A Payer Perspective of the Costs of Urinary Tract and Skin and Soft Tissue Infections in Adults with Diabetes and the Relationship to Oral Antidiabetic Medication Nonadherence

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ABSTRACT

BACKGROUND: Controlling costs and improving quality outcomes are important considerations of the triple aim in health care. Medication adherence to oral antidiabetic (OAD) medications is an outcome measure for those with diabetes. However, there is little research reporting the costs associated with OAD medication adherence among adults with diabetes and comorbid infections.

OBJECTIVE: To provide nationally representative cost and utilization estimates from a payer perspective of 2 common comorbid infections: urinary tract infection (UTI) and skin and soft tissue infection (SSTI) among adults with diabetes in relation to OAD medication nonadherence to quantify cost per outcome.

METHODS: A retrospective observational study for years 2010-2015 used longitudinal panel data in the public domain from the Medical Expenditure Panel Survey (MEPS). The study included individuals aged ≥ 18 years with diabetes (excluding gestational diabetes) who were prescribed OAD medications and then stratified by infection status, that is, without infection versus with UTI and/or SSTI. Outcomes measured included medication adherence, defined as medication possession ratio (MPR); treated prevalence of UTI and SSTI; and associated direct medical costs paid by insurers.

RESULTS: 4,633 adults with diabetes were included; of those, 12% reported a UTI or SSTI, with the weighted sample representing 2.2 million U.S. residents. The mean MPR was 0.61 and 0.63 in the infection and noninfection groups, respectively. Less than 35% in each group were adherent to OAD medications. Having a UTI or SSTI increased the adjusted total health expenses by 53.7% ($P < 0.001$), but adherence to OAD medications did not significantly affect total health care costs.

CONCLUSIONS: In adults with diabetes, a UTI or SSTI diagnosis did not influence medication adherence to OAD medication but increased health care utilization and costs significantly.

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What this study adds

- The treated prevalence of UTI and SSTI in U.S. adults with diabetes for the years 2010-2015 was approximately 12%.
- Less than 35% of the adults with diabetes and UTI/SSTI were adherent to oral antidiabetic medications.
- UTI/SSTI increased total health expenses by 53.7% in U.S. adults with diabetes after adjustment.

Diabetes is known to be underreported, yet official data show that it affects 9.4% of the U.S. population (30 million); another 86 million people have prediabetes. Diabetes ranks as the seventh leading cause of death in the United States.¹ Medical costs are 2.3 times greater in patients with diabetes compared with those without, and the direct and indirect health care costs for diabetes continue to increase.¹

Adherence to oral antidiabetic (OAD) medication improves diabetes outcomes. Through its quality measures, the Centers for Medicare & Medicaid Services (CMS) monitors medication adherence to OAD medications.² By monitoring OAD adherence, CMS hopes to decrease OAD nonadherence rates and the associated poor health outcomes.

Although OAD medication adherence improves treatment outcomes, little is known about OAD nonadherence in subpopulations with comorbid infections common in diabetes, specifically 2 of the most prevalent infections, urinary tract infections (UTIs) and skin and soft tissue infections (SSTIs). There is little research to document cost outcomes of OAD nonadherence in this subgroup. As the U.S. health system increasingly monitors quality health care outcomes and ties those outcomes to reimbursement, health care providers and policy and decision makers need research about costs per outcome.^{3,4}

Medication adherence in diabetes remains below the standard reference cut point of 80%, and the percentage of adherence across several studies ranges from 38.5% to 93.1%.⁵⁻⁷ Importantly, during the first year after initiating diabetes-controlling medications, on average 50% of patients fail to take 80% of their prescribed medications.^{8,9} Adherence to OAD medications improves hemoglobin A1c levels¹⁰⁻¹² and reduces complications (e.g., microvascular complications, ulcers,

What is already known about this subject

- Comorbid conditions in diabetes could influence medication use behavior.
- Poor glycemic control increases the risk of urinary tract infection (UTI) and skin and soft tissue infection (SSTI).
- The presence of infection among adults with diabetes may influence glycemic control and increase acute health care utilization.

