

# Health Outcomes From an Innovative Enhanced Medication Therapy Management Model

Alan Stein, MD, PhD; Stephanie Finnel, PhD; David Bankes, PharmD, BCGP;  
Huaichuan Jin, MS; Michael S. Awadalla, PharmD, BCGP;  
Joshua Johnson, PharmD, BCGP; and Jacques Turgeon, BPharm, PhD

## Introduction

In 2003, the Medicare Prescription Drug, Improvement, and Modernization Act required that Part D prescription drug plans (PDPs) offer beneficiaries a nondispensing clinical pharmacy service, called medication therapy management (MTM), as a way to optimize medication use and ultimately improve outcomes.<sup>1</sup> PDPs have substantially differed in their ability to achieve those goals.<sup>2,3</sup> In 2017, the Center for Medicare & Medicaid Innovation (CMMI) initiated a 5-year Enhanced MTM model test. CMMI is testing whether providing PDPs with regulatory latitude and financial incentives can promote enhancements in the MTM program, catalyzing improved therapeutic outcomes and reduced net Medicare expenditures. To meet these objectives, participating PDPs are permitted to try innovative strategies that can optimize beneficiary medication use.<sup>4-6</sup>

PDPs that identify and implement innovative strategies that prioritize adverse drug event (ADE) prevention could be successful within this model. ADEs are prevalent among older Americans and contribute to several negative outcomes, such as emergency department (ED) visits, hospitalization, death, and higher health care costs.<sup>7-13</sup> Improving these outcomes is possible because consistent research shows that about half of all ADEs are preventable.<sup>14</sup> However, achieving these ends requires a strategic approach. First, individuals at high risk of ADEs must be accurately identified. Next, their specific pharmacological risk factors must be made known to clinicians, who can design interventions that mitigate relevant safety concerns.

In the 2 previous articles in this supplement,<sup>15,16</sup> we demonstrated how a computer-based risk algorithm with an integrated clinical decision-support system (CDSS) has facilitated this process in Medicare Part D beneficiaries. To recap, the MedWise Risk Score (MRS) identified beneficiaries at risk of medication-related morbidity; the inputs to the risk-scoring algorithm came exclusively from pharmacological characteristics found within beneficiaries' Part D claims. Specifically, each 1-point increase in the MRS was associated with a greater chance of ADEs, higher medical costs, more hospitalizations, more ED visits, and greater

## ABSTRACT

**Objective:** To evaluate the impact of pharmacist-delivered medication safety reviews (MSRs) on total medical expenditures, hospitalizations, emergency department (ED) visits, and mortality in Medicare Part D beneficiaries, whose plan was a participant of the Enhanced Medication Therapy Management model.

**Study Design:** Retrospective, pre-post, cohort study.

**Methods:** We evaluated the aforementioned outcomes for beneficiaries who were targeted, according to their MedWise Risk Scores (MRS), for MSR services in both 2018 and 2019. The "MSR" cohort included those who received their first-ever MSR in 2018 and received another MSR in 2019. The "failed to engage" (FTE) cohort included beneficiaries who were targeted in both 2018 and 2019 but did not engage in an MSR at any point through the end of 2019. For both cohorts, we calculated the change from 2018 to 2019 for each outcome and then determined whether unadjusted year-over-year changes differed significantly between cohorts. Additionally, these difference-in-differences (DiD) analyses were adjusted for baseline MRS and multimorbidity.

**Results:** A total of 11,436 beneficiaries were targeted for MSRs in both 2018 and 2019. Beneficiaries were, on average, aged  $76.6 \pm 10.0$  years. The MSR cohort (N=4384) outperformed the FTE cohort (N=7052) in total medical costs (DiD=\$958/y [7.5% savings];  $P=.042$ ), hospitalizations (DiD=3.9 admissions/100 beneficiaries/y [10% reduction];  $P=.032$ ), ED visits (DiD=6.2 visits/100 beneficiaries/y [10% reduction];  $P=.014$ ), and mortality (2.1% fewer died in 2019;  $P<.001$ ). Each outcome remained significant after adjusting for baseline MRS and multimorbidity.

**Conclusion:** MSRs were effective at improving annual health care costs, hospitalizations, ED visits, and mortality in Medicare beneficiaries targeted according to MRS.

*Am J Manag Care.* 2021;27:S300-S308

For author information and disclosures, see end of text.

mortality. Next, high-MRS beneficiaries were then targeted for risk-mitigating interventions as part of their PDP's participation within the CMMI model. When supported by MedWise—a CDSS that helps identify medication-related problems contributing to a beneficiary's MRS—pharmacists overwhelmingly prioritized problems pertaining to medication safety and proposed recommendations that would significantly decrease the MRS. Specifically, adverse drug reactions, drug interactions, and unnecessary medication use accounted for approximately 85% of all medication-related problems identified. To resolve these problems, pharmacists proposed recommendations—particularly deprescribing and changing existing therapies to safer alternatives—capable of reducing the mean MRS by nearly 5 points.

In sum, the first article in this supplement<sup>15</sup> demonstrated the association between MRS and poor health outcomes, and the second<sup>16</sup> demonstrated that MedWise-CDSS-supported pharmacists prioritized interventions capable of reducing the risk of poor outcomes in individuals targeted according to their MRS. But do these interventions actually improve patient health and save money for the health care system? To conclude this supplement, in this article, we will evaluate the impact of MedWise-CDSS-supported, pharmacist-driven interventions on Medicare Parts A and B costs, hospital admissions, ED visits, and all-cause mortality in beneficiaries of a PDP that is participating in CMMI's Enhanced MTM model. The research presented here was conducted by Tabula Rasa HealthCare (TRHC), with the oversight of ClearStone Solutions, the contracted Part D administrator for plan participant Blue Cross and Blue Shield Northern Plains Alliance (BCBS-NPA), without input from CMS.

## Methods

### Study Design and Data Sources

This was a retrospective, pre-post, cohort study that evaluated the outcomes of PDP beneficiaries in 2 cohorts: one that received MSRs and a comparable group that did not. This study used Medicare Part A and Part B claims as the primary data source for outcomes. The Biomedical Research Alliance of New York Institutional Review Board (protocol number 19-12-172-427; approved May 24, 2019) provided ethical oversight and waived requirements for obtaining informed consent.

### Context and Setting

This study involved beneficiaries living in Medicare Part D Region 25 (Iowa, Minnesota, Montana, Nebraska, North Dakota, South Dakota, and Wyoming) covered under the BCBS-NPA. NPA members qualify for Medicare, but they may have types of insurance outside NPA. NPA's Medicare Part D administrator, ClearStone Solutions, hired TRHC to deliver Enhanced MTM services. TRHC is a medication risk-mitigation company that developed the aforementioned computer-based risk-predictive model (ie, the MRS) and the advanced

CDSS (ie, MedWise). Several previously published studies describe the validity of the MRS<sup>17-21</sup> and the application of the advanced CDSS in cases.<sup>22-29</sup>

### Intervention

A pharmacist-provided medication safety review (MSR) was the intervention under investigation. Compared with comprehensive medication reviews in traditional MTM,<sup>30</sup> MSRs have 2 distinct features described in the previous literature.<sup>31</sup> First, MSRs do not focus on improving CMS star ratings or on ensuring medication and guideline adherence. Rather, MSRs apply the principles of pharmacodynamics, pharmacokinetics, pharmacogenomics, and chronopharmacology to enhance medication safety and prevent ADEs. Second, MSRs address simultaneous multidrug interactions in the context of the entire drug regimen using the aforementioned CDSS. This approach updates other methodologies of assessing drug interactions as pairwise comparisons and subsequently generating numerous alerts.

