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Abstract

We study the causal effect of hospital births on infant survival in Malawi and Ethiopia. We find that the hospital births has a strong and statistical significant impact on infant survival. In order to overcome the endogeneity of hospital births, we utilize two different instrument variables (IVs). The first IV is the timing of labor contraction. If the pregnant woman feel labor contraction during night time, she is less likely to go to hospital to give a birth due to concern for the safety and transportation. The second iv is the interaction of distance to hospital and rainfall. Rainfall makes more exogenous variation by distance in the traveling cost to the health facility. We find a consistent sign of the causal estimates across two IVs and two different countries. We also provide the suggestive evidence that hospital births is likely to incentivize mothers to utilize hospital or medical care for their children after the births and this may link the relationship between hospital births and infant survival.

JEL Classification Codes:

Keywords: Hospital births, Infant survival, Malawi, Ethiopia

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1 Introduction

Reducing neonatal and infant mortality[1] rate has been an important goal in developing countries. The infant mortality rate has decreased from 63 deaths per 1,000 live births in 1990 to 32 deaths per 1,000 live births in 2015 in the world (World Health Organization). By 2030, the Sustainable Development Goals (SDG) aim to reduce neonatal mortality as low as 12 per 1,000 live births. However, we still observe a lot of neonatal and infant deaths especially in low income countries. According to Global Health Observatory data published by World Health Organization (WHO) in 2015, 4.5 million deaths are occurred within a year of life. This accounts for 75 % of all under-five deaths. Among them, approximately 2.7 million deaths (about 45 % of all under-five deaths) occurred during the first 28 days of life while one million neonatal deaths occurred on the day of birth. Most of these deaths are occurred in sub-Saharan Africa and South Asia. WHO report (2016) says that each year in Africa, approximately one million babies are stillborn and 300,000 die during labor. African countries has been on the top rank as the highest risk of neonatal death, 15 countries in the top 20 countries.

This paper investigates the effect of health facility births on newborn mortality, focusing on the case of Malawi and Ethiopia. Although the health facility in African countries lack quality care/medical resources and qualified medical personnel, our hypothesis is that health facility births are still conducive to increasing child survival. As Adhvaryu and Nyshadham (2015) estimated, return to the formal health care is large especially in low income countries. Thus, the return to formal health care service with regards to newborn births is also expected to be positive. However, empirical studies have shown mixed results of the effect of hospital births on child outcomes. For example, Panis and Lillard (1994), Maitra (2004), Darmstadt et al. (2009), Goudar et al. (2015), and Fink et al. (2015) have found the positive association with child health outcomes, while Chinkhumba et al. (2014) have found the negative association with the outcomes. The goal of this paper is to address three questions: First, is there evidence of casual effect of hospital births on child survival in Malawi and Ethiopia? Second, how does the effect differ across different samples and countries? Third, what would be the suggestive link of the effect if there is any effect?

We estimate the casual effect of hospital births using three different individual-level data

[1] Neonatal mortality defines the death in the first 28 days of life. Infant mortality defines the death in the first year of life.

from Malawi and Ethiopia. According to World Bank, the infant mortality rate as of 2015 is 43 per 1,000 newborn births in Malawi and 41 per 1,000 newborn births in Ethiopia. This number is relatively high compared to other developing countries such as Bangladesh (31), India(38), Kenya(36), Indonesia(23) and North Korea(20).[2] In addition, the facility newborn delivery rate is approximately 70% in Malawi and 14% in Ethiopia (Demographic and Health Survey Malawi and Ethiopia). Based on the fact that Malawi and Ethiopia are suffering from high infant mortality rate, these two countries provide good settings for this micro study. The first data set is the unique survey data that have been conducted since 2012 in Chimutu, Lilongwe in Malawi. This survey collected the potential and actual pregnant women information including basic demographics, health information and child vaccination information. We also used Demographic and Health Survey(DHS) in Malawi (2010) and Ethiopia (2011). DHS is a survey of representative sample containing the various individual level information. We find consistent results over three data set, which lends support to our hypothesis.

