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ORIGINAL ARTICLE

Impact of High Deductible Health Plans on Cardiovascular Medication Adherence and Health Disparities

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BACKGROUND: High deductible health plans (HDHP) are associated with high levels of patient cost-sharing and are becoming increasingly used in the United Status as a means of reducing healthcare utilization and spending. Our objective is to determine whether HDHP enrollment is associated with a change in adherence to evidence-based medications to treat cardiovascular risk factors and whether such changes vary based on race/ethnicity or socioeconomic status.

METHODS AND RESULTS: We conducted a retrospective cohort study using an interrupted time series with concurrent control group design among beneficiaries of Aetna—a national commercial insurer. We included 14 866 patients who filled prescriptions for medications to treat hypertension, high cholesterol, or diabetes mellitus between 2009 and 2014 and who switched from a traditional plan into an HDHP and 14 866 controls who did not switch to an HDHP matched based on calendar time, medication class, race/ethnicity, socioeconomic status, and propensity score. We were specifically interested in evaluating 4 prespecified subgroups based on race/ethnicity (white versus nonwhite) and socioeconomic status (higher versus lower). The main outcome was medication adherence as measured by proportion of days covered. The overall cohort had an average age of 53 years, and 44% were women. Baseline adherence was the lowest in the nonwhite patient group. Switching to an HDHP was associated with a decrease in the level of adherence of 5 percentage points across all 4 subgroups (change in level, –5.0%; 95% CI, –5.9% to –4.0%; $P<0.0001$).

CONCLUSIONS: HDHP enrollment was associated with a reduction in adherence to medications to treat cardiovascular risk factors. The magnitude of this effect did not vary based on race/ethnicity or socioeconomic status. Because racial/ethnic minorities have lower rates of medication adherence, future studies should evaluate whether HDHP-associated changes in adherence have greater clinical consequences for these patients.

Key Words: health policy ■ humans ■ medication adherence ■ risk factors ■ social class

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WHAT IS KNOWN

- High deductible health plans are one of the fastest growing health insurance plans in the country and are designed to make patients more cost-conscious about the care they seek.
- Individuals enrolled in high deductible health plans use less medical care compared with those enrolled in traditional health plans. Low-income individuals may be at higher risk of reducing the use of medically necessary care.

WHAT THE STUDY ADDS

- High deductible health plan enrollment is associated with an absolute 5% point drop in the level of adherence to evidence-based medications for hypertension, high cholesterol, and diabetes mellitus compared with individuals who did not switch insurance plans. This effect does not change by race/ethnicity (white versus nonwhite) or socioeconomic status (high versus lower).
- Features of plan design, such as enrollment in a health savings account or health reimbursement account, are associated with different effects on medication adherence and need to be more closely studied.

Cardiovascular disease is the leading cause of death in the United States. Deaths from cardiovascular disease have declined by almost 50% during the past few decades due in large part to control of cardiovascular risk factors, such as hypertension, high cholesterol, and diabetes mellitus.[1–3] The burden of these chronic conditions is growing and threatens to reverse some of the gains achieved in improved cardiovascular outcomes.[4,5] Ongoing risk factor management with lifestyle interventions and evidence-based medications is necessary, and understanding how changes in health insurance coverage may impact medication use and disease control is critical.

High deductible health plans (HDHPs) are increasingly used in the group and individual health insurance market as a way to regulate healthcare spending. Almost 30% of workers with employee-sponsored health insurance are enrolled in HDHPs—a 45% increase during the past 2 years.[6] In the Affordable Care Act marketplace, almost 90% of enrollees are in plans that qualify as an HDHP, not accounting for tax credits for cost-sharing reductions.[7] Such plans are associated with lower monthly premiums and begin paying insurance benefits only after an individual's out-of-pocket spending has exceeded her or his deductible amount. To qualify as an HDHP, plans must meet a minimum deductible set by the Internal Revenue Service, which was $1300 for an individual and $2600 for a family in 2016. In practice, actual deductibles can be far higher.[7]

By requiring patients to shoulder a larger proportion of total healthcare costs through out-of-pocket deductibles, HDHPs are designed to make patients more cost-conscious about the care they seek.[8] Consistent with this theory, HDHPs reduce ambulatory outpatient visits,[9–11] emergency department visits,[12] diagnostic imaging,[13] and medication use.[10,14,15] However, in addition to encouraging patients to reduce their utilization of potentially unnecessary care, HDHPs can have the unintended consequence of also reducing the utilization of high-value health services.[11,16,17]

HDHPs have historically been chosen by individuals who were healthier, wealthier, and more highly educated. As these plans increasingly become the only health plan option offered by employers or essentially the only affordable health plan option, an increasing number of more vulnerable patients are expected to enroll in HDHPs, which may worsen health disparities.[17,18] Existing data from single employers in the Midwest[11] and insurance plans in Massachusetts[12,16,19] and California[20] suggest that lower income individuals are at particular risk for the adverse effects of HDHP. Racial/ethnic minorities are also disproportionally affected by high cost-sharing, even when socioeconomic status (SES) is taken into account,[21,22] yet the impact of HDHPs for these populations has not been rigorously evaluated. This is of particular importance as interventions to minimize cost-sharing have had greater success in nonwhite patient groups.[23,24]

METHODS

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure.

Setting and Design

We used an interrupted time series with concurrent control group design to evaluate the impact of switching to an HDHP on adherence to evidence-based medicines for cardiovascular risk factors, specifically, hypertension, high cholesterol, and diabetes mellitus among patients insured by a large national insurer. Specifically, we examined how adherence changed based on race/ethnicity and SES. This design allows us to compare actual adherence rates after HDHP switch to rates that would have been expected if the preswitch adherence rates were projected into the future, while controlling for trends in a comparison population that did not change insurance benefits.

