HSR Health Services Research

DOI: 10.1111/j.1475-6773.2010.01191.x
RESEARCH ARTICLE

Impact of High-Deductible Health Plans on Health Care Utilization and Costs

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Background. High-deductible health plans (HDHPs) are of high interest to employers, policy makers, and insurers because of potential benefits and risks of this fundamentally new coverage model.
Objective. To investigate the impact of HDHPs on health care utilization and costs in a heterogeneous group of enrollees from a variety of individual and employer-based health plans.
Data. Claims and member data from a major insurer and zip code-level census data.
Study Design. Retrospective difference-in-differences analyses were used to examine the impact of HDHP plans. This analytical approach compared changes in utilization and expenditures over time (2007 versus 2005) across the two comparison groups (HDHP switchers versus matched PPO controls).
Results. In two-part models, HDHP enrollment was associated with reduced emergency room use, increases in prescription medication use, and no change in overall outpatient expenditures. The impact of HDHPs on utilization differed by subgroup. Chronically ill enrollees and those who clearly had a choice of plans were more likely to increase utilization in specific categories after switching to an HDHP plan.
Conclusions. Whether HDHPs are associated with lower costs is far from settled. Various subgroups of enrollees may choose HDHPs for different reasons and react differently to plan incentives.

Key Words. High-deductible health plans, health insurance, health care utilization, chronically ill

While enrollment in high-deductible health plans (HDHPs) is still a small fraction of the commercially insured market, the growth and experience of these plans are of high interest to employers, policy makers, and the health care industry in general because of the potential benefits and risks of this fundamentally new coverage model. A number of studies have sought to measure the impact of HDHP plans on health care utilization and cost, but various data limitations make further studies important. Using a large statewide database containing utilization data for a large group of enrollees across a

wide range of employers and plans, we examine the impact of HDHP plans on health care utilization and spending.

BACKGROUND

HDHPs have become increasingly popular since the Medicare Modernization Act of 2003 authorized portable, tax-advantaged health savings accounts (HSAs) designed to be coupled with these plans. According to America's Health Insurance Plans research, enrollment in HDHPs grew by more than 40 percent in 2006, and 34 percent in 2007, and 31 percent in 2008, from 3.2 million enrollees in January 2006 to more than 8 million enrollees in January 2009 (America's Health Insurance Plans 2009).

Proponents herald these plans as an effective mechanism for controlling health care costs by creating cost-conscious health care consumers who will look for "health care value." Opponents warn that HDHPs are tailor-made for young, healthy, and sophisticated consumers, and that the widespread availability of these plans will (1) create a "separating equilibrium" that only benefits low-cost users, leaving the sickest and oldest patients in the traditional plans, making these plans more expensive; and (2) adversely affect those sicker/older patients who do end up in HDHPs by giving them incentives to choose less care initially and resulting in higher morbidity and overall expenditures for these individuals.

Previous Evidence

A number of studies have sought to measure the impact of these incentive-driven plans on plan selection, health care utilization, and cost. In general, most studies of plan selection find that large-group HDHP enrollees are more likely to be younger, single, and male and have lower health care utilization

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than others, although there are notable exceptions (Parente, Feldman, and Christianson 2004; Tollen, Ross, and Poor 2004; United States GAO 2006; Barry et al. 2008). Evidence regarding the impact on health care utilization and cost has been mixed. Parente, Feldman, and Christianson (2004) found that total expenditures for HDHP enrollees of a single large employer in Minnesota were lower when compared to their PPO counterparts, but higher when compared to HMO enrollees. More recently, however, these authors found that HDHP plans were unable to control costs over time, with substantial cost increases relative to both PPO and POS plans (Feldman, Parente, and Christianson 2007). A recently released study, however, suggests that HDHPs may reduce overall health care expenditures by 1.5 percent (Burke and Pipich 2008).