Very few papers have studied the causal effect of health facility births on child survival although several studies have studied the association between hospital births and child outcomes. The main challenge in causal estimation of the effect is that individuals select into formal health care use (Grossman (2000); Adhvaryu and Nyshadham (2015)). Recent studies by Daysal et al. (2015) estimated the effect of home births on infant outcomes in Netherlands using distance to hospital from mother's residence area as an instrument variable (IV) to overcome the endogeneity of hospital choice. Pal (2015) also used the similar approaches by using access to local health facilities as an IV in Bangladesh. Okeke and Chari (2015) leveraged the public health policy program, Performance Based Financing (PBF), which was randomly implemented. Using the randomization of the program provision, they have overcome the endogeneity of hospital choice. Our empirical strategy exploits an exogenous variation in distance to health facility by rainfall at the time of birth for the analysis using DHS data. We interact the distance (to the nearest health facility) and rainfall at the time of birth to predict the hospital choice as a birth delivery in the first stage. Our intuition is same as Adhvaryu and Nyshadham (2015) in that rainfall makes exogenous variation in the traveling cost to the health facility. Since the placement of health facility is likely to be endogenous, particularly in developing countries, using as an IV only the distance to the hospital may confound the effect

[2] USA (5.87), South Korea(3.86), Japan(2.08), DR Congo(75)

due to unobservable characteristics that can be correlated with hospital location (or residence area) and newborn outcomes. In addition, we also use a different IV with our unique survey data to consider the different type (compliers) of people to choose hospital as a birth place. In our unique survey data, we asked mothers the beginning timing of labor contraction. We categorize the timing into four different time zones. Those pregnant women who start feeling labor contraction at night are less likely to go to health facility due to high cost (in terms of risk, transportation). Using this IV provides a different local average treatment effect than the estimates from using the distance and rainfall IV. We support our findings by displaying the consistent results across different specifications.

We find that the first IV (distance*rainfall) strongly predicts the health facility births in the first stage in both Malawi and Ethiopia DHS. Health facility births are less frequent when the accessibility decreases due to long distance or heavy rainfall. We also find that second IV (timing of labor contraction) marginally predicts the health facility births. Based on the prediction from the first stage, we estimate the second stage effect on early mortality (7 days after birth), neonatal mortality (28 days after birth) and infant mortality (1-year after birth). We find the significant positive effect on early mortality and neonatal mortality. This IV-2SLS estimates are much larger in magnitude than the ordinary least squares (OLS) estimates and the sign of the effect even flipped.

We provide suggestive mechanism that pregnant women who give births at health facility are more likely to experience the first check-up after the births. Using Ethiopia DHS, we also have found the positive effect on the frequency of vaccination. Taken together, these results are consistent with Adhvaryu and Nyshadham (2015) that those who have an experience in being benefited from hospital are continuously benefited from the health service at hospital. We also conjecture that the positive effect on child survival may be due to medical care in the emergency case of delivery (Daysal et al. (2015)), which is, unfortunately, hard to show in this study because of the dearth of information.

Our contribution is mainly threefold. First, we are estimating the causal effect of institutional deliveries on neonatal/infant mortality by taking into account the selection into hospital choice. Our instrument variables are only picking up the variation in the use of health facility and provide more reliable estimates of the effect compared to previous studies. Since the quality of health centers is difficult to control for due to lack of information, our estimate may be confounded by the supply factors. Even though we have limits in this regard, we contribute to the existing literature by providing the evidence that promoting the health facility deliveries in developing countries can reduce infant/child mortally. Second, we secure the consistency of our contention by examining the effect with different data set and different countries. IV-2SLS estimates only the local average treatment effect but showing consistent effect across different IVs may help us conjecture the average treatment effect. Third, although the rigorous investigation of mechanisms is difficult, the distribution of medical information and treatment (physical wise and information wise) can be the reason for the positive effect of hospital births.

The remainder of the paper is organized as follows. Section 2 introduces the model of conceptual framework. Section 3 and 4 presents the data background and identification strategy. We discuss our results in the discussion section 5 and will conclude in section 6.

2 Literature Review

As Daysal et al. (2015) mentioned in their paper, this paper is in part of a large literature on returns to formal health care. Some of them focus on supply side effect such as hospital quality and medical personnel quality (Buchmueller et al. (2006); Doyle et al. (2010)) while some others focus on demand side effect such as treatment seeking behavior (Almond and Doyle (2011)). However, only a few studies have estimated the returns to hospital births.

Panis and Lillard (1994) is a seminal article that has estimated the relationship between hospital births and infant mortality in Malaysia. They developed a health production function with various input factors such as prenatal care visits and place of births and a demand function of place of births to jointly estimate the effect by using maximum likelihood. They have found the significant beneficial effect on child survival. However, their approach may be confounded due to omitted variable bias and non-excludable exogenous variables. The exogenous covariates in the demand function of place of birth can also affect the outcome through other channels. Very similar to this paper but with more input variables in the production/demand function, Maitra (2004) have examined the case in India. This study has also found the significant beneficial effect on child survival but the similar concern as Panis and Lillard (1994) for the potential bias still exists.