Our study cohort consisted of commercially insured individuals, whose medical and prescription drug insurance benefits were administered by Aetna—a large national insurer that covers >20 million individuals in all 50 states. The HDHPs included in this study were all offered with a savings option, either a Health Savings Account (HSA) or Health Reimbursement Account (HRA). Both accounts allow the beneficiary (HSA) or employer (HRA) to apply tax-exempt funds to cover out-of-pocket costs for qualified medical expenses, such as deductibles, copayments, or coinsurance amounts.

The study was approved by the Brigham and Women's Hospital Institutional Review Board.

HDHP Cohort

We identified all beneficiaries >18 years of age who switched from a typical health insurance plan to an HDHP between January 2009 and March 2014. For each HDHP member, we identified the HDHP switch date—a preswitch baseline period of ≤15 months and a postswitch follow-up period of ≤12 months. Patients were required to contribute a minimum of 1 month to the preswitch (in addition to at least 6 months of baseline eligibility) and 1 month to the postswitch period.

We restricted our cohort to individuals who filled at least 1 prescription for a medication to treat hypertension, high cholesterol, or diabetes mellitus (Table S1 in the Data Supplement) in the 15-month period before their HDHP switch date and who had at least 6 months of continuous eligibility before the first fill of this medication. Patients could be new or prevalent users and could enter the cohort at any time before switch as long as they filled an eligible prescription and met the inclusion criteria above. If patients had multiple medications that qualified them to enter the cohort, we chose 1 class at random so that each patient was represented in the cohort once and defined their first fill date as their index date (see Table S1 in the Data Supplement for included medication classes).

To ensure that we only included individuals who switched from a typical health plan to an HDHP, we excluded all individuals whose preswitch plans had high levels of out-of-pocket spending. To do this, we calculated, on a monthly basis, the ratio of the total deductible amount paid by all members of each non-HDHP plan by the total allowed amounts for the beneficiaries of that plan. If this ratio was ≥0.6 during any month, we excluded the plan and all of its members from the cohort. We chose 0.6 as a conservative estimate based on the actuarial value of bronze marketplace plans.[25] In addition, we excluded patients who switched plan sponsors or had multiple sponsors, as well as patients with missing demographic data, including race/ethnicity and ZIP codes (Figure 1).

Control Cohort

We created the control cohort by identifying all Aetna beneficiaries who filled at least 1 eligible prescription during the same eligibility period as for the HDHP cohort but who did not enroll in an HDHP. As for HDHP subjects, potential controls were required to have had at least 6 months of continuous eligibility before their index date. We also excluded patients enrolled in plans with high out-of-pocket spending, who switched plan sponsors or were missing key demographic data.

We matched potential controls to HDHP subjects based on calendar time of index date, medication class, race/ethnicity, SES status (lower versus higher), and a propensity score estimated using a logistic regression model based on baseline covariates in Table 1. Subjects were matched to controls in a 1:1 ratio using a nearest neighbor algorithm and within a caliper width of 0.05 on the propensity score. Matching on additional baseline characteristics in addition to the propensity score allowed the race/ethnicity and SES subgroups to be well balanced with regard to baseline characteristics. We allowed controls to enter the cohort multiple times; however, they were only allowed to be matched to an HDHP cohort member once. After matching, controls were assigned the same switch date as the matched HDHP cohort member.

Covariates

We measured baseline patient characteristics in the 6-month period before the index date for all patients in our cohort.

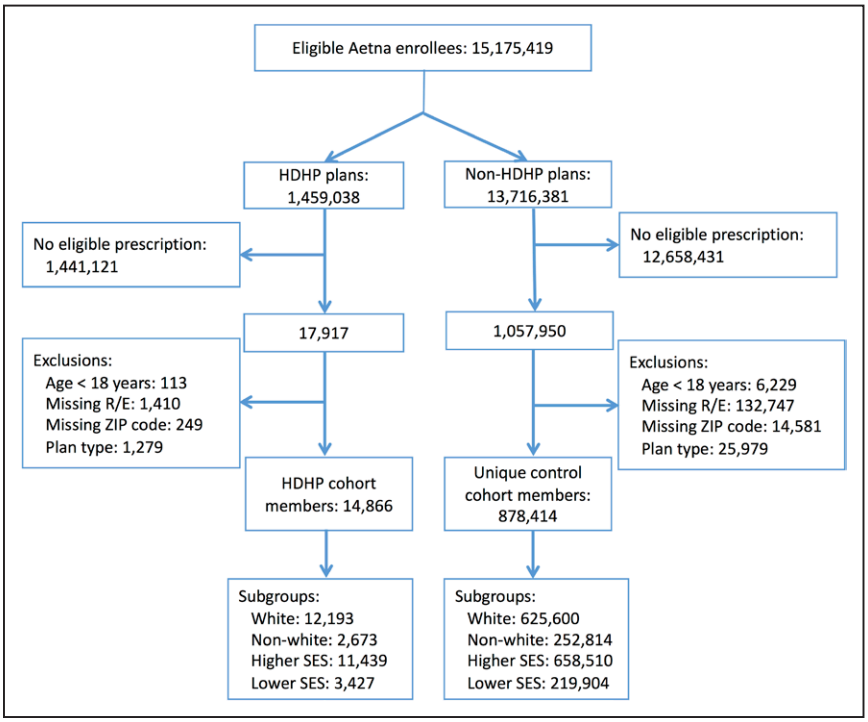

Figure 1. Consort diagram of patients included in the high deductible health plan (HDHP) and control cohorts.
Each Aetna enrollee can exist multiple times within the control cohort until matched; unique control cohort members are presented here. R/E indicates race/ethnicity; and SES, socioeconomic status.

