

Long-term Medication Adherence and Preventive vs Reactive Care Utilization Among Older Adults With Diabetes

Aliza R. Karpes Matusевич, PhD; Christy Xavier, PharmD; and Rafia S. Rasu, PhD

Non-insulin-dependent diabetes is the main cause of end-stage renal disease and blindness and the seventh-leading cause of death in the United States.¹ One-third of Medicare beneficiaries had diabetes in 2016 and almost 1% receive a diagnosis each year.¹⁻³ In 2017, this population experienced 3.3 million emergency visits and more than 14 million inpatient days, resulting in an annual, per-person excess medical cost of \$13,240.⁴

Despite metabolic agents accounting for the highest medication expenditure for Medicare beneficiaries, many patients do not take their medications as prescribed. Medication adherence is “the extent to which a patient acts in accordance with the prescribed interval and dose of a dosing regimen.”^{5,6} Depending on the method and data source, adherence rates ranged from 9% to 93% for oral diabetic medications.⁷⁻⁹ Mean adherence when using electronic dose monitoring was 67% to 85%.⁸ Low adherence could explain why only half of patients with diabetes reach their target hemoglobin A_{1c} (HbA_{1c}) goal, and it accounts for approximately 75% of the difference when comparing drug efficacy as seen in randomized controlled trials with effectiveness as measured using real-world data.^{10,11}

The adverse effects of medication nonadherence have been demonstrated in multiple studies. For example, better diabetic control can lead to decreases of 9%, 20%, and 13% in risk for cardiovascular disease, nephropathy, and retinopathy, respectively.¹⁰ The increased morbidity associated with medication nonadherence is of great concern to policy makers. This is demonstrated by the emphasis that CMS places on medication management, especially in terms of Star Ratings. Overall, 50% of a health plan's performance is related to medication-related behavior, highlighting the importance of adherence to health plan managers interested in improving their Star Rating.¹² Upgrading from a 3- to a 4-star rating has been associated with increased enrollment and revenue.¹³ Moreover, CMS recently implemented an innovative out-of-pocket spending cap on insulin at \$35 per month, which is projected to substantially influence adherence to lifesaving medication for management of diabetes among beneficiaries.²

Furthermore, a 10% increase in the medication possession ratio (MPR) has been shown to decrease annual health care costs by nearly 9%.^{14,15} Nonadherence to diabetes medication is estimated

ABSTRACT

OBJECTIVES: To assess long-term adherence to oral hypoglycemic agents (OHAs) and determine if adherence affects total health care expenditures of reactive vs preventive services.

STUDY DESIGN: Retrospective cohort study.

METHODS: This study measured adherence to OHAs using Medical Expenditure Panel Survey 2013-2017 data. Adults 65 years and older who had diabetes and were taking at least 1 OHA were included. Respondents with a medication possession ratio (MPR) of at least 80% were considered adherent. Health care utilization and expenditure were compared among adherent and nonadherent respondents for preventive and reactive services. Utilization data were analyzed using negative binomial regression and expenditure data using γ -family generalized linear regression models.

RESULTS: Approximately 67% of the cohort (n = 1279) were adherent. The adherent group had greater health care expenditure overall than nonadherent respondents [\$29,985 [95% CI, \$27,161-\$32,743] vs \$24,623 [95% CI, \$21,623-\$28,122]; $P < .05$]. Although expenditure was higher for prescription medications and office visits, mean emergency department expenditures were higher for adherent respondents. The utilization and proportion of expenditure on preventive vs reactive health care services did not differ by adherence as defined by an MPR of at least 80%.

CONCLUSIONS: Increasing adherence provides an opportunity to improve CMS quality ratings. Our finding that adherence does not affect the financial burden of disease might be explained by the increased costs of preventive medication and increased comorbidity burden of these patients. Low adherence to OHAs encourages clinicians to be more proactive in ensuring that prescription medications are refilled regularly. By emphasizing equitable diabetes education and tailoring quality initiatives that minimize racial disparities, adherence can be better achieved.

Am J Manag Care. 2022;28(10):e378-e387. doi:10.37765/ajmc.2022.89255

to cost \$24.6 billion a year.¹⁶ Despite this, our preliminary analysis of the Medical Expenditure Panel Survey (MEPS) data showed that adherent older adults had higher health care expenditure and greater utilization of preventive services (medication and office visits) rather than reactive care (emergency department [ED] visits and hospitalizations).

Objectives and Definitions

The objectives of this study were to (1) calculate long-term adherence to oral hypoglycemic agents (OHAs) and associated factors in a nationally representative population of adults 65 years and older and (2) assess whether the proportions of expenditure and utilization for prescribed medication, outpatient facility and office visits, hospital admissions, and ED visits differed between respondents who were adherent over the long term and those who were not.

DESIGN AND METHODS

Design

This was a longitudinal, retrospective observational study using publicly available data from the MEPS.

Data Source

MEPS is a nationally representative longitudinal panel survey of the US civilian noninstitutionalized population based on a stratified area sample design. Sampling weights were adjusted for the complex design and take into account nonresponse and population totals.¹⁷ Respondents are enrolled for 2 years of data collection and are interviewed in person 5 times. The average recall period is 5 months.¹⁸ A new panel begins each year. The MEPS Household Component collects respondent demographics, health status and conditions, use of medical care services, and health insurance coverage. The events files provide information about prescribed medication use, medical diagnoses, and related utilization.¹⁹ A comparison of MEPS prescription drug data with Medicare Part D claims found the quality to be reasonably accurate and adequate for the purpose of determining medical expenditures.¹⁸

Cohort

Our cohort consisted of adults 65 years and older who participated in MEPS panels 18 to 21 (2013–2017). Respondents were included if they answered yes in the first round of the panel to ever having been diagnosed with diabetes.^{20–23} Furthermore, respondents were required to have at least 1 record of a drug of interest in the prescription events files.

Definition of Adherence

We identified OHAs using the MULTUM Lexicon variables for therapeutic class and subclass. We measured adherence using the

TAKEAWAY POINTS

Adherent adults had greater health care expenditures overall, and utilization and expenditure of preventive vs reactive health care services did not differ markedly based on adherence.

- ▶ Adherent adults tend to be female, have incomes greater than the federal poverty level, have multiple medications, and be sicker than nonadherent adults.
- ▶ Addressing predisposing, need, and enabling factors can reduce racial disparities in medication use and improve Star Rating measures, which reflect the experiences of beneficiaries.
- ▶ These findings represent an opportunity for providers to improve CMS Star Ratings by increasing adherence by offering tools to foster engagement among informed and active Medicare beneficiaries.

MPR, a validated method commonly used in retrospective database research.^{5,24–27} For respondents taking 1 OHA, we calculated MPR by summing the days' supply for each agent over the course of the panel and dividing by the total number of days of the interview rounds in which the drugs were purchased. MPR was truncated at 100%. We defined respondents as adherent if they had an MPR value of at least 80%.^{20,28–30}

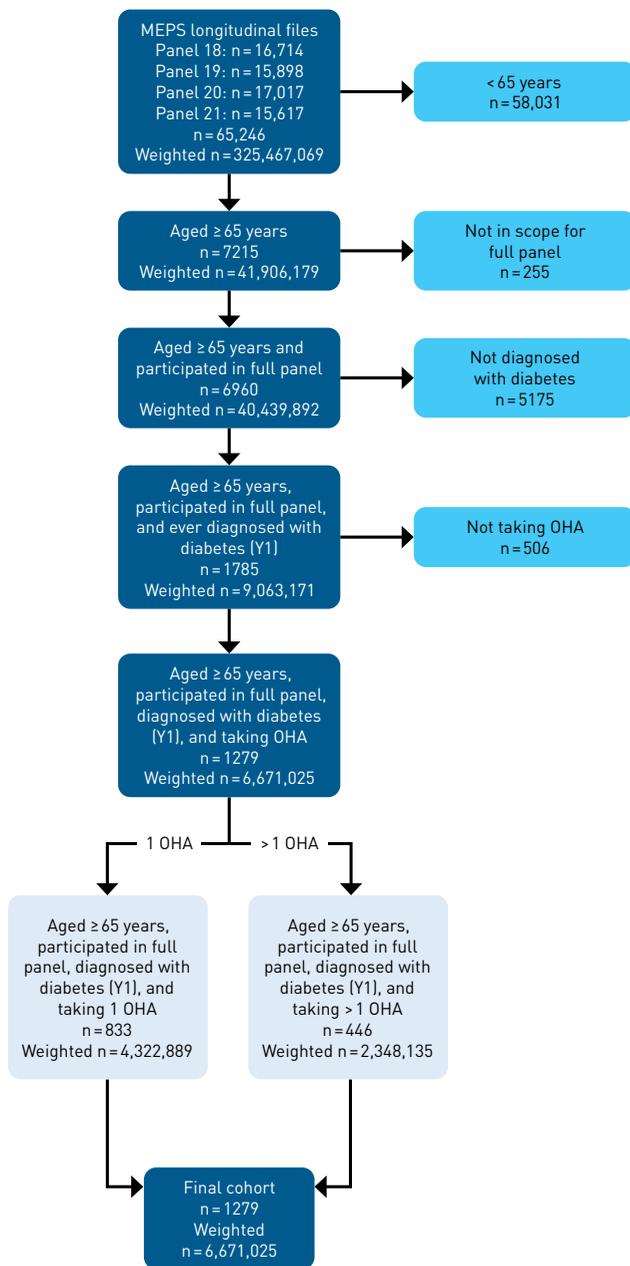
There is no standardized adherence measurement method for individuals taking multiple medications, and the different composite measures have been shown to perform equivalently in predicting outcomes in patients with diabetes.^{31,32} Furthermore, in a population of adolescents with diabetes, no difference in adherence was found when adding oral medications to existing OHAs.³³ Based on this, and because most patients use metformin as an anchor drug,³⁴ we used adherence to metformin as a proxy for overall adherence for patients taking 2 or more OHAs.

