

Medication Utilization and Adherence in a Health Savings Account–Eligible Plan

Paul Fronstin, PhD; Martin-J. Sepulveda, MD; and M. Christopher Roebuck, PhD, MBA

Objectives: To evaluate the impact of a consumer-directed health plan with a health savings account (CDHP-HSA) on utilization of and adherence to medications among individuals with chronic disease.

Study Design: Pre-post comparison study with matched control group (difference-in-differences analysis).

Methods: Data on workers and dependents with 1 or more of 5 chronic conditions—hypertension, dyslipidemia, diabetes, asthma/chronic obstructive pulmonary disease (COPD), and depression—were obtained from an employer that fully replaced its preferred provider organizations (PPOs) with a CDHP-HSA in 2007. A control group of participants from an employer that maintained its PPO throughout the 3-year study period (2006-2008) was created by matching on preperiod (2006) individual characteristics. Difference-in-differences estimates of the impact of the CDHP-HSA were derived by chronic condition for number of prescriptions, proportion of days covered (PDC), and an indicator for a PDC of 0.80 or higher.

Results: During the first year after implementation, enrollees with hypertension, dyslipidemia, and diabetes had significantly less medication utilization (by 1-2 prescriptions) and lower adherence rates (by 0.05-0.09 in PDC; 0.04-0.13 in the proportion adherent). These reductions abated, yet remained, after 2 years among hypertension and dyslipidemia patients. The PDC was significantly lower in patients with depression by 0.07 and 0.05 after 1 and 2 years under the new plan, respectively. No statistically significant impacts were detected on enrollees with asthma/COPD.

Conclusions: A CDHP-HSA full replacement was associated with reduced adherence for 4 of 5 conditions. If this reduced adherence is sustained, it could adversely impact productivity and medical costs.

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For author information and disclosures, see end of text.

Medication is important in the management of noncommunicable chronic diseases, which affect nearly one-half of adults and cause approximately 70% of deaths in the United States.¹ Prescription drugs accounted for 12% of healthcare spending in 2012, more than double the level of 30 years ago (5%).² In general, this shift toward greater use of pharmacotherapy has provided net societal benefits.³ For example, medical cost offsets in Medicare A and B have been documented as a result of adding drug coverage under Medicare Part D.⁴ Prior work has found that medication adherence produced substantial savings as a result of reductions in hospitalization and emergency department use, and it is thus a matter of great importance to policy makers, insurance plan sponsors, physicians, and patients.⁵

Despite clinical and economic benefits, only about half of patients take medications for their chronic conditions as recommended by their physicians.⁶ Moreover, as much as one-third of initial prescriptions go unfilled.^{7,8} For example, studies have found that more than 25% of patients with coronary artery disease discontinued drug therapy within 6 months of initiation,⁹ and adherence among patients receiving statins fell from nearly 80% within the first 3 months of treatment to only 25% after 5 years.¹⁰ Overall, adherence rates across a number of therapeutic classes have been reported at between 28% and 66% after 6 months, and 18% to 54% after 1 year.¹¹ Nonadherence has been estimated to cost the US healthcare system between \$100 billion and \$289 billion,¹² and has spawned new plan designs such as value-based insurance design to address this challenge.¹³ Public efforts to raise awareness of the adverse effects of nonadherence have also been initiated, such as the “Script Your Future” campaign of the National Consumers League.¹⁴

Medication adherence is known to be affected by out-of-pocket cost to patients.⁶ For this reason, it is important to understand medication adherence in populations enrolled in relatively new types of health plans that combine potentially high out-of-pocket costs as a result of high deductibles with tax-preferred savings accounts (consumer-directed health plans; CDHPs). First introduced in 2001 with health reimbursement arrangements (HRAs), savings account–based high-deductible plans were extended by the Medicare Modernization Act of 2003, which authorized high-deductible health plans with health savings accounts (HSAs). Both types of CDHPs have grown steadily over the past decade such that by 2011, 23% of employers had offered either an HRA- or HSA-eligible CDHP—covering

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about 21 million individuals or about 12% of the privately insured market.^{15,16} About 13.5 million individuals were in a CDHP with an HSA account by January 2012.¹⁷ Importantly, as of 2012, 8% of large employers had completely replaced their healthcare coverage with only a CDHP.¹⁸

Much of the existing literature on the impact of CDHPs on use of health services and costs focuses on HRAs.