Several studies have focused on the impact of HDHPs on specific areas of health care utilization. Parente, Feldman, and Christianson (2004) found that while physician and pharmaceutical costs were lower in the HDHP population compared with the other groups, inpatient admissions and expenditures were significantly higher.[1] More recently, several authors have focused on the impact of HDHPs on specific prescription drug categories. A 2007 report suggests that HDHP enrollment is associated with significant reductions in brand-name drugs and modest increases in generic drug use (Fairman, Sundar, and Cox 2007). Utilization of specific classes of medications, however, appeared unaffected by plan type. This finding is in direct contrast to more recent data published by Greene et al. (2008); they found that HDHP enrollees were more likely to discontinue two of five drug classes. Thus, evidence as to the effectiveness of HDHPs in achieving their goals is, to date, equivocal.

New Contribution

The value of our study lies in the breadth, depth, and heterogeneity of the data. Most prior studies have used data from one or a few large employers who may not be representative of the demographics and health care needs of the overall U.S. population. The few studies that have employed larger data samples typically have not had a wide range of health care utilization data.

This study presents findings from a retrospective study of HDHP versus PPO enrollee health care utilization, using a large statewide database provided by a major insurer. Our data cover all areas of health care utilization except inpatient hospitalizations; these data were housed in a separate system and not available for the study. While our database only involves a single state, we are able to examine the impact of HDHP plan enrollment on a heterogeneous

population, including enrollees from a wide range of employer sizes and types, across a geographically dispersed area and from a more diverse range of income, education, and racial backgrounds than the individuals represented in previous studies. Our ability to study the same population over a 3-year period also allows us to avoid significant selection issues (i.e., consistent differences between HDHP enrollees and comparison enrollees) that have been problematic in many studies.

Study Data and Methods

Study Setting

The major insurer supplying data in this study, BlueCross BlueShield of Tennessee (BCBST), has offered HDHPs since 2004. BCBST is the largest commercial health insurance carrier in Tennessee, with market share ranging between 51 and 57 percent of the total market (1.87 million PPO enrollees, including employer-based and individual plans).[2] It offers HDHPs with a variety of deductibles and premiums. Plans have deductibles ranging from US$1,700 to US$6,000; 83 percent of HDHPs in this study had a deductible of US$5,000. Some plans include separate deductibles for prescription drugs. For the time period of the study, HDHP enrollees used the standard PPO formulary and paid providers and pharmacies the BCBST contracted amount(s) for services or prescription drugs before meeting their deductible. No copayments were required during the study period for this group.

When selecting a health plan, consumers can choose to pay a larger premium amount monthly and less at the point of service (typical of the PPO plan), or a smaller premium amount monthly and a larger amount at the point of service (typical of the HDHP plan). In general, many HDHP enrollees pay lower premiums but face higher out-of-pocket expenses at all but the highest levels of health care expenditures. In the population studied here, at the 20th percentile or approximately US$120 of annual total spending (both health plan spending and that by the insured), 45 percent is paid out-of-pocket in the traditional PPO plan, while 66 percent is paid out-of-pocket in the HDHP. At the 40th percentile of spending (approximately US$480), 29 percent is paid out-of-pocket in the traditional PPO plan and 64 percent is paid out-of-pocket in the HDHP. At the 90th percentile of spending (approximately US$6,600), 27 percent is paid out-of-pocket in the traditional PPO plan, while 33 percent is paid out-of-pocket in the HDHP.

Study Sample

Member benefit data for the years 2005 through 2007 were used to construct the study sample. The HDHP "switch group" was defined as all enrollees who (a) were initially enrolled in a PPO plan in 2005, (b) switched to a HDHP plan in either 2006 or 2007, and (c) were continuously enrolled for all 3 study years (2005 through 2007). This approach yielded a sample of 1,376 HDHP "switchers" who were enrolled in a variety of individual and employer-based health plans. Although many of these plans were combined with an HSA or an HRA, information on these companion financial instruments was not collected by BCBST.

