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Cost-Effectiveness Analysis of Pharmaceutical Care in a Medicare Drug Benefit Program

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ABSTRACT

Objectives: Although there has recently been substantial interest in a Medicare drug benefit program, little attention has focused on ensuring improved access to medication monitoring for Medicare beneficiaries. Using a societal perspective, we evaluated the impact pharmacists could have on inappropriate prescribing, patient compliance, and medication-related morbidity and mortality within a Medicare drug benefits program.

Methods: A cost-effectiveness analysis from a societal perspective was performed. A comprehensive MEDLINE search for relevant literature identified data sources and model parameters.

Results: In the base case, a pharmaceutical care benefit in the elderly population would cost $2100 (year 2000 prices) per life-year saved, which is highly cost-effective. Reasonable changes in model parameters did not raise the cost-effectiveness ratio above $13,000 per life-year saved.

Conclusion: Despite limitations in both the quantity and the specificity of data available, pharmaceutical care appears to be a highly cost-effective augmentation to a Medicare drug benefit program. This result is robust to model parameter changes. This model is conservative in that it does not include ongoing benefits from medication monitoring or increased elderly drug utilization and polypharmacy as the Medicare drug program is phased in.

Keywords: cost-effectiveness analysis, drug utilization, gerontology, Medicare, pharmaceutical care.

Introduction

The cost of medication-related morbidity and mortality has received increasing attention in recent years [1–4]. As the number and complexity of prescriptions filled each year increases, the cost associated with medication misuse also increases [2,3]. Adding to the increased interest is the recently released Institute of Medicine (IOM) report (2000), *To Err is Human*, and Congress' consideration of adding a comprehensive prescription drug benefit to Medicare, the primary health-care payer for elderly and disabled Americans [6].

Medicare PART B (nonhospital benefits) currently offers only limited coverage of outpatient medications. Since 1999, there has been renewed interest in expanding Medicare coverage to include outpatient prescription medications because of the increasing burden that the cost of medications has placed on the elderly. In that year, the National Academy of Social Insurance estimated that the average Medicare enrollee spent $942 on prescription medications [7].

This is not the first attempt to expand Medicare coverage to include prescription drugs. The Medicare Catastrophic Coverage Act of 1988 offered catastrophic prescription drug coverage, but was repealed in 1989. The proposed 1994 Health Security Act would have added a prescription benefit to Medicare part B. The cost of implementing a drug benefit is controversial, and dependent on program design. Recent estimates of adding a comprehensive drug benefit to the Medicare program are upwards of $30 billion annually [8]. To our knowledge, none of the proposals circulated on Capitol Hill during the 107th congress include explicit reimbursement for medication misuse monitoring and drug information counseling to augment the drug benefit program.

The direct cost of medication-misuse-related events, including additional physician visits, hospital admissions, emergency department visits, long-

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term-care facility admissions, and additional prescriptions, has been estimated at $177.4 billion (in year 2000 US$) [2]. Costs to a managed care plan for elderly patients taking a potentially inappropriate medication were more than double that of patients not receiving such medication during a 6-month time period [9]. In addition to the direct costs, it has been estimated that 106,000 patients die in hospitals [10] and a total of 218,113 people die each year because of medication-related adverse events [2].

The IOM (2000) report defines error as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim" [5]. Regarding the use of medication, this includes not only administration errors (delivering the wrong drug to the wrong patient), but also errors in diagnosis and prescribing on the part of the provider and compliance on the part of the patient.

Medication-related errors as defined by the IOM are especially of concern in the elderly population. In 1995, Medicare beneficiaries on average spent more than four times as much as the nonelderly population on prescriptions [6]. In addition, the elderly may be especially susceptible to adverse medication events as a result of multiple concurrent chronic diseases and decreased physiologic ability to eliminate or metabolize medications [11]. With nearly 3 billion prescriptions filled in the United States in 2000 [12,13], the need for medication management has become apparent [14].