These plans have been in existence longer, and data on HSAs are not as readily available. Moreover, several studies were limited to examining the impact of CDHP on healthcare spending.¹⁹⁻²¹ Peer-reviewed articles about the impact on prescription drug use of adopting a CDHP have largely concentrated on the number of prescription drug fills, generic and brand use, and mail order use by CDHP enrollees compared with non-CDHP enrollees.²²⁻²⁷ Sometimes, populations with specific diseases were examined.

We identified only 2 studies that report on the impact of a CDHP on medication adherence. An early study examining 1 year of data after the adoption of an HRA found that 17% of those enrolled in the highest deductible CDHP and taking medication to treat hypertension in late 2003 were no longer persistent with therapy in 2004, though adherence was unchanged among individuals who continued to take medications after moving to the CDHP.²⁸ A more recent study using data from 2005 and 2006 found that after enrolling in a CDHP (both HRAs and HSAs were examined), individuals were less likely to refill prescriptions for cardiac conditions and elevated cholesterol. The CDHP members with asthma, cardiac conditions, and high cholesterol also had reduced medication adherence and persistence with medications.²⁹

Given that CDHPs alter out-of-pocket cost for prescription drugs by subjecting them to the high deductible, one might expect this plan design to impact medication adherence. The magnitude and duration of the effect are unclear, however, because an individual with a CDHP plan may have money in an HRA or HSA, and individuals' use of these funds will influence out-of-pocket costs for prescription drugs over time. The account type, employer contribution level, account ownership, and rollover provisions will further complicate the issue.

This study evaluates the impact of adopting an HSA-eligible CDHP (CDHP-HSA) on medication adherence for individuals with chronic disease. Data come from a large manufacturer that replaced all of its existing health insurance options with a CDHP-HSA. Pre-post changes in medication adherence were derived from pharmacy claims and were com-

Take-Away Points

We examined the impact of plan design on medication utilization and adherence among individuals with chronic disease employed by a company that adopted a consumer-directed health plan (CDHP) with a health savings account (HSA) for all workers.

- During the first year after CDHP-HSA implementation, enrollees with hypertension, dyslipidemia, and diabetes had significantly less medication utilization and lower adherence rates. These reductions abated, yet remained, after 2 years among hypertension and dyslipidemia patients.
- Adherence was significantly lower in patients with depression after 2 years.
- There were no statistically significant impacts on enrollees with asthma/chronic obstructive pulmonary disease.

pared with changes in adherence in a matched control group of a second employer that did not alter its healthcare coverage.

DATA AND METHODS

CDHP Group

On January 1, 2007, a large Midwestern manufacturer fully replaced its existing preferred provider organization (PPO) health insurance plans with CDHP plans with an HSA. All active employees and their dependents were transitioned to the new plan and were given a choice between 2 annual deductible levels: \$1250 individual/\$2150 family or \$2150 individual/\$4300 family. The employer contributed the same amount to the HSA regardless of deductible level, though contributions were higher for those with family coverage.

To evaluate the impact of this plan design change on medication utilization and adherence, integrated pharmacy and medical administrative claims data, as well as enrollment information, were used. A control group was constructed, as described below, using data on another larger employer's workers, who were consistently covered under traditional PPO plans. To be included in the analysis, subjects were required to be continuously eligible for benefits during the 3-year study period (January 1, 2006, through December 31, 2008) and aged at least 18 years as of January 1, 2006, but less than 65 years as of December 31, 2008. Furthermore, individuals must have had 1 or more of 5 chronic conditions: hypertension, dyslipidemia, diabetes, asthma/chronic obstructive pulmonary disease (COPD), and depression. These conditions were chosen because they are highly prevalent, costly, and routinely managed with pharmacotherapy.³⁰ Patients were defined as having a condition if they had at least 1 inpatient or 2 outpatient claims with an *International Classification of Diseases, Clinical Modification Ninth Revision* diagnosis code for the illness and at least 1 prescription drug fill indicated for the condition in 2006. **Table 1** shows the classifications utilized. These inclusion criteria were met by 1023 CDHP-HSA enrollees with hypertension, 1184 with dyslipidemia, 314 with diabetes, 169 with asthma/COPD, and 430 with depression.