Following the work of An,²⁰ we used 5 methods to impute days' supply for the 32.3% of prescription medication records with missing values: (1) match days' supply based on identical respondent, drug name, National Drug Code, strength, and quantity dispensed (6.0%); (2) match days' supply based on identical respondent, drug name, strength, and quantity dispensed (12.2%); (3) calculate days' supply by dividing the quantity supplied by the common number of pills per day for that same respondent, drug name, and strength (16.8%); (4) calculate days' supply by dividing the quantity supplied by the common number of pills per day for each drug and dosage (61.3%)²⁰; and (5) calculate days' supply based on the National Drug Code (0.2%). A total of 673 records pertaining to 117 respondents could not be matched by any of these methods. Ninety-two (79%) of these respondents were included in the analysis with an alternative drug, mostly metformin (n = 55; 59.8%).

Outcomes

The primary outcome measures were overall adherence and proportion of total health care expenditure for 5 categories of health care: prescribed medication, outpatient events, office visits, hospital admissions, and ED visits. Secondary outcomes were differences in general and diabetes-related utilization.

FIGURE 1. Sample Selection Flow Chart



MEPS, Medical Expenditure Panel Survey; OHA, oral hyperglycemic agent.

Covariates

We selected covariates based on Aday and Andersen’s framework for the study of access to medical care³⁵ to examine how predisposing, need, and enabling factors affect realized access to care in terms of utilization and expenditure, thereby allowing evaluation of a health care system or policy’s effectiveness, equity, and efficiency.

Predisposing covariates were age, sex, race, ethnicity, marital status, and region. Education, income level, health insurance, and prescribed medication insurance were entered as enabling factors.

Lastly, need factors were self-reported physical and mental health status, body mass index, current smoking status, non-OHA poly-pharmacy (taking ≥ 5 unique medications³⁶), number of nondiabetes drugs taken, number of OHA drugs taken, years since diabetes diagnosis, insulin use at baseline, use of diet modifications, and number of MEPS priority conditions.

Statistical Analyses

Data analysis was performed using SAS Enterprise Guide Version 7.15 (SAS Institute) and Stata IC/12 (StataCorp).

The MPR was calculated and dichotomized as described earlier. An empirical study demonstrated that a higher cutoff point might be more appropriate for patients with diabetes, hence a 90% value was used in sensitivity analysis.^{16,29}

We used χ^2 and *t* tests to compare covariates between the groups. γ -Family generalized linear regression models (GLMs) with log link function assessed the relationship between continuous dependent variables and the independent variable, adherence at the 80% level compared with nonadherence. We used Poisson-family GLMs with log link function to assess the relationship between count variables and our adherence variable. The models were adjusted for individual predisposing, enabling factors, and need factors as discussed earlier. Education was not included because it was missing for 48% of the population and highly correlated with income category.

All estimations used statistical procedures that take into account survey strata, clusters, and weights. This improves the accuracy of parameter estimates. Strata consisting of single sampling units were centered at the overall mean when calculating the SE. Dollar values were inflated to 2017 levels using the personal health care expenditure component of the National Health Expenditure Accounts.³⁴

RESULTS

The MEPS longitudinal panels for 2013 to 2017 included 65,246 respondents, of whom 1279, representing 6,671,025 noninstitutionalized, civilian Americans, met all inclusion criteria. The sample selection flowchart is in **Figure 1**.

The analytic sample had a mean age of 74.5 years, was majority female (51.8%), and was largely White (79.2%) and non-Hispanic (87.8%) (**Table 1**). The mean MPR was 81.3%, and 61.6% of the analytic sample were considered adherent as defined by an MPR of at least 80%. Only 49.6% were adherent as defined by an MPR of at least 90%. Of those defined as adherent (MPR ≥ 80%), 75% had an MPR of at least 90%. The range of adherence levels was much wider among the nonadherent (median, 61.3%; IQR, 48.8%-72.7%). Adherent respondents were significantly more likely to be female, have incomes between 200% and 400% of the federal poverty level, be enrolled in Medicare Part D, and have more need factors. Of note, adherent respondents were more likely to be taking at least 5 nondiabetes medications compared with nonadherent respondents (90% vs 80%; *P* < .05).

TABLE 1. Predisposing, Enabling, and Need Characteristics for Adults 65 Years and Older With Diabetes From the MEPS, by Adherence Group, 2013-2017^a

Weighted sample proportion ^b	MPR ≥ 80%			OR (95% CI)	P
	All n = 1269; weighted n = 6,605,672 % ^c	Yes n = 801 (61.6%); weighted n = 4,106,506 % ^d	No n = 478 (38.4%); weighted n = 2,564,519 % ^d		
Predisposing factors					
Age in years, mean (95% CI) ^a	74.5 (74.1-74.9)	74.6 (73.6-75.0)	74.3 (73.6-75.0)		.43
65-69	40.2%	38.6%	43.0%	Ref	
70-74	23.2%	23.1%	23.3%	1.09 (0.75-1.59)	.65
75-79	19.3%	20.9%	16.9%	1.38 (0.87-2.19)	.17
≥80	17.2%	17.5%	16.8%	1.16 (0.78-1.74)	.47
Sex					.04
Male	48.2%	44.9%	53.5%	Ref	
Female	51.8%	55.1%	46.5%	1.42 (1.01-1.97)	
Race					.95
White	79.2%	78.9%	79.6%	Ref	
African American	11.5%	11.6%	11.3%	1.04 (0.74-1.46)	.81
Other race	9.3%	9.5%	9.1%	1.05 (0.65-1.70)	.85
Hispanic	12.2%	12.1%	12.3%	0.98 (0.69-1.39)	.91
Marital status					.72
Married	55.7%	54.3%	57.8%	Ref	
Divorced/separated	23.4%	23.5%	23.2%	1.08 (0.74-1.57)	.69
Widowed	16.4%	17.4%	14.7%	1.26 (0.57-2.32)	.69
Never married	4.6%	4.7%	4.3%	1.15 (0.83-1.91)	.28
Enabling factors					
Education					
Less than high school	20.1%	20.5%	19.4%	Ref	
High school or GED	49.7%	47.5%	53.0%	0.85 (0.59-1.22)	.37
More than high school	30.3%	32.0%	27.6%	1.10 (0.69-1.75)	.69
Income category (as percent of FPL)					
Poor and near poor (< 124%)	18.0%	20.1%	14.7%	Ref	
Low income (125%-199%)	15.6%	16.3%	14.5%	0.82 (0.50-1.34)	.42
Middle income (200%-399%)	30.3%	29.0%	32.5%	0.65 (0.43-0.99)	.05
High income (>400%)	36.0%	34.5%	38.3%	0.66 (0.43-1.01)	.06
Insurance coverage					
Public only	50.2%	52.4%	46.7%	Ref	
Any private	49.6%	47.4%	53.0%	0.80 (0.60-1.07)	.12
Uninsured	0.3%	0.2%	0.3%	0.61 (0.20-1.90)	.39
Covered by Medicare Part D	62.3%	65.2%	57.9%	1.39 (1.01-1.92)	.05
Other prescribed medication insurance	33.0%	31.7%	35.0%	0.86 (0.63-1.17)	.34

(continued)

Expenditures were higher for adherent respondents across almost all health services (Figure 2). Mean total expenditures over the 2 years of the survey were significantly higher ($P < .05$) for respondents who were adherent (MPR ≥ 80%) compared with nonadherent respondents (\$29,985 vs \$24,623), both in the adjusted

and unadjusted models. When looking at adherence as an MPR of at least 90%, total expenditures were significantly higher only for adherent respondents in the unadjusted model.

