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PATIENT COST-SHARING AND HEALTHCARE UTILIZATION IN EARLY CHILDHOOD: EVIDENCE FROM A REGRESSION DISCONTINUITY DESIGN

Tzu-Ting Yang, Hsing-Wen Han, Hsien-Ming Lien

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Abstract

Healthcare for young children is highly subsidized in many public health insurance programs around the world. However, the existing literature lacks evidence on how the demand for young children?s healthcare reacts to these medical subsidy policies. This paper exploits a sharp increase in the required level of patient cost-sharing, the share of healthcare costs the patient must pay out of their own pocket, at age 3 in Taiwan that results from young children "aging out" of the cost-sharing subsidy. This price shock on the 3rd birthday allows us to use a regression discontinuity design to examine the causal effect of cost sharing on the demand for young children's healthcare by comparing the expenditure and utilization of healthcare for young children right before and after the 3rd birthday. Our results show that the increase in the level of patient cost sharing at the 3rd birthday significantly reduces total outpatient expenditure. The implied price elasticity of outpatient expenditure is around -0.10. However, the demand for inpatient care for young children *does not* respond to a change in cost sharing at the 3rd birthday even though the price variation is much larger. This result implies that the full coverage of inpatient care could improve the welfare of young children.

JEL Classification: G22; I12; I18; J13

Key words: patient cost-sharing, health insurance, children health

Corresponding Author:

Tzu-Ting Yang*
PhD candidate
Vancouver School of Economics
University of British Columbia
Email: nestofdata@gmail.com

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1 Introduction

Health conditions and medical treatments in early childhood are widely believed to have a substantial impact on health and labor outcomes in adulthood (Bharadwaj et al., 2013; Almond et al., 2011; Currie, 2009; Almond, 2006; Case et al., 2005; Currie and Madrian, 1999).[1] On the other hand, young children also bring about sizeable medical costs for their parents since they are vulnerable to diseases.[2] In line with this evidence, many public health insurance programs around the world subsidize healthcare service for young children by requiring relatively low patient cost sharing from this age group.[3] For example, the United States regulates the level of patient cost sharing in Medicaid and the Children's Health Insurance Program (CHIP) to ensure that children from middle and low-income families can afford essential medical treatment.[4] Recently, due to tight budgets, many state governments have considered raising the level of patient cost sharing for Medicaid and CHIP, which has led to many debates on the possible impact.[5] Similarly, national health insurance in Japan and Korea offers children under 6 years of age a lower level of patient cost sharing than those above age 6, to promote health investments in early childhood.[6]

To evaluate the effectiveness of these subsidy policies and the impact of future reforms to public health insurance for children, we need to understand healthcare expenditure elasticities for young children, that is, the response of healthcare demand to a change in out-of-pocket costs (referred to as the "price" from here on). If the children's price elasticity

[1] Several recent studies (Bharadwaj et al., 2013; Almond et al., 2011) present convincing evidence showing that early-life medical treatments can reduce mortality and even result in better long-run academic achievements in school. That is, health intervention in early childhood could be an investment with high returns.

[2] For example, in Taiwan, the number of outpatient visits for children under 3 years of age is around 20 per year. Compared with adults (12 visits per year), this age group has an especially high demand for healthcare service.

[3] That is, the share of healthcare costs paid out-of-pocket by the patient is lower.

[4] The federal requirement for Medicaid eligibility varies by according to the children's age.For children under age 6 (young children), Medicaid eligibility requires family incomes to be lower than 133% of the federal poverty level (FPL). For children ages aged 6-19 (older children), family incomes is required to be below 100% of FPL. Thus, the coverage of Medicaid for children under 6 is much higher than for those above 6.

[5] Since the passing of the Deficit Reduction Act (DRA) of 2005, states have had the right to increase the level of cost sharing in public health insurance programs, such as Medicaid and CHIP, for specific populations and medical services (Selden et al., 2009)

[6] National health insurance in Japan covers almost all medical services, such as outpatient and inpatient care, for all citizens. The patient cost sharing for children under age 6 (pre-school age) is 20% of the original healthcare cost. For children above age six (school-age), patient cost sharing rises to 30% of medical costs.More details of Japanese national health insurance can be found at this web page:http://www.shigakokuho.or.jp/kokuho_sys/kokuho_en.pdf. In Korea, their national health insurance exempts cost sharing for inpatient services for children under age 6.

of healthcare expenditure is zero or very small, then providing full insurance for children's healthcare could be welfare improving because lower patient cost sharing would not raise the cost from the moral hazard of healthcare use but would fully protect a household's financial risk, arising from out-of-pocket costs.[7] In addition, lower patient cost sharing could benefit children's health by increasing their access to necessary healthcare services. If children's healthcare expenditures is sensitive to pricing, then higher patient cost sharing could substantially reduce the cost of from moral hazard behavior and allocate medical resources more efficiently.

To date, very little is known about how young children's healthcare demand reacts to changes in patient the level of cost sharing. Most estimates of price elasticity focus on adults' and the elderly's healthcare demands (Cherkin et al., 1989; Selby et al., 1996; Rice and Matsuoka, 2004; Chandra et al., 2010*a*; Chandra et al., 2010*b*; Chandra et al., 2014; Shigeoka, 2014).[8] However, these estimates might not be valid for the healthcare demand of young children for two reasons. First, the types of healthcare services used by adults and children are quite different. Children's outpatient visits are rarely for chronic diseases and mostly for acute diseases, which need timely treatment and should not be sensitive to a price change. In addition, the majority of children's inpatient admissions do not require surgery but are treated with bed rest or medication. Shigeoka (2014) found that inpatient admissions for surgery, especially elective surgery (e.g., cataract surgery), were more price sensitive than those for non-surgery. He also found that admissions for the respiratory diseases typically treated with bed rest or medication did not respond to a change in cost sharing at age 70 in Japan. Card et al. (2008) obtained similar findings for Medicare eligibility at age 65 in the United States. Second, healthcare intervention in early childhood could substantially benefit an individual's later life, as addressed by recent studies (Bharadwaj et al., 2013; Almond et al., 2011). Given such high returns, parents might not be willing to adjust their children's medical care in response to price changes. Based on the above two reasons, we expect healthcare demand for young children to be less price sensitive than that for an older demographic group.

Credible estimates of price elasticity for children still rely on evidence from the RAND

[7] Since insured people do not pay the full cost of medical services, the optimal utilization of healthcare for an individual would be larger than the social optimum, leading to a loss of social welfare. Lower patient cost sharing could induce individuals to use more healthcare in an inefficient way (moral hazard).

[8] Shigeoka (2014) exploited the sharp reduction in patient cost sharing at age 70 in Japan and applied a regression discontinuity (RD) design to estimate the price elasticity of outpatient and inpatient visits by the elderly. He found the use of both health services to respond strongly to the price change with obvious drops at age 70. The estimated price elasticities were around -0.17 (outpatient) and -0.15 (inpatient). Chandra et al. (2014) used cost sharing reform in Massachusetts as an exogenous variation in price and obtained a price elasticity of healthcare expenditure of around -0.15 for low-income adults.

Health Insurance Experiment (RAND HIE), which was an influential randomized social experiment conducted in the mid 1970s.[9] Its sample comprised people of 62 years of age or under and randomly assigned participating households to different levels of patient cost-sharing (ranging from free care to 95% cost-sharing). The RAND HIE provided the estimates of the price elasticity of healthcare demand for children under 14 years of age (Leibowitz et al., 1985; Manning et al., 1981). It found that higher patient payments significantly reduced children's outpatient expenditure and utilization but mixed evidence of the cost sharing effect on children's demand for inpatient care.[10] The estimated price elasticity of the total healthcare expenditures was around -0.12.[11] However, the sample size for children in the RAND HIE was not big. Some estimates or subgroup analyses were not precise enough to confirm the presence or absence of a cost-sharing response (Leibowitz et al., 1985).[12] Additionally, the RAND HIE evidence is now over 30 years old. Both medical technology and the market structure have changed considerably during the past three decades. The varying healthcare environment could affect the way in which demand for healthcare changes in response to differences in price. Therefore, our paper fills this gap by providing the latest estimates of the price elasticity of children's healthcare demand.

In this paper, we exploit a sharp increase in patient cost-sharing in Taiwan at the 3rd birthday that results from young children "aging out" of the cost-sharing subsidy. On average, turning age 3 leads to an increase in price per outpatient visit (from 59 to 133 NT$)

[9] Before the passing of the DRA of 2005, state governments had little right to adjust the level of patient cost sharing in their public insurance programs (i.e., Medicaid and CHIP) for children. Thus, there is little evidence on the effect of cost sharing on children's healthcare demand. To the best of our knowledge, only one recent study (Sen et al., 2012) has used the copayment change in the CHIP in Alabama, USA, to analyze this issue. However, their study mainly relied on pre-/post-policy analysis, which suffers from the an estimation bias due to uncontrolled trends in children's medical utilization.

[10] For children under age 4, the RAND HIE found that inpatient care was price sensitive. Children assigned to a free plan had a significantly higher rate of inpatient admission than children assigned to 95% cost-sharing. For children aged between 5 and 13, no consistent pattern of a cost sharing effect on inpatient use was found (Leibowitz et al., 1985).

[11] The health insurance contracts in RAND HIE adopted non-linear pricing, which makes estimating price elasticity challenging. Specifically, the insurance plans required initial cost-sharing (free care, 25%, 50% and 95%) but had an annual stop-loss (Maximum Dollar Expenditure), in that the total out-of-pocket medical costs per year could not exceed 4,000 US$. Thus, the patient cost-sharing would fall to zero when annual out-of-pocket medical costs reached 4,000 US$. Such non-linear pricing imposes on patients different prices for the same health care at different times in the year. To summarize the estimated price elasticity, RAND researchers defined four kinds of price that patients respond to when making their healthcare decision: (1) the current "spot" price, (2) the expected end-of-year price, (3) the realized end-of-year price, and (4) the weighted-average of the price paid over a year (Aron-Dine et al., 2013). The price elasticity of children's healthcare mentioned here is calculated by defining price as definition (1).

[12] 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"

by more than 100% and a dramatic rise in price per inpatient admission from zero to 1,300 NT$.[13] The change in out-of-pocket costs at the 3rd birthday allows us to use a regression discontinuity (RD) design to examine the causal effect of patient cost sharing on young children's healthcare demand by comparing the expenditure and utilization of healthcare for young children just before and after the 3rd birthday.

We obtain three key findings. First, the increase in out-of-pocket cost at the 3rd birthday significantly reduces outpatient expenditure by 6.9%. The implied price elasticity of outpatient expenditure is around -0.10. Second, the sharp price increase at age 3 not only results in fewer outpatient visits (extensive margin) but also reduces the expenditure of each visit (intensive margin), namely, it induces patients to switch from high to low-quality providers (e.g., substitution of teaching hospitals with clinics or community hospitals). We find losing the cost-sharing subsidy reduces visits to teaching hospitals by 50%.[14] Further investigating possible heterogeneous effects in detail, we also find preventive care and mental health services to have larger price responses than healthcare for acute respiratory diseases. Third, in sharp contrast to outpatient services, the demand for inpatient services does not respond to the price change at the 3rd birthday. The estimated price elasticity of inpatient expenditure is close to zero (about -0.004). This finding is a surprising result because the variation in the inpatient price at age 3 is much larger than that in the outpatient price in terms of its level and percentage change. The above findings suggest that the level of patient cost sharing for young children should differ depending on the healthcare service. For example, our results imply that full coverage of the medical costs (i.e., no cost sharing) of inpatient services for young children could be optimal because the elasticity of inpatient expenditure is almost zero. Providing full insurance coverage might not stimulate excessive hospital use (moral hazard) but it might substantially reduce the financial risk for households.

Our paper contributes to the research on patient cost sharing in three areas. Firstly, our paper provides new evidence on the causal effect of patient cost sharing on the healthcare demand of young children. In particular, many public health insurance programs in developed countries (e.g., the United States, Japan, and Korea) require a relatively low level of patient cost sharing for young children. However, the literature is lacking in providing knowledge of how the healthcare demand of young children reacts to changes in these medical subsidy policies. Our elasticity estimates fill this gap and provide evidence on the price responsiveness of young children's healthcare demand, which could have important implications for evaluating current cost-sharing policies and possible reforms in the future. Furthermore, our

[13] 1 US$ is equal to 32.5 NT$ in 2006 price.

