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# Patient Cost-Sharing and Healthcare Utilization in Early Childhood: Evidence from a Regression Discontinuity Design†

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*This paper estimates the price elasticity of healthcare utilization in early childhood. We employ a regression discontinuity design by exploiting a subsidy that reduces patient cost-sharing for children under age 3 in Taiwan. Using longitudinal medical claims of over 410,000 children, we find a modest price elasticity of outpatient expenditure (e.g., −0.10 for regular outpatient care). Furthermore, increased cost-sharing at age 3 largely decreases the chance of visiting high-intensity healthcare providers (e.g., teaching hospitals) for minor illnesses. In contrast, children's utilization of inpatient care is price insensitive, providing a rationale for full inpatient care coverage to children.* (*JEL* H51, I11, I12, I13, I18, J13)

Investment in health is considered one of the most valuable contributions to the early stages of a child's life (Almond et al. 2010; Bharadwaj, Løken, and Neilson 2013; Currie 2009).[1] As such, countries across the world have exempted—either partially or fully—the cost-sharing of children's medical care.[2] For instance, the Children's Health Insurance Program, administered by the US government, regulates the level of cost-sharing in order to ensure middle- and low-income families

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[1] Bharadwaj, Løken, and Neilson (2013) and Almond et al. (2010) present convincing evidence that early life medical treatments can reduce mortality and even result in better academic performance in school. Thus, health intervention in early childhood can be seen as an investment with high returns.

[2] Young children are not only vulnerable to various diseases, but they are also likely to incur large medical expenses for their families. In Taiwan, children under four years of age have the second-highest healthcare spending levels (individuals over 65 have the highest), and the number of outpatient visits for this age range is approximately

can afford medical treatment for their children. Even nations with universal health insurance, such as Japan and Korea, provide subsidies to reduce the coinsurance rate for children under 6. While the subsidy policy is well received in public, the low level of cost-sharing could encourage patients to overuse healthcare services with low marginal value, thereby exacerbating the extent of the moral hazard involved in healthcare. In spite of children, particularly young children, being at the center of cost-sharing policies, there is scant empirical evidence regarding the effect of cost-sharing on young children. Most existing studies focus on more mature cohorts, for example the elderly (Chandra, Gruber, and McKnight 2010a; Shigeoka 2014; Fukushima et al. 2016), adults (Chandra, Gruber, and McKnight 2014, 2010b), and and school-age children or adolescents (Iizuka and Shigeoka 2018, Nilsson and Paul 2018). Consequently, it is still unclear how cost-sharing affects healthcare utilization in early childhood.

In this paper, we study the issue by exploiting a cost-sharing subsidy policy in Taiwan. Since March 2002, all children under the age of 3 have been completely *exempt*, in the case of both inpatient and outpatient services, from copayments (coinsurance) under the Taiwanese National Health Insurance (NHI) scheme.[3] Therefore, when the cost-sharing subsidy expires on the child's third birthday, this results in a drastic increase in patient cost-sharing. We utilize data on the longitudinal insurance claims of more than 0.41 million children and a regression discontinuity (RD) design by comparing these children's healthcare utilization just before and just after their third birthdays.[4]

We obtain three key findings from our research. First, we find that an increase in cost-sharing at the age of 3 significantly reduces children's use of outpatient care. Our study indicates that the implied price elasticity for outpatient expenditure is $-0.10$ for regular outpatient care and slightly less (in absolute value) for emergency room care ($-0.06$). This estimate is somewhat smaller than the figures obtained in previous studies (in absolute values), mostly on adults and the elderly (Manning et al. 1987; Shigeoka 2014; Fukushima et al. 2016; Chandra, Gruber, and McKnight 2014).[5] The smaller price response in healthcare for young children might reveal that the types of healthcare services used by adults are quite different from those used by children. Indeed, the majority of outpatient visits for children are for acute diseases (e.g., respiratory infections), usually associated with noticeable symptoms (e.g., fever, cough, muscle pain, or difficulty breathing), rather than for chronic diseases (e.g., diabetes). We think that parents, particularly inexperienced ones, could overweigh such symptoms than actual risks, resulting in a lack of adjustment in healthcare utilization in response to the price change due to behavioral hazard (Baicker, Mullainathan, and Schwartzstein 2015). Such an explanation is consistent with the observation of smaller estimates of price elasticity (in absolute

20 per year (see online Appendix A). Compared with adults—at approximately 15 visits per year—this cohort has an especially high need for healthcare services.

[3] For an outpatient visit, a patient still needs to pay a registration fee, which is not covered by the NHI.

[4] In the online Appendix, by using mortality data from the death registry and tracking inpatient admissions of children with serious health problems at an older age, we also examine whether the additional use of healthcare induced by the cost-sharing subsidy produces any positive effect on children's health.

[5] For example, the RAND HIE found the price elasticity of outpatient care for adults to be $-0.2$, and Shigeoka (2014) and Fukushima et al. (2016) obtained similar estimates for the elderly in Japan.

values) for first-born children (i.e., −0.09 for regular outpatient care and −0.04 for emergency room care).

Second, we find that the choice of provider in outpatient care is sensitive to the tiered copayments charged by different levels of healthcare providers. Taiwan, like many Asian countries (e.g., Japan, South Korea, and China), does not implement a "gatekeeping" system. In order to control patient flow, Taiwan's NHI has established a tiered copayment scheme for outpatient services whereby the copayment differs according to the level of healthcare provider.[6] Therefore, patients can visit any specialist at a teaching hospital, without having to obtain a referral from their primary care physician, as long as they are willing to pay a higher copayment. The cost-sharing subsidy for children has substantially reduced the differences in out-of-pocket (OOP) expenses among various levels of healthcare providers, inducing patients to visit high-intensity providers (i.e., teaching hospitals) before reaching the age of 3. Our results suggest the proportion of teaching hospital visits decreases significantly, by around 40 percent, at the age of 3 when patients have to make tiered copayments, the majority of which is due to visits for minor medical issues.[7]

Third, our estimate of the price elasticity of inpatient expenditure is almost zero. A large increase in OOP expenses at the age of 3 leads to little change in the utilization of children's inpatient care. Based on a 95 percent confidence interval of our estimates, we can rule out price elasticity for inpatient expenditure greater than −0.045 (in absolute value), while for the number of inpatient admissions, we can even rule out price elasticity greater than −0.02 (in absolute value). Such price elasticity for inpatient cases is substantially lower than found in previous studies examining this subject (Manning et al. 1987; Shigeoka 2014; Chandra, Gruber, and McKnight 2014; Fukushima et al. 2016). For instance, the RAND Health Insurance Experiment (RAND HIE) found that the price elasticity of inpatient care was −0.17 for adults (Manning et al. 1987),[8] while Shigeoka (2014) and Fukushima et al. (2016) found the elasticity for the elderly to be approximately −0.2 and −0.16, respectively.[9] More importantly, our results offer a rationale for providing full coverage to young

[6] The NHI implements a tiered copayment scheme based on the accreditations of healthcare providers. There are four types of healthcare providers: major teaching hospitals, minor teaching hospitals, community hospitals, and clinics. A major teaching hospital (clinic) visit requires the highest (lowest) copayment. In Section IA, we will discuss this issue in detail.

[7] In a recent paper, Brot-Goldberg et al. (2017) also investigated the effect of cost-sharing on patients' choice of provider (i.e., price-shopping behavior). They exploited a large shift in employees' health insurance plans, from zero cost-sharing to a high-deductible plan. Their results demonstrated that a high deductible/coinsurance amount had little impact on a patient's choice of provider. Nonetheless, in contrast to the situation covered in Brot-Goldberg et al. (2017), Taiwanese patients are free to choose their own healthcare providers, and they always know their OOP expenses in advance. For this reason, they are more likely to respond to the financial incentive embedded in the cost-sharing policy.

[8] The RAND HIE, conducted in the mid-1970s, randomly assigned participating households to different levels of patient cost-sharing (ranging from free care to 95 percent cost-sharing).

[9] Shigeoka (2014) exploited the sharp reduction in patient cost-sharing at age 70 in Japan and applied an RD design to estimate the price elasticity of healthcare utilization for the elderly. He found that inpatient care for this group was price sensitive, with the estimated elasticity of inpatient admissions standing at around −0.2. Fukushima et al. (2016) also exploited the sharp reduction in patient cost-sharing at age 70 in Japan, but they used administrative claims data to conclude that the price elasticity for inpatient expenditure was approximately −0.16 (i.e., statistically insignificant). Chandra, Gruber, and McKnight (2014) used cost-sharing reform in Massachusetts as an exogenous variation in price, obtaining the price elasticity of total medical expenses at around −0.16 for low-income adults. Nonetheless, the point estimate of price elasticity for inpatient care was sizable (−0.12), albeit statistically insignificant.

children for inpatient care, since full coverage substantially lessens the financial risk faced by households and does not increase additional healthcare.[10]

Our paper stands apart from previous literature on patient cost-sharing in the following ways. First, the institutional setting in Taiwan makes our estimates of the cost-sharing effect immune from bias arising from either confounding demand-side or supply-side factors. Previous studies estimating the price sensitivity of health demand have faced two major challenges. To start with, the composition of insurance enrollees might have been endogenously determined by the level of the cost-sharing, an issue confronted by US studies (Selby, Fireman, and Swain 1996; Goldman et al. 2004; Trivedi, Rakowski, and Ayanian 2008; Chandra, Gruber, and McKnight 2010a, 2014). In addition, the estimates of patients' demands could have been influenced by supply factors, such as the restriction of a medical care provider or insurers' payments to health providers (Cutler 1998, Wu 2010, Clemens and Gottlieb 2017), which is well-discussed in Shigeoka (2014). To some extent, both of these concerns are mitigated under Taiwan's institutional setting; because the nation's NHI is a compulsory single-payer system, everyone has to enroll in it. This single-payer feature not only ensures that the composition of children enrollees will not be influenced by the expiration of the cost-sharing subsidy, but also prevents the provider from cost-shifting among various health insurance plans.[11]

Second, our study examines the effect of cost-sharing on patients' provider choice—an important issue seldom discussed in the previous literature. As mentioned previously, Taiwan's healthcare system does not employ a gatekeeper system, so patients are free to choose any healthcare provider they wish. Given that the cost-sharing subsidy essentially eliminates tiered copayments for children under the age of 3, this gives us a unique opportunity to examine the impact of the tiered copayments on patients' provider choices by comparing choices made immediately before the third birthday (i.e., without the tiered copayments) to those made immediately thereafter (i.e., with the tiered copayments). Our findings shed some light on how tiered copayments affect a patient's provider choices by discouraging those with minor illnesses from seeking care at high-intensity healthcare providers like teaching hospitals.

Lastly, our paper contributes to a small but growing body of literature on the demand for healthcare among children. Up to now, estimates of the price elasticity for children's healthcare utilization still relies on evidence from the RAND HIE, which found that higher patient cost-sharing could significantly reduce the outpatient care of children under the age of 14 (Leibowitz et al. 1985, Manning et al. 1987).[12] However, the experiment cannot reach a conclusion on the effect of cost-sharing on

[10] In the online Appendix, we provide suggestive evidence of the impact of patient cost-sharing on children's health. Our results show that health status, as measured by the occurrence of serious pediatric health problems (i.e., pediatric complex chronic conditions) and by mortality, is not influenced by the expiration of the cost-sharing subsidy at the age of 3. More importantly, we find that the additional outpatient visits induced by the cost-sharing subsidy at ages 2–3 have little impact on children's long-term or medium-term health, measured by the rate of occurrence of serious pediatric health problems at ages 5–11.

[11] Besides changes in cost-sharing, premium changes could also affect people's decision to enroll in health insurance (Dague 2014).

[12] On average, children assigned to the no-cost-sharing plan would make one fewer office visit per year than those assigned to the cost-sharing plan.

children's inpatient utilization, due to the limited sample size.[13] Two recent papers (Iizuka and Shigeoka 2018, Nilsson and Paul 2018) using a quasi-experimental design obtained similar estimates of price elasticities for outpatient care found in this paper. Compared with them, our paper focuses on a relatively policy-relevant age group (i.e., young children), examines more comprehensive utilization behavior (i.e., choice of healthcare provider) and healthcare services (i.e., emergency room care and inpatient care), and uses a population-wide dataset.[14]

The remainder of this paper is organized as follows. Section I provides a brief overview of the institutional background. In Section II, we discuss our data and sample selection. In Section III, we discuss the results on healthcare utilization. Section IV provides a general discussion of our results. Finally, in Section V, we provide concluding remarks.

## I. Policy Background

### A. *Taiwan's National Health Insurance*

In March 1995, Taiwan implemented NHI, a government-run, single-payer health insurance plan. Prior to this, health insurance had been provided through three major social insurance plans: labor insurance for workers in the private sector, government-employee insurance for public employees, and farmers' insurance for farmers and fishermen. In total, these three social insurance plans covered approximately 57 percent of the Taiwanese population (Lien, Chou, and Liu 2008); the remainder of the population consisted of the elderly, children under 14, and the unemployed. The implementation of NHI sharply raised the coverage rate to 92 percent of the population by the end of 1995. Since 2000, the coverage rate of NHI has remained steady, at more than 99 percent of the population.

Three features of Taiwan's NHI are particularly relevant to our analysis. First, enrollees receive identical, generous benefits, which include outpatient and inpatient services, dental care, prescription drugs, and even traditional Chinese medicine services. Particularly for children under 3, almost all medical services are covered.[15]

Second, Taiwan does not employ a gatekeeping system; patients are able to access specialists directly, without first obtaining a referral from their primary care doctor.[16] To properly control patient flow and allocate medical resources efficiently, NHI includes a tiered copayment scheme for different accreditations of healthcare

[13] As Leibowitz et al. (1985) comment, "Because hospitalizations for children are infrequent, our estimates of hospital use have wide confidence intervals, and we can be less certain than for outpatient care about the presence or absence of a cost-sharing response."

[14] Iizuka and Shigeoka (2018) exploited the various changes in patient cost-sharing for school-aged children (7–14 years old) whose parents worked for large corporations and lived in the six largest prefectures in Japan, while Nilsson and Paul (2018) utilized exemptions to copayment for outpatient care among children between 7 and 19 years old in one region in Sweden. In Section IVB, we compare the estimates in this paper with those cited in the above two papers.

[15] Some discretionary healthcare services, such as plastic surgery, sex reassignment surgery, and assisted reproductive technology, are not covered by NHI. Patients must pay the full cost of such services.

[16] The gatekeeping system is an important feature of many health systems found in North America and Europe. For instance, the National Health Service (NHS) in the United Kingdom requires a patient to obtain a referral from a primary care physician before they can see a specialist or other doctor.

providers: major teaching hospitals, minor teaching hospitals, community hospitals, and clinics. In general, a higher copayment is charged for teaching hospitals and for the use of emergency room services. Therefore, patients suffering from minor medical issues are more likely to seek care at nearby clinics or community hospitals, leaving teaching hospitals available to help patients with more serious illnesses.

The teaching hospitals usually provide more intense and costly treatments for their patients than the clinics and community hospitals do. Table B2 of online Appendix B shows that the average expenditure for a regular outpatient visit to a major teaching hospital is around NT$1,000, which is more than double that for a visit to a clinic.[17] This is because physicians at teaching hospitals can carry out more complicated treatments and medical examinations. The average examination/treatment fee at a major teaching hospital is NT$465, but it is only NT$16 at a clinic. Thus, in the following analysis, we categorize teaching hospitals as high-intensity providers and clinics/community hospitals as low-intensity providers. In online Appendix B, we offer more detailed information about healthcare providers in Taiwan.

