Cost-Effectiveness of Comprehensive Medication Reviews Versus Noncomprehensive Medication Review Interventions and Subsequent Successful Medication Changes in a Medicare Part D Population

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ABSTRACT

BACKGROUND: An estimated 1.5 million preventable medication-related adverse events occur annually, with some resulting in serious injury and even death. To help address this issue, the Centers for Medicare & Medicaid Services (CMS) now require medication therapy management (MTM) programs to offer comprehensive medication reviews (CMRs) to all Medicare Part D beneficiaries at least once a year. During a CMR, patients receive an extensive amount of medication and educational information. In contrast, noncomprehensive medication reviews (non-CMRs) are more targeted and focus on resolving a particular medication-related problem (MRP) via short patient consultations, patient letters, and direct provider interventions.

OBJECTIVE: To conduct a cost-effectiveness analysis comparing CMRs with non-CMR interventions on successful medication regimen changes and reductions in adverse drug events (ADEs).

METHODS: This decision analytic model compared the cost-effectiveness of CMRs with other intervention methods (non-CMRs) from a payer's perspective. For this model, a successful outcome was defined as a beneficiary case devoid of an ADE due to MRPs. The model was extensively tested and subjected to a thorough one-way sensitivity analysis and a second-order probabilistic sensitivity analysis with 10,000 iterations from the variable distributions.

RESULTS: Non-CMR interventions were less costly and more effective than CMRs. The point estimate for direct medical costs was \$193 for CMRs and \$157 for non-CMRs, and the estimated probability of avoiding an ADE was 0.93 and 0.94 for CMRs and non-CMRs, respectively. The 10,000 iteration-Monte Carlo simulation scatterplot and cost-effectiveness acceptability curve (CEAC) revealed a dominance by non-CMRs in preventing harmful ADEs from cost and effectiveness perspectives; however, there was an overlap in the 95% CIs for both cost and ADEs prevented. Despite this, a non-CMR intervention saved estimated \$5,377.08 per ADE prevented. One-way sensitivity analysis indicated the results were sensitive to the cost of treating a preventable ADE. In 100% of cases, the CEAC demonstrated that non-CMRs were likely the most cost-effective intervention regardless of the health plan's willingness to pay.

CONCLUSIONS: The cost-effectiveness acceptability curve suggests that non-CMR interventions were less costly and more effective than CMRs; however, there was overlap in the 95% CIs for costs and ADEs prevented. In all cases, the CEAC demonstrated that non-CMRs were the most economical intervention with regard to time and cost. Non-CMRs show promise as a viable method to address MRPs, reduce ADEs, and improve patient-related health outcomes.

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What is already known about this subject

- Medication-related problems (MRPs) are frequent and critical problems in the United States, with some leading to harmful adverse drug events (ADEs) and subsequent medical costs.
- Potential MRPs identified during a targeted medical review (TMR) may be addressed via comprehensive medication reviews (CMRs) or more targeted means such as short patient consultations, patient letters, and direct provider interventions (non-CMRs).
- TMRs and CMRs are required for Medicare Part D beneficiaries who meet minimum qualification criteria, yet the Centers for Medicare & Medicaid Services (CMS) use only the annual percentage of patients who receive a CMR as a performance metric or star rating for medication therapy management programs.

What this study adds

- This study provides a cost-effectiveness analysis comparing CMRs with non-CMR interventions on successful medication regimen changes and reductions in ADEs from a payer's perspective.
- Study results suggest that non-CMR interventions are more effective and less costly than CMRs.
- Important new information is provided regarding non-CMR interventions that suggests the need for consideration and integration of these interventions into the CMS star ratings program.

