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Association between high deductible health plan coverage and age at pediatric umbilical hernia repair

Morgan E Doty,[1] Lindsay A Gil,[2] Jennifer N Cooper [3]

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[1]The Ohio State University College of Medicine, Columbus, Ohio, USA
[2]Department of Surgery, Nationwide Children's Hospital, The Ohio State University, Columbus, Ohio, USA
[3]Department of Pediatrics, Nationwide Children's Hospital, The Ohio State University, Columbus, Ohio, USA

Correspondence to
Dr Jennifer N Cooper; jennifer.njoroge@gmail.com

ABSTRACT

Background High deductible health plans (HDHPs) are associated with the avoidance of both necessary and unnecessary healthcare. Umbilical hernia repair (UHR) is a procedure that is frequently unnecessarily performed in young children, contrary to best practice guidelines. We hypothesized that children with HDHPs, as compared with other types of commercial health plans, are less likely to undergo UHR before 4 years of age but are also more likely to have UHR delayed beyond 5 years of age.

Methods Children aged 0–18 years old residing in metropolitan statistical areas (MSAs) who underwent UHR in 2012–2019 were identified in the IBM Marketscan Commercial Claims and Encounters Database. A quasi-experimental study design using MSA/year-level HDHP prevalence among children as an instrumental variable was employed to account for selection bias in HDHP enrollment. Two-stage least squares regression modeling was used to evaluate the association between HDHP coverage and age at UHR.

Results A total of 8601 children were included (median age 5 years, IQR 3–7). Univariable analysis revealed no differences between the HDHP and non-HDHP groups in the likelihood of UHR being performed before 4 years of age (27.7% vs 28.7%, p=0.37) or after 5 years of age (39.8% vs 38.9%, p=0.52). Geographical region, metropolitan area size, and year were associated with HDHP enrollment. Instrumental variable analysis demonstrated no association between HDHP coverage and undergoing UHR at <4 years of age (p=0.76) or >5 years of age (p=0.87).

Conclusions HDHP coverage is not associated with age at pediatric UHR. Future studies should investigate other means by which UHRs in young children can be avoided.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ High deductible health plans (HDHPs) have been associated with delays in care-seeking behavior.

WHAT THIS STUDY ADDS

⇒ HDHPs are not associated with a lower likelihood of unnecessary umbilical hernia repair (UHR) before 4 years of age.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Further research should investigate other factors that can be targeted to reduce unnecessary UHRs in young children in accordance with best practice guidelines.

INTRODUCTION

Of the 60% of children in the USA who have private health insurance coverage, nearly half are enrolled in a high deductible health plan (HDHP).[1–3] HDHPs, defined as plans that meet the Internal Revenue Service (IRS)'s deductible threshold for a health savings account-qualified plan, which for family coverage in 2021 was $2800, have become increasingly common in recent years.[2 4] HDHPs confer some advantages over traditional health plans, namely, that they are associated with lower premiums and reductions in overall aggregate healthcare costs.[5–7] They have also been associated with other beneficial effects, such as reductions in low-acuity emergency department visits and low-value imaging and laboratory services and increases in generic drug use.[5 8–10] However, HDHPs also have some negative effects, such as driving down the use of necessary healthcare.[11–13] Many studies have reported decreases in the use of both necessary and unnecessary care among adults with HDHPs.[13–16] Rigorous quasi-experimental studies have found that HDHPs are associated with lower medication adherence in adults with chronic diseases,[17–20] delays in care-seeking for chronic disease-related complications,[21 22] and fewer outpatient office visits.[8 18 20] However, to date, there has been very limited research into the effects of HDHPs on pediatric healthcare use or child health. Data from the National Health Interview Survey indicate that families with HDHPs are twice as likely as similar families with lower deductible commercial health insurance plans to report delaying or forgoing medical care for their children due to cost in the last year.[3] With regard to specific types of healthcare services, there is evidence that HDHPs are not associated with reduced use of well-child visits.[23] However, the association

between HDHPs and use of pediatric elective surgery has yet to be determined.

