease (80)	Aspirin	34 (42.5)	40.0	39.6	77.7
Diabetes mellitus (57)	Aspirin	23 (40.4)	16.4	50.0	77.7
Heart failure (26)	Angiotensin-converting enzyme inhibitor	11 (42.3)	50.0	−200.0	66.7
Heart failure (26)	β-blocker	18 (69.2)	−33.3	0.0	57.5
Myocardial infarction (26)	β-blocker	16 (61.5)	0.0	−14.1	100.0

* [(number of patients with inappropriate rating on admission)–(number of patients with inappropriate rating at discharge)]/number of patients with inappropriate rating on admission. Zero indicates no improvement; 100% indicates maximum improvement; negative values indicate deterioration from admission to discharge.

only moderate effect when direct involvement of the pharmacist was limited.[10]

The geriatricians caring for patients in the present study were trained in geriatric pharmacotherapy. Therefore, the differences might have been larger between the control and intervention groups had the physicians not had such training.

This study is one of the first to show that pharmaceutical care can substantially improve underprescribing for multiple conditions simultaneously. Underuse of medicines in older people is indeed prevalent[6,7,25–28] and linked to increased morbidity and mortality, but there are scarce data on approaches for improvement.[7,12,36,37]

Two pharmaceutical care studies reported comparable improvements in MAI scores, but neither had a control group.[36,38] Other controlled studies involving collaborative approaches reported significant but lower improvements in MAI scores,[12,15,34] but the baseline MAI scores were lower than in the current study. The use of the MAI questions by the pharmacist to review prescribing in the present study was probably an important determinant of better identification of opportunities for optimization. Therefore, the systematic use of this approach should perhaps be part of routine practice in drug regimen review.

Pharmaceutical care appeared not to improve the drugs-to-avoid criteria. As in other studies, prescribing drugs from the Beers' list was frequent at baseline[39–42] but was substantially less at discharge in both groups. In the current study, this decrease was larger than reported in previous studies[12,43–45] and than in the historical control group. This result was ascribed to contamination, because the study was not blinded and identifying "bad drugs" and discontinuing them is easier (and more prone to contamination) than identifying and resolving problems related to underuse, indication, or dosage. A small effect was achieved for the benzodiazepine fall criterion. This could be related to the known difficulty in discontinuing these drugs.[46–48]

The prevalence of unnecessary drug use on admission was alarming, and the intervention lowered that burden. The inclusion of inappropriate choice of drug in this measure (in addition to inappropriate indication and duplication) is questionable and could overestimate the true rate of unnecessary drug use. It is nevertheless a better quality measure than polymedication (number of prescribed drugs).

This study has limitations. First, generalization is a concern, because one clinical pharmacist on a single unit provided the intervention. The time required to apply the measures of appropriateness (more specifically the MAI) would compromise the feasibility of a multicenter study, yet the intervention could be replicated elsewhere, provided that a similar pharmaceutical care model is followed. Second, the study was not double-blinded, and MAI evaluations at discharge were unblinded. Third, the study was not powered to detect an effect on clinical outcomes. Fourth, whether the intervention improved compliance and quality of life and decreased adverse drug events was not evaluated (although an analysis of all interventions made by the clinical pharmacist suggests that this might have been the case).[18] Further work on the pharmacoeconomic benefit of the intervention is also needed.

In conclusion, this study shows that the prescribing of medicines in frail elderly patients can be substantially improved during hospital admission, with persistent effects after discharge, when a clinical pharmacist plays a proactive and structured role in drug treatment review within the context of a GEM program. Combined efforts are necessary to improve the care of patients with complex drug regimens, multiple comorbidities, and other risk factors for drug-related morbidities. The present approach has the potential to minimize risk and improve patient outcomes.