The changing role of pharmacy in monitoring medication usage is subsumed under the term "pharmaceutical care." Hepler and Strand [15] defined "pharmaceutical care" as ". . . responsible provision of drug therapy for the purpose of achieving definite outcomes that improve a patient's quality of life." Pharmacists have been shown to decrease prescribing errors in an intensive care unit by 66% by participating in physician rounds [16]. Patients monitored by pharmacists in a skilled nursing facility in Los Angeles had significantly fewer deaths and greater discharges to lower levels of care compared with patients not receiving this service [17]. Pharmacists working in nursing homes have been projected to improve optimal therapeutic outcomes by 18% and to save $3.6 billion annually in costs from avoided medication-related problems [18].

In a community pharmacy setting, pharmacists are able to provide a variety of pharmaceutical care services. This includes reviewing prescriptions for appropriateness for each individual patient according to the patient's age, other medical conditions, concurrent medications, and other relevant factors. Pharmacists are also able to track refill patterns and counsel patients, when necessary, on the importance of compliance with their medication regimen. Additionally, pharmacists are in the position to monitor a medication's effectiveness by performing blood pressure readings, cholesterol checks, blood glucose checks, etc., and to detect potential side effects by discussing with the patient any concerns that he or she might have.

Pharmacists are in a unique position to affect medication-related morbidity and mortality in the ambulatory setting. Pharmacists have substantial contact with patients as most are seen monthly for prescription refills. Also, pharmacists provide the final review of a prescription before a patient receives a new medication, often have greatest knowledge of all the prescription medications a patient is taking, and can screen for drug interactions and other potential problems.

Although pharmacists are in an optimal position to provide pharmaceutical care, currently feasible opportunities are limited. Pharmacies are reimbursed only for dispensing prescriptions and not for providing medication management services. This focus on filling prescriptions often does not allow time to fully review a patient's medication history and refill patterns and to counsel the patient on the importance of compliance and potential side effects [19]. Additionally, if a pharmacist reviews a prescription and considers it potentially inappropriate and the consultation with the prescriber results in the discontinuation of that prescription, the pharmacist receives no compensation for the service provided and has also lost the reimbursement for the dispensing of that medication.

Public officials have recently recognized the potential beneficial impact of pharmacists on medication therapy. In May 2001, Senator Tim Johnson of South Dakota introduced legislation that would expand the Social Security Act to provide for coverage of pharmacist services under part B of the Medicare program (Senate Bill S.294). To our knowledge, there has been no analysis to date of the cost-effectiveness of a comprehensive plan to provide pharmaceutical care in the ambulatory setting to elderly Americans. Such an analysis would provide decision makers with beneficial information for the evaluation of any proposed Medicare drug benefit plan.

Objectives

The purpose of this study was to evaluate the effect that community pharmacists could have on medication-related morbidity and mortality in the elderly population in the United States if a comprehensive pharmaceutical care intervention were included in a Medicare drug benefit program. The objectives were to quantify from society's perspective the cost-effectiveness of the impact pharmacists could have on inappropriate prescribing and patient compliance and the subsequent impact on medication-related hospitalizations, emergency room visits, nursing home admissions, and mortality.

Methods

Cost-Effectiveness Methods

The cost-effectiveness model was constructed from a societal perspective; however, we were not able to include indirect costs because of lack of data. All costs and benefits were estimated for the remaining lifetime of all elderly persons in the United States in the year 2000, in which all costs and benefits recurred annually until death. All cost estimates were inflated to year 2000 dollars using the medical care component of the Consumer Price Index (http://www.bls.gov/oes/1999/oes2910591.htm, accessed June 19, 2001). The base case discount rate for costs and benefits was 3% [20].