In addition, several correlation studies have presented mixed empirical findings. Goudar et al. (2015) have found the significant positive association between institutional delivery and perinatal and neonatal survival in Southern and Central India. Darmstadt et al. (2009) have also found the positive effect of skilled birth attendants on child health outcomes. On the contrary, Chinkhumba et al. (2014) have found the significant negative association between hospital births and neonatal survival, which is possibly due to selection bias. The most recent correlational study is Fink et al. (2015) where they have found that facility delivery is weakly related with early neonatal mortality in developing countries. They have used the Demographic and Health Survey (DHS) of 67 low and middle income countries and pooled 1.47 million birth records to see the relationship between hospital births and neonatal mortality, which resulted in the positive association between institutional delivery and early neonatal survival. As the figure (1) shows, we observe the existing correlation between them.

As mentioned in the introduction, the main challenge in the empirical strategy is to solve the endogeneity of selection into hospital births. Okeke and Chari (2015) have provided more reliable causal estimation in the effect of hospital births on child survival. In order to overcome the endogenous selection into hospital births, they leveraged the randomized controlled public health program. In Rwanda in 2001, Performance-based financing (PBF) program was introduced to improve pregnant women and children health. The districts were randomly selected the timing of receipt of this program (phase 1 in 2006 and phase 2 in 2008) and pregnant women and children in the selected districts were incentivized to use health facility for several programs such as prenatal care, child immunization and hospital births. The village people were supported $4.59 if they used hospital as a place of birth. Using this randomization, they predict the hospital births in the first stage (9 percentage points increase in hospital births) and estimate the effect on child survival where they have found no significant effect. The empirical strategy using the program rollout as an IV may confound the true effect of hospital births because the program was not designed exclusively to increase hospital births.

Pal (2015) and Daysal et al. (2015) have used distance to the nearest hospital as an IV for hospital births. Pal (2015) has found the significant positive effect on early, neo and infant child survival in Bangladesh. This paper has also identified the heterogeneity effect of hospital births by mother's age at birth that hospital births are more beneficial for older mothers. Daysal et al. (2015) used large data set of pregnant women in Netherlands (Samples are approximately 700,000). They have found the significant positive effect on 7-day and 28-day survival. In addition to distance to health facility, we exploited the interaction of distance and rainfall to make the IV more random at the district level so that we provide more reliable identification. Given the developing countries context, taking the rainfall into account for considering the traveling cost are more convincing than just using the distance an an IV.

3 Data

3.1 Malawi Chimutu survey

In July, 2010, the Ministry of Foreign Affairs and Trade, Republic of Korea has granted the Africa Future Foundation (AFF) USD 2 million from Air-Ticket Solidarity Contribution Korea for health projects (HIV/AIDS prevention and Mother and Child Health project) in Malawi over a period of three years. In addition, the Ministry of Foreign Affairs and Trade granted another USD 0.8 million for the follow up program provision. AFF's implementing body is the Daeyang Luke Hospital, one of the main health care centers in Lilongwe, Malawi. Daeyang Luke Hospital has been assigned two districts by the Malawian government, Chimutu and Chitukula in Lilongwe. Chimutu and Chitukula are rural areas with populations of 90,000 and 30,000 respectively.

The baseline survey was completed in September, 2013. The total number of pregnant women in the main sample is 1,307 (Table 1). This survey contains demographic information of household of each pregnant women, children0s information, birth history, diseases history (depression, HIV/AIDS, malaria, tuberculosis, diarrhea, cough, fever and so on), nutrition information, asset information, household consumption pattern, general health and treatment seeking behavior, savings and entrepreneurship, HIV/AIDS knowledge, sexual behavior and time/risk preference. This survey questions consist of 31 sections with 311 questions. Especially, this survey asked the questions about place of birth and timing of labor contraction. The place of births include home births, government and non-governmental births place. The timing of labor contraction is categorized into four timing zones: 11PM-5AM, 5AM-9AM, 9AM-5PM and 5PM-11PM. For the main analysis, we construct a dummy variable for the timing of labor contraction by assigning 0 for the contraction between 9AM-5PM (day time) and assigning 1 otherwise.