We evaluated the proportion of expenditure spent on preventive compared with reactive health care services. As seen in Table 2,

MANAGERIAL

TABLE 1. (Continued) Predisposing, Enabling, and Need Characteristics for Adults 65 Years and Older With Diabetes From the MEPS, by Adherence Group, 2013-2017^a

Weighted sample proportion ^b	MPR ≥ 80%			OR (95% CI)	P
	All n = 1269; weighted n = 6,605,672	Yes n = 801 (61.6%); weighted n = 4,106,506	No n = 478 (38.4%); weighted n = 2,564,519		
	% ^c	% ^d	% ^d		
Need factors					
Self-reported health					
Excellent	6.0%	5.6%	6.6%	Ref	
Very good	26.2%	23.2%	31.0%	0.88 [0.44-1.77]	.72
Good	37.5%	39.7%	33.8%	1.38 [0.73-2.63]	.32
Fair	23.4%	22.7%	24.6%	1.09 [0.57-2.07]	.80
Poor	6.9%	8.7%	4.0%	2.57 (1.04-6.32)	.04
Self-reported mental health					
Excellent	26.9%	26.8%	27.2%	Ref	
Very good	29.5%	27.6%	32.5%	0.86 [0.60-1.24]	.42
Good	32.8%	34.7%	29.8%	1.18 [0.81-1.73]	.40
Fair	8.9%	8.4%	9.6%	0.89 [0.51-1.56]	.69
Poor	1.9%	2.5%	1.0%	2.60 [0.80-8.45]	.11
BMI, mean (95% CI) ^e	29.6 (29.1-30.1)	29.5 (28.8-30.3)	29.7 (29.1-30.4)		.69
Underweight-normal (<25)	19.5%	20.9%	17.3%	Ref	
Overweight (25-30)	33.8%	30.7%	38.9%	0.65 (0.43-0.97)	.03
Obese (30-35)	26.6%	27.9%	24.5%	0.94 [0.59-1.50]	.80
Very obese (≥35)	20.0%	20.5%	19.3%	0.88 [0.55-1.39]	.57
Currently smoke	7.3%	8.3%	5.6%	1.53 [0.78-3.00]	.19
Polypharmacy (≥ 5 nondiabetes medications)	86.2%	89.9%	80.2%	2.20 (1.48-3.28)	.0004
Number of nondiabetes drugs taken, mean (95% CI) ^e	10.3 (9.8-10.7)	10.4 (9.9-10.9)	9.9 (9.2-10.7)		.28
Number of diabetes drugs taken, mean (95% CI) ^e	2.0 (1.9-2.1)	2.0 (1.9-2.1)	1.9 (1.7-2.0)		.16
Taking > 1 OHA	35.2%	37.2%	32.1%	1.25 [0.88-1.78]	.20
Years on diabetes drugs, mean (95% CI) ^e	7.8 (7.2-8.5)	8.4 (7.5-9.4)	7.0 (6.1-7.9)		.08
Years since diabetes diagnosis, mean (95% CI) ^e	14.6 (13.9-15.3)	15.1 (14.1-16.0)	13.0 (12.6-15.0)		.09
Insulin	24.3%	26.0%	21.7%	1.27 [0.93-1.73]	.12
Number of MEPS priority conditions (excluding diabetes), mean (95% CI) ^e	3.6 (3.5-3.8)	3.8 (3.6-4.0)	3.4 (3.2-3.6)		.006
0-2 conditions	26.3%	23.8%	30.4%	Ref	
3 conditions	25.5%	25.4%	25.6%	1.27 [0.81-2.00]	.29
≥ 4 conditions	48.2%	50.8%	44.0%	1.48 [1.02-2.14]	.40
MPR, mean (95% CI) ^e	81.3 (79.6-83.0)	95.9 [0.003]	58.0 [0.010]	N/A	

BMI, body mass index; FPL, federal poverty level; GED, General Educational Development; MEPS, Medical Expenditure Panel Survey; MPR, medication possession ratio; N/A, not applicable; OHA, oral hypoglycemic agent; OR, odds ratio; ref, reference.

^aBolded values indicate $P < .05$.

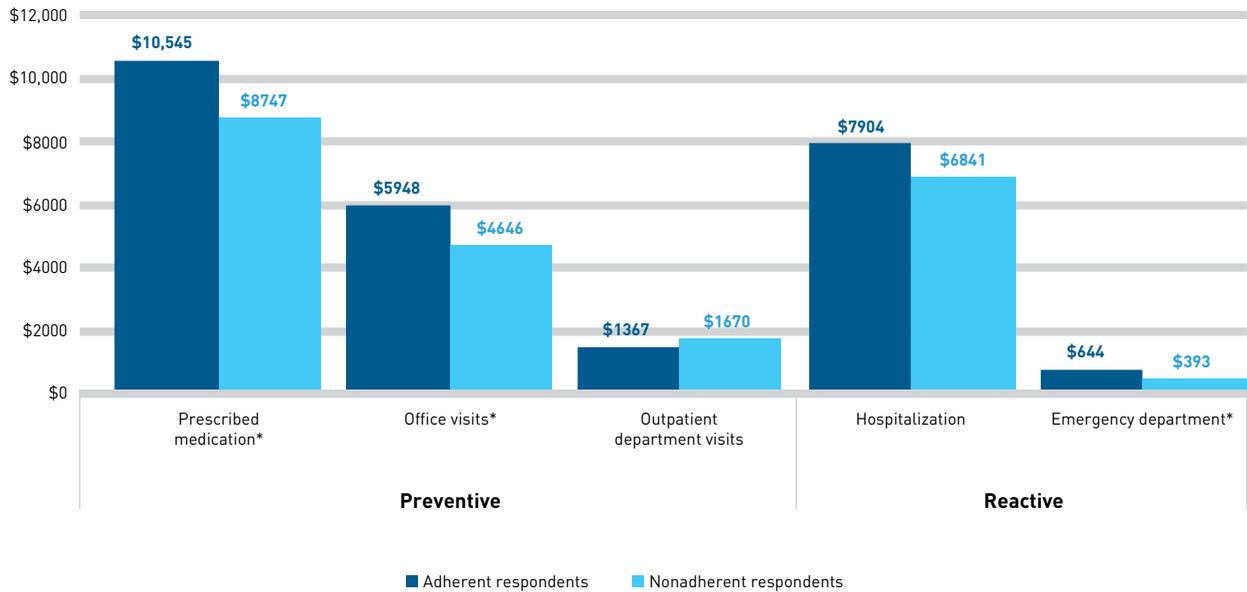
^bWeighted percentages represent the proportion of noninstitutionalized US adults who are and are not adherent at the cutoff of an MPR of at least 80%.

^cColumn percentage; totals may not add up to 100% because of rounding.

^dRow percentage; totals may not add up to 100% because of rounding.

^eMedians and IQRs for continuous variables are in the eAppendix.

FIGURE 2. Preventive and Reactive Expenditure Comparison Among Adherent and Nonadherent Respondents (MPR ≥ 80%)^a



MPR, medication possession ratio.

^aAnalysis performed in Stata using survey-specific γ -family generalized linear regression model with log link function. 95% CIs, means, IQRs, and *P* values can be found in the eAppendix. Asterisks indicate statistical significance at *P* < .05.

TABLE 2. Proportion of Total Health Care Expenditures Spent on Health Care Services^a

	80% MPR			90% MPR		
	Adherent	Nonadherent	<i>P</i> ^b	Adherent	Nonadherent	<i>P</i> ^b
Prescribed medication	41.1%	39.5%	.99	41.3%	39.7%	.38
Office visits	26.3%	28.8%	.74	26.4%	28.1%	.54
Outpatient visits	4.6%	5.8%	.05	4.4%	5.6%	.06
In-hospital	14.1%	14.0%	.39	13.6%	14.6%	.93
Emergency department	2.2%	1.6%	.10	2.4%	1.5%	.03

MPR, medication possession ratio.

^aAnalysis performed in Stata using survey-specific γ -family generalized linear regression model with log link function. Bold indicates statistical significance at *P* < .05.

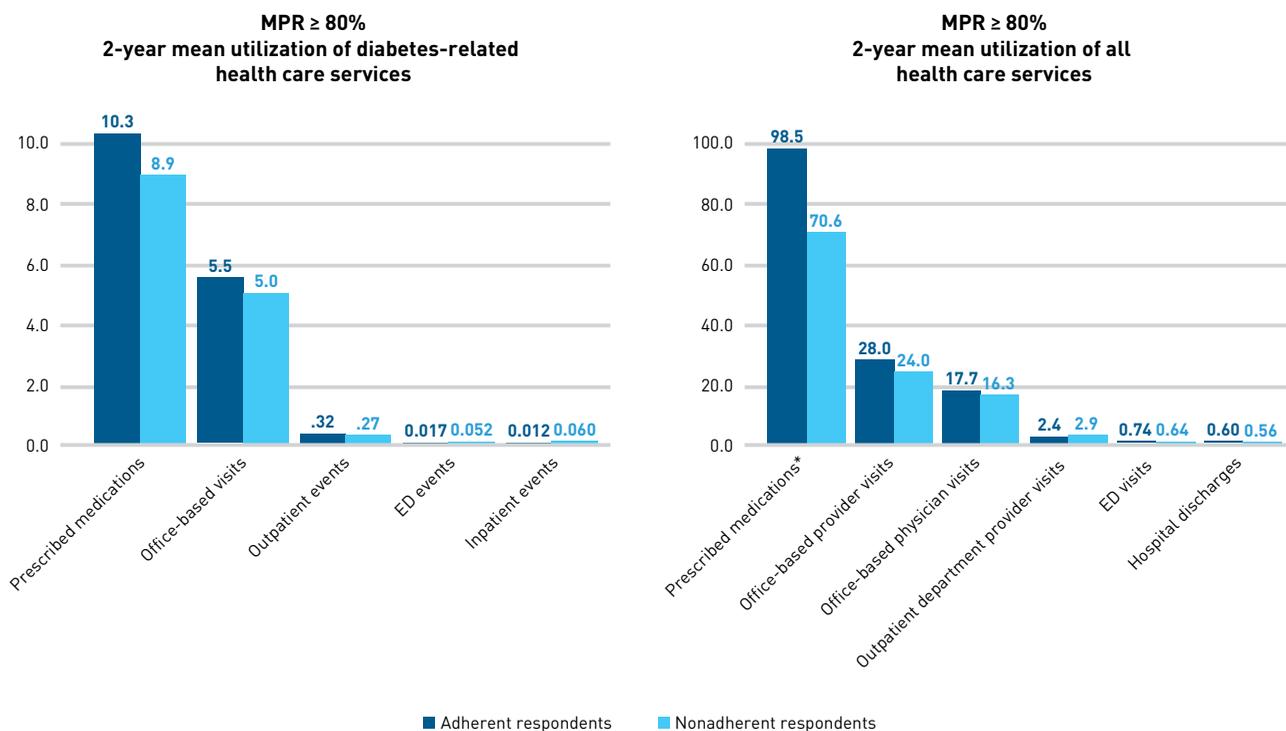
^bThe analysis adjusted for age category, sex, race, Hispanic, marital status, poverty level, geographic region, self-reported health, self-reported mental health, insurance coverage, part D insurance coverage, private prescription medication coverage, body mass index category, smoking status, polypharmacy, diet modifications, use of insulin, number of diabetes medications, number of nondiabetes medications, first year total expenditure, and first year total prescription expenditure.

