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RESEARCH ARTICLE

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High-deductible health plans and low-value imaging in the emergency department

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Abstract

Objective: To examine the effect of an employer-mandated switch to high-deductible health plans (HDHP) on emergency department (ED) low-value imaging.

Data Sources: Claims data of a large national insurer between 2003 and 2014.

Study Design: Difference-in-differences analysis with matched control groups.

Data Collection/Extraction Methods: The primary outcome is low-value imaging during ED visits for syncope, headache, or low back pain. We included members aged 19-63 years whose employers offered only low-deductible (≤$500) plans for one (baseline) year and, in the next (follow-up) year, offered only HDHPs (≥$1000). Contemporaneous members whose employers offered only low-deductible plans for two consecutive years served as controls. The groups were matched by person and employer propensity for HDHP switch, employer size, baseline calendar year, and baseline year quarterly number of total and imaged ED visits for each condition. We modeled the visit-level probability of low-value imaging using multivariable logistic regression with member-clustered standard errors. We also calculated population level monthly cumulative ED visit rates and modeled their trends using generalized linear regression adjusting for serial autocorrelation.

Principal Findings: After matching, we included 524 998 members in the HDHP group and 5 448 803 in the control group with a mean age of approximately 42 years and 48% female in both groups. On visit-level analyses, there were no significant differential changes in the probability of low-value imaging use in the HDHP and control groups. In population-level analyses, compared with control group members, members who switched to HDHPs experienced a relative decrease of 5.9% (95% CI − 10.3, −1.6) in ED visits for the study conditions and a relative decrease of 5.1% (95%CI −9.6, −0.6) in the subset of ED visits with low-value imaging.

Conclusion: Though HDHP switches decreased ED utilization, they had no significant effect on low-value imaging use after patients have decided to seek ED care.

KEYWORDS

deductibles, diagnostic imaging, emergency department

1 | INTRODUCTION

Reducing wasteful medical spending remains an important goal as policy makers seek to control growing health care costs. Unnecessary care, including low-value services, accounts for approximately 25%-30% of the total US health expenditure.[1,2] For patients, low-value services may lead to additional financial burdens and trigger further downstream testing with risks and expenditures without clear benefits.[3,4]

In recent years, high-deductible health plans (HDHPs) have emerged as a popular insurance product design to control health care costs. Under HDHPs, for most medical services, insurance coverage begins after members have paid a prespecified amount of money for care, known as the annual deductible. Since 2016, over half of US employees had an annual deductible of $1000 or more.[5] Advocates have argued that increased out-of-pocket costs would incentivize patients to reduce the use of low-value care.[6,7] Employers may also see HDHPs as an alternative to shift more health care costs to employees. Others, however, have raised concerns that higher cost-sharing would disproportionately impact those who are financially and medically vulnerable and could paradoxically increase spending.[8]

Our central question was whether HDHPs influence care decisions during an emergency department (ED) visit. Past HDHP studies often focused on services over which patients have considerable control. In some scenarios, people who switched to HDHPs tended to choose high-value over low-value care, such as opting for a lower-cost colorectal cancer screening test[9] and decreasing low-severity ED visits.[10] Patients also maintained primary care visits, cancer screening, medication use, and other preventive services when these were exempted from the deductibles.[11-16] However, there is evidence that HDHP members delay some important high-value care, such as cancer diagnosis and treatment.[17,18] Furthermore, low-income (but not high-income) patients delay high-severity ED visits.[19] In particular, low-income diabetic patients delay outpatient care for acute complications, leading to downstream adverse events.[16,20] However, little research exists on how HDHPs influence services ordered *during* clinical encounters such as an ED visit. The RAND health insurance experiment of the 1970s to 1980s, which randomized members to plans with varying levels of cost-sharing, found little to no change in service use after patients have presented for care.[21] However, clinical care and the financial stake for both patients and clinicians have grown substantially since that time.

More recent studies examining HDHPs offered limited insights. One study found that HDHPs were associated with decreased overall diagnostic imaging use,[22] but did not account for the substantial selection bias of healthier individuals choosing to enroll in HDHPs. A controlled pre-post study found that employer-mandated switches from low-deductible insurance products to HDHPs were associated with slightly lower overall laboratory testing, but preventive testing and radiographic imaging remained unchanged.[11] However, this study did not specifically examine low-value services. Therefore, how HDHPs affect decisions on low-value care during clinician-patient encounters remains unknown.

What is Known on this Topic

- Health insurers increasingly offer high-deductible insurance products in hopes of improving care value by giving patients "skin in the game."
- Past studies showed that high deductible reduce outpatient medical visits or tests, which are primarily under patient control, such as attending appointments, cancer screening, or ED visits.
- Less is known about the impact of high deductibles on care decisions during a visit (such as after patients presented to the ED) where clinicians and patients both participate in decision making, particularly around expensive tests that often provide little benefit (low-value imaging).