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FIGURE 1 Study Population

MEPS=Medical Expenditure Panel Survey; OAD=oral antidiabetic; SSTI=skin and soft tissue infections; UTI=urinary tract infection.

retinopathy, myocardial infarction, neuropathy, and/or amputation); health care utilization (e.g., hospitalizations and ED visits)¹³; and medical costs.¹⁴

Diabetes increases the risk of infection,¹⁵ and the presence of infection among those with diabetes increases the risk of hospitalization,¹⁶ poor glycemic control,¹⁷ sepsis, and mortality.¹⁸ The relative risk for UTI in diabetes ranges from 1.5 to 4, a risk greater than that in the general population.¹⁹⁻²² UTI in diabetes increases the risk of complications, poor outcomes, and increased economic burden.^{23,24} Diabetes also increases the risk for SSTIs, with the pathogen most frequently cited as *Staphylococcus aureus*, and, of those, one third are methicillin-resistant *S. aureus* (MRSA).²⁵⁻²⁹ In a nationally representative sample of U.S. adults with diabetes for years 2006-2011, the most common infections in hospitalized patients included UTI followed by sepsis, SSTIs, and pneumonia, with total aggregate hospital charges approaching \$48 billion.³⁰ In addition, diabetes mutes the body's immune response and is associated with complications, such as neuropathy or vascular disease, that predispose individuals to skin breakdown and ulceration. These in turn may increase the risk for recurrent infections including MRSA, another poor and costly outcome.³¹ There is sparse research examining associations between medication adherence and infections in diabetes. However, poor glycemic control increases the risk for infection, and medication adherence is significantly associated with glycemic control.¹⁴

There is also little research examining the costs associated with OAD medication adherence among adults with diabetes and comorbid infections. The purpose of this study was

to provide nationally representative estimates of the costs of 2 common comorbid infections (UTI and SSTI) among adults with diabetes in relation to OAD medication nonadherence to quantify value per outcome.

Methods

Data Source

This study used the Medical Expenditure Panel Survey (MEPS), a long-standing annual nationally representative survey of the U.S. civilian noninstitutionalized population with comprehensive information about health care service use, costs, payment, and health insurance. MEPS sampling frame, overlapping panel design, and 2-year survey data collected in 5 interview rounds are described in detail by the Agency for Healthcare Research and Quality (AHRQ).³² We used public domain data from the MEPS household component (MEPS-HC) longitudinal files and pooled 5 years of panels: panel 15 (2010-2011), panel 16 (2011-2012), panel 17 (2012-2013), panel 18 (2013-2014), and panel 19 (2014-2015). MEPS-HC longitudinal panels were then linked to corresponding medical conditions and event files to produce nationally representative estimates by applying the longitudinal weight. The longitudinal weight is a variable that can be applied to the study sample to produce a weighted population estimate for the U.S. noninstitutionalized population for the entire 2-year period. This weighted sample allowed us to make national estimates. The longitudinal data files included respondents who completed all 5 survey rounds in the 2-year period and were assigned a weight greater than zero.

Study Population

The study population was first identified by those with longitudinal weights >0 and then included those aged ≥ 18 years during the first interview round. The study population was further refined to those with diabetes prescribed OAD medications by accessing the MEPS medical condition files. We also used Clinical Classification Software (CCS) codes for diabetes (49 and 50) linked to the Lexicon Multum Therapeutic Classification (drug class and subclass) variable from the prescribed medication files to identify OAD medication use. CCS code 159 identified UTIs and CCS code 197 identified SSTIs. The study population of adults with diabetes and prescribed OAD medications was then divided by infection status: (a) with UTI or SSTI and (b) without UTI or SSTI (Figure 1). CCS codes, developed in partnership with the Healthcare Cost and Utilization Project and AHRQ, categorize *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnoses and procedure codes into meaningful groupings for research purposes.³³

Outcome Measures

This study explored the treated prevalence of UTI and SSTI, medication adherence, and health care expenses. MEPS only provides treated prevalence; therefore, medication possession ratio (MPR) was calculated for individual OAD medication use over 2 years ($\text{MPR} = \text{sum of days supplied} / \text{panel time period}$). Adherence was defined as $\text{MPR} \geq 0.80$.

The economic outcome measures included average health care expenses (per person per year) during the study period. Expenses included all health care-related expenses, as well as categorized medical and prescription drug expenses. Expenses were defined as amounts paid by the MEPS individual respondent's medical insurer, federal government, state, and local sources. Total health care expenses summed all medical and prescription drug expenses. Medical expenses were identified from the medical event files and included expenses for physician office visits, hospitalization, outpatient visits, emergency department (ED) visits, and other services.