[14] This result is due to copayments varying between health providers in Taiwan. We will discuss this issue in more detail in Sections 2 and 5.

identification strategy of a RD design provides a unique opportunity to obtain estimates in a local randomized experiment. The comparison at the 3rd birthday convincingly isolates the impact of patient cost sharing on healthcare demand from other factors because children should have similar healthcare demands right before and right after their 3rd birthdays if there is no change in patient cost sharing at age 3.[15] Therefore, our research design gives us highly credible estimates of the price elasticity of the healthcare demand of young children.

In addition, our estimates should also avoid the bias from a change in the composition of enrollees induced by the change in cost sharing. Several recent US studies (Chandra et al., 2010*a*; Chandra et al., 2010*b*; Chandra et al., 2014) have used a quasi-experimental design by exploiting a change in the copayments of one health insurance plan and using unchanged insurance plans as a control group. However, the change in cost sharing could also affect people's decision to enroll in insurance plans. Such self-selection behavior could bias the elasticity estimates. For example, a larger proportion of people with less price sensitivity may continue their enrollment after the a cost-sharing increase, which may "downward" bias the elasticity estimates in absolute value. However, the Taiwanese National Health Insurance (NHI) is a single-payer scheme and every citizen is required to join the program.[16] Thus, our elasticity estimates are free of bias from any change in the composition of the enrollees after the cost-sharing change.

Finally, the data we use in this paper is administrative insurance claim data that contains all NHI records of healthcare payments and use for children under 4 years of age in Taiwan during our sample period.[17] Compared with survey data, administrative data have a number of advantages, such as much less measurement error and larger sample sizes. These features allow us to get precise estimates of the heterogeneity in the cost-sharing effect across different subgroups or types of healthcare (diagnoses) that could not be analyzed precisely in the RAND HIE because of its limited sample of children.

The rest of the paper is organized as follows. Section 2 gives a brief overview of the institutional background. In Section 3, we discuss our data and sample selection. Section 4 describes our empirical strategy. In Section 5, we analyze the main results. Section 6 provides concluding remarks.

[15]In Taiwan, turning age 3 does not coincide with any confounding factors, such as age of starting school or a recommended immunization schedule. We will discuss this issue in Section 4.

[16]The only exceptions are citizens who lose their citizenship, die or are missing for more than six months.

[17]99% of the Taiwanese population is covered by NHI. Furthermore, NHI covers almost all medical services. We will discuss this issue in more detail later.

2 Policy Background

2.1 National Health Insurance in Taiwan

In March 1995, Taiwan established the NHI, which is a government-run, single-payer scheme administered by the Bureau of National Health Insurance. Prior to this, health insurance was provided through three main occupational forms labor insurance for private-sector workers, government employee insurance, and farmer's insurance and these systems accounted for only 57% of the Taiwanese population (Lien et al., 2008).The remainder of the population were not employed: people over 65, children under 14, and unemployed workers. The implementation of the NHI raised the coverage rate of health insurance sharply to 92% by the end of 1995, and since 2000, it has stayed above 99%.

The NHI provides universal insurance coverage, with almost all medical services covered, such as outpatient, inpatient, dental, and mental health services, prescription drugs, and even traditional Chinese medicine. The NHI classifies healthcare providers into four categories based on accreditation: major teaching hospitals, minor teaching hospitals, community hospitals, and clinics.[18] As in most Asian countries, enrollees are free to choose their care providers and do not need to go through a general practitioner (i.e., family physician) to obtain a referral. For example, patients can directly access specialists in a major teaching hospital without a referral. In other words, the NHI does not adopt a gatekeeper system.[19]

2.2 Patient Cost-Sharing

Patient cost sharing in Taiwan comprises two parts: (1) the NHI copayment (coinsurance);[20] (2) other non-NHI-covered medical costs (e.g., a registration fee for an outpatient visit).[21]

2.2.1 Cost-Sharing for Outpatient Service

With respect to outpatient care, a patient pays a NHI copayment plus a registration fee for each visit.[22] If a physician prescribes a drug at a visit and the drug cost is above 100 NT$,

[18] The clinic is similar to the physician's office in Canada and the US.

[19] For example, the National Health Service (NHS) in the United Kingdom adopts a gatekeeper system. Patients cannot directly obtain outpatient services at hospitals. Instead, they need to get a referral from a general practitioner. Provincial Health Insurance in Canada adopts a similar system.

[20] A copayment is a fixed fee paid by the insurance enrollee each time a medical service is accessed. Coinsurance is a percentage of the medical payment that the insured person has to pay. The NHI adopts copayments for outpatient care and coinsurance for outpatient prescription drugs and inpatient care.

[21] More discretionary healthcare, such as plastic surgery, sex reassignment surgery and assisted reproductive technology, etc., are not covered by the NHI. Patients have to pay the full cost for these services.

[22] Both are fixed amounts.

the patient also needs to pay a share of the cost of the prescription drug, which is 20% of total drug cost. However, most visits for the children under age 3 have drug costs below 100 NT$ so patients usually do not pay for their prescription drug.[23] Compared with the NHI copayment, the average out-of-pocket cost for outpatient prescription drugs (under age 3) is quite small, at only 2.5 NT$ per visit.[24]

The NHI copayments are based on a national fee schedule. In general, a higher copayment is set for the health providers that have higher accreditation.[25] The first rows of Panel A in Table 1 summarize the NHI copayments for four types of providers during our sample period (2005 to 2008). A major teaching hospital can charge a patient a copayment of 360 NT$ (12 US$) per outpatient visit, which accounts for 29% of the total expenditure of each visit. However, the NHI copayment for one clinic visit is only 50 NT$ (1.7 US$) and covers 13% of the total expenditure of each visit.[26] In other words, the copayments for outpatient services at teaching hospitals are much higher than those for clinics/community hospitals in terms of both their level and their share of the cost.

The spirit of this design is to use the differential copayments to guide patients to properly choose their health providers based on the severity of an illness so as to better allocate medical resources to the patients who need them most. This design is needed because patients in Taiwan (and other Asian countries) have no restrictions on their choice of healthcare providers. If there were no difference in the level of patient cost sharing between hospitals and clinics, patients might abuse the limited medical resources of the hospitals and crowd out other patients whose illnesses could only be treated at hospitals.[27]

In addition to the NHI copayment, the patient must also pay a registration fee for each outpatient visit, which is not covered by the NHI. The registration fee reflects the health providers administrative costs and is determined by the provider.[28]

[23]If drug cost is under 100 NT$, a patient has no out-of-pocket cost.

[24]The average drug cost per visit is only 61 NT$, which is under 100 NT$ and thus, patients do not pay any out-of-pocket cost at most visits.

[25]The NHI in Korea has a similar cost-sharing policy. Patients have to pay 40-50% of total medical costs when visiting hospitals but only 15-30% when visiting clinics.

[26]For more detailed information about the NHI copayment schedule, please see the note in Table 1. A reimbursement is also paid according to the provider's accreditation. That is, major teaching hospitals can obtain the highest reimbursement for their medical services.

[27]For example, patients might use hospital outpatient services for illnesses which could be cured in a clinic (e.g., a cold).

[28]Our main dataset lacks this information. However, the NHI has another database that provides information about the registration fees of all health providers during our sample period (2005-2008). Major teaching hospitals usually charge 150 NT$, minor and community hospitals 100 NT$, and clinics 50 NT$. We use this information to impute the registration fees for the four types of providers.

2.2.2 Cost-Sharing for Inpatient Services

For inpatient admissions, the patient cost sharing takes place through coinsurance. Depending on the length of the stay and the type of admission (acute or chronic admission), the coinsurance rate is 10% to 30% of the total medical costs per admission. For example, a patient must pay 10% of the hospitalization costs for the first 30 days they stay in an acute admission unit and 20% for the next 30 days. Almost all inpatient admissions for young children (99.5%) are acute admissions and the length of a stay in our sample is always within 30 days.[29] Thus, coinsurance rates for most admissions are around 10%. Panel B in Table 1 lists the coinsurance rates for inpatient services.

Because inpatient care usually results in larger financial risks than outpatient care, the NHI has a stop-loss policy (maximum out-of-pocket cost) for inpatient admissions. The out-of-pocket cost must be no greater than the stop-loss, which is calculated annually as 10% of the gross domestic product per capita in Taiwan. The NHI covers all costs above the stop-loss.[30] According to NHI statistics, very few patients (less than 1%) reach this stop-loss, so the non-linearity imposed by it should not seriously bias our estimates of price elasticity.[31] Moreover, in contrast to health insurance plans in the US and other countries, the NHI does not require patients to pay deductibles before insurance coverage begins. The above two features substantially simplify our computation of the price elasticities.[32]

2.3 Change in Patient Cost Sharing at the 3rd Birthday

To reduce the financial burden on parents and ensure that every child obtains essential medical treatment in her early childhood, in March 2002, the Taiwan government enacted the Taiwan Children's Medical Subsidy Program (TCMSP). This program, through subsidies, exempts all NHI copayments and coinsurance for outpatient visits, outpatient prescription drugs, inpatient admissions, and emergency room visits for children under the age of 3. A patient loses their eligibility for subsidies at her 3rd birthday. Since the implementation of TCMSP, a patient under 3 years of age has only had to pay the medical costs not covered by the NHI (e.g., the registration fee for outpatient care and other non-covered medical

[29] In our empirical analysis, we limit our estimated sample for inpatient services to the cases with acute admissions with length of stay within 30 days.

[30] In 2008, the annual maximum out-of-pocket cost is about 50,000 NT$.

[31] This is because the NHI waives the cost-sharing for patients with catastrophic illnesses (e.g., cancer), who would have a greater probability of reaching the stop-loss if their cost sharing were not waived.

[32] In health insurance, the deductible is the amount that an insured person has to pay before an insurer (e.g., the insurance company) starts to pay.

services).[33]

Figure 1 plots the observed age profile of average out-of-pocket cost per outpatient visit and that of average out-of-pocket cost per inpatient admission (180 days before and after the 3rd birthday).[34] Figures 1a and 1b reveal that patients experience a sharp increase in price for both outpatient and inpatient services at their 3rd birthday. Especially for inpatient services, the out-of-pocket cost per admission suddenly rises from zero to almost 1,300 NT$, which could bring about sizeable financial risk to a household with young children turning 3 years old.[35]

Note that the observed price changes per visit at the 3rd birthday are endogenous. Especially for outpatient services, the price change at the 3rd birthday is larger for visits to a teaching hospital than to a clinic or community hospital. For example, the price per visit for a major teaching hospital increases by 240% (from 150 to 510 NT$) at the 3rd birthday and the price for a minor teaching hospital rises by 240% (from 100 to 340 NT$). However, the visit price for a clinic only increases by 100% (from 50 to 100 NT$). In other words, the TCMSP indeed subsidizes outpatient services in teaching hospitals much more than those in clinics or community hospitals. Therefore, patients might also change their choices of providers at their 3rd birthday, which could make the observed out-of-pocket cost per visit after the 3rd birthday endogenous (i.e., already reflected in the change in choice of provider). To obtain the exogenous price change at the 3rd birthday, we need to fix the utilization of each type of provider.

Table 2 presents the weighted average out-of-pocket cost per visit before and after the 3rd birthday.[36] The weights are the average daily utilization of each type of providers 90 days before the 3rd birthday. Thus, the numbers in the first row are the actual weighted average out-of-pocket costs per visit *before* the 3rd birthday and the numbers in the second row are counterfactual weighted average out-of-pocket costs per visit *after* the 3rd birthday, which uses the share of utilization of providers at age 2 (i.e., 90 days before the 3rd birthday) as weights. In this way, we can compute the difference between rows (1) and (2) to obtain the exogenous change in out-of-pocket costs per visit/admission at the 3rd birthday. Table 2 shows that the average price of outpatient visits rises by more than 100% (from 58.9 to

[33]If they use medical services not covered by the NHI, they will have to pay all expenses. However, the NHI does cover most health services. Those that are not covered are mostly quite discretionary, such as plastic surgery, sex reassignment surgery and assisted reproductive technology, etc.