What This Study Adds

- We found that switching from low-deductible to high-deductible plans did not lower the likelihood of low-value imaging use during an ED visit.
- However, switching to high-deductible plans did reduce the number of ED visits with low-value imaging because of an overall decrease in ED visits for these conditions.
- Our results suggest that increasing patient financial risks have a minimal influence on the decision making during ED visits and future studies could test interventions that may promote cost-conscious decision making among clinicians.

ED visits offer unique advantages when examining clinician-patient decisions. In the office setting, an acute illness episode may span several encounters. As a result, whether care decisions are based on initial or follow-up evaluations (including phone and electronic encounters) are often difficult to distinguish within a dataset, especially when the visit is for acute exacerbations of chronic illnesses.[23] Furthermore, clinician practice patterns may be modified by longitudinal knowledge of a patient in addition to the clinical presentation. In contrast, ED visits are distinct episodes of care where ED clinicians evaluate patients at their initial presentation and provided diagnostic and treatment services during the visit. The "one-stop-shop" characteristic allows for strong linkages between the clinicians' initial evaluations and the services received. Furthermore, patients and clinicians are unlikely to have pre-existing relationships. Therefore, care patterns can reflect the true tendencies of the ED clinicians under the prespecified clinical scenarios.

In this study, we examined the association between HDHPs and ED visits with imaging for syncope, atraumatic headache, and low back pain. Although most ED patients present with symptoms concerning for severe medical conditions,[24] many may be safely evaluated without advanced testing. Specifically, imaging studies are considered to have low clinical utility for ED patients with

syncope,[25,26] atraumatic headache,[27,28] and low back pain[29] and are highlighted as low-value care by the Choosing Wisely campaign.[30] We hypothesized that an employer-mandated switch to HDHPs would be associated with reduced low-value imaging during ED visits for these conditions, because HDHP members who must pay a greater share of their medical expenditure out-of-pocket may be less likely to desire high-cost imaging studies that offer limited benefits.

2 | METHODS

2.1 | Dataset

We analyzed commercially insured members in a commercial (and Medicare Advantage) claims database from January 1, 2003, to December 31, 2014. The database included all medical, pharmacy, and hospitalization claims and the associated out-of-pocket and total care costs, the latter estimating the combined health plan and patient payments standardized across geography and time. This analysis was approved by the Harvard Pilgrim Health Care Institute institutional review board.

The database contains deductible level data for smaller employers (≤100 employees). Because the dataset does not contain plan deductible data for most (but not all) large employers (>100 employees), we used an previously validated algorithm[16,20] to derive the annual deductible levels for each employer plan-year (Technical Appendix in File S1).

2.2 | Study population

We identified adult, nonelderly members (aged 19 to 63 during baseline year) with at least 2 years of continuous enrollment in the dataset. To minimize member self-selection within an employer, we included only members associated with employers who exclusively offered either low-deductible health plans (annual deductibles of ≤$500) or HDHPs (annual deductibles of ≥$1000) during the study period.

The HDHP group included members who enrolled in a low-deductible plan for 12 months (baseline year) followed by 12 months in an HDHP after an employer-mandated switch. The index month for the HDHP group was the calendar month of the first day with HDHP coverage. The control group included members with at least 24 months of continuous enrollment in a LDHP. We defined the index month as the calendar month of the day that control group employers renewed their yearly account (the "anniversary month"). If a member (and their employer) had multiple potential index months (for example, three consecutive years with a LDHP), we randomly selected one.

We excluded members with cancer diagnoses (International Classification of Diseases 9th edition 140xx-208xx, 230xx-239xx) in the baseline period because these patients may need imaging for the study conditions. We illustrated the study population selection process in Appendix A1 in File S1.

2.3 | Emergency department visits

We identified all ED visits among the study population with the principal diagnosis of syncope, headache or low-back pain. For each condition, we adopted claims definitions used in prior research on low-value care and excluded visits with secondary diagnoses for which imaging is often necessary,[31,32] such as intracranial bleeding (Appendix A2 in File S1). Among the included visits, we further identified the subset of visits during which members received low-value imaging, including computed tomography (CT) or magnetic resonance imaging (MRI) of the brain for syncope or headache and lumbar spine imaging (x-ray, CT, or MRI) for low-back pain. We excluded ED visits that were preceded by another ED visit with the same diagnosis within 30 days prior because imaging indications at repeat visits may be different than initial presentations. For syncope and headache, we further excluded visits if members had any concurrent prescription for anticoagulation (Appendix A3 in File S1), which may be an indication for brain imaging.