Two types of health care expenses were measured from the event files: expenses from any disease defined as all-cause and disease-specific expenses categorized as diabetes-related and infection-related (UTI, SSTI, or both), based on CCS codes. All expenses were inflated to year 2015 using the personal consumption expenditure health indices.³⁸

Covariates and Potential Factors Associated with Infection

This study controlled for sociodemographic characteristics, perceived health status, and comorbidity as defined by the Charlson Comorbidity Index (CCI; Table 1). A CCI score of zero means no comorbidity; higher scores mean greater disease burden. The self-reported perceived health status was collapsed into 3 categories (excellent/very good, good, and fair/poor).

Data Analysis

Univariate analysis (frequencies and relative frequencies) described baseline characteristics of the study population. Bivariate analysis (chi-square test) examined differences between a "case" (those with a UTI or SSTI) and a "control" (those without a comorbid UTI or SSTI) by sociodemographic, clinical, and comorbidity variables and diabetes treatment patterns. Unpaired t-tests compared health care utilization and costs between those with infection and those with no infection. The multivariate logistic regression models evaluated factors associated with infection in the study population with diabetes. Generalized linear regression with log link and gamma distribution examined the effects of infection and adherence on health care costs by payer in the study population with diabetes prescribed 1 or more OAD. The study adjusted for the complex survey design and included appropriate weights, clustering, and primary sampling unit variables to provide weighted, nationally representative treated prevalence estimates. We used SAS version 9.4 (SAS Institute, Cary, NC) to conduct all data analyses.

Results

This study identified 4,633 adults diagnosed with diabetes who were prescribed OAD medications, representing 17.4 million U.S. individuals after applying longitudinal weight. Of those, 11.9% ($n=533$) reported infection (UTI and/or SSTI), representing 2.2 million U.S. individuals (Figure 1).

Table 1 summarizes the characteristics of the study population and shows the factors likely to be associated with infection. Significantly, the odds of infection decreased for the following factors among adults with diabetes: males (vs. females), blacks (vs. whites), and middle income (vs. high income) by 49%, 45%, and 30%, respectively. Those with poor/fair health status (vs. excellent/very good) had 53% increased odds of infection.

OAD medication use patterns, shown in Appendix A (available in online article), were similar in adults with or without skin infection. Metformin, sulfonylureas, and dipeptidyl peptidase 4 (DPP-4) inhibitors represented the 3 most commonly used OAD medications. There was no significant difference in OAD medication adherence between the infection ($\text{MPR}=0.61$) and noninfection ($\text{MPR}=0.63$) groups. Less than 35% of the adults in both groups were adherent to OAD medications ($\text{MPR} \geq 0.80$) for the 2-year study period.

On average, those with infection showed greater all-cause health care utilization versus noninfection, including greater number of office visits (14.0 vs. 9.8, $P<0.001$); prescription fills (49.8 vs. 41.1, $P<0.001$); ED visits per 1,000 person-months (49.1 vs. 24.8, $P<0.001$); and hospitalizations per 1,000 person-months (36.9 vs. 16.9, $P<0.001$; Table 2). Moreover, the infection group showed greater diabetes-related health care utilization than the noninfection group, such as diabetes-related office visits (3.0 vs. 2.5, $P=0.002$) and prescription fills (5.4 vs. 4.7, $P<0.001$).

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TABLE 1 Characteristics of the Study Population and Factors Associated with UTI/SSTI in Adults with Diabetes from MEPS Pooled Years 2010-2015