Medication-related errors are frequent and important problems in the United States.¹ An estimated 1.5 million preventable medication-related adverse events occur each year, with some leading to serious injury and even death.² Adverse drug events (ADEs) are associated with longer hospitalizations (e.g., 8 to 12 days) and higher hospital costs (e.g., \$16,000 to \$24,000 per patient),² resulting in an additional \$177 billion in medication-related morbidity and mortality.³ Furthermore, using multiple medications increases the risk of experiencing an ADE.⁴⁻⁷ Medication mismanagement and nonadherence are also common causes of medication-related problems (MRPs) and ADEs,⁸ and poor medication adherence (i.e., nonadherence) is associated with 33%-69% of medication-related hospital admissions.⁹ Patients with low

health literacy are at higher risk for adverse outcomes due to misunderstandings,¹⁰ and increased age may be an independent risk factor for medication errors and ADEs.^{11,12} Despite these challenges, studies show that clinical pharmacists can effectively detect and prevent critical MRPs. In particular, 41%-96% of pharmacist recommendations are accepted by prescribers.¹³⁻¹⁷ Finally, pharmacist-led discharge counseling contributes to better clinical outcomes (e.g., fewer heart failure events and nonfatal stroke) and improved economic outcomes.¹⁸⁻²⁰

The role of the pharmacist as a key partner on an interprofessional health care team has drawn much public attention with the inclusion of medication therapy management (MTM) services as part of the Medicare Modernization Act of 2003.²¹ While other health care providers can provide MTM services, pharmacists receive extensive training in pharmacology, medicinal chemistry, pharmacotherapy, pharmacokinetics, and drug-drug interactions, which equips them with the skills and knowledge to solve drug-related problems (DRPs; also known as medication-related problems [MRPs]) and implement treatment solutions.²²

MTM comprises a broad range of services and intervention strategies that involve pharmacists working in tandem with other health care providers, most notably physicians.²³⁻²⁵ In general, MTM services provide a variety of medication therapy protocols, depending on the type of service center—some programs provide face-to-face consultation while others utilize phone consultation.

As part of MTM services, the Centers for Medicare & Medicaid Services (CMS) mandate that all programs offer comprehensive medication reviews (CMRs) to eligible beneficiaries at least once a year. As defined by CMS, a CMR is a detailed comprehensive review of a beneficiary's medications and chronic conditions aimed at optimizing patient outcomes. CMRs require extensive patient consultations with additional written follow-up, which is a time-consuming task for pharmacists and patients. During a CMR, a large amount of complex information is provided to patients, some of whom may have limited health literacy.²⁶ CMS also requires targeted medication reviews (TMRs) for ongoing medication monitoring at least quarterly, based on beneficiary eligibility. A TMR is defined as a review that assesses medication use (e.g., beta2-agonists are recommended for patients with acute symptoms), monitoring for DRPs, or other unresolved issues.²⁷ MTM programs can also utilize non-CMR interventions such as brief targeted consultations, patient letters, and direct provider interventions to address DRPs and optimize patient outcomes. In contrast, non-CMR interventions are more succinct, are specific to DRPs, and can be less intimidating for patients.²⁶ Interestingly, prescribers are more likely to approve recommended medication changes resulting from targeted interventions (non-CMRs).²⁶ In general, MTM programs seldom use non-CMR interventions, since CMS evaluates program performance based on the percentage of patients annually who receive a CMR.

Recent studies reporting the benefits of MTM services have gained attention from insurers, payers, providers, and policymakers given that these services may have a positive impact on clinical, economic, and humanistic outcomes.²⁸⁻³² Additionally, several studies assert that MTM services are cost-effective and provide a positive return on investment (ROI).^{30,33,34} One study reported that a \$1 expenditure resulted in a \$12 ROI.³⁰ Although a plethora of research studies exists on the clinical and economic benefits of MTM, there is a dearth of studies comparing the benefit of CMRs with non-CMR interventions. Thus, the purpose of this study was to compare the cost-effectiveness of CMRs with non-CMR interventions at a large MTM program providing telephone-based services.

Methods

The Model

This study was a cost-effectiveness evaluation of the Medication Management Center (MMC) program at the University of Arizona College of Pharmacy, which provides MTM services to 10 million patients—both Medicare and private insurance beneficiaries—throughout the United States, using a centralized call center approach. The cost-effectiveness model compared CMRs and non-CMR interventions in Medicare Part D patients who (a) were automatically enrolled into the MTM because they met all of CMS requirements in 2012, including having at least 3 chronic health conditions, taking at least 3 medications, and incurring costs for medication greater than \$3,100 annually,³⁵ and (b) had at least 1 MRP (e.g., adjustment of treatment regimen, potential drug interaction, or untreated indication).

