The Benefits of Prenatal Care: Evidence from the SARS Epidemic in Taiwan

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Abstract

The 2003 SARS epidemic caused widespread panic in Taiwan and sharply declined prenatal care utilization by 20%. Exploiting this exogenous shock, this paper adopts social learning effects to instrument the reduction in prenatal care visits with the average visits in one's peer group. Using administrative data, we find that prenatal care significantly decreased low birth weight, preterm birth, and infant mortality. The effects on infant mortality only persist among the firstborn, suggesting that information is especially important for first-time mothers. However, we find no effect on maternal complications during delivery.

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1 Introduction

The estimated costs due to adverse maternal and birth outcomes from conception to one-year-old in the US amounted to 21.9 billion in 2019 (O'Neil et al. 2021). One effective and probably low-cost measure to improve maternal and child outcomes is to ensure that pregnant women have early and regular prenatal care. Indeed, pregnancy and maternity care are covered as essential health benefits under the Affordable Care Act. For the same reason, Taiwan's National Health Insurance (NHI) offers ten free prenatal visits to pregnant women.[1] Despite these efforts, there is only sparse empirical evidence that causally identified the benefits of prenatal care. This is mainly because the unobservables (e.g., health conditions and health behaviors) tend to correlate with the utilization of medical inputs and, ultimately, health outcomes. In this study, we employ a novel identification strategy that exploits the exogenous reductions in prenatal care visits during the severe acute respiratory syndrome (SARS) outbreak to estimate the benefits of prenatal care utilization in Taiwan.

The SARS outbreak occurred in Taiwan in April 2003, leading to 483 cases and 260 deaths. Similar to COVID-19, fears of the unknown virus caused large behavioral changes. For instance, foot traffic in crowded areas declined, panic buying occurred, and hospital utilization decreased.[2] Indeed, healthcare utilization declined sharply during the SARS epidemic due to fear of catching the SARS virus (Chang et al. 2004, Chen et al. 2006, Bennett et al. 2015). Figure 1 displays the average number of prenatal care visits between 2001 and 2006. Clearly, the average number of visits decreased from 9.3 to 7.3 (or more than 20%) after the outbreak. The number returned to the pre-SARS level almost two years after Taiwan was declared as a SARS containment area in May 2003.

This paper exploits this sharp reduction in prenatal care visits as an exogenous shock to estimate the benefits of prenatal care. We employ an instrumental variable (IV) approach adopting social learning effects. In light of uncertainty, people may form risk perceptions through their peer group, leading to herd behaviors or information crusades that amplify public fears (Banerjee 1992, Bikhchandani et al. 1992, Welch 1992).[3] Indeed, Bennett et al. (2015) finds that social interactions with the local community substantially amplifies

[1]In 2020, 75% of pregnant women received adequate and early prenatal care in the US. The information on the proportion of pregnant women who receive early and adequate prenatal care can be assessed here.

[2]During the SARS epidemic in Taiwan, people avoided traveling by public transit, hoarded N95 masks, and reduced hospital visits (Chang et al. 2004, Chen et al. 2006, Fong & Chang 2011, Wang 2014, Hsu et al. 2017).

[3]Herd behaviors or informational cascades occur when individuals disregard their own information and instead imitate the behavior of others to make decisions.

responses to the SARS outbreak in Taiwan.[4][5] Under this scenario, pregnant mothers might schedule their prenatal visits according to the risk perception formed by the peer group instead of their personal health needs. Using richer data, we follow their findings to construct a proxy peer group of women who visited the same prenatal care facility and gave birth at the same age in the same year. We instrument a mother's number of prenatal visits with the average number from her peer group.

Our primary data source comes from the National Health Insurance Research Database (NHIRD), which records the medical claims of the entire population in Taiwan.[6] We merge the longitudinal inpatient and outpatient claim data of more than 800,000 women with hospital registry files between 2001 and 2006. We focus on pregnant women who experienced a substantial drop in prenatal care utilization—women who gave birth between 2001Q4 and 2004Q1.[7]. Our outcomes of interest include both mother's and child's outcomes—maternal complications, preterm birth, low birth weight (LBW), neonatal mortality, infant mortality, and whether the child is diagnosed with a catastrophic illness before age six.

We find positive, significant, and robust effects of prenatal care. Our OLS estimates suggest that prenatal care reduces the likelihood of low birth weight, preterm birth, and infant mortality. After employing healthcare use of peer groups as instruments, our estimates yield a smaller but significant effect on preterm birth, low birth weight, and neonatal and infant mortality. For instance, the SARS outbreak decreased prenatal care by two visits on average, which led to a 1.2% increase in preterm births. When we stratify our sample by parity, prenatal care only decreases mortality rates among the firstborn but not the later-born; this might be because first-time mothers benefit more from the information provided when receiving prenatal care. In addition, our findings are robust even accounting for the presence of higher stress or anxiety during the SARS epidemic, which might confound with adverse birth and health outcomes (Aizer et al. 2016, Persson & Rossin-Slater 2018).

This paper contributes to the literature that identifies the benefits of medical care before or at birth. To our knowledge, only a few studies have overcome the challenge of causally identifying medical care benefits with unobserved heterogeneity in underlying

[4] Bennett et al. (2015) define the local community using age, cohort, and where people pay their outpatient visits.

[5] For example, according to Pomfret (2003), the SMS text message "There is a fatal flu in Guangzhou" was sent 126 million times between February 8 and 10 in Guangzhou city alone. According to Eysenbach (2003), as of June 30, 2003, PubMed lists 881 articles containing the keywords "severe acute respiratory syndrome" or "SARS"; however, Google finds 358,000 pages in English with the phrase "severe acute respiratory syndrome" alone.

[6] More than 95% of the population are insured in the National Health Insurance program in Taiwan.

[7] The SARS outbreak occurred in 2001 Q1; 2004 Q1 is nine months after Taiwan was removed from the WHO SARS list.

health and behaviors. In one directly related study, Evans & Lien (2005) examines the impact of prenatal visits on birth outcomes using the 1992 Port Authority Transit strike as an exogenous source of variation. While their OLS results confirm the positive impact of prenatal care on birth weight, gestation, and maternal weight, their IV results are not precisely estimated. In contrast, our IV results continued to show a smaller but significant impact of prenatal care. Another related study by Almond et al. (2010) adopts a regression discontinuity design to exploit differential medical inputs at the very low birth weight (VLBW) diagnostic threshold. Similar to our findings, they show that medical care for infants just below the VLBW threshold reduced neonatal mortality by one percentage point compared to their counterparts.

This paper also adds to the literature on the positive association between childhood health and adulthood outcomes. The fetal origins hypothesis states that *in utero* conditions have significant influences on later-life outcomes.[8] Birth weight often serves as a primary measure for *in utero* conditions that proxies long-term outcomes. Previous studies have shown that low birth weight explains negative labor market and education outcomes (Black et al. 2007, Almond & Mazumder 2011). In addition, researchers also find that early health intervention improves education and adulthood achievement (Chay et al. 2009, Bharadwaj et al. 2013). In this paper, we highlight that adequate prenatal care can effectively protect the well-being of fetuses and improve the health conditions of children right after their births. In the long term, prenatal care can have some of the same consequences in adulthood.

When studying the causal impacts of preventive care, endogeneity issues arise because of self-selection related to precautionary behaviors and unobserved underlying health conditions. Relying on an exogenous shock in a specific context that engaged social learning, we can estimate the benefits regardless of the endogeneity. We conclude that prenatal care has positive and significant impacts on birth outcomes, which is policy relevant. Specifically, our findings suggest that adequate and early prenatal care reduced low birth weight by 2.6%.[9] The cost-benefit analyses can be easily assessed with this estimation and information on low-birth-weight-related expenditure. It is also likely that better birth outcomes improved later-life outcomes, and what this paper estimates is the lower bound.

[8] See Almond & Currie (2011) for the review.

[9] We use a different definition for adequate and early prenatal care because the system and guidelines in National Health Insurance in Taiwan are different from those in the US. Since National Health Insurance provides 10 free prenatal care, we define paying at least 10 prenatal care visits as adequate and early.