Table 1. Baseline Characteristics After Matching Among White, Nonwhite, Higher SES, and Lower SES HDHP and Control Cohorts

	Race/Ethnicity				SES			
	White		Nonwhite		Higher SES		Lower SES	
	HDHP	Control	HDHP	Control	HDHP	Control	HDHP	Control
	n=11848	n=11848	n=2464	n=2464	n=11076	n=11076	n=3236	n=3236
Age, y	52.9 (9.5)	53.8 (10.0)	50.6 (9.8)	51.0 (10.1)	52.6 (9.6)	53.4 (10.03)	52.4 (9.6)	53.0 (10.2)
Women, n (%)	5307 (44.8%)	5063 (42.7%)	1189 (48.3%)	1172 (47.6%)	4925 (44.5%)	4757 (42.95%)	1571 (48.6%)	1478 (45.7%)
Cohort year								
2009	3580	3580	663	663	3287	3287	956	956
2010	2404	2404	471	471	2240	2240	635	635
2011	2261	2261	491	491	2213	2213	539	539
2012	2300	2300	511	511	2092	2092	719	719
2013	1303	1303	328	328	1244	1244	387	387
Region, n (%)								
Northeast	3378 (28.5%)	3416 (28.8%)	645 (26.2%)	545 (22.1%)	3111 (28.1%)	3365 (30.4%)	912 (28.2%)*	596 (18.42%)*
South	3805 (32.1%)	3922 (33.1%)	1023 (41.5%)	987 (40.1%)	3349 (30.2%)	3355 (30.3%)	1479 (45.7%)	1554 (48.02%)
Midwest	1812 (15.3%)	1872 (15.8%)	198 (8.0%)	200 (8.1%)	1630 (14.7%)	1570 (14.2%)	380 (11.7%)*	502 (15.51%)*
West	2853 (24.1%)	2638 (22.3%)	598 (24.3%)*	732 (29.7%)*	2986 (27.0%)	2786 (25.1%)	465 (14.4%)	584 (18.05%)
Race/ethnicity, n (%)								
White	11848 (100%)	11848 (100%)	0	0	9366 (84.6%)	9366 (84.6%)	2482 (76.7%)	2482 (76.7%)
Black	0	0	527 (21.39%)	527 (21.39%)	295 (2.7%)	295 (2.7%)	232 (7.2%)	232 (7.2%)
Hispanic	0	0	723 (29.34%)	723 (29.34%)	408 (3.7%)	408 (3.7%)	315 (9.7%)	315 (9.7%)
Other	0	0	1214 (49.3%)	1214 (49.3%)	1007 (9.1%)	1007 (9.1%)	207 (6.4%)	207 (6.4%)
Socioeconomic characteristics								
Median household income, $	72697 (26784)	71939 (26241)	65236 (25872)	64998 (24814)	80112 (24076)	79224 (23485)	41637 (6453)	41720 (6610)
Lower SES, n (%)	2482 (21.0%)	2482 (21.0%)	754 (30.60%)	754 (30.60%)	0	0	3236 (100%)	3236 (100%)
Proportion of households below poverty level in ZIP code	10.4 (7.0)	10.7 (7.2)	15.0 (9.8)	14.9 (9.8)	8.47 (4.95)	8.48 (4.85)	20.40 (8.41)*	21.34 (8.25)*
Proportion of high-school graduates in ZIP code	89.9 (7.1)	89.6 (7.0)	83.8 (11.8)	83.8 (11.9)	91.22 (5.88)	91.16 (5.72)	80.54 (10.27)	79.72 (9.69)
Combined comorbidity score	0.01 (1.10)	−0.04 (1.09)	−0.01 (1.12)	−0.07 (1.03)	0.01 (1.10)	−0.04 (1.07)	−0.02 (1.12)	−0.03 (1.12)
Coexisting illnesses, n (%)								
Hypertension	5805 (49.0%)	6385 (53.9%)	1303 (52.88%)	1343 (54.50%)	5324 (48.1%)	5888 (53.2%)	1784 (55.1%)	1840 (56.9%)
Heart failure	161 (1.4%)	187 (1.6%)	49 (1.99%)	41 (1.66%)	152 (1.4%)	163 (1.5%)	58 (1.8%)	65 (2.0%)
Coronary artery disease	1040 (8.8%)	1206 (10.2%)	207 (8.40%)	179 (7.26%)	943 (8.5%)	1078 (9.7%)	304 (9.4%)	307 (9.5%)
Type 2 diabetes mellitus	1744 (14.7%)	2038 (17.2%)	531 (21.55%)	608 (24.68%)	1661 (15.0%)	1948 (17.6%)	614 (19.0%)	698 (21.6%)
Lipid disorder	3726 (31.5%)	3964 (33.5%)	747 (30.32%)	738 (29.95%)	3397 (30.7%)	3677 (33.2%)	1076 (33.3%)	1025 (31.7%)
COPD	500 (4.2%)	536 (4.5%)	85 (3.45%)	65 (2.64%)	418 (3.8%)	435 (3.9%)	167 (5.2%)	166 (5.1%)
Cancer	1627 (13.7%)	1650 (13.9%)	222 (9.01%)	158 (6.41%)	1508 (13.6%)	1479 (13.4%)	341 (10.5%)	329 (10.2%)
Chronic renal insufficiency	220 (1.9%)	237 (2.0%)	58 (2.35%)	55 (2.23%)	216 (2.0%)	223 (2.0%)	62 (1.9%)	69 (2.1%)
Healthcare utilization†								
No. of distinct medications	4.70 (3.76)	4.88 (3.83)	4.20 (3.56)	4.29 (3.56)	4.61 (3.71)	4.78 (3.79)	4.62 (3.81)	4.78 (3.82)

(*Continued*)