Once an MRP was detected, the MMC staff (pharmacists, pharmacy interns, and pharmacy technicians) made telephone calls to the patient to conduct a CMR. If the patient agreed, he or she was included in the CMR intervention group. If the patient did not receive a CMR (i.e., not interested in receiving the CMR or unreachable), that patient was included in the non-CMR intervention group. MMC staff made recommendations to prescribers to resolve the identified drug therapy issues. A successful recommendation change was defined as an expected medication change identified in subsequent pharmacy claims.²⁶ For the model, successful outcomes included (a) a change in therapy resulting from a CMR or non-CMR or (b) no change in therapy from a CMR or non-CMR and no documented ADE. A change in therapy resulting from a CMR or non-CMR was included as an outcome, since it served as a reasonable proxy to long-term clinical outcomes that were not available in pharmacy claims data. No change in therapy from a CMR or non-CMR and no documented ADE were included as an outcome based on the assumption that other causes of ADEs besides MRPs would be very uncommon. On the other hand, unresolved MRPs could lead to ADEs and, in some cases, might require additional health care resource utilization such as hospitalization and/or emergency department visits

FIGURE 1 Decision Analytic Model for Non-CMRs and CMRs from a Health Care System Perspective

ADE = adverse drug event; CMR = comprehensive medication review; ED = emergency department; non-CMR = noncomprehensive medication review; MD = physician.

(Figure 1).^{3,36,37} Given the unavailability of data to suggest otherwise, we assumed that medication adherence rates were similar in the CMR and non-CMR groups; therefore, this adherence variable was excluded from the model. The perspective of a health care payer was chosen with a 1-year time period, since we used data from a study investigating ADE costs incurred in 1 year.³⁸ Thus, discounting was not required.

A systematic review of published ADE-related research was conducted to identify probabilities associated costs to populate the model. The literature searches in PubMed and Google Scholar were conducted between October 2013 and February 2014. The Boolean operator “AND” was used to identify studies describing the relationship between MRPs and harmful ADEs that require additional health care services for treatment. The first theme was MRPs, identified by the consolidation of Medical Subject Heading (MeSH) terms *drug-related side effects* and *adverse reactions* OR *adverse drug reaction reporting systems* OR *medication error* OR text words *DRP** OR *MRP** OR *error**. The second theme was harmful consequences of MRPs, identified by the consolidation of MeSH terms *hospitalization* OR *emergency service*, *hospital* OR text words *admission** OR *ER**. From these studies, the probability of harmful ADEs due to

MRPs was identified (Table 1). In order to obtain average costs associated with ADEs due to MRPs, the first search term mentioned was combined with another theme, health care expenditure, which was identified by consolidation of MeSH terms *costs* and *cost analysis* OR text words *costs** OR *cost-of-illness** (Table 1). We considered articles published only in English and those that were original studies or observational studies for inclusion. References obtained from the retrieved studies were also searched for additional articles. Titles and abstracts were screened, followed by full-text review.

Cost-Effective Model Inputs

MRPs and Successful Medication Changes. We used unpublished quality improvement data to assess the impact of CMRs and non-CMR interventions on MRPs and positive medication changes to populate the event probabilities in the model.²⁶ These probabilities were obtained from a sample size of more than 400,000 beneficiaries in which 288,701 had MRPs. These de-identified beneficiary data were obtained from the MMC’s Medicare Part D 2012 CMS annual report, which contained summary information for each beneficiary enrolled in the center’s MTM program. In this sample, 12.2% of beneficiaries were

Cost-Effectiveness of Comprehensive Medication Reviews Versus Noncomprehensive Medication Review Interventions and Subsequent Successful Medication Changes in a Medicare Part D Population