2 Background

2.1 SARS Outbreak in Taiwan and the Fear of Visit Healthcare Facilities

SARS was the first severe, readily-transmissible disease in the early 21st century. The first SARS case, retrospectively identified on November 16 of 2012, emerged in the southern Chinese province of Guangdong. On February 21 of 2003, Hong Kong reported the first case outside of China: a medical doctor who had treated patients in Guangdong.[10] Guests staying in the same hotel with the doctor subsequently carried the virus and spread out to other countries. On March 12, WHO issued its first global alert, describing outbreaks of the yet-unnamed respiratory disease in both Hong Kong and Vietnam (Knobler et al. 2004). On July 5, when WHO announced the containment of a global epidemic, SARS caused nearly 800 deaths across more than 30 countries (*World Health Organization* 2003). The estimated economic losses attributable to SARS was about US$40 billion (Lee et al. 2004, Oberholtzer et al. 2004).

Despite extensive business interactions between Taiwan and Hong Kong, only sporadic cases of SARS were reported in Taiwan during March and early April 2003. On April 12 of 2003, however, a cluster of eight infections was found in Hoping Hospital, a major municipal hospital in Taipei, resulting in 26 deaths within one month.[11] Health authorities quickly responded to this outbreak by tightening surveillance, strengthening infection control measures, and launching a mass education campaign across the country. Nonetheless, the disease spread quickly throughout certain regions of the nation. As of May 22, a total of 483 probable cases and 60 deaths were reported (Figure 2), of which the majority occurred in Taipei City and Taipei County (now New Taipei City), making Taiwan the third largest outbreak in the world, following China and Hong Kong.[12] On July 5, the outbreak was contained, and Taiwan was removed from the WHO list of affected areas. In total, WHO reports indicate a total of 674 probable cases and 87 deaths.[13] Figure 3 summarizes key dates for the SARS outbreak in Taiwan. Based on this timeline, we define the SARS epidemic in Taiwan as between March 14, 2003, and July 5, 2003.

Similar to Covid-19, SARS has generated enormous economic and social impacts and even social disturbances in Taiwan; some schools and hospitals closed, restaurants and

[10] The Chinese government did not officially report an outbreak, involving 305 probable cases and 5 deaths, of acute respiratory syndrome to the WHO until February 10, 2003, nearly three months later. (See here for references.)

[11] A laundry worker, an unrecognized SCoV-carrier, at the hospital in Taipei City ignited the SARS outbreak in Taiwan.

[12] Revised estimates from WHO and Taiwan CDC indicate that the total number of confirmed cases between February and July 2003 was 346. Taipei City and New Taipei City had a total of 279 confirmed cases. (See here for references.)

[13] See here.

shopping malls were vacated, thousands of people were quarantined, and extensive protective health measures (e.g. wearing surgical masks, avoiding public areas) were undertaken. The unanticipated outbreak of a new virus and its containment strategies exerted significant psychological effects on healthcare workers and the community at large, resulting in unprecedented public panic. Many studies show that patients were afraid to visit healthcare facilities and some even delayed their surgeries (Maunder 2004, Nickell et al. 2004).[14]

Indeed, Bennett et al. (2015) finds that "SARS fears" in Taiwan decreased outpatient visits by 30% in short order mainly through the mechanism of social learning. The reduction is also evident when we focus on prenatal care visits. Figure 1 shows that the average number of total visits decreased from 9.3 to 7.3 following the SARS outbreak. From Figure 1, it is clear that the decline occurred even before the mass outbreak in Taiwan. This is probably due to the alarms generated by the news regarding the first case in Taiwan. As more and more cases were reported, the number of prenatal visits continued to drop by more than 20% and remained between 7.3 and 7.7 visits for one and half years. The declined prenatal care visits caused by social learning in the unanticipated shock are critical to our identification strategy.

2.2 National Health Insurance and Prenatal Care in Taiwan

Taiwan implemented a single-payer system of National Health Insurance (NHI) in 1995, providing universal health coverage to its entire population of about 23 million. The vast majority of health services are covered under NHI, including outpatient and inpatient visits, prescription drugs, dental care, and traditional Chinese medical care. Co-payments are relatively low, and patients can obtain care from virtually any clinics or hospitals affiliated with NHI.[15]

For pregnant women, NHI covers ten free prenatal care visits[16] (see Appendix A Figure A1). Two visits are recommended in the first trimester (weeks 0-16), two other visits in the second trimester (weeks 17-28), and six more visits in the third trimester (weeks 29-40). In the first visit (usually prior to week 12), each pregnant mother was given the "Mother's Book" which records their medical history and lifestyle behaviors (e.g., tobacco, alcohol, and substance use) as well as the necessary educational information regarding

[14] A Lexis Nexis Academic newspaper search of the phrase "SARS fears" for the year 2003 yields about 840 articles (in English).

[15] For example, outpatients pay approximately US$5 for visits to clinics and US$8 for visits to hospitals; while inpatients pay 10% of the cost of their care, but with a maximum payment of 10% of the average national income per person. Further, some specific groups (e.g., indigenous people accounting for about 2% of the population) qualify for the exemption from all cost-sharing.

[16] See here for more details about the NHI prenatal care program.

pregnancy and preterm labor. Several important tests and screenings are performed during the regular visits. For instance, an ultrasound examination is provided on the third visit. Gestational diabetes screening occurs between 24 to 28 weeks, and screening tests for hepatitis B, rubella, and syphilis are given around the 32nd week of pregnancy (fifth visit).

3 Methodology

3.1 OLS Estimation and Issues

We exploit the exogenous shock on prenatal care utilization to study its impacts on maternal and birth outcomes. In specific, we examine both the decrease (during sample) and increase (post sample) in Figure 1. The baseline specification follows

$$Y_{ijkt} = \alpha_0 + \alpha_1 PC_{ijkt} + X_{ijkt}\alpha_2 + \tau_j + \tau_k + \tau_t + \epsilon_{ijkt} \tag{1}$$

where i denotes mother, j hospital of delivery, k prenatal care facility township, and t year of birth.[17] Y_{ijkt} represents maternal and birth outcomes in terms of delivery complications, low birth weight, preterm birth, infant mortality, as well as whether the child suffers from catastrophic illness up to age five.

PC_{ijkt} denotes the number of prenatal care visits. X_{ijkt} is a vector of maternal characteristics which includes age dummies, education, birth parity, infant gender, and two observable health conditions: maternal hypertension and diabetes. τ_j, τ_k, and τ_t represent fixed effects of the hospital of delivery, township by where mothers received prenatal care, and year by birth, respectively. ϵ_{ijkt} captures idiosyncratic factors that are assumed independent of the unobservables and all other terms in the equation. in an additional specification, we replace hospital fixed effects with H_j, a vector of hospital characteristics including dummies for ownership type (non-profit and for-profit) and teaching status (major teaching, minor teaching, and community).

The number of prenatal care visits, PC_{ijkt}, is the main explanatory variable of interest. We compute the total number of free prenatal visits occurring throughout the entire pregnancy. For that purpose, we eliminate women without a complete pregnancy history. Since NHI covers 10 free prenatal care visits, we also construct an indicator specifying whether a mother had at least 10 prenatal care visits as an alternative robustness check.

A critical issue in implementing OLS (Equation 1) is how to account for unobserved maternal behaviors that might correlate with both outcomes of interest (Y_{ijkt}) and pre-

[17] A town is equivalent to a district in a city or a village.

natal care utilization (PC_{ijkt}). If not properly accounted for, the estimated coefficient of interest, α_1, might be subject to omitted variable biases. For instance, relatively risk-averse mothers are more likely to abide by recommended prenatal care guidelines and engage in healthier behaviors that are associated with better birth outcomes, which leads to a positive correlation between PC_{ijkt} and ϵ_{ijkt} and overestimating the benefits of prenatal care. Conversely, mothers who expect to have poorer birth outcomes may increase prenatal care utilization, which leads to an underestimation and presumably an incorrect sign. Therefore, the direction of omitted variable bias is unclear.