Data Collection and Selection

Model parameters were derived through review of the literature. Base case parameter values were taken as the medians from ranges identified in included studies. Studies were identified by searching for the following key words in MEDLINE: medication errors, prescription drugs, adverse effects, economics, statistics and numerical data, mortality, pharmaceutical services, pharmacists, drug therapy, and community pharmacy services. From these articles, additional literature was identified from the references cited. In general, sources were excluded if conducted outside of the United States [21–23]. Studies reviewed from the literature did not receive differential weights based on a quality adjustment. Instead, a full range of parameter estimates reported in the literature was incorporated into model sensitivity analysis.

Base case model equations are presented in Table 1 and parameters are presented in Tables 2 and 3. Calculated parameters related to the impact of medication-related morbidity and mortality and pharmaceutical care are given in Table 2. The remaining base case parameters are shown in Table 3.

Costs of Medication-Related Morbidity and Mortality

Hospitalizations. Published sources were used to estimate the percentage of hospitalizations per year that are medication-related. This estimate was then combined with the percentage of hospitalizations that are elderly to calculate the number of hospitalizations per year that occur in the elderly because of medication-related adverse events (Table 1).

The base case percent of medication-related hospitalizations (5.1%) is the median of several published sources (Table 2) [2,24–27]. Studies were excluded if they reported the medication-related admits as a percentage of the emergency admissions rather than as a percentage of the total admissions [28].

The percentage of medication-related hospitalizations resulting from inappropriate prescribing (48.6%) and compliance (31.6%) is based on pub-

Table 1 Calculation of model parameters

Parameter	Equation
Hospitalizations that are medication-related	Total number of hospitalizations in the United States per year × percentage of hospitalized patients who are elderly × percentage of hospitalizations that are medication-related × average cost of a hospitalization
ED visits that are medication-related	Total number of ED visits made by the elderly per year × percentage of ED visits that are medication-related × the average cost of an ED visit
Office visits that are medication-related	Total number of medication-related office visits per year × percentage of office visits that are used by the elderly
NH admissions that are medication-related	Total number of NH admissions per year × percentage of NH residents that are elderly × percentage of NH admissions that are medication-related × 6 months × average monthly cost of NH care
Cost of providing pharmaceutical care	(*P*(not dying from any cause during the year) × cost of pharmaceutical care for the first year) + (*P*(not dying from any cause during the year) × cost of pharmaceutical care in subsequent years) + (*P*(dying from any cause) × the cost of pharmaceutical care in subsequent years)
Discounted life expectancy at every age	*P*(not dying from any cause during this year) + *P*(not dying from any cause) × discounted life expectancy from the subsequent year + *P*(dying from any cause this year) × 0.5

Abbreviations: ED, emergency department; NH, nursing home.

Table 2 Medical utilization and pharmaceutical care parameters

Percentage of hospitalizations resulting from medication-related morbidity and mortality	
Schneitman-McIntier et al., 1996 [24]	0.57
Lakshmanan et al., 1986 [27]	4.20
Einarson, 1993 [26]	5.10
Ernst and Grizzle, 2001 [2]	28
Col et al., 1990 [25]	28.20
Median	*5.10*
Percentage of medication-related hospitalizations resulting from noncompliance	
Einarson, 1993 [26]	22.7
Col et al., 1990 [25]	40.4
Median	*31.6*
Percentage of medication-related hospitalizations resulting from inappropriate prescribing	
Lakshmanan et al., 1986 [27]	*48.6*
Emergency department visits as a result of medication-related morbidity and mortality	
Schneitman-McIntier and Farnen et al., 1996 [24]	0.56
Ernst and Grizzle, 2001 [2]	1.86
Prince et al., 1992 [29]	1.9
Dennehy et al., 1996 [1]	3.9
Median	*1.9*
Percentage of medication-related emergency room visits that are due to noncompliance	
Dennehy et al., 1996 [1]	32.0
Prince et al., 1992 [29]	43.9
Median	*38.0*
Percentage of medication-related emergency room visits that are due to inappropriate prescribing	
Dennehy et al., 1996 [1]	58.0
Increase in compliance as a result of pharmaceutical care (%)	
Faulkner et al., 2000 [39]	24
Faulkner et al., 2000 [39]	25
Faulkner et al., 2000 [39]	27
McKenney et al., 1978 [40]	28
Bond and Monson, 1984 [41]	52
Bond and Monson, 1984 [41]	55
Median	*28*
Decrease in inappropriate prescribing as a result of pharmaceutical care (%)	
Dobie and Rascati, 1994 [52]	4.0
Christensen et al., 2000 [51]	8.9
Rupp, 1992 [54]	11.8
Hanlon et al., 1996 [56]	19
Hanlon et al., 1996 [56]	23
Rupp, 1998 [53]	30
Tamai et al., 1987 [55]	40
Morrill and Barreuther, 1988 [57]	121.6
Median	*21.0*
Percentage of medications discontinued as a result of pharmaceutical care	
Hanlon et al., 1996 [56]	9
Tamai et al., 1987 [55]	22
Borgsdorf et al., 1994 [59]	39.9
Median	*22*
Decrease in mortality as a result of pharmaceutical care (%)	
Yuan et al., 2003 [63]	*7.9*
Decrease in hospitalizations as a result of pharmaceutical care (%)	
Yuan et al., 2003 [63]	*2.8*