Table 1. Continued

	Race/Ethnicity				SES			
	White		Nonwhite		Higher SES		Lower SES	
	HDHP	Control	HDHP	Control	HDHP	Control	HDHP	Control
	n=11848	n=11848	n=2464	n=2464	n=11076	n=11076	n=3236	n=3236
No. of hospitalizations	0.05 (0.26)	0.05 (0.26)	0.06 (0.30)	0.04 (0.23)	0.05 (0.27)	0.05 (0.26)	0.06 (0.26)	0.05 (0.25)
No. of office visits	5.66 (7.17)	5.51 (6.69)	4.84 (6.02)	4.63 (6.82)	5.63 (7.14)	5.50 (6.82)	5.12 (6.45)	4.85 (6.35)
No. of emergency room visits	0.12 (0.46)	0.11 (0.46)	0.14 (0.48)	0.15 (0.47)	0.11 (0.43)	0.11 (0.44)	0.14 (0.56)	0.15 (0.52)
Insurance medical spending, $	3823 (14689)	3744 (16803)	3896 (16317)	3603 (27948)	3787 (14699)	3802 (20703)	3998 (15913)	3436 (12696)
Out-of-pocket medical spending, $	576 (1052)	550 (1013)	519 (1049)	424 (910)	557 (1035)	536 (996)	596 (1105)	502 (1000)
Medical deductible spending > $300, n (%)	2945 (24.9%)	2838 (24.0%)	534 (21.67%)	450 (18.26%)	2654 (23.9%)	2602 (23.5%)	825 (25.49%)	686 (21.20%)
Medication use,† n (%)								
ACE inhibitor/ARB	3389 (28.6%)	3772 (31.8%)	689 (27.96%)	758 (30.76%)	3117 (28.1%)	3501 (31.6%)	961 (29.70%)	1029 (31.80%)
β-Blocker	2479 (20.9%)	2684 (22.7%)	471 (19.12%)	474 (19.24%)	2256 (20.4%)	2431 (22.0%)	694 (21.45%)	727 (22.47%)
Calcium channel blocker	1305 (11.0%)	1513 (12.8%)	341 (13.84%)	417 (16.92%)	1234 (11.1%)	1437 (13.0%)	412 (12.73%)	493 (15.23%)
Thiazide diuretic	2645 (22.3%)	3039 (25.7%)	582 (23.62%)	646 (26.22%)	2419 (21.8%)	2803 (25.3%)	808 (24.97%)	882 (27.26%)
Ezetimibe	579 (4.9%)	704 (5.9%)	79 (3.21%)	84 (3.41%)	530 (4.8%)	634 (5.7%)	128 (3.96%)	154 (4.76%)
Statin	5122 (43.2%)	5243 (44.3%)	854 (34.66%)	883 (35.84%)	4784 (43.2%)	4882 (44.1%)	1192 (36.84%)	1244 (38.44%)
DPP-4 inhibitor	269 (2.3%)	315 (2.7%)	67 (2.72%)	88 (3.57%)	261 (2.4%)	301 (2.7%)	75 (2.32%)	102 (3.15%)
Metformin	1077 (9.1%)	1269 (10.7%)	318 (12.91%)	372 (15.10%)	1046 (9.4%)	1217 (11.0%)	349 (10.78%)	424 (13.10%)
Sulfonylurea	386 (3.3%)	554 (4.7%)	133 (5.40%)	179 (7.26%)	367 (3.3%)	522 (4.7%)	152 (4.70%)	211 (6.52%)
Thiazoledinedione	241 (2.0%)	360 (3.0%)	73 (2.96%)	109 (4.42%)	249 (2.3%)	350 (3.2%)	65 (2.01%)	119 (3.68%)
Health plan characteristics, n (%)								
Large health plan	8302 (70.1%)	8312 (70.2%)	1869 (75.9%)	1916 (77.8%)	8038 (72.6%)	7900 (71.3%)	2133 (65.9%)*	2328 (71.9%)*
HDHP characteristics, n (%)‡								
Full replacement HDHP	5520 (46.6%)		1037 (42.09%)		4882 (44.1%)		1675 (51.8%)	
HSA-eligible HDHP	10214 (86.2%)		1937 (78.61%)		9444 (85.3%)		2707 (83.7%)	
HRA-eligible HDHP	1634 (13.8%)		527 (21.39%)		1632 (14.7%)		529 (16.4%)	

All values are mean (SD) unless otherwise indicated. ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; COPD, chronic obstructive pulmonary disease; DPP-4, dipeptidyl peptidase-4; HDHP, high deductible health plan; HRA, health reimbursement account; HSA, health savings account; and SES, socioeconomic status.

*After matching the standardized differences between the HDHP and control cohorts was ≤0.1 for all variables except as indicated.

†During the 180 days before index date.

‡Variables not used in matching or PS.

Demographic variables were collected from the enrollment files. Race/ethnicity data were provided by Aetna and were obtained either through self-report or estimated by Aetna using the Bayesian Improved Surname Geocoding method.[26] This method links an individual's address and surname to the US Census data to infer race/ethnicity and is highly correlated to self-reported race/ethnicity.[26] Approximately 40% of the matched cohort had self-reported race available.

We linked patient ZIP code to 2010 US Census data to determine several community-level variables, including geographic region, median household income, and high-school graduation rates. Patients were characterized as having lower SES status if median household income was in the lowest quartile of the entire cohort. Healthcare utilization variables and clinical comorbidities are listed in Table 1. We assessed clinical comorbidities using *International Classification of Diseases*, *Ninth Revision* codes on the basis of medical service and pharmacy claims at any time during enrollment up until the index date. We also used a comorbidity score that captures general health status and combines conditions included in both the Charlson index and Elixhauser system.[27]