[34]Each dot represents the ten days average price of each outpatient visit (inpatient admission) at a given age. The line is obtained by fitting a linear regression to the age variables fully interacted with a dummy indicating whether the child is age 3 or older.

[35]This cost can account for about 4% of average monthly salary in 2006.

[36]The bandwidth is 90 days. Thus, we use out-of-pocket cost per visit/admission within the 90 days before and after the 3rd birthday to obtain the estimates in Table 2

132.7 NT$) at the 3rd birthday, and the average price of inpatient admissions jumps sharply from zero to 1296 NT$. To sum up, in terms of both the level and the percentage change, the out-of-pocket cost for each inpatient admission sees a much larger increase than that for each outpatient visit.

3 Data and Sample

3.1 Data

To implement our empirical analysis, we need the following information: (1) the enrollee's exact age to the day at the time of a visit;[37] (2) the utilization of the outpatient or inpatient services; (3) the expenditures of the outpatient or inpatient services. We use unique claims data from Taiwan's National Health Insurance Research Database (NHIRD), which contains detailed information about patient's out-of-of pocket costs, total medical expenditures and healthcare utilization for each outpatient visit (inpatient admission) of all NHI enrollees in Taiwan.[38] In addition, the NHIRD includes the exact dates of outpatient visits (inpatient admissions) and the exact birth date of every enrollee, which allows us to precisely measure the children's ages in days for our RD design.

For our purposes, we linked information from four types of files in the NHIRD: outpatient claims files, inpatient claims files, enrollment files, and provider files. First, outpatient (inpatient) claims files record information about payments and medical treatments for each visit. These files contain the enrollees ID and birth date, the hospital or clinic ID, the date of the visit, the total medical expenditures, total out-of-pocket costs, diagnosis[39], and medical treatment.[40] Second, we use the enrollee ID to merge the enrollment files and obtain each enrollee's demographic information, such as gender, household's monthly income, number of siblings, and town of residence. Finally, we use the hospital or clinic ID to link with the information (e.g., provider's accreditation) in the provider files.

[37] That is, we measure age in days.

[38] Due to privacy concern, NHIRD only allows at most 10% sampling for each research application. Thus, we only use claims data of sample with age 2 and 3 during 2005-2008 and 1997-2001.

[39] Diagnoses are recorded in five digits according to the ICD9 (International Classification of Diseases, Ninth Revision, Clinical Modification).

[40] Inpatient claims files also have information about length of stay

3.2 Sample

To avoid the effect of the variation in the cohort size on our estimation, we focus on the healthcare use from the same cohort (fixed panel). Our original sample is all NHI enrollees born between 2003 and 2004. The original sample size is 435,206 (see Table 3).[41] We further restrict our sample to those enrollees who were continuously registered in the NHI while aged 2 and 3, which reduces the sample size by 8,619. In addition, we eliminate those enrollees in the sample with cost-sharing waivers, such as children with catastrophic illnesses and children from very low-income families, since these children would not experience any price change when turning 3. The above procedure reduces our original sample by 5.7%, making the final sample size for estimation 410,517. Table 3 provides summary statistics of the characteristics of the enrollees at age 3, in the original sample and the final sample used in our empirical analysis. We find that the selected characteristics are quite similar between the two samples.

We use 2005-2008 NHIRD data to obtain all records of outpatient visits and inpatient admissions of these children when aged 2 or 3.[42] Following Lien et al. (2008), we also exclude visits relating to dental services, Chinese medicine, and health check-ups with a copayment waiver.[43]

Table 4 provides the descriptive statistics for the outpatient visits and inpatient admissions and compares their characteristics within 90 days before and after the 3rd birthday.[44] We find that children use more outpatient and inpatient care before their 3rd birthday. Most young children visit clinics for outpatient services. However, they tend to visit teaching hospitals more frequently before their 3rd birthday than after it.

4 Empirical Specification

Our identification strategy is similar to that in recent studies utilizing "age discontinuity" to identify the insurance coverage effect (Card et al., 2008; Card et al., 2009;Anderson et al., 2012) or patient cost-sharing effect (Shigeoka, 2014) on medical utilization by adults or the elderly. We are the first to apply the RD design to study the impact of patient cost sharing

[41] Since 99% of Taiwanese are covered by the NHI, these samples represent nearly the entire population of children born between 2003 and 2004 in Taiwan.

[42] The sample period was chosen because children born in 2003 are aged 2 in 2005-2006 and children born in 2004 are aged 3 in 2007-2008.

[43] The NHI provides nine health check-ups with copayment waiver for children under the age of 7. Since patient cost sharing for these visits does not change at the 3rd birthday, we eliminate them to avoid biased estimations.

[44] We make this choice because our main results use 90 days as the bandwidth.

on healthcare utilization and expenditure for young children. The general form of our RD regression is as follows:

$$Y_i = \beta_0 + \beta_1 Age3_i + f(a_i; \gamma) + \varepsilon_i \tag{1}$$

where Y_i is the outcome of interest for the child i, namely (1) the number of outpatient visits or inpatient admissions; (2) the total medical expenditure of outpatient or inpatient care; (3) the medical expenditure per outpatient visit (inpatient admission) at a given age. The variable a_i is child i's age and is measured in days from her 3rd birthday, which is the 1096th day after birth.[45] The $Age3_i$ is a treatment dummy that captures the higher level of patient cost sharing (loss of cost-sharing subsidy) at the 3rd birthday and is equal to one if child i is age 3 or older ($a_i \geq 1096$). The key assumption of the RD design is that the age profile of the healthcare demand is smooth (continuous). Thus, we assume $f(a_i; \gamma)$ to be a smooth function of age with parameter vector γ that accommodates the age profile of the outcome variables. The ε_i is an error term that reflects all of the other factors that affect the outcome variables. Our primary interest is β_1, that measures any deviation from the continuous relation between age and the outcomes Y_i at child i's 3rd birthday (when the treatment variable switches from 0 to 1). If no other factors change discontinuously around the child's 3rd birthday, that is, $E[\varepsilon_i|a_i]$ is continuous at age 3, β_1 represents the causal effect of the higher level of patient cost sharing on the expenditure and on utilization of young children's healthcare. In general, there are two ways to estimate β_1, typically referred to as the global polynomial approach and the local linear approach (Lee and Lemieux, 2010).

In the global polynomial approach, we can use all available data to capture the age profile of healthcare demand $f(a_i; \gamma)$ by using a flexible parametric function (e.g., in our analysis we use a third-order polynomial of age used).[46] One caveat of this approach is that an incorrect functional form for the regression could create a biased estimate of β_1. To avoid a misspecification bias, we adopt a local linear regression as our main specification and present the global polynomial estimates for comparison.

In the local linear approach, we capture the age trend of the healthcare use $f(a_i; \gamma)$ by estimating a linear function over a specific narrow range of data on either side of the threshold (3rd birthday). The local linear estimates of the treatment effect are the differences between

[45] Since 2004 is leap year, its February has 29 days. For the children born before 2004 February 29th, their 3rd birthday would be 1096th day after birth (365 x 3 + 1 = 1096). For those born after 2004 March 1st, their 3rd birthday would be 1095th day after birth.

[46] We have all NHI records of medical utilization within 365 days before and after each individual's 3rd birthday (i.e., from 2nd birthday to their 4th birthday).

the estimated limits of the outcome variables on each side of the discontinuity. Our baseline specification is the following local linear regression:

$$Y_i = \beta_0 + \beta_1 Age3_i + \gamma_1(a_i - 1096) + \gamma_2 Age3_i(a_i - 1096) + \varepsilon_i \quad (2)$$

In practice, we obtain the estimated treatment effect β_1 by allowing the slope of the age profile to be different on either side of the 3rd birthday, by interacting the age variable fully with intercept and $Age3_i$. The equation (2) is estimated via weighted least squares using a triangular kernel (i.e., giving more weight to the data points close to the 3rd birthday). We restrict our sample to the 90 days before and after the 3rd birthday. The choice of bandwidth and the computation of the standard errors of the discontinuity estimates are important issues for local linear estimation. In Table A3, we show that our main estimates are robust to various choices of bandwidth and different methods of calculating the standard errors.[47]

Following Card et al. (2009), Anderson et al. (2012) and Lemieux and Milligan (2008), we collapse the individual-level data into age cells (measured in days), which gives us the same estimates as the results from the individual-level data but substantially reduces the computational burden. Therefore, our regressions are estimated on day-level means for each day of age:

$$Y_a = \beta_0 + \beta_1 Age3 + \gamma_1(a - 1096) + \gamma_2 Age3(a - 1096) + \varepsilon_a \quad (3)$$

[47] Deciding how "narrow a range of data to use, namely, choice of bandwidth, is critical to local linear estimation. If the bandwidth were too wide, the local linear estimate β_1 could be biased due to misspecification. That is, the linear function would be unable to capture the age profile over such a "wide range of data. If the bandwidth were too narrow, there would not be enough data for the estimation to get a precise local linear estimate. Thus, the optimal bandwidth needs to balance bias and precision (variance) to estimate β_1. This is quite an active field in the nonparametric literature and there are many competing methods of selecting the optimal bandwidth, such as the plug-in approach (Imbens and Kalyanaraman, 2012; Cattaneo et al., 2013) and the cross-validation approach (Ludwig and Miller, 2007). In Table A3, we show that our main estimates are robust across various optimal bandwidth selectors. In addition, the standard error of the discontinuity estimate is an important issue in local linear estimation since the available bandwidth selectors tend to give a "large bandwidth and lead to biased local linear estimates. One solution is to use bias-correction estimates. However, the conventional standard error of the bias-correction estimates fails to consider the variability of additional second-order bias estimates, which results in standard errors that are too small and false statistical inferences.Cattaneo et al. (2013) proposes a method of accounting for this variability to obtain the robust standard error and confidence interval. In Table A3, we show that the statistical inferences of our main estimates are still valid even if we use more conservative way to compute our standard error.

We also take logs of our dependent variables to allow β_1 to be interpreted as the percentage change in the dependent variables. That is, the dependent variables for the RD estimation are the log of total outpatient (inpatient) expenditure, the log of the total number of outpatient visits (inpatient admissions), and the log of outpatient (inpatient) expenditure per visit, at each day of age. The most important assumption for our RD estimation is that, except for the higher level of patient cost sharing, there is no change in any other confounding factors that affect the healthcare demand at the 3rd birthday. For this age group, potential confounding factors could include vaccination and pre-school attendance. The recommended immunization schedule could mechanically increase the healthcare spending and use of young children at age 3. However, this concern is alleviated since children in Taiwan do not need to have vaccines at age 3 and indeed take most vaccines before they are 2 years of age (Center of Disease and Control, 2013).[48] On the other hand, entering pre-school could increase the chance of a child picking up illnesses (e.g., the flu), which would affect children's healthcare use. This factor might not interfere with the cost-sharing change at age 3 because the age of entry for "public pre-schools is 4 years of age and the government does not specify a statutory attendance age for "private kindergartens. Most importantly, we measure the children's age at a daily level, so our RD design will be invalid only if these factors also change abruptly within one or two days of the 3rd birthday. This fact substantially alleviates the concern that our estimates could be biased by other factors. We conduct several placebo tests to further confirm the validity of our RD design (e.g., using data before 2002 when TCMSP was implemented).

5 Results

In this section, we examine the impact of the higher cost sharing at children's 3rd birthdays on their healthcare expenditure and utilization. As mentioned above, our sample consists of the children born between 2003 and 2004 who were continuously enrolled in the NHI over the ages of 2 and 3. We follow these individuals across their 3rd birthdays to estimate the change in healthcare utilization and expenditure at age 3. We will examine outpatient care first and then impatient care.

[48] http://www.cdc.gov.tw/professional/page.aspx?treeid=5B0231BEB94EDFFC&nowtreeid=1B4BACA0D1FDDB84

5.1 Outpatient Visits and Expenditure

From Section 2, we know that the average out-of-pocket cost for each outpatient visit increases by more than 100% when a child passes their 3rd birthday. Our main question is how children's healthcare utilization and expenditure respond to this exogenous price change. We begin with a graphical analysis.