Variable	No UTI/SSTI (n = 4,100) Weighted %	UTI/SSTI (n = 533) Weighted %	P Value	Adjusted OR (95% CI) ^a	P Value
Age, years			0.014		
18-45	11.4	9.1		1.00	
46-64	46.2	40.0		0.96 (0.62-1.47)	0.845
65+	42.4	50.9		1.27 (0.80-2.00)	0.306
Body mass index			0.548		
Underweight/normal	12.3	13.0		1.00	
Overweight	31.4	28.4		0.97 (0.64-1.48)	0.891
Obese	56.3	58.5		1.11 (0.75-1.64)	0.598
Race			< 0.001		
White	61.8	71.3		1.00	
Black	12.8	8.2		0.55 (0.40-0.78)	0.001
Other	25.4	20.4		0.73 (0.55-0.96)	0.029
Sex			< 0.001		
Female	47.9	65.2		1.00	
Male	52.1	34.8		0.51 (0.38-0.68)	< 0.001
Education			0.208		
Not a high school graduate	20.8	25.2		1.00	
High school/some college	60.8	57.3		0.88 (0.67-1.14)	0.324
College graduate	18.5	17.4		0.93 (0.62-1.42)	0.749
Family size			0.018		
≤2	70.9	76.3		1.00	
>2	29.1	23.7		0.92 (0.70-1.21)	0.558
Geographic region			0.078		
Northeast	17.8	17.8		1.00	
Midwest	22.8	24.6		1.18 (0.79-1.75)	0.411
South	40.4	39.6		1.16 (0.81-1.66)	0.418
West	18.9	18.0		1.12 (0.71-1.74)	0.633
Marital status			0.003		
Yes	59.1	50.7		1.00	
No	40.9	49.3		1.17 (0.92-1.49)	0.191
Income^b			0.137		
High	31.6	32.3		1.00	
Middle	32.4	26.5		0.70 (0.50-0.95)	0.023
Low	14.8	17.3		0.97 (0.64-1.47)	0.878
Poor	21.2	24.0		0.87 (0.60-1.25)	0.438
Insurance coverage			0.114		
Private	58.1	56.5		1.00	
Public	33.5	37.6		0.91 (0.67-1.23)	0.536
Uninsured	8.4	5.9		0.79 (0.51-1.24)	0.312
Perceived health status			0.009		
Excellent/very good	26.5	19.3		1.00	
Good	35.8	35.5		1.35 (0.96-1.91)	0.088
Fair/poor	37.7	45.2		1.53 (1.07-2.21)	0.021
Comorbidity score			0.003		
0	64.1	56.3		1.00	
1	12.6	12.0		1.03 (0.73-1.46)	0.861
≥2	23.3	31.7		1.32 (0.98-1.79)	0.071

Note: N = 4,633, weighted N = 86,824,256.

^aMultivariate logistic regression model was applied to examine the association between UTI/SSTI and study population characteristics.

^bPoor was defined as income < 100% of FPL; low income was defined as 100%-199% of FPL; middle income was defined as 200%-399% of FPL; and high income was defined as ≥ 400% of FPL.

CI = confidence interval; FPL = federal poverty line; MEPS = Medical Expenditure Panel Survey; OR = odds ratio; SSTI = skin and soft tissue infections; UTI = urinary tract infection.

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TABLE 2 Health Care Utilization Patterns by UTI/SSTI in Adults with Diabetes from MEPS Pooled Years 2010-2015

	No UTI/SSTI (n = 4,100) Mean (SE)	UTI/SSTI (n = 533) Mean (SE)	P Value
All-cause health service utilization			
Office visits	9.8 (0.3)	14.0 (0.7)	<0.001
Outpatient visits	1.1 (0.1)	1.6 (0.2)	0.032
Prescription fills	41.1 (0.8)	49.8 (2.0)	<0.001
ED visits per 1,000 patient-months	24.8 (1.2)	49.1 (3.9)	<0.001
Hospitalization per 1,000 patient-months	16.9 (0.9)	36.9 (3.4)	<0.001
Diabetes-related health service utilization			
Office visits	2.5 (0.1)	3.0 (0.2)	0.002
Outpatient visits	0.2 (0.0)	0.2 (0.0)	0.376
Prescription fills	4.7 (0.1)	5.4 (0.2)	0.001
ED visits per 1,000 patient-months	2.1 (0.2)	3.4 (0.9)	0.030
Hospitalization per 1,000 patient-months	1.1 (0.1)	2.5 (0.7)	0.016
Infection-related health service utilization			
Office visits		1.1 (0.1)	
Outpatient visits		0.2 (0.1)	
Prescription fills		0.6 (0.1)	
ED visits per 1,000 patient-months		11.8 (1.2)	
Hospitalization per 1,000 patient-months		7.7 (1.2)	

Note: N = 4,633, weighted N = 86,824,256.

ED = emergency department; MEPS = Medical Expenditure Panel Survey;
SE = standard error; SSTI = skin and soft tissue infections; UTI = urinary tract infection.