lished sources (Table 2). Other reasons cited for medication-related hospitalizations and emergency department visits include idiosyncratic adverse drug reactions, including undocumented allergies, and inappropriate self-medication [25,29].

Emergency department visits. Published sources were used to estimate the percent of emergency department (ED) visits per year that are medication-related. This estimate was then used to calculate the number of ED visits per year that occur in the elderly as a result of adverse events (Table 1).

The base case percentage of ED visits (1.9%) is the median of several published sources (Table 2) [1,2,24,29]. Studies were excluded if they defined a medication-related visit from using the following ICD-9 codes: E930.0 to E947.9 [30]. These were excluded because medication-related visits that are identified only by the ICD-9 code used would not include visits related to compliance, inappropriate prescribing, or therapeutic failure and would significantly underreport the total number of visits per year.

The percentage of medication-related ED visits that were a result of inappropriate prescribing (58.0%) and compliance (38.0%) were based on published literature (Table 2).

Office visits. The number of medication-related office visits per year incurred by the elderly was calculated by multiplying the percentage of office visits that were elderly by the estimated number of medication-related office visits per year (Tables 1 and 3). This was then multiplied by the average cost of an office visit in 2000 to determine the total cost of medication-related office visits for the elderly per year.

Nursing home admissions. It has been well established that polypharmacy and inappropriate medication use in the elderly leads to impaired cognition and falls [31–36]. Because these events are risk factors for nursing home admission [37,38], it is reasonable to assume that many nursing home admissions are a result of improper medication use. We estimate that 25% of nursing home (NH) admissions are medication-related. This estimate was used to calculate the number of NH admissions that occur in the elderly per year because of adverse events (Table 3). Since it is most likely that many of these residents would have been admitted at some point for other comorbid reasons, our model conservatively assumes that medication-related events cause an admission to occur 6 months prematurely, but does not increase the total number of nursing home admissions.

Benefits of Pharmaceutical Care

Compliance. Pharmacists' impact on compliance was estimated as the median of several published sources (increase of 28%) in the base case (Table 2) [39–41]. Studies were excluded if the measure used to evaluate compliance, such as a compliance score, could not be combined with the measure used in the source data, which was the percentage of patients compliant with medications [42–44]. Studies were also excluded if they reported unrealistic baseline or control compliance, which was compliance greater than 85% with no intervention [45,46].

Inappropriate prescribing. It was assumed the median rate of inappropriate prescribing in the elderly population is 9%. This is the average of rates reported in several studies of retrospective reviews of inappropriate medication use in the elderly [47–50]. Studies reporting the number of errors found by pharmacists in a community setting were used to calculate the percentage of errors identified from the number of errors expected for the quantity of prescriptions filled [51–54].