2.4 | Outcomes

Our primary outcome measure was the probability of low-value imaging during ED visits. Notably, this measure used ED visits of the study conditions as the denominator and low-value imaging among these visits as the numerator; therefore, the results may be influenced by changes in the ED visits for the three study conditions. Prior studies have shown that HDHPs disproportionately decrease low-severity ED visits.[10,19] As a result, ED visits after the HDHP switch would likely be of higher acuity, implying that clinicians would be more likely to obtain low-value imaging. However, we used this visit-level measure as the primary outcome because it allowed an intuitive assessment of clinical decision making during the ED visit, and the direction of bias is known. We examined this outcome for the three study conditions as a composite measure as well as each condition individually.

Given the limitations of the visit-level outcome, we also examined potential changes in its denominator and numerator separately as our secondary analyses. Thus, we measured the rate of (a) ED visits for headache, syncope, or low back pain and (b) the subset of these ED visits where members received low-value imaging among the entire population (ie, per person-year). We similarly examined these measures for the three study conditions as a composite measure as well as each condition individually. Although concerns for increased severity of ED visits after the HDHP switch remain, these population-level measures allow us to distinguish changes in ED utilization vs changes in low-value imaging during ED visits.

2.5 | Covariates

We developed various member characteristics which served as covariates in the subsequent models, including the propensity models. We adopted version 10 of the Johns Hopkins ACG System to

calculate members' baseline comorbidity score and categorized included members by quintiles of ACG score.[33] Using validated census-based measures,[34] we derived proxy demographic measures from American Community Survey 5-year estimates from 2008 to 2012 at the census tract level linked to each member's most recent residential zip code provided by the data vendor. Through this approach, we categorized members' neighborhoods by poverty levels (<5%, 5% to 9.9%, 10% to 19.9%, and ≥20% of residents living below the federal poverty level) and education levels (<15%, 15% to 24.9%, 25% to 39.9%, and ≥40% of residents with less than a high-school education). We categorized members' neighborhood as predominantly black, white, or Hispanic if they lived in a census block group with ≥75% population reported as the corresponding racial group. We further categorized members as Hispanic or Asian using the E-Tech system (Ethnic Technologies), which analyzes full names and geographic locations of individuals.[35] We categorized members who did not fit into these categories as living in mixed neighborhoods. We categorized members by age (19-29, 30-39, 40-49, and 50-64 years), sex, US region (West, Midwest, South, or Northeast), and employer size (0-49, 50-99, 100-249, 250-499, 500-999, or ≥1000 employees). We also calculated the total number of ED visits, inpatient episodes, outpatient medical visits, and mental health visits in the baseline year as a proxy for members' baseline medical utilization.

2.6 | Study design and matching

We performed a controlled, difference-in-differences analysis to examine the differential changes in ED low-value imaging rates between ED visits in the HDHP group and a matched control group from baseline to follow-up year. The goal of our study design is to simulate a randomized study of HDHP implementation. Matching the baseline characteristics between two populations allows for a robust longitudinal study design to examine how an HDHP switch may influence ED visits within a population.

We calculated the employer propensity to switch to an HDHP and the member propensity to be employed by an employer that switched. The employer propensity model incorporated employer characteristics (index month, geographic area, and employer size), aggregated employee characteristics (age, sex, race/ethnicity, census tract education and poverty levels, and ACG score), and employer-level cost data (total standardized cost, employee out-of-pocket spending, and the ratio of the two costs). The member propensity model accounted for member characteristics including demographics, zip-level education, and poverty levels, ACG score, member cost data (total standardized cost, out-of-pocket spending, and the ratio of the two costs), baseline year clinical utilization (the number of ED visits, inpatient admissions, outpatient visits), and index month. We then used coarsened exact matching[36] to match control group members to HDHP group members by terciles of employer and member propensity scores, employer size, and the calendar year of the index month. Additionally, we matched by the number of ED visits for each condition in each quarter of the baseline year to further account for potential unmeasured imbalances.[37] Detailed matching procedure available in the Technical Appendix in File S1.

2.7 | Statistical analysis

We calculated baseline characteristics of the HDHP and control groups before and after matching, comparing study groups using standardized mean differences.[38] To assess the degree of exposure to high out-of-pocket costs, we calculated and plotted mean monthly total out-of-pocket spending in both groups during the study period as well as the ED visit out-of-pocket cost. We calculated and plotted the cumulative monthly ED visit rate to visually demonstrate the accumulated differences in ED visit rates over time between the HDHP and control groups.