3.2 Instrument Variable Construction and 2SLS Estimation

To address the omitted variable bias, we employ an instrumental variable approach and utilize two-stage least squares (2SLS) estimation. We follow Bennett et al. (2015) to instrument a mother's number of prenatal care visits using the average visits of their peer group. The peer group is defined as all other mothers who were the same age at delivery, gave birth in the same year, and visited the same hospital or clinic for prenatal care as the index mother.[18][19] Figure 4 suggests that prenatal care visit trends were similar across all age groups. One can see from Figure 4 that one major source of variation of prenatal visits among women, particularly among those aged below 30, was predominantly induced by SARS.

In our two-stage least squares (2SLS) estimation, the first stage takes the form:

$$PC_{ijkt} = b_0 + b_1\overline{PC}_{-ijkt} + X_{ijkt}b_2 + \eta_j + \eta_k + \eta_t + \mu_{ijkt} \tag{2}$$

where $\overline{PC}_{-ijkt}$ represents the IV, or the average number of visits occurring within mother i's social group. μ_{ijkt} denotes the unobservable, while other notations follow the same set of definition as Equation 1. b_1 captures the social learning effect. Given the situation of the SARS outbreak, we expect that $b_1 > 0$, such that mothers imitate or mimic behaviors of their social group.[20] As Bennett et al. (2015) has discussed, we are unlikely to over-estimate the social learning effect through SARS contagion among peers because of the

[18] Bennett et al. (2015) defines a peer group as cohorts visiting the same physician in medical facilities because of the highly localized outpatient healthcare market in Taiwan. They show that non-movers are more responsive to the defined peers compared to movers. In our case, if anything, the prenatal care market should be more localized. When mothers prefer going to the same physician for their 10 visits, they tend to choose hospitals or clinics closer to home.

[19] To prevent the selection issue, we use age rather than education level to define a peer group. This is because more highly educated mothers may behave systematically differently from less educated mothers, which violates the instrument exogeneity.

[20] $b_1 > 0$ indicates mothers respond in accordance within their social group; $b_1 < 0$ indicates mothers modify their behaviors opposite to the social groups, and $b_1 = 0$ suggests that the evidence for a social learning effect is weak.

low prevalence rate.[21] While the negative correlation through congestion in health care facilities among peers may lead to underestimating the peer effects, which implies that what we find here is the lower bound.

We then estimate Equation 3 using 2SLS, with standard errors clustered by maternal age and the town of the hospital providing prenatal care.

$$Y_{ijkt} = \beta_0 + \beta_1 \overline{PC}_{ijkt} + X_{ijkt}\beta_2 + \tau'_j + \tau'_k + \tau'_t + \epsilon'_{ijkt} \tag{3}$$

β_1 is the coefficient of interest and represents the causal impact of prenatal care on birth outcomes.

3.3 The Validity of IV

Two conditions must be satisfied for the validity of IV. To start with, the IV must strongly correlate with prenatal care utilization. As seen below in Section 5.2, we present strong first-stage estimation to support the presence of social learning effect. That is, prenatal care utilization in the peer group does affect a given mother's prenatal care utilization.

More importantly, the instrument should not correlate with unobserved maternal characteristics. In our specific context, two main sources of unobservables are likely to confound our estimation findings. The first is the maternal stress. Maternal stress has been shown to generate adverse effects on birth outcomes (Aizer et al. 2016, Persson & Rossin-Slater 2018). This is especially likely to occur for mothers conceived during the SARS outbreak. Mothers in the During sample might have experienced negative effects on the fetus due to unexpectedly high levels of stress and anxiety; alternatively, these mothers might have also engaged in more precautionary behaviors in response to the epidemic. To address these concerns, we provide an additional analysis using the During sample. More specifically, for each outcome of interest, we randomly assign a given percentage of mothers with adverse outcomes to be "stressed" using an indicator. In Section 6.2, we show whether those various levels of "stress" affect our estimates.

The second source of unobservables is selection bias. For instance, mothers who are more risk-averse or educated might decide to delay the timing of pregnancy and therefore self-select into the Post sample. In this case, although we control for educational attainment in our estimation, mothers in the During and Post samples might behave systematically differently; more educated mothers are likely to sort into the Post sample. To gauge the extent of selection bias toward the estimated results, we randomly drop a certain percentage of mothers with high school degrees to see if our results are robust (see Section 6.3).

[21] 346 deaths occurred during the epidemic with a 23.5 million population.

Lastly, we provide evidence for the exclusion restriction through balance tests. We show that the IV does not correlate with other observed characteristics following

$$D_{ijkt} = \gamma_0 + \gamma_1 \overline{PC}_{ijkt} + \kappa_j + \kappa_k + \kappa_t + \epsilon_{ijkt} \tag{4}$$

We perform a separate regression taking each independent variable included in vector X of Equations 1 to 3 as the dependent variables, D_{ijkt}. κ denotes the fixed effects. To support the instrumental exogeneity, we expect that γ_1 should not be significantly different from 0 in all regressions. We discuss the results in Section 5.1.

4 Data

4.1 Sample Construction

Our primary data source is the full count claim data, which contain the longitudinal inpatient and outpatient claims, between 2001 and 2006 from the National Health Insurance Research Database (NHIRD) of Taiwan. Personal identifiers, diagnosis-related group (DRG) codes, ICD-9 codes, hospital identifiers, admission dates, and patient characteristics (e.g., gender, age, residency) are available in the database. To acquire hospital characteristics, including township, ownership types, etc, we link the claim data to the NHIRD hospital registry files using unique hospital identifiers.

To construct our analysis sample between 2001 and 2006, we use DRG codes from the inpatient claim data to select all vaginal and Cesarean section delivery cases occurring between November 1, 2001, and December 31, 2006.[22] This allows the inclusion of mothers who had three trimesters of prenatal care visits and delivered prior to the global SARS outbreak, as well as mothers who were never exposed to SARS during pregnancy. We then use personal identifiers to link this analysis sample with two different datasets. First, we link this sample to their outpatient claims and identify prenatal care visits based on birth-associated ICD-9 codes as well as if the visits were free of charge. Second, we link the analysis sample with birth certificates to obtain birth weight, gestational age (calculated from the date of the last menstrual period and reported in completed weeks), maternal age, and mother's and father's education attainment. To identify birth outcomes in terms of neonatal mortality, we match the analysis sample to death certificates to obtain death dates using the infants' personal identifiers.

We made a number of sample restrictions due to a number of reasons. First, we eliminate women who had fewer than three free prenatal visits. These cases were highly

[22] We use DRG codes 0371A, 0373A, 0373B, and 0373C to identify mothers underwent the vaginal and C-section surgeries.

correlated with ectopic or molar pregnancies, abortive outcomes, and intrauterine death.[23] Thus, the negative shock on prenatal care utilization had little impact on the pregnancy and birth outcomes. Second, to prevent a broad variation in the underlying health conditions within the analytical sample, we exclude cases with multiple births, miscarriages, parity over six, birth weight below 400 or above 6,500 grams, and maternal age younger than 15 or older than 45 years old. In addition, gestational length is restricted to a minimum of 29 weeks a maximum of 42 weeks. Third, we eliminate deliveries outside the mainland (e.g., Kinmen, Penghu, etc) because of scarce healthcare resources in those places, which makes up less than 1% of the sample. We also exclude non-citizen mothers for two reasons: (i) they might have received different prenatal care guidelines from their home countries, which could be unobserved confounding factors contributing to our outcomes of interest; and (2) they might not have stayed in Taiwan for their whole gestational periods, and thus complete prenatal visit records were not available. Finally, we eliminate records with missing education or geographic information.

We construct two samples following the decreasing and increasing phase in Figure 1 as mothers might behave differently. The During SARS sample that contains mothers exposed to SARS during their pregnancies (i.e., births between November 1, 2001 and December 31, 2004). The Post SARS sample contains mothers experienced but were unexposed to SARS outbreak during their pregnancies (i.e., births between January 1, 2005 and December 31, 2006). These samples yield 420,377 and 414,692 unique births, respectively.

4.2 Summary Statistics

The upper part of Table 1 shows summary statistics of the number of maternal visits as well as outcome measures for mother's risks at the delivery and child's health, separated by the during and the post sample. We consider both the during sample and the post sample because these two samples exhibit the opposite trends with regard to the average number of maternal visits. As one can see from Figure 1, one decreases over time (the during sample) while the other increases over time (the post sample). On average, the number of prenatal care visits is quite close in these two samples: 8.65 for the during sample and 8.20 for the post sample, showing that a substantial proportion of mothers did not partake in all ten free visits offered by NHI. Nonetheless, the percentage of mothers who have at least 10 visits is higher in the during than the post sample. Almost 50% of mothers have completed 10 maternal visits, but that percentage drops 10 percent to 38.7% in the post sample.