Our previous paper<sup>16</sup> described the process of MSR delivery. As a brief summary, beneficiaries were stratified according to their MRS, which was computed from Part D claims. Next, beneficiaries with the highest risk scores were prioritized for MSR outreach by pharmacy staff (technicians, interns, or pharmacists). Staff then conducted a medication reconciliation with each beneficiary who agreed to an MSR, asking them to verify the medications they were taking. The result was an accurate, up-to-date medication list that pharmacists could use to guide their recommendations. Beneficiaries then met with pharmacists either face to face or by telephone for the official MSR consultation. Once the consultation was complete, pharmacists produced several documents to close out the encounter. First, each beneficiary received an action plan. Written in patient-friendly language, this document described the medication-related problems(s) identified during the MSR with the corresponding resolving recommendation(s). If appropriate, the pharmacist sent a similar document to the beneficiary's prescriber, except that this document used professional and clinical terminology. Prescribers would not receive such correspondence if patients did not provide consent to the pharmacist, or if the medication-related problems were either of minor severity or resolvable by the patient (eg, time-of-day administration changes). Last, beneficiaries received an updated medication list, which was based on their MSR encounter. Pharmacy technicians and pharmacists contacted beneficiaries for follow-up MSRs approximately 3 months later, but no earlier.

### Participants and Outcomes

To be considered for this study, beneficiaries must have been (a) aged at least 21 years, and (b) continuously enrolled in and eligible for Enhanced MTM for the entirety of 2018 and 2019 ( $n = 170,820$ ). Because of their propensity to consume a disproportionate amount of financial resources,<sup>32</sup> patients with end-stage renal disease (ESRD)

were excluded from all analyses. A patient with ESRD was defined as anyone with a Beneficiary Medicare Status Code (ie, the BENE\_MDCR\_STUS\_CD variable) of 11, 21, or 31 (from the Claim and Claim Line Feed files). From the continuously eligible beneficiaries without ESRD, we included anyone targeted (because of MRS) for an MSR in both years ( $n=13,941$ ). Our intervention cohort (ie, MSR) included anyone who had their first-ever MSR in 2018 and also had at least 1 MSR in 2019 ( $n=4384$ ). The MSR in 2018 had to be the beneficiary's first-ever MSR, because we believe the opportunity to make an impact is greatest with patients who have never had an MSR. This MSR cohort was compared against targeted beneficiaries who failed to receive any MSR services within the study window or at any point before ("failed to engage" [FTE] cohort,  $n=7052$ ). Such individuals failed to engage with the pharmacy team (eg, did not answer the phone or refused the MSR). **eAppendix Figure 1** (eAppendix available at [ajmc.com](https://ajmc.com)) summarizes data management for cohort selection.

We considered several outcomes for analysis: Medicare Parts A and B costs, number of hospitalizations, and number of ED visits not resulting in a hospitalization. We examined changes from 2018 to 2019 in the various outcomes for each cohort.

In addition to examining changes from 2018 to 2019 in outcomes among beneficiaries who were eligible across both years, we assessed 2019 all-cause mortality among beneficiaries in the 2 cohorts who were alive at the end of 2018. To qualify for this analysis, beneficiaries had to be continuously eligible and targeted only in 2018. We then identified those who had their first-ever MSR in 2018 and those who failed to engage in 2018. Finally, we calculated the fraction of beneficiaries in each cohort who died in 2019.

Parts A and B costs were the total annual adjudicated amount paid by CMS (US\$) in the claims data. Hospitalizations and ED visits not resulting in a hospitalization were identified by line-item claims. Death date was obtained from the beneficiary demographics provided as part of the claims data.

## Analysis

First, we evaluated descriptive statistics to ensure the 2 cohorts were comparable at baseline and to adjust for any differences that did emerge. In addition to looking at basic demographics (eg, age, sex, ethnicity), we examined baseline scores on 2 indicators of acuity: (1) the hierarchical condition category (HCC) score and (2) the MRS of the beneficiary just before their data were input into MedWise CDSS and queued for MSR outreach (typically, beneficiary data are imported into MedWise CDSS very shortly after targeting).

Our analysis methods differed for mortality vs the other outcomes. For the other outcomes, we first calculated the change in each outcome for both cohorts from 2018 to 2019. Next, we compared the 2 cohorts' changes in outcomes (ie, difference-in-differences [DiD]) from 2018 to 2019 using 2-sample *t*-tests and Wilcoxon tests. To account for any potential confounding due to multimorbidity or MRS, *t*-tests were

weighted using each beneficiary's baseline CMS HCC score<sup>33</sup> and MRS (at the time of targeting). In other words, we weighted the FTE cohort to make its HCC and MRS distributions closely resemble those of the MSR cohort. For the DiD analysis, our alternative hypothesis assumed that those receiving MSRs would outperform the FTE cohort (1-sided test). This was based on MTM studies that have demonstrated that pharmacist-driven interventions can reduce total costs,<sup>34-36</sup> ED utilization,<sup>37</sup> and hospitalization rates<sup>35-37</sup> compared with patients not receiving MTM services. We considered *P* values  $< .05$  statistically significant. All analyses were performed in R (v. 3.5.2). **eAppendix Figure 2** summarizes the method for analysis.

The mortality analysis used the same procedures, except that it did not examine changes in outcomes from 2018 to 2019. Instead, it defined 2 cohorts of targeted beneficiaries in 2018: those who had their first-ever MSR in 2018 (MSR) and those who failed to engage in 2018 (FTE). Among those alive at the end of 2018, we then calculated the fraction of beneficiaries in each cohort who died in 2019 and compared the 2 death rates using a 2-sample *t*-test. As with the other outcomes, we ran the same analysis adjusting for baseline HCC and MRS using weighted *t*-tests.

## Results

The 2 cohorts consisted of 11,436 beneficiaries, of which 4384 and 7052 beneficiaries, respectively, made up the MSR and FTE cohorts. **Table 1** reports each cohort's individual and combined demographics (as received by claims data), along with those of all beneficiaries ( $n=170,820$ ). To summarize, the 2 cohorts were well balanced at baseline. Both groups were predominantly female (MSR: 63.4% vs FTE: 64.3%), were overwhelmingly non-Hispanic white (MSR: 99.1% vs FTE: 98.7%;  $P < .009$ ), were aged an average of  $76.6 \pm 10.0$  years (MSR:  $77.1 \pm 9.0$  vs FTE:  $76.3 \pm 10.6$ ;  $P < .001$ ), and were taking an average of  $10.9 \pm 3.7$  medications (MSR:  $10.6 \pm 3.6$  vs FTE:  $11.0 \pm 3.7$ ;  $P < .001$ ). Regarding medication and multimorbidity, both groups had similar HCC scores (MSR:  $1.4 \pm 1.1$  vs FTE:  $1.4 \pm 1.0$ ;  $P = .60$ ); however, the FTE group had a markedly higher mean MRS just prior to being imported into MedWise CDSS (MSR:  $17.8 \pm 6.1$  vs FTE:  $19.0 \pm 6.1$ ;  $P < .001$ ). **eAppendix Figure 3** shows distributions of HCC and MRS in the 2 cohorts.