Finally, in contrast with health plans in the United States, NHI does not require patients to pay deductibles. For outpatient care, the OOP expenses are comprised of two parts: a fixed lump-sum copayment and a registration fee that covers the administrative costs of the healthcare provider.[18] Note that our data do not include information regarding the registration fees, so we propose a two-step procedure for "predicting" the registration fee of each regular outpatient and emergency room visit. We discuss the details of the estimation/imputation procedure in online Appendix C. To illustrate the differences in OOP expenses among healthcare providers and health services, panels A and B of Table 1 show the fee schedule for outpatient care during our sample period (2005–2008). As one can see from the first row, the copayment is NT$360 (i.e., US$11; US$1 is NT$32.50 in 2006) for a regular outpatient visit at a major teaching hospital; NT$240 (i.e., US$7) at a minor teaching hospital; NT$80 (i.e., US$2.50) at a community hospital; and NT$50 (i.e., US$1.50) at a clinic. Compared with a regular outpatient visit, the copayment for an emergency room visit at a community hospital nearly doubles. Clearly, the tiered copayment scheme provides an incentive for patients who are not seriously ill to get relatively simple treatments at clinics rather than utilize high-intensity medical services at teaching hospitals.

The OOP expense for an inpatient admission is a fixed proportion (known as the coinsurance rate) of the inpatient expenditure, depending on the length and type of admission (acute or chronic). For an acute admission, a patient pays for 10 percent of the inpatient expenditure for the first 30 days of their hospital stay, and a higher percentage thereafter (see panel C of Table 1). In addition, during our sample period, there is an annual OOP maximum of roughly NT$47,000 (i.e., 10 percent of the

[17] Note that US$1 is NT$32.50 in 2006.

[18] In Taiwan, patients must pay 20 percent of the prescription drug costs but these are capped at NT$1,000. The maximum copayment is thus NT$200. Nonetheless, drugs costing under NT$100 do not require a copayment. Given that most visits by children under age 3 incur drug expenditure below NT$100, the average OOP expense for prescription drugs (under age 3) is quite small, at only NT$2.50 per visit. We have included this payment when calculating the OOP expense of an outpatient visit.

Table 1—Patient Cost-Sharing in Taiwan NHI

| | Patient cost-sharing | | | |
|---|---|---|---|---|
| | Major teaching hospital | Minor teaching hospital | Community hospital | Clinic |
| *Panel A. Regular outpatient visit* | | | | |
| Copayment | 360 | 240 | 80 | 50 |
| Average registration fee | 111 | 91 | 82 | 76 |
| *Panel B. Emergency room visit* | | | | |
| Copayment | 450 | 300 | 150 | 150 |
| Average registration fee | 221 | 194 | 178 | 132 |
| *Panel C. Inpatient care* | | | | |
| 1–30 days | | 10% | | |
| 31–60 days | | 20% | | |
| After 61 days | | 30% | | |

*Notes:* US$1 is NT$32.50 in 2006. For outpatient care, patient cost-sharing is through a copayment, which the patient pays as well as a registration fee at each visit. Information about copayments is taken from the NHIRD codebook (2012 version). The NHI has implemented this fee schedule since July 2005. Since our sample period is from July 1, 2005 to June 30, 2008, all outpatient visits in our sample are based on the above fee schedule. Before July 1, 2005, copayment for a regular outpatient (emergency room) visit was according to the following fee scheme: NT$210 (420) for a major teaching hospital, NT$140 (300) for a minor teaching hospital, NT$50 (200) for a community hospital, and NT$50 (150) for a clinic. In addition, for regular outpatient care, people who get a referral at the lower-rank providers only pay NT$210 for a major teaching hospital visit, NT$140 for a minor teaching hospital visit, and NT$50 for a community hospital visit. However, very few patients get a referral at the lower-rank providers (i.e., fewer than 0.5 percent of total teaching hospital visits). We calculate the average registration fee based on the method described in online Appendix C. For inpatient care, patient cost-sharing takes place through coinsurance. Depending on length of stay and the type of admission (acute or chronic admission), a patient is required to pay 10 percent to 30 percent of the expenditure per admission. The above fee schedule is only for acute inpatient admissions, since we only focus on acute inpatient admissions for fewer than 30 days. Chronic inpatient admissions and acute inpatient admissions with more than a 30-day stay only account for 0.6 percent and 0.1 percent of total inpatient admissions for children between the ages of 2 and 4.

GDP per capita in Taiwan) and an OOP maximum per admission of NT$28,000.[19] According to NHI statistics, very few patients (less than 1 percent) reach the OOP maximum.[20]

### B. *Taiwan Children's Medical Subsidy Program*

To reduce the financial burden on parents and to ensure essential medical care was provided to young children, the Taiwan Children's Medical Subsidy Program (TCMSP) was launched in March 2002. This program, estimated to cost NT$1.8 billion annually, covers all copayments for outpatient care, prescription drugs, and inpatient care for children under the age of 3. Therefore, parents of children under

[19] Note that the above information is based on the NHI rules in 2008. The OOP maximum rule does not apply for acute inpatient stays longer than 30 days or chronic inpatient stays longer than 180 days.

[20] This is because NHI waives the cost-sharing expense for patients with catastrophic illnesses (e.g., cancer), which generally have a higher probability of reaching the OOP maximum.

3 need only pay the registration fees for outpatient care, and almost nothing for inpatient care.

Figure 1, panel A plots the age profiles of the OOP expenses per regular outpatient visit.[21] We have separate plots for each type of provider. Each dot in these figures represents the ten-day average OOP expense per visit at a given age, measured in days from the patient's third birthday. Due to the expiration of the cost-sharing subsidy at age 3, one can see that the OOP expenses per visit are larger after that birthday than before it. Furthermore, the difference in OOP expenses between teaching hospitals and community hospitals/clinics becomes much larger after the child's third birthday. This same observation applies to the average OOP expenses for emergency room care, as shown in Figure 1, panel B.

Figure 1, panel C presents the age profile of the OOP expenses per inpatient admission (180 days before and after the third birthday). Again, because of the expiration of the cost-sharing subsidy at age 3, one can see that the average OOP expense jumps from zero to approximately NT$1,300 after the child passes that birthday.

## II. Data and Sample

### A. *Data*

Our healthcare utilization data come from the National Health Insurance Research Database (NHIRD). The NHIRD data contain outpatient and inpatient claims that include information on patients' date of birth, dates of visits (admissions), diagnoses using codes from the International Classification of Diseases (ICD 9), and services provided, as well as the OOP expenses and total expenditure on outpatient visits (inpatient admissions).[22] We use a child's birthday and the date of the visit (admission) to precisely measure our key variable—a patient's age at the time of the visit. Moreover, these claim files contain two scrambled but unique identifiers: patient IDs and provider IDs. The first identifier, the patient ID, can be merged with the enrollment files to obtain the family's information, including a child's birth order, age, gender, and total number of siblings.[23] The second identifier, the provider ID, can be merged with the provider files to obtain a healthcare provider's ownership (i.e., public, private, or nonprofit), accreditation level (i.e., major teaching hospital, minor teaching hospital, community hospital, or clinic), and the number of beds at their facility.

[21] We plot OOP expenses within the 180 days before and after the third birthday and group them into ten-day bins. For example, we group the first ten days after the third birthday to construct the first bin after the cutoff (i.e., the nineteenth bin in the graph). Thus, the bins of OOP expenses to the right of the third birthday do not include the observations exposed to the TCMSP (i.e., the cost-sharing subsidy). Therefore, we have 36 ten-day average OOP expense bins (i.e., 18 bins before and 18 bins after the third birthday).

[22] Note that we add an imputed registration fee to construct OOP expenses for each outpatient visit.

[23] Because the NHI allows children to be enrolled through either the mother or the father, this offers some incentive for children to be enrolled through the parent with the lower salary in order to reduce the insurance premium, which is based on the parent's salary.

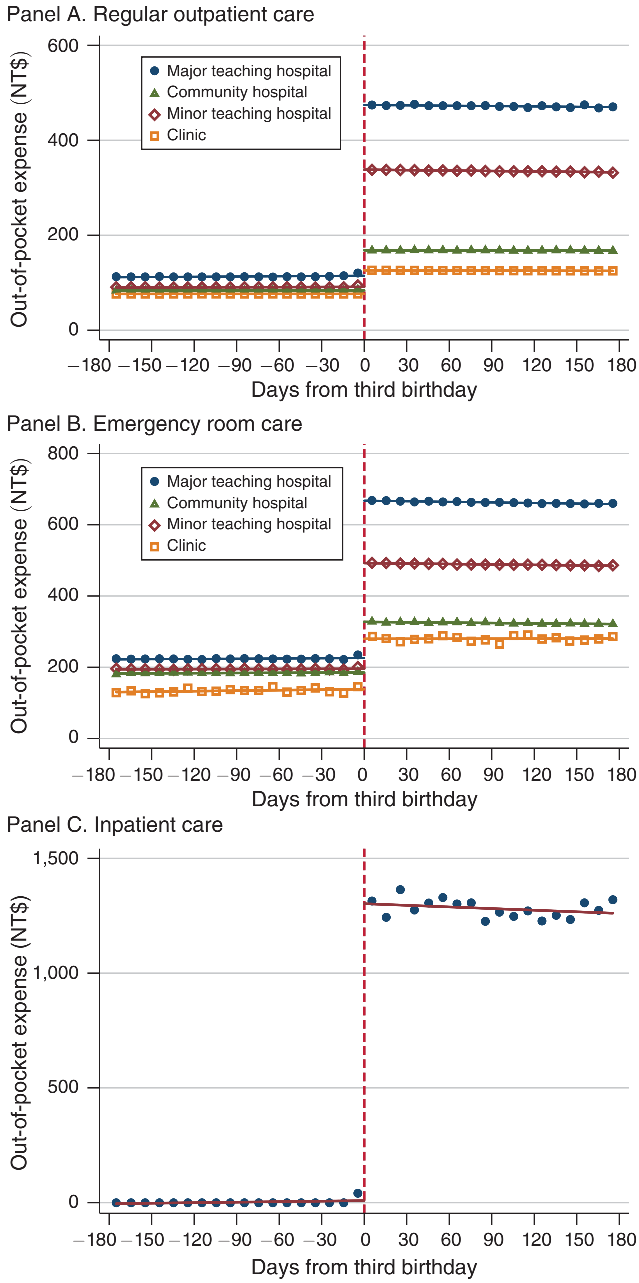


FIGURE 1. AVERAGE OUT-OF-POCKET EXPENSES BEFORE AND AFTER THE THIRD BIRTHDAY

*Notes:* We pool NHI claims for the 2003–2004 birth cohort, using 2005–2008 NHIRD data, which records patients' NHI copayments (coinsurance) for each regular outpatient visit (panel A), emergency room visit (panel B), and inpatient admission (panel C). For regular outpatient visits and emergency room visits, we impute registration fees, using the method described in online Appendix C. The dependent variable is the average OOP expenses according to patient age at the time of a visit (admission). Average OOP expenses are measured in New Taiwan dollars (NT$), with US$1 equal to NT$32.50 in 2006. All expenses in our sample period are inflation-adjusted (NT$ in 2006). The age at visit is measured in days. We plot the dependent variable within 180 days before and after the third birthday, and group it every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variable.

### B. *Sample*

To mitigate the effect of a change in sample composition on our estimates, we focus on the same group of children over time. Specifically, our estimated sample comprises the children born between 2003 and 2004 for which complete demographic information is available (e.g., gender, birth date). We track their healthcare utilization from 180 days before their third birthday to 180 days after it using claims data from the NHIRD from July 2005 to June 2008. Since NHI covers almost the entire population, the estimated sample essentially uses all children born in Taiwan between 2003 and 2004. Our empirical analysis includes outpatient and inpatient care, excluding services related to dental care, Chinese medicine, free health checkups, chronic inpatient admissions, and acute inpatient admissions whose length of stay is more than 30 days, because these visits/admissions have quite different cost-sharing rules.[24]

We restrict our sample in a number of ways. First, we select only those children who were enrolled in NHI at both age 2 and age 3.[25] Then, we eliminate children suffering from catastrophic illnesses, as well as those from very low-income families, given that in both of these cases copayments are waived so there is no price increase when the child turns 3.[26] In total, these restrictions reduce the number of observations from 430,548 to 414,282, or by 3.8 percent. Table D1 of online Appendix D provides summary statistics for the characteristics of the children at age 3, both before and after the sample selection criteria were applied. From Table D1, it is quite evident that the children's characteristics remain almost unchanged after the sample selection procedure. In the later analysis, we utilize the sample years (1997–2001) before the introduction of cost-sharing subsidy to conduct a placebo test. We follow the same sample selection criteria and use the children born between 1995 and 1997 (i.e., pre-reform data) to construct a sample for placebo test. Table D2 of online Appendix D provides summary statistics of sample selection process for the pre-reform sample.

Table 2 provides the descriptive statistics for regular outpatient care, emergency room care, and inpatient care. To illustrate the health utilization around the child's third birthday (i.e., the expiration of the subsidy), the upper panel shows the visit (admission) rate per 10,000 persons (on a daily basis), 90 days before the third

[24] For example, the NHI copayment for outpatient visits for dental care and Chinese medicine is always NT$50, regardless of the type of healthcare provider. In addition, chronic inpatient admissions and acute inpatient admissions where there is a stay of more than 30 days have different rules for patient cost-sharing. The coinsurance rate for chronic admissions is 5 percent for 1–30 days of stay, 10 percent for 31–90 days of stay, 20 percent for 91–180 days of stay, and 30 percent for more than 181 days of stay. The OOP maximum rule does not apply for acute inpatient stays longer than 30 days or chronic inpatient stays longer than 180 days. The chronic inpatient admissions and acute inpatient admissions involving stays of more than 30 days only account for 0.6 percent and 0.1 percent respectively of total inpatient admissions for children between ages 2 and 4.

[25] This selection reduces the number of children by 4,480. Since NHI is compulsory, those who did not continue to enroll may have either emigrated or died.

[26] During our sample period (July 2005 to June 2008), the eligibility rule for very low-income families required the monthly income per household member to be below a specific threshold, depending on the cost of living in the particular residential city/county. For example, the highest income cutoff was NT$14,152 in Taipei and the lowest income cutoff was NT$9,829 in other cities/counties. In addition to the income test, eligible families also needed to pass an asset test. For example, the total wealth of the eligible families had to be lower than NT$3.5 million if they were living in Taipei.

TABLE 2—SUMMARY STATISTICS: ESTIMATED SAMPLE BEFORE AND AFTER THIRD BIRTHDAY

| | Regular outpatient care | | Emergency room care | | Inpatient care | |
|---|---|---|---|---|---|---|
| | Before third birthday | After third birthday | Before third birthday | After third birthday | Before third birthday | After third birthday |
| Visit rate | 541.74 | 522.52 | 16.30 | 15.12 | 3.92 | 3.68 |
| Number of visits per person per year | 19.77 | 19.07 | 0.59 | 0.55 | 0.14 | 0.13 |
| Share of major teaching hospital | 0.04 | 0.02 | 0.35 | 0.34 | 0.29 | 0.30 |
| Share of minor teaching hospital | 0.06 | 0.04 | 0.52 | 0.47 | 0.59 | 0.58 |
| Share of community hospital | 0.04 | 0.05 | 0.12 | 0.18 | 0.13 | 0.12 |
| Share of clinic | 0.87 | 0.90 | 0.01 | 0.01 | 0.00 | 0.00 |
| Average expenditure | 457.75 | 452.57 | 1,620.39 | 1,621.72 | 12,776.43 | 13,001.53 |
| (per visit) | (0.43) | (0.42) | (4.83) | (4.88) | (110.91) | (123.73) |
| Average OOP expenses | 78.92 | 142.67 | 203.02 | 515.82 | 0 | 1,292.48 |
| (per visit) | (0.01) | (0.05) | (0.20) | (0.55) | (0) | (12.61) |
| Share of OOP expenses | 0.20 | 0.36 | 0.16 | 0.40 | 0 | 0.10 |
| Number of children | 364,966 | 359,055 | 48,358 | 46,307 | 13,417 | 12,677 |
| Number of children-visit | 2,019,904 | 1,948,220 | 60,775 | 56,391 | 14,604 | 13,737 |

*Notes:* Data are from the 2005–2008 NHIRD. The summary statistics are based on healthcare utilization happening within 90 days before the third birthday and 90 days thereafter. The visit rate is the number of visits per 10,000 person-days. Average expenditure and average OOP expenses are reported in New Taiwan dollars (NT$), with US$1 equating to NT$32.50 in 2006. All expenditures/expenses in our sample period are inflation-adjusted (NT$ in 2006).

birthday and 90 days after it, as well as the market share of the healthcare provider. From Table 2, it is clear that the average number of visits per 10,000 person-days for regular outpatient care is lower after than before the third birthday, dropping from 541.7 to 522.5 at age 3. Similarly, the number of emergency room visits person-days falls from 16.3 to 15.1. At the same time, we see almost no change in the number of inpatient admissions. The composition of healthcare providers also indicates an interesting change: the shares of regular outpatient visits to major and minor teaching hospitals after the third birthday change from 4 percent to 2 percent and from 6 percent to 4 percent, respectively. In other words, young children tend to visit large hospitals more frequently during the copayment exemption period. A similar observation can be made about the emergency room care. In contrast, there is no change in provider choices for inpatient care.