Outcomes

Our primary outcome was medication adherence. We measured adherence based on prescriptions actually filled by estimating the number of days of medication available or the proportion of days covered in each month between the index date until the end of follow-up.[24] To do this, we created a supply diary for each patient-day by aggregating consecutive fills of each medication class being studied based on dispensing dates, quantity dispensed, and reported days' supply. The proportion of days covered was calculated by dividing the number of days of medication available to each patient within a given month by the number of calendar days in that month. In the first month that a patient enters the study cohort, they are by definition given credit for being adherent for most of that month. In total, 30% of the cohort (8850 patients) entered the cohort during the first month of the baseline period with the rest of the cohort entering in during the course of the remaining baseline period. Because adherence decreases among those who are already in the cohort and is proportional to the duration of time that the medication is prescribed, average adherence falls until the point that no new patients are entering the cohort (ie, right before the HDHP switch date). This trend is well documented in other observational studies of adherence using pharmacy claims.[28–30] Medications within the same class based on mechanism of action (eg, β-blockers) were considered to be interchangeable. Patients were censored at the time of death, loss of enrollment, or 365 days after switch date, whichever occurred first. We also measured full adherence to index medication class, as assessed by the proportion of days covered ≥80%. This is a widely used threshold at which patients appear to derive adequate clinical benefit from most medications.[31]

Statistical Analysis

We plotted monthly adherence rates for the HDHP and control groups before and after HDHP switch date, stratified by race/ethnicity (white versus nonwhite) and SES (higher versus lower). We then used segmented linear regression models to compare the change in level and slope of adherence before and after the HDHP switch as compared with controls in each of the 4 subgroups. Interaction terms with race and SES were modeled separately using the entire cohort. We used generalized estimating equations with exchangeable correlation structure assuming normally distributed errors to adjust for the repeated measurements of adherence for each individual. We modeled full adherence using binomially distributed errors and logit link function. We eliminated a 2-month transition period from the analysis, the last month before HDHP switch and the first month after switching. We eliminated this transition period because patient behavior may change immediately before or after switching insurance plans. Interaction terms were included for all models to test for effect modification. An interaction term P value <0.05 was considered statistically significant. We used SAS 9.4 software for all analyses.

Sensitivity Analyses

The HDHP cohort included patients who selected to switch into an HDHP, as well as patients who were required to switch by their employer. Given the potential for selection effects, we conducted a number of preplanned subgroup analyses. We repeated our analysis in patients who were required to switch, as assessed by enrollment in a full replacement HDHP, defined as those plans in which >70% of beneficiaries enrolled in an HDHP. Patients not enrolled in a full replacement plan were considered to have chosen an HDHP. We recalculated the propensity score and repeated the matching algorithm and analysis among all HDHP cohort members who were and were not enrolled in full replacement plans, as well as among HDHP enrollees who participated in an HSA- versus HRA-eligible plan.

We repeated our analysis by censoring both members of a matched pair at the time when one of them was censored. We also repeated the model without the slope term (difference in differences analysis). These results were similar to our primary analysis and are presented in Tables S6 and S7 in the Data Supplement.

RESULTS

Study Cohort and Baseline Characteristics

Among >15 million beneficiaries, almost 1.5 million enrolled in an HDHP during our study period (Figure 1). Baseline characteristics of the HDHP cohort and potential controls, before matching, are presented in Tables S2 through S5 in the Data Supplement. The baseline characteristics after matching are presented in Table 1. Approximately 18% were nonwhite, and 23% were considered lower SES. Proportions of patients matched were high (>90%) in all 4 subgroups.

The overall age was 53 years, and slightly less than half of the cohort was female. Approximately half of the patients had a diagnosis code for hypertension, a third had a lipid disorder, and slightly less than a fifth had diabetes mellitus. HDHPs associated with an HSA were far more common than HDHPs associated with an HRA (85% versus 15% of all HDHPs, respectively). Compared with whites, nonwhite patients were younger (51 versus 53 years of age, respectively) and had higher rates of hypertension and diabetes mellitus compared with white patients. Lower SES patients were more likely to live in the South and had a median household income that was almost half of that of high SES patients.

Medication Adherence

Baseline adherence rates to evidence-based medications were well matched in the HDHP and control cohorts (Figure 2). Adherence was low in all 4 subgroups and decreased over time (Figure 2; Table 2). Overall, switching to an HDHP was associated with a decrease in the level of adherence of 5% points compared with control patients who did not switch plans (change in level, –5.0%; 95% CI, –5.9% to –4.0%; P<0.0001). The time trend of adherence rate (slope) increased slightly across the entire cohort at 0.21% per month (0.21; 95% CI, 0.1–0.32; P=0.0001). The odds