TABLE 3 Health Expenses by UTI/SSTI in Adults with Diabetes from MEPS Pooled Years 2010-2015

	No UTI/SSTI (n = 4,100) Mean (SE)	UTI/SSTI (n = 533) Mean (SE)	P Value
All-cause health expenses (\$), mean (SE)			
Medical expenses	6,221 (219)	9,828 (995)	0.002
Office	1,876 (63)	2,718 (258)	0.002
Outpatient	763 (64)	1,050 (137)	0.049
ED	259 (16)	527 (53)	<0.001
Hospitalization	2,670 (171)	5,532 (689)	<0.001
Other	653 (48)	1,147 (142)	<0.001
Prescription drugs	2,837 (86)	4,734 (907)	<0.001
Total expenses	9,058 (257)	15,712 (1,205)	<0.001
Diabetes-related health expenses (\$), mean (SE)			
Medical expenses	650 (38)	982 (116)	0.003
Office	409 (19)	518 (61)	0.020
Outpatient	67 (16)	70 (23)	0.783
ED	19 (3)	46 (13)	0.014
Hospitalization	155 (28)	348 (97)	0.029
Prescription drugs	570 (27)	1,645 (870)	0.071
Total expenses	1,220 (50)	2,627 (879)	0.005
Infection-related health expenses (\$), mean (SE)			
Medical expenses		1,137 (226)	
Office		162 (24)	
Outpatient		50 (17)	
ED		86 (16)	
Hospitalization		838 (212)	
Prescription drugs		70 (12)	
Total expenses		1,207 (228)	

Note: N = 4,633, weighted N = 86,824,256.

ED = emergency department; MEPS = Medical Expenditure Panel Survey;
SE = standard error; SSTI = skin and soft tissue infections; UTI = urinary tract infection.

Overall, we observed higher all-cause and diabetes-related annual health expenses in adults with infection versus adults with no infection, including all-cause medical (\$9,828 vs. \$6,221, $P < 0.002$); prescription drug (\$4,734 vs. \$2,837, $P < 0.001$); and total expenses (\$15,712 vs. \$9,058, $P < 0.001$) and diabetes-related medical (\$982 vs. \$650, $P = 0.003$); prescription drug (\$1,645 vs. \$570, $P = 0.001$); and total expenses (\$2,627 vs. \$9,058, $P = 0.001$; Table 3). In the infection group, diabetes-related and infection-related health expenses accounted for 16.7% and 7.6% of total health expenses, respectively.

The effect of infection and adherence on the adjusted total health expenses by controlling for demographics and comorbidity is shown in Table 4. Infection increased the adjusted total health care expenses by 53.7% ($P < 0.001$), but no significant difference in health expenses was shown between adherence and nonadherence groups in adults with diabetes or infection. The full results of the regression analyses are shown in Appendix B (available in online article).

Discussion

This study found a treated prevalence of having ≥ 1 UTI and/or SSTI as 12% in adults with diabetes. Poor to fair health status compared with excellent health status showed a 53% increased odds of a UTI or SSTI. OAD medication use patterns between those with and without infection were similar with metformin, sulfonylureas, and DPP-4 inhibitors, the 3 most frequently prescribed OAD medications. Medication adherence to OAD medications were similar with MPR = 0.63 in infection group and 0.61 in noninfection group. Utilization for office visits, prescription fills, ED visits, and hospitalizations were all significantly greater for those with UTI and/or SSTI versus no infection. Costs were significantly greater across all measures (all-cause, diabetes related, and infection related) in the infection group versus no infection with diabetes-related and infection-related health expenses accounting for 16.7% and 7.6% of total health expenses respectively. UTI/SSTI increased the adjusted total health expenses by 53.7% ($P < 0.001$). Adherence to OAD did not affect total health care costs significantly.

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TABLE 4 Effects of Infection and Adherence on Total Health Expenses in Adults with Diabetes from MEPS Pooled Years 2010-2015

Study Population	Independent Variable	Estimated Log Coefficient ^a (SE)	Change in Percentage ^b	P Value
Adults with diabetes (N=4,633, weighted N=86,824,256)	UTI/SSTI (yes vs. no)	0.43 (0.08)	+53.7	<0.001
	Adherence (yes vs. no)	0.05 (0.06)	+5.1	0.403
Adults with diabetes and infection (n=533, weighted n=11,099,855)	Adherence (yes vs. no)	-0.06 (0.12)	-5.8	0.600

^aGeneralized linear regression models with log link and gamma distribution were applied to assess the association between UTI/SSTI and health expenses and association between adherence and health expense by adjusting for age, BMI, sex, race, marital status, family size, education, poverty line, insurance coverage, comorbidity, and perceived health status.