Table 2 also displays the average medical expenditure per visit, the average OOP expense per visit, and the share of OOP expense within the 90 days before and after the third birthday. As seen in the lower part of this table, due to the expiration of the cost-sharing subsidy, the OOP expense is substantially higher immediately after the third birthday than immediately before it. Nonetheless, the average medical expenditure shows only a small difference. Thus, the patients' parents pay a much higher share of the medical expenses before the patients reach the age of 3.

Finally, in Table 3, we give a breakdown of the visits/admissions by showing the top five diagnoses in each healthcare service. Table 3 demonstrates that all of the top five diagnoses for regular outpatient care are related to upper respiratory infections. The top five diagnoses in emergency room care and inpatient care—including, for

TABLE 3—LIST OF TOP FIVE DIAGNOSES IN EACH HEALTHCARE SERVICE

| Diagnosis | ICD 9 code | Share |
|---|---|---|
| *Panel A. Regular outpatient care* | | |
| Acute upper respiratory infections | 465 | 25.7% |
| Acute bronchitis and bronchiolitis | 466 | 12.2% |
| Acute sinusitis | 461 | 10.6% |
| Acute tonsillitis | 463 | 5.8% |
| Acute nasopharyngitis | 460 | 5.1% |
| *Panel B. Emergency room care* | | |
| Alteration of consciousness (e.g., coma) | 780 | 12.3% |
| Acute upper respiratory infections | 465 | 9.2% |
| Gastroenteritis and colitis | 558 | 7.2% |
| Acute pharyngitis | 462 | 6.6% |
| Acute tonsillitis | 463 | 6.2% |
| *Panel C. Inpatient care* | | |
| Bronchopneumonia | 485 | 17.1% |
| Gastroenteritis and colitis | 558 | 10.5% |
| Pneumonia | 486 | 8.1% |
| Herpangina | 74 | 7.9% |
| Acute tonsillitis | 463 | 6.5% |

*Notes:* This table lists the top five diagnoses and their corresponding ICD 9 code in regular outpatient care, emergency room care, and inpatient care. We calculate the share of visits for each diagnosis, using claim data from the 2005–2008 NHIRD.

example, alteration of consciousness (e.g., comas), bronchopneumonia, and pneumonia—are more severe than those in regular outpatient care.[27]

## III. Results on Healthcare Utilization

In this section, we estimate the causal effect of patients' cost-sharing on children's utilization of outpatient and inpatient care by using an RD design that compares the utilization outcomes immediately before and after a patient's third birthday.

### A. *Identification Strategy*

Our identification strategy is similar to that of other recent studies using an "age discontinuity" to identify the insurance coverage effect (Card, Dobkin, and Maestas 2008, 2009; Anderson, Dobkin, and Gross 2012) and the patient cost-sharing effect

[27] In this paper, an emergency room visit represents a direct visit to the emergency department. While the emergency room is generally regarded as a department dealing with more severe conditions—such as comas, broken legs, head injuries, poisonings, heart attacks, strokes, or severe burns—this is not necessarily true in our case because some parents might consider a fever or allergic reaction life-threatening for their young children. Thus, it is possible that emergency rooms, especially for children, are sometimes used for less serious illnesses. Overall, however, an emergency room visit is considered to be more severe than a regular outpatient visit. For example, comas (altered state of consciousness) are the top cause of emergency room visits and account for 12.3 percent of them (see Table 3). Other severe diagnoses, such as gastroenteritis and colitis, also account for a significant share of emergency room visits. In contrast, the top five diagnoses (making up more than 70 percent) of regular outpatient visits are, as mentioned, related to acute upper respiratory infections, which are usually considered minor illnesses.

(Shigeoka 2014, Fukushima et al. 2016, Nilsson and Paul 2018) on the medical utilization of more mature populations. The general form of our estimated regression is as follows:

$$(1) \qquad Y_{ia} = \beta_0 + \beta_1 Age3_{ia} + f(a;\gamma) + \varepsilon_{ia},$$

where $Y_{ia}$ is the outcome of healthcare utilization for child $i$ at age $a$, including (i) total healthcare expenditure, (ii) the number of visits (admissions), and (iii) expenditure per visit (admission). The variable $a$ is child $i$'s age and is measured in days. The variable $Age3_{ia}$ is a treatment dummy that captures the higher level of the patient's cost-sharing due to the expiration of the subsidy after the third birthday, being equal to 1 if child $i$'s age at the time of their visit is greater than 3.[28] The function $f(a;\gamma)$ is a smooth function of age that controls the age profile of healthcare utilization. The variable $\gamma$ refers a set of parameters in function $f(a;\gamma)$. The variable $\varepsilon_{ia}$ is an error term that reflects all of the other factors that affect the outcome variables.

Our primary interest is in $\beta_1$, which measures any deviation from the continuous relation between the age and the outcomes $Y_{ia}$ at child $i$'s third birthday (i.e., when the treatment variable switches from 0 to 1). The key identification assumption is that all factors except the patient's cost-sharing vary continuously around the child's third birthday, so that $\beta_1$ can be interpreted as the causal effect of the increased cost-sharing on the outcome variable.

For this age group, potential confounding factors could include vaccination and preschool attendance. The recommended immunization schedule could mechanically increase healthcare spending and use for young children at age 3. However, this concern is alleviated by the fact that most children in Taiwan do not need to have vaccines at age 3, as most are given before the child turns 2 years old (Taiwan Centers for Disease Control 2013).[29] Another factor is that the likelihood of going to preschool could affect the chance of a child picking up diseases (e.g., the flu), which would affect their healthcare use. Yet, this factor may not interfere with the cost-sharing change at age 3 because the age of entry for "public" preschools is 4 years of age and the government does not specify a statutory attendance age for "private" kindergartens. Note that the treatment variation in our analysis is based on days (i.e., age is measured in days). These two factors are unlikely to change on a daily basis, and are therefore unlikely to confound the effect of the change in patient cost-sharing at age 3. As we will show in a later section, we examine our identification assumption—no other confounding factors change at age 3—by using pre-reform data. Specifically, we investigate whether there was any discontinuity in healthcare utilization at the third birthday in the sample years before the introduction of the cost-sharing subsidy (1997–2001).

Because the policy variation occurs at the age level—following Card, Dobkin, and Maestas (2009); Anderson, Dobkin, and Gross (2012); and Lemieux and

[28] Note that the third birthday is either the 1,096th or 1,095th day after birth. Since 2004 was a leap year, February 2004 had 29 days. Thus, for the children born before February 29, 2004, their third birthday would have been the 1,096th day after their birth ($365 \times 3 + 1 = 1{,}096$), while for those born after March 1, 2004, their third birthday would have been the 1,095th day after their birth.

[29] See https://www.cdc.gov.tw/Category/List/lpWZqtnmkJfQPfgnaP4lnw.

Milligan (2008)—we collapse the individual-level data into age cells (measured in days). According to Lee and Card (2008), the cell-level regression (weighting each cell by cell size) is equivalent to the individual-level regression using the clustered standard error (i.e., standard errors are clustered by age).[30] Since we follow the same birth cohort (i.e., 414,282 children born in 2003 and 2004) over time, the size of each cell's population is fixed.[31] Our baseline specification is the age-cell version of equation (1):

$$Y_a = \beta_0 + \beta_1 Age3_a + \gamma_1 (a - 3bd) + \gamma_2 Age3_a (a - 3bd) + \varepsilon_a. \tag{2}$$

Here, $Y_a$ is the outcome of interest, aggregated at age $a$. In our main results, we estimate equation (2) locally within a bandwidth of 90 days before and 90 days after the third birthday (i.e., $3bd$) and specify $f(a;\gamma)$ as a linear function but allow the slope to be different on either side of the cutoff (i.e., we interact the age variable fully with the intercept and $Age\,3_a$). In online Appendices E, F, and G of this paper, we examine whether our main results are sensitive to different bandwidth choices and specifications. Additionally, to ensure that $\beta_1$ can be interpreted as the percentage change in the dependent variable directly, in the estimation we take logs of $Y_a$ and recenter the age variable on the third birthday.[32]

## B. *Outpatient Care*

*Change in Utilization of Outpatient Care at the Third Birthday*.—We begin our analysis by examining the effect of the increased cost-sharing on the utilization of outpatient care. Table 4 displays the results for regular outpatient care (panel A) and emergency room care (panel B). The first row of Table 4 reports the change in OOP expenses per visit, induced by the expiration of the cost-sharing subsidy at the age of 3. Note that the observed change in OOP expenses per visit at the age of 3 is endogenous and already reflects changes in healthcare utilization, such as in a patient's choice of provider.[33] In order to compute the change in OOP expenses per visit, which is driven exclusively by policy rather than an individual's choice, we calculate a counterfactual OOP expenses per visit for patients right after the age of 3 (i.e., 90 days after the third birthday), assuming that they made the same healthcare utilization decision (i.e., had the same number of visits and visited the same healthcare provider) as those right before age 3 (i.e., 90 days before the third

[30] See Lee and Card (2008, 660): "This shows that the clustered standard error formula in the micro-level regression is equivalent to using the conventional heteroskedasticity-consistent standard error in a 'cell-level' regression of $Y_j$ on $W_j$, weighting each cell by the weight $n_j/(N/J)$. Consider the simplified case where $n_j = n_0$ for all cells, so the weight becomes 1…" Here, $n_j$ is the sample size in cell $j$; $N$ is the total sample size and $J$ is the number of cells; $Y_j$ and $W_j$ represent a dependent variable and independent variables, respectively.

[31] Due to this fact, the estimated discontinuity in the aggregate-level outcomes at a given age can be interpreted as average estimates of discontinuity in the outcomes at a given age. In addition, using cell-level regression helps us to avoid the estimation problem of zero spending/visits when we take the log of our outcome variables, especially at the per person-day level.

[32] For those children born on or before February 29, 2004, the age variable is $a - 1{,}096$. For those born on or after March 1, 2004, the age variable is $a - 1{,}095$.

[33] In a later section, we find a patient's choice of provider is affected by the expiration of the cost-sharing subsidy at the age of 3.

birthday).[34] In other words, the difference in OOP expenses per visit between patients above the age of 3 and those below age 3 only comes from a change in the copayment rule (i.e., the expiration of the cost-sharing subsidy at the age of 3).

The first row in column 1 suggests that the expiration of the cost-sharing subsidy results in an increase of NT$74 in the OOP expenses per regular outpatient visit. Relative to the baseline mean of NT$79 in Table 2 (i.e., average OOP expenses per visit before the third birthday), this represents a 94 percent increase. The expiration of the subsidy leads to a larger increase in the OOP expenses for an emergency room visit of NT$330 (i.e., a 172 percent increase) because emergency services require a higher copayment and are usually operated by hospitals (see the third row in column 1).

Figure 2 shows how the utilization of regular outpatient care varies with a patient's age at the time of their visit. Figure 2, panel A presents the total expenditure per 10,000 person-days for regular outpatient care.[35] Corresponding to the higher level of cost-sharing after the third birthday, the figure reveals that the total expenditure on regular outpatient visits decreases immediately after age 3. The change in total expenditure is a combination of the change in the number of visits and the expenditure per visit. Figure 2, panels C and E reveal that both the visit rate and the expenditure per visit decline immediately after age 3.

The first row in columns 2–5 of Table 4 presents estimates of the change in utilization of regular outpatient visits at age 3. Column 2 shows that the increased cost-sharing at age 3 causes the total expenditure on regular outpatient visits to decrease significantly, by 6.6 percent. The estimated price elasticity of expenditure on a regular outpatient visit is approximately $-0.10$, which is close to the lower bound of price elasticity (in absolute value) produced by the RAND HIE for outpatient care: $-0.17$ to $-0.31$ (Keeler and Rolph 1988).[36] The change in total expenditure can be decomposed into two margins: the number of visits (extensive margin) and the expenditure per visit (intensive margin). Column 3 reveals that the increased cost-sharing at age 3 reduces the number of visits by 4.8 percent. Since several previous studies (Chandra, Gruber, and McKnight 2010a; Shigeoka 2014) use the number of visits to represent healthcare utilization, here we also report the implied price elasticity based on the number of visits ($-0.08$, for comparison). Note that the change in the number of regular outpatient visits is smaller than the change in total expenditure because the increased cost-sharing at age 3 also leads to a 1.8 percent decrease in the expenditure per visit (column 4).

[34] We calculate this counterfactual OOP expenses per visit figure by using outpatient visits for those right before age 3 but applying real copayment rules after age 3 to each outpatient visit.

[35] We computed these dots by dividing the total expenditure at a particular age by the number of enrollees born in 2003 and 2004, and then multiplying this figure by 10,000. This is a common way to present data in the health economics and public health literature, and it allows us to compare the estimated results across different sample periods and subgroups.

[36] Following previous research (Leibowitz et al. 1985; Manning et al. 1987; Chandra, Gruber, and McKnight 2010a), we compute the price elasticity using an arc elasticity calculated as $((Q_2 - Q_1)/((Q_1 + Q_2)/2))/((P_2 - P_1)/((P_1 + P_2)/2))$, where $Q_1$ and $P_1$ denote, respectively, the baseline healthcare utilization and patient's OOP expense (i.e., the average $Q$ and $P$ within the 90 days before the third birthday), and $Q_2$ and $P_2$ are the healthcare utilization and patient's OOP expense affected by the cost-sharing subsidy (i.e., the average $Q$ and $P$ within the 90 days after the third birthday). This formula is especially suitable for empirical analysis in health economics. Since $P_1$ could be zero in some cases (e.g., the free plan in the RAND HIE, or the zero OOP expense for inpatient care discussed in this paper), the denominator of the price elasticity would be undefined.