TABLE 1 Parameters Utilized in the Economic Model

Model Parameter	Base Case	Distribution/Range	Source of Data/Comments
Probabilities			
Probability of medication change according to CMR recommendation	0.28	Beta distribution range (min-max): 0.27-0.29	Buhl et al. ²⁶
Probability of medication change according to non-CMR recommendation	0.35	Beta distribution range (min-max): 0.34-0.35	Buhl et al. ²⁶
Probability of having harmful ADE due to MRP	0.09	Beta distribution range (min-max): 0.05-0.15	Kuo et al. ³⁶
Probability of death due to ADE	0.02	Beta distribution range (min-max): 3.46×10^{-6} -0.21	Kuo et al. ³⁶
Costs			
Incremental costs of providing CMRs (over non-CMR interventions)	\$15.02	Gamma distribution range (min-max): \$2.64-\$52.80	Based on extra time required to perform CMRs (over non-CMR interventions) per prescription (average time = 10.13 minutes, SD = 5.31 minutes)
Cost of treating a preventable ADE	\$2,643.93	Gamma distribution range (min-max): \$116.87-\$10,056.44	Field et al., adjusted to 2012 numbers by using Consumer Price Index ^{38,44}

ADE = adverse drug event; CMR = comprehensive medication review; max = maximum; min = minimum; MMC = Medication Management Center; MRP = medication-related problem; non-CMR = noncomprehensive medication review; SD = standard deviation.

interested in receiving CMRs; therefore, they were classified in the CMR group. Those beneficiaries in the CMR group had an average age of 73 years (standard deviation [SD] = 10 years). Those beneficiaries in the non-CMR group (87.7% of those in the sample) had an average age of 75 years (SD = 10 years). Non-CMR patients with MRPs were more likely to have a successful medication change resulting from the intervention (odds ratio = 1.24 with 95% confidence interval [CI] = 1.21-1.28).²⁶ The University of Arizona Institutional Review Board considered this project as exempt.

Benefits and Costs of CMRs Versus Non-CMRs. A key variable in the model was provider acceptance of CMR or non-CMR recommendations by pharmacists. The MMC software tracks each intervention, and these data were extracted for this analysis. Any CMR or non-CMR recommendation approved by a health care provider was assumed to have no associated adverse clinical consequences. Telephone consultation duration and documentation time was randomly collected for 50 calls each for CMRs and non-CMR interventions (Appendix A, available in online article). On average, completing a CMR took 10:13 minutes longer (SD = 5:31 minutes) than the non-CMR intervention; these variables were used to populate the model. The direct costs of providing CMRs and non-CMR interventions were calculated by multiplying average call duration by the personnel cost for the provider's intervention using a fringe benefit rate of 30% for personnel. Given that CMRs and non-CMR interventions were conducted in the same office setting, it was assumed that the facilities and administrative costs were identical for each type of intervention and were, therefore, excluded from the analysis.

Clinical Events and Subsequent Costs. Preventable ADEs were considered a potential consequence of providers not accepting pharmacists' CMR or non-CMR recommendations. ADE-related consequences included subsequent hospitalization, emergency department visits, physician visits, additional medications, and death.^{3,39-41} The preventable ADE data were obtained from a cross-sectional observational study conducted with online data collection (Table 1).³⁶ Several studies have investigated the costs of ADEs.^{3,39,42,43} However, these studies were conducted in non-ambulatory care settings. Instead, the cost of preventable ADEs was estimated from a study conducted in an ambulatory care setting.³⁸ These costs were adjusted to January 2012 prices using the Consumer Price Index annual inflation rate.⁴⁴

Base-Case Analysis

The base-case analysis included the point estimates and plausible ranges for all relevant costs and probabilities used in the model (Table 1). The model is from a health care payer's perspective, so the base-case analysis included direct medical costs associated with providing CMRs or non-CMR interventions and with treating ADEs. The results reported here include the differences in cost between CMRs and non-CMR interventions given that the infrastructure costs were the same for both interventions. The incremental cost-effectiveness ratio (ICER) for differences in cost and effectiveness between CMRs and non-CMR interventions was calculated. TreeAge Pro software (TreeAge Software, Inc., Williamstown, MA) was used to develop the decision model.