Umbilical hernia repair (UHR) is an elective pediatric surgical procedure that is frequently unnecessarily performed in young children, as most pediatric umbilical hernias close spontaneously within the first few years of life.[24] Current guidelines recommend careful observation until children are 4 years of age with the goal of also reducing pediatric anesthesia-related risks, especially repeated anesthesia in the setting of hernia recurrence.[25] However, nearly 30% of pediatric UHRs are performed in children under 4 years of age.[26] As HDHPs and out-of-pocket costs have been shown to motivate patients and families to delay or avoid medical care, patients with HDHPs may be less likely to undergo UHR before 4 years of age. Out-of-pocket cost considerations may also motivate families to delay UHR even beyond 5 years of age, perhaps long after it is recommended by a physician to be performed. It is also possible that physician preferences play a greater role than parental preferences in the timing of UHR, from the decision to refer for surgical consultation to the pursuance and timing of surgery after surgeon consultation. As a result, it may be that out-of-pocket cost considerations have little effect on age at pediatric UHR. This study aimed to evaluate whether children with HDHPs, as compared with other types of commercial health plans, are less likely to undergo UHR before 4 years of age but are more likely to undergo UHR after 5 years of age. We also aimed to evaluate whether children with HDHPs more often undergo UHR toward the end of the calendar year, when their families are more likely to have already met their health plan's deductible.

METHODS

Data source and cohort identification

This was a cross-sectional retrospective study using data from 2012 to 2019 from the IBM Marketscan Commercial Claims and Encounters Database. This database includes person-specific enrollment, clinical use, and expenditure data across inpatient, outpatient, and prescription drug services for active employees, early retirees, Consolidated Omnibus Budget Reconciliation Act (COBRA) continuees, and dependents with employer-sponsored health insurance. The data come from a selection of over 350 large employers and health plans, and each year, data are available on over 40 million individuals, including approximately 10 million children.

This study included children (aged 0–18 years) who underwent uncomplicated UHR and who resided in a metropolitan statistical area (MSA). Children from MSAs were selected because of the selection bias that is inherent in HDHP coverage. Namely, a variety of unobserved factors that predict families' HDHP enrollment may also be correlated with their health care-seeking behaviors. To address this, we elected to employ instrumental variable analyses. Over the past decade, HDHP coverage has grown rapidly, from approximately 20% to 50%, among commercially insured children. However, there has been a large variation in this growth across MSAs.[3 27] We exploited this geographical variation in HDHP growth over time by using MSA/year-level HDHP prevalence among children in the Marketscan Commercial Claims and Encounters database as an instrumental variable.

Uncomplicated UHRs were identified using Current Procedural Technology, International Classification of Diseases (ICD), Ninth Revision, Clinical Modification and ICD-10 Procedure Coding System procedure codes and diagnosis codes (online supplemental appendix table 1). We excluded neonates (infants 30 days of age or less), children with a diagnosis of omphalocele or gastroschisis, children not from MSAs, children from MSAs with fewer than 5000 children in the Marketscan Commercial Claims and Encounters Database in any year of the study period, and children from MSAs with a >10% rate of missingness of health plan type in any year of the study period. The MSA-related exclusion criteria were implemented because our instrumental variable was defined at the MSA-year level and because we wished to include a sample of children from each MSA that was relatively stable in size and in demographic and socioeconomic characteristics over time. These exclusions resulted in the inclusion of children from 100 MSAs, spread across 35 states in all regions of the USA (online supplemental appendix table 2).

Statistical methods

As noted previously, to address selection bias in HDHP coverage, we implemented a quasi-experimental study design using instrumental variable analysis. We exploited the variation in HDHP prevalence across MSAs and over time to test our hypothesis that HDHPs are causally associated with a decrease in the proportion of UHRs performed in children under 4 years of age and an increase in the proportion of UHRs performed in children 6 years of age and older. Our primary outcomes were the occurrence of UHR in a child under 4 years of age and the occurrence of UHR in a child 6 years of age or older.