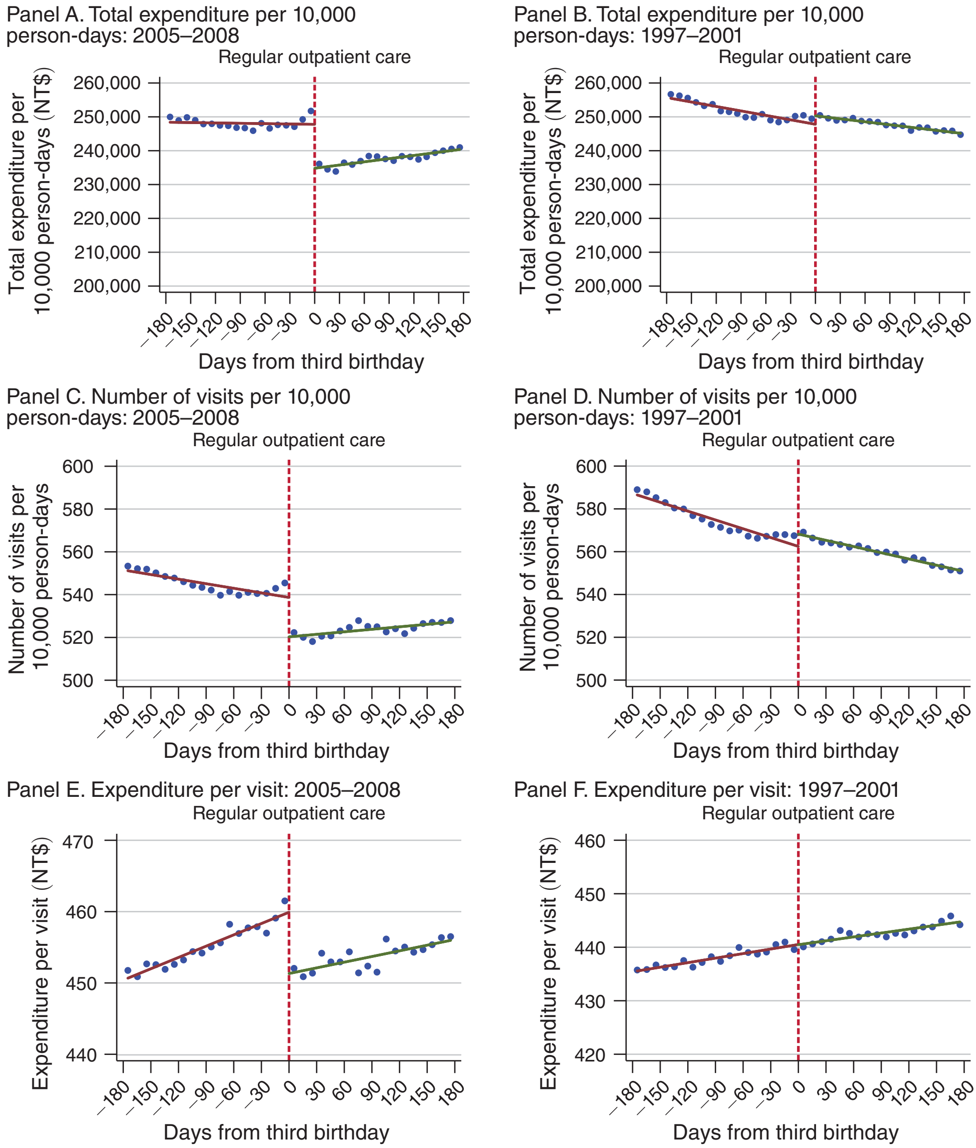


Figure 2. Utilization of Regular Outpatient Care before and after the Third Birthday

*Notes:* We pool NHI claims of regular outpatient care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. The dependent variables are total expenditure (NT$) per 10,000 person-days, number of visits per 10,000 person-days, and expenditure (NT$) per visit by patient age at the time of the visit, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). The age at visit is measured in days. We plot the dependent variables within 180 days before and after the third birthday, and we group it every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variables. The line is from fitting a linear regression on age variables fully interacted with *Age*3.

The change in the expenditure per visit is likely to be a mixture of two forces. First, the marginal patients who visit the doctor only because there is a subsidy in place are not as sick as those who would use the healthcare services regardless of

Table 4—The Effect of Patient Cost-Sharing on Utilization of Outpatient Care at the Age of 3

| Variables | OOP expense (1) | log(total expenditure) (2) | log(number of visits) (3) | log(expenditure/visit) (4) | Elasticity (5) |
|---|---|---|---|---|---|
| *Panel A. Regular outpatient care* | | | | | |
| Sample: 2005–2008 | | | | | |
| *Age*3 | 73.82 | −6.63 | −4.82 | −1.81 | −0.10 |
| | | (0.47) | (0.32) | (0.27) | |
| Sample: 1997–2001 | | | | | |
| *Age*3 | | 0.19 | 0.25 | −0.06 | |
| | | (0.23) | (0.17) | (0.12) | |
| *Panel B. Emergency visit* | | | | | |
| Sample: 2005–2008 | | | | | |
| *Age*3 | 329.90 | −5.59 | −6.38 | 0.78 | −0.06 |
| | | (1.53) | (1.15) | (0.78) | |
| Sample: 1997–2001 | | | | | |
| *Age*3 | | 1.35 | 0.72 | 0.63 | |
| | | (1.18) | (1.02) | (0.83) | |

*Notes:* The estimated samples in the first and third rows are 414,282 children born in 2003 or 2004. We use 2005–2008 NHIRD data to get their healthcare utilization at around age 3. The estimated samples in the second and fourth rows are 866,383 children born between 1995 and 1997. We use 1997–2001 NHIRD data to get their healthcare utilization at around age 3. We collapse the individual-level data into age cells and measure age in days. Column 1 displays the estimated change in OOP expenses (NT$) per visit at the age of 3. We estimate the change in out-of-pocket expenses per visit by assuming patients above the age of 3 (i.e., 90 days after their third birthday) made the same healthcare utilization decision (i.e., had the same number of visits and visited the same healthcare provider) as those immediately below the age of 3 did (i.e., 90 days before the third birthday). By doing so, the estimated change in out-of-pocket expenses per visit at the age of 3 is driven exclusively by expiration of the cost-sharing subsidy rather than an individual's choice. Columns 2–4 present the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth (i.e., 180 observations). The dependent variables in all the regressions above are the log of total expenditure, the log of numbers of visits and the log of expenditure per visit, at each age in days. For columns 2–4, the estimated coefficients are multiplied by 100 to show the percentage change in the outcome. Column 5 displays the estimated price elasticity of total expenditure, using information from columns 1 and 2, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). Robust standard errors are in parentheses.

the subsidy. In other words, patients who visit the doctor after their third birthday are more likely to have a serious illness than those who visit the doctor before age 3. Therefore, the expenditure per visit could be higher after age 3.[37] Second, the expiration of the subsidy causes a larger increase in cost-sharing for high-intensity providers than for low-intensity providers due to the tiered copayments. This incentivizes patients to reduce their utilization of healthcare services at high-intensity providers (i.e., teaching hospitals) after age 3. Note that a visit to a high-intensity provider usually incurs greater expenditure than one to a low-intensity provider. Thus, the expiration of the cost-sharing subsidy could reduce the expenditure per visit after age 3. Our estimates imply that the latter force dominates the former. In a later section, we discuss this issue in more detail.

We replicate our RD design for the emergency room care. Figure 3 reveals that emergency room visits also see a salient change in utilization around the third birthday during the post-reform period (2005–2008). The third row in columns 2–5 of

[37] This assumes that healthcare providers spend more on treating sicker patients.

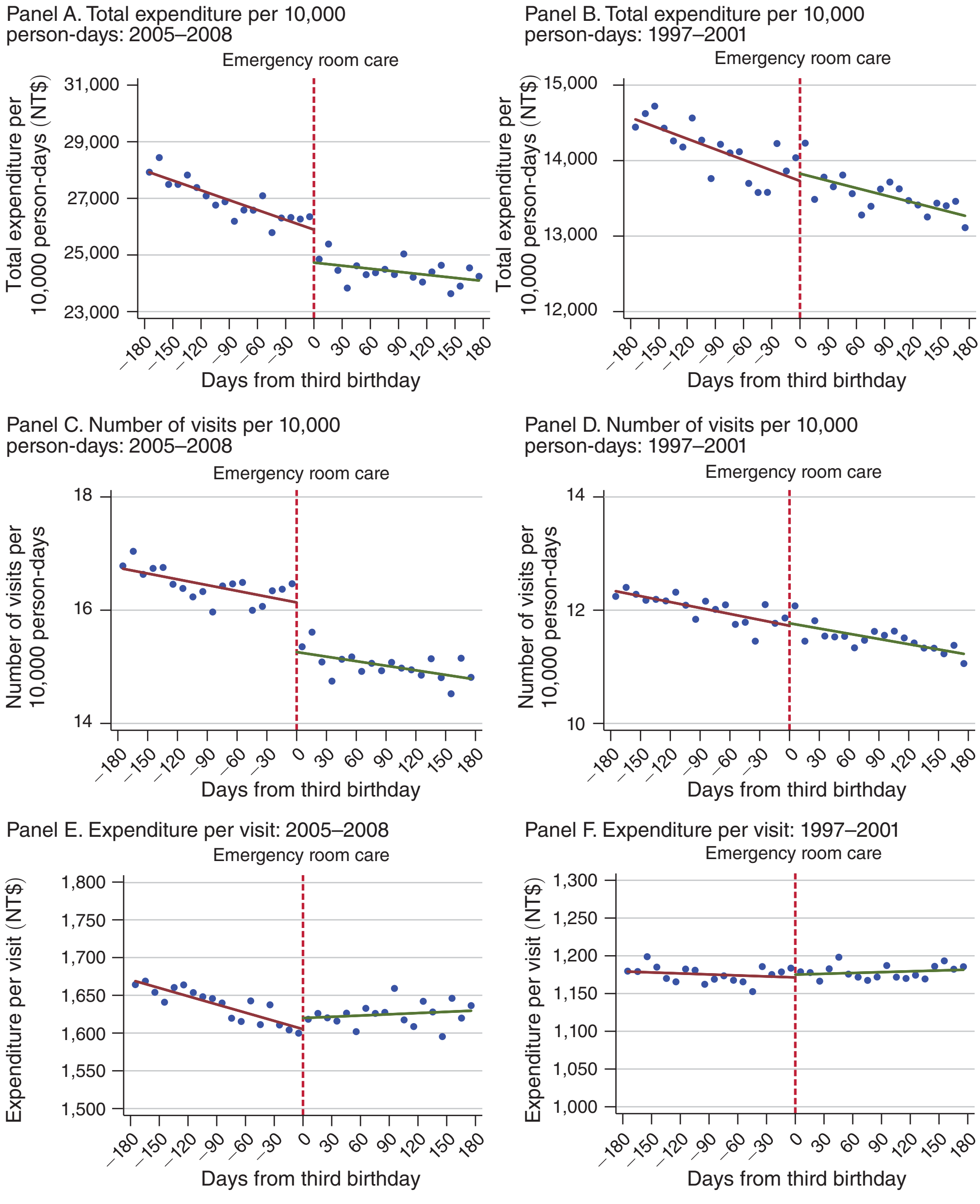


Figure 3. Utilization of Emergency Room Care before and after the Third Birthday

*Notes:* We pool NHI claims of emergency room care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. The dependent variables are total expenditure (NT$) per 10,000 person-days, number of visits per 10,000 person-days and expenditure (NT$) per visit by patient age at the time of the visit, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). The age at visit is measured in days. We plot the dependent variables within 180 days before and after the third birthday, and we group it every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variables. The line is from fitting a linear regression on age variables fully interacted with *Age*3.

Table 4 shows that the increased cost-sharing at age 3 significantly reduces the total expenditure for emergency room care by 5.6 percent. The estimated price elasticity of total expenditure for an emergency room visit is around −0.06. Again, this change can be decomposed into a 6.4 percent decrease in the number of visits (statistically significant) and a 0.8 percent increase in the medical expense per visit (statistically insignificant).

To examine any confounding factors affecting our estimates, we repeat the above analysis using pre-reform data (1997–2001) as a placebo test. Since children under the age of 3 were not eligible for the cost-sharing subsidy during this period, we should not observe any discontinuity in our outcomes if our main results are driven by the expiration of the cost-sharing subsidy. In sharp contrast to the graphs presented above, here we find no visible discontinuity in utilization at the third birthday for either regular outpatient care (Figure 2) or emergency room care (Figure 3). Consistent with the graphical evidence, the second and fourth rows in columns 2–5 of Table 4 show that the estimated coefficients of *Age*3 are never significant and are much smaller in magnitude than the earlier results. These results confirm the validity of our RD design.

In online Appendices E, F, and G, we present a series of robustness checks for our main results. Figures E1 and E2 systematically examine the sensitivity of our RD estimates to different bandwidths. Tables F1 and F2 examine the sensitivity of our RD estimates to various specifications (e.g., a quadratic specification) over different windows. In general, our main results are quite robust to the bandwidth choices and different empirical specifications. However, one caveat could threaten the validity of our RD design. Because every child eventually "ages out" of his/her cost-sharing subsidy, parents may anticipate the sharp increase in the price of healthcare services after the child's third birthday and strategically "stock up" on outpatient care.[38] This behavioral response would represent an intertemporal substitution of healthcare (i.e., substituting future healthcare with current healthcare) rather than a "real" change (increase) in utilization induced by the cost-sharing subsidy, which is our main point of interest. Such a behavioral response would tend to upwardly bias our estimates of the change in healthcare utilization at age 3 (in absolute values). Indeed, we see in Figure 2, panels A and C that the total expenditure and the number of visits suddenly rise 20 days before the third birthday. In order to account for the possible anticipation effect, we decompose the effect of the age 3 cutoff into intertemporal substitution and true demand-response. We estimate equation (2) but exclude from the sample those whose age is within 20 days before and after the third birthday. We then use the estimated regression (2) to predict counterfactual outcomes for those excluded ages as if there was no distorted response from the strategic stock-up behavior. Our decomposition result shows that only 9 percent of the change in total expenditure at the third birthday can be attributed to intertemporal substitution.

In addition, following previous studies (Barreca et al. 2011, Shigeoka 2014), we conduct a "donut" RD by systematically excluding the utilization of outpatient care within 3 to 21 days of the third birthday. Although there is no consensus on the

[38] Since most visits of young children are for acute diseases (e.g., 74 percent of visits are for acute respiratory diseases), it is possible for parents to foresee the need for upcoming medical treatments, and then visit doctors one or two days earlier.

Table 5—The Effect of Patient Cost-Sharing on Utilization of Regular Outpatient Care at the Age of 3: By Type of Visit

| Variables | OOP expense (1) | log(total expenditure) (2) | log(number of visits) (3) | log(expenditure /visit) (4) | Elasticity (5) |
|---|---|---|---|---|---|
| *Panel A. By beneficial care* | | | | | |
| More beneficial care | 76.62 | −5.03 | −4.11 | −0.91 | −0.08 |
| | | (0.69) | (0.60) | (0.27) | |
| Less beneficial care | 73.39 | −6.85 | −4.93 | −1.92 | −0.11 |
| | | (0.50) | (0.35) | (0.30) | |
| *Panel B. By essential healthcare* | | | | | |
| More essential healthcare | 60.63 | −2.23 | −4.10 | 1.87 | −0.04 |
| | | (4.44) | (3.75) | (2.51) | |
| Less essential healthcare | 73.84 | −6.65 | −4.83 | −1.82 | −0.10 |
| | | (0.47) | (0.32) | (0.27) | |
| *Panel C. By preventive care* | | | | | |
| Mental illness | 202.52 | −24.71 | −25.49 | 0.78 | −0.24 |
| | | (2.95) | (2.56) | (1.56) | |
| Preventive care | 170.89 | −50.64 | −54.57 | 3.93 | −0.53 |
| | | (8.28) | (6.49) | (6.37) | |

*Notes:* The estimated sample includes 414,282 children born in 2003 or 2004. We use 2005–2008 NHIRD data to get their healthcare utilization at around the age of 3. We collapse the individual-level data into age cells and measure age in days. In panel A, we define beneficial care as the diagnosis list (three-digit ICD 9 code) in online Appendix Table H. In panel B, we define essential care as the diagnosis list (three-digit ICD 9 code) in online Appendix I. In panel C, we define preventive care using the following three-digit ICD 9 codes: V70, V72, V20, V03-V06, and define mental health services using ICD 9 codes 290-319. Column 1 displays the estimated change in OOP expenses (NT$) per visit at the age of 3. We estimate the change in out-of-pocket expenses per visit by assuming patients above the age of 3 (i.e., 90 days after third birthday) made the same healthcare utilization decision (i.e., had the same number of visits and visited the same healthcare provider) as those right below age 3 did (i.e., 90 days before their third birthday). By doing so, the estimated change in out-of-pocket expenses per visit at the age of 3 is driven exclusively by cost-sharing subsidy expiration rather than an individual's choice. Columns 2–4 present the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth (i.e., 180 observations). The dependent variables in all of the regressions above are the log of total expenditure, the log of numbers of visits, and the log of expenditure per visit, at each age in days. For columns 2–4, the estimated coefficients are multiplied by 100 to show the percentage change in the outcome. Column 5 displays the estimated price elasticity of total expenditure, using information from columns 1 and 2, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). Robust standard errors are in parentheses.

optimal size of a donut hole, and while eliminating the sample around the threshold seems to contrast with the spirit of RD design, this type of estimation can still provide us some sense of how the "stocking up" effect influences our estimates. Tables G1 and G2 indicate that the estimates from different sizes of donut holes are very similar to our main estimates.