5.1.1 Graphical Analysis

Figure 2a shows the actual and fitted age profiles of total outpatient expenditure for children born between 2003 and 2004. The dots in the figure represent total outpatient expenditure per 10,000 person-years by patient's age at each visit (measured in days).[49] The solid line shows the fitted values from a local linear regression that interacts intercept and the age variables fully with a dummy indicating that the child has passed her 3rd birthday.[50] Corresponding to a sharp increase in patient cost sharing at the 3rd birthday, there is an obvious discrete reduction in outpatient expenditure when the children turn 3. The change in total outpatient expenditure can be decomposed into the change in the number of visits and the outpatient expenditure per visit. Figures 2c and 2e represent the actual and fitted age profiles of outpatient visits per 10,000 person-years[51] and outpatient expenditure per visit, respectively. We find that both variables also suddenly jump down, right after the children's 3rd birthday. On the other hand, we use pre-reform data (1997-2001) to plot the related outcome variables in Figures 2b, 2d and 2f. In sharp contrast to the graphs presented above, We find no visible discontinuity at the 3rd birthday.

5.1.2 Main Results

Table 5 presents the estimated impact of the 3rd birthday on outpatient expenditure and visits before (1997-2001) and after (2005-2008) the TCMSP was introduced. Each panel displays results for different dependent variables of interest. Odd-numbered columns present RD estimates from a nonparametric local linear regression and even-numbered columns present RD estimates from a parametric OLS regression (cubic spline). Column (1) of Table 5 presents

[49] We compute the total outpatient expenditure per 10,000 person-years by dividing the total outpatient expenditure at a particular age by the number of enrollees born between 2003 and 2004 and then multiplying this by 10,000. This is a common way to present data in the health economics and public health literatures and helps us to compare the estimated results across different sample periods and subgroups. Each dot represents 10-days average of the dependent variable.

[50] We use 90 days as our bandwidth.

[51] Again, each dot represents outpatient visits per 10,000 person-years at a given age, averaged over 10 days.

our main results for outpatient services and displays the estimates from a local linear regression with a triangular kernel function and a bandwidth of 90 days of age.[52] Corresponding to the sharp drop in outpatient expenditure at the 3rd birthday in Figure 2a, Panel A shows that the rise in the level of patient cost-sharing at the 3rd birthday causes overall outpatient expenditure to decrease significantly by 6.9%. The implied price elasticity of outpatient expenditure is around -0.10.[53]

The change in total outpatient expenditure comes from two margins: (1) the number of visits (extensive margin); (2) the outpatient expenditure per visit (intensive margin). Panel B reveals that the number of outpatient visits decreases by 4.7% at the 3rd birthday, which is smaller than the change in total expenditure. The remaining change comes from the change in the outpatient expenditures per visit. Panel C reveals that the outpatient expenditure per visit decreases significantly, by 2.2%, at the 3rd birthday. In fact, this result is likely to be a combination of two forces. First, higher cost sharing at the 3rd birthday could change the composition of patients and result in higher outpatient expenditure per visit at age 3. Assuming that the marginal patients are not as sick as those who use healthcare service regardless of cost-sharing subsidy eligibility, the average health of the patients may drop discretely at the 3rd birthday, leading to higher expenditures per visit.[54] Second, losing the cost-sharing subsidy at the 3rd birthday could also affect patients choice of provider (quality of each visit) and lead to lower outpatient expenditure per visit at age 3. As mentioned in Section 2, TCMSP indeed subsidizes more out-of-pocket costs for teaching hospital patients than clinic and community hospital patients, which would encourage patients to use outpatient services at teaching hospitals before the 3rd birthday, as patients could thereby extract greater subsidies but also receive a better quality of medical service.[55] Therefore, when patients lose their eligibility for the cost-sharing subsidy at the 3rd birthday, they may reduce their visits to teaching hospitals, resulting in a lower expenditures per visit.[56] Our

[52] I only use sample whose age at each visit is within 90 days before and after 3rd birthday

[53] This elasticity is calculated in the form of arc-elasticity. The standard formula for the price elasticity of demand is $((Q_2 - Q_1)/Q_1)/((P_2 - P_1)/P_1)$, where Q_1 and P_1 denote the baseline healthcare demand and patient cost sharing, respectively, and Q_2 and P_2 are the healthcare demand and patient cost sharing after the change in cost sharing. However, in the health economics literature, many studies (Leibowitz et al., 1985; Manning et al., 1981; Chandra et al., 2010*a*) also use the arc-elasticity, which denotes the percentage change relative to the average, since P_1 could be zero in some cases (e.g., the free plan in Rand HIE or zero out-of-pocket cost for inpatient care in this paper) and then the denominator of the price elasticity would be undefined. That is, the arc-elasticity is calculated as $((Q_2 - Q_1)/((Q_1 + Q_2)/2))/((P_2 - P_1)/((P_1 + P_2)/2)$

[54] This assumes that healthcare providers spend more on treating less healthy patients.

[55] Every three to four years, the Ministry of Health and Welfare evaluates every NHI-contracted hospital/clinic to determine their accreditation. The category of "major teaching hospital is seen as indicating the best-quality providers.

[56] Because the teaching hospitals may provide more medical services at each visit, such as health checks or medical treatments, it will cost more for each visit.

estimates in Panel C imply that the latter force dominates the former, causing outpatient expenditure per visit to exhibit a discrete drop at the 3rd birthday. In Section 5.1.4, we will discuss this issue in more detail.

5.1.3 Validity and Robustness Checks

Columns (3) and (4) in Table 5 display the results of a placebo test using pre-reform data (1997-2001). The results reveal that there is no discontinuity in our outcome variables at the 3rd birthday before 2002 (when TCMSP was introduced). The point estimates are insignificant and close to zero, which substantially reduces concerns about the impact of other confounding factors on our estimates. In Table A1, we conduct another placebo test by examining any discontinuities at other age cut-offs. We find our outcome variables (log of outpatient expenditure and number of visits) to be smooth across all selected age cut-offs, except for the 3rd birthday (1096 days old).[57]

For a robustness check of our main specification, we use an alternative method (global polynomial approach) to estimate the discontinuity in the outcome variables at the 3rd birthday using all available data (365 days before and after the 3rd birthday) and a third-order polynomial age function with different slopes on either side of the 3rd birthday. The results in column (2) present very similar estimates to our main results. In Table A2, we systematically examine the sensitivity of our RD estimates to different bandwidths and orders of polynomial. The estimates are fairly stable across different specifications. In Table A3, we present various local linear estimates from three different bandwidth selectors and kernel functions to show that our main results are robust to these choices.

One caveat could threaten the validity of our RD design. Because every child eventually “ages out of her cost-sharing subsidy, parents may anticipate the sharp increase in the price of medical services after the child’s 3rd birthday and “stock up on outpatient care.[58] This behavioral response would represent an inter-temporal substitution of healthcare (i.e., substituting future healthcare with current healthcare) and not a “real change (increase) in the demand for healthcare induced by the cost-sharing subsidy, which is our main interest. Such a behavioral response would tend to bias upward our estimates of the change in healthcare demand at the 3rd birthday (i.e., the price elasticity of healthcare demand). From Figures 2a and 2c, we indeed find that outpatient expenditure and visits suddenly rise 20 days be-

[57] There are several “significant” discontinuities at other age cut-offs. However, their magnitudes are quite small.

[58] Since most outpatient visits of young children are for acute diseases (e.g., 74% of visits are for respiratory diseases), it is hard to believe that parents would be able to substitute children’s outpatient care today for care in one month. However, it would be possible to substitute outpatient care within a few days.

fore the 3rd birthday. In order to account for the possible anticipation effect, we conduct a "donut" RD (Barreca et al., 2011; Shigeoka, 2014) by systematically excluding outpatient expenditure and visits within 3-21 days before and after the 3rd birthday (see Table A4 in appendix). Although there is no consensus on the 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 give us some sense of the "stocking up effect on our estimates. The estimates from different sizes of donut hole give us very similar results to our main RD estimates.

5.1.4 Change in Choice of Providers at 3rd birthday

The NHI in Taiwan (and other Asian countries) does not adopt a gatekeeper system to restrict patients' choices of providers. Instead, the NHI sets different levels of cost sharing (copayments) for four different types of providers to encourage patients to choose the most suitable provider based on their understanding of the seriousness of the illness and to rectify possible moral hazard behaviors in choosing providers. As mentioned before, the TCMSP exempts all NHI copayments for children under the age of 3, which gives us a unique opportunity to examine the impact of differential copayments on the patient's choice of provider by comparing the choices right before the 3rd birthday (uniform copayments) with those right after the 3rd birthday (differential copayments).[59]

Figures 3a to 3d present the age profiles of the outpatient visits by type of provider. We find that outpatient visits to major and minor teaching hospitals see strikingly discrete reductions just after the 3rd birthday. However, the number of visits to community hospitals exhibit the opposite pattern, namely jumping at the 3rd birthday, and there is a less obvious drop in visits to clinics after the 3rd birthday. Most of the decline in the overall number of outpatient visits indeed comes from the teaching hospitals. The visual evidence suggests that the change in relative prices at the 3rd birthday results in a significant redistribution of caseloads across different types of providers.

Coinciding with the graphical evidence, the RD estimates in Panel B of Table 6 show that turning age 3 substantially reduces the number of outpatient visits to major and minor teaching hospitals, by 59% and 44%, respectively. However, outpatient visits to community hospitals increase by 18% and the caseloads of clinics decrease only slightly, by 2%. This result indicates that patients are quite sensitive to the relative prices (cost sharing) of different types of providers, and can switch providers easily. The question that follows is what kind

[59]Before the 3rd birthday, patients still need to a pay registration fee. However, the registration fee does not vary substantially across different providers.

of healthcare can easily be substituted between teaching hospitals and clinics (community hospitals)?

In Panel C of Table 6, we use outpatient expenditure per visit as a proxy for severity of illness.[60] The estimates in Panel C reveal that turning age 3 substantially increases the expenditure per visit to the major and minor teaching hospitals by 20% and 6%, respectively. This result implies that most of the reduction in visits to teaching hospitals at the 3rd birthday is actually related to less severe diseases. Since patients reduce their utilization of teaching hospitals right after the 3rd birthday, we suspect that these foregone visits relate to illnesses for which it is not necessary to attend a teaching hospital. That is, they can be treated at clinics or community hospitals instead, which implies a substantial moral hazard whereby outpatient services in teaching hospitals are abused before the 3rd birthday. The above results suggest that the differing levels of copayments are an important factor in patients' choice of providers. Maintaining differential copayments between different types of providers could be a powerful tool for allocating medical resources efficiently.

5.1.5 Heterogeneous Effect

In this section, we investigate the heterogeneity of price response across different types of diagnoses and various subgroups of young children. Each row displays a different type of diagnosis and subgroup. The column (1) in Table 7 presents the rate of outpatient visits per 10,000 person years 90 days before the 3rd birthday to give us some insights about the relative size of outpatient visits across different types of diagnoses and subgroups before a child's 3rd birthday. The column (2) and (3) in Table 7 display the RD estimates of outpatient expenditure (take log) and implied price elasticity of expenditure, respectively. Panel A in Table 7 presents the results for selected diagnoses. The first three rows in Panel A list the top three common visit diagnoses for young children and all of them are acute respiratory diseases: upper respiratory infection (URI), acute bronchitis, and acute sinusitis, which accounts for 40% of total outpatient visits.[61] For some diseases, such as, acute bronchitis and sinusitis, receiving proper outpatient care could be beneficial to children's health. Column (2) in Panel A shows that the outpatient expenditure for these common diagnoses significantly decline after the 3rd birthday. However, the estimated sizes of the reduction at the 3rd birthday for these diseases are smaller than estimates from overall outpatient expenditure. The implied price elasticities of expenditure are only -0.04 to -0.08, which reveals patients

[60] Here we assume that more severe diseases would incur higher expenditures per visit.