^bThe estimated log coefficients were interpreted as a percentage change in expense in the study population. $\text{Exp}(0.43) - 1 = 0.537$ (i.e., +53.7%), $\text{Exp}(0.05) - 1 = 0.051$ (i.e., 5.1%), $\text{Exp}(-0.06) - 1 = -0.058$ (i.e., -5.8%).

ED=emergency department; BMI=body mass index; MEPS=Medical Expenditure Panel Survey; SE=standard error; SSTI=skin and soft tissue infections; UTI=urinary tract infection.

Diabetes, UTI, and SSTI remain significant health care cost drivers in adults with diabetes. These findings are in line with another study that reported significant health care cost outcomes among those with infection in type 2 diabetes.²⁴ Few studies have isolated UTI or SSTI and their associated costs with the significant factors associated with increased risk for these infections in the adult population with type 2 diabetes across the health system's various points of care. Yu et al. (2014) reported the prevalent and incident UTI cases as 10% in adults with type 2 diabetes versus our study of combined UTI and SSTI treated prevalence of 12%.²⁴ Yu et al. limited their findings to 1 year of prevalence, incidence rate, and health care cost outcomes to include antibiotic prescription costs but also went further by calculating total all-cause incremental costs per patient as \$7,045 (95% confidence interval=\$4,130-\$13,051) in adults with diabetes and ≥ 1 UTI. Yu et al. also reported utilization and costs for hospital, outpatient, and prescription services.²⁴ There are notable differences in the data between the Yu study and our study. Yu et al. used a claims database representative of employer-based health insurance plans over a 1-year time frame, whereas our study used a nationally representative survey that captured data over 2 years.

Although utilization studies report UTI as the most common cause of hospitalization for infection, with SSTI a close second, and show the associated aggregate hospital charges for UTI and SSTI,³⁰ our research goes further to quantify in-patient, outpatient, and prescribed drug expenses associated with UTI and SSTI in adults with diabetes prescribed OAD medication. Our treated prevalence for UTI and SSTI (12%) in hospitalized adults with diabetes is slightly more than the prevalence of UTI in diabetes as reported in previous studies (8.2%-9.4%) of UTI and SSTI.²³ Our research shows the health care costs associated with UTI and SSTI and further delineates where the cost drivers are in the health care system. The significant difference in the amount of office visits, ED utilization, and hospitalizations between those with UTI and

SSTI versus those without infection (14.0 vs. 9.8, 49.1 vs. 24.8, and 36.9 vs. 16.9, respectively) suggests that these areas may be centrally important in finding solutions that address cost reduction.

Preventing unnecessary ED visits and hospitalizations have been shown to reduce health care costs.³⁹ Determining the individualized underlying reasons for increased or unnecessary health care utilization should help control costs. Interestingly, poor perceived health status, rather than comorbidity, showed greater increased odds of infection (53% vs. 32%). Poor perceived health status and other self-reported measures of health have been significantly associated with all-cause mortality in cardiovascular disease, the age adjusted mortality rate in men, and increased mortality in diabetes.⁴⁰⁻⁴³ Poor perceived health status may serve to alert health care providers of those most at risk for UTI and SSTI and should be considered in the health history and periodic health assessments for those with diabetes.

Surprisingly, adherence to OAD medications showed no significant differences in total health care, diabetes, or infection-related health care expenses. Similar to previous studies, the adult population prescribed OAD medications showed poor OAD medication adherence. Our results showed OAD medication adherence as indicated by MPR for the infection group versus noninfection were 0.61 and 0.63, respectively, and fewer than 35% of the study sample were adherent to OAD medications using an MPR cut point of ≥ 0.80 . Although poor medication adherence is significantly associated with poor glycemic control, particularly in those adults more recently diagnosed with diabetes,⁴⁴ our study showed no significant differences between those with and without infection. Because poor glycemic control is associated with increased serious infection,⁴⁵ we expected to see a significant association with our OAD medication adherence findings and our adjusted total health expenses.