**Table 2** reports economic and clinical utilization outcomes for both cohorts. First, mean total medical costs (ie, combined Parts A and B) increased from 2018 to 2019 in both cohorts, although the increase was less pronounced for the MSR cohort. Specifically, MSR members' costs increased by \$1158 (95% CI, \$350-\$1965) per member, whereas FTE members' costs increased by \$2116 (95% CI, \$1395-\$2838) per member. This \$958 difference between groups was significant ( $P = .042$  using *t*-test) and represented a 7.5% annual overall cost savings in favor of the MSR cohort. This trend was the same when we repeated the analysis for individual Part A and B expenditures. Next, we found that the hospitalization rate decreased

**TABLE 1.** Study Demographics

Characteristic	All	MSR + FTE	MSR	FTE	P value <sup>a</sup>
Beneficiaries, n (%)	170,820	11,436 (6.7%)	4384 (2.6%)	7052 (4.1%)	
Age, mean±SD <sup>b</sup>	76.0±8.4	76.6±10.0	77.1±9.0	76.3±10.6	<.001
Female, n (%)	100,959 (59.1%)	7315 (64.0%)	2778 (63.4%)	4537 (64.3%)	.29
Number of profiled medications, mean±SD <sup>c</sup>	6.1±3.8	10.9±3.7	10.6±3.6	11.0±3.7	<.001
MedWise Risk Score, <sup>d</sup> mean±SD	NA	18.6±6.1	17.8±6.1	19.0±6.1	<.001
HCC score, mean±SD <sup>e</sup>	0.9±0.8	1.4±1.1	1.4±1.1	1.4±1.0	.60
Ethnicity, n (%)					
Non-Hispanic white	165,746 (98.8%)	11,186 (98.9%)	4308 (99.1%)	6878 (98.7%)	.009
Black	499 (0.3%)	41 (0.4%)	11 (0.3%)	30 (0.4%)	.13
Hispanic	111 (0.1%)	10 (0.1%)	1 (0.0%)	9 (0.1%)	.065
Asian	246 (0.2%)	7 (0.1%)	3 (0.1%)	4 (0.1%)	.81
North American Native	301 (0.2%)	29 (0.3%)	12 (0.3%)	17 (0.2%)	.74
Other	875 (0.5%)	42 (0.4%)	14 (0.3%)	28 (0.4%)	.50
Unknown	3032 (1.8%)	121 (1.1%)	35 (0.8%)	86 (1.2%)	.032
Common chronic conditions (ICD-10), % <sup>f</sup>					
Essential hypertension (I10)	73,825 (43.2%)	5875 (51.4%)	2303 (52.5%)	3572 (50.7%)	.05
Type 2 diabetes mellitus (E11)	31,953 (18.7%)	3180 (27.8%)	1267 (28.9%)	1913 (27.1%)	.041
Hyperlipidemia (E78)	47,955 (28.1%)	3087 (27.0%)	1275 (29.1%)	1812 (25.7%)	<.001
Atrial fibrillation (I48)	18,466 (10.8%)	2712 (23.7%)	1109 (25.3%)	1603 (22.7%)	.002
Coronary heart disease (I25)	19,690 (11.5%)	2080 (18.2%)	867 (19.8%)	1213 (17.2%)	<.001
Hypothyroidism (E03)	19,626 (11.5%)	1676 (14.7%)	639 (14.6%)	1037 (14.7%)	.85
Heart failure (I25)	7859 (4.6%)	1351 (11.8%)	539 (12.3%)	812 (11.5%)	.21
Pertinent risk outcomes at baseline <sup>g</sup>					
Total medical expenditures, mean (95% CI), US\$ <sup>h</sup>	\$7793 (\$7712, \$7873)	\$13,365 (\$12,921, \$13,808)	\$13,553 (\$12,906, \$14,200)	\$13,249 (\$12,652, \$13,845)	.50
Part A medical expenditures, mean (95% CI), US\$	\$5732 (\$5660, \$5803)	\$10,339 (\$9938, \$10,742)	\$10,329 (\$9757, \$10,902)	\$10,347 (\$9800, \$10,893)	.96
Part B medical expenditures, mean (95% CI), US\$	\$2061 (\$2037, \$2085)	\$3025 (\$2916, \$3135)	\$3224 (\$3026, \$3422)	\$2902 (\$2773, \$3031)	.013
Hospital admissions, mean (95% CI), #/100 beneficiaries/y	19.3 (19.1, 19.6)	38.4 (36.9, 40.0)	38.1 (35.6, 40.5)	38.6 (36.6, 40.6)	.74
Days in hospital, mean (95% CI), days	1.04 (1.02, 1.07)	2.23 (2.11, 2.35)	2.07 (1.89, 2.24)	2.33 (2.16, 2.50)	.030
ED visits without hospitalization, mean (95% CI), #/100 beneficiaries/y	34.0 (33.6, 34.5)	62.6 (60.0, 65.2)	64.8 (60.5, 69.0)	61.2 (57.9, 64.5)	.19

ED, emergency department; FTE, failed to engage; HCC, hierarchical condition category; ICD-10, International Classification of Diseases, 10th Revision; US\$, United States dollars.

<sup>a</sup>Significance tests were conducted on means (using 2-sided *t*-test) and proportions (using 2-sided *Z*-test) between MSR and FTE cohorts.

<sup>b</sup>Age reflects the member's age at the end of 2018.

<sup>c</sup>The number of medications reflects the number of medications the member was taking at the time of their maximum MedWise Risk Score in 2018.

<sup>d</sup>The score just prior to load into MedWise in 2018.

<sup>e</sup>The HCC score is the score that CMS released for the member in December 2019 and includes ICD-10 codes from 2018 claims.

<sup>f</sup>The top ICD-10 codes come from claims for beneficiaries in 2018.

<sup>g</sup>The risk outcomes at baseline reflect all of 2018.

<sup>h</sup>Total medical expenditures include Part A and Part B expenditures.