[23] We use ICD-9 codes ranging from 630 to 634.9 to determine cases with abortive outcomes.

We use six outcome variables: two related to risks at the delivery, and four related to prenatal health. Variables of risks at the delivery include birth complications during labor and delivery and preterm that equals one if the gestational age is fewer than 30 weeks[24] Variables of a child's health include low birth weight (LBW), neonatal mortality since birth, one year mortality since birth, and an indicator of catastrophic illness LBW is a dummy which equals to one if the birth weight is less than 2,500 grams, and 0 otherwise. A dummy of catastrophic illness equals to one if the baby was diagnosed as one of catastrophic illness categorized by NHI and zero otherwise.

In the during sample, approximately 3% of the mothers experienced at least one birth complication. Around 6% mothers had babes fewer than 30 weeks of gestational age. The percentage of LBW was close to 4%. Neonatal and infant mortality per 1,000 births is 1.4 and 3.1 respectively in the during sample. And the percentage of catastrophic illness is 5.2 per 10,000 babies. Except that the mortality number is lower in the post sample, the other summary statistics looks quite similar in the during and post sample.

The middle part of Table 1 demonstrates the ownership and teaching status of health providers by the during and the post sample. About 60% of health providers are for profits, of which more than half are private clinics. Approximately 70% of the babies are delivered in the hospitals. In terms of hospital teaching status, 17% were major teaching, 27% were minor teaching, and nearly one-quarter were community hospitals. Interestingly, almost no changes in the percentage of teaching and ownership status between the during and the post sample.

The lower part of Table 1 demonstrates the characteristics and health of mothers at the time of delivery. Again, we separate the sample into the during and post sample. Approximately 40% have education equal or higher than general high school. The average age of mothers in the during sample were 28.5 years old, of which half of them are first-borns. In comparison, the age at the delivery in the post sample is a little bit larger, 29.2 years old, and more than half of them have education high school or above; this might indicate the possibility of selection.

[24] An indicator of complications during the labor and delivery equals one if the following symptoms, including maternal fever, excessive bleeding, maternal seizure, precipitous labor, prolonged labor, dysfunctional labor, anesthetic complications, fetal distress, uterus rupture during labor, and chorioamnionitis, are observed at the delivery and zero otherwise (Currie & MacLeod 2008).

5 Results

5.1 Exclusion Restriction for IV

We start by presenting the balance test results in Table 2. In both samples, our IV significantly predicted being firstborn. This is plausible since first-time inexperienced mothers are more likely to follow their peers to attend more prenatal visits. To test if this correlation biases our estimation, we further stratify a sample into two groups by whether the birth is firstborn in Section 5.3. As expected, the During sample involves less selection because these mothers were unlikely to engage in precautionary behaviors in response to the SARS outbreak. In particular, these mothers conceived before this unanticipated event. Observed characteristics other than parity all pass the balance test. We thus use birth records between 2001 Q1 and 2004 Q1 as our main sample.

On the other hand, the Post sample might engage selections and behavioral changes. It is plausible that more cautious women and less healthy women might delay birth. Indeed, in Table 2, this sample includes more highly educated and unhealthy mothers. As these selections can bias our estimates with ambiguous directions, we use births between 2004 Q2 and 2006 Q4 for additional analysis. We also address the selection on education in Section 6.3.

5.2 Main Results Using the During Sample (2001Q4-2004Q1 Data)

Table 3 reports results of OLS, first stage, and IV estimation. Panel A provides OLS estimates following Equation 1. This specification shows that prenatal care visits would increase the likelihood of maternal complication and reduce the odds of low birth weight, preterm birth, and neonatal and infant mortality. However, as discussed, the OLS estimates are likely to suffer from omitted variable bias. We thus instrument a mother's own prenatal care visit number with the average visit number occurring within the peer group (excluding the index mother). Column (7) provides the first stage estimates, which indicates that a mother's prenatal care visit number is highly correlated with her peer group's average visit number.

Panel B presents IV estimates following Equation 3. The coefficient of maternal complication is no longer significant. Meanwhile, although the magnitudes decrease substantially compared to our OLS estimates, the coefficients of low birth weight, preterm birth, and infant mortality remain significant with the same signs. While OLS estimates suggest that one more prenatal care visit reduces the likelihood of low birth weight and preterm birth by 1.35% and 2.26% respectively among all births, IV estimates suggest that one more prenatal care visit reduces low birth weight and preterm birth by 0.4% and and

0.6% respectively. Likewise, the possibility of neonatal and infant mortality was reduced by 14% and 22% every 1,000 births, respectively, only one-third to one half of OLS estimates. To conclude, prenatal care improves infants' birth outcomes but not maternal outcomes, though the benefits are much smaller after accounting for omitted variable using IV estimation method..

5.3 Heterogeneous Effects By Parity

We stratify our main sample into two groups by whether the current birth is firstborn because the balance test results show that our IV strongly predicts firstborn status in Table 2. This happens when mothers of the firstborn are more likely to learn from their peers than mothers of the non-firstborn. Table 4 reports OLS and IV estimates for the firstborn sample in Panel A and the later-born sample in Panel B. The OLS estimates for both sample are similar to the results in Table 3, except that the coefficient of preterm birth among the non-firstborn becomes insignificant. We further address the selection issues using an IV estimation. The results show that, among the firstborn, prenatal care reduces the odds of low birth weight, preterm birth, neonatal mortality, and infant mortality, which is similar to our main findings. However, among the non-firstborn, prenatal care only reduces the probability of low birth weight and preterm birth. Prenatal care visits have no impact on infant mortality rates among the non-firstborn.

It is important to highlight that prenatal care improves birth outcomes not only through monitoring and early detection but also by providing adequate patient education (Kogan et al. 1994, Alexander & Korenbrot 1995, Sanders et al. 2009, Lockwood & Magriples 2017). If information and guidelines from prenatal care visits are especially crucial for first-time parents, the firstborn will benefit more from patient education during prenatal care visits. We conclude that the correlation between the IV and the firstborn status does not change our estimates substantially. However, the firstborn benefit from prenatal care more through the channel of receiving necessary information.

5.4 Additional Results Using the Post Sample (2004Q2-2006Q4 Data)

To test the generalizability of our methodology, we further use the Post sample, births between 2004 Q2 and 2006 Q4, to conduct the same set of analyses. Figures 1 and 4 show that the total prenatal care visit number was returning to the pre-SARS level in this period. This provides another source of identification that we can examine the benefits of prenatal care. We further address the selection issue of the Post sample in Section 6.3.

Table 5 provides OLS, first stage, and IV estimates following the same method. As expected, the results are similar to those in our main specification: the first stage predicts a strong and significant correlation between total visit numbers and our IV. Except for the neonatal mortality rates, Table 5 Panel B reports that the coefficients of low birth weight, preterm birth, and one-year infant mortality are negatively significant and have similar magnitudes to the findings of our main specification in Table 3. Given that one-year mortality is a more pervasive definition of infant mortality, we conclude that our method is externally valid when we conduct the analyses using a different sample.

6 Robustness Check

6.1 Sensitivity Analysis

We test the sensitivity of our findings using two additional specifications. First, we replace total prenatal care visit numbers with an indicator for at least 10 visits as the main explanatory variable. Second, we adopt only the perspective of patient markets and do not control for delivery hospital fixed effects.

One concern in our estimation is that the number of visits does not impact the maternal and birth outcomes linearly. What matters more might be whether a mother has early and adequate prenatal care. Given that the NIH prenatal care guideline is designed differently from the US system, it would be problematic to apply Kessner Index directly as an indicator of prenatal care adequacy. Since NHI covers ten free prenatal care visits across three trimesters, we thus use whether a mother had at least 10 prenatal visits as a proxy of adequacy. In Table 6, Panel A reports the IV estimates using a dummy variable indicating whether a mother has attended at least 10 visits as an explanatory variable. The findings are similar to our main results: adequate prenatal care significantly reduces the probability of low birth weight, preterm birth, and neonatal and infant mortality.