■ **Table 1.** Diagnosis Codes and Prescription Drugs Used to Define Disease Cohorts

Condition	ICD-9-CM Diagnosis Codes	Prescription Drugs
Hypertension	401.xx-405.xx	Angiotensin-converting enzyme inhibitors, aldosterone receptor blockers, alpha-1 blockers, central alpha-2 agonists, angiotensin receptor blockers, beta blockers, calcium channel blockers, diuretics, or vasodilators
Dyslipidemia	272.0-272.4	Statins, selective cholesterol absorption inhibitors, bile acid sequestrants, fibrates, or prescription-strength niacin
Diabetes	250.xx	Oral antidiabetic medications (sulfonylureas, meglitinides, biguanides, thiazolidinediones, and alpha-glucosidase inhibitors) or insulins
Asthma or chronic obstructive pulmonary disease	493.0x, 493.1x, 493.2x, 493.81, 493.82, 493.9x, 491.xx, 492.xx, 496.xx	Formulations intended for long-term (daily) use of inhaled corticosteroids and steroids, leukotriene modifiers, mast cell stabilizers, methylxanthines, anticholinergic agents, long-acting beta-2 agonists, systemic corticosteroids, or immunomodulators
Depression	300.4x, 296.2x, 296.3x, 311.xx, 309.0x, 309.1x, 309.28	Selective serotonin reuptake inhibitors, serotonin-norepinephrine reuptake inhibitors, tricyclic antidepressants

ICD-9-CM indicates *International Classification of Diseases, Ninth Revision, Clinical Modification*.

Control Group

A control group was created using data from another larger national employer. We attempted to pair each member of the CDHP group with 1 individual from the comparison pool using coarsened exact matching, a technique that reduces dimensionality through the binning of variables used in the match process.³¹ Specifically, for each chronic condition, subjects were exactly matched on baseline (2006) values of the following variables with specified cut points (in parentheses): sex; age (25, 35, 45, and 55 years); geographic region; Charlson Comorbidity Index score (0, 1, 2, 3)^{32,33}; proportion of days covered (PDC; 0.2, 0.4, 0.6, 0.8); and an indicator for whether or not the first prescription occurred after April 1, 2006 (ie, a proxy measure for a new user because the patient apparently did not have medication on hand at the beginning of 2006). Using these parameters, matches were obtained for a majority (68%-92%) of study subjects. Final sample sizes for the CDHP and control groups were 937 with hypertension, 1057 with dyslipidemia, 226 with diabetes, 115 with asthma/COPD, and 347 with depression.

Dependent Variables

Three annual measures of medication utilization and adherence were used as dependent variables: (1) the number of 30-day adjusted prescriptions filled for the condition; (2) the PDC for the condition, which represents the fraction of days in the period that the patient had at least 1 drug for the condition on hand; and 3) a flag indicating a PDC of 0.80 or higher, a commonly used threshold for adherence.⁵ Proportion of days

covered is now used, for example, by the Centers for Medicare & Medicaid Services as a quality measure component of the Star Ratings calculation for stand-alone prescription drug plans, as well as Medicare Advantage Plans.³⁴

Statistical Analysis

In addition to univariate and bivariate analyses, multivariate models were estimated using a difference-in-differences design. Specifically, for each of the 3 dependent measures, a model was specified, which included the following as independent variables: age, sex, region, Charlson Comorbidity Index score, year dummies, a CDHP group indicator, and a flag for whether or not the individual was the policy holder. Additionally, 2 interaction terms for CDHP group in 2007 and CDHP group in 2008 were entered into the equations to identify the CDHP effects in the post implementation period. Given its count properties, number of prescriptions was specified using a negative binomial model. The PDC model was estimated using ordinary least squares, and adherent was cast as a probit. In all models, standard errors were clustered by individual. Finally, marginal effect estimates of the CDHP impact in 2007 and 2008 were derived, taken at the mean of the regressors, using the delta method. All analyses were conducted using Stata release MP 12.1.³⁵

RESULTS

Characteristics of the CDHP and control groups for each of the 5 chronic diseases are shown in **Table 2**. The average age was 52 years for individuals with hypertension, dyslipid-