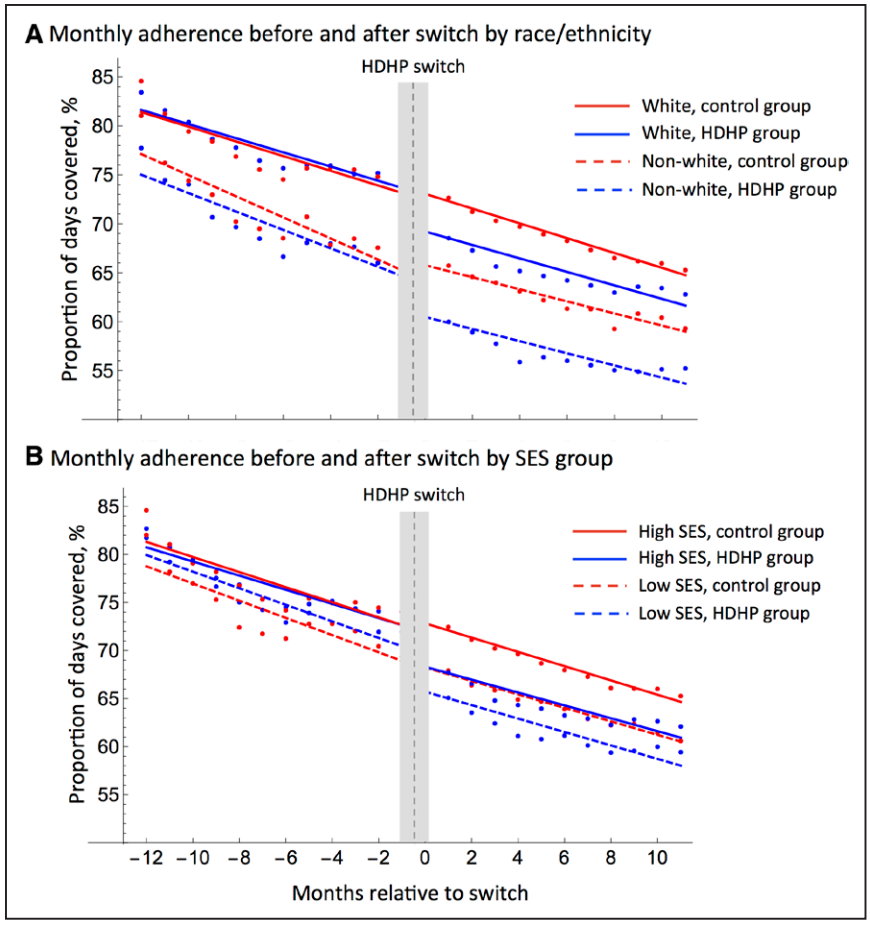

Figure 2. Switching to high deductible health plan (HDHP) decreases adherence among white and nonwhite groups (A) and higher and lower socioeconomic status (SES) groups (B).

of full adherence decreased by 20% (95% CI, 0.76–0.83; *P*<0.0001).

Baseline adherence during the 12 months before HDHP enrollment in the nonwhite cohort was lower than in the white cohort (70% versus 77%). HDHP enrollment was associated with similar decrease in the level of adherence in nonwhite and white patients (–4.6% and –5.0%, respectively) compared with patients in the control cohort. The time trend of adherence rate (slope) increased slightly in both groups (0.17% and 0.22% per month, respectively). The interaction terms between nonwhite and white

Table 2. Change in Adherence as a Function of Race/Ethnicity and SES

All Plans	Entire Cohort	Race/Ethnicity			SES		
		White	Nonwhite	Interaction Term *P* Value	Higher SES	Lower SES	Interaction Term *P* Value
PDC							
Change in level (%)	–5.0 (–5.9 to –4.0)*	–5.0 (–6.1 to –4.0)*	–4.6 (–7.0 to –2.2)†	0.61	–5.2 (–6.4 to –4.1)*	–4.9 (–7.2 to –2.7)*	0.37
Change in slope (percentage per month)	0.21 (0.1 to 0.32)†	0.22 (0.1 to 0.34)†	0.17 (–0.09 to 0.44)	0.95	0.21 (0.09 to 0.34)‡	0.21 (–0.03 to 0.44)	0.76
Odds of full adherence							
Change in level (%)	0.80 (0.76 to 0.83)*	0.79 (0.75 to 0.83)*	0.81 (0.73 to 0.89)*	0.85	0.78 (0.74 to 0.82)*	0.85 (0.77 to 0.93)‡	0.47
Change in slope (percentage per month)	1.01 (1.00 to 1.01)†	1.01 (1.00 to 1.01)†	1.01 (1.00 to 1.02)	0.23	1.01 (1.01 to 1.02)†	1.01 (1.00 to 1.02)	0.56

Changes in level and slope represent percentage point change (level) and percentage point change per month (slope) with 95% CIs. Odds of full adherence represents the odds ratio with 95% CI. Interaction term is considered significant at *P*<0.5. PDC indicates proportion of days covered; and SES, socioeconomic status.

*<0.0001.

†<0.003.

‡<0.05.

patients were not significant for adherence level (*P*=0.61) and slope (*P*=0.95).

In the lower SES and higher SES HDHP cohorts, baseline adherence was similar (75% versus 77%, respectively), and HDHP enrollment was associated with similar changes in the level (–4.9% and –5.2%, respectively; interaction term *P*=0.37) and slope (0.21% per month for both; interaction term *P*=0.76) of adherence. The change in the odds of full adherence also did not differ significantly between nonwhites and whites (interaction term *P*=0.85) and low SES and high SES patients (interaction term *P*=0.47).

Sensitivity Analyses

Results of our sensitivity analyses are presented in Table 3. Among patients enrolled in full replacement plans (patients without plan choice), adherence levels decreased more substantially among nonwhites compared with whites (7.7% versus 2.8%, respectively) after HDHP enrollment compared with controls, although the interaction term was not significant (*P*=0.23). Changes in adherence levels were similar among low and high SES patients (interaction term *P*=0.65). Among patients not enrolled in full replacement plans (patients with plan choice), adherence levels decreased to a greater extent among low SES (–6.7%) compared with high SES (–4.4%) patients compared with controls, although again the interaction term was not significant (*P*=0.12).

HDHP enrollment among patients enrolled in HSA-eligible plans was associated with a similar decrease in adherence level and odds of full adherence as compared with the primary analysis. Among patients enrolled in HRA-eligible plans, HDHP enrollment was not associated with a statistically significant decrease in adherence level, slope of adherence, or odds of full adherence in the entire cohort or any of the race/ethnicity or SES groups.