[61] $(119+51+48)/542 = 0.40$

(parents) are not price sensitive to outpatient care for acute respiratory diseases.[62]

The remaining rows in Panel A presents RD estimates for other selective diagnoses that may be less serious but need timely treatment to improve living quality, such as, skin diseases. Losing cost sharing subsidy causes a 14.9% reduction in outpatient expenditure for skin diseases, which is much larger than the overall decline in outpatient expenditure. Much larger decrease can also be found for outpatient care that are more discretionary but could reduce future healthcare cost, such as mental health service and preventive care. Turning three substantially reduces outpatient expenditure for mental diseases by 23.2% and for preventive care by 24.5%. The implied price elasticities for this type of healthcare are quite large (-0.33 for mental health service and -0.69 for preventive care).[63] Early detection and treatment for children's mental disorders (e.g., Autism) could result in better treatment outcomes. Our results suggest preventive and mental care are quite price sensitive and cost sharing subsidy might encourage more children to use these care before age 3, which could substantially reduce future medical costs.

Panels B to D in Table 7 examine the distinct price response across various subgroups of young children. Panel B displays the results by birth order. In general, 1st born children have a lower rate of outpatient visits and show a slightly lower price elasticity of expenditure (in absolute term). Panel C presents RD estimates by gender. Compared with females, males have more outpatient visits and a slightly larger price elasticity of expenditure (in absolute term). Panel D presents RD estimates based on household income. We find children from low income families have fewer outpatient visits. However, two groups have similar responses to price change at 3rd birthday, suggesting the liquidity effect is limited.

5.2 Inpatient Admissions and Expenditures

For young children, inpatient admissions are much 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. Nevertheless, the cost to the patient of one inpatient admission is 29 times more than that per outpatient visit and 17% of healthcare spending for young children is attributed to inpatient care. More importantly, patient cost sharing for inpatient admissions experiences a much larger increase at the 3rd birthday than does that for outpatient visits, in terms of both the level and the percent-

[62]We use the same method mentioned in section 2 to obtain exogenous price change at the 3rd birthday for each disease and then calculate price elasticity (arc-elasticity).

[63]We use the same method mentioned in section 2 to obtain exogenous price change at 3rd birthday for each disease and then calculate price elasticity

age change.[64] That is, inpatient care could have substantial impacts on overall healthcare spending and individuals' out-of-pocket medical expenditure. Hence, understanding how young children's demand for inpatient care responds to cost sharing has important policy and welfare implications.

However, the effect of turning age 3 (losing the cost-sharing subsidy) on the utilization of inpatient care is theoretically ambiguous. On the one hand, children may have fewer inpatient admissions and lower expenditure after they turn 3 because the patient cost sharing for inpatient care increases sharply at the 3rd birthday. On the other hand, the type of inpatient care that young children usually use could be less price sensitive than in the case of outpatient visits. Most admission diagnoses in early childhood, such as pneumonia and acute gastroenteritis, can be treated with medication or bed rest. Previous studies (Card et al., 2008; Shigeoka, 2014) have found that patient cost sharing (or insurance coverage) has less impact on this type of diagnosis for the elderly. In addition, for young children, admissions requiring surgery are seldom selective (e.g., osteoarthritis, hip and knee replacement) but more likely life threatening and essential (e.g., congenital heart disease). Thus, we should expect inpatient care for young children to be less sensitive to price changes at the 3rd birthday.

5.2.1 Graphical Analysis

Figure 5a shows the actual and fitted age profiles of inpatient admissions for children born between 2003 and 2004. Similar to the graphs for outpatient care (Figure 2), the markers represent total inpatient expenditure per 10,000 person-years at the given age, which is measured in days from the 3rd birthday. The solid line shows the predicted values from a local linear regression that interacts the age variables fully with intercept and a dummy indicating that the child has passed her or his 3rd birthday. Surprisingly, in contrast to the sharp drop in outpatient expenditure, Figure 5a shows that inpatient expenditure exhibits no change at the 3rd birthday. Similarly, Figures 5c and 5e represent the actual and predicted age profiles of inpatient admissions and inpatient expenditure per admission. We also find that there is little visual evidence of any discontinuity in either inpatient admissions or inpatient expenditure per admission at the 3rd birthday. When we compare these with the graphs plotted using pre-reform data (1997-2001), we find the outcome variables in the pre and post-reform periods to have very similar age profiles.

[64] Average patient cost sharing for one inpatient admission increases by 1296 NT$ at the 3rd birthday. However, the average price for one outpatient visit only rises by just 74 NT$.

5.2.2 Main Results

Table 8 presents the estimated effect of the 3rd birthday on inpatient expenditure and admissions before (1997-2001) and after (2005-2008) the introduction of the TCMSP. As in Table 5 for outpatient services, each panel displays results for a different dependent variable of interest. Odd-numbered columns present the RD estimates from nonparametric local linear regressions and even-numbered columns present the RD estimates from parametric OLS regressions (cubic spline). Consistent with the graphical evidence in Figure 5, all RD specifications in Table 8 suggest there is no statistically significant impact of turning age 3 on inpatient expenditure and utilization. The point estimates in column (1) of Table 8 (our baseline estimation) are close to zero and insignificant. They reveal that losing the cost-sharing subsidy reduces the total inpatient expenditure by only 0.89% and the number of inpatient admissions by 0.18%. The implied price elasticity of inpatient expenditure is about -0.004.[65]

There is little evidence on the impact of patient cost sharing on the demand for inpatient services. Our results are consistent with the findings in the prior literature. Shigeoka (2014) finds that the demand for inpatient admissions treated with bed rest and medication do not respond to the price change at age 70 in Japan. Card et al. (2008) obtained similar findings for Medicare recipients in the US. Since most admissions for young children involve these types of inpatient care, our results suggest that the utilization of inpatient care for young children could have a very limited response to patient cost sharing, which implies that young children's demand for inpatient care may not be discretionary but necessary. According to our estimates, providing full insurance coverage of young children's inpatient services should be welfare improving since it will not cause a moral hazard but will substantially reduce the financial risk brought about by inpatient admissions.

6 Conclusion

Many developed countries subsidize young children's healthcare by requiring relatively low patient cost sharing of this demographic group in their public insurance programs. The rationale behind these medical subsidy policies is that young children are heavy users of healthcare, which might impose sizeable financial risk on young households. More importantly, these early-life health interventions are widely believed to be beneficial to the individual's future life. To assess the efficacy of these subsidy policies, understanding how

[65] Again, it uses price change in Table 2 and is calculated in the form of arc-elasticity.

young children's healthcare demand responds to patient cost sharing is essential. Yet, in the existing literature, very little is known about this issue.

In this paper, we provide convincing evidence on the price response of healthcare for young children. We exploit a sharp increase in the required level of patient cost sharing at age 3 in Taiwan that occurs when young children "age out" of the cost-sharing subsidy, which results in a higher level of patient cost sharing for children just after their 3rd birthdays than just before. We apply an RD design to estimate the impact of cost sharing on healthcare demand in early childhood. We reach three conclusions. First, the demand for outpatient services responds significantly to the change in copayments, but the estimated price elasticity of outpatient expenditure is modest (at around -0.10). Second, differential copayments for outpatient services between hospitals and clinics represent a powerful policy tool for encouraging patients to use suitable providers based on the seriousness of their illness. According to our estimates, due to the differential copayments, the number of visits to teaching hospitals is reduced by 50% and most of the foregone visits are for less severe conditions. Finally, the demand for inpatient services does not respond to the price change. The implied arc-elasticity of inpatient expenditure is close to zero. Rand HIE found mixed evidence on this issue and could not draw strong conclusions. Our results largely support the view that inpatient services for young children are not price sensitive. Taken together, these results suggest that the level of patient cost sharing for young children should differ between healthcare services and healthcare providers. For example, the NHI should fully cover the medical costs of inpatient care for young children since this will not generate excess spending due to moral hazard but will fully protect the patient against the risk of out-of-pocket expenses. On the other hand, the NHI should set a higher level of patient cost sharing for outpatient services at teaching hospitals so as to reduce possible moral hazard behavior when patients are choosing providers, namely, attending teaching hospitals when they do not need to do so.

Several important questions have not been analyzed in this paper, such as the long-run health impact of this cost-sharing subsidy program. Future research could focus on this issue and this would give us a more complete picture of the effect of similar programs around the world.

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7 Tables and Figures

Table 1:
Patient Cost-Sharing in Taiwan NHI

	Patient Cost-Sharing			
	Major Teaching Hospital	Minor Teaching Hospital	Community Hospital	Clinic
Panel A: Outpatient service				
NHI Copay	360	240	80	50
Register Fee	150	100	100	50
Panel B: Inpatient service				
1-30 days		10%		
31-60 days		20%		
after 61 days		30%		

Note: 1 US$ is 32.5 NT$ in 2006. For outpatient service, patient cost-sharing is through copyment. A patient pays NHI copayment plus registration fee for each visit. If a physician prescribes a drug at a visit and the drug cost is above 100 NT$, the patient also needs to pay a share of the cost of the prescription drug, which is 20% of total drug cost. However, most visits for the children under age 3 have drug costs below 100 NT$ so patients usually do not pay for their prescription drugs. On average, The out-of-pocket cost of prescription drugs per visit is very small (i.e., only 2.5 NT$). Information about NHI Copay is from National Health Insurance Research Database codebook (2012). NHI implements this fee schedule since July 2005. Since our sample period is from Janunary 1st 2005 to December 31st 2008, most of ourpatient visits in our sample, except visits on Janunary 1st 2005 to June 30th 2005, are based on the above fee schedule. Before July 1st 2005, NHI Copay for outpatient service is according to the following fee scheme: 210 NT$ for major teaching hospital, 140 NT$ for minor teaching hospital, 50 NT$ for community hospital, and 50 NT$ for clinic. Information about registration Fee is from an online database of NHI registration fee survey: http://www.nhi.gov.tw/amountinfoweb/Search.aspx?Q5C1_ID=2&Q5C2_ID=900002&Hosp_ID=1131100010&rtype=2 For inpatient care, patient cost-sharing takes place through coinsurance. Depending on the days of stay and the type of admission (acute or chronic admission), a patient is required to pay 10% to 30% of the total medical expense per admission. The above fee schudle is only for acute admission since we eliminate all chronic admissions, which only accounts for 0.3% of inpatient admissions.

Table 2:
Weighted Average Out-of-pocket cost per visit/admission

	Out-of-pocket cost per visit/admission	
Type of Service	Before 3rd birthday	After 3rd birthday
Outpatient service	58.9	132.7
Inpatient service	0	1296

Note: Data are pooled NHI claims records 2005-2008. Weighted average out-of-pocket costs per visit/admission are reported in New Taiwan Dollar (NT$). 1 US$ is 32.5 NT$ in 2006.

Table 3:
Selected characteristics at age three before and after sample selection

	(1) Original Sample	(2) Continuous enrollment at age two and three	(3) Eliminating cost-sharing waiver
Male	0.525	0.525	0.524
Birith year: 2003	0.510	0.509	0.509
Birith year: 2004	0.490	0.491	0.491
1st birth	0.519	0.520	0.520
2nd birth	0.368	0.370	0.370
3rd birth (above)	0.113	0.112	0.110
Number of siblings	1.761	1.760	1.759
	(0.671)	(0.671)	(0.669)
Number of children	435,206	426,587	410,517

Note: Column (1) presents the selected characteristics for original sample: all NHI enrollee born in 2003 and 2004. Column (2) restrict sample to enrollee who continuously register in NHI at age 2 and 3. Column (3) eliminates sample with cosh-sharing waiver, such as, children with catastrophic illness (e.g., cancer) and children from very low income families since these children do not experience any price change when turning three.

Table 4:
Descriptive Statistics

	Outpatient Service		Inpatient Service	
	Before 3rd birthday	After 3rd birthday	Before 3rd birthday	After 3rd birthday
Utilization				
Average annual visits	19.8	19.0	0.14	0.13
Average out-of-pocket cost per visit (NT$)	58.9	123.1	0	1289.7
Average medical expenditure per visit (NT$)	443.5	438.7	12980.6	13013.9
Choice of providers				
Major Teaching Hospital	4.1%	2.3%	28.4%	29.8%
Minor Teaching Hospital	5.6%	3.7%	58.6%	58.2%
Community Hosptial	3.8%	4.6%	12.8%	11.9%
Clinic	86.5%	89.4%	0%	0%
Number of children (visits $>$ 0)	375,493	364,075	13,252	12,666
Number of children-visit	2,003,097	1,954,591	19,356	18,163

Note: Data are pooled NHI claims records 2005-2008. The above descriptive statistics is based on records about outpatient(inpatient) service happened within 90 days before 3rd birthday and 90 days after 3rd birthday. Average annual visits is calculated by average visits at each age (measured in day) times 365. Average out-of-pocket costs and medical expenditures are reported in New Taiwan Dollar (NT$). 1 US$ is 32.5 NT$ in 2006.