**TABLE 2.** Unadjusted Economic and Clinical Utilization Outcomes for Medication Safety Review (N=4384) and Failed to Engage (N=7052) Cohorts<sup>a</sup>

Outcome and cohort	2018	2019	Change in #	Change in %	DiD <sup>b</sup> # (%)	P value <sup>c</sup>
Total medical expenditures (mean \$/member)						
MSR	\$13,553 (\$12,906, \$14,200)	\$14,711 (\$14,005, \$15,417)	\$1158 (\$350, \$1965)	8.5% (2.6%, 14.5%)	-\$958 (-7.5%)	t: .042 W: .001
FTE	\$13,248 (\$12,652, \$13,845)	\$15,364 (\$14,748, \$15,980)	\$2116 (\$1395, \$2838)	16.0% (10.5%, 21.4%)		
Part A medical expenditures (mean \$/member)						
MSR	\$10,329 (\$9757, \$10,902)	\$11,068 (\$10,442, \$11,693)	\$739 (-\$4, \$1482)	7.2% (0.0%, 14.3%)	-\$830 (-8.0%)	t: .05 W: .002
FTE	\$10,346 (\$9800, \$10,893)	\$11,916 (\$11,371, \$12,460)	\$1569 (\$903, \$2236)	15.2% (8.7%, 21.6%)		
Part B medical expenditures (mean \$/member)						
MSR	\$3224 (\$3026, \$3422)	\$3643 (\$3430, \$3855)	\$419 (\$241, \$597)	13.0% (7.5%, 18.5%)	-\$128 (-5.8%)	t: .14 W: .025
FTE	\$2902 (\$2773, \$3031)	\$3449 (\$3274, \$3624)	\$547 (\$401, \$693)	18.8% (13.8%, 23.9%)		
Hospital admissions (#/100 beneficiaries)						
MSR	38.1 (35.6, 40.5)	36.8 (34.3, 39.3)	-1.3 (-4.4, 1.9)	-3.4% (-11.6%, 4.9%)	-3.9 (-10.0%)	t: .032 W: .031
FTE	38.6 (36.6, 40.6)	41.2 (39.1, 43.3)	2.6 (0.0, 5.1)	6.6% (0.0%, 13.3%)		
ED visits <sup>d</sup> (#/100 beneficiaries)						
MSR	64.8 (60.5, 69.0)	66.2 (62.0, 70.5)	1.5 (-2.7, 5.7)	2.3% (-4.2%, 8.8%)	-6.2 (-10.3%)	t: .014 W: .034
FTE	61.2 (57.9, 64.5)	68.9 (65.0, 72.8)	7.7 (4.1, 11.3)	12.6% (6.7%, 18.5%)		

DiD, difference-in-differences; ED, emergency department; FTE, failed to engage; MSR, medication safety review.

<sup>a</sup>Numbers in parentheses are 2-sided 95% confidence intervals. Numbers in the first 2 columns are rounded, but # change and % change are calculated using raw, unrounded data.

<sup>b</sup>MSR - FTE.

<sup>c</sup>t reflects the *t*-test *P* value, and *W* represents the Wilcoxon test *P* value.

<sup>d</sup>Those that occurred without hospitalization.

by 1.3 admissions/100 beneficiaries/y (95% CI, -4.4 to 1.9) in the MSR cohort. In contrast, the FTE cohort experienced a year-over-year increase of 2.6 admissions/100 beneficiaries/y (95% CI, 0.0-5.1). Overall, the difference between groups was significant ( $P = .032$  using *t*-test) and represented a 10% decrease in annual hospitalizations favoring the MSR cohort. Finally, ED utilization increased in both the MSR cohort with 1.5 visits/100 beneficiaries/y (95% CI, -2.7 to 5.7) and the FTE cohort with 7.7 visits/100 beneficiaries/y (95% CI, 4.1-11.3), but the increase was less steep in the MSR cohort. The intergroup comparison was significant ( $P = .014$ ), representing an overall 10.3% decrease in annual ED visits in favor of the MSR group. As revealed in **Tables 3** and **4**, the significant intergroup differences in total cost, hospitalizations, and ED visits were maintained even after adjusting for HCC (Table 3) and MRS (Table 4).

**Table 5** reports mortality data. Of those who had their first-ever MSR in 2018 ( $n = 10,442$ ), 6.8% (95% CI, 6.3%-7.2%) died by the end

of 2019. Comparatively, 8.9% (95% CI, 8.4%-9.3%) of those who were FTE in 2018 ( $n = 15,895$ ) died in 2019. This 2.1 percentage point difference (8.9% minus 6.8%) in mortality rates was significant ( $P < .001$ ). Significance was maintained, even after adjusting for HCC and MRS.

## Discussion

This study of more than 11,000 Medicare Part D beneficiaries found that those receiving repeated MedWise CDSS-supported, pharmacist-provided, safety-oriented interventions had improvements in several pertinent outcomes year-over-year. Relative to beneficiaries who were targeted for but did not receive services, the MSR cohort experienced an average savings of \$958 per member (7.5% savings) in total Part A and B medical costs; an average reduction in hospitalizations of approximately 4 admissions/100 beneficiaries (10% reduction); an average reduction in ED visits of approximately 6 visits/100 beneficiaries (10% reduction); and a mortality rate that was

**TABLE 3.** Economic and Clinical Utilization Outcomes for Medication Safety Review (N=4384) and Failed to Engage (N=7052) Cohorts, Adjusted for Baseline Hierarchical Condition Category Score<sup>a</sup>

Outcome and cohort	2018	2019	Change in #	Change in %	DiD <sup>b</sup> , # (%)	P value <sup>c</sup>
Total medical expenditures (mean \$/member)						
MSR	\$13,553 (\$12,906, \$14,200)	\$14,711 (\$14,005, \$15,417)	\$1158 (\$350, \$1966)	8.5% (2.6%, 14.5%)	-\$926 (-7.0%)	.049
FTE	\$13,414 (\$12,803, \$14,025)	\$15,497 (\$14,866, \$16,129)	\$2084 (\$1343, \$2824)	15.5% (10.0%, 21.1%)		
Part A medical expenditures (mean \$/member)						
MSR	\$10,329 (\$9757, \$10,902)	\$11,068 (\$10,442, \$11,693)	\$739 (-\$4, \$1482)	7.2% (0.0%, 14.3%)	-785 (-7.4%)	.06
FTE	\$10,458 (\$9899, \$11,018)	\$11,982 (\$11,430, \$12,535)	\$1524 (\$842, \$2206)	14.6% (8.0%, 21.1%)		
Part B medical expenditures (mean \$/member)						
MSR	\$3224 (\$3026, \$3422)	\$3643 (\$3430, \$3855)	\$419 (\$241, \$597)	13.0% (7.5%, 18.5%)	-141 (-5.9%)	.13
FTE	\$2956 (\$2818, \$3092)	\$3515 (\$3317, \$3713)	\$560 (\$399, \$720)	18.9% (13.5%, 24.4%)		
Hospital admissions (#/100 beneficiaries)						
MSR	38.1 (35.6, 40.5)	36.8 (34.3, 39.3)	-1.3 (-4.4, 1.9)	-3.4% (-11.6%, 4.9%)	-3.4 (-8.9%)	.049
FTE	39.2 (37.2, 41.2)	41.3 (39.2, 43.5)	2.1 (-0.4, 4.8)	5.5% (-1.1%, 12.1%)		
ED visits <sup>d</sup> (#/100 beneficiaries)						
MSR	64.8 (60.5, 69.0)	66.2 (62.0, 70.5)	1.5 (-2.8, 5.7)	2.3% (-4.2%, 8.8%)	-5.8 (-9.5%)	.020
FTE	61.2 (58.4, 65.1)	69.1 (65.2, 72.9)	7.3 (3.7, 10.9)	11.8% (6.0%, 17.7%)		

DiD, difference-in-differences; ED, emergency department; FTE, failed to engage; HCC, hierarchical condition category; MSR, medication safety review.