DISCUSSION

In our study of commercially insured beneficiaries of a large national insurer, we found enrollment in an HDHP was associated with an absolute 5 percentage point drop in the level of adherence to evidence-based medications for hypertension, high cholesterol, and diabetes mellitus compared with individuals who did not switch insurance plans. HDHP enrollment was also associated with a 20% relative decrease in the odds of full adherence. The impact was similar for vulnerable patient groups (nonwhite and lower SES patients) compared with nonvulnerable patient groups (white and high SES patients). Adherence rates decreased substantially over time, consistent with established patterns in chronic medication use[28] and were lower in nonwhite patients compared with whites at all time points. By the end of follow-up, the average adherence was 55% in nonwhites compared with 63% among whites. Lower adherence levels among nonwhite patient groups have been well documented and may in part explain why cardiovascular morbidity and mortality is higher in this patient population.[23,32]

In patients with and without preexisting cardiovascular disease, nonadherence to the medication classes we studied is associated with increased morbidity and mortality.[33–37] Health insurance design is an important mediator of cardiovascular medication use and meaningfully impacts outcomes. The introduction of a coinsurance cost-sharing plan in Quebec was associated with decreased adherence to chronic disease medications and higher rates of hospitalizations and death.[38] Conversely, eliminating out-of-pocket costs for secondary prevention medication after myocardial infarction improved adherence and lead to lower rates of total major vascular events and revascularization and had differential effects on white versus nonwhite patients.[23,37] We sought to understand one of the most widely used insurance designs on cardiovascular medication adherence and disparities.

HDHP plans are increasingly used as a method of reducing health spending, but prior studies have shown that reductions in necessary care and evidence-based treatments also occur and may have adverse effects in the long term, especially for vulnerable populations. Low-income patients with hypertension randomized to high deductibles in the RAND Health Insurance Experiment had significantly lower healthcare costs but worse control of blood pressure with a higher predicted risk of mortality compared with those who received free care.[39] Other studies have demonstrated that low-income patients enrolling in HDHPs reduce the number of low- and high-priority outpatient visits to a greater degree[11] and paradoxically reduce their use of high-severity ED visits[16] compared with higher income patients.

In contrast to the studies above, we found a similar magnitude of effects for low and high SES patients. We also found similar effects for different racial/ethnic groups—a population that has not been studied previously. One possible explanation is that patients may respond differently to the relatively lower out-of-pocket costs of medications compared with higher cost care, such as an emergency room visit. Although nonwhite patients report higher rates of cost-related medication nonadherence, this finding did not translate into differences in medication use in our cohort by race.[21,22] Our cohort may differ from prior patient cohorts in age, insurance coverage, and medical comorbidities—all factors that influence medication adherence. Furthermore, generic medications are increasingly used for the conditions we studied, which may mitigate any differential effect by race of high out-of-pocket costs.[40]

Table 3. Change in Adherence by Insurance Plan Design

	Entire Cohort	Race/Ethnicity			SES		
		White	Nonwhite	Interaction Term *P* Value	Higher SES	Lower SES	Interaction Term *P* Value
Full replacement plans							
PDC							
Change in level (%)	−3.5 (−5.0 to −2.1)*	−2.8 (−4.3 to −1.2)†	−7.7 (−11.5 to −3.9)*	0.23	−3.3 (−5.1 to −1.5)‡	−4.2 (−7.3 to −1.1)†	0.65
Change in slope (percentage per month)	0.02 (−0.14 to 0.18)	−0.05 (−0.22 to 0.12)	0.41 (0 to 0.82)	0.28	0.01 (−0.17 to 0.19)	0.07 (−0.26 to 0.39)	0.81
Odds of full adherence							
Change in level (%)	0.85 (0.80 to 0.91)*	0.86 (0.80 to 0.93)‡	0.78 (0.66 to 0.92)†	0.99	0.85 (0.79 to 0.92)*	0.85 (0.74 to 0.96)†	0.95
Change in slope (percentage per month)	1.0 (0.99 to 1.01)	1.0 (0.99 to 1.01)	1.01 (0.99 to 1.03)	0.10	1.00 (0.99 to 1.01)	1.00 (0.99 to 1.02)	0.44
Nonfull replacement plans							
PDC							
Change in level (%)	−4.7 (−6.0 to −3.3)*	−5.0 (−6.5 to −3.5)*	−3.3 (−6.5 to −0.08)*	0.85	−4.4 (−6.0 to −2.8)*	−6.7 (−10.1 to −3.3)‡	0.12
Change in slope (percentage per month)	0.18 (0.03 to 0.33)†	0.23 (0.06 to 0.39)†	−0.03 (−0.37 to 0.32)	0.24	0.17 (0.01 to 0.34)†	0.21 (−0.14 to 0.55)	0.27
Odds of full adherence							
Change in level (%)	0.80 (0.75 to 0.86)*	0.79 (0.74 to 0.85)*	0.84 (0.73 to 0.96)†	0.71	0.81 (0.76 to 0.87)*	0.78 (0.67 to 0.90)†	0.37
Change in slope (percentage per month)	1.01 (1.00 to 1.02)‡	1.01 (1.00 to 1.02)‡	1.01 (0.99 to 1.02)	0.59	1.01 (1.00 to 1.02)†	1.01 (1.00 to 1.03)	0.44
HSA-eligible plans							
PDC							
Change in level (%)	−4.9 (−6.0 to −3.9)*	−4.8 (−6.0 to −3.7)*	−5.7 (−8.5 to −2.9)*	0.29	−5.2 (−6.5 to −3.9)*	−4.6 (−7.0 to −2.1)*	0.70
Change in slope (percentage per month)	0.1 (−0.02 to 0.22)	0.09 (−0.04 to 0.22)	0.15 (−0.17 to 0.46)	0.52	0.12 (−0.01 to 0.25)	0.03 (−0.23 to 0.29)	0.10
Odds of full adherence							
Change in level (%)	0.81 (0.77 to 0.85)*	0.81 (0.76 to 0.85)*	0.82 (0.73 to 0.93)‡	0.58	0.81 (0.76 to 0.86)*	0.82 (0.74 to 0.91)‡	0.17
Change in slope (percentage per month)	1.01 (1.00 to 1.01)†	1.01 (1.00 to 1.01)	1.01 (0.99 to 1.02)	0.55	1.01 (1.00 to 1.01)†	1.00 (0.99 to 1.01)	0.18
HRA-eligible plans							
PDC							
Change in level (%)	0.54 (−1.8 to 2.8)	0.75 (−1.8 to 3.3)	−0.23 (−5.3 to 4.8)	0.76	1.4 (−1.3 to 4.2)	−2.4 (−7.8 to 3.0)	0.13
Change in slope (percentage per month)	0 (−0.26 to 0.26)	−0.02 (−0.31 to 0.27)	0.05 (−0.5 to 0.61)	0.12	−0.07 (−0.36 to 0.22)	0.25 (−0.33 to 0.83)	0.45
Odds of full adherence							
Change in level (%)	1.0 (0.90 to 1.1)	1.0 (0.90 to 1.2)	0.92 (0.74 to 1.1)	0.33	1.0 (0.81 to 1.1)	0.95 (0.77 to 1.2)	0.31
Change in slope (percentage per month)	1.0 (0.99 to 1.01)	0.99 (0.98 to 1.01)	1.01 (0.99 to 1.04)	0.50	0.99 (0.98 to 1.01)	1.0 (0.98 to 1.03)	0.27