Pharmacists' impact on inappropriate prescribing was estimated as the median of several published sources (decrease of 21%) in the base case [51–57]. Studies were excluded from the analysis if they included only errors of dosage or incomplete prescriptions [58], were not representative owing to the subjects being referred patients [59], reported the number of interventions per patient versus per number of prescriptions [60], reported unrealistic results (0.6 errors per 100 prescriptions) [61], or did not report the corrected errors as a percentage of total prescriptions screened [62].

Pharmacist impact on hospitalizations and office visits. Pharmaceutical care has been found to decrease overall hospitalizations by 2.8% (Table 2) [63]. This corresponds to a relative decrease of 55% of medication-related hospitalizations. In the base case, the estimated cost savings using this source ($3.8 billion per year) was averaged with the estimated cost savings from the reduction in hospitalizations as a result of increased compliance ($606 million per year) and decreased inappropriate prescribing ($711 million per year).

The estimate of medication-related office visits was not divided into those that were related to inappropriate prescribing and those related to noncompliance. For this reason, the impact of pharmaceutical care on office visits was assumed to be the mean of the impact on compliance and inappropriate prescribing. Since these are factors related to emergency department visits and hospitalizations, it is reasonable to assume that they are also related to office visits and that any impact on compliance and inappropriate prescribing would lead to a decrease in medication-related office visits as well.

Costs of Providing Pharmaceutical Care

It was assumed that 5 hours of pharmaceutical care would be provided to each patient in the first year of implementation and then 2.5 hours per year in each subsequent year. The majority of intervention time would occur during the beginning of the year with follow-up occurring as needed (e.g., after a change in therapy or assessment of noncompliance) throughout the rest of the year. The additional time would be required in the initial year to review a patient's medication history and provide more intensive counseling on the importance of compliance, etc. In the following years, the pharmacists would then monitor changes in the patient's medi-

Table 3 Base case parameters

Parameter	Value
Total number of hospitalizations in the United States per year	34,180,563 [63]
Percentage of hospitalized patients who are elderly	36 [63]
Average cost of a hospitalization	$11,112.37*
Total number of ED visits made by the elderly per year	15,482,000 [66]
Average cost of an ED visit	$516.81†
Total number of medication-related office visits per year	126,846,567 [2]
Percentage of office visits by patients who are elderly	23.8 [65]
Cost of an office visit	$109 [2]
Total number of NH admissions per year	1,800,000 [67]
Percentage of NH residents who are age 65 and older	91 [64]
Percentage of NH admissions that are medication-related	25
Average monthly charge for NH stay	$3891 [65]
Number of elderly people in the United States	34,910,122‡
Total expenditures on prescriptions per year	$121 billion§
Hourly compensation of a pharmacist	$51
Number of medication-related deaths in the United States per year	218,000 [2]

*Healthcare Cost and Utilization Project 1997: http://hcup.ahrq.gov/HCUP-net.asp, accessed May 27, 2001.
†National Medical Expenditures Survey 1987 (2000 aged data).
‡Resident population estimates of the United States by age and sex: http://www.census.gov, accessed July 27, 2001.
§*Personal Health Care Expenditures, by Type of Expenditure for Calendar Years 1994–2001,* Health Care Financing Administration: http://www.hcfa.gov/stats/nhe-oact/tables/t9.htm, accessed May 10, 2002.
Abbreviations: ED, emergency department; NH, nursing home.

cation regimen and recounsel the patient regarding compliance when deemed necessary (e.g., if refill patterns indicate the patient is exhibiting noncompliance). Christensen et al. [51] reported an average of 7.5 minutes per prescription was required for each intervention initiated. Using this estimate, patients could have five prescriptions filled per month and still require less than 5 hours of pharmaceutical care in the first year.

The cost equations are shown in Table 1. To be conservative, $40 was chosen as the base case pharmacist hourly wage. The median wage for a pharmacist in the United States in 1999 was $32.16. The 19th percentile was $42.68 (Bureau of Labor Statistics). Including fringe benefits of 27% (http://www.bls.gov/ncs/home.htm, accessed September 22, 2001); this amounts to $51 per hour (Table 3).