*Subgroup Analysis: By Type of Visit.*—In this section, we investigate the heterogeneity in price responses by type of visit. Tables 5 and 6 present the results for regular outpatient care and emergency room care, respectively. Each row displays the RD estimates (coefficients of *Age*3) for the various subgroups.

In panel A and panel B, we use ICD 9 codes to define beneficial or essential healthcare based on previous literature. The extent to which the utilization of beneficial or essential children's healthcare services can be affected by price has an

Table 6—The Effect of Patient Cost-Sharing on Utilization of Emergency Room Care at the Age of 3: By Type of Visit

| Variables | OOP expense (1) | log(total expenditure) (2) | log(number of visits) (3) | log(expenditure/visit) (4) | Elasticity (5) |
|---|---|---|---|---|---|
| *Panel A. By beneficial care* | | | | | |
| More beneficial care | 346.91 | −4.45 | −5.73 | 1.28 | −0.05 |
| | | (2.60) | (2.33) | (1.43) | |
| Less beneficial care | 324.26 | −5.86 | −6.56 | 0.70 | −0.07 |
| | | (1.78) | (1.25) | (0.94) | |
| *Panel B. By essential healthcare* | | | | | |
| More essential healthcare | 317.34 | 5.00 | 3.31 | 1.69 | 0.06 |
| | | (8.31) | (6.55) | (5.53) | |
| Less essential healthcare | 330.35 | −6.08 | −6.68 | 0.61 | −0.07 |
| | | (1.53) | (1.18) | (0.77) | |

*Notes:* The estimated sample includes 414,282 children born in 2003 or 2004. We use 2005–2008 NHIRD data to find their healthcare utilization around the age of 3. We collapse the individual-level data into age cells and measure age in days. In panel A, we define beneficial care as the diagnosis list (three-digit ICD 9 code) in online Appendix H. In panel B, we define essential care (i.e., nondeferrable visits) as the diagnosis list (three-digit ICD 9 code) in online Appendix I. Column 1 displays the estimated change in OOP expenses (NT$) per visit at the age of 3. We estimate the change in out-of-pocket expenses per visit by assuming patients above the age of 3 (i.e., 90 days after their third birthday) made the same healthcare utilization decision (i.e., had the same number of visits and visited the same healthcare provider) as those immediately below age 3 did (i.e., 90 days before their third birthday). By doing so, the estimated change in out-of-pocket expenses per visit at the age of 3 is driven exclusively by the expiration of the cost-sharing subsidy rather than an individual's choice. Columns 2–4 present the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth (i.e., 180 observations). The dependent variables in all of the regressions above are the log of total expenditure, the log of numbers of visits, and the log of expenditure per visit, at each age in days. For columns 2–4, the estimated coefficients are multiplied by 100 to show the percentage change in the outcome. Column 5 displays the estimated price elasticity of total expenditure, using information from columns 1 and 2, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). Robust standard errors are in parentheses.

important policy implication. If such utilization is sensitive to price, a cost-sharing subsidy might benefit children's health by increasing the use of this type of healthcare service. Panel A displays the estimates by beneficial or less beneficial treatment. Following Iizuka and Shigeoka (2018) and Gadomsk, Jenkins, and Nichols (1998), we use diagnoses listed as Ambulatory Care Sensitive Conditions (ACSCs) to represent beneficial treatments. ACSCs were developed by the Agency for Healthcare Research and Quality (AHRQ) to study the type of outpatient care that may reduce the need for inpatient admissions. Thus, these types of outpatient care are usually considered beneficial treatments (i.e., having less moral hazard). For example, proper outpatient care for asthma, which is listed among the ACSCs, can substantially reduce children's utilization of inpatient care (Homer et al. 1996, Lieu et al. 1997). Table H1 of online Appendix H lists the diagnoses (ICD 9 codes) defined as beneficial treatments. We find that the utilization of beneficial outpatient care is sensitive to price, which is similar to the finding in Iizuka and Shigeoka (2018). Moreover, our result suggests that increased cost-sharing at the age of 3 leads to a smaller decline in the utilization of beneficial outpatient care than the situation seen for less beneficial care. For example, Table 5 shows that expenditure on beneficial regular outpatient care decreases by 5 percent (i.e., price elasticity is −0.08), but expenditure on less beneficial regular outpatient care decreases by 6.9 percent (i.e., price elasticity is $-0.11$). However, the difference in price responses between beneficial and nonbeneficial care is not statistically significant. A similar pattern can be found in Table 6 for emergency room care.[39]

Furthermore, we examine the heterogeneity in price responses based on essential healthcare—patients' nondeferrable medical conditions (see panel B). Inspired by Card, Dobkin, and Maestas (2009), we identify the visits for nondeferrable conditions by using pre-reform (i.e., 2000–2001) data and a set of three-digit ICD 9 diagnosis codes that have similar visit rates on weekdays and weekends. For instance, if a given diagnosis code has similar emergency room visit rates on weekends and weekdays, then weekend visits should account for around 0.29 $(2/7)$ of all visits for this specific diagnosis code. Therefore, we define the visits with diagnosis codes whose fraction of weekend visits is close to 0.29 as visits for nondeferrable conditions. Table I1 of online Appendix I lists the top five diagnoses that are considered nondeferrable conditions and their corresponding ICD 9 codes. For example, tracheostomy complications and concussions are very serious situations and should be treated immediately. They are the top diagnoses among nondeferrable regular outpatient visits and emergency room visits, respectively. The estimates in Tables 5 and 6 suggest that the effect of patient cost-sharing on the utilization of nondeferrable care is statistically insignificant. For example, the increased cost-sharing at age 3 reduces the expenditure on nondeferrable regular outpatient care insignificantly, by 2.2 percent (i.e., price elasticity is $-0.04$).

Finally, we display the estimated price elasticities for preventive care and mental health services. We focus on preventive care because it could substantially reduce future medical costs. Likewise, early treatment for children's mental disorders (e.g., autism) could lead to better treatment outcomes. Panel C in Table 5 shows that increased cost-sharing at the age of 3 reduced medical expenditure on mental illnesses by 24.7 percent and on preventive care by 50.6 percent. The implied price elasticities for these types of healthcare services are quite large (in absolute values, $-0.24$ for mental health services and $-0.53$ for preventive care), for which we provide two possible reasons. First, the NHI provides seven free health checkups for children under the age of 7, and these include a basic body check (e.g., height, weight, nutrition status, and vision) and an early developmental assessment (e.g., cognitive skills, language skills, or motor skills, which cover basic preventive care or mental health services). Since our sample excludes these free health checkups, the preventive care and mental health service in our analysis could be more discretionary. This fact could help explain why we find large price elasticity for these healthcare services (in absolute values). Second, neither preventive care nor mental health services provides immediate health benefits, and so patients (parents) might think it is not worth utilizing these healthcare services when they need to pay a copayment.[40]

[39] In fact, our result is consistent with the findings in RAND HIE (Manning et al. 1987) and a recent study by Brot-Goldberg et al. (2017), suggesting patients do not distinguish between beneficial and nonbeneficial care.

[40] A recent study (Cohen, Neumann, and Weinstein 2008) performed an extensive meta-analysis and found that distributions of cost estimates per quality-adjusted life year are essentially the same when comparing preventive services to other services. However, it is also possible that people might not fully understand the value of

To sum up the findings in panel A to panel C, our results suggest parents are less willing to adjust the utilization of beneficial or essential (nondeferrable) outpatient care for their children in response to the increased cost-sharing at age 3. However, we also find that healthcare services that might not have immediate health benefits but could reduce future medical costs for young children—such as preventive care and mental health services—are somewhat price sensitive.

*Subgroup Analysis: By Patient Type*.—In Tables 7 and 8, we utilize demographic information from the NHIRD to investigate the heterogeneity in price responses by patient type. Panel A displays the results by birth order. Previous studies (Price 2008; Monfardini and See 2011; Lehmann, Nuevo-Chiquero, and Vidal-Fernandez 2018) have shown that parents are more cautious and make more parental investments (i.e., spend more time or money) when raising their first child. In addition, parents raising their first child could have limited experience and knowledge about making medical decisions for them. Especially acute diseases are major causes of outpatient visits for young children, and usually involve the appearance of salient symptoms (e.g., fever, cough, muscle pain, or difficulty breathing). Some of them, such as the common cold, might not necessarily require medical intervention. However, new parents could overweigh salient symptoms due to behavioral hazard (Baicker, Mullainathan, Schwartzstein 2015) so that they might not adjust the healthcare utilization of their children in response to the price change. The results show that first-born children's utilization of outpatient care is less price sensitive than that of non-first-born children, especially for emergency room care.

Panel B presents the results by gender. We find the increased cost-sharing at age 3 significantly reduces the utilization of regular outpatient care for boys and girls. However, girls' utilization of emergency room care is more price sensitive than that of boys, suggesting that parents might think a daughter's emergency room visit is more discretionary than a son's visit. This result is consistent with Taiwanese parents' general preference for sons over daughters (Lin, Liu, and Qian 2014).

Panel C presents the results based on household income (per capita).[41] This subgroup analysis helps us understand whether the current levels of copayment create a situation in which some patients are unable to afford outpatient care. If affordability plays an important role in a patient's utilization decision, we would expect the utilization response to the increased cost-sharing at age 3 to vary by household income.

these healthcare services and therefore underutilize them, due to behavioral hazards (Baicker, Mullainathan, and Schwartzstein 2015).

[41] Note that the NHIRD does not include a direct measure of household income. However, it does have information on insured income for people who are working, and the nonworking household members (e.g., children) must enroll in NHI through one of their household's working members. Thus, we use insured income as a proxy for household income. Since insured income is a better approximation of an employee's income than self-employed income, in this subgroup analysis we only use that portion of the sample whose parents are private-sector or public-sector employees. In this sense, we might underestimate the household income. A low-income household is defined as one ranked below the twenty-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$27,000). A middle-income household is defined as one ranked between the twenty-fifth and seventy-fifth percentiles of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$51,000). A high-income household is defined as one ranked above the seventy-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$98,000).

Table 7—The Effect of Patient Cost-Sharing on Utilization of Regular Outpatient Care at the Age of 3: By Patient Type

| Variables | OOP expense (1) | log(total expenditure) (2) | log(number of visits) (3) | log(expenditure/visit) (4) | Elasticity (5) |
|---|---|---|---|---|---|
| *Panel A. By birth order* | | | | | |
| 1st child | 76.46 | −5.96 | −4.69 | −1.27 | −0.09 |
| | | (0.53) | (0.33) | (0.38) | |
| 2nd child | 71.39 | −7.25 | −4.88 | −2.38 | −0.12 |
| | | (0.65) | (0.44) | (0.39) | |
| 3rd child (above) | 68.87 | −8.08 | −5.01 | −3.08 | −0.13 |
| | | (1.33) | (0.76) | (1.04) | |
| *Panel B. By gender* | | | | | |
| Male | 75.38 | −7.24 | −4.89 | −2.36 | −0.11 |
| | | (0.59) | (0.37) | (0.40) | |
| Female | 71.90 | −5.84 | −4.74 | −1.10 | −0.09 |
| | | (0.57) | (0.38) | (0.33) | |
| *Panel C. By income* | | | | | |
| Low-income | 71.93 | −6.80 | −4.85 | −1.95 | −0.11 |
| | | (0.77) | (0.55) | (0.61) | |
| Middle-income | 73.97 | −6.78 | −4.16 | −2.62 | −0.11 |
| | | (0.67) | (0.44) | (0.46) | |
| High-income | 78.40 | −6.35 | −4.59 | −1.77 | −0.10 |
| | | (0.85) | (0.49) | (0.62) | |
| *Panel D. By health status* | | | | | |
| Sickly children | 83.36 | −8.16 | −5.48 | −2.68 | −0.12 |
| | | (0.62) | (0.45) | (0.43) | |
| Healthy children | 67.96 | −5.64 | −4.42 | −1.21 | −0.09 |
| | | (0.54) | (0.35) | (0.32) | |
| *Panel E. By healthcare accessibility* | | | | | |
| Greater access to healthcare | 78.35 | −5.51 | −4.09 | −1.41 | −0.08 |
| | | (0.72) | (0.47) | (0.47) | |
| Less access to healthcare | 72.09 | −6.96 | −5.02 | −1.95 | −0.11 |
| | | (0.47) | (0.34) | (0.28) | |

*Notes:* The estimated sample includes 414,282 children born in 2003 or 2004. We use 2005–2008 NHIRD data to find their healthcare utilization around the age of 3. We collapse the individual-level data into age cells and measure age in days. In panel C, a low-income household is defined as one ranked below the twenty-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$27,000). A middle-income household is defined as one ranked between the twenty-fifth percentile and the seventy-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$51,000). A high-income household is defined as one ranked above the seventy-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$98,000). In panel D, the sicker children are defined as those with inpatient spendings while aged 1–2 above the median. The definition of healthier children is the opposite. On average, the sicker children spend more than NT$20,000 at 1–2 years old. In contrast, healthier children have no inpatient admissions (i.e., zero inpatient spending) during this age range. In Panel E, we use those children born in counties with more than 14 pediatricians per 10,000 persons, to indicate the subgroup that has greater access to healthcare services. Column 1 displays the estimated change in OOP expenses (NT$) per visit at the age of 3. We estimate the change in out-of-pocket expenses per visit by assuming patients above the age of 3 (i.e., 90 days after their third birthday) made the same healthcare utilization decision (i.e., had the same number of visits and visited the same healthcare provider) as those immediately below age 3 did (i.e., 90 days before their third birthday). By doing so, the estimated change in out-of-pocket expenses per visit at the age of 3 is driven exclusively by expiration of the cost-sharing subsidy rather than an individual's choice. Columns 2–4 present the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth (i.e., 180 observations). The dependent variables in all of the regressions above are the log of total expenditure, the log of number of visits, and the log of expenditure per visit, at each age in days. For columns 2–4, the estimated coefficients are multiplied by 100 to show the percentage change in the outcome. Column 5 displays the estimated price elasticity of total expenditure, using the information from columns 1 and 2, with US$1 equal to NT$32.50 in 2006. All expenditures/incomes in our sample period are inflation-adjusted (NT$ in 2006). Robust standard errors are in parentheses.