Efforts to address glycemic control should not only include measures to address OAD medication nonadherence, and the

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treatment choice for the medication regimen, but also other factors related to self-care disease management such as exercise and weight management.⁴⁶ This suggests that controlling health care costs among those at risk for infection, particularly UTI and SSTI, is multifactorial and complex and requires tireless effort for caregivers, providers, and patients.

Limitations

There are several strengths and limitations to consider when interpreting this study's findings. The results provide a nationally representative sample of adults with diabetes, adjusted for demographic, socioeconomic, and other health-related factors that may affect health care costs among those with UTI or SSTI. However, the MEPS public use files are limited to a 3-digit general broad category of ICD-9-CM diagnostic codes rather than the full 5-digit codes, and CCS codes categorize diabetes into diabetes with or without complications. This limits the ability to determine disease severity and the specificity of determining those with type 2 diabetes to a proxy measure—those prescribed OAD medications. Although MPR is a validated, commonly used prescription refill adherence measure for observational research or administrative data, and the cut point of 80% gives acceptable sensitivity and specificity, this measure does not account for the behavior of taking the medication.⁴⁷ The observational study design of MEPS also prevents determining causality.

Conclusions

In this study, there are 3 major findings concerning adults with diabetes and UTI and/or SSTI. First, consistent with other studies, OAD medication use was suboptimal in the infection and noninfection groups, suggesting that infection did not change overall medication use behavior significantly. Second, infection increased total health care utilization and costs. Finally, adherence did not influence total health care costs significantly in this study population. This is the first study to examine medication adherence in adults with diabetes and infection. Further study is needed to confirm the findings and identify possible reasons associated with adherence.

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DISCLOSURES

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APPENDIX A UTI/SSTI and OAD Use Patterns in Adults with Diabetes from MEPS Pooled Years 2010-2015

	No UTI/SSTI (n = 4,100)	UTI/SSTI (n = 533)	P Value
	Weighted %	Weighted %	
Infection			
SSTI		37.5	
UTI		66.3	
OAD			
Sulfonylureas	43.2	44.6	0.619
Biguanides	76.3	79.7	0.206
α -glucoside inhibitors	0.4	0.5	0.796
Thiazolidinediones	9.9	9.9	0.996
Meglitinides	0.7	0.9	0.605
DPP-4 inhibitors	12.7	14.3	0.399
SGLT2 inhibitors	1.6	2.8	0.140
Combination	10.3	8.7	0.326
Insulin	19.1	24.2	0.037
OAD adherence			
MPR, mean (SE)	0.60 (0.01)	0.62 (0.02)	0.831
Adherence (MPR $\geq$ 0.8), %	32.1	31.7	0.853

Note: N = 4,633, weighted N = 86,824,256.

DPP-4 = dipeptidyl peptidase 4; MEPS = Medical Expenditure Panel Survey;
MPR = medication possession ratio; OAD = oral antidiabetic drug; SE = standard
error; SGLT2 = sodium-glucose cotransporter 2; SSTI = skin and soft tissue
infections; UTI = urinary tract infection.

**A Payer Perspective of the Costs of Urinary Tract and Skin and Soft Tissue Infections
in Adults with Diabetes and the Relationship to Oral Antidiabetic Medication Nonadherence**

APPENDIX B Effect of UTI/SSTI and OAD Adherence on Total Health Expenses in Adults with Diabetes and Adults with Diabetes and UTI/SSTI from MEPS Pooled Years 2010-2015