Control group members were drawn from the pool of enrollees who were continuously enrolled in a PPO plan for all study years (2005 through 2007; $N = 63{,}055$). Because estimation of our two-part Bayesian models was computationally intense, we selected a matched control group using a propensity score matching (PSM) technique. This was a three-stage process: In stage 1, we estimated a logistic regression to predict HDHP plan membership as a function of enrollee age, enrollee gender, enrollee diagnostic cost group (DCG) category, the percent of residents in a zip code with college or more education, the percent of residents in a zip code who were unemployed, the percent of the zip code who were white, and per capita income for the zip code. Zip code data were extracted from tables of the U.S. Census Bureau. DCG scores were developed by Pope, Ellis, and colleagues and are often used as a tool for characterizing health care risk and expected utilization (Ash et al. 2000; Pope et al. 2000). In stage 2 of the matching process, we constructed propensity (or probability) scores using the estimated coefficients from the logistic regression and the actual values of the explanatory variables for each individual in the sample(s). Finally, in stage 3, we sought to select one match for each member of the intervention group by searching for control group members with similar propensity scores (Parsons 2000; Parsons 2001).[3] Using this approach, we were able to match 1,354 HDHP switchers with 1,354 controls, for a final sample of 2,708 continuously enrolled members.

Study Variables

Utilization (visits or counts) and expenditure measures based on BCBST-allowed rates were constructed for the various types of health care use (primary care physician, specialty physician, other outpatient, ER, and prescription drug use). In addition, counts and expenditure measures for several prescription drug subcategories were constructed.

Brand versus Generic Medication Use. Because of the cost-saving implications from increasing generic medications, we separately examined the impact of HDHP plans on brand versus generic medication use. Brand medication was further divided into "preferred" and "nonpreferred" medications based on the health plan formulary. In general, brands with generic equivalents were placed in the nonpreferred benefit category as were the most expensive multiple source brands, while the remainder of brands were placed in the preferred prescription drug benefit category.

Essential versus Discretionary Medication Use. Using previous literature as a guide, certain medications were classified as "essential medications" (e.g., insulin and cardiac drugs) or as "discretionary medications" (e.g., nonsteroidal antiinflammatory agents) based on criteria utilized in other studies (Austvoll-Dahlgreen et al. 2007). These categories were mutually exclusive, but not exhaustive (i.e., many medications were neither essential nor discretionary).

Analytic Strategy

Our study employed a difference-in-difference (DID) approach to studying the impact of HDHP plans. This analytical approach compared changes in utilization and expenditures over time (2007 versus 2005) across the two major comparison groups (HDHP switchers versus PPO controls). While DID models with only one preintervention and one postintervention observation cannot control for differences in time trends in the treatment and control groups, it does allow us to control for permanent unobserved differences between the groups.

We also conducted a number of subgroup analyses to examine whether the impact of HDHP membership was more acutely felt by specific types of individuals. Of special interest was the impact of HDHP membership on less healthy populations. To explore whether sicker patients were especially sensitive to the incentives created in HDHP plans, we looked at two vulnerable subgroups: those with high DCG classification and those with high baseline (2005) pharmaceutical expenditures. Finally, because some individuals may have chosen to join a HDHP plan while others were given no other option, we conducted a separate analysis limited to HDHP enrollees, comparing those with a clear choice of plans versus those who did not.

Explanatory variables in each regression model included year (Year = 1 for 2007, Year = 0 for 2005), study group (Group = 1 for HDHP, Group = 0

for controls), and an interaction term (Year × Group) as well as control variables for DCG Risk Score, copayment levels, and deductibles. The general functional form was as follows[4]:

$$\begin{aligned} Y = &\beta_0 + \beta_1 \times \text{Year} + \beta_2 \times \text{Group} + \beta_3 \times (\text{Year} \times \text{Group}) \\ &+ \beta_4 \,\text{Controls} + \varepsilon \end{aligned} \tag{1}$$

For example, when Y is a utilization or expenditure measure, β_0 represents the baseline average of Y, β_1 represents the change in Y over time (2007 versus 2005), β_2 represents the difference between HDHP switchers and the PPO control group, and β_3 provides the DID estimate, representing the estimated impact of HDHP membership.

As a preliminary analytic step, we analyze "one-part" utilization and expenditure models combining data for all enrollees, whether or not they have positive utilization or expenditures in a particular area. While these models ignore the threshold issue (large number of enrollees with zero utilization in a particular area), they do provide insight regarding the overall impact of HDHP enrollment. Models were estimated for each of the study outcome variables discussed above.