■ **Table 2.** Baseline Sample Characteristics (2006)^a

Characteristics	Hypertension		Dyslipidemia		Diabetes		Asthma/COPD		Depression	
	CDHP Group (n = 937)	Control Group (n = 937)	CDHP Group (n = 1057)	Control Group (n = 1057)	CDHP Group (n = 226)	Control Group (n = 226)	CDHP Group (n = 115)	Control Group (n = 115)	CDHP Group (n = 347)	Control Group (n = 347)
Age, y	51.59	51.51	51.68	51.50	51.52	51.61	43.35	42.97	44.16	43.98
Age group 18-24 y ^b	0.00	0.00	0.00	0.00	0.01	0.01	0.11	0.11	0.06	0.06
Age group 25-34 y ^b	0.01	0.01	0.01	0.01	0.01	0.01	0.10	0.10	0.10	0.10
Age group 35-44 y ^b	0.12	0.12	0.11	0.11	0.11	0.11	0.22	0.22	0.26	0.26
Age group 45-54 y ^b	0.52	0.52	0.52	0.52	0.51	0.51	0.46	0.46	0.45	0.45
Age group 55-64 y ^b	0.35	0.35	0.35	0.35	0.36	0.36	0.10	0.10	0.12	0.12
Male ^b	0.58	0.58	0.68	0.68	0.66	0.66	0.35	0.35	0.28	0.28
Policy holder	0.69	0.66	0.74	0.71	0.71	0.68	0.47	0.43	0.48	0.47
Northeast ^b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Midwest ^b	0.96	0.96	0.96	0.96	0.97	0.97	0.94	0.94	0.96	0.96
South ^b	0.03	0.03	0.03	0.03	0.02	0.02	0.06	0.06	0.03	0.03
West ^b	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01
Charlson Comorbidity Index score ^b	0.44	0.45	0.38	0.36	1.36	1.35	1.08	1.08	0.20	0.25
New user ^b	0.14	0.14	0.22	0.22	0.13	0.13	0.27	0.27	0.23	0.23
PDC, mean	0.91	0.91	0.85	0.85	0.89	0.90	0.60	0.59	0.81	0.82
PDC 0.00-0.19 ^b	0.00	0.00	0.02	0.02	0.00	0.00	0.20	0.20	0.02	0.02
PDC 0.20-0.39 ^b	0.01	0.01	0.03	0.03	0.02	0.02	0.10	0.10	0.06	0.06
PDC 0.40-0.59 ^b	0.03	0.03	0.06	0.06	0.04	0.04	0.16	0.16	0.08	0.08
PDC 0.60-0.79 ^b	0.08	0.08	0.14	0.14	0.11	0.11	0.15	0.15	0.14	0.14
PDC 0.80-1.00 ^b	0.88	0.88	0.75	0.75	0.84	0.84	0.39	0.39	0.70	0.70

CDHP indicates consumer-directed health plan; COPD, chronic obstructive pulmonary disease; PDC, proportion of days covered.

^aValues are proportions unless denoted otherwise. There were no statistically significant differences in mean values across CDHP/control groups (ie, all were $P > .10$).

^bVariables were used in the coarsened exact matching process.

emia, and diabetes, and 43 to 44 years for individuals with asthma/COPD and individuals with depression. Those with hypertension, dyslipidemia, and diabetes were more likely to be male and the policy holder compared with members with asthma/COPD and depression, who were more likely to be female and a dependent. Members were overwhelmingly from the Midwest. As reflected in the Charlson Comorbidity Index score, diabetic patients were the least healthy, followed by asthma/COPD patients.

Baseline adherence as measured by the average PDC ranged from 0.59 for asthma/COPD to 0.91 for hypertension. Using the commonly used threshold of 0.80, the percentage of patients who were adherent prior to CDHP adoption was 88% for hypertension, 75% for dyslipidemia, 84% for diabetes, 39% for asthma/COPD, and 70% for depression. As expected from the coarsened exact matching process, no statistically significant differences were observed in baseline mean values between the CDHP and control groups.