Our instrumental variable was the MSA/year-level proportion of children in the database who had an HDHP. Using the Marketscan Benefit Plan Design (BPD) database, we were able to verify that approximately 80% of children in the Marketscan Commercial Claims and Encounters Database in 2012–2019 who had a consumer-directed health plan (CDHP) with plan information in the BPD had deductibles that exceeded the IRS's deductible threshold for HDHPs in that year. Thus, we grouped children with CDHPs and HDHPs together into a single HDHP group. We used our instrumental variable to predict each included child's HDHP versus traditional health plan status in that year. We then used a two-stage least squares regression model in which the first stage predicted an individual child's type of health insurance based on their value of the instrumental variable

and the second stage incorporated the child's probability of having a HDHP as estimated in the first stage. These models included heteroskedasticity-robust SEs and adjusted for MSA, year, child sex, whether the child had any chronic condition,[28 29] whether the child underwent a concurrent surgical procedure,[30] and the MSA/year-level median household income in households with children and the percentage of children of non-Hispanic white race/ethnicity. These particular variables were chosen because they have previously been shown to be associated with either HDHP coverage or age at pediatric UHR.

We also evaluated sociodemographic, clinical, and geographical characteristics of the study population and described these characteristics overall and according to whether a child had HDHP coverage. We compared characteristics between children with and without HDHP using χ^2 tests, t-tests, and Mann-Whitney U tests as appropriate. To assess the appropriateness of the instrumental variable, we also evaluated associations between these characteristics and the instrumental variable by calculating standardized differences between groups defined by instrumental variable quartiles. We also conducted an F test to test whether the instrumental variable's inclusion significantly contributed to the first stage of the instrumental variable model.

In a sensitivity analysis, we excluded children who were over 10 years of age at the time of their surgery, under the assumption that a greater proportion of the UHRs in this age group, compared with younger children, may have been for acquired hernias from previous laparoscopic procedures. In a second sensitivity analysis, we also evaluated CDHPs and HDHPs separately. In a final sensitivity analysis, we excluded children who underwent any other surgical procedure concurrent with their UHR rather than adjusting for this. Finally, we evaluated whether HDHP coverage was associated with the timing of UHR during the calendar year, as the resetting of deductibles at the start of a calendar year may drive families with high deductibles to schedule elective procedures toward the end of a calendar year, when they are more likely to have met their deductible. To conduct this analysis, we stratified the cohort by HDHP status, calculated the percentages of procedures in a calendar year that were performed in each month of the year and averaged these percentages across all years in the study period. Log-binomial regression models were then used to compare the relative probabilities of UHR being performed in November or December versus earlier months in the same calendar year between children with versus without HDHPs. SAS Enterprise Guide V.7.12 (SAS Institute Inc, Cary, NC) and Stata/SE V.15 were used for the statistical analyses.

RESULTS

The study cohort consisted of 8601 children. Table 1 shows the characteristics of these children at the time of their UHR, overall and in groups defined by HDHP versus non-HDHP insurance coverage. The median age was 5 years in both groups, and no significant difference was found between the two groups in terms of the outcomes of interest, namely, being less than 4 years of age or being greater than 5 years of age at the time of UHR. However, geographical region, metropolitan area size, and year were all found to be associated with HDHP status. No association was found between having a chronic condition or undergoing a concurrent surgical procedure at the time of UHR and HDHP status.

Table 2 shows that there were no associations between our instrumental variable and patient sex, whether any chronic condition was present, or whether any concurrent surgical procedure was performed. Thus, these characteristics among children undergoing UHR did not vary across metropolitan areas according to these areas' rates of HDHP coverage among privately insured children. However, some population-level characteristics of metropolitan areas did vary across quartiles of the instrument. Namely, the MSA/year-level median household income among families with children and the percentage of children of non-Hispanic white race/ethnicity both increased with increasing quartiles of the instrument. As expected, the percentage of included children who had HDHP coverage increased with increasing quartiles of the instrument. An F test from the first-stage model also demonstrated the strength of the instrument, as the instrument contributed significantly to the instrumental variable model ($F_{1,8031}$=189.49, p<0.001).

Two-stage least squares regression analysis incorporating the instrument demonstrated no significant association between HDHP coverage and the probability of a child undergoing UHR at an age less than 4 years, with the difference in this probability being 2.4% (–13.0% to 17.7%, p=0.76). Similarly, two-stage least squares regression analysis incorporating the same instrument demonstrated no significant association between HDHP coverage and the probability of a child undergoing UHR at an age greater than 5 years, with the difference in this probability being 1.4% (–15.7% to –18.5%, p=0.87). The results of both analyses were similar when they were restricted to children who were 10 years of age or younger at the time of their surgery (table 3).