Within the matched cohort, we performed a visit-level analysis to directly examine the changes in the probability of low-value imaging use during an ED visit. We constructed a visit-level dataset with each row of data representing an ED visit with the corresponding member and employer characteristics from the baseline year. We utilized logistic regression with member-level clustered robust standard errors to model the probability of low-value imaging during ED visits. The model included an indicator for HDHP or control group, an indicator for baseline versus follow-up year, and the interaction of the two variables. We adjusted for member demographic variables (age, sex, race/ethnicity, and neighborhood poverty and education levels), the calendar year of the switch date, baseline comorbidity score, census region, employer size, and baseline year number of outpatient medical visits, psychiatric visits, and inpatient visits. We used marginal estimation methods[39] to calculate the estimated observed probability for low-value imaging for each group in the baseline year and the follow-up year. We then calculated the changes in the probability of low-value imaging during each ED visit associated with the HDHP switch relative to the changes in the control group. Statistical tests were considered significant at an alpha of 0.05 for a two-sided test. All statistical analyses were performed using SAS 9.4 and STATA 15.

2.8 | Secondary analyses

We conducted two additional analyses using population-level ED visit rates as outcomes to separately examine the changes in ED visits and low-value imaging that underlie the visit-level outcomes. First, we examined the effect of HDHPs at the person-level. Each member had two rows representing the baseline and follow-up years, and each row included the number of ED visits for each condition and the number of ED visits with low-value imaging for each condition in the corresponding year. We used generalized estimating equations with log link, negative binomial distribution, and heteroscedastic robust standard errors to model the annual number of ED visits, accounting for member-level clustering. The model included

TABLE 1 Baseline demographic characteristics of unmatched and matched cohorts

	Unmatched					Matched				
	HDHP		Control			HDHP		Control		
	N	%	N	%	SMD[d]	N	%	Weighted N	%	SMD[d]
Sample size	525 762		5 524 401			524 998		5 448 803		
Employer size, N (%)										
0-49	235 171	44.7	703 294	12.7	1.311	235 037	44.8	2 439 381	44.8	0.000
50-99	97 179	18.5	380 947	6.9		97 044	18.5	1 007 192	18.5	
100-249	102 304	19.5	677 453	12.3		102 184	19.5	1 060 538	19.5	
250-499	40 010	7.6	592 837	10.7		39 941	7.6	414 536	7.6	
500-999	27 594	5.2	572 684	10.4		27 295	5.2	283 287	5.2	
≥1000	23 504	4.5	2 597 186	47.0		23 497	4.5	243 869	4.5	
Female, N (%)	252 882	48.1	2 804 411	50.8	−0.053	252 410	48.1	2 634 640	48.4	−0.005
Age by years, N (%)										
19-29	93 672	17.8	1 084 312	19.7	0.064	93 545	17.8	1 039 506	19.1	0.042
30-39	117 788	22.4	1 327 336	24.0		117 576	22.4	1 263 946	23.2	
40-49	150 712	28.7	1 516 472	27.5		150 506	28.7	1 527 073	28.0	
50-64	163 590	31.1	1 596 281	28.9		163 371	31.1	1 618 278	29.7	
Neighborhood poverty level,[a] N (%)										
<5%	127 791	24.3	1 502 441	27.2	0.087	127 617	24.3	1 361 580	25.0	0.041
5%-9.9%	144 374	27.5	1 533 393	27.8		144 186	27.5	1 506 556	27.6	
10%-19.9%	160 534	30.5	1 581 875	28.6		160 277	30.5	1 642 871	30.2	
>=20%	93 063	17.7	906 692	16.4		92 918	17.7	937 796	17.2	
Neighborhood education level,[b] N (%)										
<15%	383 796	73.0	4 092 667	74.1	0.027	383 292	73.0	4 016 869	73.7	0.027
15%-24.9%	92 647	17.6	943 175	17.1		92 485	17.6	949 870	17.4	
25%-39.9%	38 932	7.4	392 953	7.1		38 861	7.4	383 934	7.0	
>=40%	10 387	2.0	95 606	1.7		10 360	2.0	98 130	1.8	
Race/ethnicity, N (%)										
Hispanic	48 816	9.3	535 175	9.7	0.134	48 715	9.3	486 226	8.9	0.026
Asian	14 673	2.8	235 861	4.3		14 665	2.8	159 995	2.9	
Black neighborhood	9103	1.7	141 937	2.6		9087	1.7	98 303	1.8	
Mixed neighborhood	101 231	19.3	1 227 419	22.2		101 058	19.2	1 067 419	19.6	
White neighborhood	351 939	66.9	3 384 009	61.3		351 473	66.9	3 636 861	66.7	

(Continues)

TABLE 1 (Continued)