Our main analysis employed two-part Bayesian estimation techniques to model utilization and expenditure data (Koop, Poirier, and Tobias 2007); the two-part models allowed us to account for the large number of zeros (no utilization, no expenditures) found in the data. For the utilization data, we employed two-part Hurdle Poisson models that were appropriate for "rate" data (e.g., visits per year) and yielded two sets of coefficients, one related to the probability of any utilization and the other related to the level of utilization conditional on having any utilization (Cameron and Trivedi 1998; Winkelmann 2004). For the expenditure data, we employed two-part lognormal models (Duan et al. 1983) to accommodate the high level of skewness in the expenditure data. Again, this approach yielded two sets of coefficients: one related to probability of any expenditure and the other related to level of expenditure (conditional on having any expenditures). Further details regarding computational methods used are contained in Section E of our technical appendix.

Study Findings

Health Care Utilization and Expenditures

Results for the one-part regression models are presented in Table 1. For parsimony and ease of interpretation, we only present the coefficients on the DID

Table 1: Health Care Utilization and Expenditures One-Part Models: HDHP versus Controls (Difference in Differences Coefficients)

Utilization Area	*Level of Use*[†]	*Expenditures*[‡]
Total outpatient care[§]	—	0.30
Primary care physician	−0.49*	−0.31*
Specialty physician	0.44*	0.03
Outpatient	−0.11	−0.50
Emergency room	−0.94	−0.36
Prescription drugs	0.65**	0.44*
Subcategories of prescription drugs		
Preferred (brand)	0.62*	0.16
Nonpreferred (brand)	0.74**	0.70*
Generic	0.66**	0.10
Essential	0.76*	−0.04
Discretionary	0.55	−0.06

[†]Generalized linear models (GLM) assuming a Poisson distribution with standard errors corrected for overdispersion.

[‡]Quasi-GLM models assuming a gamma distribution and a log link function.

[§]Sum of all expenditures in PCP, specialty physician, outpatient, ER, and prescription drugs.

*Significant at the $p \leq .05$ level.

**Significant at the $p \leq .01$ level.

variable. More detailed results are presented in our technical appendix. In the one-part models, HDHP enrollment was associated with significantly lower PCP utilization and expenditures and significantly higher prescription drug utilization and expenditures. Specialty physician visits and specific categories of prescriptions were also higher. Overall expenditures were not significantly different.

Results for the two-part regression models are presented in Table 2. Perhaps, most striking in this table is the large number of significant coefficients in the probability of use and level of use columns, but a singular lack of significant coefficients in the expenditure column. All three of these areas are important to examine. The probability of use addresses whether enrollment in HDHP plans was associated with an increasing number of enrollees having any use/expenditures in a particular category, while the "level of use" captures the "average" utilization/expenditure for those who have any use/expenditure. While increases in either type of variable (probability of use versus level of use/expenditure) can result in increases in overall expenditures, the disparate results may have important implications for policy.

In general, our results suggest that HDHP enrollment was associated with decreased emergency room use, but increased prescription drug use

Table 2: Health Care Utilization and Expenditures Two-Part Models: HDHP versus Controls (Difference in Differences Coefficients)

Utilization Area	*Probability of Any Use/Expenditure*	*Level of Use*†	*Expenditures*†
Total outpatient care‡	−.17**	—	0.04
Primary care physician	−.21	−0.33**	−0.14
Specialty physician	.31*	0.04	0.15
Outpatient	−.07	−0.14**	0.20
Emergency room	−.50*	−0.36**	−0.45
Prescription drugs	.39*	0.41**	0.24
Subcategories of prescription drugs			
Preferred (brand)	.36*	0.23**	0.26
Nonpreferred (brand)	.21	0.64**	0.50
Generic	.40*	0.36**	0.23
Essential	.37*	0.36**	0.001
Discretionary	.60**	0.01	−0.43

†Conditional on any level of use/expenditures.