Sensitivity Analysis

Two types of sensitivity analyses were performed: univariate sensitivity analysis and probabilistic sensitivity analysis. All variables were examined using plausible ranges based on SDs

Cost-Effectiveness of Comprehensive Medication Reviews Versus Noncomprehensive Medication Review Interventions and Subsequent Successful Medication Changes in a Medicare Part D Population

TABLE 2 Cost-Effectiveness Analysis from Base-Case Analysis and Monte Carlo Simulation

Strategy	Probability of Avoiding a Preventable ADE Mean (95% CI) ^a	Cost Per ADE Prevented Mean (95% CI) ^a	Incremental Cost-Effectiveness Ratio (95% CI) ^a
CMR ^b	0.93 (0.91 to 0.95)	\$192.60 (\$68.96 to \$391.52)	Dominated
Non-CMR	0.94 (0.92 to 0.96)	\$157.02 (\$46.20 to \$337.03)	(-\$8,356.04 to -\$3,122.00)

^aThe 95% CIs were estimated from the Monte Carlo simulation.

^bComparator is CMR.

ADE=adverse drug event; CI=confidence interval; CMR=comprehensive medication review; non-CMR=noncomprehensive medication review.

for the univariate sensitivity analysis (Table 1). For probabilistic sensitivity analysis, beta distributions were used for probability variables, and gamma distributions were used for cost variables. A Monte Carlo simulation was run 10,000 times to determine the mean and SD results for effectiveness (defined as no ADE event rates) and costs for CMRs and non-CMR interventions. A cost-effectiveness acceptability curve (CEAC) was created to demonstrate the likelihood of 1 intervention being cost-effective across a range of willingness-to-pay (WTP) values; WTP values ranged from 0 to 30,000 dollars.

Results

Base-Case Analysis

The point-estimate results for non-CMRs were \$157.02 per 0.94 ADEs prevented, while the CMR results were \$192.60 per 0.93 ADEs prevented (Appendix B1, available in online article). The model estimated that non-CMRs saved \$5,377.08 per ADE prevented compared with CMRs. Given that non-CMRs cost less (\$157.02 vs. \$192.60) and were more effective (0.94 vs. 0.93), they dominated CMRs in this analysis (Table 2).

Sensitivity Analysis Testing

Table 2 summarizes the probabilistic sensitivity analysis results from the Monte Carlo simulation and provides the mean and 95% CI results for the costs and ADE events avoided for CMRs and non-CMRs. An overlap in the 95% CIs was observed between non-CMRs and CMRs for cost and proportion of patients not experiencing ADEs (Appendix B2, available in online article). The Monte Carlo simulation with the costs per ADE avoided were used to generate the cost-effectiveness scatter plot by taking into account the variable distributions for probabilities and costs (Appendix B2). Although there is overlap in the 95% CIs for costs and ADEs avoided, the majority of points on the scatter plot from non-CMRs show greater effectiveness (i.e., right side of plot) compared with CMRs.

Figure 2 presents the ICER scatter plot. With 10,000 simulation iterations, the mean ICER was -\$5,377.08 (95% CI=-\$8,356.04 to -\$3,122.00). This figure clearly illustrates the location of the incremental effectiveness data to the right of the vertical axis, indicating that the non-CMR interventions resulted in a larger number of patients without ADEs (i.e., more

successful interventions). In addition, all points on the ICER scatter plot of non-CMRs versus CMRs were in the lower right quadrant of the plane. That is, non-CMRs led to a greater proportion of ADEs avoided (i.e., more successful interventions) at a lower cost than CMRs. The CEAC from the Monte Carlo simulation demonstrates that in 100% of scenarios, non-CMRs were the most likely cost-effective option when compared with CMRs, regardless of the health plan's willingness to pay (Appendix C, available in online article).

Univariate Sensitivity Analyses

Univariate or one-way sensitivity analyses of the most influential variables are included in a tornado diagram (Figure 3). In the diagram, each bar represents the impact of uncertainty an individual parameter has on the results by varying the values within their plausible ranges (Table 1). The variables with the greatest impact in this analysis were the cost of treating a preventable ADE and incremental costs of providing CMRs (over non-CMR interventions; Figure 3). However, the model was robust—no individual variable changed the conclusion that non-CMRs were most cost-effective, since the ICERs remained in the positive area.