Furthermore, when CDHPs and HDHPs were evaluated separately, neither type of health plan was associated with the probability of a child undergoing UHR at an age less than 4 years or the probability of a child undergoing UHR at an age greater than 5 years (online supplemental appendix table 3). In a final sensitivity analysis that excluded children who underwent any other surgical procedure concurrent with their UHR, instrumental variable analysis again demonstrated no significant association between HDHP coverage and the probability of a child undergoing UHR at an age less than 4 years or the probability of a child undergoing UHR at an age greater than 5 years (online supplemental appendix table 4).

Although HDHP coverage was not associated with delaying UHR until after 4 years of age, figure 1 shows

Table 1 Characteristics of included children at the time of UHR

Characteristics	Total study population (N=8601)	HDHP at the time of UHR (n=1858)	Other type of health plan at the time of UHR (n=6743)	P value
Age (years)	5 (3–7)	5 (3–7)	5 (3–7)	0.38
Age <4 years	2451 (28.5)	514 (27.7)	1937 (28.7)	0.37
Age >5 years	3365 (39.1)	739 (39.8)	2626 (38.9)	0.52
Female	4155 (48.31)	933 (50.22)	3222 (47.79)	0.06
Geographical region				<0.0001
Northeast	705 (8.20)	100 (5.38)	605 (8.97)	
North Central	2170 (25.23)	600 (32.29)	1570 (23.28)	
South	4442 (51.64)	933 (50.22)	3509 (52.04)	
West	1284 (14.93)	225 (12.11)	1059 (15.71)	
Metro area size				<0.0001
Large (≥1 million residents)	6602 (76.76)	1528 (82.24)	5074 (75.25)	
Small/moderate (<1 million residents)	1999 (23.24)	330 (17.76)	1669 (24.75)	
Year				<0.0001
2012	1700 (19.77)	157 (8.50)	1543 (22.88)	
2013	1422 (16.53)	232 (12.49)	1190 (17.65)	
2014	1390 (16.16)	280 (15.07)	1110 (16.46)	
2015	946 (11.00)	240 (12.92)	706 (10.47)	
2016	942 (10.95)	236 (12.70)	706 (10.47)	
2017	769 (8.94)	243 (13.08)	526 (7.80)	
2018	705 (8.20)	225 (25.19)	480 (7.12)	
2019	727 (8.45)	245 (13.19)	482 (7.15)	
Any chronic condition	1322 (15.4)	294 (15.8)	1028 (15.3)	0.54
Any concurrent surgical procedure	2016 (23.44)	439 (23.63)	1577 (23.39)	0.83

Data are shown as median (IQR) or number (column %).
HDHP, high deductible health plan; IQR, interquartile range; N, total sample; UHR, umbilical hernia repair.

that children with HDHPs compared with other types of commercial health plans were more likely to undergo UHR in November or December versus earlier in the same calendar year. In regression analysis, we found that children with HDHPs were 12% (95% CI 1% to 23%) more likely than children with other types of commercial health plans to undergo surgery in November or December versus earlier in the same calendar year. This was the case for children who were under 4 years of age at the time of surgery as well as for children older than age 5 years (online supplemental appendix figures S1 and S2).

DISCUSSION

This study found that, despite the greater incentive of families with HDHPs compared with traditional commercial health plans to avoid or delay medical care, HDHP coverage was not associated with a lower likelihood of children undergoing UHR at less than 4 years of age or a higher likelihood of children undergoing UHR after 5 years of age. Our results are somewhat inconsistent with studies of use of elective surgeryin adults. For example, a 2019 study by Chhabra *et al* showed that use of bariatric surgery and cost sharing is inversely related.[31] While our analysis did not reveal an association between delaying a common elective surgery in children and HDHPs, we did see results consistent with other studies in terms of the seasonal variation in use of elective surgery. The study by Chhabra *et al* and others reported an increase in use of elective surgery at the end of the calendar year.[31] This is thought to reflect an increase in the number of privately insured persons with met deductibles toward the end of the insurance year who wish to undergo elective procedures before their annual deductible resets. Pediatric procedures, including UHR, are not exempt from this end-of-year uptick. A recent study comparing privately insured to publicly insured children showed that the so-called 'December effect' was present for numerous elective pediatric procedures, including UHR, among privately insured children overall.[32] Our study was consistent with these results and showed that the end-of-year uptick in UHRs among privately insured children is particularly high among those with HDHPs. This suggests that families' anticipated cost sharing may influence their decision making about the timing of UHR once