our hypothesis that adherent respondents with diabetes spent proportionately more on preventive services and less on reactive services than nonadherent respondents was not supported. After controlling for covariates, over the course of the full survey there were no significant differences in the proportion of health care expenditure spent on preventive vs reactive services. When looking at specific services, we saw that adherent patients as defined by an MPR of at least 80% had a lower proportion of outpatient facility visits than nonadherent patients (4.6% vs 5.8%; *P* = .05). At the adherence level defined by MPR of at least 90%, adherent patients spent a higher

proportion of health care expenditure on ED visits (2.4% vs 1.5%; *P* = .03). Both of these findings contradict our initial hypothesis.

Similarly, when looking at absolute expenditures (Figure 2), we noted that although the higher mean expenditure among adherent vs nonadherent patients on prescribed medications (\$10,545 [95% CI, \$9161-\$11,929] vs \$8747 [95% CI, \$6626-\$10,859]) and office visits (\$5948 [95% CI, \$5208-\$6687] vs \$4646 [95% CI, \$4073-\$5220]) was not unexpected, the significantly higher mean ED expenditure (\$644 [95% CI, \$499-\$789] vs \$393 [95% CI, \$285-\$501]) was surprising. Although not statistically significant, the differences in mean

FIGURE 3. Utilization Comparison Among Adherent and Nonadherent Respondents (MPR ≥ 80%)^a



ED, emergency department; MPR, medication possession ratio.

* $P < .05$.

^aAnalysis performed in Stata using survey-specific Poisson family generalized linear regression model with log link function. Adults are noninstitutionalized civilians. Utilization refers to number of reported events.

outpatient and inpatient expenditures were not in the hypothesized direction. Respondents with an MPR of at least 90% had significantly higher ED expenditures than nonadherent respondents. No other statistically significant differences were seen at this adherence level definition. Full details can be seen in the [Appendix](#) (available at [ajmc.com](#)).

When analyzing utilization, we saw that respondents had similar numbers of unique prescriptions purchased over the 2 years (Table 1). However, adherent respondents, unsurprisingly, had significantly more total and diabetes-related prescriptions in each year (Figure 3). There were no significant differences in utilization of other health care services in either of the analyses using MPR of at least 80% and MPR of at least 90%.

DISCUSSION

Our analysis of MEPS data from 2013 to 2017 showed that 61.6% of adults 65 years and older who take OHAs filled 80% of their expected prescriptions. Only 49.6% filled at least 90% of their prescriptions.

We found adherence to be associated with female sex, White race, Part D prescription medication insurance, and higher number of need factors. Adherent patients were more than twice as likely to rate

their health as poor and to take at least 5 nondiabetes medications, and they had more MEPS priority conditions and were more likely to be overweight. Compared with patients who were not adherent, those who were adherent had higher health expenditure across all categories assessed. Overall, adherence was not associated with lower all-cause nor diabetes-specific health services utilization.

When controlling for covariates, we found that adherent patients did not spend relatively more on preventive services and less on reactive care. Results were not materially different when using the cutoff of MPR of at least 90%. This is probably because most (> 75%) patients who were adherent at an MPR of at least 80% also had an MPR of at least 90%, thus making the 2 analyses very similar. Our specific findings that adherent patients at the cutoff of MPR of at least 80% spent proportionately less on outpatient facility services and that those adherent at the MPR cutoff of at least 90% spent proportionately more on ED services than their nonadherent counterparts contradict our initial hypothesis. This is likely a random finding due to small numbers of individuals utilizing these services overall.

The rate of enrollment in Medicare Advantage plans is growing, and CMS' Star Rating program provides a tool for these consumers to select higher-rated plans.³⁷ These annual performance ratings

are thus not only tied to quality bonus payments and incentives but also are crucial to a health plan's expansion. Increasing patient medication adherence provides an opportunity to improve ratings given both the scope for improvement shown here and its outside influence on plan performance. Our counterintuitive findings indicate an opportunity for plans to also consider that ostensibly adherent patients may be adhering to inadequate regimens because of clinical inertia, thus increasing their incidence of complications and costs. For more than 50% of patients, treatment is intensified only a year or more after an increased HbA_{1c} result.³⁸ The concomitant increase in diabetes-related complications³⁹ is associated with substantial costs.^{40,41} Moreover, recent publications highlight racial and socioeconomic disparities in both medication adherence and clinical inertia.³⁹ Managed care pharmacies play a crucial role in mitigating these factors by providing affordable and high-quality care for all. Our study findings reveal that highly adherent individuals are generally female, higher income, and with polypharmacy or multimorbidity, and because of medication adherence, they are generally more likely to get the preventive and reactive care necessary. Addressing medication nonadherence among other groups can improve outcomes and ensure accessibility to care and proper medication utilization.

Our mean MPR of 79.6% is similar to the 78.2% calculated in Medicare enrollees taking metformin.⁴² Our rate of 61.6% adherent defined by an MPR of at least 80% is similar to the weighted mean (62.2%) reported in a recent meta-analysis.⁹ Looking at commercial insurance claims, Hansen et al found an adherence rate of 56.7% to 61%.⁴³ Another study looking at MEPS found a lower rate (36.2%), but because they looked at those younger than 65 years, this is likely because of a high uninsurance rate that was correlated with adherence.²⁶ Most studies have found that an increase in adherence is associated with savings in the form of fewer hospitalizations and outpatient costs despite higher drug costs.^{7,15,43} However, just 1 study looked at only older adults, and it is possible that the increased number and costs of OHAs since this study's publication in 2003 may have changed the association for this population.¹⁴ It is also likely that the multimorbidity of the analytical cohort masks diabetes-specific expenditure and utilization; studies examining associations among regional adherence levels, Medicare Part D, and overall medical spending also found no correlation among these variables.^{44,45} It is possible that the sample size was not adequate to capture these differences.

Limitations and Strengths

Our study was limited by factors typically associated with retrospective observational studies, such as selection bias, missing and incomplete information, use of proxy respondents,⁴⁶ and unmeasured confounding factors. To account for potential confounders, we used multivariate analyses, but multivariate analyses could not account for unmeasured variables such as disease severity (measured by HbA_{1c} levels and serum glucose) and ongoing complications. If these factors were more pronounced in adherent patients, this

might account for the observed results. Another limitation is the sole reliance on MPR as a measure of adherence; although MPR is a widely used and accepted measure,⁷ it is prone to overestimation of adherence. The accuracy of MPR measurement is often impeded by missing days' supply records and lack of access to prescription fill dates. To overcome these limitations, we calculated MPR in different ways. We were further limited by our reliance on pharmacy records (primary adherence), which do not necessarily correlate with patients taking the medication as prescribed (secondary adherence).⁴⁷

Finally, the data do not allow differentiation between type 1 and type 2 diabetes, and it is likely that 5% to 10% of our sample have insulin-dependent diabetes,¹ which has different expenditure and utilization patterns. We could not account for the similarity in prescription expenditures, given the differences in number of prescription purchases. Deeper analysis of all medications purchased would need to be required, and this would be limited by the lack of information on expenditure per prescription purchase. Given the limitations of MEPS data, future studies using administrative claims or electronic health records are needed to examine these questions further.

This was the first study that we know of to compare expenditure on specific health care services as a proportion of total expenditure. The significant strength of this study is its generalizability. The MEPS is a nationally representative survey. Although it is restricted to the noninstitutionalized population, only 4% of older Americans live in group settings⁴⁸ and this population is unlikely to make a difference to the findings. A noted limitation of previous studies was the inclusion of both incident and prevalent cases of diabetes.⁷ Ninety-five percent of our sample had received their diagnosis more than a year earlier, and time since diagnosis was controlled for in analyses, thus taking into account the increased costs and utilization associated with newly diagnosed disease.⁷ In addition, because we included only respondents who were in scope for the full panel, our results were not biased by censoring.