Table 5:
RD estimates on outpatient care at age 3

	2005-2008		1997-2001	
Specification	(1) Nonparametric Local linear	(2) Parametric Cubic spline	(3) Nonparametric Local linear	(4) Parametric Cubic spline
Visits rate at age 2 (per 10,000 person-years)	542		568	
Bandwidth (days)	90	365	90	365
Panel A: Log(outpatient expenditures)				
*Age*3 (X100)	-6.90***	-6.99***	0.09	0.29
	[0.49]	[0.46]	[0.24]	[0.22]
Panel B: Log(number of visits)				
*Age*3 (X100)	-4.73***	-4.77***	0.22	0.20
	[0.31]	[0.32]	[0.17]	[0.16]
Panel C: Log(outpatient expenditures per visit)				
*Age*3 (X100)	-2.17***	-2.22***	-0.12	0.09
	[0.29]	[0.27]	[0.13]	[0.13]

Note: We collapse the individual-level data into age cells. Age is measured in days. The first two columns present our main results. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure, the log of the total number of outpatient visits, and the log of outpatient expenditure per visit, at each day of age. Odded columns use data within 90 days before and after 3rd birthday (bandwidth is 90 days) and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday (equation (3)). Evened columns present estimated regression discontinuities by using all available data (365 days before and after 3rd birthday) and flexible polynominal regression (cubic spline), allowing different slope on the either side of 3rd birthday. In the last two columns, we use the same selection criteria to create pre-reform sample: enrolee born between 1995 and 1997 (when they are age 2 and 3). Therefore, we use 1997-2001 NHI data to obtain the above estimated results. All coefficients on *Age*3 and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Table 6:
RD estimates on outpatient care at age 3: By choice of providers

Providers	(1) Major teaching hospital	(2) Minor teaching hospital	(3) Community hospital	(4) Clinic
Visits rate at age 2 (per 10,000 person-years)	22	30	20	469
Panel A: Log(outpatient expenditures)				
*Age*3 (X100)	-39.29***	-38.89***	17.76***	-1.92***
	[2.63]	[2.40]	[1.64]	[0.33]
Panel B: Log(number of visits)				
*Age*3 (X100)	-59.29***	-43.89***	17.71***	-1.73***
	[1.96]	[1.65]	[1.64]	[0.32]
Panel C: Log(outpatient expenditures per visit)				
*Age*3 (X100)	19.85***	5.76***	0.05	-0.19*
	[2.24]	[1.77]	[1.67]	[0.10]

Note: We collapse the individual-level data into age cells. Age is measured in days. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure, the log of the total number of outpatient visits, and the log of outpatient expenditure per visit, at each day of age. Column (1)-(4) present RD estimates of each interested outcome for four types of health provides by using data within 90 days before and after 3rd birthday (bandwidth is 90 days) and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday (equation (3)). All coefficients on *Age*3 and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Table 7:
RD estimates on outpatient care at age 3: By diagnoses, birth order, gender, and household income

	(1) Visits rate at age 2 (per 10,000 person-years)	(2) Log(outpatient expenditure)	(3) Expenditure Elasticity
Panel A: By visit diagnoses			
URI	119	-2.38***	-0.037***
		[0.65]	[0.010]
Acute bronchitis	51	-5.56***	-0.084***
		[0.73]	[0.014]
Acute sinusitis	48	-4.10***	-0.064***
		[1.10]	[0.019]
Skin diseases	20	-14.88***	-0.259***
		[1.55]	[0.041]
Mental disorder	4	-23.18***	-0.328***
		[3.62]	[0.061]
Preventive care	2	-24.54***	-0.689***
		[6.07]	[0.29]
Panel B: By birth order			
1st birth	535	-5.97***	-0.084***
		[0.57]	[0.009]
2nd birth (above)	549	-7.90***	-0.115***
		[0.40]	[0.012]
Panel C: By gender			
Male	570	-7.65***	-0.109***
		[0.59]	[0.010]
Female	511	-5.93***	-0.085***
		[0.67]	[0.011]
Panel D: By household income			
Low	525	-6.98***	-0.101***
		[0.63]	[0.010]
High	562	-6.81***	-0.097***
		[0.54]	[0.011]

Note: We collapse the individual-level data into age cells. Age is measured in days. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure. Panel A to D report RD estimates of each interested outcome for various subgroups. Low income household in Panel D is defined as monthly household income is below 40,000 NT$. High income refers households with monthly household above 40,001 NT$ We use data within 90 days before and after 3rd birthday (bandwidth is 90 days) and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday. All coefficients on $Age3$ and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Table 8:
RD ESTIMATES ON INPATIENT CARE AT AGE 3

Specification	2005-2008 (1) Nonparametric Local linear	2005-2008 (2) Parametric Cubic spline	1997-2001 (3) Nonparametric Local linear	1997-2001 (4) Parametric Cubic spline
Visits rate at age 2 (per 10,000 person-years)	3.9		2.5	
Bandwidth (days)	90	365	90	365
Panel A: Log(inpatient expenditure)				
*Age*3 (X100)	-0.89	0.46	1.36	2.72
	[4.85]	[4.31]	[2.38]	[2.20]
Panel B: Log(number of admission)				
*Age*3 (X100)	-0.18	-1.26	1.14	3.12
	[2.82]	[2.56]	[2.89]	[3.13]
Panel C: Log(inpatient expenditure per admission)				
*Age*3 (X100)	-0.71	1.72	0.20	-0.40
	[3.49]	[3.21]	[2.36]	[2.48]

Note: We collapse the individual-level data into age cells. Age is measured in days. The first two columns present our main results. Each observation (age cell) represents inpatient expenditures and admissions from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total inpatient expenditure, the log of the total number of inpatient admission, and the log of inpatient expenditure per visit, at each day of age. Odded columns use data within 90 days before and after 3rd birthday (bandwidth is 90 days) and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday (equation (3)). Evened columns present estimated regression discontinuities by using all available data (365 days before and after 3rd birthday) and flexible polynominal regression (cubic spline), allowing different slope on the either side of 3rd birthday. In the last two columns, we use the same selection criteria to create pre-reform sample: enrolee born between 1995 and 1997 (when they are age 2 and 3). Therefore, we use 1997-2001 NHI data to obtain the above estimated results. All coefficients on *Age*3 and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Table A1:
PLACEBO TEST FOR OTHER AGE CUTOFF

Panel A: Log(outpatient expenditure)

Cutoff Age (days)	Coefficient on cutoff	Cutoff Age (days)	Coefficient on cutoff
886	0.66	1186	-0.63
	[0.42]		[0.39]
916	0.09	1216	-0.31
	[0.37]		[0.42]
946	-0.55	1246	0.85*
	[0.39]		[0.50]
976	-0.46	1276	-0.59
	[0.38]		[0.42]
1006	0.01	1306	-0.22
	[0.38]		[0.42]
1096	-6.90***	1336	0.51
(or 1095)	[0.49]		[0.44]

Panel B: Log(outpatient visits)

Cutoff Age (days)	Coefficient on cutoff	Cutoff Age (days)	Coefficient on cutoff
886	0.24	1186	-0.80***
	[0.25]		[0.30]
916	-0.21	1216	-0.23
	[0.29]		[0.27]
946	-0.21	1246	0.59*
	[0.27]		[0.30]
976	-0.26	1276	-0.60**
	[0.25]		[0.26]
1006	-0.26	1306	-0.12
	[0.22]		[0.31]
1096	-4.73***	1336	0.19
(or 1095)	[0.31]		[0.31]

Note: We collapse the individual-level data into age cells. Age is measured in days. The first two columns present our main results. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure and the log of the total number of outpatient visits at each day of age. Column (1) and (3) indicates different cutoff age (measured in days) used in RD estimation. Note that 1096th (or 1095th) age day is 3rd birthday and its estimate is corresponding to our main result in Table 5. Column (2) and (4) present estimated regression discontinuities of each interested outcome using data within 90 days before and after 3rd birthday and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday (equation (3)). All coefficients on *Age*3 and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Table A2:
Sensitivity to Bandwidth and Polynomial Selection in Parametric RD Regressions

	Log(outpatient expenditure)					
Bandwidth (days)	60	120	180	240	300	360
Polynominal						
1	-6.69***	-6.19***	-5.54***	-5.10***	-4.54***	-4.65***
	[0.48]	[0.33]	[0.28]	[0.24]	[0.23]	[0.20]
2	-6.58***	-6.90***	-6.61***	-6.24***	-6.06***	-5.29***
	[0.74]	[0.51]	[0.40]	[0.37]	[0.32]	[0.30]
3	-7.07***	-6.68***	-7.04***	-6.98***	-6.85***	-6.94***
	[1.11]	[0.70]	[0.56]	[0.47]	[0.42]	[0.40]

	Log(outpatient visits)					
Bandwidth (days)	60	120	180	240	300	360
Polynominal						
1	-4.55***	-3.92***	-3.39***	-2.88***	-2.35***	-2.52***
	[0.34]	[0.24]	[0.20]	[0.18]	[0.17]	[0.15]
2	-4.33***	-4.97***	-4.36***	-4.12***	-3.89***	-3.04***
	[0.53]	[0.37]	[0.29]	[0.26]	[0.23]	[0.23]
3	-4.86***	-4.41***	-5.07***	-4.72***	-4.68***	-4.84***
	[0.83]	[0.49]	[0.41]	[0.33]	[0.30]	[0.29]

Note: We collapse the individual-level data into age cells. Age is measured in days. The first two columns present our main results. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure and the log of the total number of outpatient visits at each day of age. Each row indicates different order of polynominals used in RD estimation and each column denotes various bandwidth choice. We obtain RD estimates using OLS regression with uniform kernel function (similar to the parametric estimation in Table 5). Robust standard error in parentheses. All coefficients on *Age3* and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Table A3:
Sensitivity to Bandwidth Selector and Kernel Function Selection in Nonparametric RD Regressions

	Log(outpatient expenditure)			Log(outpatient visits)		
Bandwidth selector	CCT	IK	CV	CCT	IK	CV
Kernel function						
Triangular	-6.64***	-6.63***	-6.56***	-4.48***	-4.51***	-4.45***
	[0.48]	[0.44]	[0.40]	[0.39]	[0.35]	[0.45]
Bandwidth	81	89	105	67	79	54
Uniform	-6.68***	-6.69***	-6.58***	-4.46***	-4.46***	-4.40***
	[0.47]	[0.46]	[0.52]	[0.36]	[0.36]	[0.37]
Bandwidth	65	66	54	56	56	54
Epanechnikov	-6.64***	-6.64***	-6.64***	-4.45***	-4.49***	-4.43***
	[0.47]	[0.44]	[0.42]	[0.39]	[0.35]	[0.42]
Bandwidth	75	82	88	61	70	54

Note: We collapse the individual-level data into age cells. Age is measured in days. The first two columns present our main results. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure and the log of the total number of outpatient visits at each day of age. Each row indicates the specific kernel function used in nonparametric RD estimation and each column denotes the optimal bandwidth selector for choosing bandwidth. CCT is an optimal bandwidth selection method proposed by Matias D. Cattaneo, Sebastian Calonico and Rocio Titiunik (2013). IK is an optimal bandwidth selection procedure proposed by imbens and kalyanaraman (2012). CV is an optimal bandwidth selection procedure proposed by Ludwig and Miller (2007). The above table present estimated regression discontinuities of each interested outcome using data within specific bandwidth before and after 3rd birthday and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday (equation (3)). All coefficients on $Age3$ and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