Table 2 Balance in MSA/year-level population characteristics and patient-level characteristics across levels of the instrument

	Instrumental variable quartiles (% of all children in the database from the included child's MSA in that year who had an HDHP)						
	Quartile 1 1.23%–10.35% (n=2152)	Quartile 2 10.37%–20.26% (n=2146)	Quartile 3 20.33%–28.18% (n=2151)	Quartile 4 28.25%–69.92% (n=2151)	SD quartile 1 versus quartile 2	SD quartile 1 versus quartile 3	SD quartile 1 versus quartile 4
Patient-level characteristics							
HDHP coverage	113 (5.3)	317 (14.8)	527 (24.5)	901 (41.9)	0.32	0.56	0.96
Female	1032 (48.0)	1054 (49.1)	1006 (46.8)	1063 (49.4)	0.02	0.02	0.03
Any chronic condition	285 (13.2)	296 (13.8)	359 (16.7)	382 (17.8)	0.02	0.10	0.13
Any concurrent surgical procedure	495 (23.0)	494 (23.0)	505 (23.5)	522 (24.3)	0.00	0.01	0.03
MSA/year-level population characteristics							
Median household income among households with children	65 786.5 (17 507.1)	72 899.0 (21 006.1)	73 514.2 (14710.6)	75 612.6 (13 978.9)	0.37	0.48	0.62
Percentage of non-Hispanic white children	44.2 (15.1)	48.7 (13.5)	49.5 (15.9)	55.0 (13.6)	0.32	0.35	0.75

Descriptive statistics shown are number (column %) or mean (SD).
HDHP, high deductible health plan; MSA, metropolitan statistical area.

Table 3 Results of instrumental variable analyses to estimate the association of HDHPs with the probability of umbilical hernia repair being performed before age 4 years or after age 5 years

	Risk difference (95% CI)	P value
Surgery before age 4 years		
Total cohort	0.024 (–0.130 to 0.177)	0.76
Children ≤10 years of age	0.040 (–0.126 to 0.206)	0.64
Surgery after age 5 years		
Total cohort	0.014 (–0.157 to 0.185)	0.87
Children ≤10 years of age	–0.026 (–0.197 to 0.145)	0.77

The results are from two-stage least squares regression models with heteroskedasticity-robust SEs that included MSA, year, child sex, the presence of any chronic condition, whether a concurrent surgical procedure was performed, and the MSA/year-level median household income in households with children and MSA/year-level percentage of children of non-Hispanic white race/ethnicity.
HDHP, high deductible health plan; MSA, metropolitan statistical area.

a decision is made to pursue surgery but perhaps does not greatly influence decision making about whether a child should undergo surgery versus wait for the hernia to potentially resolve on its own.

Previous studies have identified several patient and family characteristics associated with early asymptomatic UHR in children. In one recent study, lower income, public health insurance, and female sex were found to be associated with hernia repair occurring at an age under 3 years. The association with public health insurance was interpreted as suggesting that the absence of cost sharing in Medicaid may incentivize unnecessary early operations in children with Medicaid coverage, whereas the often high-cost sharing required of privately insured families for surgical care may incentivize waiting.[33] While our study did not compare publicly versus privately insured children, we did find that HDHPs, as compared with other types of commercial health plans, were not

Figure 1 Month of pediatric umbilical hernia repair in commercially insured children with versus without a high deductible health plan.

associated with a lower likelihood of undergoing UHR before 4 years of age or a higher likelihood of undergoing UHR at age 6 years or older. This suggests that families' high-cost sharing may not be a strong driver of decision making about whether and at what age to pursue UHR in children. Instead, physician practice patterns may play a greater role in the timing of UHR, from the decision to refer for surgical consultation to the pursuance and timing of surgery after surgeon consultation. Primary care providers' practices surrounding criteria for surgical referral and surgeons' practices surrounding the timing of surgery vary based on a variety of factors, including differences in training, financial incentives, perceived risk of incarceration or spontaneous closure, and personal responses to parental concerns and anxiety.[25 34–36] However, given the risks associated with unnecessary surgery, the risks associated with additional anesthesia in the setting of reoperation for recurrence,[25] and the increased rates of readmission and postoperative complications in children who undergo UHR before 4 years of age,[26 37] it is critical to provide education with regard to best practice guidelines and continued advocacy for watchful waiting in children under 4 years of age.