3.2 Demographic and Health Survey

Our another data are the Demographic and Health Survey (DHS) of Malawi, 2010 and Ethiopia, 2011. DHS is a nationally representative household survey conducted every 5 years. The survey includes various topics such as pregnancy, fertility, child care, health information and domestic violence at the individual level. DHS collects the information about the place of births. The place of births include home, government hospital, government health center, government health post, other public health center, mission hospital or health center, private hospital or clinic. We define home births if the respondents answer home births and hospital births if the respondents answer public or private health center. DHS allows respondents to answer for the last three children's place of births. We used mother's residence information to calculate the distance to the nearest health center. Malawi DHS (MDHS) collects the additional information about the location information (latitude and longitude) of health center across the nation. Thus, we could calculate the distance to the nearest health center from the residence area by utilizing the exact GPS information. However, Ethiopia DHS (EDHS) does not provide the GPS information about the health center, we exploit the survey questions asking "how far is the health center" to construct the distance variable. This is probably suffering from the measurement error but no accurate information about the location of the health center is accessible from EDHS.

Table 1 displays the summary statistics of the samples we use in DHS. Our final sample consists of 11,832 observations in MDHS, 11,492 observations in EDHS and 1,307 observations in Chimutu survey data. The samples in Chimutu survey and MDHS are different from several aspects while the hospital births rate is similar around 70%. Mothers are older in Chimutu survey and have higher level of education. Most of women in Chimutu survey are from Chew ethnics (92%). 7-day survival rate is higher in MDHS but 1-year survival rate is higher in Chimutu survey. In MDHS, the survival rate is very similar between facility delivery and home delivery. On the contrary, the survival rate is lower for those who was born in hospital in Chimutu survey. Consistent, those who have higher level of education use hospital births more.

EDHS summary descriptives are also displayed in the bottom panel. Hospital birth rate is remarkably lower in Ethiopia (13.7%). As the figure (1) plots the hospital births rate in the graph, the hospital birth in Ethiopia is the lowest in the world. 7-day and 28-day survival rate is lower for home births and higher educated mother use hospital births more. Compared to MDHS and Chimutu survey, EDHS displays the lower infant and child survival rate with much lower facility delivery rate. The primary school completion rate is also much lower in EDHS sample than MDHS and Chimutu sample.

3.3 Rainfall data

We use University of Delaware Center for Climatic Research's "Terrestrial Precipitation: Gridded Monthly Time Series (1900-2008) (Version 2.01)" rainfall that uses interpolation algorithm based on the spherical version of Shepard's distance-weighting method to combine data from 20 nearby weather stations for every 0.5 latitude by 0.5 longitude grid. We calculate the district-year-specific weighted average of rainfall. Then, we assign this rainfall value to each infant children by matching their year of birth, month of birth and district of birth.

In order to construct the IV as explained in the previous section, we interact rainfall by distance to health. Thus, the IV used in MDHS and EDHS is the interaction variable. Since our hypothesis is higher number of interaction value induces the higher traveling cost, we make a dummy variable by assigning 1 to the interaction value over 75 percentile interaction value. This is intended to capture the extreme effect because the effect of interaction on hospital births may not be linear. Thus, the final IV that are used for the main regression is a dummy variable.

4 Empirical Strategy

In this section, we describe our identification strategy. As explained in the earlier section, ordinary least square estimates will be potentially biased due to selection issue. We suggest instrument variables approach by using two different exogenous variations for the use of health facility deliveries. The basic structure of the regression is same across two different IVs.

Using our unique Chimutu survey data, our estimates is IV-2SLS specified as two stages:

$$\text{1st stage} : Delivery_{ijt} = \alpha_1 Timing_{ijt} + X_{ijt}\alpha_2 + V_t + \mu_j + \epsilon_{ijt} \tag{1}$$

$$\text{2nd stage} : Mortality_{it} = \beta_1 Deli\hat{v}ery_{it} + X_{ijt}\beta_2 + V_t + \mu_j + \nu_{ijt} \tag{2}$$

where we define i as an individual child, j as a group village where the child's mother has lived, and t is the year of child's birth. The instrument variable $Timing_{ijt}$ is a dummy variable which is equal to 1 if the labor contraction starts between 5PM and 9AM. Thus, we compare this group to pregnant women whose labor contraction starts between 9AM and 5PM. For additional checks, we also use three different timing dummies as instrument variables. That is, we compare pregnant women whose labor timing is between 9AM-5PM (daylight time) to pregnant women with timing between 11PM-5AM (timing 1), 5AM-9AM (timing 2), and 5PM-11PM (timing 3) respectively. The instrument variable will not be valid if the beginning time of labor contraction is related to factors that also affect child mortality. Since there is no reason to believe that child care or parent's investment in children to help child survival depends on the beginning time of labor contraction, this IV satisfies the exclusion restriction.