	Unmatched					Matched				
	HDHP		Control			HDHP		Control		
	N	%	N	%	SMD[d]	N	%	Weighted N	%	SMD[d]
United States Region, N (%)										
West	60 661	11.5	805 729	14.6	0.253	60 595	11.5	675 501	12.4	0.082
South	245 704	46.7	2 373 351	43.0		245 297	46.7	2 415 686	44.3	
Midwest	183 756	35.0	1 636 682	29.6		183 505	35.0	1 931 952	35.5	
Northeast	35 641	6.8	708 639	12.8		35 601	6.8	425 664	7.8	
Annual Out-of-pocket Cost, Mean $ (SD)	591.91	1089.46	493.54	891.65	0.099	590.15	1086.72	568.58	998.99	0.021
ACG score, Mean (SD)[c]	0.77	1.37	0.78	1.36	−0.007	0.76	1.36	0.77	1.34	0.000
Baseline ED Visits (per 10 000 persons), Mean (SD)										
Syncope	16.2	40.9	17.6	42.4	−0.003	13.2	365.4	13.2	363.3	0.000
Headache	48.4	84.6	50.9	87.6	−0.003	39.0	653.8	39.0	655.1	0.000
Low back pain	46.9	73.2	48.9	74.3	−0.003	41.8	651.3	41.8	651.4	0.000
Baseline ED low-value imaging (per 10 000 persons), Mean (SD)										
Syncope	5.9	24.4	5.9	24.4	−0.000	4.4	210.2	4.4	210.2	0.000
Headache	19.3	44.6	20.2	45.6	−0.002	17.1	413.2	17.1	413.4	0.000
Low Back Pain	13.1	36.7	12.8	36.0	0.001	11.3	335.3	11.3	335.3	0.000

Abbreviations: ED, emergency department; HDHP, high-deductible health plan; SD, standard deviation; SMD, standardized mean difference.

[a]Living in neighborhoods with % population below poverty level.

[b]Living in neighborhoods with % population below high-school education levels.

[c]ACG score of 1.0 is the mean score of the reference population that represent the general US population.

[d]Standardized mean differences of <0.2 indicates negligible difference.

an indicator for HDHP or control group, an indicator for baseline versus follow-up year, and the interaction of the two variables. We adjusted for the same member characteristics as the primary analyses. We used marginal estimation methods to calculate the estimated observed ED visit rates for each group in the baseline and follow-up years as well as the difference-in-difference estimates.

Second, we examined the effect of HDHP switch in the study population. We used the calculated monthly cumulative ED visit rates as data point to construct aggregate-level segmented regression models. These generalized linear models included an intercept, a baseline continuous monthly trend, a trend change, and a quadratic trend change (to account for any change in change in the follow-up year) for the HDHP and control groups, with robust standard errors accounting for autocorrelation. Using marginal effects methods,[39] we estimated baseline and follow-up year ED visit rates and calculated the relative changes in the HDHP group versus the control group.

Because a key assumption of these analyses is that the study groups have parallel baseline trends, we compared the linear trends of cumulative monthly ED visit rates between the HDHP and the control groups in the baseline year using aggregate-level segmented regression, accounting for autocorrelation. We also performed a robustness check by additionally matching on network types, including point-of-service (POS) plans, health management organizations (HMO), preferred provider organizations (PPO), and exclusive provider organizations (EPO), in the baseline and follow-up year.

3 | RESULTS

3.1 | Baseline characteristics

After matching, there were 524 998 members in the HDHP group and 5 448 803 members in the control group. The standardized differences of the baseline characteristics between the control and HDHP groups were <0.2, indicating minimal differences (Table 1).[38] The mean age of the study groups was approximately 42 years, with 48% female, 17% living in neighborhoods with >=20% living below the federal poverty level, 9% living in neighborhoods with >=25% below high-school education, and 67% living in neighborhoods with predominantly non-Hispanic white residents.

The mean annual out-of-pocket spending in the baseline year was similar after matching ($590.15 for HDHP group and $568.58 for control). When plotted monthly from baseline to follow-up year, the HDHP group had a substantial increase in out-of-pocket spending in the follow-up year compared with the control group (Figure 1).

3.2 | Visit-level difference-in-differences analyses

Difference-in-differences analyses showed no significant differential changes in the probability of low-value imaging use during ED visits in both composite and condition-specific analyses (Table 2).

3.3 | Member-level difference-in-differences analyses

In member-level difference-in-differences analyses, only changes in composite overall ED visits (−5.0% [95% CI −9.5, −0.5]) and headache visits (−7.0% [95% CI −13.9, −0.05]) associated with the HDHP switch reached statistical significance (Appendix A4 in File S1).

3.4 | Population-level segmented regression analysis

In the cumulative plots, ED visits and the subset of ED visits with low-value imaging diverged slightly after the HDHP switch, with the HDHP group experiencing lower visit rates, in both composite (Figure 2) and condition-specific plots (Appendix A5 in File S1).