This study was limited primarily by a lack of availability of some important data within the Marketscan database. Clinical data such as severity and frequency of symptoms at presentation, ease of reduction, size of the fascial defect, progression over time, and other important clinical details were not available, although these factors likely would not differ across groups defined by commercial health insurance plan type. As in any administrative database, there was also likely some degree of miscoding of diagnoses and procedures. However, per the specifications of the data use agreement, we were unfortunately unable to identify patients to conduct chart review validation. We were also unable to evaluate patient-level socioeconomic status or race/ethnicity and therefore could not investigate how our findings differed according to these factors. While we did not find an association between HDHP status and the avoidance of early UHR, it is possible that there may be such an association among lower income or racial/ethnic minority families, who are often less able to bear the burden of high cost-sharing. We were, however, able to evaluate median income and racial/ethnic distribution at the MSA/year level. At this level, we found that median household income among families with children and the percentage of non-Hispanic white children increased with increasing HDHP prevalence. Since both factors are associated with higher healthcare use in general,[38 39] they were used as exogenous variables in our instrumental variable analysis. However, future studies that account for patient-level socioeconomic status and race/ethnicity would be valuable. Unfortunately, we were also not able to assess surgeon preferences or practice patterns in this study because the majority of the included cases (>60%) lacked a surgeon national provider identifier in the database that could be used to track how often a particular surgeon had performed UHR in children under 4 years of age or what proportion of children of different ages who had consulted with a particular surgeon about UHR then proceeded to undergo the procedure. Future studies that evaluate the relative importance of parent, surgeon, and primary care physician preferences on age at pediatric UHR would be valuable. Last, our inclusion criterion requiring MSAs to have no more than 10% missing data on health plan type in any year of the study period resulted in the exclusion of 36 MSAs (representing 2170 patients). Although this is a sizeable number, the remaining included MSAs still represented a large and geographically diverse population across 35 states. We did not use multiple imputation to impute missing health plan type because, unfortunately, the Marketscan database lacks the information needed to accurately impute this, especially employer IDs and data on the types of health plans offered by employers in a given year.

In conclusion, we did not find that HDHP coverage is associated with a lower likelihood of children undergoing UHR before 4 years of age. Thus, our results do not suggest that HDHPs reduce potentially unnecessary surgical procedures or reduce deviation from best practice guidelines for the management of pediatric umbilical hernias. It is possible that future investigations of this or other procedures may yield different results, as the prevalence of HDHPs and the average deductible size in HDHPs have continued to rise in recent years.[3 7 40] However, further research should investigate other factors that can be targeted to reduce unnecessary UHRs in young children, in accordance with best practice guidelines.

Twitter Lindsay A Gil @lindsaygil6

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Contributors MED and JNC contributed to study conception, planning, and design, and conducted data manipulation and data analysis, interpreted the results, drafted the manuscript, and critically revised the manuscript. LAG interpreted the results, drafted the manuscript, and critically revised the manuscript. JNC takes responsibility for the overall content as guarantor.

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Patient consent for publication Not applicable.

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ORCID iD
Jennifer N Cooper http://orcid.org/0000-0001-7590-7166

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Online Appendix

Table 1. Procedure and Diagnosis Codes Used to Identify Umbilical Hernia Repairs

PROCEDURE CODES	
CPT	
49580	Repair umbilical hernia, < 5 years, reducible
49585	Repair umbilical hernia, >5 years, reducible
49652	Laparoscopy, surgical, repair, ventral, umbilical, spigelian, or epigastric hernia, reducible
49659	Unlisted laparoscopy procedure, hernioplasty, herniorrhaphy, herniotomy
ICD-9-CM	
53.4	Repair of umbilical hernia
53.41	Other and open repair of umbilical hernia with graft or prosthesis
53.42	Laparoscopic repair of umbilical hernia with graft or prosthesis
53.43	Other laparoscopic umbilical herniorrhaphy
53.49	Other open umbilical herniorrhaphy
ICD-10-PCS	
0WQF0ZZ	Repair abdominal wall, open approach
0WQF3ZZ	Repair abdominal wall, percutaneous approach
0WQF4ZZ	Repair abdominal wall, percutaneous endoscopic approach
DIAGNOSIS CODES	
ICD-9-CM	
553.1	Umbilical hernia without mention of obstruction or gangrene
ICD-10-CM	
K42.9	Umbilical hernia without obstruction or gangrene