‡Sum of all expenditures in PCP, specialty physician, outpatient, ER, and prescription drugs.

*Significant at the $p \leq .05$ level.

**Significant at the $p \leq .01$ level.

(including various subcategories). HDHP enrollment also appeared to be associated with decreased PCP use and increased specialty visits, although for these areas, one of the coefficients (probability of use/level of use) was not significant. HDHP enrollment was not associated with a significant change in overall outpatient expenditures.

DCG Group

Enrollees were divided into three mutually exclusive groups according to their DCG category. Enrollees in DCG Category 1 were individuals whose expected cost was between 0.02 and 0.54 times the average cost of BCBST enrollee based on prior year utilization. Similarly, enrollees in DCG Category 2 were individuals whose expected cost was between 0.54 and 2.7 times the average cost of BCBST enrollee. Enrollees in the final DCG Category (≥ 3) had expected costs at least 2.7 times the average cost of a BCBST enrollee. DID coefficients for models focused on these three populations are presented in Table 3.

Within the DCG Category 1 enrollees (arguably, the healthiest members), HDHP plan membership was associated with an increased likelihood of using any preferred prescriptions ($p \leq .05$) and a decreased likelihood of using any emergency room services ($p \leq .05$). For DCG Category 2 enrollees,

Table 3: Health Care Utilization and Expenditures, by DCG Category, HDHP versus Controls (Difference in Differences Coefficients)

	Probability of Any Use/Expenditure	*Level of Use*[¶]	*Expenditures*[¶]
DCG category 1[†]			
Total outpatient care [‖]	−.15	—	−0.25
Primary care physician	−.35	−0.24	−0.12
Specialty physician	.31	0.12	0.05
Outpatient	.08	−0.23	−0.33
Emergency room	−.88*	−1.38	−0.68
Prescription drugs	.13	−0.17	0.24
Subcategories of prescription drugs			
Preferred (brand)	.63*	0.37	0.15
Nonpreferred (brand)	−.04	0.68	0.60
Generic	.02	−0.26	−0.16
Essential	.41	0.07	0.58
Discretionary	.35	−0.27	−0.57
DCG category 2[‡]			
Total outpatient care [‖]	−.24	—	0.83**
Primary care physician	−.14	−0.57**	−0.28
Specialty physician	.75	−0.14	−0.03
Outpatient	−.03	−0.65	0.69
Emergency room	−.76	−0.06	−0.11
Prescription drugs	.96	0.42*	0.53
Subcategories of prescription drugs			
Preferred (brand)	.12	0.75*	0.80
Nonpreferred (brand)	−.02	0.46	0.25
Generic	1.15**	0.68**	0.63
Essential	.88	0.60	−0.19
Discretionary	.47	0.38	−0.01
DCG category 3 or higher[§]			
Total outpatient care [‖]	.99	—	−0.08
Primary care physician	1.16	−0.32	−0.08
Specialty physician	.99	0.32	0.35
Outpatient	−.53	−0.14	−0.15
Emergency room	−.003	−0.77	−0.87
Prescription drugs	1.74	0.04	−0.25
Subcategories of prescription drugs			
Preferred (brand)	−.16	−0.30	0.01
Nonpreferred (brand)	1.40**	−0.21	−0.09
Generic	2.25*	−0.003	−0.29
Essential	−.55	0.15	−0.11
Discretionary	2.16**	0.008	−0.88

[†]Expected cost = 0.02–0.54 × average cost.

[‡]Expected cost = 0.54–2.69 × average cost.

[§]Expected cost (≥ 2.7 × average cost).

[¶]Conditional on any level of use/expenditures.

[‖] Sum of all expenditures in PCP, specialty physician, outpatient, ER, and prescription drugs.

*Significant at the $p \leq .05$ level

**Significant at the $p \leq .01$ level.

HDHP enrollment was associated with a significant increase in overall health care expenditures ($p \leq .01$) that appears to be driven by increases in the number of prescriptions ($p \leq .05$), which was partially offset by reduced PCP visits ($p \leq .01$).