Prescription Drug Utilization and Adherence by Year/Group

Table 3 presents mean levels of the number of prescriptions, PDC, and proportion adherent ($PDC \geq 0.80$) for each of the 5 chronic diseases by year and group. By design of the matching process, baseline (2006) values were not statistically significant across the CDHP and control groups except for number of depression prescriptions—a point we will return to. With most of the chronic diseases, the 3 outcome measures decreased from 2006 to 2007 for both groups, although the 2007 levels were significantly ($P < .05$) lower in the CDHP group for all conditions except asthma/COPD. For example, the percentage of hypertension patients who were adherent fell from 88% to 73% for CDHP enrollees compared with a drop from 88% to 78% among control group members, representing a statistically significant ($P < .05$) difference of 5 percentage points. By 2008, the CDHP hypertension and depression groups had lower drug utilization and PDC than their control counter-

■ **Table 3.** Unadjusted Mean Prescription Drug Utilization and Adherence by Year/Group^a

Conditions and Measures of Adherence ^b	CDHP Group			Control Group		
	2006	2007	2008	2006	2007	2008
Hypertension						
Number of prescriptions	15.90	14.79 ^c	15.78 ^c	16.66	16.71	17.05
PDC	0.91	0.81 ^c	0.82 ^d	0.91	0.87	0.85
Adherent (PDC ≥0.80)	0.88	0.73 ^e	0.75	0.88	0.78	0.78
Dyslipidemia						
Number of prescriptions	10.66	9.32 ^c	9.39 ^c	10.80	10.78	10.67
PDC	0.85	0.70 ^c	0.68 ^c	0.85	0.79	0.76
Adherent (PDC ≥0.80)	0.75	0.54 ^c	0.54 ^c	0.75	0.67	0.64
Diabetes						
Number of prescriptions	18.15	16.05 ^c	17.63	19.07	19.25	19.18
PDC	0.89	0.78 ^c	0.79	0.90	0.85	0.83
Adherent (PDC ≥0.80)	0.84	0.62 ^c	0.68	0.84	0.75	0.73
Asthma/COPD						
Number of prescriptions	9.69	8.87	8.38	10.12	9.03	8.55
PDC	0.60	0.47	0.43	0.59	0.48	0.46
Adherent (PDC ≥0.80)	0.39	0.27	0.28	0.39	0.30	0.27
Depression						
Number of prescriptions	10.51 ^e	9.30 ^c	8.85 ^e	11.74	10.84	9.85
PDC	0.81	0.61 ^e	0.57 ^e	0.82	0.69	0.63
Adherent (PDC ≥0.80)	0.70	0.48	0.46	0.70	0.51	0.50

CDHP indicates consumer-directed health plan; COPD, chronic obstructive pulmonary disease; PDC, proportion of days covered.
^aFull replacement CDHPs commenced on January 1, 2007, for the CDHP group.
^bAll prescription drug measures were chronic condition specific. The number of prescriptions was calculated using 30-day-supply equivalents.
^c $P \leq .01$.
^d $P \leq .10$.
^e $P \leq .05$.

parts. Moreover, 2008 levels of all 3 measures for dyslipidemia were significantly ($P < .01$) lower for the CDHP group.

Regression Analysis

Table 4 presents estimates of the impact of the CDHP-HSA on prescription drug utilization and adherence in 2007 and 2008. After adjusting for the characteristics in **Table 2** using the difference-in-differences multivariate models described above, the differential changes in the mean values of the measures observed in the bivariate analysis (**Table 3**) were confirmed. Specifically, adoption of the CDHP-HSA was associated with decreases in the number of prescriptions filled, the PDC, and the percentage of individuals who were adherent to their medications in the first year for hypertension, dyslipidemia, and diabetes. The magnitudes of the reductions for these 3 chronic diseases in 2007 ranged from -1.2 to -2.4 prescriptions, -0.05 to -0.09 PDC, and -0.04 to -0.13 in the proportion of patients who were adherent. No signifi-

cant effects were detected in the asthma/COPD analyses. In patients with depression, only the PDC significantly ($P < .05$) declined, which may suggest a greater rate of first- and second-fill drop-offs (ie, the lower end of the PDC distribution) because the proportion adherent (ie, the higher end of the PDC distribution) was not significantly affected.