We also use different instrument variables using the interaction of distance to health center and rainfall in MDHS and EDHS sample. The first stage is specified as:

$$\text{1st stage} : Delivery_{ijt} = \alpha_1(d_{ijt} * R_{ijt}) + \alpha_2 d_{ijt} + \alpha_3 R_{ijt} + X_{ijt}\alpha_4 + V_t + \mu_j + \epsilon_{ijt} \quad (3)$$

$$\text{2nd stage} : Mortality_{it} = \beta_1 \hat{Delivery}_{it} + \beta_2 d_{ijt} + \beta_3 R_{ijt} + X_{ijt}\beta_4 + V_t + \mu_j + \nu_{ijt} \quad (4)$$

where d_{ijt} is the distance from the house to health center and R_{ijt} is the monthly average rainfall which is weighted average of all the station rainfall information by using the distance as a reverse weight. Figure 2 shows the correlation between distance*rainfall and hospital births. This is a residual plot after we control for covariates that may affect both hospital births and distance*rainfall. As the figure 2 presents, the relationship between hospital births and distance*rainfall IV is not linear and as the higher the distance*rainfall is, the lower the hospital births is. Both in the first and second specifications, we include several control variables. X_{ijt} includes mother's education level, birth order and family size. V_t controls for child's year of birth fixed effect, mother's year of birth fixed effect and also control for mother's age at birth. The standard errors are clustered at either group village level or mother level. For robustness check, we control for ethnicity and the number of prenatal care (or prenatal care dummy which is equal to 1 if the number of prenatal care is above two[3]).

[3]The recommended number of prenatal care is three according to WHO guideline

5 Results

5.1 First Stage Results

The table 2 reports the first stage results of 2SLS specifications. In the upper panel, we present the results using timing of labor contraction as an IV for Chimutu survey. In all cases, the IV coefficients have the expected sign with significance. Robust F-statistics are presented in the bottom of the table 3. In the first column, we find that if the timing of labor contraction is between 5PM and 11PM, the hospital births rate is decreased by 11 percentage points compared to those who feel labor contraction between 9AM and 5PM. In the second column, the results are presented when the standard errors are clustered at the group village level. We find a significance for the timing of labor contraction between 11PM and 5AM. In the column (3) and (4), we make an IV as a dummy variable by comparing those who feel labor contraction in the daylight (9AM-5PM) and the night/very early in there morning (5PM-9AM). When the pregnant women feel labor contraction between 5PM and 9AM, the probability of hospital births decreased by 8.2 percentage points. As you may notice in the table 3, the robust first stage F statistics is below than 10, 8.08, which may suffer from weak instrument variable problems.

In the bottom panel, we report the results of MDHS and EDHS. IV is a dummy variable when the continuous measure of interaction is above 75 percentile to capture the extreme cases. When the pregnant women live in the high traveling cost area due to either long distance to hospital or high rainfall, we expect the decrease in hospital births by approximately 7 percentage points. The robust first F statistics as presented in the table 3, it is well above 10. Thus, the weak instrument variable problems do not exist in this sample.

5.2 Neonatal and infant mortality

The table 3 presents the main results of 2SLS. We only report the main coefficient of interest. In the upper panel of Chimutu sample, hospital births increase the infant survival: The column (1) is the 7 days survival, the column (2) is the 28 days survival and column (3) is 1 year survival. Hospital births increase 7 days survival rate by 8.1 percentage points, 28 days survival rate by 9.5 percentage points and 1 year survival rate by 35.9 percentage points. In the middle panel and bottom panel, we report the results of 2SLS in MDHS and EDHS. In MDHS sample, hospital births increase the 7 days survival rate by 16.6 percentage points, 28 days survival rate by 13.1 percentage points. However, no significant effect is found for the 1 year survival. In EDHS, hospital births increase the 7 days survival rate by 12.4 percentage points, 28 days survival rate by 14.6 percentage points and 6.2 percentage points for 1 year survival rate but with no significance.