Decreased Cost of Prescriptions as a Result of Discontinuation of Medications

Pharmacists' impact on the discontinuation of duplicate, nonindicated, or contraindicated medications were taken as the median of several published sources (Table 2) [55,56,59]. Total drug expenditures for the elderly were calculated by multiplying the total expenditure on prescription drugs in the United States (Table 3) by the percentage of medication expenditures that are incurred by the elderly [64]. The savings per year from discontinued medications was calculated by multiplying pharmacists' impact on discontinuation by the total pharmacy expenditures of the elderly per year.

Cost of Additional Prescription Fills as a Result of Increased Compliance

Assuming that pharmaceutical care resulting in a 28% increase in compliance, the cost of the additional prescription fills was calculated by multiplying this percentage by the total pharmacy expenditures for the elderly per year (see "Decreased Cost of Prescriptions as a Result of Discontainment of Medications").

Calculation of Cost of Pharmaceutical Care

Savings owing to decreased hospitalizations and emergency department visits were calculated by multiplying pharmacists' impact on compliance and inappropriate prescribing by the percentage of hospitalizations and emergency department visits resulting from these two factors. The overall cost of pharmaceutical care per year was determined by subtracting the savings from the reduction in medication costs, hospitalizations, emergency department, office visits, and nursing home admissions from the cost of providing additional medications and pharmaceutical care. All costs were measured in year 2000 US dollars. The cost of providing pharmaceutical care over the course of a lifetime was calculated using a Markov probability-based backward induction algorithm (Table 1). Total costs for the cohort of elderly individuals in the United States were estimated.

Benefits

Life-years saved. The number of life-years saved was calculated using a Markov probability-based backward induction algorithm (Table 1). Standard annual mortality probabilities at ages 65 to 100 were obtained from National Center for Health Statistics (NCHS) Web site [68].

The base case probability of dying for the general population from medication-related problem (9.3%) was determined by using the projected number of 218,000 medication-related deaths in the total population per year [2] divided by total number of deaths (2,337,356) in the United States per year [69]. This probability was then adjusted to the elderly population by multiplying the general population's probability of dying from a medication-related problem by the probability of dying at each year of age between 65 and 100 (as reported in the NCHS life-tables). This resulted in an estimated 168,000 medication-related deaths in the elderly per year. Pharmaceutical care has been found to decrease overall mortality by 7.9% [63]. This translates into an 85% risk reduction in medication-related deaths per year.

Since inappropriate prescribing and lack of compliance are factors in increased health-care utilization, it is reasonable to assume that they would also be factors in medication-related deaths. An intervention that would impact health-care utilization would most likely also subsequently affect the number of medication-related deaths in a proportional manner. Since the study conducted by Yuan et al. [63] is conducted in a managed care population, to be conservative, we assumed that pharmacists' impact on mortality was the average of the impact on compliance, inappropriate prescribing, and the reduction in medication-related deaths per year (Fig. 1).

Results

Base Case

Using the "best choice" parameter values described above (Tables 2 and 3), a comprehensive pharmaceutical care program applied to the entire Medicare elderly population (after accounting for savings seen in decreased medication use, hospital admissions, emergency department and office visits, and nursing home admissions) would have a net cost of $16.7 billion annually. The total number of life-years saved was projected to be 7.9 million for a cost-effectiveness ratio of $2100 per life-year saved (Table 4).