Table 8—The Effect of Patient Cost-Sharing on Utilization of Emergency Room Care at the Age of 3: By Patient Type

| Variables | OOP expense (1) | log(total expenditure) (2) | log(number of visits) (3) | log(expenditure/visit) (4) | Elasticity (5) |
|---|---|---|---|---|---|
| *Panel A. By birth order* | | | | | |
| 1st child | 334.39 | −3.29 | −5.76 | 2.47 | −0.04 |
| | | (1.87) | (1.59) | (0.96) | |
| 2nd child | 324.57 | −8.27 | −6.56 | −1.71 | −0.09 |
| | | (2.82) | (2.20) | (1.59) | |
| 3rd child (above) | 315.43 | −14.59 | −11.76 | −2.83 | −0.17 |
| | | (5.80) | (4.58) | (3.46) | |
| *Panel B. By gender* | | | | | |
| Male | 329.95 | −2.86 | −5.58 | 2.72 | −0.03 |
| | | (2.03) | (1.50) | (0.98) | |
| Female | 329.81 | −9.27 | −7.43 | −1.84 | −0.10 |
| | | (2.24) | (1.53) | (1.32) | |
| *Panel C. By household income* | | | | | |
| Low-income | 331.20 | −11.87 | −14.81 | 2.95 | −0.13 |
| | | (3.53) | (3.05) | (1.73) | |
| Middle-income | 332.89 | −1.73 | −2.10 | 0.36 | −0.02 |
| | | (2.37) | (2.05) | (1.33) | |
| High-income | 343.06 | −4.71 | −4.94 | 0.22 | −0.05 |
| | | (3.41) | (2.97) | (1.75) | |
| *Panel D. By health status* | | | | | |
| Sickly children | 329.31 | −4.94 | −7.16 | 2.22 | −0.05 |
| | | (2.20) | (1.88) | (1.25) | |
| Healthy children | 330.44 | −6.09 | −5.69 | −0.39 | −0.07 |
| | | (1.95) | (1.61) | (1.04) | |
| *Panel E. By healthcare accessibility* | | | | | |
| Greater access to healthcare | 355.92 | −6.85 | −6.61 | −0.23 | −0.07 |
| | | (2.67) | (2.16) | (1.47) | |
| Less access to healthcare | 318.39 | −5.34 | −6.33 | 0.99 | −0.06 |
| | | (1.93) | (1.49) | (0.90) | |

*Notes:* The estimated sample includes 414,282 children born in 2003 or 2004. We use 2005–2008 NHIRD data to find their healthcare utilization around the age of 3. We collapse the individual-level data into age cells and measure age in days. In panel C, a low-income household is defined as one ranked below the twenty-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$27,000). A middle-income household is defined as one ranked between the twenty-fifth percentile and the seventy-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$51,000). A high-income household is defined as one ranked above the seventy-fifth percentile of the household income (per capita) distribution (i.e., the average monthly household income for this subgroup is around NT$98,000). In panel D, the sicker children are defined as those with inpatient spendings while aged 1–2 above the median. The definition of healthier children is the opposite. On average, the sicker children spend more than NT$20,000 at 1–2 years old. In contrast, healthier children have no inpatient admissions (i.e., zero inpatient spending) during this age range. In Panel E, we use those children born in counties with more than 14 pediatricians per 10,000 persons, to indicate the subgroup that has greater access to healthcare services. Column 1 displays the estimated change in OOP expenses (NT$) per visit at the age of 3. We estimate the change in out-of-pocket expenses per visit by assuming patients above the age of 3 (i.e., 90 days after their third birthday) made the same healthcare utilization decision (i.e., had the same number of visits and visited the same healthcare provider) as those immediately below age 3 did (i.e., 90 days before their third birthday). By doing so, the estimated change in out-of-pocket expenses per visit at the age of 3 is driven exclusively by expiration of the cost-sharing subsidy rather than an individual's choice. Columns 2–4 present the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth (i.e., 180 observations). The dependent variables in all of the regressions above are the log of total expenditure, the log of number of visits, and the log of expenditure per visit, at each age in days. For columns 2–4, the estimated coefficients are multiplied by 100 to show the percentage change in the outcome. Column 5 displays the estimated price elasticity of total expenditure, using the information from columns 1 and 2, with US$1 equal to NT$32.50 in 2006. All expenditures/incomes in our sample period are inflation-adjusted (NT$ in 2006). Robust standard errors are in parentheses.

In particular, the use of outpatient care by low-income children should exhibit a larger decrease after age 3 because low-income children, who are more likely to be liquidity constrained, might not be able to afford care. Before discussing our results, an important reminder is that our analysis excludes very low-income families since their copayments are waived. For regular outpatient care, our results show that the increased cost-sharing at age 3 leads to similar reductions in utilization across the different income groups. Thus, the estimated price elasticities are quite similar. This implies that healthcare affordability might play a limited role in the utilization of regular outpatient care. In contrast, we find that the increased cost-sharing at age 3 causes a significant decrease in emergency room use for low-income children, but not for middle- or high-income children.[42] This finding implies that some parents of low-income children might not be able to afford emergency room services once they have to pay the NHI copayment.

Panel D examines the heterogeneity in price responses by patient's health status. Inspired by previous studies (Iizuka and Shigeoka 2018, Dranove et al. 2003), we categorize children into two types of health status—sickly or healthy—using prior healthcare spending (i.e., median inpatient spending between ages 1 and 2). Specifically, the sickly children are defined as those with inpatient spending above the median. The definition of healthy children is the opposite. On average, the sickly children's parents spend more than NT$20,000 on their healthcare between ages 1 and 2. In contrast, healthy children do not have any inpatient admissions at all (i.e., zero inpatient spending) during this age range. Panel D displays RD estimates separately for sickly and healthy children. We find the increased cost-sharing at age 3 significantly reduces both sickly and healthy children's utilization of outpatient care (i.e., regular outpatient care and emergency room care).[43]

In order to investigate the heterogeneity in price responses by accessibility of healthcare services, panel E presents the results based on healthcare accessibility in children's birth counties. Supply-side factors, such as the supply capacity of healthcare services, could affect the price elasticities of healthcare demand. Panel E uses children born in counties with more than 14 pediatricians per 10,000 persons (i.e., the median value of this measure) to represent the subgroup with better access to healthcare services. Our results suggest that the increased cost-sharing at age 3 significantly reduces utilization of outpatient care regardless of living area with good or bad healthcare accessibility.

*Change in Choice of Provider at the Third Birthday*.—In this section, we examine the impact of cost-sharing on patients' choice of provider of outpatient care. As mentioned before, NHI has a tiered copayment scheme (i.e., patients pay a higher copayment for teaching hospitals) to reduce the number of visits to teaching

[42] Nilsson and Paul (2018) utilized Swedish data and obtained similar findings. They found that outpatient utilization by low-income children had a larger price response than that by high-income ones.

[43] The existing evidence is mixed. RAND HIE (Manning et al. 1987) found that the healthcare utilization of both healthier and sicker patients respond to the change in patient cost-sharing significantly. However, Brot-Goldberg et al. (2017) found that the sickest patients reduce their healthcare spending the most when faced with a high-deductible plan. Some other studies using quasi-experimental design have found smaller price responsiveness among sicker adults (Chandra, Gruber, and McKnight 2014; Fukushima et al. 2016) and children (Iizuka and Shigeoka 2018).

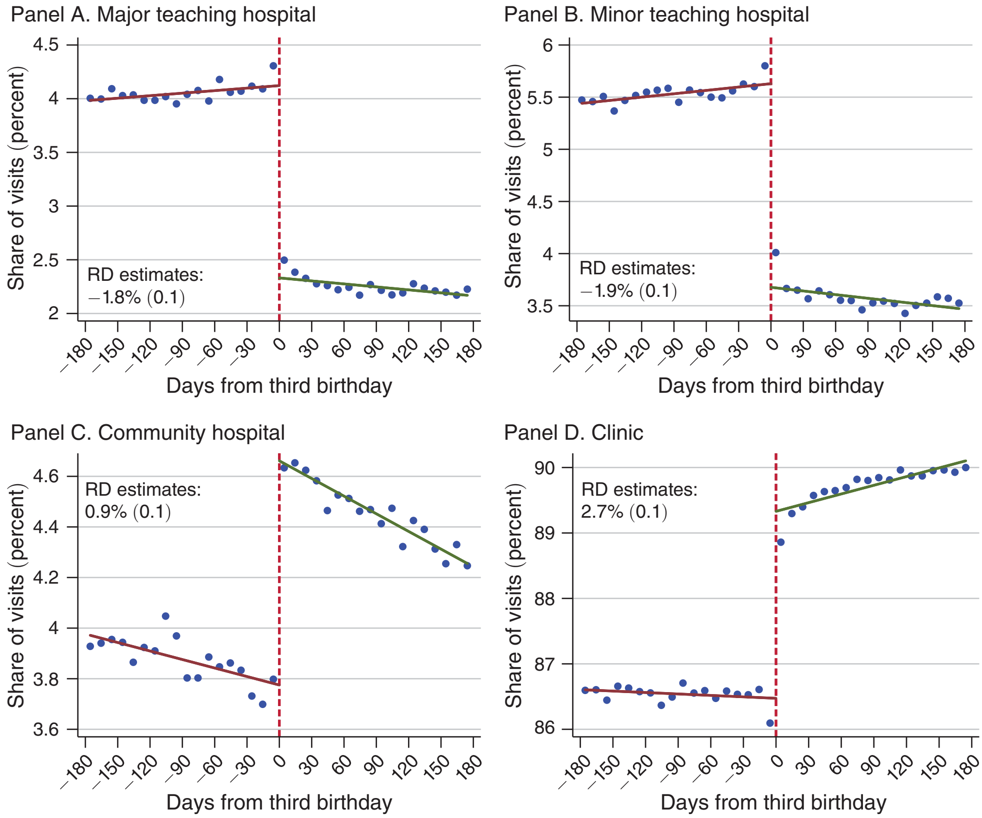


Figure 4. Provider Choice before and after the Third Birthday: Regular Outpatient Care

*Notes:* We pool NHI claims of regular outpatient care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. The dependent variable is share of visits for each type of healthcare provider. The age at the time of each visit is measured in days. We plot the dependent variable within 180 days before and after the third birthday, and we group it every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variable. The line is from fitting a linear regression on age variables fully interacted with *Age*3. The RD estimates are based on an estimated coefficient on *Age*3 in equation (2) using a 90-day bandwidth. The standard errors of the RD estimates are presented in parentheses.

hospitals for minor ailments due to free access to healthcare services. In other words, the tiered copayments should incentivize patients not to choose teaching hospitals if their illness can be cured by a simple treatment at a clinic or community hospital. The cost-sharing subsidy essentially eliminates this incentive for the patients under age 3. Thus, we can investigate how the tiered copayments affect patients' provider choices by comparing the choices made immediately after the third birthday (i.e., under tiered copayments) to those made immediately before the third birthday (i.e., without tiered copayments). Note that prior to the third birthday, patients have to pay a registration fee that varies according to the type of healthcare provider.

To examine whether the tiered copayments discourage patients from visiting teaching hospitals (i.e., high-intensity providers), Figure 4, panels A to D present the age profiles of the share of regular outpatient visits by provider type. Figure 4, panel A shows that the share of visits to major teaching hospitals declines immediately after the third birthday, by 1.8 percentage points (from 4.2 percent to 2.4 percent). Compared to the baseline mean (i.e., 4.2 percent of visits before the third birthday), this result suggests tiered copayments reduce the share of visits to major teaching hospitals by 43 percent. Similarly, the share of visits to minor teaching hospitals exhibits a substantial drop—of around 1.9 percentage points—at age 3 (from 5.6 percent to 3.7 percent, see Figure 4, panel B). In contrast, the share of visits to community hospitals and to clinics exhibit the opposite pattern, showing increases of 0.9 and 2.7 percentage points respectively at age 3. In online Appendix J, we show that the change in choice of healthcare providers is related to whether patients reside nearby major teaching hospitals.[44]

To further explore this issue, we utilize the panel structure of our dataset to calculate the conditional probability of a shift in provider, given the type of provider of the last visit. Conditional on a patient's last visit having been to a high-intensity provider (i.e., a teaching hospital) or a low-intensity provider (i.e., a clinic/community hospital), there are in total four types of shifting behaviors: (i) from high- to high-intensity provider; (ii) from high- to low-intensity provider; (iii) from low- to low-intensity provider; (iv) from low- to high-intensity provider. The type (ii) conditional probability, for instance, can be defined as follows:

$$\Pr\left(visit_t = low \mid visit_{t-1} = high\right) = \frac{N_l^h}{N_h^h + N_l^h}, \tag{3}$$

where $N_h^h$ ($N_l^h$) represents the number of visits to high-intensity providers (low-intensity providers) given that the last visit was to a high-intensity provider.[45] Thus, equation (3) represents the conditional probability of the current visit being to a low-intensity provider given that the last visit was to a high-intensity provider. In online Appendix K, we provide details of the construction of the conditional probability of a shift in healthcare provider.

Figure 5, panels B and A show how the conditional probability of a shift in provider changes at age 3. From Figure 5, panel A, it can be seen that under age 3 about 44 percent of children whose last visit was to a high-intensity provider switch to a low-intensity provider on the next visit.[46] However, this conditional probability jumps sharply to 58 percent once patients pass the age of 3. This result implies patients tend to switch to low-intensity providers when they face tiered copayments.

[44] As shown in Table B1 of online Appendix B, most major teaching hospitals are located in cities (i.e., urban areas) but almost every city/county has at least one minor teaching hospital. Thus, Figures J1 and J2 in online Appendix J display the change in the share of regular outpatient visits by provider type for the part of the sample born in cities/counties with and without a major teaching hospital, respectively. Figure J1a suggests that for the children born in the cities/counties with major teaching hospitals, the increased cost-sharing at age 3 reduces the share of major teaching hospital visits by 2.4 percentage points (i.e., from 5.4 percent to 3 percent). However, for the children born in the cities/counties without a major teaching hospital, the increased cost-sharing at age 3 reduces the share of major teaching hospital visits by only 1 percentage point (i.e., from 2.4 percent to 1.4 percent). A similar pattern can be found for the emergency room visits (Figures L2 and L3 in online Appendix L). In other words, it is indeed true that proximity to medical centers matters—children residing in locations without a major teaching hospital close by are less likely to visit a teaching hospital.

[45] $N$ denotes the number of visits to a specific type of provider given the provider type of the last visit. The superscript of $N$ denotes the provider type of the last visit and the subscript of $N$ denotes the provider type of the current visit. Therefore, $N^h = N_h^h + N_l^h$ represents the number of last visits to high-intensity providers.

[46] In other words, for the children under age 3 about 56 percent of patients whose previous visit was to a high-intensity provider again visit a high-intensity provider the next time.

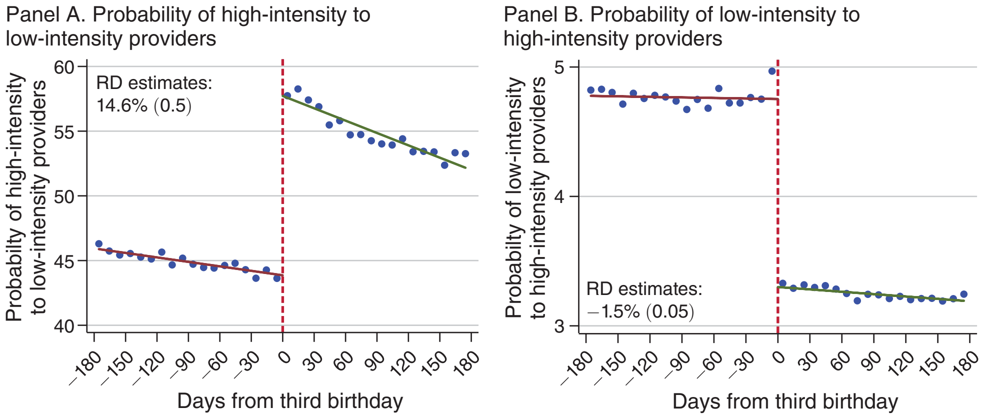


Figure 5. Providers Switching before and after the Third Birthday: Regular Outpatient Care

*Notes:* We pool NHI claims of regular outpatient care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. The dependent variable in panel A is the conditional probability that the current visit is to a low-intensity provider (i.e., community hospital/clinic), given the last visit was to a high-intensity provider (i.e., a teaching hospital). The dependent variable in panel B is the conditional probability that the current visit is to a high-intensity provider (i.e., a teaching hospital), given the last visit was to a low-intensity provider (i.e., community hospital/clinic). We plot the dependent variable within 180 days before and after the third birthday, and we group it every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variable. The line is from fitting a linear regression on age variables fully interacted with *Age*3.