When we modeled the aggregate-level data, compared with the control group, the HDHP group had a significant decrease in ED visits (−5.9% [95% CI −10.3, −1.6]) as well as the subset of ED visit with low-value imaging (−5.1% [95% CI −9.6, −0.6]) after the HDHP switch (Table 3). In condition-specific analyses, compared with the control

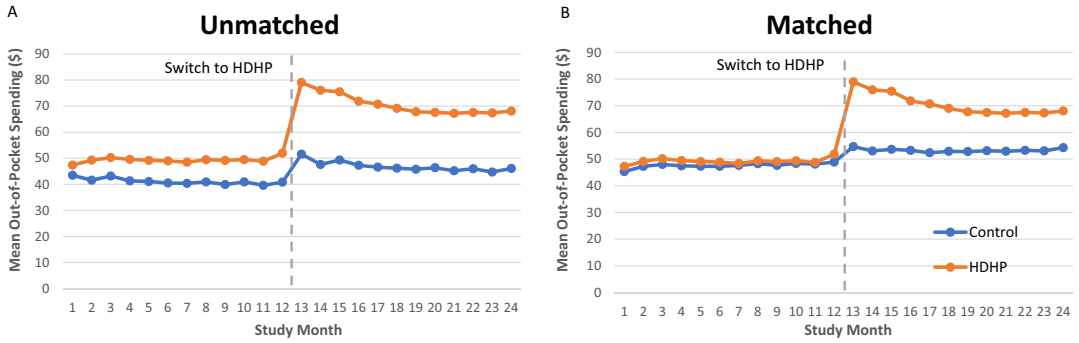

FIGURE 1 Mean monthly total out-of-pocket spending for the high-deductible health plan group and the control group (A) before and, (B) after matching. [Color figure can be viewed at wileyonlinelibrary.com]
Note: Abbreviation: HDHP, high-deductible health plan

TABLE 2 Adjusted probability of low-value imaging use during an ED visit, among HDHP and matched comparison groups at baseline and follow-up year

	% ED visits with low-value Imaging			
	Baseline year	Follow-up year	Difference-in-difference	
Composite (n = 84 875)			Absolute	Relative (%)
HDHP	35.2	35.8	0.07 (−2.2, 2.4)	0.2 (−6.3, 6.7)
Comparison	35.2	35.8		$P = .95$
Syncope (n = 12 366)				
HDHP	31.7	37.0	−0.8 (−7.5, 6.0)	−2.0 (−19.7, 15.5)
Comparison	32.3	38.5		$P = .82$
Headache (n = 34 686)				
HDHP	44.1	46.0	2.2 (−1.4, 5.8)	5.0 (−3.6, 13.6)
Comparison	44.2	43.8		$P = .25$
Back pain (n = 37 823)				
HDHP	27.2	25.5	−1.4 (−4.6, 1.8)	−5.2 (−16.6, 6.1)
Comparison	27.3	27.0		$P = .37$

Note: Composite low-value imaging rate is the number of ED imaging for syncope, atraumatic headache, and low back pain divided by the sum of ED visits for the three study conditions. All estimates were calculated using multivariable logistic regression adjusted for age, sex, poverty, education, race, region, plan switch month, comorbidity score, baseline out-of-pocket spending, and baseline total standardized cost, using robust standard errors accounting for member-level clustering.

Abbreviations: ED, emergency department; HDHP, high-deductible health plan.

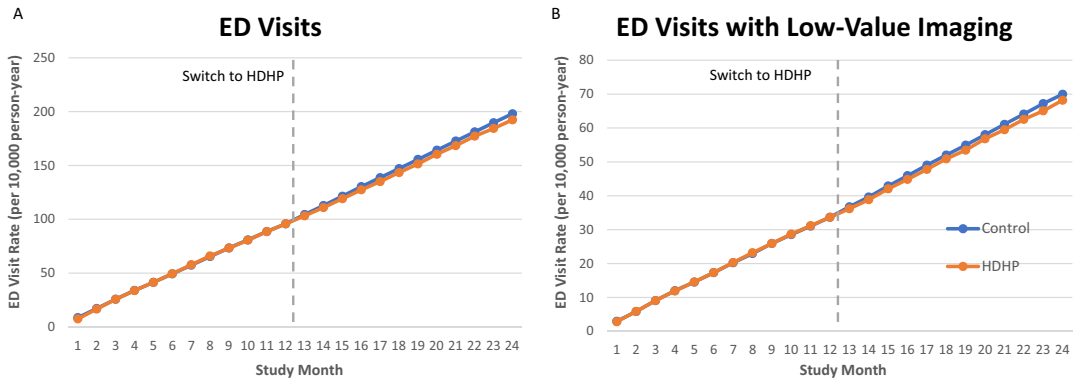

FIGURE 2 Cumulative monthly ED visit rate comparing the HDHP and matched control group for (A) composite ED visits for syncope, headache, and back pain and (B) the subset of these ED visits where low-value imaging was obtained. [Color figure can be viewed at wiley onlinelibrary.com]