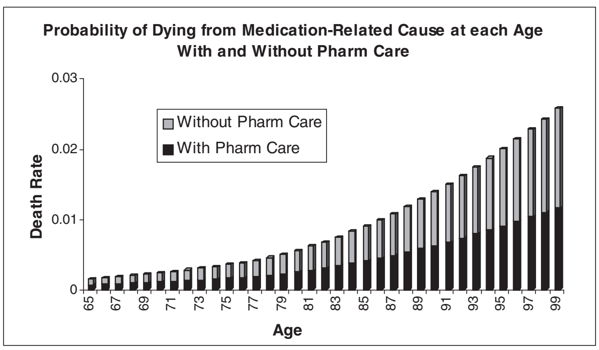

Figure 1 Probability of dying at each age from medication-related causes with and without pharmaceutical care.

Table 4 Summary of base case results

Outcome	Cost savings
Direct cost of pharmaceutical care	$47.9 billion
Cost of increased compliance	$109.2 billion
Savings from hospitalizations, ED and office visits, and NH admissions	$53.3 billion
Savings from discontinued medications	$87.2 billion
Net cost of pharmaceutical care	$19.2 billion
Number of life-years saved	7.9 million
Cost per life-year saved	$2100

Abbreviations: ED, emergency department; NH, nursing home.

Sensitivity Analyses

One-way sensitivity analyses were performed on selected variables (Table 5). Ranges were selected based on the high and low values from studies previously identified. The lower bound for annual deaths that are medication-related was based on Lazarou et al. [10]. Since this estimate is based on a hospitalized population rather than a general population it is most likely an underestimate of the total number of medication-related deaths [10].

The one-way sensitivity analyses are shown in Fig. 2. The variable that elicits the greatest impact on the model is the discontinuation of medications as a result of pharmaceutical care. Similarly, the additional costs resulting from increased compliance also exhibit great impact on the model. These two parameters dominate the overall cost of pharmaceutical care. The percentage of nursing home admissions delayed for 6 months because of pharmaceutical care has relatively little impact on the model and excluding this benefit altogether results in a cost-effectiveness ratio of $4586 per life-year saved.

Fifty-thousand dollars per life-year saved is often cited as an upper threshold value for interventions that should be adopted [70,71]. The base case assumes that pharmacists would spend 5 hours per

Table 5 Variables and ranges used in one-way sensitivity analyses

Variable	Range
1. Number of medication-related deaths per year	106,000–218,000
2. Pharmacist impact (%) on compliance	24–55
3. Pharmacist impact (%) on inappropriate prescribing	3.9–40
4. Pharmacist impact (%) on discontinuing edications	9–39.9
5. Average number of hours of pharmaceutical care required in the first year (with 50% of the amount provided in subsequent years)	3–7.5

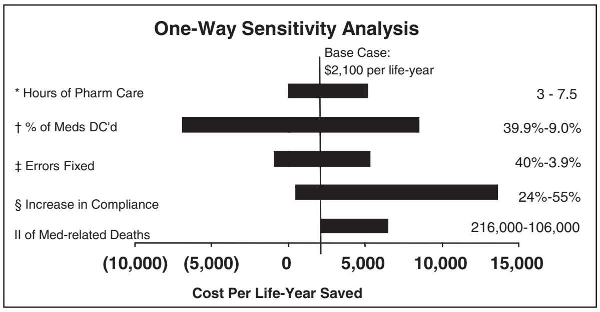

Figure 2 One-way sensitivity analyses of model parameters. *The hours of pharmaceutical care provided in the first year (with 50% provided in the subsequent years). †The percentage of medications discontinued as a result of pharmaceutical care. ‡The percentage of medication errors related to prescriptions fixed as a result of pharmaceutical care. §The percentage increase in compliance rate as a result of pharmaceutical care. ||The number of medication-related deaths in the total population per year.

year the first year and then 2.5 hours per year thereafter on the pharmaceutical care interventions. Holding other factors constant, the pharmacist could provide as much as 44 hours of pharmaceutical care in the first year and 22 hours in each subsequent year and still fall below the cost-effectiveness threshold of $50,000 per life-year saved.

Inserting the most conservative value of each range for each variable (Table 5) the intervention is still below the cost-effectiveness threshold at $28,934 per life-year saved. Utilizing the most conservative values for all variables, the intervention surpasses the $50,000 cost-effectiveness threshold when the number of annual medication error-related deaths without pharmaceutical care is assumed lower than 60,000 ($51,249 per life-year saved).