In line with this finding, Figure 5, panel B suggests that, for the patients whose last visit was to a low-intensity provider, the share of patients who shift to a high-intensity provider drops sharply, from 4.8 percent to 3.3 percent at age 3.[47] In sum, the above results suggest that tiered copayments play an important role in a patient's choice of provider. A patient's provider choice is quite sensitive to the differences in copayments between high- and low-intensity providers. Once patients have to pay tiered copayments, they are less likely to visit high-intensity providers.

So far, we have found that tiered copayments can substantially discourage patients to use outpatient care at teaching hospitals (i.e., high-intensity providers). However, it remains unclear what type of care at teaching hospitals are reduced. To answer this question, we estimate the change in the number of visits to teaching hospitals by the expenditure per visit, which serves as a proxy for the seriousness of the medical condition. Patients with more serious medical conditions usually incur more costly treatments, only available at teaching hospitals. In particular, the outcome of interest is number of visits (taking log) and we estimate equation (2) separately for four categories of expenditure per visit: (i) NT\$0–600, (ii) NT\$601–1,200, (iii) NT\$1,201–1,800, and (iv) above NT\$1,801. About 95 percent of visits that cost less than NT\$600 are to clinics or community hospitals. The leading causes of such visits are all related to upper respiratory diseases, including common colds, which are considered minor conditions. In contrast, of the visits that cost more than NT\$1,800, less than 25 percent are to clinics or community hospitals. Asthma,

[47] Again, this implies that for the children under age 3 about 95.2 percent of patients whose previous visit was to a low-intensity provider again visit a low-intensity provider the next time.

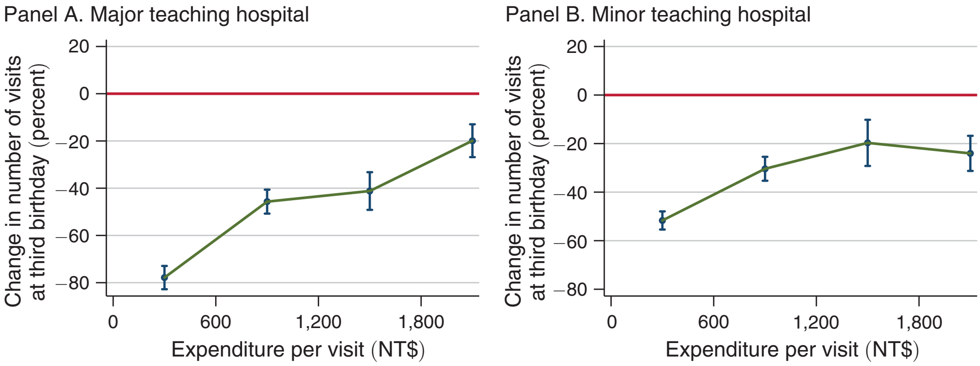


Figure 6. Utilization Responses at the Third Birthday by Expenditure per Regular Outpatient Visit

*Notes:* We pool NHI claims of regular outpatient care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. We estimate equation (2) separately by expenditure per regular outpatient visit: (i) NT$0–600; (ii) NT$601–1,200; (iii) NT$1,201–1,800; (iv) above NT$1,801 for major teaching hospital visits (see panel A) and minor teaching hospital visits (see panel B). The dotted line in panels A and B displays the estimated coefficients on *Age*3 from equation (2) and the corresponding 95 percent confidence intervals, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006).

considered a serious condition for children, is the leading cause of such visits. The dotted lines in Figure 6, panels A and B display the estimated coefficients on *Age*3 in equation (2) across the distribution of medical expenditure per visit (i.e., across the four categories). We find that increased cost-sharing after age 3 can significantly reduce the number of regular outpatient visits to major teaching hospitals that cost less than NT$600, by 79 percent. By comparison, the number of visits that cost over NT$1,800 decreases by only 20 percent. Figure 6, panel B suggests that a similar pattern emerges for minor teaching hospitals as well.

In sum, our results suggest that tiered copayments have a much larger effect on the utilization of outpatient care for minor illnesses at teaching hospitals. Consistent with this finding, Figure 7 shows that tiered copayments lead to a change in the case mix of regular outpatient visits to teaching hospitals. We find that the share of teaching hospital visits for minor illnesses (i.e., visits that cost less than NT$600) drops significantly, by 5.9 percentage points, from 74.8 to 68.9 percent, at age 3 (see Figure 7, panel A). In addition, Figure 7, panel B shows how the share of visits related to the common cold—a leading cause of minor illnesses for young children—changes before and after age 3. We find that it declines significantly at age 3, by 1.2 percentage points. In contrast, the shares of teaching hospital visits for two leading causes of serious illnesses for young children—asthma and delays in development—significantly increase, by 1 percentage points and 0.5 percentage points, respectively, immediately after age 3 (see Figure 7, panels C and D).

Regarding emergency room care, we replicate the above analysis in online Appendix L and find similar results.[48] To sum up, for both regular outpatient

[48] Similarly to the case of regular outpatient care, Figure L1 in online Appendix L shows that the increased cost-sharing (i.e., paying tiered copayments) at age 3 can discourage patients from using emergency room care

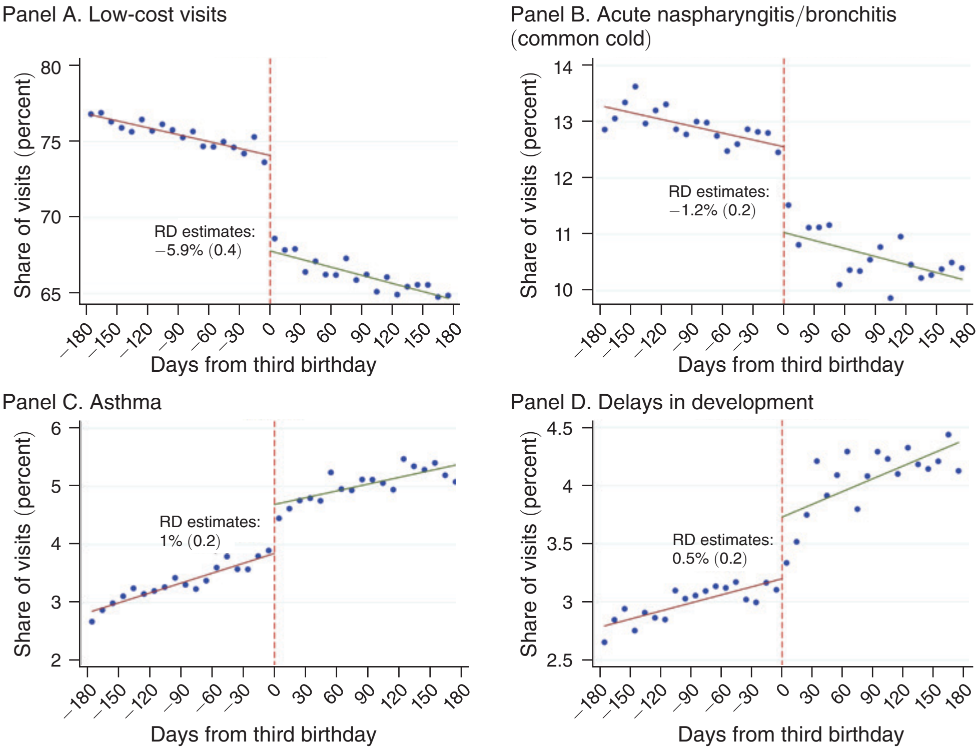


Figure 7. Composition Change in Teaching Hospital Visits at the Third Birthday: Regular Outpatient Care

*Notes:* We pool NHI claims of regular outpatient care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. The dependent variable is the share of visits for selected diagnoses. The three-digit ICD 9 codes are for: acute nasopharyngitis/bronchitis (common cold), 460 and 466; asthma, 493; and delays in development, 315. Age at the time of the visit is measured in days. We plot the dependent variable within 180 days before and after the third birthday, and we group it every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variable. The line is from fitting a linear regression on age variables fully interacted with *Age*3. The RD estimates are based on the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth. The standard errors of the RD estimates are presented in parentheses.

care and emergency room care, we find that the tiered copayments substantially reduce the number of visits for relatively simple treatments (i.e., minor illnesses) at high-intensity providers. This indicates that there is a substantial moral hazard

at teaching hospitals. The shares of emergency room visits to major teaching hospitals and minor teaching hospitals decline by 2 percentage points and 3.3 percentage points, respectively, immediately after the third birthday. Corresponding to this result, the share of emergency room visits to community hospitals increases by 5.6 percentage points at age 3. Figure L4 reinforces the above findings, demonstrating that patients are less likely to switch from low-intensity providers to high-intensity providers for emergency room services after the third birthday (i.e., once they have to pay the tiered copayments). In addition, similar to the situation with regular outpatient visits, Figure L5 suggests that the tiered copayments have a significantly negative effect on the utilization of emergency room services for minor illnesses (i.e., visits that cost less than NT$1,200) at teaching hospitals. The leading cause of such emergency room visits is acute upper respiratory infections. In contrast, the tiered copayments have little impact on the emergency room visits to teaching hospitals that cost more than NT$1,200. Open wounds on the head, which are considered a serious condition, are the number one cause of such emergency room visits. Finally, we find that the tiered copayments can also reduce the share of emergency room visits to teaching hospitals for minor illnesses; however, the estimates are not precise (see Figure L6).

in terms of an increase in the use of high-intensity providers when patients are not exposed to the full cost.

### C. *Inpatient Care*

For young children, inpatient admissions are less common than outpatient visits. Among our sample at age 2, the average annual number of outpatient visits is 19.8, but the average annual number of inpatient admissions is only 0.14.[49] Nevertheless, the expenditure for an inpatient admission is 27 times that for an outpatient visit, and 17 percent of healthcare spending for young children can be attributed to inpatient care. More importantly, the expiration of the cost-sharing subsidy at age 3 induces a much larger increase in OOP expenses for inpatient care than for outpatient care. Hence, inpatient care could have substantial impacts on both overall healthcare spending and individuals' OOP expenses. Understanding how young children's utilization of inpatient care responds to cost-sharing could produce important policy and welfare implications.

The effect of the increased cost-sharing on the utilization of inpatient care is intuitively ambiguous. On the one hand, higher cost-sharing could discourage marginal patients from using inpatient care, which would decrease inpatient expenditure. On the other hand, the type of inpatient care that young children usually have might be price inelastic: the leading causes of inpatient admissions in early childhood (see Table 3) are bronchopneumonia, gastroenteritis (colitis), and pneumonia, which could result in serious symptoms for young children and can be treated with medication or bed rest.[50] Previous studies (Card, Dobkin, and Maestas 2008; Shigeoka 2014) have found that neither patient cost-sharing nor insurance coverage has a significant impact on this type of admission for the elderly. In addition, for young children, admissions requiring surgery are seldom selective (e.g., hip and knee replacements), but tend to be due to more life-threatening conditions (e.g., congenital heart disease) and therefore essential. Thus, we should expect the utilization of inpatient care for young children to be less sensitive to the price changes that occur at the time of the third birthday.

*Changes in the Utilization of Inpatient Care at the Third Birthday*.—In order to understand the change in OOP expense per visit induced by the expiration of the cost-sharing subsidy at age 3, we follow the same way shown in outpatient care to compute a counterfactual OOP expense per inpatient admission for those right after their third birthday. The first row in column 1 of Table 9 shows that the expiration of the cost-sharing subsidy at age 3 increase the OOP expense per admission by NT$1,299.

Figure 8 displays the age profile for the utilization of inpatient care. Surprisingly, in contrast to the dramatic change in the utilization of outpatient care from immediately before to immediately after the third birthday, Figure 8, panels A, C, and E show that there is little visual evidence of any discontinuity in inpatient

[49] The number of outpatient visits is the sum of all regular outpatient visits and emergency room visits combined.
[50] In our estimated sample, about 95 percent of admissions do not require surgery.

Table 9—The Effect of Patient Cost-Sharing on Utilization of Inpatient Care at the Age of 3

| Variables | OOP expense (1) | log(total expenditure) (2) | log(number of admissions) (3) | log(expenditure/admission) (4) | Elasticity (5) |
|---|---|---|---|---|---|
| Sample: 2005–2008 | | | | | |
| *Age*3 | 1,299.04 | 0.17 | −1.36 | 1.52 | 0.00 |
| | | (4.35) | (2.62) | (3.17) | |
| Sample: 1997–2001 | | | | | |
| *Age*3 | | 4.20 | 2.99 | 1.21 | |
| | | (3.64) | (2.07) | (3.16) | |

*Notes:* The estimated sample in the first and third rows include 414,282 children born in 2003 or 2004. We use 2005–2008 NHIRD data to get their healthcare utilization around age 3. We collapse the individual-level data into age cells and measure age in days. The estimated sample in the second and fourth rows are 866,383 children born between 1995 and 1997. We use 1997–2001 NHIRD data to get their healthcare utilization around age 3. Column 1 displays the estimated change in OOP expenses (NT$) per admission at the age of 3. We estimate the change in out-of-pocket expense per admission by assuming patients right above the age of 3 (i.e., 90 days after third birthday) made the same healthcare utilization decision (i.e., had the same number of admissions and visited the same healthcare provider) as those right below age 3 did (i.e., 90 days before their third birthday). By doing so, the estimated change in out-of-pocket expenses per admission at the age of 3 is driven exclusively by cost-sharing subsidy expiration rather than an individual's choice. Columns 2–4 present the estimated coefficient on *Age*3 in equation (2), using a 90-day bandwidth (i.e., 180 observations). The dependent variables in all of the regressions above are the log of total expenditure, the log of number of admissions, and the log of expenditure per admission, at each age in days. For columns 2–4, the estimated coefficients are multiplied by 100 to show the percentage change in the outcome. Column 5 displays the estimated price elasticity of total expenditure, using the information from columns 1 and 2, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). Robust standard errors are in parentheses.

expenditure, the number of inpatient admissions, or the expenditure per admission around patients' third birthdays. In fact, we find that the age profiles of these outcome variables are very similar to those obtained using pre-reform (1997–2001) data (see Figure 8, panels B, D, and F).