Another concern is that controlling for hospitals where the birth occurs might not be the most proper. Many mothers do not give birth in hospitals or clinics where they receive prenatal care. From patients' (or mothers') perspectives, the location in which the mothers receive prenatal care might be well more important than where they delivered the babies. In this case, controlling for birth hospital fixed effects does not provide new information that helps explain the outcomes. In Table 6, Panel B reports the IV estimates when we no longer control for birth hospital fixed effects. Consistently, the effect sizes of all the estimates are similar to our findings in the main specification described in Table 3 Panel B. The results support that prenatal care has impacts on infants' birth outcomes but not maternal outcomes.

6.2 Unobserved Stress in the During Sample

Stress and anxiety during pregnancies may lead to adverse birth outcomes, while it can also make mothers engage in more precautionary behaviors. Without data on individual stress levels during the epidemic, we do not know the direction of this omitted variable bias. Using the During sample, we follow to randomly assign 5%, 10%, 20%, 30%, and 40% of the sample with each adverse outcome a new indicator "stress=1," respectively. Table 7 reports the results when we further control for the stress indicator. The patterns for both OLS and IV estimation are similar: the effect becomes sizes get smaller when more and more women are classified as stressed. However, even if 40% of the births are assigned to be born to stressed mothers, prenatal care still significantly reduces the odds of low birth weight, preterm birth, and one-year mortality.[25] Consistently, prenatal care has no impact on maternal complications and catastrophic illness.

6.3 Self Selection in the Post Sample

Highly educated women are more risk averse and therefore more likely to delay their pregnancy to the post period. Following a similar fashion, we examine whether our results are robust to this extent of selection bias. We randomly drop 1%, 5%, and 10% of births to mothers with high school degrees to address the concern that highly educated mothers might self-select into the Post sample. Notice that this selection would lead to overestimating the benefit of prenatal care particularly when mothers with higher education are also healthier. Table 8 reports the results after accounting for selection bias. For both OLS and IV estimation, excluding up to 10% of births to mothers with high school degrees does not change the estimates significantly. If anything, Panel B shows that, in the IV estimation, the effect sizes of low birth weight, preterm birth, and one-year mortality are slightly increasing as we drop more relatively highly educated mothers. However, the differences are modest and insignificant.

7 Conclusion

In April of 2003, the outbreak of SARS caused 483 cases and 60 deaths in Taiwan. Like COVID-19, SARS induced pregnant women avoid seeing the doctors, reducing the average number of prenatal care visits from 9.3 to 7.3 (more than 20%). Bennett et al. (2015) finds that the declined prenatal care visit was largely influenced by reactions of one's peer group. Similarly, we define a woman's peer group as women who visited the same prenatal

[25] Estimates of neonatal mortality are significant at the 10% level when 30% and 40% of the births passed away within one month were born to stressed mothers.

care facility and gave birth at the same age in the same year. To estimate the benefits of prenatal care, we exploit this sharp reduction of prenatal care visits and instrument it with the average visit number in the peer group.

We use the administrative data covering the inpatient and outpatient claims of more than 800,000 women in Taiwan between 2001 and 2006. Our OLS results suggest that the increase in prenatal care decreases the likelihood of low birth weight, preterm birth, as well as neonatal and infant mortality. Our IV estimates yield a smaller but significant and positive impact on these four outcomes, indicating positive bias associated with the prenatal care use. According to our estimates, for instance, SARS outbreak on average decreased prenatal care by two visits, which led the increase of preterm births by 1.2% and 4.5% based on IV and OLS estimates, respectively. Importantly, the results are robust when accounting for the presence of higher stress or anxiety during SARS pandemic that might confound with adverse birth and health outcomes.

Many studies have found the adverse consequences of low birth weight on education and labor market outcomes (Black et al. 2007, Bharadwaj et al. 2013, Chyn et al. 2021). As our data do not allow us to observe children's long-term outcomes, our findings are likely to underestimate the overall benefits of prenatal care. Moreover, our results indicate that IV estimates are much smaller than OLS estimates. While the findings could be driven by the positive bias between unobserved errors and the number of prenatal visits, we caution the readers another possibility, that is, the missing visits are the ones with smaller benefits. As a result, the local treatment effect obtained from IV estimates represent a smaller health benefit than the average treatment effect of prenatal care. In that case, our estimates could be regarded as the lower bound of the benefits of prenatal care.

We now discuss some limitations of this study. First, our sample restricts to women who had prenatal care more than three visits and whose gestational week is more than 29. Our purpose is to ensure a complete history of women's prenatal visits, dropping those who are likely to have partial prenatal care outside of Taiwan. While our sample selection ignores women who had very early preterm births, those observations consist of less than 3 percent of total births. In addition, we believe their birth outcomes are less affected by the level of prenatal care.

Second, the instrumental variable method employed in this study is able to mitigate the endogenous due to the fact that a woman's prenatal care is influenced by her unobserved personal health status However, it does not eliminate the bias if that factor also affects the average number of visits by their peer groups (e.g. maternal stress or self-selection). Nonetheless, our sensitivity analysis has shown that our results are not largely affected by the presence of large maternal stress or self-selection, implying the robustness of our estimates.

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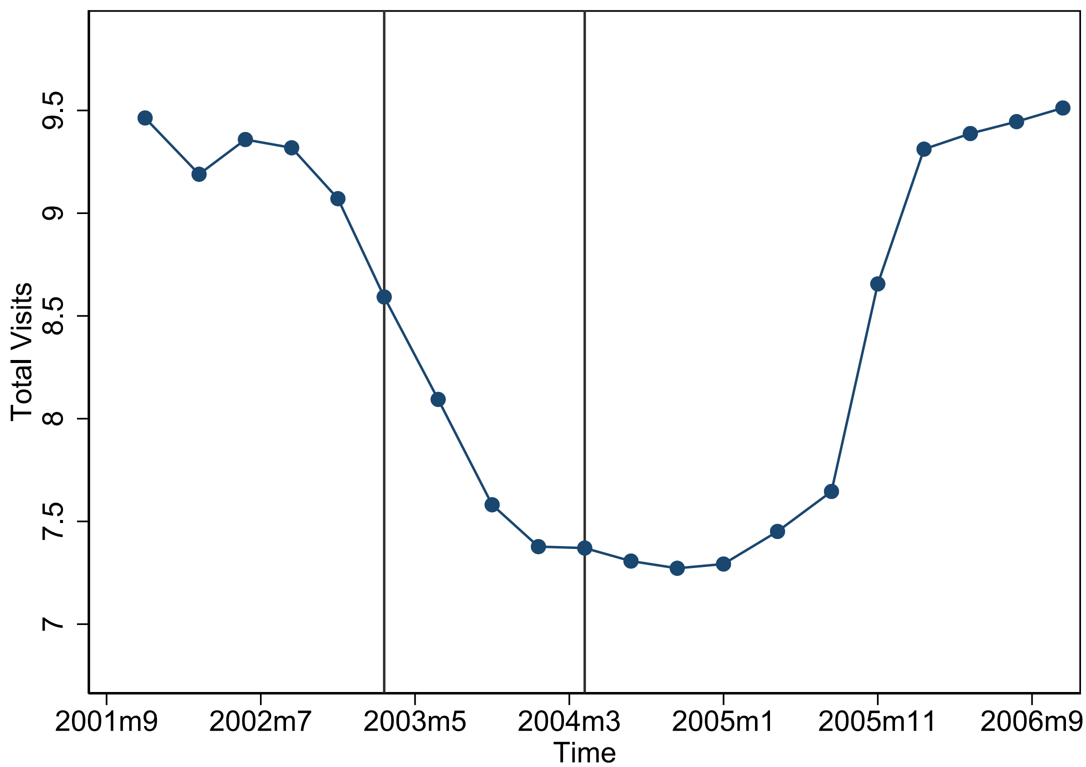