Discussion

This analysis shows the cost-effectiveness of utilizing pharmaceutical care for the Medicare-eligible elderly population of the United States. The pharmaceutical care interventions cited in this study used various methods to provide medication management services including patient counseling at the time of dispensing [40,46], medication review at the time of dispensing [52–56], telephone contact [39], and chart review and counseling at a clinic [41,44]. Although this study does not specify a particular method of delivery, any medication monitoring system for ambulatory patients that can deliver the base case 28% reduction in noncompliance and 21% reduction in inappropriate prescription errors assumed for a pharmacist-delivered intervention at a cost of $2244 in the first year and $1122 per year thereafter would be cost-effective. These interventions may include any combination of the following: monitoring of patient compliance via refill patterns, counseling of patients on the importance of compliance, and review of patient medication histories for therapy duplication, drug–drug interactions, drug–disease interactions, medications that are no longer necessary, or inappropriate medications.

Pharmacists are already in shortage, and excess demand for pharmacy manpower is projected for the foreseeable future [72]. However, our cost-effectiveness model is not restricted to pharmacist-only interventions. Any medication therapy management services provided by a qualified health-care professional that meet the base case assumptions above would be cost-effective. This suggests tremendous potential for a variety of programs that can enhance medication monitoring.

Unfortunately, because of the lack of data describing the change in patient utility as a result of pharmaceutical care, we were unable to include cost per quality-adjusted life-year measures in this analysis. It may be hypothesized that patients who receive pharmaceutical care would experience better management of chronic disease states and subsequently enjoy a higher quality of life. However, in some asymptomatic disease states, such as hypertension, some patients may actually experience a decreased quality of life from an increase in compliance and subsequent increase in undesirable side effects from the medications. An analysis including change in quality of life would need to be performed across all specific disease states.

Limitations of this analysis result from the lack of precise estimates for many of the parameters. The estimate of medication-related deaths is based on a decision model analysis that utilized an expert panel to obtain probabilities for the decision tree [2], ICD-9 codes for medication-related deaths, or estimation based on inpatient data [10]. Additionally, the varying definitions of "medication-related," "adverse drug reaction," and "medication error" in the literature led to nonstandard reporting methods in many of the studies used. Similarly, the practice sites represented for the pharmacist interventions varied in both nature and type. Although most were community pharmacies, some were outpatient services connected with a medical center.

Because of limited elderly-specific data, the model includes studies that were conducted in the general population. It may be argued that the elderly are more susceptible to medication-related morbidity and mortality. In this case, the potential savings from pharmaceutical care would be increased. This model would then be a conservative projection of the cost-effectiveness of pharmaceutical care in the elderly.

Despite these limitations, the model presented produces robust results. Aside from the number of deaths that are medication-related, no individual variations in parameters raised the cost-effectiveness ratio above $14,000 per life-year saved. Even at this level, pharmaceutical care is an extremely cost-effective intervention. Using the most conservative estimates for all parameters, the employment of pharmaceutical care in the elderly population was still well below the common threshold value of $50,000 per life-year saved. Because of the variety of practice sites represented—with little change in overall outcome—it can also be suggested that pharmaceutical care would be cost-effective across many practice settings.

Further work should be performed to determine the additional benefits received from pharmacists' monitoring of patients' medication regimens. This study did not address the cost-effectiveness or potential cost savings of pharmacists' monitoring of medication therapy and did not include any costs or benefits associated with these additional services. This will most likely need to be done on a disease-by-disease basis to determine the medical cost and life-year savings achieved by monitoring blood pressure, lipid levels, blood glucose levels, and other secondary indicators of effectiveness to maximize the benefits received from medication therapy.

L.R.E. was in the USC Department of Pharmaceutical Economics and Policy the time this study was conducted.

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