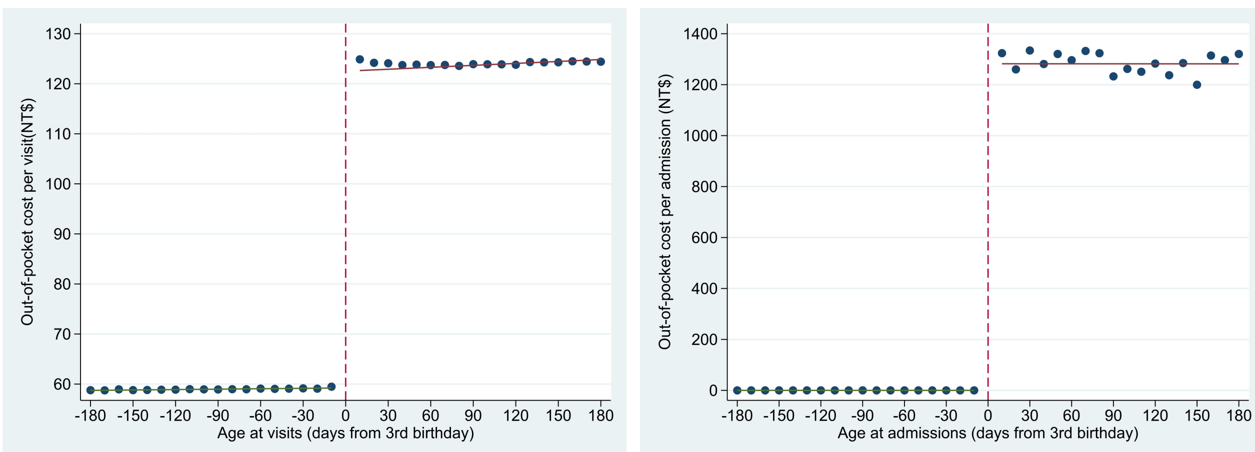
Table A4:
Donut RD for Outpatient Expenditure and Visits

	Log(outpatient expenditure)							
Size of Donut around 3rd birthday	0	3	6	9	12	15	18	21
*Age*3 (X100)	-6.90***	-6.67***	-6.84***	-6.56***	-6.20***	-6.30***	-6.61***	-6.42***
	[0.54]	[0.48]	[0.52]	[0.54]	[0.55]	[0.61]	[0.65]	[0.76]
	Log(outpatient visits)							
Size of Donut around 3rd birthday	0	3	6	9	12	15	18	21
*Age*3 (X100)	-4.73***	-4.43***	-4.42***	-4.46***	-4.37***	-4.54***	-4.70***	-4.88***
	[0.38]	[0.27]	[0.27]	[0.29]	[0.29]	[0.36]	[0.42]	[0.45]

Note: We collapse the individual-level data into age cells. Age is measured in days. The first two columns present our main results. Each observation (age cell) represents outpatient expenditures and visits from 410,517 children who were born in 2003 and 2004 (when they are age 2 and 3). Therefore, we use 2005-2008 NHI data to obtain the above estimated results. The dependent variables for the RD estimation are the log of total outpatient expenditure and the log of the total number of outpatient visits at each day of age. Each column presents estimated regression discontinuities of each interested outcome using data within 90 days before and after 3rd birthday and report the difference in local linear regression estimates just before and after 3rd birthday by using a triangular kernel, which gives higher wieght on the data close to 3rd birthday (equation (3)). we conduct a "donut" RD (Barreca et al., 2011; Shigeoka, 2014) by systematically excluding outpatient expenditure and visits within 3-21 days before and after the 3rd birthday All coefficients on *Age*3 and their standard errors have been multiplied by 100. Robust standard errors are in parentheses. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level

Figure 1: Age profile of out-of-pocket cost

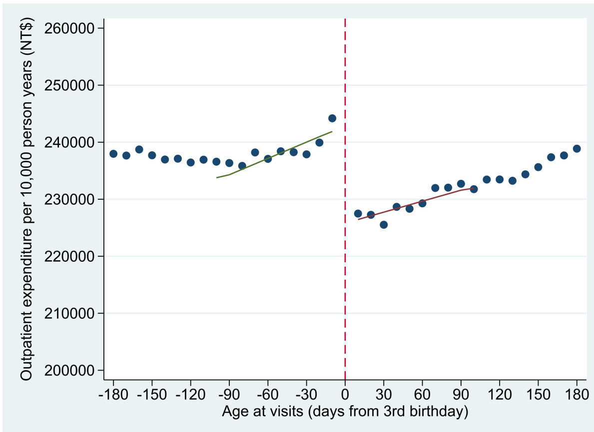
(a) Average price per outpatient visit (NT$) (b) Average price per inpatient admission (NT$)



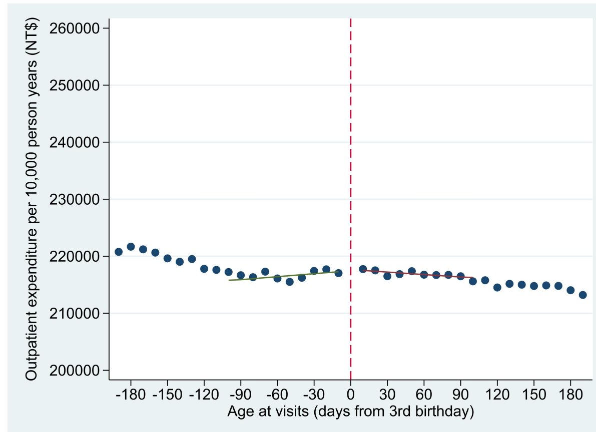
Notes: The line is from fitted a linear regression on age variables fully interacted with $Age3_i$, a dummy indicating after 3rd birthday. The dependent variable are average price per outpatient visit (inpatient admission) by patient's age at visit (measured in days, 180 days before and after 3rd birthday). Each dot represents the 10-day average of the dependent variable.

Figure 2: Age profile of outpatient expenditure and visits

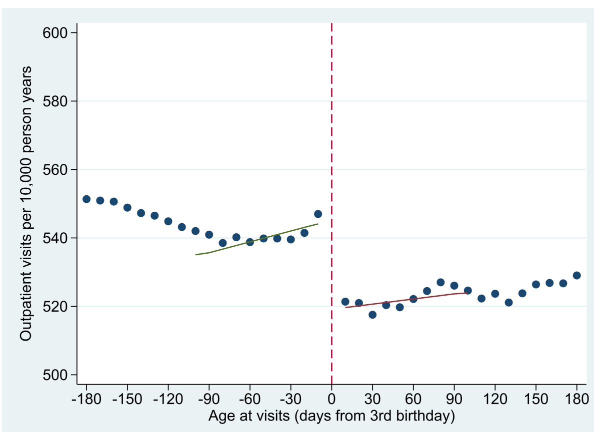
(a) Outpatient expenditures per 10,000 person-years: 2005-2008



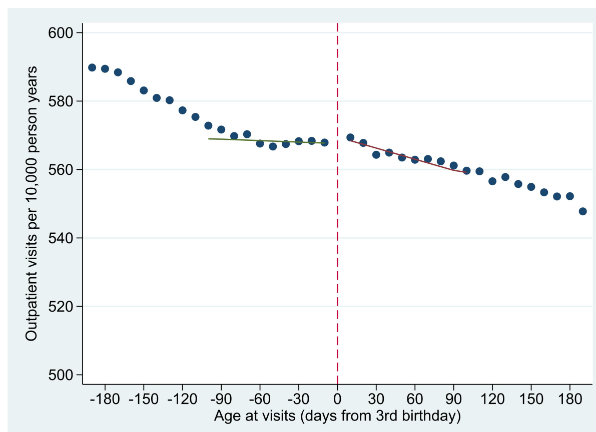
(b) Outpatient expenditures per 10,000 person-years: 1997-2001



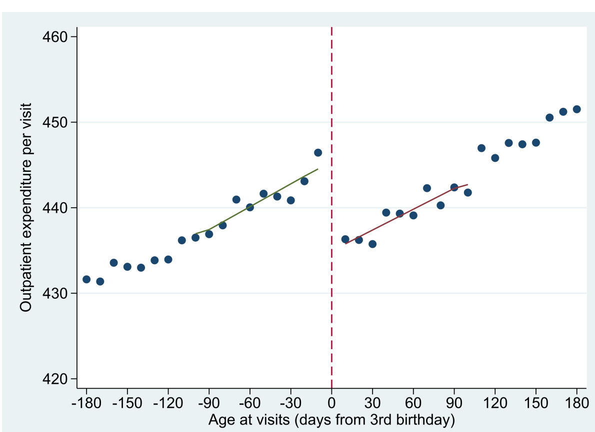
(c) Outpatient visits per 10,000 person-years: 2005-2008



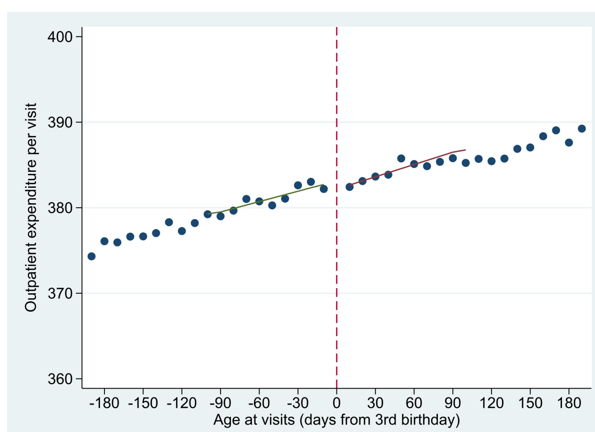
(d) Outpatient visits per 10,000 person-years: 1997-2001



(e) Outpatient expenditures per visit: 2005-2008



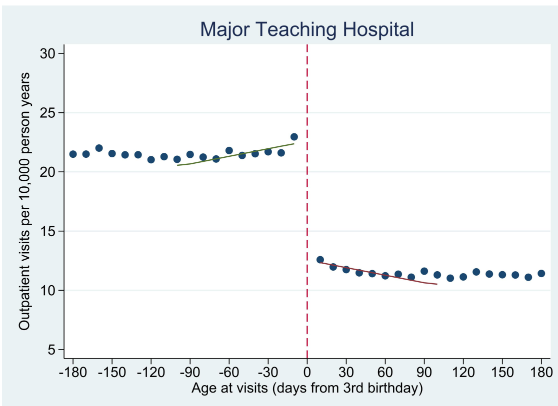
(f) Outpatient expenditures per visit: 1997-2001



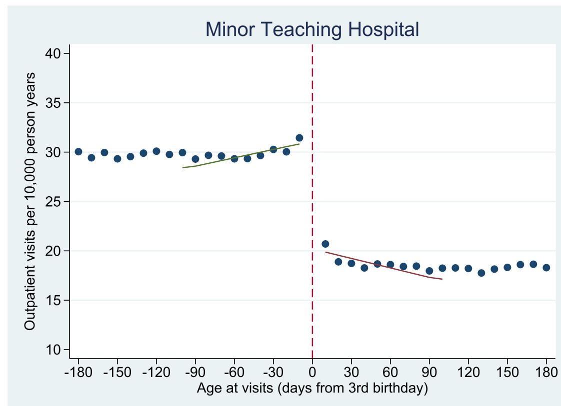
Notes: The line is from fitted a linear regression on age variables fully interacted with $Age3_i$, a dummy indicating after 3rd birthday (90 days bandwidth). The dependent variables are outpatient expenditure per 10,000 person years, outpatient visits per 10,000 person years, and outpatient expenditure per visit by patient's age at visit (measured in days, 180 days before and after 3rd birthday). Each dot represents the 10-day average of the dependent variable.