As illustrated in the figures, the first row of columns 2–5 of Table 9 suggests that the increased cost-sharing at age 3 has little impact on the utilization of inpatient care for young children. There is no significant change in the total expenditure, number of admissions, or expenditure per admission around the third birthday. The estimated price elasticity of expenditure is close to zero, suggesting that children's utilization of inpatient care is price insensitive. One possible explanation for this result could be that the majority of children's inpatient admissions are for serious respiratory diseases or gastroenteritis that can be treated with bed rest or medication. Previous studies have found this type of inpatient care not to be price sensitive. For example, in Japan, Shigeoka (2014) found that inpatient admissions treated with medication or bed rest, such as heart failure, bronchitis, and pneumonia, did not respond to a price change at age 70. Card, Dobkin, and Maestas (2008) obtained similar findings for Medicare recipients in the United States. Most admissions for young children involve these types of inpatient care (e.g., gastroenteritis, bronchitis, and pneumonia).[51] Therefore, we conclude that making inpatient care free should

[51] A patient could be treated by medication or bed rest in the following situations: (i) Their condition does not require surgical intervention, such as in the case of bronchopneumonia or pneumonia, which could still be quite

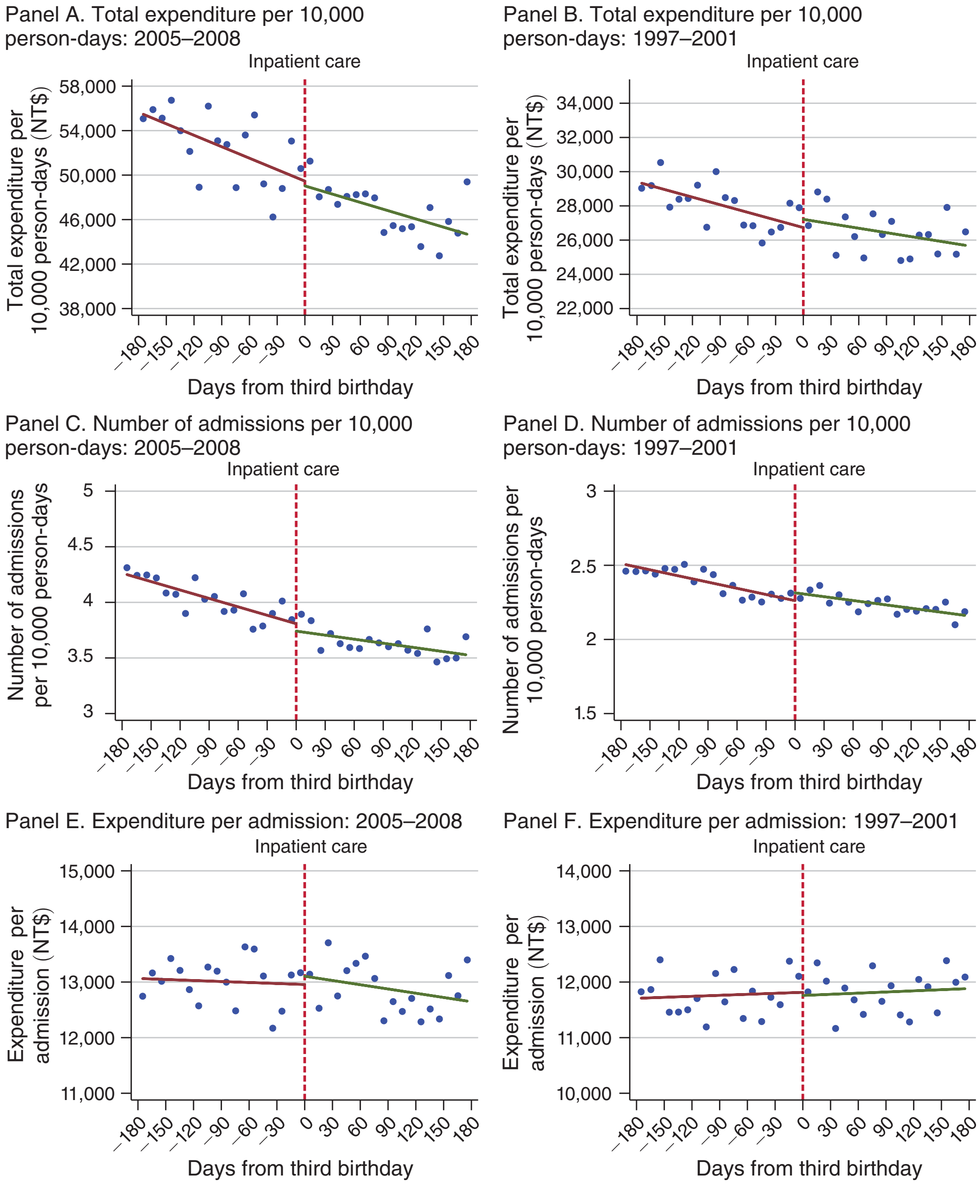


Figure 8. Utilization of Inpatient Care before and after the Third Birthday

*Notes:* We pool NHI claims of inpatient care for the 2003–2004 birth cohort, using 2005–2008 NHIRD data. The dependent variables are total expenditure (NT$) per 10,000 person-days, number of visits per 10,000 person-days and expenditure (NT$) per visit by patient age at the time of the visit, with US$1 equal to NT$32.50 in 2006. All expenditures in our sample period are inflation-adjusted (NT$ in 2006). Age at the time of the visit is measured in days. We plot the dependent variables within 180 days before and after the third birthday, and we group every ten days as a bin from the third birthday. Thus, each dot represents the ten-day average of the dependent variables. The line is from fitting a linear regression on age variables fully interacted with *Age*3.

serious diseases. (ii) Their physical status prevents them from being suited to receiving an aggressive treatment (e.g., surgery). Therefore, the inpatient admissions treated by bed rest or medication might be less discretionary and less price responsive than those that require surgery. We think the above argument could especially apply to young children, since their physical status might make them unsuited to surgery.

not result in an excessive use of inpatient services. In online Appendices E and F, we examine the robustness of our results to different bandwidth choices and specifications. Figure E3 and Table F3 suggest that the RD estimates are quite stable across bandwidth choices and different empirical specifications.

## IV. Discussion

### A. *Own-Price Elasticity versus Cross-Price Elasticity*

So far, we have estimated the price elasticities of regular outpatient care, emergency room care, and inpatient care separately. One potential concern regarding the above analysis is that our estimates might represent both own-price and cross-price effects, since the OOP expenses for these healthcare services all increase substantially at age 3. To examine the impact of cross-price effects on our estimates, inspired by Shigeoka (2014), we group diagnoses into 56 groups based on the Basic Tabulations of Diagnoses (see a list of diagnosis groups in Table M1 of online Appendix M) and compare the price elasticities of diagnosis groups for which the majority of healthcare expenditure occurs in regular outpatient care, emergency room care, or inpatient care, and the overall estimates for each healthcare service.[52] These subgroup estimates are more likely to represent own-price elasticity. If cross-price effects matter a lot, we should find that the above subgroup estimates are statistically different from our main estimates.

Specifically, we first select the diagnosis groups for which regular outpatient care accounts for the highest fraction of expenditure among the three types of healthcare services, to represent own-price elasticity for regular outpatient care. These diagnosis groups include diseases of the upper respiratory tract, parasitic diseases, and others. For example, the fraction of expenditure on diseases of the upper respiratory tract (diagnosis group 31) is 92 percent. The first row in Table M2 of online Appendix M shows that the RD estimate for regular outpatient expenditure for these diagnosis groups is −6.3 percent, which is not statistically different from the overall estimate of −6.6 percent. In addition, the estimated price elasticities for the diagnosis groups predominated by regular outpatient care are quite similar to the overall price elasticity.

We use the same criteria to select the diagnosis groups that are more likely to represent own-price elasticity of emergency care or inpatient care. For emergency care, only three diagnosis groups satisfy these criteria. For example, emergency care can account for 51 percent of total expenditure on intracranial and internal injuries (diagnosis group 49). The second row in Table M2 suggests that the RD estimate for emergency care expenditure for these diagnosis groups is −9.4 percent, which is somewhat higher than the overall estimate of −5.6 percent (although not statistically significantly different).

[52] Unlike for the elderly (those around age 70) studied in Shigeoka (2014), the healthcare utilization of young children is predominated by regular outpatient care in terms of the number of visits. Thus, we use total expenditure to determine which diagnosis groups are mainly treated by regular outpatient care, emergency care, and inpatient care, respectively.

For inpatient care, fifteen diagnosis groups, including diseases of the urinary system (diagnosis group 35), immunity disorders (diagnosis group 18), and fractures (diagnosis group 47), are included in the subgroup analysis. Inpatient care can account for at least 54 percent of the total expenditure in these diagnosis groups. The last row in Table M2 suggests that the RD estimate for inpatient expenditure for these diagnosis groups is 1.36 percent, which is not statistically significantly different from the overall estimate of 0.17 percent.

In sum, the above results suggest that, for diagnosis groups where cross-price effects are limited, the subgroup RD estimate is similar to the overall estimate, which includes both cross-price and own-price effects. This suggests that cross-price effects have a limited impact on our main estimates.

### B. *Comparison to Previous Literature*

Although young children are considered one of the biggest spenders on healthcare, empirical evidence regarding the cost-sharing effect for this age group is limited. Credible evidence still relies on subgroup results for children under age 14 in the RAND HIE. The results from the RAND HIE showed that higher cost-sharing would reduce children's utilization of outpatient care but might not change inpatient use. Our results suggest that the price elasticities of outpatient expenditure for children around the age of 3 are $-0.10$ (for regular outpatient care) and $-0.06$ (for emergency room care). Furthermore, we find that the price elasticity of inpatient expenditure for this age group is close to zero. In general, the above results are consistent with findings in the RAND HIE. However, the RAND HIE did not report the estimated price elasticities for their children subgroup. Two recent papers (Iizuka and Shigeoka 2018, Nilsson and Paul 2018) provide estimated price elasticities of outpatient care for school-age children in Japan and Sweden, based on quasi-experimental designs. For example, the estimate in Iizuka and Shigeoka (2018) suggests that the arc price elasticity of outpatient expenditure is $-0.11$ for children aged 7.[53] Our estimated price elasticity of outpatient care is similar to their figures.

In spite of that, we would like to caution readers that many institutional differences exist between Taiwan and other countries (e.g., the United States). One important difference is that Taiwan, like Japan and Korea, does not have a primary physician system that helps direct patients' choice of health provider. It is common for patients in Taiwan to do doctor shopping and therefore have a high number of visits per year. This feature implies that some outpatient visits might be discretionary. As a result, our estimated price elasticity of outpatient care should be considered an upper bound (in absolute values) for young children in countries employing a gatekeeper system. In addition, our results represent particular estimates of price elasticity for young children, and might not generalize well to other cases (e.g., other age groups or other changes in cost-sharing). Readers should be cautious when applying our estimates to other age groups and institutional settings.

[53] Both Iizuka and Shigeoka (2018) and Nilsson and Paul (2018) reported semi-arc price elasticities. We use a formula offered by Iizuka and Shigeoka (2018), which they used to calculate their arc price elasticities.

### C. *The Effect of Patient Cost-Sharing on Children's Health*

In this section, we summarize the results of the cost-sharing effect on children's contemporaneous and later-life health outcomes. The details of the empirical specifications and results are discussed in online Appendix N. In sum, our results suggest that the increased cost-sharing at age 3 has little impact on children's short-term health status, as measured by mortality and by the occurrence of serious pediatric health problems (i.e., pediatric complex chronic conditions). Furthermore, we examine whether the lower level of patient cost-sharing in early childhood has any effect on the health of children at older ages. We find that the additional outpatient utilization induced by the cost-sharing subsidy at age 2–3 does not affect the rate of occurrence of serious pediatric health problems at age 5–11.[54] Here, we would like to remind readers to be cautious about interpreting our results on health effects. Since deaths and serious pediatric health problems are quite rare for this age group in Taiwan, we might not have sufficiently precise estimates to draw a strong conclusion on this issue.

### D. *Implications for Optimal Health Insurance*

Finally, we discuss the implications of our estimates for cost-sharing policies (i.e., for determining the appropriate level of patient cost-sharing). In online Appendix O, we conduct a sufficient statistic approach for welfare analysis based on a simplified model without behavioral hazards, taken from Baicker, Mullainathan, and Schwartzstein (2015). Here, we summarize the major results of this model. Combining the sufficient statistic formula in online Appendix O with our estimates provides some insights into the design of a cost-sharing policy for young children. Our results suggest that young children's demand for inpatient care is price insensitive, and so increasing patient cost-sharing for inpatient care will only result in welfare loss, due to a reduction in the insurance value. This result implies that full insurance coverage for young children's inpatient care could be efficient, because having free inpatient care will not raise the total amount of healthcare expenditure but could actually increase the insurance value for sick individuals by easing their financial risk. On the other hand, we find that young children's utilization of outpatient care is moderately sensitive to the change in patient cost-sharing. Our results imply that a certain level of patient cost-sharing is necessary for outpatient care; since OOP expenses for outpatient care are quite low in Taiwan, keeping it constant or increasing it should produce only a limited welfare loss in terms of risk protection (i.e., insurance value), but it could substantially reduce the excessive use of

[54] Several recent papers (Wherry and Meyer 2016, Wherry et al. 2018) have studied the effect of the US Medicaid expansion on children's long-term health. They have found that increasing the health insurance coverage for children could reduce mortality rates and hospitalization rates in adulthood. However, their results stem from the mixed effects of the health insurance provision per se and changes in health insurance generosity. The policy change used in this paper is only related to a change in cost-sharing (i.e., health insurance generosity), which is not confounded by large wealth effects coming from the provision of health insurance. In fact, our result is consistent with the findings in a recent paper (Iizuka and Shigeoka 2018) using changes in patient cost-sharing for school-aged children in Japan.

outpatient care (i.e., moral hazard), especially for low-value care available through high-intensity providers (i.e., teaching hospitals).[55]

## V. Conclusion

In this paper, we estimate the causal effect of patient cost-sharing on healthcare utilization in early childhood. Since 2002, Taiwan has implemented a cost-sharing subsidy policy that exempts NHI copayments (coinsurance) for children under the age of 3. This medical subsidy policy has resulted in variations in out-of-pocket expenses based only on a patient's age, allowing us to employ a regression discontinuity design to estimate the price elasticity of various health services. Using longitudinal medical claims of over 410,000 children covered by universal health insurances in Taiwan, we find modest price elasticities in terms of health expenditure for outpatient care ($-0.10$ for regular outpatient care and $-0.06$ for emergency room care). In addition, we find that the expiration of the cost-sharing subsidy at the age of 3 significantly decreases the chance of visiting a specialist at a teaching hospital for minor illnesses. In contrast, the sharp increase in OOP expenses for inpatient care does not reduce the utilization of inpatient care. Finally, additional healthcare utilization induced by this cost-sharing subsidy seems to have a negligible impact on children's health outcomes.

Our findings point toward some fruitful directions for future research. To start with, our study appears to be the first analysis to show a credible estimate—almost zero—price elasticity for children's inpatient care. According to the 95 percent confidence interval of our estimates, the estimated price elasticity of inpatient expenditure is smaller than $-0.045$ (in absolute value). This price insensitivity implies that the extent of overuse in healthcare is very limited, thereby suggesting full inpatient care coverage for young children. In light of its importance in policy implications, we encourage additional empirical evidence to confirm our findings on the price elasticity of children's inpatient care.

Second, our findings indicate that patient cost-sharing not only affects the frequency of doctor visits, but also changes a patient's choice of healthcare provider, especially for one with a minor illness. This finding is perhaps related to one important feature in the Taiwanese healthcare system: a patient can visit any healthcare provider freely without a primary doctor's referral. Given that this feature is common among Asian countries (e.g., China, Japan, and South Korea), it would

[55] Note that our model does not include behavioral hazards (Baicker, Mullainathan, and Schwartzstein 2015); in fact, we find that the utilization of healthcare services that could involve a behavioral hazard, such as preventive care and mental health services, involves much greater price elasticities (in absolute values) than the overall estimates. If we consider behavioral hazards, reducing patient cost-sharing for such types of healthcare could be efficient, as people might overestimate current medical costs and undervalue future health benefits, thus myopically utilizing healthcare too little unless encouraged to do so through a cost-sharing reduction. Investigating health responses to patient cost-sharing can help us infer the degree of behavioral hazard. Our results indicate that the subsidy-induced outpatient utilization has little impact on children's health. However, it is possible that health benefits, though small on average, concentrate on a subgroup of children (e.g., children with psychiatric problems). Due to data limitations, we are unable to explore this issue, so we cannot quantify the magnitude of behavioral hazards for preventive care and mental health services.

be interesting to examine if similar phenomena occur in other countries adopting a no-gatekeeper system.

Finally, we find additional health utilization induced by this cost-sharing subsidy has little impact on children's health at ages 5–11. Nonetheless, our analysis of health outcomes is subject to data limitations. Most problematic is that our data sample is not long enough to secure valid measures of health outcomes, so future research should seek to employ better health measures to help understand the full impact of induced healthcare use on children's long-term health.

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