The reductions observed in the first year after adoption of the CDHP-HSA appear to have diminished in its second year (2008). Dyslipidemia and hypertension were the only chronic conditions in which changes after CDHP adoption persisted for 2 or more measures of drug utilization and adherence for 2 years. The PDC among CDHP enrollees with depression also remained significantly lower after 2 years. We explicitly tested whether the changes in the measures from 2007 to 2008 were statistically significant, and year-over-year improvements did emerge after CDHP-HSA implementation (**Table 4**, right-hand column). Specifically, the number of prescriptions filled for diabetes and hypertension significantly increased. More-

■ **Table 4.** Estimates of CDHP Impact on Prescription Drug Utilization and Adherence

Conditions and Measures of Adherence ^b	CDHP Effect After 1 Year (2007)	CDHP Effect After 2 Years (2008)	CDHP Effect Between Years (2007-2008)
Hypertension			
Number of prescriptions	-1.19 ^c	-0.58 ^d	0.61 ^e
PDC	-0.06 ^c	-0.03 ^c	0.02 ^c
Adherent (PDC ≥0.80)	-0.04 ^d	-0.03	0.01
Dyslipidemia			
Number of prescriptions	-1.36 ^c	-1.23 ^c	0.13
PDC	-0.09 ^c	-0.08 ^c	0.01
Adherent (PDC ≥0.80)	-0.13 ^c	-0.10 ^c	0.03 ^d
Diabetes			
Number of prescriptions	-2.43 ^c	-0.69	1.73 ^e
PDC	-0.05 ^c	-0.04	0.02
Adherent (PDC ≥0.80)	-0.1 ^e	-0.04	0.07 ^d
Asthma/COPD			
Number of prescriptions	0.18	-1.10	-1.27
PDC	-0.02	-0.06	-0.04
Adherent (PDC ≥0.80)	-0.03	-0.01	0.01
Depression			
Number of prescriptions	-0.57	-0.11	0.45
PDC	-0.07 ^c	-0.05 ^d	0.02
Adherent (PDC ≥0.80)	-0.04	-0.04	0.01

CDHP indicates consumer-directed health plan; COPD, chronic obstructive pulmonary disease; PDC, proportion of days covered.

^aPresented are marginal effects of the difference-in-differences estimators, calculated at the mean values of all other regressors, which included indicators for male, policy holder, 5 age groups, 4 geographic regions, 2 years, CDHP, and 2 CDHP times year interaction terms (presented), as well as the Charlson Comorbidity Index score. A negative binomial model was used for number of prescriptions, PDC used ordinary least squares, and adherent was specified as a probit. Statistical significance was based upon standard errors clustered by individual.

^bAll prescription drug measures were chronic condition specific. Number of prescriptions was calculated using 30-day-supply equivalents.

^c $P < .01$.

^d $P < .10$.

^e $P < .05$.

over, the proportion adherent among individuals with dyslipidemia and diabetes was 0.03 and 0.07 higher, respectively, in 2008 than in 2007, and the PDC for hypertension patients was also slightly higher.

DISCUSSION

This study evaluated the impact of a full-replacement CDHP-HSA on utilization of and adherence to medications for 5 chronic conditions. In the first year under the new plan, the number of prescriptions filled, the PDC, and the proportion of patients who were adherent declined for all conditions except asthma/COPD, although for depression, only the drop in PDC was statistically significant. These results are consistent with existing literature indicating that increased patient cost-sharing is associated with decreased health services utilization,³⁶ specifically prescription drug consumption.¹³ Except

for asthma/COPD, these effects emerged across our fairly heterogeneous set of conditions, a finding also consistent with prior work.^{28,29} During the second year of the new plan, CDHP-HSA effects persisted in individuals with hypertension, dyslipidemia, and depression, but levels were not as low due to some significant increases in utilization and adherence from year 1 to year 2, particularly among patients with diabetes. It is possible that second-year improvements were due to members learning about the importance of medication adherence and the parameters of their new CDHP. Alternatively, beneficiaries may have had residual funds in their HSAs—rolled over from the first year—that they used to purchase more prescription drugs.