Even though the magnitude of the coefficients vary across different samples, we find the consistent positive effect of hospital births on infant survival after we control for the endogeneity of hospital births. The table 4 shows the OLS results. In Chimutu and MDHS sample, no significant relationship is found and the effect is almost null. The null effect may be due to the endogeneity of hospital births. That is, if less healthier mothers are more likely to go to hospital for births, and less healthier mothers are more likely to have less healthier children, this may offset the positive effect of hospital births on infant survival. In EDHS sample, we find the negative and significant association between hospital births and infant child survival. This can also be explained by selection bias. Compared to the OLS estimates in the table 4, we observe the larger coefficients in the 2SLS specifications in the table 3. We interpret this differences with two possible reasons. First, as already addressed, OLS estimates suffer from the endogeneity of hospital births, especially selection issue. This is why the coefficient in OLS is almost converged to 0 or even the sign of the coefficient is flipped. Second, the OLS coefficient corresponds to the average treatment effect while IV-2SLS coefficient corresponds to the local average treatment effect. While the average treatment effect considers the always takers (who would go to hospital anyway) and the never takers (who would not go to hospital anyway), the effect of hospital births may be muted. This possibly drives the difference between OLS and 2SLS coefficients.

Consistently, we find the significant positive causal effect of hospital births on infant child survival. Our estimates is comparable to the estimates in Pal (2015), where the hospital births increase the 7 days survival by 15.8 percentage points, the 28 days survival by 16.1 percentage points and 1 year survival by 22.9 percentage points. However, our estimates are smaller than the estimates in Daysal et al. (2015), where they have found that the hospital births increase the 7 days survival by 31 percent at the mean. Given that the hospital births are important inputs for good infant health production function, it is needed to understand why the hospital births are conducive to increasing infant survival.

5.3 Mechanisms

The most convincing empirical causal estimation of the effect of hospital births so far is Pal (2015) and Daysal et al. (2015). However, Pal (2015) has not explained the mechanism while Daysal et al. (2015) provided the potential mechanism. Daysal et al. (2015) indicates that the mortality reductions come from medical care provided after the births. In order to check this link, they separately run a regression by the hospital type if the hospital is equipped with a neonatal intensive-care unit (NICU). They have found the larger magnitude of the main coefficient for the hospital with NICU. They argue that this is an evidence for the medical care as a potential mechanism.

Since the rigorous mechanism check requires an additional exogenous shock to mechanism variable to clarify the direction of the effect, our suggestive mechanism needs to be cautiously interpreted. We run several potential mechanism variables on the hospital births predicted by the IV. The table 5 presents the mechanism check for MDHS and EDHS. We utilize the medical treatment usage information for mechanism check. In the column (1), we find the positive and significant effect of hospital births on first medical check-up after the delivery. Those who use hospital for their births experience more first check-up by 51.3 percentage points in EDHS sample. We also checked for vaccination frequency. From the column (2) to (4), we run the same specifications on polio vaccine. In EDHS sample, we find the positive effect on polio vaccine. We also find the positive impact on other vaccines such as DPT and measles. It is very suggestive but we argue that this is an evidence for the more frequent medical treatment seeking if the mothers give births at hospital. Thus, hospital births reduce the infant child mortality by motivating mothers to get proper treatment after the birth for babies. However, one potential concern for this argument is that our IV may pick up not only the variation in hospital births but also the variation in the vaccine usage. Unfortunately, we don't have good quality data to check this link. However, both in Malawi and Ethiopia, Health Extension Worker who is in charge of basic health care in the village level can provide the vaccination or basic medical check up in the health post that is temporary-moving health center. Thus, vaccination requires relatively lower traveling costs and is less affected by distance*rainfall.

6 Robustness and potential threats

In this section we perform some robustness checks. First, we check the heterogeneous effect of the hospital births on infant survival by wealth and education. The table 6 and the table 7 reports the heterogenous effect of hospital births. When we run the specifications separately by wealth and education, the sample size is reduced so that may cause the weaker significance in the results. In the table 6, we find the positive and significant effect of hospital births on 7 days survival for MDHS sample for wealthier mothers. However, we don't find the significance for other specifications. In the table 7, we check the heterogeneous effect by education level. We find the significant effect on 7 days survival and 28 days survival for EDHS sample for the less education group. Especially in Ethiopia, most people do not graduate from primary school, our main coefficient results come from the less educated group.

We also check the results when we only use the sample of the last born birth (table 8) and use the additional control variables such as ethnicity (table 9) and the number of prenatal care (table 10). When we focus on the last born child, we lose a lot of samples leading to possibly large standard error. In the table 9 and the table 10, even though only some of the coefficients show the significance, we consistently find the positive effect of hospital births on infant survival. This lends support to our argument that hospital births in Malawi and Ethiopia are conducive to reducing infant mortality.