<sup>a</sup>The FTE cohort is weighted to match the MSR cohort in terms of baseline HCC score distribution. Numbers in parentheses are 2-sided 95% confidence intervals. Numbers in the first 2 columns are rounded, but # change and % change are calculated using raw, unrounded data.

<sup>b</sup>MSR - FTE.

<sup>c</sup>The P-value associated with a 1-sided t-test comparing the MSR and FTE cohorts.

<sup>d</sup>Those that occurred without hospitalization.

lower by 2 percentage points. Importantly, all of the aforementioned outcomes remained significant, at a similar magnitude of effect, even after adjusting for the difference in baseline MRS between the FTE and MSR cohorts. As noted by Acumen's most recent evaluation of Enhanced MTM, these effects may not have been robust enough to extend to NPA's entire population of 240,000 beneficiaries.<sup>38</sup> Nevertheless, MSRs impact a very specific subset: those deemed to be at high risk of ADEs as defined by MRS stratification (ie, those with elevated MRS within the population). Therefore, the results of this study indicate that MSRs are effective at improving annual health care costs, hospitalizations, ED visits, and mortality in Medicare Part D beneficiaries targeted according to MRS.

This finding is relevant for payers seeking to optimize MTM delivery amid a climate of rising health care costs.<sup>39</sup> Relevance becomes apparent when placed in the context of traditional MTM and its broader literature. For several years now, Medicare programs

(as well as private payers) have deployed MTM to optimize medication regimens and thus improve clinical and economic outcomes. Plans have used a fairly standard approach to target those who have the greatest need for pharmaceutical care. Specifically, beneficiaries have been targeted by disease burden, drug costs, and/or polypharmacy.<sup>4</sup> Under this paradigm, some traditional MTM programs have demonstrated success, even when prioritizing medication-related problems unrelated to medication safety. For example, a 2019 study found that targeted medication reviews predominantly aiming to correct medication nonadherence were effective at reducing hospital and ED utilization compared with a matched control.<sup>37</sup> In a collaborative model, Brophy et al described an adherence-focused MTM program designed strictly for patients with diabetes that was able to reduce total medical costs and hospitalizations in a treatment group compared with a control group.<sup>36</sup> Other controlled studies have described traditional MTM programs that decreased

**TABLE 4.** Economic and Clinical Utilization Outcomes for Medication Safety Review (N=4384) and Failed to Engage (N=7052) Cohorts, Adjusted for MedWise Risk Score Just Prior to MedWise Data Import in 2018<sup>a</sup>

Outcome and cohort	2018	2019	Change in #	Change in %	DiD <sup>b</sup> , # (%)	P value <sup>c</sup>
Total medical expenditures (mean \$/member)						
MSR	\$13,553 (\$12,906, \$14,200)	\$14,711 (\$14,005, \$15,417)	\$1158 (\$350, \$1966)	8.5% (2.6%, 14.5%)	-\$919 (-7.3%)	.048
FTE	\$13,132 (\$12,540, \$13,723)	\$15,208 (\$14,597, \$15,820)	\$2077 (\$1361, \$2793)	15.8% (10.4%, 21.3%)		
Part A medical expenditures (mean \$/member)						
MSR	\$10,329 (\$9757, \$10,902)	\$11,068 (\$10,442, \$11,693)	\$739 (-\$4, \$1482)	7.2% (0.0%, 14.3%)	-\$791 (-7.8%)	.06
FTE	\$10,218 (\$9677, \$10,758)	\$11,748 (\$11,210, \$12,285)	\$1530 (\$869, \$2191)	15.0% (8.5%, 21.4%)		
Part B medical expenditures (mean \$/member)						
MSR	\$3224 (\$3026, \$3422)	\$3643 (\$3430, \$3855)	\$419 (\$241, \$597)	13.0% (7.5%, 18.5%)	-\$128 (-5.8%)	.14
FTE	\$2914 (\$2779, \$3048)	\$3461 (\$3278, \$3643)	\$547 (\$397, \$697)	18.8% (13.6%, 23.9%)		
Hospital admissions (#/100 beneficiaries)						
MSR	38.1 (35.6, 40.5)	36.8 (34.3, 39.3)	-1.3 (-4.4, 1.9)	-3.4% (-11.6%, 4.9%)	-3.5 (-9.1%)	.046
FTE	38.3 (36.3, 40.3)	40.5 (38.4, 42.6)	2.2 (-0.4, 4.7)	5.7% (-0.9%, 12.3%)		
ED visits <sup>d</sup> (#/100 beneficiaries)						
MSR	64.8 (60.5, 69.0)	66.2 (62.0, 70.5)	1.5 (-2.7, 5.7)	2.3% (-4.2%, 8.8%)	-5.6 (-9.5%)	.022
FTE	60.2 (57.0, 63.5)	67.3 (63.5, 71.2)	7.1 (3.6, 10.7)	11.8% (6.0%, 17.7%)		

DiD, difference-in-differences; ED, emergency department; FTE, failed to engage; MSR, medication safety review.

<sup>a</sup>The FTE cohort is weighted to match the MSR cohort in terms of MRS distribution in 2018. Numbers in parentheses are 2-sided 95% confidence intervals. Numbers in the first 2 columns are rounded, but # change and % change are calculated using raw, unrounded data.

<sup>b</sup>MSR - FTE.

<sup>c</sup>The P-value associated with a 1-sided t-test comparing the MSR and FTE cohorts.

<sup>d</sup>Those that occurred without hospitalization.

total health care costs<sup>34</sup> and reduced hospital admissions<sup>40</sup> and mortality against a control.<sup>40,41</sup>

With this context, our results imply that the scope and effectiveness of MTM can expand. There are 2 specific implications. First, we have demonstrated a novel intervention whose targeting approach deviates from the normative paradigm. The MRS can help identify individuals for whom a safety-based approach with repeated MSRs is indicated. Certainly, some of these individuals likely would be missed using traditional targeting methods, leaving risks unmitigated and unknown. Now, payers can identify such individuals and deploy a specific intervention to help optimize their regimens. Nevertheless, future studies need to specifically examine (1) the extent of overlap between traditional targeting and MRS-driven targeting, as well as (2) the clinical and demographic differences between members who do not overlap. Second, integrating MRS and MedWise CDSS into traditional MTM could help avoid siloed interventions that would unknowingly and inadvertently increase

the MRS despite following evidence-based clinical practice guidelines. For example, programs aiming to improve statin adherence could do so in the context of the MRS. Specifically, several statins are implicated in serious cytochrome P450-mediated drug interactions,<sup>42</sup> which would be captured by the MRS and the MedWise CDSS. If interactions are identified, differently metabolized statins could be recommended to reduce the MRS. This ensures that the benefits obtained by improving adherence (ie, cardiovascular risk reduction) will not be undermined by a potentially serious ADE (ie, from a drug interaction). Again, future research should explore the effectiveness of the MRS and MedWise CDSS when deployed in traditional MTM settings in a complementary fashion.