Implications

Plan managers can focus on improving patient engagement with an emphasis on targeted diabetes education and a particular focus on consequences of nonadherence; this could reduce barriers to appropriate medical management of diabetes³ and address racial disparities in medication use as "influenced by factors such as culture, provider bias, and patient trust in medical advice."⁴⁹ The latter, in particular, can be achieved by tailoring prescription "coverage policies, program designs, and quality initiatives" to those directly affected by racial disparities.⁴⁹ Recently, managed care pharmacies and organizations have been rebuked for perpetuating racial disparities in medication use, which has prompted a call for deeper understanding and mitigation of social inequalities in medication use⁴⁹ that are most often influenced by the enabling and need factors described in our findings. Managed care pharmacy experts need to address the enabling and need factors that are associated with adherence such as those identified here, as well as social support, enhanced

care coordination, increased trust in the medical establishment, and improved health literacy.^{50,51} From a policy perspective, there is a need to minimize racial disparities in medication use through internal and external reporting and quality improvement activities.⁴⁹ Lastly, steps to overcome the fragmented nature of the health care system, thus enabling more efficient communication between prescribers and pharmacies, also have the potential to increase adherence and improve health and wellness.⁵²

On the other hand, health care providers can make better use of available tools to identify patients at higher risk of nonadherence, as well as utilize medication review and reconciliation tools for older adults. Recently, using an innovative Part D model, CMS capped out-of-pocket spending at no more than \$35 per month for beneficiaries⁵³ for lifesaving medications such as insulin, an essential therapy for appropriate medical management of diabetes. Nevertheless, plan managers can integrate sophisticated data analytics with a multidisciplinary approach to empower patients to be actively involved in their health care and to provide targeted assistance to overcome barriers to care, such as eliminating co-payments for chronic medications.¹²

CONCLUSIONS

To our knowledge, this is the first study to use MEPS data to address the cost implications of adherence to OHAs in older adults. Our finding that adherence does not affect the financial burden of disease might be explained by the increased costs of preventive medication and the increased comorbidity burden of these patients. Our finding that increased adherence is not associated with relatively higher use of preventive care and less use of reactive care is likely explained by unmeasured clinical factors in the population, as well as treatment inertia.

The repeated finding of low adherence to OHAs has urgent implications for practice, indicating that prescribers, pharmacists, and insurers need to be more proactive in ensuring that prescription medications are refilled regularly. A targeted strategy may emphasize diabetes education, strengthening the implications of nonadherence in an equitable way that is personally relevant to older adults, and tailoring quality initiatives that can directly minimize racial disparities. ■

Author Affiliations: Department of Pharmacotherapy, The University of North Texas Health Science Center at Fort Worth, College of Pharmacy (ARKM, CX, RSR), Fort Worth, TX.

Source of Funding: None.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (ARKM, RSR); acquisition of data (ARKM); analysis and interpretation of data (ARKM, RSR); drafting of the manuscript (ARKM, RSR); critical revision of the manuscript for important intellectual content (ARKM, CX, RSR); statistical analysis (ARKM); provision of patients or study materials (ARKM, CX); administrative, technical, or logistic support (CX, RSR); and supervision (RSR).

Address Correspondence to: Rafia S. Rasu, PhD, Department of Pharmacotherapy, College of Pharmacy, The University of North Texas Health Science Center at Fort Worth, 3500 Camp Bowie Blvd, Fort Worth, TX 76107. Email: Rafia.Rasu@unthsc.edu.

REFERENCES

- National Diabetes Statistics Report. CDC. Accessed February 21, 2020. <https://www.cdc.gov/diabetes/data/statistics/statistics-report.html>
- Trish E, Kaiser K, Joyce G. Association of out-of-pocket spending with insulin adherence in Medicare Part D. *JAMA Netw Open*. 2021;4(1):e2033988. doi:10.1001/jamanetworkopen.2020.33988
- Herkert D, Vijayakumar P, Luo J, et al. Cost-related insulin underuse among patients with diabetes. *JAMA Intern Med*. 2019;179(1):112-114. doi:10.1001/jamainternmed.2018.5008
- American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. *Diabetes Care*. 2018;41(5):917-928. doi:10.2337/dc18-0007
- Cramer JA, Roy A, Burrell A, et al. Medication compliance and persistence: terminology and definitions. *Value Health*. 2008;11(1):44-47. doi:10.1111/j.1524-4733.2007.00213.x
- Roemer M. Expenditures for the top five therapeutic classes of outpatient prescription drugs, Medicare beneficiaries, age 65 and older, US civilian noninstitutionalized population, 2012. Agency for Healthcare Research and Quality statistical brief No. 469. February 2015. Accessed May 15, 2020. https://www.mepsahrq.gov/data_files/publications/st469/stat469.pdf
- Salas M, Hughes D, Zuluaga A, Vardeva K, Lebmeier M. Costs of medication nonadherence in patients with diabetes mellitus: a systematic review and critical analysis of the literature. *Value Health*. 2009;12(6):915-922. doi:10.1111/j.1524-4733.2009.00539.x
- Cramer JA. A systematic review of adherence with medications for diabetes. *Diabetes Care*. 2004;27(5):1218-1224. doi:10.2337/diacare.27.5.1218
- Khunti K, Seidu S, Kunutsor S, Davies M. Association between adherence to pharmacotherapy and outcomes in type 2 diabetes: a meta-analysis. *Diabetes Care*. 2017;40(11):1588-1596. doi:10.2337/dc16-1925
- Giugliano D, Maiorino MI, Bellastella G, Esposito K. Glycemic control in type 2 diabetes: from medication nonadherence to residual vascular risk. *Endocrine*. 2018;61(1):23-27. doi:10.1007/s12020-017-1517-9
- Carls GS, Tuttle E, Tan RD, et al. Understanding the gap between efficacy in randomized controlled trials and effectiveness in real-world use of GLP-1 RA and DPP-4 therapies in patients with type 2 diabetes. *Diabetes Care*. 2017;40(11):1469-1478. doi:10.2337/dc16-2725
- Rose J. Medication adherence: the lever to improve Medicare Advantage star ratings. *The American Journal of Managed Care*. August 12, 2021. Accessed September 29, 2022. <https://www.ajmc.com/view/medication-adherence-the-lever-to-improve-medicare-advantage-star-ratings>
- Bajner RM, Meinkow E, Munroe J, Smith JR, Stanley C, McHugh J. The impact of star ratings on rapidly growing Medicare Advantage market. Guidehouse. February 2018. Accessed May 15, 2020. <https://guidehouse.com/-/media/www/site/insights/healthcare/2018/medicare-advantage-analysis.pdf>
- Balkrishnan R, Rajagopalan R, Camacho FT, Huston SA, Murray FT, Anderson RT. Predictors of medication adherence and associated health care costs in an older population with type 2 diabetes mellitus: a longitudinal cohort study. *Clin Ther*. 2003;25(11):2958-2971. doi:10.1016/s0149-2918(03)80347-8
- Boye KS, Curtis SE, Lage MJ, Garcia-Perez LE. Associations between adherence and outcomes among older, type 2 diabetes patients: evidence from a Medicare supplemental database. *Patient Prefer Adherence*. 2016;10:1573-1581. doi:10.2147/PPA.S107543
- Morello C, Hirsch J. Strategies for addressing the cost of nonadherence in diabetes. *Am J Manag Care*. 2017;23(suppl 13):S247-S252.
- Feldman DJ, Valero-Elizondo J, Salami JA, et al. Is diabetes mellitus equivalent to atherosclerotic cardiovascular disease from a healthcare cost perspective? insights from the Medical Expenditure Panel Survey: 2010-2013. *Cardiovasc Endocrinol Metab*. 2018;7(3):64-67. doi:10.1097/XCE.0000000000000151
- Hill SC, Zurek SH, Zodet MW. Validity of reported Medicare Part D enrollment in the Medical Expenditure Panel Survey. *Med Care Res Rev*. 2012;69(6):737-750. doi:10.1177/1077558712457595
- Cohen JW, Monheit AC, Beauregard KM, et al. The Medical Expenditure Panel Survey: a national health information resource. *Inquiry*. 1996;33(4):373-389.
- An J. The impact of patient-centered medical homes on quality of care and medication adherence in patients with diabetes mellitus. *J Manag Care Spec Pharm*. 2016;22(11):1272-1284. doi:10.18553/jmcp.2016.22.11.1272
- Davis-Ajami ML, Wu J, Fink JC. Differences in health services utilization and costs between antihypertensive medication users versus nonusers in adults with diabetes and concomitant hypertension from Medical Expenditure Panel Survey pooled years 2006 to 2009. *Value Health*. 2014;17(1):51-61. doi:10.1016/j.jval.2013.11.008
- Zhou X, Zhang P, Kahn HS, Bardenheier BH, Li R, Gregg EW. Change in medical spending attributable to diabetes: national data from 1987 to 2011. *Diabetes Care*. 2015;38(4):581-587. doi:10.2337/dc14-1687
- Wang G, Zhou X, Zhou X, Zhang P. Annual total medical expenditures associated with hypertension by diabetes status in U.S. adults. *Am J Prev Med*. 2017;53(6S2):S182-S189. doi:10.1016/j.amepre.2017.07.018
- Wu J, Davis-Ajami ML, Noxon V, Lu ZK. Venue of receiving diabetes self-management education and training and its impact on oral diabetic medication adherence. *Prim Care Diabetes*. 2017;11(2):162-170. doi:10.1016/j.pcd.2016.10.005
- Sikka R, Xia F, Aubert RE. Estimating medication persistency using administrative claims data. *Am J Manag Care*. 2005;11(7):449-457.
- Miller GE, Sarpong EM, Hill SC. Does increased adherence to medications change health care financial burdens for adults with diabetes? *J Diabetes*. 2015;7(6):872-880. doi:10.1111/1753-0407.12292
- Karve S, Cleves MA, Helm M, Hudson TJ, West DS, Martin BC. Good and poor adherence: optimal cut-point for adherence measures using administrative claims data. *Curr Med Res Opin*. 2009;25(9):2303-2310. doi:10.1185/03007990903126833
- McGovern A, Tippu Z, Hinton W, Munro N, Whyte M, de Lusignan S. Comparison of medication adherence and persistence in type 2 diabetes: a systematic review and meta-analysis. *Diabetes Obes Metab*. 2018;20(4):1040-1043. doi:10.1111/dom.13160
- Clifford S, Perez-Nieves M, Skalicky AM, Reaney M, Coyne KS. A systematic literature review of methodologies used to assess medication adherence in patients with diabetes. *Curr Med Res Opin*. 2014;30(6):1071-1085. doi:10.1185/03007995.2014.884491
- American Diabetes Association. Promoting health and reducing disparities in populations. *Diabetes Care*. 2017;40(suppl 1):S4-S10. doi:10.2337/dc17-S004
- Pednekar PP, Ágh T, Malmenäs M, et al. Methods for measuring multiple medication adherence: a systematic review-report of the ISPOR Medication Adherence and Persistence Special Interest Group. *Value Health*. 2019;22(2):139-156. doi:10.1016/j.jval.2018.08.006