There is a potential concern for the main results using Chimutu sample. That is, our IV may affect mother's behavior through the perception that visiting hospital at night is not helpful due to an absence of medical personnel. Although the Ministry of Malawi forces at least one medical personnel to stay at health center at night, it is practically possible that no medical services are available during the night. Unfortunately, we don't have good quality measure of medical absence. However, according to a qualitative study by Kumbani et al. (2013), the biggest reason for not delivering a baby at health center is either due to safety issue when it is night or due to long distance and high rainfall. Although this evidence is only suggestive, we can conjecture that the absence of medical personnel is less likely to confound our main results.

7 Conclusion

In this paper, we have studied the causal effect of hospital births on infant survival in Malawi and Ethiopia. We find that the hospital births has a strong and statistical significant impact on infant survival. The estimated effect is quite comparable to similar study conducted in Bangladesh (Pal (2015)) and much smaller than the study in Netherladns (Daysal et al. (2015)). This finding is consistent with the cross-country evidence (Fink et al. (2015)) that more hospital births are closely related to lower infant mortality rates.

Only a few studies have investigated the causal effect of hospital births on infant health outcomes due to difficulties in controlling for the endogeneity of hospital births. In order to control for the endogeneity, we use as an IV the timing of labor contraction and the interaction of distance to hospital and rainfall. Our results are quite consistent across different IVs and different samples. Two different IVs provide two different local average treatment effects. Having consistent sign of the causal estimates over two IV specifications strongly supports our hypothesis that hospital births causally affects the infant survival. We contribute to the existing literature of the relationship between hospital births and infant outcomes by adding a causal evidence in developing countries. We also provide the suggestive evidence that hospital births is likely to incentivize mothers to utilize hospital or medical care for their children after the births. Conditional on the limited supply of health care, the demand for hospital at child's birth can increase the demand for the hospital service in the future. This effect may be strengthened by additional supply side intervention. Thus, in developing countries, providing the quality health service in the supply side may boost the demand for health service and will maximize the returns to formal health care.

Figure 1: The association between institutional deliveries and neonatal deaths-Cited from Fink et al. (2015)