Figure 1: Numbers of Total Visits Over Time

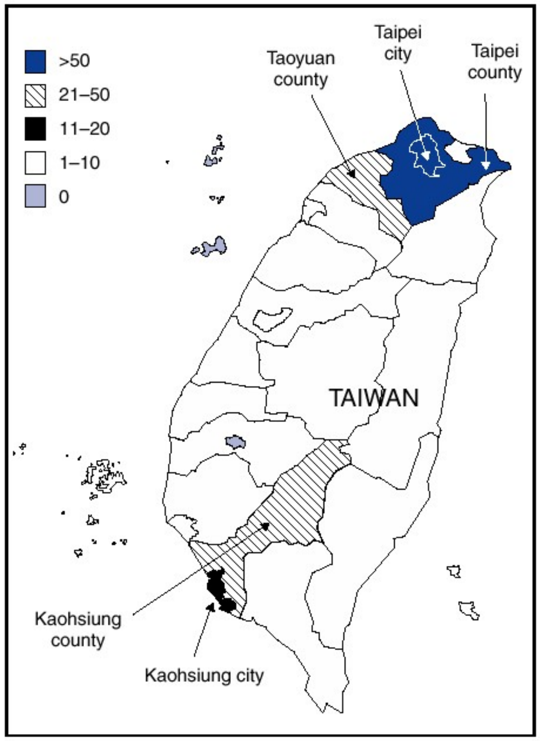

Figure 2: Geographic Distribution of Probable Case of SARS in Taiwan

Notes: N= 483. As of May 22.
Source: Centers for Disease Control and Prevention (CDC) (2003) Accessed from here.

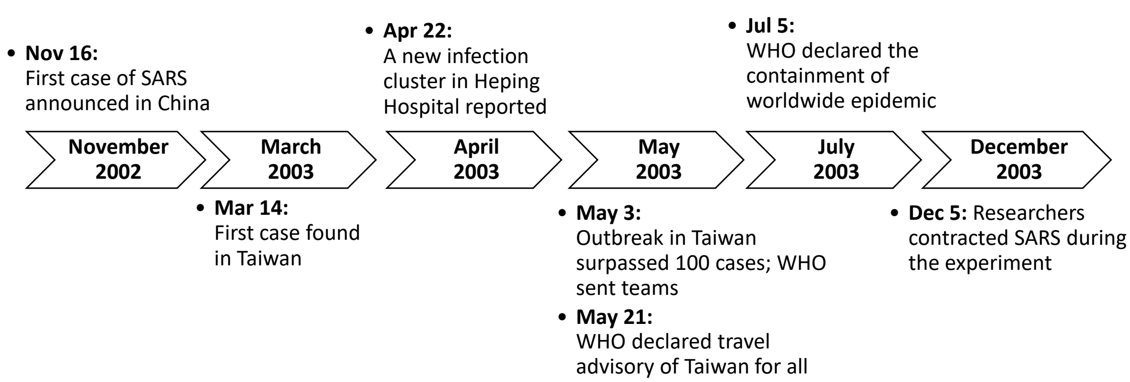

Figure 3: Important SARS Timeline in Taiwan

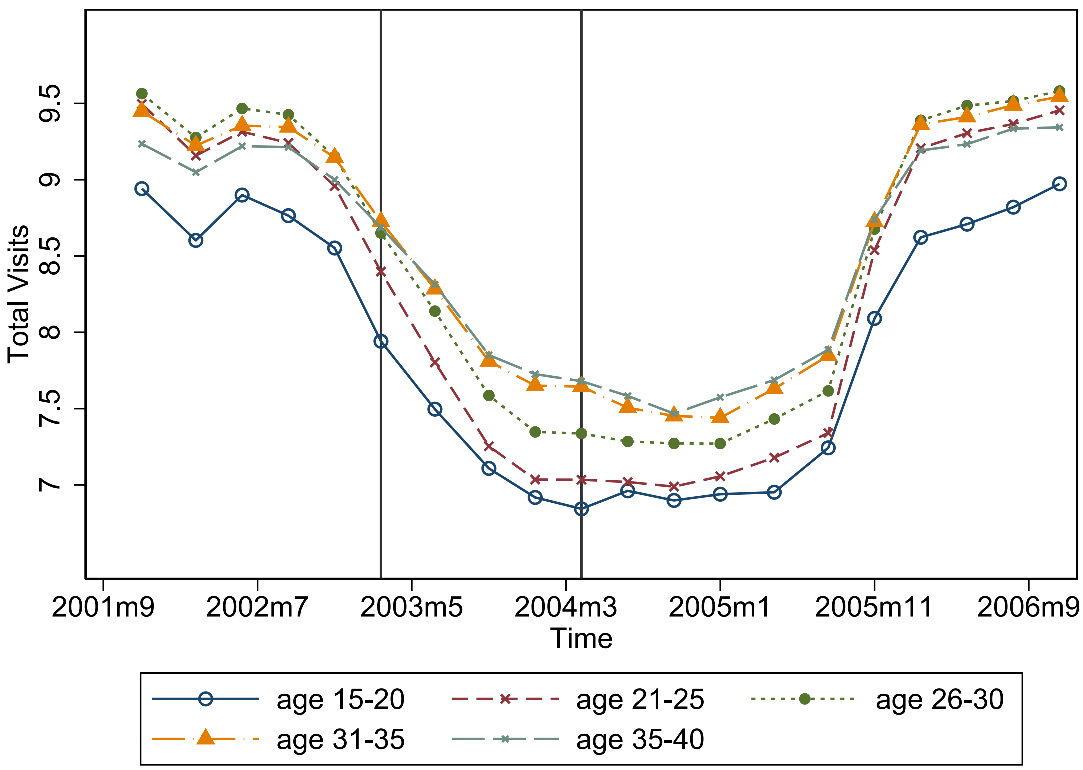

Figure 4: Numbers of Total Visits by Age Groups Over Time

Table 1: Summary Statistics

	During (2001Q4-2004Q1)	Post (2004Q2-2006Q4)
Number of Prenatal Care Visits		
Total Number	8.65	8.20
Total Number>=10 (Binary)	48.78%	38.72%
Outcomes		
Birth Complications	3.37%	3.07%
Low Birth Weight (<2500 Grams)	4.85%	4.89%
Preterm	5.94%	5.97%
Neonatal Mortality (per 1,000)	1.43	1.32
Infant Mortality (per 1,000)	3.11	2.65
Catastrophic Illness (per 10,000)	5.23	5.96
Hospital Characteristics		
Provider Ownership Type		
Not-for-profit	30.10%	31.90%
For-Profit	58.92%	58.21%
Teaching Status		
Major Teaching Hospital	17.05%	17.47%
Minor Teaching Hospital	26.94%	26.49%
Community Hospital	23.87%	24.23%
Clinic	32.14%	31.80%
Maternal and Infant Characteristics		
Maternal Age at Delivery	28.57	29.15
Mothers with High School Degree	40.17%	50.99%
Birth Parity=1	49.42%	51.99%
Infant Gender: Male	52.35%	52.29%
Maternal Hypertension	1.31%	1.54%
Maternal Diabetes	3.38%	3.87%
Sample size	420,377	414,692

Table 2: Balanced Test

	During (2001Q4-2004Q1)	Post (2004Q2-2006Q4)
Years of Schooling (Mother)		
Above 12 Years (high school completion)	0.0017	0.0050***
	(0.001)	(0.001)
Maternal and Infant Characteristics		
Parity=1	0.0052***	0.0090***
	(0.001)	(0.001)
Infant Gender: Male	0.0007	0.0002
	(0.001)	(0.001)
Maternal Hypertension	-0.0000	-0.0003
	(0.000)	(0.000)
Maternal Diabetes	-0.0005	-0.0012*
	(0.001)	(0.001)

Table 3: Impacts of Prenatal Care on Maternal and Birth Outcomes: OLS, First Stage, and IV Estimation

	(1) Complication	(2) LBW	(3) Preterm	(4) Neonatal Mortality	(5) Infant Mortality	(6) Catastrophic Illness	(7) Total Visits
Panel A	OLS Estimation						First Stage
Total Visits	0.0003*	-0.0135***	-0.0226***	-0.3439***	-0.4799***	-0.3392	
	(0.0002)	(0.0004)	(0.0007)	(0.0395)	(0.0535)	(0.2085)	
Total Visits in Social Groups							0.9494***
							(0.0066)
F value							1,052.48
Panel B	IV Estimation						
Total Visits	0.0001	-0.0039***	-0.0060***	-0.1420*	-0.2183*	-0.3907	
	(0.0003)	(0.0004)	(0.0006)	(0.0619)	(0.0912)	(0.3800)	
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	420377	420377	420377	420377	420377	420377	420377

Notes: [a] Clustered Standard errors at the prenatal care hospital area/ maternal age levels in parentheses. [b] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [c] Birth-specific characters are controlled, which includes the birth year, infant gender, parity, maternal age, a mutually exclusive indicator for mother's education attainment by 9 and 12 years, and mother's health conditions (hypertension and diabetes). [d] Hospital teaching status, ownership types, and the number of beds are controlled for taking hospital-specific characteristics into consideration. [e] LBW and preterm are indicators indicating a birth being low birth weight and preterm birth, respectively. Neonatal and infant mortality rates are defined as the number of death every 1,000 birth in a given period. Catastrophic illness rates are defined as the number of births with catastrophic illness every 10,000 birth. [f] The first stage rejects the null hypothesis.