32. Basak R, Bentley JP, McCaffrey DJ III, West-Strum D, Przybyla SM, Banahan BF III. Comparing algorithms for composite measures of intra-disease multiple medication adherence: the case of diabetes. *Res Social Adm Pharm*. 2019;15(9):1160-1167. doi:10.1016/j.sapharm.2018.09.024
33. Shah R, McKay SV, Levitt Katz LE, et al. Adherence to multiple medications in the TODAY (Treatment Options for type 2 Diabetes in Adolescents and Youth) cohort: effect of additional medications on adherence to primary diabetes medication. *J Pediatr Endocrinol Metab*. 2020;33(2):191-198. doi:10.1515/jpem-2019-0315
34. Garber AJ, Handelsman Y, Grunberger G, et al. Consensus statement by the American Association of Clinical Endocrinologists and American College of Endocrinology on the comprehensive type 2 diabetes management algorithm – 2020 executive summary. *Endocr Pract*. 2020;26(1):107-139. doi:10.4158/CS-2019-0472
35. Aday LA, Andersen R. A framework for the study of access to medical care. *Health Serv Res*. 1974;9(3):208-220.
36. Dunn A, Grosse SD, Zuvekas SH. Adjusting health expenditures for inflation: a review of measures for health services research in the United States. *Health Serv Res*. 2018;53(1):175-196. doi:10.1111/1475-6773.12612
37. Freed A, Neuman T. A dozen facts about Medicare Advantage in 2020. Kaiser Family Foundation. Accessed January 8, 2021. <https://www.kff.org/medicare/issue-brief/a-dozen-facts-about-medicare-advantage-in-2020/>
38. Khunti K, Gomes MB, Pocock S, et al. Therapeutic inertia in the treatment of hyperglycaemia in patients with type 2 diabetes: a systematic review. *Diabetes Obes Metab*. 2018;20(2):427-437. doi:10.1111/dom.13088
39. Correa MF, Li Y, Kum HC, Lawley MA. Assessing the effect of clinical inertia on diabetes outcomes: a modeling approach. *J Gen Intern Med*. 2019;34(3):372-378. doi:10.1007/s11606-018-4773-3
40. Lindvig A, Tran MP, Kidd R, Tikkanen CK, Gaede P. The economic burden of poor glycemic control associated with therapeutic inertia in patients with type 2 diabetes in Denmark. *Curr Med Res Opin*. 2021;37(6):949-956. doi:10.1080/03007995.2021.1904863
41. Ali SN, Dang-Tan T, Valentine WJ, Hansen BB. Evaluation of the clinical and economic burden of poor glycemic control associated with therapeutic inertia in patients with type 2 diabetes in the United States. *Adv Ther*. 2020;37(2):869-882. doi:10.1007/s12325-019-01199-8
42. McWilliams JM, Najafzadeh M, Shrank WH, Polinski JM. Association of changes in medication use and adherence with accountable care organization exposure in patients with cardiovascular disease or diabetes. *JAMA Cardiol*. 2017;2(9):1019-1023. doi:10.1001/jamacardio.2017.2172
43. Hansen RA, Farley JF, Droegge M, Maciejewski ML. A retrospective cohort study of economic outcomes and adherence to monotherapy with metformin, pioglitazone, or a sulfonylurea among patients with type 2 diabetes mellitus in the United States from 2003 to 2005. *Clin Ther*. 2010;32(7):1308-1319. doi:10.1016/j.clinthera.2010.07.011
44. Zhang Y, Baicker K, Newhouse JP. Geographic variation in Medicare drug spending. *N Engl J Med*. 2010;363(5):405-409. doi:10.1056/NEJMp1004872
45. Stuart B, Shoemaker JS, Dai M, Davidoff AJ. Regions with higher Medicare Part D spending show better drug adherence, but not lower Medicare costs for two diseases. *Health Aff (Millwood)*. 2013;32(1):120-126. doi:10.1377/hlthaff.2011.0727
46. Hill SC, Zuvekas SH, Zodet MW. Implications of the accuracy of MEPS prescription drug data for health services research. *Inquiry*. 2011;48(3):242-259. doi:10.5034/inquiryjrnl_48.03.04.
47. Steiner JF. Measuring adherence with medications: time is of the essence. *Pharmacoepidemiol Drug Saf*. 2016;25(3):333-335. doi:10.1002/pds.3932
48. Stepler R. Smaller share of women ages 65 and older are living alone. Pew Research Center. February 18, 2016. Accessed May 15, 2020. <https://www.pewresearch.org/social-trends/2016/02/18/smaller-share-of-women-ages-65-and-older-are-living-alone/>
49. Kogut SJ. Racial disparities in medication use: imperatives for managed care pharmacy. *J Manag Care Spec Pharm*. 2020;26(11):1468-1474. doi:10.18553/jmcp.2020.26.11.1468
50. Aitken M, Valkova S. Avoidable costs in US healthcare: the \$200 billion opportunity from using medicines more responsibly. IMS Institute for Healthcare Informatics. June 2013. Accessed April 13, 2020. https://offers.premierinc.com/rs/381-NBB-525/images/Avoidable_Costs_in%20US_Healthcare-IHII_AvoidableCosts_2013%5B1%5D.pdf
51. Rasu RS, Bawa WA, Suminski R, Snella K, Warady B. Health literacy impact on national healthcare utilization and expenditure. *Int J Health Policy Manag*. 2015;4(11):747-755. doi:10.15171/ijhpm.2015.151
52. Ditusa L, Luzier AB, Brady PG, Reinhardt RM, Snyder BD. A pharmacy-based approach to cholesterol management. *Am J Manag Care*. 2001;7(10):973-979.

Visit ajmc.com/link/89255 to download PDF and eAppendix

eAppendix

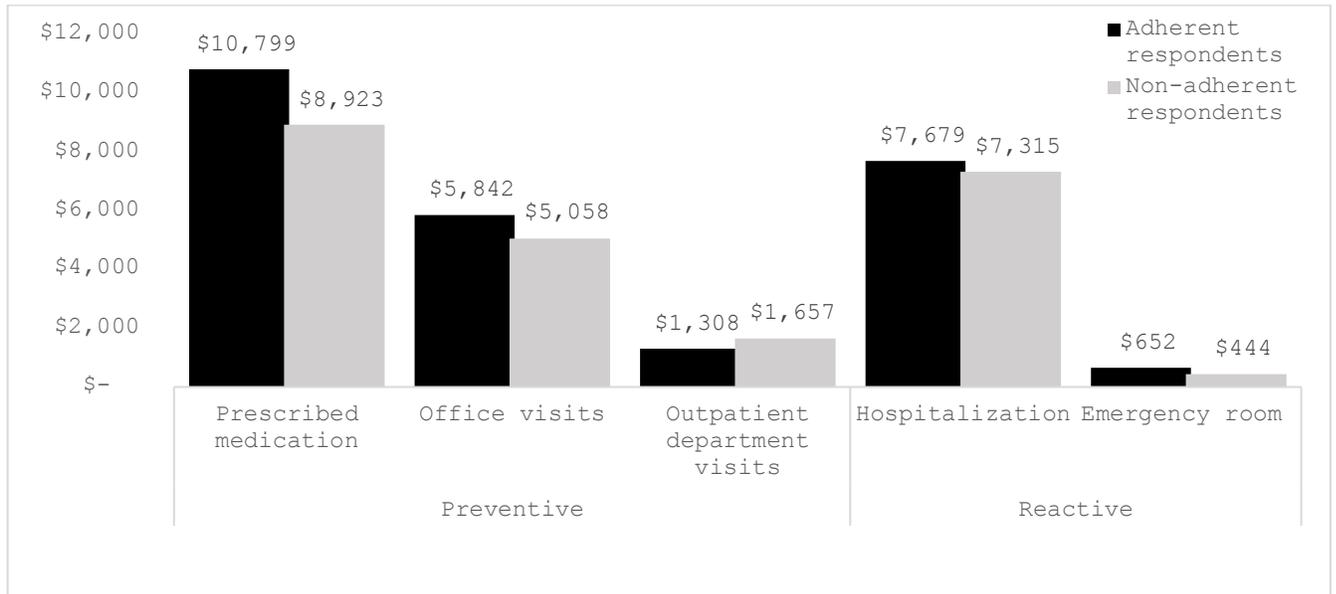
eAppendix A. Mean and interquartile ranges for continuous covariates for adults aged 65 and over with diabetes from the Medical Expenditure Panel Survey, by adherence group, 2013-2017