### Limitations

A primary limitation of this study is self-selection bias. Although we attempted to adjust for any differences related to ADE risk (ie, MRS) and multimorbidity (ie, HCC), some unmeasurable or

unknown variable could have confounded results. For example, members in the FTE cohort may have been less interested in their overall health compared with those who engaged in MSRs. Second, we did not account for timing of MSRs during the year or the total number of MSRs received. For example, the first MSR being performed early in 2018 compared with later in 2018 could have led us to underestimate the impact of the MSR approach, because outcomes throughout 2018 until the MSR encounter were considered in the overall outcome measures for these patients. Moreover, those receiving the minimum number of MSRs (ie, one in 2018 and one in 2019) may have performed differently from those who received multiple MSRs in both years. Therefore, future analyses are needed to determine the precise effect of repeated engagements. Third, we did not attempt to differentiate between MSR delivery methods. Our results were an aggregate of MSRs performed telephonically by call-center pharmacists and those performed face to face by community pharmacists. Fourth, our sample was almost entirely made up of non-Hispanic whites living in 7 Midwestern states. Therefore, future research should include a greater diversity of ethnicities and geographies for this proof of concept to be fully realized. Finally, we did not have cause of death available within our dataset. It is possible that causes differed between the 2 groups in such a way as to bias our findings. For example, it could be possible that there were more patients with terminal illnesses in the FTE cohort.

## Conclusions

Risk-stratified Medicare beneficiaries who received repeated pharmacist-provided, MedWise CDSS-supported MSRs demonstrated significant improvements in year-over-year medical costs, hospital admissions, ED visits, and mortality compared with MSR-eligible beneficiaries who did not receive services. All outcomes remained significant even after adjusting analyses for the baseline differences in MRS between the MSR and FTE cohorts. Because MSRs represent an entirely novel and effective service model that deviates from traditional MTM paradigms, their incorporation should expand the scope and effectiveness of traditional MTM.

## Acknowledgements

The authors thank Dr Calvin Knowlton and Dr Orsula Knowlton for their forward-looking vision and unequivocal, lifelong dedication to the advancement of the pharmacy profession; Brian Litten for legal counsel and support of the program; Steve Gilbert for supporting operational and clinical quality; Beth Eichfeld for her involvement as program manager; Stephanie Carletti for her unwavering support of the program, facilitating operational efficiency and success; Jeffrey Difrancesco for his support of data analyses; the following pharmacists for their sincere efforts to improve the safety, appropriateness, and quality of the Enhanced MTM beneficiaries' medication regimens: Amanda Mastrogiovanni, Courtney Christopher, Craig Rein, Daniel Green, Danielle Cantalupo, Darria Zangari, Debbie Lukose, Desiree Massari, Dina Amer, Drusty Bavishi, Gabriella Latorre, JT Skelly, Jennifer Metzler, Jessica Growette, Joseph Wood, Kaitlin Savona, Kirsten Demarco, Kirsten Gallo, Lauren Petroski, Loren Martinez, Megan Lew, Melissa Metzger, Natalie Ferro, Neil Patel, Palak Gohil, Richard Chang, Scott Raymond, and Valerie Buchanan; the

**TABLE 5.** 2019 Mortality in Medication Safety Review<sup>a</sup> and Failed to Engage<sup>b</sup> Cohorts

Cohort	Beneficiaries alive at end of 2018	Percent who died by end of 2019	DiD <sup>c</sup>	P value <sup>d</sup>
Mortality, unadjusted				
MSR	10,442	6.8% (95% CI, 6.3%-7.2%)	-2.1%	< .001
FTE	15,895	8.9% (95% CI, 8.4%-9.3%)		
Mortality, adjusted for baseline HCC score <sup>e</sup>				
MSR	10,442	6.8% (95% CI, 6.3%-7.2%)	-2.1%	< .001
FTE	15,895	8.9% (95% CI, 8.5%-9.3%)		
Mortality, adjusted for MRS at targeting in 2018 <sup>f</sup>				
MSR	10,442	6.8% (95% CI, 6.3%-7.2%)	-2.0%	< .001
FTE	15,895	8.8% (95% CI, 8.3%-9.2%)		

DiD, difference-in-differences; FTE, failed to engage; HCC, hierarchical condition category; MRS, MedWise Risk Score; MSR, medication safety review.

<sup>a</sup>Targeted and had first MSR in 2018.

<sup>b</sup>Targeted and FTE in 2018; did not have MSR through the end of 2018.

<sup>c</sup>MSR - FTE.

<sup>d</sup>Two-sided, 2-sample *t*-test.

<sup>e</sup>The FTE cohort is weighted to match the MSR cohort in terms of baseline HCC score distribution.

<sup>f</sup>The FTE cohort is weighted to match the MSR cohort in terms of distribution in MRS just prior to data import into MedWise in 2018.

following technicians for their strong efforts in engaging beneficiaries and obtaining accurate medication lists: Abigail Malone, Alayna Marucci, Amanda Seals, Amber Mosteller, Andrew Palmer, Ashley Approvato, Briana Joseph, Brittany Connelly, Christina Bean, Donna Van Staveren, Emlyn Williams, Eva Duarte, Gabrielle Parker, Gregg Eppelman, Heather Green, Heather Klarmann, Helen Martin, Jaime Picchi, Jaimie Doyle, Jamie Kilmurray, Jeanna Comorote, Jonquil Steele, Josselyne Duarte, Kimberly Shaw, Krista Maniaci, Layla Pineda, Lindsey Rehberger, Maureen Molzon, Melissa Jorge, Naomi Colon, Rachael Carpenter, Raquel Rivera, Samantha O'Connell, Stacie Riker, Starr Santiago, Tara Russo, and Victor Vo; the following outreach liaisons for their strong efforts in engaging beneficiaries: Ed Demetreshon, Joan Greenhalgh, Linda Moore, and Samantha Sklikas; and the following individuals from ClearStone: Jessica Growette, Lucas Castillo, Jenny Steinke, Bonnie Haukom, Sarah Legatt, Nick Jejel, Paul Fischer, Angela Mitchell, and Nancy Sheehan. We also thank Dana Filippoli for the review of the manuscript.

**Author affiliations:** Office of Applied Pharmacotherapy, Tabula Rasa HealthCare, Moorestown, NJ (MSA); Office of Translational Research and Residency Programs, Tabula Rasa HealthCare, Moorestown, NJ (DB); Office of Healthcare Analytics, Tabula Rasa HealthCare, Moorestown, NJ (SF, HJ); ClearStone Solutions, Government Markets Division, Blue Cross and Blue Shield of Minnesota, Eagan, MN (JJ); Office of Healthcare Analytics, Tabula Rasa HealthCare, Moorestown, NJ (AS); Tabula Rasa HealthCare, Orlando, FL, and Université de Montréal, Montréal, Québec, Canada (JT).