Discussion

The point-estimate results indicate that non-CMR interventions were more effective and less costly as a method for preventing ADEs when compared with CMRs. In addition, the ICER data suggest that performing non-CMRs could save an additional \$5,377.08 for every ADE prevented. However, the results were sensitive to the cost of treating a preventable ADE. The Monte Carlo simulation of 10,000 scenarios revealed that non-CMRs dominated CMRs in almost all scenarios and was supported by the CEAC graph.

The main driving force behind the cost savings in favor of non-CMRs over CMRs was the likelihood of medication changes, since it was the only variable that had different values between the 2 interventions. There are several potential explanations for this observation. First, prescribers may pay closer attention when recommendations are focused and specific. The information provided by CMRs, although useful, may cause prescribers to be less prone to action because they

FIGURE 2 Incremental Cost-Effectiveness Scatter Plot of Non-CMR Interventions Versus CMRs

CMR = comprehensive medication review; non-CMR = noncomprehensive medication review.

feel reluctant to make multiple medication regimen changes at the same time.⁴⁵ As a result, prescribers may be more likely to accept recommendations resulting from non-CMRs. Thus, by prioritizing and suggesting the most important MRPs, this could improve the likelihood of gaining the prescribers' acceptance for non-CMR interventions.

Second, patients with chronic illness struggle with managing their day-to-day and long-term health. Health information, the health care system, and medications regimens are complex and confusing. By tailoring straightforward, more targeted approaches to addressing identified DRPs, it is possible to simplify provider-patient communication and patient engagement materials to help improve adherence, patient outcomes, and overall health. The randomized trial by Kreuter and Strecher (1996) indicates that individually tailored messages are almost 20% more likely to change at least 1 behavior.⁴⁶

The MMC's innovative software identifies MPRs (i.e., alerts), classifies them into different levels by complexity and urgency, and then assigns the individual case to receive one of several intervention strategies: CMR exclusively, CMR and non-CMR

options, or non-CMR options only (e.g., short calls, letters, or direct provider outreach). Thus, for those beneficiaries who require fewer medication changes, performing non-CMRs may be equal to or more effective than CMRs.

Non-CMRs may also help improve the efficiency of MTM programs, given that 90% of all medication changes occurred in the non-CMR group. Furthermore, almost 90% of Medicare Part D beneficiaries who met the criteria for a CMR did not participate in this type of intervention; instead, they received non-CMR interventions. Non-CMR options require, on average, 10 minutes less per beneficiary than CMRs, thus enabling the MMC staff to perform additional non-CMRs per day, providing more opportunities to detect MRPs and increase the potential to prevent subsequent ADEs. This MTM program has mechanisms in place to ensure that beneficiaries receive appropriate interventions for their MRPs. However, for some MTM programs that choose to provide only CMRs, 90% of the aforementioned beneficiaries would have received no intervention.

It is worth noting that CMS encourages intervention strategies for MRPs identified during required quarterly TMRs for

FIGURE 3 Tornado Diagram of Univariate Analyses of Model Parameters

ADE = adverse drug effect; CMR = comprehensive medication review; ICER = incremental cost effectiveness ratio; MRP = medication-related problem; non-CMR = noncomprehensive medication review.

Medicare Part D beneficiaries who meet minimum qualification criteria (i.e., multiple chronic health conditions and multiple medications). However, CMS only uses the annual percentage of patients who receive CMRs as an MTM performance metric. Thus, we know from watching measurement history that metrics drive performance. For example, a managed care organization implemented processes to ensure patients received beta-blocker therapy after the National Committee for Quality Assurance began measuring whether patients experiencing a myocardial infarction had received the respective treatment.⁴⁷ Ultimately, the new metric prompted response, and more than 90% of patients who had a myocardial infarction received beta-blocker treatment. Similarly, the current study suggests the need for inclusion of MTM intervention strategies as measures in the MTM performance metrics (i.e., star ratings for Medicare Advantage and prescription drug plans proposed by CMS) to incentivize interventions to reduce MRPs and, ultimately, to reduce the ADE-related costs for managed care organizations. These study results suggest that MTM programs have an opportunity to improve their efficiency in delivering services. Moreover, this may serve as a driving force behind the expansion of MTM services.