Note: Abbreviations: ED, emergency department; HDHP, high-deductible health plan

group, the HDHP group had no significant pre-to-post reductions in syncope and low-back pain ED visits (Table 3). However, syncope and low-back pain ED visits with low-value imaging decreased significantly (respective relative changes: −9.0% [95% CI −13.5, −4.5]; −8.1% [95% CI −14.8, −1.4]) after the HDHP switch. In contrast, there was a −8.0% (95% CI 12.5, 3.4) decrease in headache ED visits associated with the HDHP switch compared with controls, but no significant reduction in the rate of headache visits with low-value imaging (Table 3).

3.5 | Robustness checks

In linear plots, cumulative ED visit rates were similar in the baseline year between the HDHP and control groups in composite (Figure 2) as well as condition-specific analysis (Appendix A5 in File S1). Across the composite and the condition-specific analyses, the linear cumulative trends in the baseline year were not significantly different (Appendix A6 in File S1). Adding plan type to the exact match did not result in material differences in the results of visit-level analyses (Appendix A7 in File S1).

TABLE 3 Estimated ED visits per 10 000 person-year for HDHP and matched comparison group at baseline and follow-up year, population-level cumulative trend analyses

	All visits				Imaging visits			
	Baseline year	Follow-up year	Difference-in-difference		Baseline year	Follow-up year	Difference-in-difference	
Composite			Absolute	Relative %			Absolute	Relative %
HDHP	94.7	95.7	**−6.1 (−10.7, −1.4)**	**−5.9 (−10.3, −1.6)**	33.0	34.3	**−1.8 (−3.5, −0.1)**	**−5.1 (−9.6, −0.6)**
Comparison	94.5	100.6		***P* = .008**	33.0	36.0		***P* = .027**
Syncope								
HDHP	13.3	15.4	−0.6 (−1.2, −0.04)	−3.9 (−7.4, −0.3)	4.4	5.6	**−0.6 (−0.9, −0.3)**	**−9.0 (−13.5, −4.5)**
Comparison	13.3	15.8		*P* = .032	4.4	6.1		***P* < .001**
Headache								
HDHP	39.4	38.1	**−3.3 (−5.3, −1.3)**	**−8.0 (12.5, 3.4)**	17.3	17.7	−0.4 (−1.3, 0.5)	−2.3 (−7.2, 2.7)
Comparison	39.2	40.9		***P* < .001**	17.2	18.1		*P* = .373
Back pain								
HDHP	42.0	42.2	−1.8 (−4.2, 0.6)	−4.1 (−9.4, 1.1)	11.4	10.9	**−1.0 (−1.8, −0.1)**	**−8.1 (−14.8, −1.4)**
Comparison	42.1	43.7		*P* = .13	11.4	11.9		***P* = .018**

Note: Composite ED visits rate is the sum of ED visits for syncope, atraumatic headache, and low back pain divided by the study population. Estimates were calculated by modeling monthly cumulative ED visit rates with aggregate-level segmented regressions, using generalized linear regression that included an intercept, a continuous monthly trend, a trend change at index month, and a quadratic trend change for the HDHP and control groups, with robust standard errors adjusted for 1st degree autocorrelation.

Abbreviations: ED, emergency department; HDHP, high-deductible health plan.

These values are statistically significant.

4 | DISCUSSION

While prior evidence showed that HDHPs reduce ED visits,[10,19] our study adds the important finding that, after patients have decided to seek ED care, HDHPs have a limited influence on low-value imaging. In our visit-level analyses, the HDHP switch was not associated with significant changes in the probability of low-value imaging during an ED visit. However, our population-level analyses found that the HDHP switch was associated with similar decreases in ED visits and low-value imaging. These findings indicate that switching to HDHPs does decrease ED low-value imaging at the population level. However, it does so by reducing ED visits that may lead to such low-value imaging, rather than reducing low-value imaging at ED visits.