**Funding source:** Funding was obtained by Blue Cross and Blue Shield Northern Plains Alliance (NPA) in Medicare Part D Region 25 (IA, MN, MT, ND, NE, SD, and WY), the model participant, under the 5-year CMS Innovation Center's Enhanced Medication Therapy Management (MTM) model. Through its NPA's Part D plan administrator, ClearStone Solutions, funds were provided to Tabula Rasa HealthCare for delivery of Enhanced MTM services and research. In this study, data were analyzed regardless of patient's enrollment

in the Enhanced MTM program. This supplement was supported by Tabula Rasa HealthCare.

**Author disclosures:** Drs Stein, Fimmel, Bankes, Awadalla, and Turgeon and Mr Jin report employment with Tabula Rasa HealthCare, ownership of Tabula Rasa HealthCare stock, and ownership of the MedWise Risk Score used in this study. Dr Johnson reports employment with ClearStone Solutions (an affiliate of Blue Cross and Blue Shield of Minnesota), which administers the Enhanced MTM Pilot on behalf of Blue Cross and Blue Shield Northern Plains Alliance. ClearStone Solutions paid Tabula Rasa HealthCare to provide the Enhanced MTM services described. Dr Turgeon reports patents received (10,890,577: Methods of treatment having reduced drug-related toxicity and methods of identifying the likelihood of patient harm arising from prescribed medications) and patents pending (Methods of treatment having reduced drug-related toxicity and methods of identifying the likelihood of patient harm arising from prescribed medications: 17/143,936; Population-based medication risk stratification and personalized medication risk score: 16/870,517).

**Disclaimer:** The contents of this publication are solely the responsibility of the authors and do not necessarily represent the official views of the US Department of Health and Human Services or any of its agencies. The research presented here was conducted by the model participant. Findings might or might not be consistent with or confirmed by the findings of the independent evaluation contractor. CMS considers any findings from the Part D Enhanced MTM model to be preliminary until certified as valid by its Research and Rapid Cycle Evaluation Group (RREG).

**Authorship information:** Concept and design (AS, SF, HJ, JJ, JT); acquisition of data (MSA); analysis and interpretation of data (AS, SF, DB, HJ); drafting of the manuscript (SF, DB, JT); critical revision of the manuscript for important intellectual content (AS, SF, DB, MSA, JJ, JT); statistical analysis (SF, HJ); provision of study materials or patients (JJ); obtaining funding (JJ); administrative, technical, or logistical support (AS, DB, MSA, JJ, JT); supervision (AS, JT); and other—data processing (HJ).

**Address correspondence to:** Jacques Turgeon, PhD, 13485 Veterans Way, Ste 410, Orlando, FL 32827. E-mail: jturgeon@trhc.com