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REFERENCES

1. Col N, Fanale JE, Kronholm P. The role of medication noncompliance and adverse drug reactions in hospitalizations of the elderly. Arch Intern Med 1990;150:841–845.
2. Hohl CM, Dankoff J, Colacone A et al. Polypharmacy, adverse drug-related events, and potential adverse drug interactions in elderly patients presenting to an emergency department. Ann Emerg Med 2001;38:666–671.
3. Passarelli MC, Jacob-Filho W, Figueras A. Adverse drug reactions in an elderly hospitalised population: Inappropriate prescription is a leading cause. Drugs Aging 2005;22:767–777.
4. Grymonpre RE, Mitenko PA, Sitar DS et al. Drug-associated hospital admissions in older medical patients. J Am Geriatr Soc 1988;36:1092–1098.
5. Hanlon JT, Artz MB, Pieper CF et al. Inappropriate medication use among frail elderly inpatients. Ann Pharmacother 2004;38:9–14.
6. Higashi T, Shekelle PG, Solomon DH et al. The quality of pharmacologic care for vulnerable older patients. Ann Intern Med 2004;140:714–720.
7. Feldstein A, Elmer PJ, Orwoll E et al. Bone mineral density measurement and treatment for osteoporosis in older individuals with fractures: A gap in evidence-based practice guideline implementation. Arch Intern Med 2003;163:2165–2172.
8. Coleman EA, Smith JD, Raha D et al. Posthospital medication discrepancies: Prevalence and contributing factors. Arch Intern Med 2005;165:1842–1847.