Limitations

This analysis has several important limitations. The lack of availability of complete medical records prevents the ability to determine other clinical outcomes (e.g., adherence, immu-

nization rates, and health condition monitoring) that MTM interventions aim to improve, as well as long-term outcomes such as mortality. Although a difference in point estimate of avoiding a preventable ADE was examined in this study, it does not imply a difference in clinically meaningful outcomes. The innate nature of a retrospective analysis prevents randomization between CMR and non-CMR groups and so is a study limitation. Nonrandomization introduces the potential for selection bias or systematic error given that other confounders may be present that could have an impact on the dependent and independent variables. Also, patients who agreed to have a CMR may differ significantly with regard to their characteristics (e.g., demographics, chronic illness history, and health literacy) from those who received non-CMR services. There is the potential for threats to external validity given that CMRs and non-CMR interventions were conducted at a single facility. Therefore, this raises the issue whether the results are generalizable to other facilities providing MTM services. Additionally, all consultations were performed via telephone, thus, these results may not be generalizable to MTM programs that offer face-to-face consultations. Lastly, the published literature regarding written prescribing errors may have some differences compared with pharmacist telephone interventions regarding DRPs.

Conclusions

This cost-effectiveness study suggests that non-CMR interventions are less costly and more effective than CMRs in preventing ADEs and reducing health care costs, when viewed from a health

Cost-Effectiveness of Comprehensive Medication Reviews Versus Noncomprehensive Medication Review Interventions and Subsequent Successful Medication Changes in a Medicare Part D Population

care payer's perspective. The Monte Carlo simulation of 10,000 scenarios found that non-CMRs dominated CMRs in almost all scenarios. Results were most sensitive to cost of treating a preventable ADE. These results suggest the need for inclusion of non-CMR interventions in the metrics evaluating Medicare Part D MTM programs. Future research is warranted to further evaluate non-CMR interventions in other populations and to examine other potential beneficial effects such as improvement in medication adherence. In summary, non-CMRs show promise as a viable method for pharmacists and patients to address MRPs, reduce ADEs, and improve patient-related health outcomes.

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DISCLOSURES

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Concept and design were performed by Chinthammit, Boesen, Martin, and Warholak. Data were collected by Chinthammit, Armstrong, and Martin, with help from Boesen and Warholak. Data were interpreted by Warholak, Armstrong, and Chinthammit. Chinthammit, Armstrong, and Warholak wrote the manuscript with help from Boesen and Martin. The manuscript was revised by Taylor, Warholak, and Chinthammit, with help from Armstrong, Boesen, and Martin.

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Cost-Effectiveness of Comprehensive Medication Reviews Versus Noncomprehensive Medication Review Interventions and Subsequent Successful Medication Changes in a Medicare Part D Population

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Cost-Effectiveness of Comprehensive Medication Reviews Versus Noncomprehensive Medication Review Interventions and Subsequent Successful Medication Changes in a Medicare Part D Population

APPENDIX A Characteristics of Medication Management Center Call Duration

Model Parameter	Mean (SD)	Reference
Time to perform CMRs (minutes)	23:25 (11:18)	MMC internal data
Time to perform non-CMR interventions (minutes)	13:13 (7:28)	MMC internal data
Additional time to perform CMRs (over non-CMRs; minutes)	10:12 (5:31)	MMC internal data
Average pharmacist hourly wage	\$55.27	U.S. Department of Labor ⁴⁸
MMC pharmacist fringe benefit rate	30%	MMC internal data

CMR = comprehensive medication review; MMC = Medication Management Center; non-CMR = noncomprehensive medication review; SD = standard deviation.

APPENDIX B Cost-Effectiveness Point Estimates and Scatter Plots for CMRs and Non-CMR Interventions

1. Cost-Effectiveness Point Estimates

2. Cost-Effectiveness Scatter Plots

ADE = adverse drug event; CMR = comprehensive medication review; non-CMR = noncomprehensive medication review.

APPENDIX C Cost-Effectiveness Acceptability Curve

CMR = comprehensive medication review; non-CMR = noncomprehensive medication review.