## REFERENCES

- Pellegrino AN, Martin MT, Tilton JJ, Touchette DR. Medication therapy management services: definitions and outcomes. *Drugs*. 2009;69(4):393-406. doi:10.2165/00003495-200969040-00001
- Petrotch D, Marruffo G, Montesinos A, et al. Medication therapy management in chronically ill populations: final report. Published August 2013. Accessed June 23, 2021. [https://innovation.cms.gov/files/reports/mtm\\_final\\_report.pdf](https://innovation.cms.gov/files/reports/mtm_final_report.pdf)
- Viswanathan M, Kahwati LC, Golin CE, et al. Medication therapy management interventions in outpatient settings: a systematic review and meta-analysis. *JAMA Intern Med*. 2015;175(11):76-87. doi:10.1001/jamainternmed.2014.5841
- Gray C, Cooke CE, Brandt N. Evolution of the Medicare part D medication therapy management program from inception in 2006 to the present. *Am Health Drug Benefits*. 2019;12(5):243-251.
- Barlas S. CMS to test enhanced medication therapy management model: aims for greater use of pharmacists, cost savings, and better outcomes. *P T*. 2016;41(7):423-425, 441.
- Part D Enhanced Medication Therapy. CMS. Published 2018. Updated December 4, 2018. Accessed June 23, 2021. <https://innovation.cms.gov/initiatives/enhancedmtm/>
- Parameswaran Nair N, Chalmers L, Peterson GM, Bereznicki BJ, Castelino RL, Bereznicki LR. Hospitalization in older patients due to adverse drug reactions—the need for a prediction tool. *Clin Interv Aging*. 2016;11:497-505. doi:10.2147/CIA.S99097
- Watanabe JH, McInnis T, Hirsch JD. Cost of prescription drug-related morbidity and mortality. *Ann Pharmacother*. 2018;52(9):829-837. doi:10.1177/1060028018765159
- Hanlon JT, Schmadler KE, Koronkowski MJ, et al. Adverse drug events in high risk older outpatients. *J Am Geriatr Soc*. 1997;45(8):945-948. doi:10.1111/j.1532-5415.1997.tb02964.x
- Poudelet DR, Acharya P, Ghimire S, Dhital R, Bharati R. Burden of hospitalizations related to adverse drug events in the USA: a retrospective analysis from large inpatient database. *Pharmacoepidemiol Drug Saf*. 2017;26(6):635-641. doi:10.1002/pds.4184
- Sultana J, Cutroneo P, Trifiro G. Clinical and economic burden of adverse drug reactions. *J Pharmacol Pharmacother*. 2013;4(suppl. 1):S73-S77. doi:10.4103/0976-500X.120957
- Budnitz DS, Lovegrove MC, Shehab N, Richards CL. Emergency hospitalizations for adverse drug events in older Americans. *N Engl J Med*. 2011;365(21):2002-2012. doi:10.1056/NEJMs1103053
- Shehab N, Lovegrove MC, Geller AI, Rose KD, Weidle NJ, Budnitz DS. US emergency department visits for outpatient adverse drug events, 2013-2014. *JAMA*. 2016;316(20):2115-2125. doi:10.1001/jama.2016.16201
- Hakkaraianen KM, Hedna K, Petzold M, Hagg S. Percentage of patients with preventable adverse drug reactions and preventability of adverse drug reactions—a meta-analysis. *PLoS One*. 2012;7(3):e33236. doi:10.1371/journal.pone.0033236
- Michaud V, Smith MK, Bikmetov R, et al. Association of a medication risk score with health care outcomes. *Am J Manag Care*. 2021;27(suppl 16):S280-S291.
- Bankes DL, Pizzolato K, Fimmel S, et al. Medication-related problems identified by pharmacists in an enhanced MTM program. *Am J Manag Care*. 2021;27(suppl 16):S292-S299.
- Cicali B, Michaud V, Knowlton CH, Turgeon J. Application of a novel medication-related risk stratification strategy to a self-funded employer population. Published 2018. Accessed June 23, 2021. [https://www.carekinesis.com/wp-content/uploads/2018\\_Cicali\\_B\\_Benefits\\_Q\\_Application\\_of\\_a\\_novel\\_medication-related\\_risk\\_stratification\\_strategy.pdf](https://www.carekinesis.com/wp-content/uploads/2018_Cicali_B_Benefits_Q_Application_of_a_novel_medication-related_risk_stratification_strategy.pdf)
- Bankes DL, Jin H, Fimmel S, et al. Association of a novel medication risk score with adverse drug events and other pertinent outcomes among participants of the programs of all-inclusive care for the elderly. *Pharmacy (Basel)*. 2020;8(2):87-103. doi:10.3390/pharmacy8020087
- Ratigan AR, Michaud V, Turgeon J, et al. Longitudinal association of a medication risk score with mortality among ambulatory patients acquired through electronic health record data. *J Patient Saf*. 2021;17(4):249-255. doi:10.1097/PTS.0000000000000829
- Al Rihani SB, Smith MK, Bikmetov R, et al. Risk of adverse drug events following the virtual addition of a technological paradigm shift to drug regimens of frail older adults with polypharmacy. *J Clin Med*. 2020;9(8):2591-2609. doi:10.3390/jcm9082591
- Turgeon J, Michaud V, Cicali B, inventors. Patent WO2019089725 - Population-based medication risk stratification and personalized medication risk score. World Intellectual Property Organization. September 5, 2019. Accessed June 23, 2021. <https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2019089725>
- Matos A, Bankes DL, Bain KT, Ballinghoff T, Turgeon J. Opioids, polypharmacy, and drug interactions: a technological paradigm shift is needed to ameliorate the ongoing opioid epidemic. *Pharmacy (Basel)*. 2020;8(3):154-172. doi:10.3390/pharmacy8030154
- Bain KT, McGain D, Cicali EJ, Knowlton CH, Michaud V, Turgeon J. Precision medication: An illustrative case series guiding the clinical application of multi-drug interactions and pharmacogenomics. *Clin Case Rep*. 2019;8(2):305-312. doi:10.1002/ccr3.2604
- Tranchina K, Turgeon J, Bingham J. Integrating a novel medication risk score and use of an advanced clinical decision support system into a pharmacist- and nurse-coordinated transition of care program to mitigate drug interactions. *Clin Case Rep J*. 2021;2(1):1-5. <https://clinicalcasereportsjournal.com/download-article-pdf/1000079>
- Bardolia C, Michaud V, Turgeon J, Amin NS. Deprescribing dual therapy in benign prostatic hyperplasia: a patient case. *Clin Case Rep J*. 2020;10(5). doi:10.37421/jccr.2020.10.134
- Ballinghoff T, Bain K, Matos A, Bardolia C, Turgeon J, Amin NS. Opioid response in an individual with altered cytochrome P450 2D6 activity: implications of a pharmacogenomics case. *Clin Case Rep J*. 2020;1(6):1-4. <https://clinicalcasereportsjournal.com/download-article-pdf/1000070>
- Bain KT, Knowlton CH, Turgeon J. Medication risk mitigation: coordinating and collaborating with health care systems, universities, and researchers to facilitate the design and execution of practice-based research. *Clin Geriatr Med*. 2017;33(2):257-281. doi:10.1016/j.cger.2017.01.009
- Knowlton CH. Medication risk mitigation matrix: a pharmaceutical care opportunity for precision medication. *J Am Pharm Assoc (2003)*. 2015;55(4):354-358. doi:10.1331/JAPHA.2015.15527
- Turgeon J, Michaud V. Clinical decision support systems: great promises for better management of patients' drug therapy. *Expert Opin Drug Metab Toxicol*. 2016;12(9):993-995. doi:10.1517/17425255.2016.1171317
- Miller DE, Roane TE, Salo JA, Hardin HC. Evaluation of comprehensive medication review completion rates using 3 patient outreach models. *J Manag Care Spec Pharm*. 2016;22(7):796-800. doi:10.18553/jmcp.2016.22.7.796
- Bankes DL, Amin NS, Bardolia C, Awadalla MS, Knowlton CH, Bain KT. Medication-related problems encountered in the Program of All-Inclusive Care for the Elderly: an observational study. *J Am Pharm Assoc (2003)*. 2020;60(2):319-327. doi:10.1016/j.japh.2019.10.012
- Foley RN, Collins AJ. End-stage renal disease in the United States: an update from the United States Renal Data System. *J Am Soc Nephrol*. 2007;18(10):2644-2648. doi:10.1681/ASN.2007020220
- Kautter J, Ingber M, Pope GC. Medicare risk adjustment for the frail elderly. *Health Care Financ Rev*. 2008;30(2):83-93. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4195052/pdf/hcfr-30-02-083.pdf>
- Ward MA, Xu Y. Pharmacist-provided telephonic medication therapy management in an MAPD plan. *Am J Manag Care*. 2011;17(10):e399-e409. [https://www.ajmc.com/view/ajmc\\_11oct\\_ward\\_e399to409](https://www.ajmc.com/view/ajmc_11oct_ward_e399to409)
- Moore JM, Shurtle D, Faudskar L, Matlin OS, Brennan TA. Impact of a patient-centered pharmacy program and intervention in a high-risk group. *J Manag Care Pharm*. 2013;19(3):228-236. doi:10.18553/jmcp.2013.19.3.228
- Brophy L, Williams A, Berman EJ, et al. Collaborative DTM reduces hospitalization and healthcare costs in patients with diabetes treated with polypharmacy. *Am J Manag Care*. 2014;20(3):e72-e81. <https://www.ajmc.com/view/collaborative-dtm-reduces-hospitalization-and-healthcare-costs-in-patients-with-diabetes-treated-with-polypharmacy>
- Ferries E, Dye JT, Hall B, Ndehi L, Schwab P, Vaccaro J. Comparison of medication therapy management services and their effects on health care utilization and medication adherence. *J Manag Care Spec Pharm*. 2019;25(6):688-695. doi:10.18553/jmcp.2019.25.6.688
- Do N, Fan B, Ghimire E, et al. Evaluation of the Part D enhanced medication therapy management (MTM) model: second evaluation report. Published November 2020. Accessed June 23, 2021. <https://innovation.cms.gov/data-and-reports/2020/mtm-secondevalrpt>
- Keenan SP, Stone DA, Poisal JA. National health expenditure projections, 2016-25: price increases, aging spur sector to 20 percent of economy. *Health Aff (Millwood)*. 2017;36(3):553-563. doi:10.1377/hlthaff.2016.1627
- Hui RL, Yamada BD, Spence MM, Jeong EW, Chan J. Impact of a Medicare MTM program: evaluating clinical and economic outcomes. *Am J Manag Care*. 2014;20(2):e43-e51. <https://www.ajmc.com/view/impact-of-a-medicare-mtm-program-evaluating-clinical-and-economic-outcomes>
- Welch EK, Delate T, Chester EA, Stubbings T. Assessment of the impact of medication therapy management delivered to home-based Medicare beneficiaries. *Ann Pharmacother*. 2009;43(4):603-610. doi:10.1345/aph.1L524
- Wiggins BS, Saseen JJ, Page RL 2nd, et al.; American Heart Association Clinical Pharmacology Committee of the Council on Clinical Cardiology; Council on Hypertension; Council on Quality of Care and Outcomes Research; and Council on Functional Genomics and Translational Biology. Recommendations for management of clinically significant drug-drug interactions with statins and select agents used in patients with cardiovascular disease: a scientific statement from the American Heart Association. *Circulation*. 2016;134(21):e468-e495. doi:10.1161/CIR.0000000000000456