9. Stuck AE, Siu AL, Wieland GD et al. Comprehensive geriatric assessment: A meta-analysis of controlled trials. Lancet 1993;342:1032–1036.
10. Lipton HL, Bero LA, Bird JA et al. The impact of clinical pharmacists' consultations on physicians' geriatric drug prescribing. A randomized controlled trial. Med Care 1992;30:646–658.
11. Owens NJ, Sherburne NJ, Silliman RA et al. The Senior Care Study. The optimal use of medications in acutely ill older patients. J Am Geriatr Soc 1990;38:1082–1087.
12. Schmader KE, Hanlon JT, Pieper CF et al. Effects of geriatric evaluation and management on adverse drug reactions and suboptimal prescribing in the frail elderly. Am J Med 2004;116:394–401.
13. Keely JL. Pharmacist scope of practice. Ann Intern Med 2002;136:79–85.
14. Hanlon JT, Lindblad CI, Gray SL. Can clinical pharmacy services have a positive impact on drug-related problems and health outcomes in community-based older adults? Am J Geriatr Pharmacother 2004;2:3–13.
15. Crotty M, Rowett D, Spurling L et al. Does the addition of a pharmacist transition coordinator improve evidence-based medication management and health outcomes in older adults moving from the hospital to a long-term care facility? Results of a randomized, controlled trial. Am J Geriatr Pharmacother 2004;2:257–264.
16. Bajorek BV, Krass I, Ogle SJ et al. Optimizing the use of antithrombotic therapy for atrial fibrillation in older people: A pharmacist-led multidisciplinary intervention. J Am Geriatr Soc 2005;53:1912–1920.
17. Charlson ME, Pompei P, Ales KL et al. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis 1987;40:373–383.
18. Spinewine A, Dhillon S, Mallet L et al. Implementation of ward-based clinical pharmacy services in Belgium—description of the impact on a geriatric unit. Ann Pharmacother 2006;40:720–728.
19. Hepler DD, Strand LM. Opportunities and responsibilities in pharmaceutical care. Am J Pharm Educ 1989;53:7S–15S.
20. Hanlon JT, Schmader KE, Samsa GP et al. A method for assessing drug therapy appropriateness. J Clin Epidemiol 1992;45:1045–1051.
21. Samsa GP, Hanlon JT, Schmader KE et al. A summated score for the medication appropriateness index: Development and assessment of clinimetric properties including content validity. J Clin Epidemiol 1994;47:891–896.
22. Spinewine A, Dumont C, Mallet L et al. Medication Appropriateness Index: Reliability and recommendations for future use. J Am Geriatr Soc 2006;54:720–722.
23. Beers MH. Explicit criteria for determining potentially inappropriate medication use by the elderly. An update. Arch Intern Med 1997;157:1531–1536.
24. Fick DM, Cooper JW, Wade WE et al. Updating the Beers criteria for potentially inappropriate medication use in older adults: Results of a U. S. consensus panel of experts. Arch Intern Med 2003;163:2716–2724.
25. Wenger NS, Solomon DH, Roth CP et al. The quality of medical care provided to vulnerable community-dwelling older patients. Ann Intern Med 2003;139:740–747.
26. Sloane PD, Gruber-Baldini AL, Zimmerman S et al. Medication undertreatment in assisted living settings. Arch Intern Med 2004;164:2031–2037.
27. Mendelson G, Aronow WS. Underutilization of beta-blockers in older patients with prior myocardial infarction or coronary artery disease in an academic, hospital-based geriatrics practice. J Am Geriatr Soc 1997;45:1360–1361.
28. Mendelson G, Aronow WS. Underutilization of warfarin in older persons with chronic nonvalvular atrial fibrillation at high risk for developing stroke. J Am Geriatr Soc 1998;46:1423–1424.
29. Wenger NS, Shekelle PG. Assessing care of vulnerable elders: ACOVE project overview. Ann Intern Med 2001;135:642–646.
30. Elliott A, Woodward M. Indicators of prescribing quality for elderly hospital inpatients. Aust J Hosp Pharm 2001;31:19–25.
31. Rathore SS, Mehta RH, Wang Y et al. Effects of age on the quality of care provided to older patients with acute myocardial infarction. Am J Med 2003;114:307–315.
32. Oborne CA, Batty GM, Maskrey V et al. Development of prescribing indicators for elderly medical inpatients. Br J Clin Pharmacol 1997;43:91–97.
33. Hajjar ER, Hanlon JT, Sloane RJ et al. Unnecessary drug use in frail older people at hospital discharge. J Am Geriatr Soc 2005;53:1518–1523.
34. Hanlon JT, Weinberger M, Samsa GP et al. A randomized, controlled trial of a clinical pharmacist intervention to improve inappropriate prescribing in elderly outpatients with polypharmacy. Am J Med 1996;100:428–437.
35. Spinewine A, Swine C, Dhillon S et al. Appropriateness of use of medicines in elderly inpatients: Qualitative study. BMJ 2005;331:935–938.
36. Lam S, Ruby CM. Impact of an interdisciplinary team on drug therapy outcomes in a geriatric clinic. Am J Health Syst Pharm 2005;62:626–629.
37. Majumdar SR, Rowe BH, Folk D et al. A controlled trial to increase detection and treatment of osteoporosis in older patients with a wrist fracture. Ann Intern Med 2004;141:366–373.
38. Jeffery S, Ruby C, Twersky J et al. Effect of an interdisciplinary team on suboptimal prescribing in a long-term care facility. Consult Pharm 1999;14:1386–1391.
39. Curtis LH, Ostbye T, Sendersky V et al. Inappropriate prescribing for elderly Americans in a large outpatient population. Arch Intern Med 2004;164:1621–1625.
40. Caterino JM, Emond JA, Camargo CA Jr. Inappropriate medication administration to the acutely ill elderly: A nationwide emergency department study, 1992–2000. J Am Geriatr Soc 2004;52:1847–1855.
41. Zhan C, Sangl J, Bierman AS et al. Potentially inappropriate medication use in the community-dwelling elderly: Findings from the 1996 Medical Expenditure Panel Survey. JAMA 2001;286:2823–2829.
42. Fialova D, Topinkova E, Gambassi G et al. Potentially inappropriate medication use among elderly home care patients in Europe. JAMA 2005;293:1348–1358.
43. Briesacher B, Limcangco R, Simoni-Wastila L et al. Evaluation of nationally mandated drug use reviews to improve patient safety in nursing homes: A natural experiment. J Am Geriatr Soc 2005;53:991–996.
44. Monane M, Matthias DM, Nagle BA et al. Improving prescribing patterns for the elderly through an online drug utilization review intervention: A system linking the physician, pharmacist, and computer. JAMA 1998;280:1249–1252.
45. Fick DM, Maclean JR, Rodriguez NA et al. A randomized study to decrease the use of potentially inappropriate medications among community-dwelling older adults in a southeastern managed care organization. Am J Manag Care 2004;10:761–768.
46. Griffith DN, Robinson M. Prescribing practice and policy for hypnotics: A model of pharmacy audit. Age Ageing 1996;25:490–492.
47. Williams ME, Pulliam CC, Hunter R et al. The short-term effect of interdisciplinary medication review on function and cost in ambulatory elderly people. J Am Geriatr Soc 2004;52:93–98.
48. Dollman WB, Leblanc VT, Stevens L et al. Achieving a sustained reduction in benzodiazepine use through implementation of an area-wide multi-strategic approach. J Clin Pharm Ther 2005;30:425–432.