Independent Variable	Dependent Variable: Total Health Expenses					
	Adults with Diabetes (N = 4,633, weighted N = 86,824,256)				Adults with Diabetes and Infection (n = 533, weighted n = 11,099,855)	
	Log Coefficient ^a (SE)	P Value	Log Coefficient ^a (SE)	P Value	Log Coefficient ^a (SE)	P Value
UTI/SSTI						
No	Reference					
Yes	0.43 (0.08)	<0.001				
OAD adherence						
No			Reference		Reference	
Yes			0.05 (0.06)	0.403	-0.06 (0.12)	0.760
Age, years						
18-45	Reference		Reference		Reference	
46-64	0.23 (0.08)	0.005	0.23 (0.08)	0.004	0.06 (0.16)	0.696
65+	0.21 (0.09)	0.015	0.23 (0.09)	0.008	0.11 (0.19)	0.566
Body mass index						
Underweight/normal	Reference		Reference		Reference	
Overweight	-0.02 (0.08)	0.804	-0.04 (0.08)	0.647	-0.26 (0.17)	0.141
Obese	0.10 (0.07)	0.135	0.10 (0.07)	0.141	0.10 (0.17)	0.570
Race						
White	Reference		Reference		Reference	
Black	-0.06 (0.06)	0.284	-0.07 (0.06)	0.148	0.06 (0.17)	0.722
Other	-0.18 (0.06)	0.003	-0.19 (0.06)	0.003	-0.15 (0.15)	0.327
Sex						
Female	Reference		Reference		Reference	
Male	-0.02 (0.05)	0.694	-0.06 (0.05)	0.238	-0.01 (0.13)	0.968
Education						
Not a high school graduate	Reference		Reference		Reference	
High school/some college	0.10 (0.06)	0.082	0.09 (0.06)	0.162	-0.04 (0.16)	0.814
College graduate	0.02 (0.08)	0.781	0.01 (0.08)	0.964	-0.14 (0.22)	0.515
Family size						
≤2	Reference		Reference		Reference	
>2	-0.32 (0.06)	<0.001	-0.34 (0.06)	<0.001	-0.55 (0.14)	<0.001
Geographic region						
Northeast	Reference		Reference		Reference	
Midwest	0.01 (0.08)	0.867	0.01 (0.08)	0.900	-0.24 (0.20)	0.231
South	-0.15 (0.07)	0.022	-0.16 (0.07)	0.024	-0.39 (0.18)	0.027
West	-0.11 (0.08)	0.162	-0.11 (0.08)	0.190	-0.31 (0.22)	0.159
Marital status						
Yes	Reference		Reference		Reference	
No	-0.06 (0.05)	0.248	-0.06 (0.05)	0.284	-0.15 (0.14)	0.306
Income^b						
High	Reference		Reference		Reference	
Middle	0.01 (0.08)	0.216	0.13 (0.10)	0.229	0.31 (0.17)	0.063
Low	-0.15 (0.07)	0.516	-0.05 (0.10)	0.635	0.35 (0.18)	0.057
Poor	-0.11 (0.08)	0.671	-0.06 (0.08)	0.487	0.03 (0.14)	0.818
Insurance coverage						
Private	Reference		Reference		Reference	
Public	0.04 (0.07)	0.584	0.02 (0.07)	0.748	-0.15 (0.14)	0.288
Uninsured	-0.80 (0.21)	<0.001	-0.83 (0.20)	<0.001	-1.52 (0.30)	<0.001

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APPENDIX B Effect of UTI/SSTI and OAD Adherence on Total Health Expenses in Adults with Diabetes and Adults with Diabetes and UTI/SSTI from MEPS Pooled Years 2010-2015 (continued)

Independent Variable	Dependent Variable: Total Health Expenses					
	Adults with Diabetes (N = 4,633, weighted N = 86,824,256)				Adults with Diabetes and Infection (n = 533, weighted n = 11,099,855)	
	Log Coefficient ^a (SE)	P Value	Log Coefficient ^a (SE)	P Value	Log Coefficient ^a (SE)	P Value
Perceived health status						
Excellent/very good	Reference		Reference		Reference	
Good	0.17 (0.08)	0.030	0.18 (0.08)	0.021	0.12 (0.17)	0.481
Fair/poor	0.49 (0.08)	<0.001	0.52 (0.08)	<0.001	0.64 (0.17)	<0.001
Comorbidity score						
0	Reference		Reference		Reference	
1	0.42 (0.06)	<0.001	0.42 (0.06)	<0.001	0.27 (0.17)	0.10
≥2	0.64 (0.06)	<0.001	0.66 (0.06)	<0.001	0.59 (0.16)	<0.001

^aGeneralized linear regression models with log link and gamma distribution were applied in the analysis.

^bPoor was defined as income <100% of FPL; low income was defined as 100%-199% of FPL; middle income was defined as 200%-399% of FPL; and high income was defined as ≥400% of FPL.

ED=emergency department; FPL=federal poverty line; MEPS=Medical Expenditure Panel Survey; SE=standard error; SSTI=skin and soft tissue infections; UTI=urinary tract infection.