Patients had to have both a procedure code and a diagnosis code

Table 2. Metropolitan Statistical Areas (MSAs) included in the study

Albany-Schenectady-Troy, NY	Milwaukee-Waukesha-West Allis, WI
Albuquerque, NM	Minneapolis-St. Paul-Bloomington, MN-WI
Ann Arbor, MI	Monroe, MI
Atlanta-Sandy Springs-Roswell, GA	Myrtle Beach-Conway-North Myrtle Beach, SC-NC
Augusta-Richmond County, GA-SC	Nashville-Davidson--Murfreesboro--Franklin, TN
Austin-Round Rock, TX	Nassau County-Suffolk County, NY
Baltimore-Columbia-Towson, MD	Newark, NJ-PA
Baton Rouge, LA	New Haven-Milford, CT
Beaumont-Port Arthur, TX	New Orleans-Metairie, LA
Boise City, ID	North Port-Sarasota-Bradenton, FL
Bridgeport-Stamford-Norwalk, CT	Oakland-Hayward-Berkeley, CA
Cambridge-Newton-Framingham, MA	Ogden-Clearfield, UT
Charleston-North Charleston, SC	Oklahoma City, OK
Charlotte-Concord-Gastonia, NC-SC	Omaha-Council Bluffs, NE-IA
Chattanooga, TN-GA	Orlando-Kissimmee-Sanford, FL
Chicago-Naperville-Arlington Heights, IL	Oxnard-Thousand Oaks-Ventura, CA
Cincinnati, OH-KY-IN	Palm Bay-Melbourne-Titusville, FL
Cleveland-Elyria, OH	Pensacola-Ferry Pass-Brent, FL
Columbia, SC	Phoenix-Mesa-Scottsdale, AZ
Corpus Christi, TX	Portland-South Portland, ME
Dallas-Plano-Irving, TX	Port St. Lucie, FL
Dayton, OH	Providence-Warwick, RI-MA
Des Moines-West Des Moines, IA	Provo-Orem, UT
Detroit-Dearborn-Livonia, MI	Raleigh, NC
Durham-Chapel Hill, NC	Richmond, VA
El Paso, TX	Riverside-San Bernardino-Ontario, CA
Evansville, IN-KY	Roanoke, VA
Flint, MI	Rochester, NY
Fort Wayne, IN	Rockford, IL
Fort Worth-Arlington, TX	Rockingham County-Strafford County, NH
Fresno, CA	Sacramento--Roseville--Arden-Arcade, CA
Grand Rapids-Wyoming, MI	St. Louis, MO-IL
Greensboro-High Point, NC	Salt Lake City, UT
Greenville-Anderson-Mauldin, SC	San Antonio-New Braunfels, TX
Hartford-West Hartford-East Hartford, CT	San Diego-Carlsbad, CA
Houston-The Woodlands-Sugar Land, TX	San Francisco-Redwood City-South San Francisco, CA
Indianapolis-Carmel-Anderson, IN	San Jose-Sunnyvale-Santa Clara, CA
Kansas City, MO-KS	Savannah, GA
Knoxville, TN	Seattle-Bellevue-Everett, WA
Lafayette, LA	Stockton-Lodi, CA
Lake County-Kenosha County, IL-WI	Tacoma-Lakewood, WA
Lakeland-Winter Haven, FL	Tampa-St. Petersburg-Clearwater, FL
Lansing-East Lansing, MI	Toledo, OH
Lexington-Fayette, KY	Trenton, NJ
Lincoln, NE	Tucson, AZ
Little Rock-North Little Rock-Conway, AR	Washington-Arlington-Alexandria, DC-VA-MD-WV
Los Angeles-Long Beach-Glendale, CA	Wilmington, DE-MD-NJ
Louisville/Jefferson County, KY-IN	Wilmington, NC
McAllen-Edinburg-Mission, TX	Winston-Salem, NC
Memphis, TN-MS-AR	Worcester, MA-CT