Figure 3: Age profile of outpatient visits per 10,000 person-years by type of provider

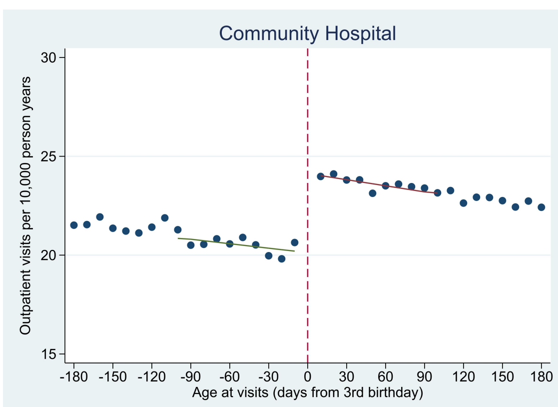
(a) Major Teaching Hospital



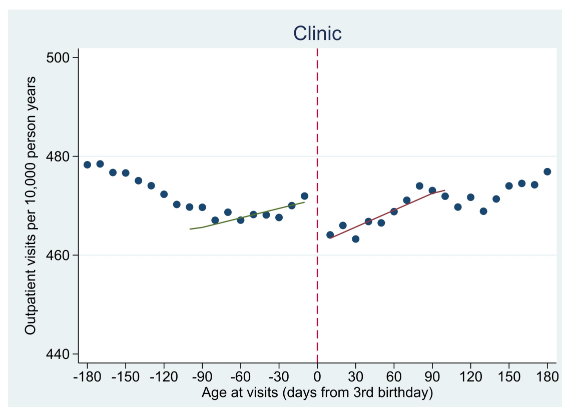
(b) Minor Teaching Hospital



(c) Community Hospital



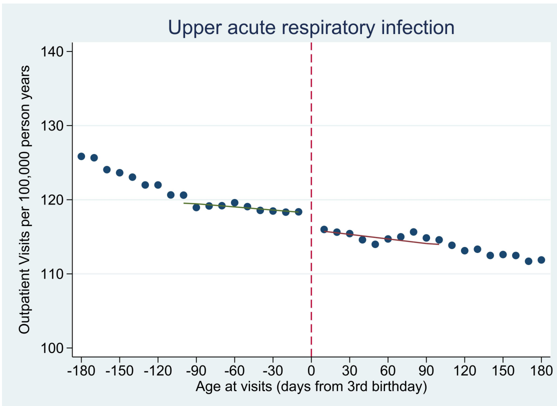
(d) Clinic



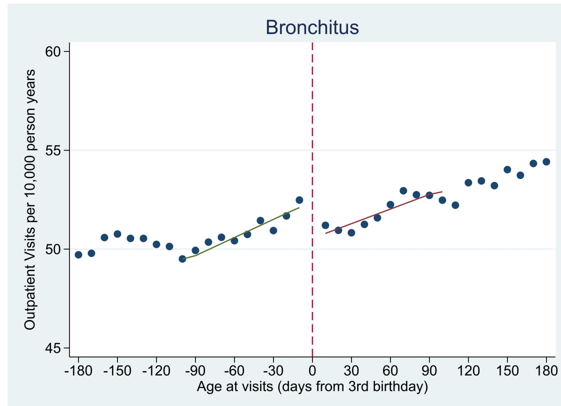
Notes: The line is from fitted a linear regression on age variables fully interacted with $Age3_i$, a dummy indicating after 3rd birthday (90 days bandwidth). The dependent variables are outpatient visits per 10,000 person years (measured in days, 180 days before and after 3rd birthday). Each dot represents the 10-day average of the dependent variable.

Figure 4: Age profile of outpatient visits per 10,000 person-years by diagnosis

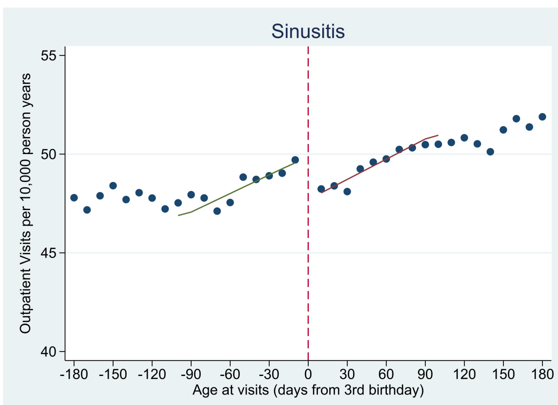
(a) Acute upper respiratory infection



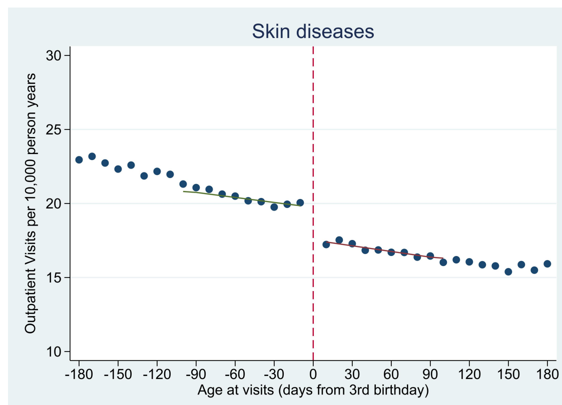
(b) Bronchitus



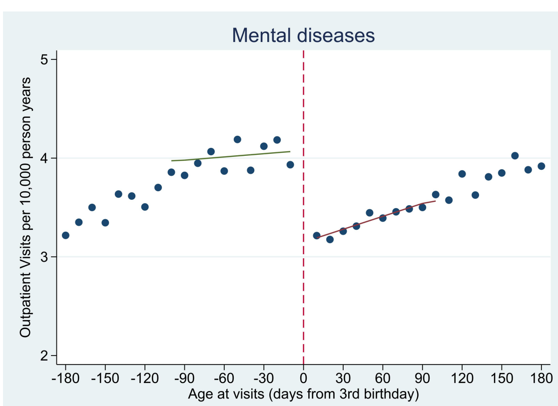
(c) Sinusitis



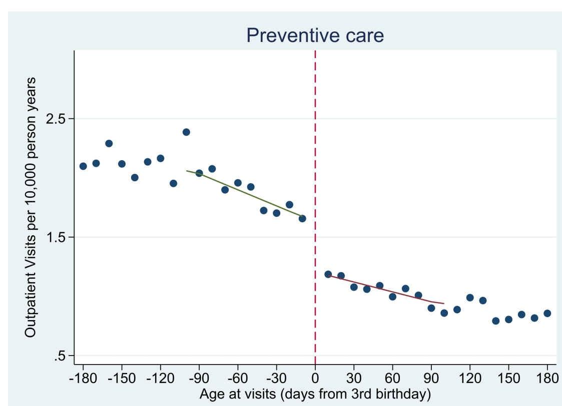
(d) Diseases of the skin



(e) Mental diseases



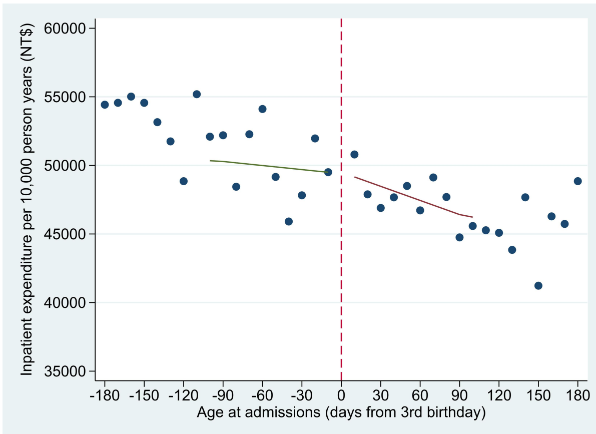
(f) Preventive care



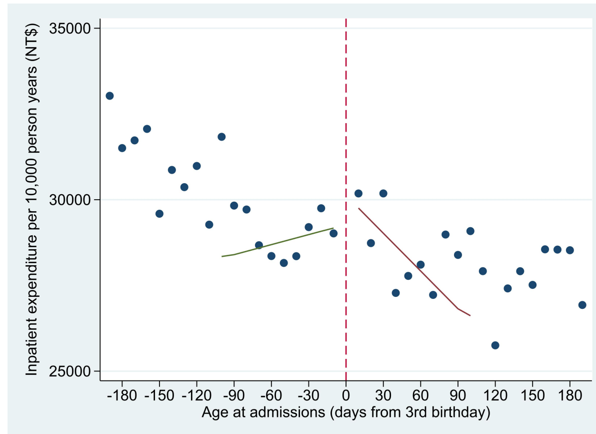
Notes: The line is from fitted a linear regression on age variables fully interacted with $Age3_i$, a dummy indicating after 3rd birthday (90 days bandwidth). The dependent variables are outpatient visits per 10,000 person years (measured in days, 180 days before and after 3rd birthday). Each dot represents the 10-day average of the dependent variable.

Figure 5: Age profile of inpatient expenditure and visits

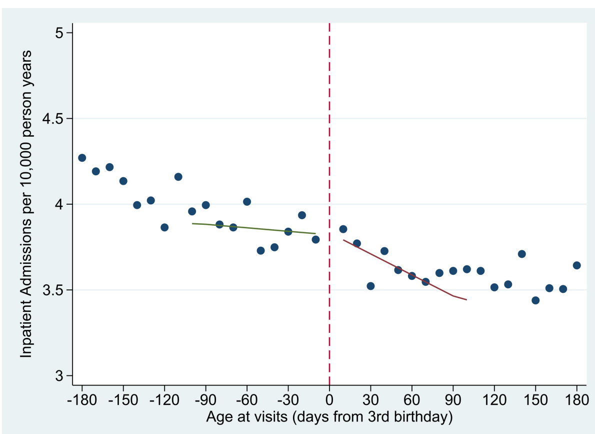
(a) Inpatient expenditures per 10,000 person-years: 2005-2008



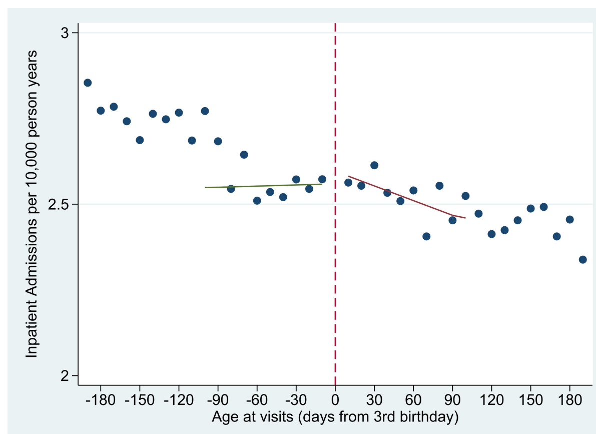
(b) Inpatient expenditures per 10,000 person-years: 1997-2001



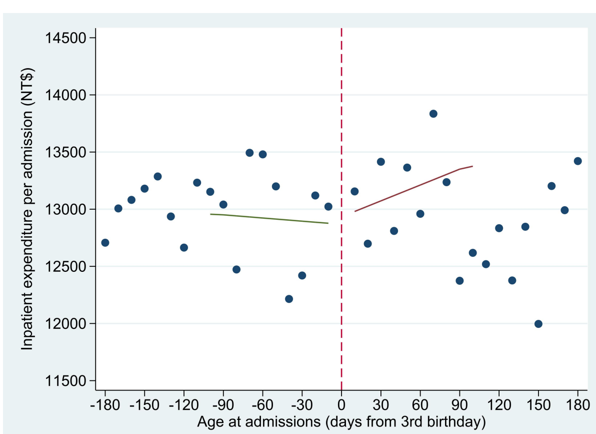
(c) Inpatient admissions per 10,000 person-years: 2005-2008



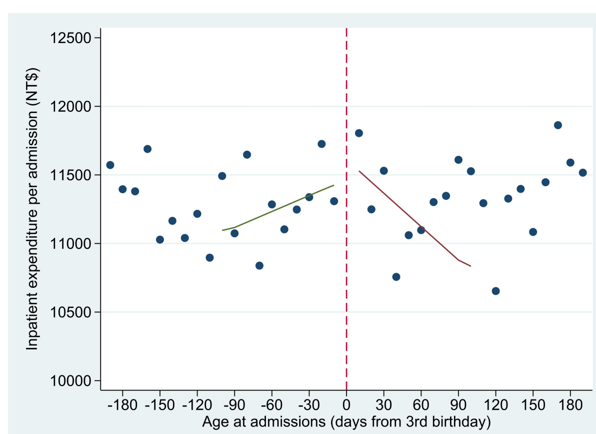
(d) Inpatient admissions per 10,000 person years: 1997-2001



(e) Inpatient expenditures per admission: 2005-2008



(f) Inpatient expenditures per admission: 1997-2001



Notes: The line is from fitted a linear regression on age variables fully interacted with $Age3_i$, a dummy indicating after 3rd birthday (90 days bandwidth). The dependent variables are inpatient expenditure per 10,000 person years, inpatient admissions per 10,000 person years, and inpatient expenditure per visit by patient's age at visit (measured in days, 180 days before and after 3rd birthday). Each dot represents the 10-day average of the dependent variable.