For the final DCG subgroup (DCG ≥ 3, likely to be the sickest members), HDHP membership was not associated with differences in overall expenditures or major categories of use/expenditures. We did find that HDHP membership for this subgroup was associated with increased likelihood of use of specific subcategories of prescription drugs. Specifically, we found that the HDHP enrollment was associated with increased probability of using nonpreferred drugs ($p \leq .05$), generic drugs ($p \leq .05$), and discretionary medications ($p \leq .01$).

High Pharmaceutical Expense Enrollees

Enrollees with high prescription expenditures (2005 prescription expenditures $\geq$ 75th percentile for the total sample) were identified for subgroup analyses (see Table 4). Among these individuals, HDHP enrollment was associated with a reduced likelihood of using preferred medications ($p \leq .05$) and a reduced likelihood of using outpatient services ($p \leq .05$). We also found that

Table 4: High Pharmaceutical Expenditure Enrollees: Health Care Utilization and Expenditures, HDHP versus Controls (Difference in Differences Coefficients)

	Probability of Any Use/Expenditure	*Level of Use*[†]	*Expenditures*[†]
Total outpatient care[‡]	.87	—	−0.30
Primary care physician	−.14	−0.53**	−0.40
Specialty physician	−.15	0.25	0.20
Outpatient	−.85*	0.07	0.14
Emergency room	−.85	−0.84	−0.94
Prescription drugs	−2.50	0.15	−0.13
Subcategories of prescription drugs			
Preferred (brand)	−1.24*	0.01	−0.01
Nonpreferred (brand)	.44	0.15	0.14
Generic			
Essential	−.12	0.20	−0.16
Discretionary	−.63	0.18	−0.88

[†]Conditional on any level of use/expenditures.

[‡]Sum of all expenditures in PCP, specialty physician, outpatient, ER, and prescription drugs.

*Significant at the $p \leq .05$ level.

**Significant at the $p \leq .01$ level.

HDHP membership was associated with reduced PCP visits ($p \leq .01$), but the impact on PCP expenditures was not significant.

Choice of Plans

Although we did not have data on plans offered to each enrollee, we were able to proxy choice by looking at whether other enrollees from the same employer health group were enrolled in HDHP and non-HDHP plans. For each year, HDHP enrollees were classified "clearly offered choice" (as evidenced by their employer group having employees enrolled in both HDHP plans and PPO plans; 933 members) or "no evidence of choice" (as evidenced by their employer group having all employees enrolled in a HDHP plan; 421 members). We hypothesized that individuals who clearly had choice might make different health care utilization decisions compared with those who had no choice about switching. These two groups of HDHP plan enrollees were then compared using the DID framework. Results are presented in Table 5; coefficients should be interpreted as the change in utilization associated with "clearly offered choice."

Several areas of utilization appear to be different between "clear choice" HDHP enrollees and the other HDHP enrollees. First, we found an increased

Table 5: HDHP Enrollees Who Clearly Had Choice versus No Evidence of Choice: Health Care Utilization and Expenditures (Difference in Differences Coefficients)

	Probability of Any Use/Expenditure	*Level of Use*†	*Expenditures*†
Total outpatient care‡	.26	—	−0.03
Primary care physician	.05	−0.001	0.05
Specialty physician	−.20	0.22*	0.24*
Outpatient	.04	0.08	−0.01
Emergency room	−.04	−0.09	−0.34
Prescription drugs	.33*	−0.002	−0.04
Subcategories of prescription drugs			
Preferred (brand)	.09	−0.09	−0.11
Nonpreferred (brand)	.25*	−0.11	−0.27
Generic	.28*	−0.02	−0.09
Essential	.30*	−0.02	−0.20
Discretionary	.24	0.01	−0.10

†Conditional on any level of use/expenditures.

‡Sum of all expenditures in PCP, specialty physician, outpatient, ER, and prescription drugs.

*Significant at the $p \leq .05$ level.

probability of using any prescription medication ($p \leq .05$); this appears to be driven by an increased likelihood of using any generic medications ($p \leq .05$), increased likelihood of using any nonpreferred medications ($p \leq .05$), and an increased likelihood of using any essential medications ($p \leq .05$). Of those who were using any specialty care, "clear choice" employees used more and spent more on specialty care ($p \leq .01$).