These findings have important policy implications. Notwithstanding the presence of HSAs and employer contributions, medication utilization and adherence declined when high deductibles were imposed. If these reduced levels of medication

adherence for chronic conditions are sustained, it is likely that they will increase medical costs and adversely impact worker productivity.^{13,37} This cost-shift impact on adherence may be mitigated by designing CDHPs with first-dollar coverage for chronic disease medications using HRAs. Regulatory change is required for first-dollar coverage for HSA-associated CDHPs, as exemptions to the deductible are governed by law. Finally, it appears prudent for plan sponsors to provide education and ongoing support to encourage appropriate use of account funds so that prescription drug use for chronic conditions is prioritized by members, even when budgets are stressed.

Our study has several strengths, the first of which is the use of a matched comparison group of employees of another company that did not alter health benefits. This group allowed for statistical control of some common medication utilization and adherence confounders such as demographics, general health status, and underlying secular trends in prescription drug supply and demand. Moreover, because the study employer fully replaced existing coverage for all employees, our results are robust to selection bias, which often plagues analysis of enrollees in CDHPs introduced as alternatives to other plans. Our study also extends the CDHP literature by reporting on experience under an HSA, as opposed to the more commonly studied HRA-linked CDHP. Finally, the examination of 2 years of data after CDHP-HSA adoption is key because we found some increases and differential effects in the second year.

Our study also has several limitations. Because our study cohort was a single manufacturing employer concentrated in the Midwest, results may not be generalizable to the broader population of national employment-based health plans implementing CDHP-HSAs. Furthermore, although a control group was utilized in the analysis, estimated impacts might still be biased if unobserved characteristics correlated with CDHP were also associated with medication utilization and adherence. For example, if despite being paired with individuals similar with respect to demographics, disease burden, and baseline utilization/adherence rates, socioeconomic status was significantly different for CDHP members compared with control group participants, then our estimates could remain biased, given this factor's influence on health-related behavior. Participant-level income data were not available for analysis, nor was the pool of members used in the matching process large enough to include geo-linked sociodemographic variables.

Similarly, although we matched on Charlson Comorbidity Index score, it is still possible that CDHP and control group members had different comorbidities at baseline, including but not limited to the diseases under study. If true, results might be biased if patients chose to decrease prescription drug utilization for some conditions (eg, asymptomatic ones) over others. We conducted an exploratory re-analysis of the multivariate

models on subsamples of individuals with more than 1 of the 5 chronic diseases. While results were qualitatively similar, differences in effect sizes suggest that individuals may make trade-offs among their concomitant therapies when faced with plan design changes that alter out-of-pocket costs. On a related note, depression has been identified as a risk factor for medication nonadherence in patients with other comorbidities.³⁸ Compared with the CDHP cohort, the depression control group had 12% more 30-day adjusted prescriptions at baseline, yet was nearly identical in terms of PDC. This indicates that the 2 groups differed slightly in terms of either their concomitant use or switching of antidepressants, which may suggest a difference in depression severity. Future research should delve more deeply into how patients with greater disease burden respond to increased cost sharing.

Another limitation is that we interpreted the medication utilization and adherence effects as being due to the newly adopted CDHP-HSA itself, or more specifically, the high deductible. It is possible that the plan's newness itself caused these disruptions. Prior research has found that preventive services not subject to the deductible were associated with lower use of those services after a CDHP was adopted.¹⁹ However, a portion of our control group also likely changed plans during the study period. Therefore, plan change would not be a plausible explanation for persistent second-year impacts. Finally, we did not possess data on HSA balances and could not address key questions related to account dynamics such as contributions, withdrawals, and roll-overs, and their association if any with medication utilization by account holders and their enrolled dependents.

Broader implementation of CDHPs is likely as health-care costs continue their upward climb.¹⁸ To ensure that these plans deliver on their promise of wiser consumption of health services while supporting chronic care needs including medication, better insight into longer-term behaviors under CDHPs is needed. Studying lengthier time periods before and after CDHP adoption, and unraveling the influences of socioeconomic and multimorbidity profiles, are good candidates for future research. Collection of biometric data—including side effect profiles—would be highly valuable to allow researchers to tease apart the causes of medication nonadherence.

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Address correspondence to: Paul Fronstin, PhD, Director, Health Research and Education Program, Employee Benefit Research Institute, 1100 13th St, NW, Ste 878, Washington, DC 20005. E-mail: Fronstin@ebri.org.

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