Table 4: Heterogeneous Effects of Prenatal Care on Maternal and Birth Outcomes By Parity

	(1) Complication	(2) LBW	(3) Preterm	(4) Neonatal Mortality	(5) Infant Mortality	(6) Catastrophic Illness
Panel A: Parity = 1						
OLS for Total Visits	0.0007**	-0.0138***	-0.0217***	-0.3141***	-0.3833***	-0.5507
	(0.0003)	(0.0005)	(0.0007)	(0.0518)	(0.0734)	(0.3222)
IV for Total Visits	-0.0004	-0.0038***	-0.0054***	-0.2094*	-0.2908*	-0.9738
	(0.0006)	(0.0006)	(0.0007)	(0.0844)	(0.1304)	(0.6093)
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	207710	207710	207710	207710	207710	207710
Panel B: Parity ≥ 2						
OLS for Total Visits	0.0000	-0.0132***	-0.0234***	-0.3800***	-0.5832***	-0.1355
	(0.0002)	(0.0004)	(0.0007)	(0.0555)	(0.0762)	(0.2635)
IV for Total Visits	0.0005	-0.0040***	-0.0064***	-0.0828	-0.1501	0.2784
	(0.0003)	(0.0005)	(0.0007)	(0.0926)	(0.1426)	(0.4720)
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	212601	212601	212601	212601	212601	212601

Notes: [a] Clustered Standard errors at the prenatal care hospital area/ maternal age levels in parentheses. [b] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [c] Birth-specific characters are controlled, which includes birth year, infant gender, parity, maternal age, a mutually exclusive indicator for mother's education attainment by 9 and 12 years, and mother's health conditions (hypertension and diabetes). [d] Hospital teaching status, ownership types, and number of beds are controlled for taking hospital-specific characteristics into consideration. [e] LBW and preterm are indicators indicating a birth being low birth weight and preterm birth, respectively. Neonatal and infant mortality rates are defined as numbers of death every 1,000 birth in a given period. Catastrophic illness rates are defined as numbers of births with catastrophic illness every 10,000 birth. [f] The first stage rejects the null hypothesis.

Table 5: Additional Analyses Using 2004Q2-2006Q4 Data: OLS, First Stage, and IV Estimation

	(1) Complication	(2) LBW	(3) Preterm	(4) Neonatal Mortality	(5) Infant Mortality	(6) Catastrophic Illness	(7) Total Visits
Panel A	OLS Estimation						First Stage
Total Visits	-0.0000	-0.0121***	-0.0210***	-0.2709***	-0.4145***	-0.3550	
	(0.0002)	(0.0004)	(0.0006)	(0.0356)	(0.0500)	(0.2030)	
Total Visits							0.9358***
in Social Groups							(0.0065)
F value							1,377.55
Panel B	IV Estimation						
Total Visits	-0.0003	-0.0037***	-0.0064***	-0.1097	-0.1855*	-0.1384	
	(0.0004)	(0.0004)	(0.0006)	(0.0677)	(0.0943)	(0.4259)	
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	414692	414692	414692	414692	414692	414692	414692

Notes: [a] Clustered Standard errors at the prenatal care hospital area/ maternal age levels in parentheses. [b] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [c] Birth-specific characters are controlled, which includes birth year, infant gender, parity, maternal age, a mutually exclusive indicator for mother's education attainment by 9 and 12 years, and mother's health conditions (hypertension and diabetes). [d] Hospital teaching status, ownership types, and number of beds are controlled for taking hospital-specific characteristics into consideration. [e] LBW and preterm are indicators indicating a birth being low birth weight and a preterm birth, respectively. Neonatal and infant mortality rates are defined as numbers of death every 1,000 birth in a given period. Catastrophic illness rates are defined as numbers of births with catastrophic illness every 10,000 birth. [f] The first stage rejects the null hypothesis.

Table 6: Robustness Check: IV Estimation

	(1) Complication	(2) LBW	(3) Preterm	(4) Neonatal Mortality	(5) Infant Mortality	(6) Catastrophic Illness
Panel A: At Least 10 Visits						
Visits 10^{+}	0.0028	-0.0263***	-0.0443***	-0.7239*	-1.2261*	-3.1617
	(0.0019)	(0.0022)	(0.0029)	(0.3467)	(0.4916)	(2.0931)
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Not Controlling for Hospital FE						
Total Visits	0.0028	-0.0035***	-0.0055***	-0.1303*	-0.2259**	-0.3364
	(0.0003)	(0.0004)	(0.0006)	(0.0584)	(0.0850)	(0.3564)
Hosp FE	No	No	No	No	No	No
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	420377	420377	420377	420377	420377	420377

Notes: [a] Clustered Standard errors at the prenatal care hospital area/ maternal age levels in parentheses. [b] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [c] Birth-specific characters are controlled, which includes birth year, infant gender, parity, maternal age, a mutually exclusive indicator for mother's education attainment by 9 and 12 years, and mother's health conditions (hypertension and diabetes). [d] Hospital teaching status, ownership types, and number of beds are controlled for taking hospital-specific characteristics into consideration. [e] LBW and preterm are indicators indicating a birth being low birth weight and a preterm birth, respectively. Neonatal and infant mortality rates are defined as numbers of death every 1,000 birth in a given period. Catastrophic illness rates are defined as numbers of births with catastrophic illness every 10,000 birth. [f] The first stage rejects the null hypothesis.

Table 7: Randomly Assignment of Stress among Births with Adverse Outcomes

	(1) Complication	(2) LBW	(3) Preterm	(4) Neonatal Mortality	(5) Infant Mortality	(6) Catastrophic Illness
Panel A: OLS Estimation						
0%	0.0003*	-0.0135***	-0.0226***	-0.3439***	-0.4799***	-0.3392
	(0.0002)	(0.0004)	(0.0395)	(0.0535)	(0.0007)	(0.2085)
5%	0.0003*	-0.0129***	-0.0216***	-0.3223***	-0.4708***	-0.3323
	(0.0002)	(0.0004)	(0.0006)	(0.0369)	(0.0525)	(0.1953)
10%	0.0003*	-0.0123***	-0.0205***	-0.2860***	-0.4223***	-0.2558
	(0.0001)	(0.0004)	(0.0006)	(0.0353)	(0.0495)	(0.1936)
20%	0.0004**	-0.0110***	-0.0184***	-0.2797***	-0.3813***	-0.1072
	(0.0001)	(0.0003)	(0.0005)	(0.0358)	(0.0477)	(0.1882)
30%	0.0002	-0.0096***	-0.0163***	-0.2312***	-0.3364***	-0.2282
	(0.0001)	(0.0003)	(0.0005)	(0.0309)	(0.0460)	(0.1735)
40%	0.0003**	-0.0085***	-0.0144***	-0.2104***	-0.2647***	-0.1635
	(0.0001)	(0.0003)	(0.0004)	(0.0306)	(0.0407)	(0.1614)
Panel B: IV Estimation						
0%	0.0001	-0.0039***	-0.0060***	-0.1420*	-0.2183*	-0.3907
	(0.0003)	(0.0004)	(0.0006)	(0.0619)	(0.0912)	(0.3800)
5%	0.0001	-0.0038***	-0.0055***	-0.1230*	-0.2145*	-0.2397
	(0.0003)	(0.0004)	(0.0006)	(0.0604)	(0.0895)	(0.3698)
10%	0.0001	-0.0036***	-0.0052***	-0.1204*	-0.2116*	-0.4394
	(0.0003)	(0.0004)	(0.0005)	(0.0583)	(0.0877)	(0.3646)
20%	0.0001	-0.0031***	-0.0048***	-0.1124*	-0.1064	-0.4915
	(0.0003)	(0.0004)	(0.0005)	(0.0565)	(0.0795)	(0.3581)
30%	0.0001	-0.0024***	-0.0042***	-0.0757	-0.2030**	-0.4977
	(0.0003)	(0.0003)	(0.0005)	(0.0514)	(0.0782)	(0.2925)
40%	0.0000	-0.0024***	-0.0039***	-0.0958	-0.1781**	-0.1979
	(0.0003)	(0.0003)	(0.0004)	(0.0503)	(0.0686)	(0.3225)
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes
Overall Observations	420377	420377	420377	420377	420377	420377