Discussion and Policy Implications

Our results strongly suggest that the impact of HDHPs on health care utilization and expenditures is dependent upon multifaceted interactions between plan and patient characteristics. Primary care physician and ER visits were lower in the HDHP group while specialist visits were higher. We found a positive association between HDHP membership and medication use (probability of use/level of use), both at a global level and in specific subcategories. Our findings suggest that HDHP plans may impact specific types of health care use in ways consistent with the intent of the HDHPs (e.g., a reduction in primary care use, increased generic drug use) or inconsistent with their intent (e.g., the rise in specialist visits).

Subgroup analyses provide important insights regarding this complex set of results and the impact of HDHPs. HDHP enrollees with high prior prescription drug expenditures reduced their utilization of certain categories of health services (e.g., a reduction in PCP and outpatient visits). Chronically ill enrollees, on the other hand, primarily increased their utilization (e.g., increases in generic, nonpreferred, and discretionary drug use) after conversion to a HDHP. Interestingly, "clear choice" HDHP enrollees also demonstrated a consistent pattern of increased utilization, with increases in all prescriptions, generic, nonpreferred, and essential prescriptions and specialist visits.

The complexity of our results suggests that the various subgroups of enrollees may have chosen HDHP membership for different reasons and have reacted differently to the incentives of the new plan. When certain groups are isolated, HDHP membership can have the predicted effect on costs and utilization. In the groups defined by disease severity (DCG scores), for example, the differences between those converting to HDHPs and the others were consistent with the theoretical underpinnings of HDHPs. The least ill (DCG Category 1), who likely did not meet their high deductible levels, reduced their likelihood of ER use and increased their likelihood of preferred medication

use. In contrast, those in DCG 3, who likely met their deductible levels, showed substantially greater likelihood of using nonpreferred and discretionary drugs. The middle group, DCG Category 2, contained both those who had met their deductible and those who had not. This heterogeneous group demonstrated an increase in overall expenditures that was likely driven by an increase in prescription drug use (especially preferred and generic), coupled with a decrease in PCP visits. Thus, when patient groups are analyzed separately based on severity of illness and prior health care expenditures, HDHPs have varying effects and may increase or reduce overall or specific health care expenditures.

The limited findings of HDHP impact in the overall analyses of all intervention enrollees versus controls may, then, result from the combined effects of heterogeneous populations affected differently by HDHP enrollment. Simply put, people enroll in HDHP for different reasons. Healthy, young enrollees, such as those in DCG category 1, may be seeking significant cost savings over a traditional PPO plan because they do not anticipate any significant medical care needs. Chronically ill individuals may be enrolling because of the information and personal control offered by HDHP plans. Individuals who anticipate significant health care expenditures, such as those in DCG category 3, are likely to save money in an HDHP plan because of the value of the "no cost" health care that they will enjoy after meeting their large deductible. Most important, in our data, no patient subgroup showed a significant fall in overall health care expenditures upon conversion to a HDHP.

Several earlier studies suggested that the typical HDHP enrollee is younger and healthier than an enrollee in a traditional plan. This outcome may be heavily driven by the optional nature of HDHP enrollment. As HDHPs grow in popularity, we may see an increase in the number of "involuntary" enrollees who more closely resemble enrollees in traditional plans. We found that voluntary HDHP enrollees were more likely to use prescription medications and specialty care after enrolling in the plan, compared with those who may have had no choice of plans ("no clear choice" group). Again, this result suggests that individuals who voluntarily select an HDHP plan may be anticipating a specific health care expenditure that is better or more easily covered under the HDHP arrangement. As plans grow to include more "involuntary" members, we may see less of this "gaming" behavior.