Weighted sample proportion ^a	ALL	MPR ≥ 80%	
		Yes	No
		n = 1269 weighted n = 6,605,672	n = 801 (61.6%) weighted n = 4,106,506
	Median(IQR)		
Age	72.7 (69.3 – 78.3)	72.8 (69.5 – 78.5)	72.5 (69.2 – 77.9)
BMI	59.1 (25.6 – 33.5)	29.2 (25.4 – 33.5)	29.0 (25.7 – 33.5)
Number of non-diabetes drugs taken	8.9 (5.5 – 12.6)	9.1 (5.9 – 12.7)	8.7 (5.0 – 12.5)
Number of diabetes drugs taken	1.1 (1.0 – 2.2)	1.2 (1.0 – 2.3)	1.0 (1.0 – 2.1)
Years on diabetes drugs	4.8 (0.9 – 11.2)	5.0 (1.2 – 12.3)	4.6 (0.6 - 9.9)
Years since diabetes diagnosis	11.5 (6.3-19.2)	11.7 (6.3-20.5)	11.0 (6.3– 17.1)
MPR	89.7 (68 .0 – 99.8	99.7 (90.4 – 99.9)	62.5 (48.8 – 72.6)
Number of MEPS priority conditions (excluding diabetes)	2.9 (1.9 – 4.2)	3.0 (2.0 – 4.4)	2.8 (1.7 – 4.0)

^a Weighted percentages represent the proportion of non-institutionalized U.S. adults who are and are not adherent at the MPR 80% Cut-off

eAppendix B. 2 year expenditure comparison^a among adherent and non-adherent respondents

(MPR \geq 90%)



^a Analysis performed in STATA with using survey-specific Gamma family generalized linear regression (GLM) model with log link function

95% confidence intervals, means, interquartile ranges and p values can be seen in Supplement C

* = statistically significant, $p < 0.05$

Bold numbers = statistically significant, $p < 0.05$

eAppendix C. Comparison^a of mean expenditure^b between adherent and non-adherent MEPS respondents over full survey period

Variable	Adherent MPR ≥ 80%				Unadjusted p	Adjusted p ^c
	Yes(n = 801)		No(n = 478)			
	Mean ^a	95%CL ^a	Mean	95%CL		
Total expenditure	\$29,952	27,161-32,743	\$24,872	21,623-28,122	0.02	0.01
Prescribed medication	\$10,545	9,161-11,929	\$8,747	6,636-10,859	0.15	0.02
In-hospital	\$7,904	6,193-9,615	\$6,841	5,146-8,536	0.34	0.08
Office visits	\$5,948	5,208-6,687	\$4,646	4,073-5,220	0.01	0.04
Home health	\$2,370	1,630-3,110	\$1,670	1,185-2,156	0.02	0.13
OPD visits	\$1,367	1,084-1,650	\$1,335	761-1,909	0.27	0.82
Dental visits	\$720	575-866	\$799	619-978	0.50	0.48
Emergency room	\$644	499-789	\$393	285-501	0.01	0.00
Other	\$344	251-437	\$303	188-418	0.61	0.17
Glasses/contact lenses	\$109	87-132	\$138	102-173	0.23	0.11

Variable	Adherent MPR ≥ 90%				Unadjusted p	Adjusted p ^c
	Yes(n = 660)		No(n = 619)			
	Mean ^a	95% CL ^a	Mean	95% CL		
Total expenditure	\$30,097	27,209-32,984	\$25,932	22,995-28,870	0.00	0.07
Prescribed medication	\$10,799	9,147-12,451	\$8,923	7,269-10,577	0.11	0.20
In-hospital	\$7,679	5,932-9,425	\$7,315	5,717-8,912	0.76	0.87
Office visits	\$5,842	5,154-6,531	\$5,058	4,356-5,760	0.12	0.09
Home health	\$2,640	1,746-3,533	\$1,315	840-1,790	0.01	0.00
OPD visits	\$1,308	980-1,636	\$1,657	1,271-2,042	0.18	0.32
Dental visits	\$704	544-864	\$796	625-966	0.45	0.74
Emergency room	\$652	490-814	\$444	325-564	0.05	0.11
Other	\$371	273-468	\$287	190-384	0.30	0.33
Glasses/contact lenses	\$102	80-125	\$138	107-169	0.08	0.11

NOTES Adults are noninstitutionalized civilians.

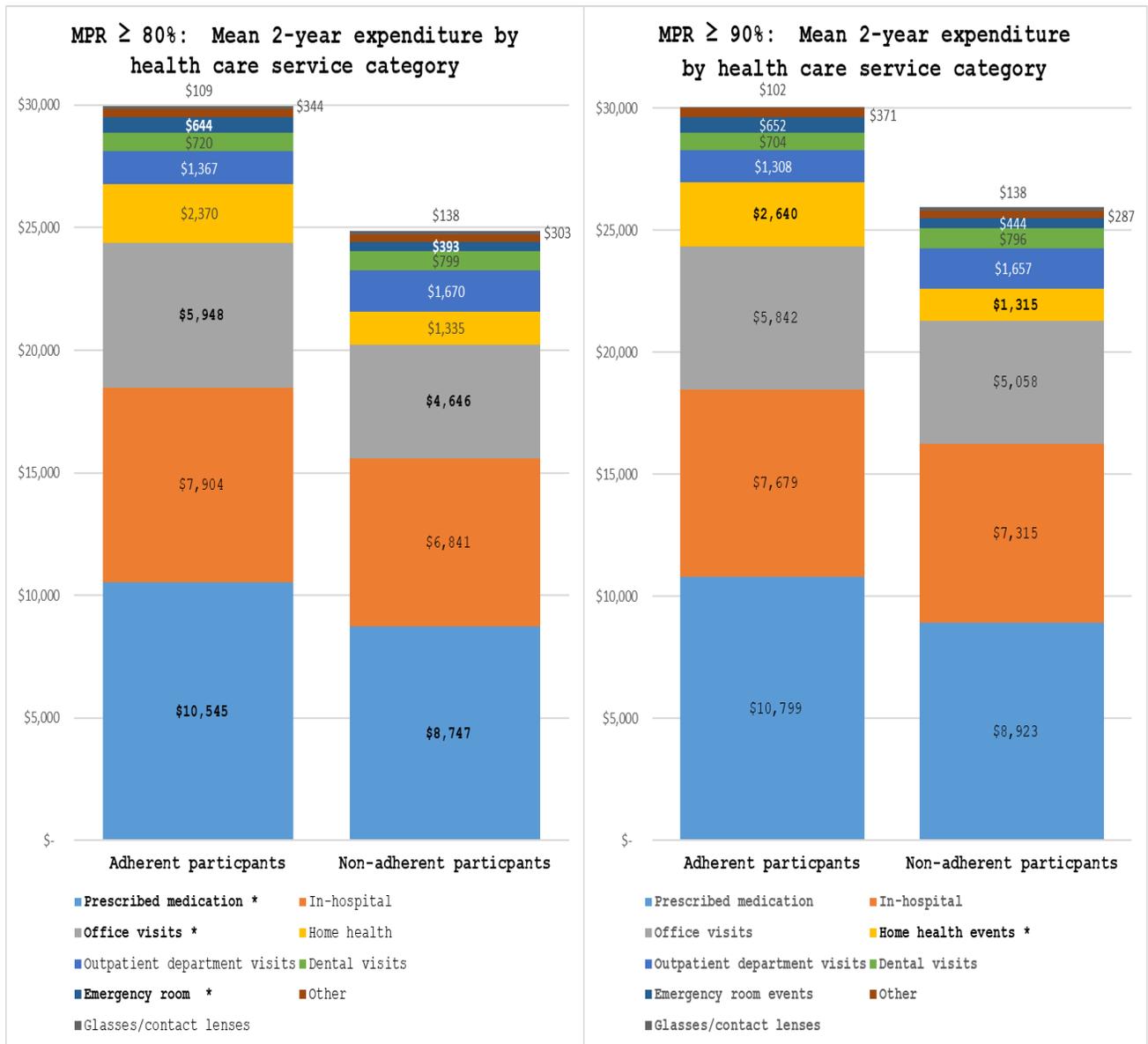
MPR = Medication possession ratio

OPD = Out-patient department

^a Analysis performed in STATA with using survey-specific Gamma family generalized linear regression (GLM) model with log link function