Changes in level and slope represent percentage point change (level) and percentage point change per month (slope) with 95% CIs. Odds of full adherence represents the odds ratio with 95% CI. Interaction term is considered significant at $P<0.5$. HRA indicates health reimbursement account; HSA, health savings account; PDC, proportion of days covered; and SES, socioeconomic status.

*<0.0001.

†<0.05.

‡<0.003.

A similar drop in adherence in white and nonwhite patient groups may nevertheless have different clinical impact in the 2 groups given the differences in the adherence levels at baseline. As demonstrated in the MI-FREEE trial (Post-Myocardial Infarction Free Rx Event and Economic Evaluation), eliminating cost-sharing for cardiovascular medications for patients after myocardial infarction improved adherence to a similar degree in white and nonwhite patient groups. Despite this, nonwhite patients experienced a significant improvement in the trial's primary clinical outcome, first readmission for vascular event, or coronary revascularization, whereas white patients experienced no improvement in clinical outcomes. This suggests that the absolute magnitude of adherence change can have differential clinical impact, in part, because of differences in the relative change of adherence.[23,37]

More nuanced insurance plan design may attenuate some of these behaviors. Excluding essential medications from the annual deductible may incentivize the use of high-value health care while maintaining the deductible to curb the use of excessive or unnecessary services.[41] Unfortunately, adding further complexity to insurance plan design may have unintended consequences because many people have limited understanding of their health insurance benefits and confusion around details of deductibles.[20,42]

We have made several interesting observations with regard to our studied subgroups. First, the decrease in adherence is seen exclusively among patients enrolled in HSA-eligible plans, whereas patients in HRA-eligible plans did not experience a significant change in adherence. Employers contribute to HRA funds, which may contribute to increased healthcare utilization and spending and offset the effect of the deductible.[43] Patients enrolled in HRA-eligible plans were more likely to live in the Northeast, less likely to be white, and more likely to work for a large employer compared with patients in HSA-eligible plans; however, other baseline characteristics were similar between the 2 groups.

Second, patients in full replacement plans, who conceivably did not choose HDHP enrollment, generally had smaller changes in adherence after plan switch compared with patients not enrolled in full replacement plans. It is possible that employers offering HDHPs as a sole insurance option may also offer more generous supplemental coverage as a result of restricting plan choice, such as providing prescription drug benefit plans subject to a lower deductible. This finding has not been described previously, because most studies have been limited to full replacement plans only, and warrants further study. Third, patients appeared to have differential changes in adherence based on race/ethnicity and SES when broken down by full replacement and nonfull replacement plans. Nonwhite patients enrolling in full replacement plans (patients without plan choice) experienced a greater decrease in adherence compared with whites (7.7% versus 2.8%, respectively), which may be mediated by differences in generosity of insurance coverage offered to nonwhite employees, patient behavior, or both. Among patients without plan choice, perceived out-of-pocket cost may be a stronger barrier to seeking care than actual out-of-pocket cost—a finding that is more marked in nonwhite populations.[20,42] Given the limited sample size in these groups and nonsignificant interaction terms, these findings can only be considered preliminary but warrant further study.

Our study has a number of limitations. Misclassification of our exposure may occur if HDHPs exist that are not associated with an HSA/HRA. We attempted to control for this by excluding non-HDHP plans with high deductible amounts. We used a combination of methods to identify race/ethnicity, including self-report and the Bayesian Improved Surname Geocoding method.[26,44] The Bayesian Improved Surname Geocoding method returns probabilities that best correlate to outcomes using self-reported race when used as regressors in the analysis compared with when they are dichotomized.[26,45] We used these continuous regressors in the propensity score, but we ultimately decided to dichotomize the results to identify our main subgroups (white versus nonwhite). Limited evidence suggests that dichotomizing race/ethnicity as we did approximates self-reported race for adherence measures but may result in different effects for clinical outcomes.[44]

We are limited in knowing additional details about health insurance design that may have also impacted behavior, such as specific dollar amount of the deductible. We assumed for our analysis that all medications would be applied to the same deductible for medical services, which would conservatively bias our results toward the null if some patients in fact had lower medication payments. Finally, we do not know why patients changed their medication use. Having a higher deductible may motivate patients to review medication necessity and lifestyle choices and result in appropriate discontinuation. However, given the acuity with which medication use appeared to drop (within months after HDHP enrollment), we suspect that discontinuation occurred inappropriately and was not planned.

In summary, our study offers the first analysis of the impact of HDHPs on healthcare utilization, specifically medication adherence, as stratified by race/ethnicity and SES. HDHP enrollment was associated with a drop in medication adherence that is likely to be clinically significant. Nonwhite individuals had lower levels of adherence throughout the study period; however, HDHP enrollment did not disproportionately affect individuals of nonwhite race or lower SES.

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