Notes: [a] Clustered Standard errors at the prenatal care hospital area/ maternal age levels in parentheses. [b] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [c] Birth-specific characters are controlled, which includes birth year, infant gender, parity, maternal age, a mutually exclusive indicator for mother's education attainment by 9 and 12 years, and mother's health conditions (hypertension and diabetes). [d] Hospital teaching status, ownership types, and number of beds are controlled for taking hospital-specific characteristics into consideration. [e] LBW and preterm are indicators for a birth being low birth weight and a preterm birth, respectively. Neonatal and infant mortality rates are defined as numbers of death every 1,000 birth in a given period. Catastrophic illness rates are defined as numbers of births with catastrophic illness every 10,000 birth. [f] The first stage rejects the null hypothesis.

Table 8: Randomly Exclusion of Mother with High School Degree

	(1) Complication	(2) LBW	(3) Preterm	(4) Neonatal Mortality	(5) Infant Mortality	(6) Catastrophic Illness
Panel A: OLS Estimation						
0%	-0.0000	-0.0121***	-0.0210***	-0.2709***	-0.4145***	-0.3550
	(0.0002)	(0.0004)	(0.0006)	(0.0356)	(0.0500)	(0.2030)
1%	-0.0000	-0.0122***	-0.0210***	-0.2725***	-0.4208***	-0.3576
	(0.0002)	(0.0004)	(0.0006)	(0.0357)	(0.0499)	(0.2039)
5%	-0.0000	-0.0122***	-0.0210***	-0.2732***	-0.4131***	-0.3842
	(0.0002)	(0.0004)	(0.0006)	(0.0364)	(0.0508)	(0.2067)
10%	-0.0001	-0.0121***	-0.0209***	-0.2745***	-0.4192***	-0.4278*
	(0.0002)	(0.0004)	(0.0006)	(0.0362)	(0.0509)	(0.2091)
Panel B: IV Estimation						
0%	-0.0003	-0.0037***	-0.0064***	-0.1097	-0.1855*	-0.1384
	(0.0004)	(0.0004)	(0.0006)	(0.0677)	(0.0943)	(0.4259)
1%	-0.0004	-0.0038***	-0.0065***	-0.1180	-0.1994*	-0.1404
	(0.0004)	(0.0004)	(0.0006)	(0.0678)	(0.0950)	(0.4277)
5%	-0.0003	-0.0038***	-0.0065***	-0.1168	-0.1738	-0.1753
	(0.0004)	(0.0004)	(0.0006)	(0.0692)	(0.0951)	(0.4313)
10%	-0.0005	-0.0038***	-0.0066***	-0.1076	-0.2163*	-0.2161
	(0.0004)	(0.0004)	(0.0006)	(0.0692)	(0.0980)	(0.4337)
Hosp FE	Yes	Yes	Yes	Yes	Yes	Yes
PC Town FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	412566	412566	412566	412566	412566	412566

Notes: [a] Clustered Standard errors at the prenatal care hospital area/ maternal age levels in parentheses. [b] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [c] Birth-specific characters are controlled, which includes birth year, infant gender, parity, maternal age, a mutually exclusive indicator for mother's education attainment by 9 and 12 years, and mother's health conditions (hypertension and diabetes). [d] Hospital teaching status, ownership types, and number of beds are controlled for taking hospital-specific characteristics into consideration. [e] LBW and preterm are indicators for a birth being low birth weight and a preterm birth, respectively. Neonatal and infant mortality rates are defined as numbers of death every 1,000 birth in a given period. Catastrophic illness rates are defined as numbers of births with catastrophic illness every 10,000 birth. [f] The first stage rejects the null hypothesis.

Appendix

A Maternal Health Booklet

2

My Pregnancy schedule Week-by-Week for prenatal test and services provided

My Pregnancy schedule Week-by-Week		Recommended weeks	Services provided
1st time	First trimester (Less than 17 weeks)	Prior to week 12	1. After confirming that there is a fetal heartbeat, the following inspections must be included: (1) Questions: Family history, expectant mother's past medical history, pregnancy history and any discomfort with the fetus,addicted habits. (2) Physical: Weight, height, blood pressure, thyroid, breast exam,pelvis exam, chest and abdomen exams. (3) Lab testing: Blood routine (WBC, RBC, Plt, Hct , Hb, MCV),blood type, Rh factor, HBsAg and HBeAg (Thosewho cannot go through these exams this time due tospecial circumstances can do so in the 5th prenataltest instead),VDRL (syphilis test) , RPR(Rapid plasma reagin), Rubella IgG (rubellanti-body), AIDS (EIA or PA) and urine routine. (Note 2) 2. Routine renatal test. (Note 1) Note: Pregnant women who tested negative for the Rubella antibody should be vaccinated after giving birth, this vaccine is government-funded. (Note 4)
2nd time		Week 16	1 . Routine prenatal test. (Note 1) 2 . Premature birth prevention guide.
3rd time	Second trimester (over 17 weeks but less than 29 weeks)	Week 20	1 . Routine prenatal test. (Note 1) 2 . Ultrasound (Those who cannot go through ultrasound at this time due to special circumstances can do so in the third trimester instead). 3 . Premature birth prevention guide.
4th time		Week 28	Routine prenatal test. (Note 1)

Benefit schedule and service items for antenatal checkups for pregnant women 3

My Pregnancy schedule Week-by-Week		Recommended weeks	Services provided
5th time	Third trimester (over 29 weeks)	Week 32	1. Routine prenatal test. (Note 1) 2. The following tests are provided around week 32: VDRL or RPR. 3. For pregnant women who are at risk of HIV infection, it is recommended to have an additional HIV test (EIA or PA).
6th time		Week 34	Routine prenatal test. (Note 1)
7th time		Week 36	1. Routine prenatal test. (Note 1) 2. Subsidy for maternal Group B Streptococcus screening. (Note 3)
8th time		Week 38	Routine prenatal test. (Note 1)
9th time		Week 39	Routine prenatal test. (Note 1)
10th time		Week 40	Routine prenatal test. (Note 1)

Expenses related to test for pregnant women who have conducted more than 10 maternal testsand more than 1 ultrasound should pay for their own expenses or they should be paid by healthcare insurance when their medical needs are diagnosed by doctors.

Note 1 : Routine prenatal test includes

(1) Questions: Prenatal discomfort such as bleeding, abdominal pain, headache and spasm, etc.

(2) Physical: Weight, blood pressure, fetal heartbeat, fetal position and edema.

(3) Lab tests: Protein and glucose in urine.

Note 2 : Regular blood check includes: White blood cells (WBC), Red blood cells (RBC), Blood platelet (Plt), Hematocrit (Hct), Hemoglobin (Hb) and Mean corpuscular volume (MCV).

Note 3 : Maternal Group B Streptococcus (GBS) screening should be provided once between weeks 35 and 37. If there are signs of premature birth, this should be dealt with by a medical doctor and this limit may not apply.

Note 4 : For information related to vaccination sites, please call preventive vaccination hotlines in each city and county to consult.

Figure A1: Prenatal Care Timeline from Maternal Health Booklet

Source: *Centers for Disease Control and Prevention (CDC)* (2003) Accessed from here.