^b *Adjusted to 2017 USD*

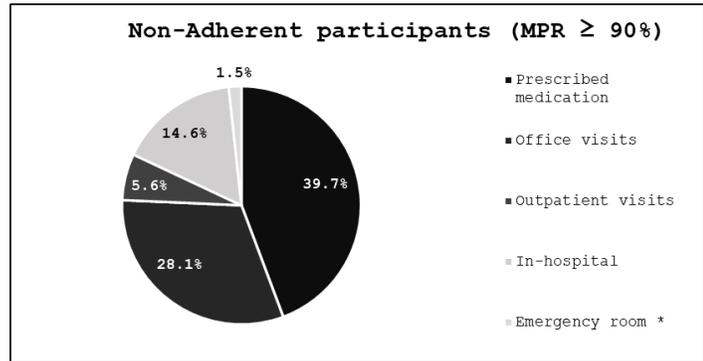
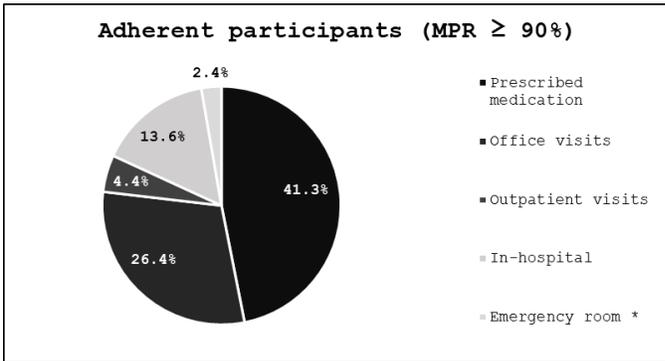
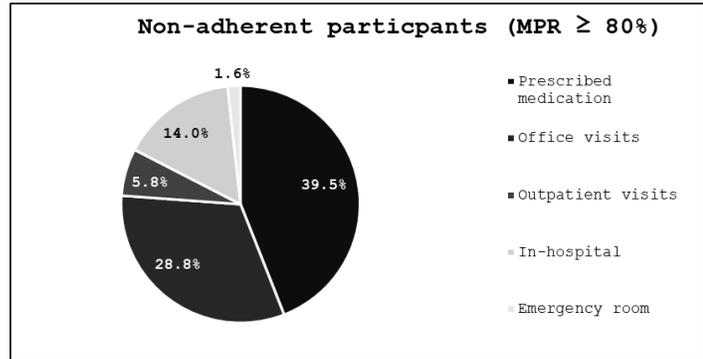
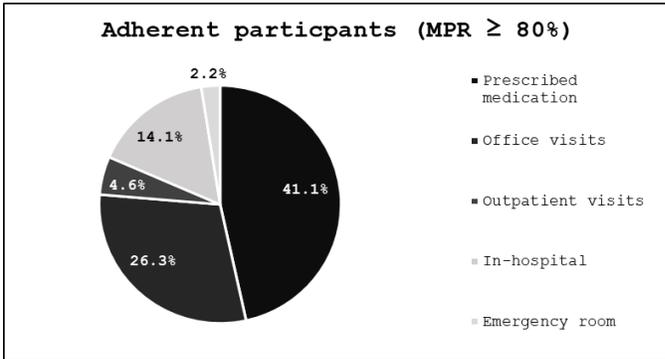
^c Adjusted for age category, sex, race, Hispanic, marital status, poverty level, geographic region, self-reported health, self-reported mental health, insurance coverage, part D insurance coverage, private prescription medication coverage, BMI category, smoking status, polypharmacy, diet modifications, use of insulin, number of diabetes medications, number of non-diabetes medications, first year total expenditure and first year total prescription expenditure.



* = statistically significant, $p < 0.05$

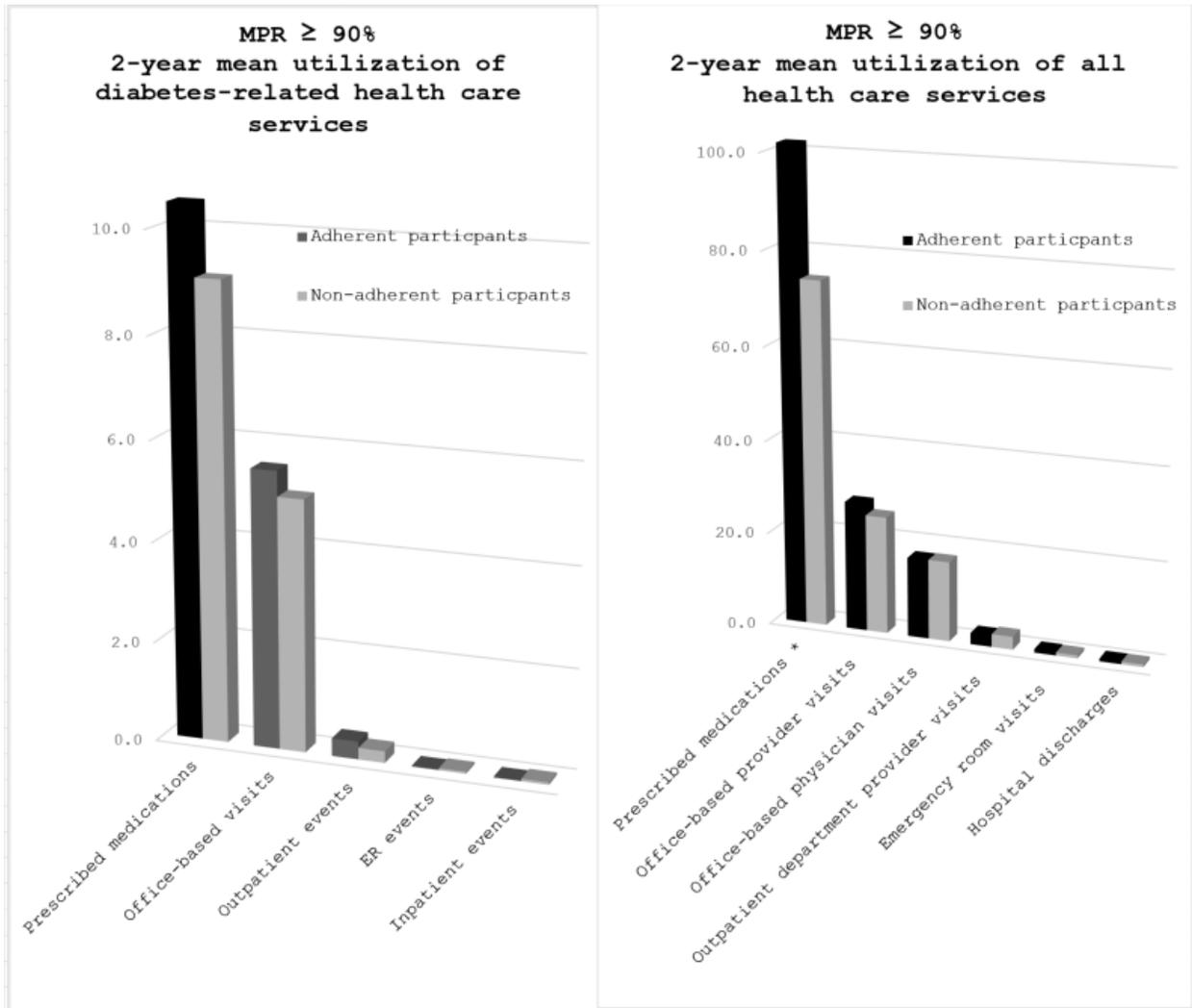
Bold numbers = statistically significant, $p < 0.05$

eAppendix D. Comparison of proportion of expenditure spent on healthcare services for adherent compared to non-adherent respondents.



^a Analysis performed in STATA with using survey-specific on Gamma family generalized linear regression (GLM) model with log link function

eAppendix E. Utilization comparison^a among adherent and non-adherent respondents (MPR^b ≥ 90%)



^aAnalysis performed in STATA with using survey-specific Poisson family GLM with log link function.

^bMPR = Medication Possession Ratio

NOTES Adults are noninstitutionalized civilians. Utilization refers to number of reported events

* = statistically significant, p < 0.05

eAppendix F. Most common oral hypoglycemic agents (OHA) used by adults aged 65 and over,
taking one OHA

Drug name	Frequency	Percent	Std Err	Weighted Frequency	Std Err
Metformin	584	69.8	2.2	3,063,763	171,862
Glipizide	97	9.9	1.25	433,381	55,818
Glimepiride	57	6.0	0.98	261,476	44,223
Sitagliptin	28	3.0	0.66	131,512	30,078
Glyburide	14	2.5	0.95	111,107	42,795
Antidiabetic Combinations	14	1.8	0.6	80,879	26,483
Metformin- Sitagliptin	12	0.9	0.28	40,034	12,360
Pioglitazone	17	2.4	0.65	107,271	29,711
Glyburide- Metformin	9	1.1	0.44	48,068	19,348
Linagliptin	10	1.3	0.58	57,572	25,530
Canagliflozin	1	0.01	0.02	781	781
Saxagliptin	4	0.5	0.26	21,172	11,308
Dapagliflozin	1	0.5	0.46	20,356	20,356
Empagliflozin	2	0.2	0.15	8,903	6,730
SglT-2 Inhibitors	0
Total	850	100		4,386,278	206,043