Table 3. Results of instrumental variable analyses to estimate the association of CDHPs or HDHPs with the probability of umbilical hernia repair being performed before age 4 years or after age 5 years

	CDHPs vs. all other types of health plans besides HDHPs		HDHPs vs. all other types of health plans besides HDHPs	
Outcome	**Risk difference (95% CI)**	**P**	**Risk difference (95% CI)**	**P**
Surgery before age 4 years	0.051 (-0.257-0.358)	0.75	0.049 (-0.249-0.347)	0.75
Surgery after age 5 years	0.029 (-0.318-0.376)	0.87	0.028 (-0.309-0.364)	0.87

Results are from two-stage least squares regression models with heteroscedasticity-robust standard errors and that included MSA, year, child sex, the presence of any chronic condition, whether a concurrent surgical procedure was performed, and the MSA/year-level median household income in households with children and MSA/year-level percentage of children of non-Hispanic White race/ethnicity.
MSA=metropolitan statistical area, CDHP=consumer-directed health plan HDHP=high deductible health plan

Table 4. Results of instrumental variable analyses to estimate the association of HDHPs with the probability of umbilical hernia repair being performed before age 4 years or after age 5 years: excluding children with concurrent surgical procedures

	Risk difference (95% CI)	P
Surgery before age 4 years	-0.014 (-0.184-0.155)	0.87
Surgery after age 5 years	0.028 (-0.169-0.225)	0.78

Results are from two-stage least squares regression models with heteroscedasticity-robust standard errors and that included MSA, year, child sex, the presence of any chronic condition, and the MSA/year-level median household income in households with children and MSA/year-level percentage of children of non-Hispanic White race/ethnicity.
MSA=metropolitan statistical area, HDHP=high deductible health plan

Figure 1. Month of umbilical hernia repair by high deductible health plan status in children under 4 years of age.

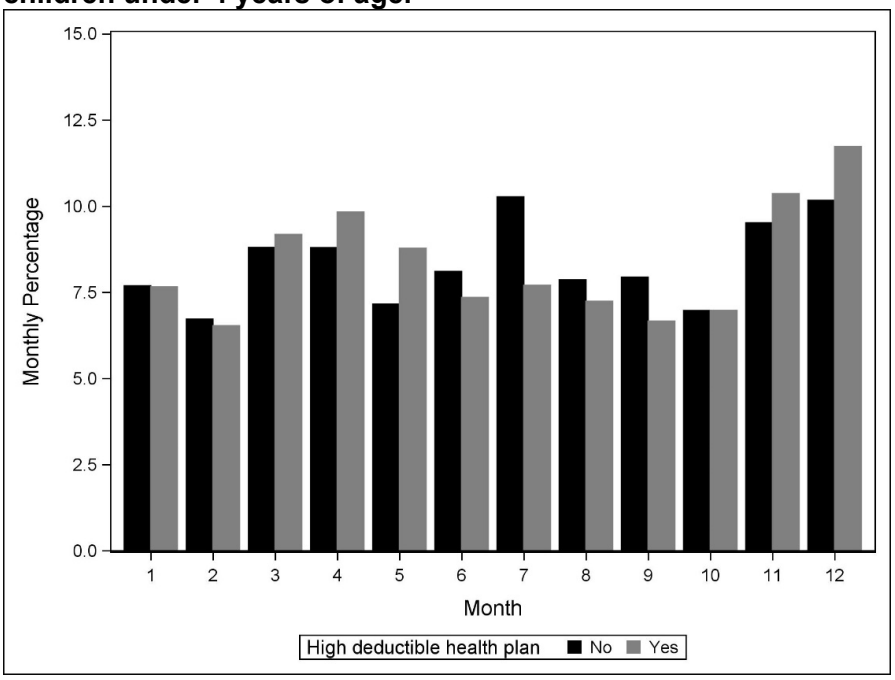

Figure 2. Month of umbilical hernia repair by high deductible health plan status in children older than 5 years of age