Several factors may explain our findings suggesting that patient financial disincentives have a limited effect on reducing low-value care during ED visits. ED clinicians likely remain the principal decision maker when considering imaging use during an ED evaluation and, if recommended, patients might not feel empowered to discuss alternative approaches despite its financial implications. Furthermore, ED patients may be less price-sensitive because most who present to the ED believe that they have an emergent condition.[40] Even if patients are price-sensitive, price information is not available in real-time to facilitate discussions around the value of ED services. Clinicians also are often unaware of the cost-sharing burden of patients' insurance and have little knowledge of the prices of the services recommended.[41,42] Finally, some HDHP members might recognize that they have already exceeded their annual deductible level or that their ED visit would push them over this level, creating little incentive to reduce care.

Prior studies examining cost-sharing in the outpatient setting found patterns consistent with our results. For example, the RAND Health Insurance Experiment found that plans with higher cost-sharing did not reduce testing use during clinical encounters, though overall reductions in health care encounters did lead to reduced testing.[21] A more recent study, which used a study design similar to our analysis, found that switching to HDHP reduced general outpatient laboratory testing but did not affect radiology testing despite the latter typically costing more than most general laboratory testing.[11] Notably, prior studies have found that switching to HDHP decreased ED hospitalizations, suggesting that ED patients can respond to differential pricing.[10] However, patients likely contemplate decisions to be admitted more carefully than diagnostic testing, given the substantial life interruption that hospitalizations cause in addition to its considerable financial implications. Taken together with our findings, we believe that patient-targeted financial incentives have a minimal influence on testing decisions during office or ED visits, where clinicians likely remain the primary driver of care decisions.

We included two key study design elements to minimize bias. First, we restricted our cohort to employers that exclusively provided only low- or high-deductible insurance products for employees in each study year, reducing self-selection bias within each employer. Second, we balanced both employer and member characteristics

that may influence outcomes using a combination of propensity score and exact matching.

Despite these measures, some limitations exist. First, ED visits for specific conditions are uncommon events; therefore, some analyses might have been unable to detect the true effects of an HDHP switch at the level of statistical significance. Second, we did not have the exact deductible information for most large employers. However, we believe this did not materially affect our study, given the high sensitivity and specificity of the imputation algorithm.[20] Third, though we adopted previously established claims definitions of low-value imaging for syncope, headache, and low back pain,[31,32] there were likely some imaging studies that were appropriate given the clinical context. However, we expect this misclassification to be small and not differ across the study groups. Lastly, we examined ED visits only one year after HDHP switch. However, prior studies examining the hospitalization have shown that the effect of HDHP, if any, diminished by the second year after HDHP switch.[19,43]

5 | POLICY IMPLICATIONS

Our findings carry several implications for future policy and research efforts. The key observation was that applying cost-sharing to clinical decisions during ED visits through deductibles does not appear to be an effective approach to facilitate cost-conscious decision making. As a result, within an ED visit, HDHPs shift the financial risk of clinical decisions from insurers and employers to patients without improving ED visit value. A growing literature has documented the clinical impact of financial burdens.[44,45] With more than half of US employees covered under HDHP, it is important to assess for potential adverse effects from high deductibles in the emergency care setting, such as financial toxicity or adverse clinical outcomes, particularly among the low-income populations who are more susceptible to health care financial burdens.

While policy makers should consider alternative cost-sharing schemes for emergency care, future research should evaluate interventions that may improve cost-conscious decision making during ED visits. Studies have shown most ED clinicians frequently involve patients in shared-decisions and patients prefer to be included in the decision making process.[46-48] While ED patients may be less price-sensitive due to higher acuity, incorporating patient participation and cost information is often feasible and desired. However, until research shows that cost-of-care discussions and price transparency in the ED lead to more informed and cost-conscious decisions, policy makers should be cautious about transferring financial risk to patients, who likely have little control over ED clinical decisions.

Since the effect of patient incentives appeared limited, policy makers seeking to improve ED visit value could consider additional emphasis on provider-directed interventions. While utilization decisions are largely patient-driven, decisions during ED visits are often directed by clinicians with limited patient input. Prior research has shown that behavioral interventions can be effective in reducing low-value imaging in the ED.[49,50] However, further studies are needed to assess whether these interventions can lead to long-term practice changes. Policy makers may also leverage financial incentives, such as alternative payment models, to influence ED physicians. However, though alternative payment models have rapidly expanded across hospital and outpatient practices, there has been a lack of integration with emergency care providers.[51] Therefore, how alternative payment models affect emergency care value remains to be studied.

6 | CONCLUSION

In this quasi-experimental study, we found that employer-mandated HDHP switches reduced ED utilization but had no significant impact on low-value imaging once patients were at the ED. Our findings suggest that applying patient cost-sharing to decisions during ED visits might have a limited influence on the value of ED care. Therefore, it is important to determine whether there are adverse consequences of high cost-sharing that may outweigh its limited benefits. Future research should also evaluate potential interventions to facilitate cost-conscious decision making and improve care value during ED visits.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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