Several limitations of our study deserve mention. Our data came from a single southeastern state; while the dataset provides important research opportunities, it cannot be construed as nationally representative. Our data did

not contain information on inpatient expenditures; as such, our study cannot address this important area of utilization. Demographic characteristics available for plan enrollees were also quite basic (age, sex, and DCG scores). To the extent that other factors were not stable over time, our results may be biased. Although we had general information about group size for our study sample (range 1–282, average 7.32, standard deviation 18.54), our lack of individual information on group size or group identifiers precluded any analysis of the impact of group size or fixed effects. Finally, we did not have information on companion HSAs or HRAs that enrollees may have acquired. It is possible that specific design features of these plans may have had additional or confounding effects on various aspects of utilization and expenditures. Recently published research indicates that employer contributions to these accounts can have a significant impact on outpatient and pharmaceutical expenditures (Lo Sasso, Helmchen, and Kaestner 2010).

It is also important to note that specific aspects of our study design have known limitations that may influence our findings. Most notably, our use of PSM algorithms to limit the control group size cannot control for unobserved differences between the HDHP and control group. To the extent that unobserved differences between the groups are correlated with study outcomes, our results will be biased. While we were unable to run our two-part models without PSM, we were able to compare one-part models with and without PSM and found that the results were generally consistent except for those related to PCP use and expenditures. We also ran several alternative models to test the robustness of our models and provide additional analyses to aide in the interpretation of our results. We ran (pooled) models that included separate DID interactions for 2006 and 2007 HDHP switchers. The results of these models were similar to those presented in Table 2, although in some cases no longer significant. Because this may be due to sample size reduction, we do not believe that these results represent a material difference from our original results. To examine the unconditional versus conditional effect of HDHP enrollment on study outcomes, we also calculated the difference in differences of unconditional and conditional (predicted) means in all utilization and expenditure areas. These results may assist in interpreting our results because they allow the reader to see the predicted impact of HDHP on specific utilization measures. All of these alternative analyses are presented in our technical appendix (Section D).

HDHP enrollee heterogeneity has significant implications for future research. First, our results suggest that it may be very difficult to extrapolate results from the various HDHP studies to the general population. Some studies

may include HDHP populations that are not representative of the general population. Alternatively, studies that include more representative populations are likely to mask underlying effects of heterogeneous subpopulations. Second, identification of homogenous subgroups in HDHP studies is critical to understanding the impact of plan incentives. Our study demonstrates that very different results are obtained when enrollees are grouped by important characteristics. This insight leads to a third implication of our results—that we need to identify those plan and patient characteristics that appear to drive differing responses to HDHP plans.

ACKNOWLEDGMENTS

Joint Acknowledgment/Disclosure Statement: This research was supported in part through a grant from Pfizer Inc., through the Pharmaceutical Economics and Policy Council. While our contract to Pfizer required their prepublication review to ensure adequacy of all reports and publications, this contractual clause specifically precluded any right to interfere in the editorial process. We also thank BlueCross and BlueShield of Tennessee (BCBST) for providing the research data. Mr. Cecil and Dr. Kasteridis were employed at BCBST during the conduct of this research project and preparation of the manuscript, but they have since left the organization. The views expressed are those of the authors and should not be attributed to the funding agency, the insurance company in the study, or the authors' employers.

Disclosures: None.

Disclaimers: None.

NOTES

1 Feldman, Parente, and Christianson (2007) generally support these same findings, with mixed results on physician expenditures.

2. BCBST PPO enrollment derived from Health Leaders Interstudy. (2008). "Enrollment," *Tennessee Health Plan Analysis* 21(3):13. Total commercial enrollment data from Kaiser Family Foundation data, "Tennessee Health Insurance Coverage of Non-Elderly (2006–2007)," available at http://www.statehealthfacts.org and the U.S. Census Bureau, "Table HIA-4. Health Insurance Coverage Status and Type of Coverage by State All People: 1999 to 2007," available at http://www.census.gov/hhes/www/hlthins/historic/index.html.

3. We selected an optimal matching algorithm to trade-off matching precision and adequate sample size. Our final control group contained 1,354 controls using a

"greedy match" algorithm that selects a control with at least a five-digit propensity score match with a particular intervention group member, followed by four-digit matches for any remaining unmatched intervention group members.

4. More detailed equations are presented in our technical appendix.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.
Appendix SA2: Technical Appendix.

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