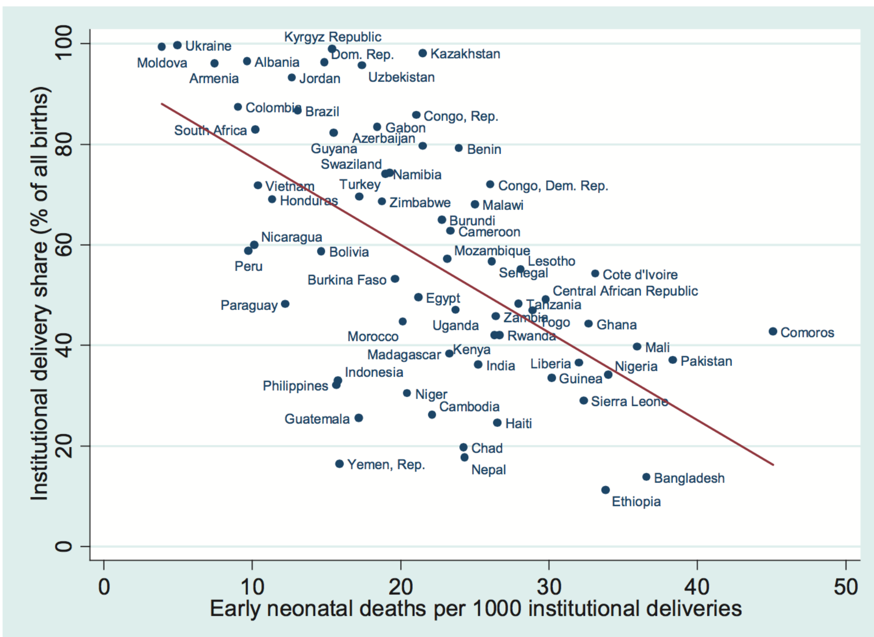

Figure 2: The distance*rainfall and hospital births

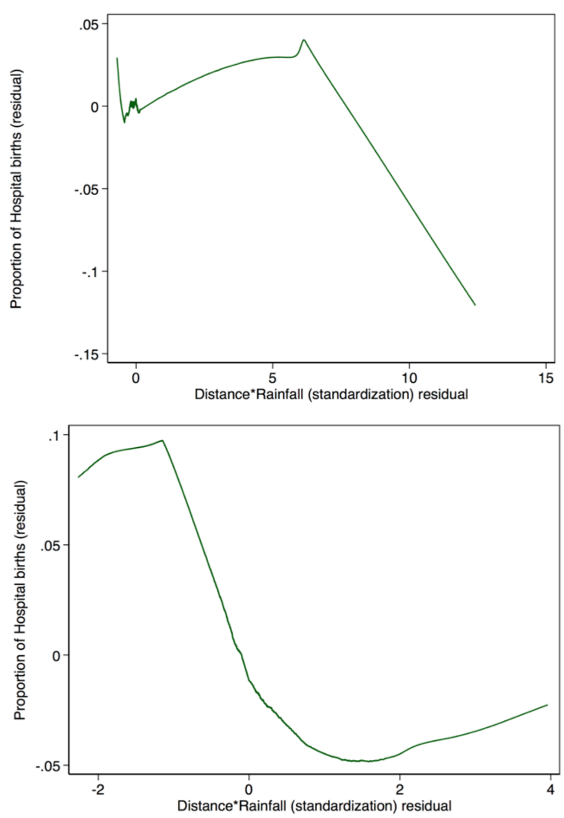

Table 1: Summary Statistics

Pooled	N	mean	sd	Facility N	mean	sd	Home N	mean	sd
Chimutu									
Facility delivery	1,307	0.689	0.463						
7-day survival	1,307	0.991	0.0954	901	0.991	0.0939	406	0.990	0.0989
28-day survival	1,307	0.987	0.113	901	0.986	0.119	406	0.990	0.0989
1-year survival	1,307	0.967	0.178	901	0.964	0.185	406	0.973	0.163
Mother Age	1,307	31.89	3.817	901	31.70	3.852	406	32.32	3.706
Number of birth	1,307	3.275	1.386	901	3.115	1.355	406	3.631	1.390
Education: Primary school	1,307	0.813	0.390	901	0.838	0.369	406	0.759	0.428
Ethnicity: Chewas	1,295	0.919	0.273	896	0.906	0.292	399	0.947	0.224
Child Age	1,307	7.656	4.056	901	7.548	4.087	406	7.894	3.981
Child gender (1= Male)	1,307	0.519	0.500	901	0.511	0.500	406	0.537	0.499
MDHS									
Facility delivery	11,832	0.722	0.448						
7-day survival	11,832	0.979	0.144	8,544	0.979	0.144	3,288	0.979	0.143
28-day survival	11,832	0.973	0.163	8,544	0.973	0.163	3,288	0.973	0.163
1-year survival	11,832	0.943	0.232	8,544	0.943	0.231	3,288	0.942	0.235
Mother Age	11,832	28.86	4.103	8,544	28.79	4.084	3,288	29.02	4.149
Number of birth	11,832	4.047	1.744	8,544	3.945	1.729	3,288	4.314	1.752
Education: Primary school	11,832	0.221	0.415	8,544	0.249	0.432	3,288	0.148	0.355
Ethnicity: Chewas	11,821	0.314	0.464	8,534	0.294	0.456	3,287	0.365	0.482
Child Age	11,832	2.499	1.467	8,544	2.429	1.482	3,288	2.682	1.411
Child gender (1= Male)	11,832	0.499	0.500	8,544	0.502	0.500	3,288	0.493	0.500
Distance*Rainfall									
<10%	1,182	0.788	0.409						
<25%	1,775	0.752	0.432						
<50%	2,956	0.719	0.450						
<75%	2,959	0.723	0.448						
>= 75%	2,958	0.681	0.466						
EDHS									
Facility delivery	11,492	0.137	0.343						
7-day survival	11,492	0.970	0.171	1,569	0.962	0.190	9,923	0.971	0.168
28-day survival	11,492	0.961	0.194	1,569	0.955	0.207	9,923	0.962	0.192
1-year survival	11,492	0.940	0.237	1,569	0.941	0.235	9,923	0.940	0.237
Mother Age	11,492	36.45	6.649	1,569	35.19	5.808	9,923	36.65	6.752
Number of birth	11,492	4.304	2.584	1,569	2.733	2.046	9,923	4.552	2.573
Education: Primary school	11,492	0.0707	0.256	1,569	0.363	0.481	9,923	0.0245	0.155
Ethnicity: Oromo	11,492	0.248	0.432	1,569	0.247	0.432	9,923	0.248	0.432
Child Age	11,492	9.444	1.495	1,569	9.354	1.503	9,923	9.458	1.493
Child gender (1= Male)	11,492	0.513	0.500	1,569	0.520	0.500	9,923	0.512	0.500
Distance*Rainfall									
<50%	5,745	0.197	0.398						
<75%	2,874	0.0828	0.276						
>= 75%	2,874	0.0699	0.255						

Table 2: The first stage result: The effect of IV on hospital births

	(1)	(2)	(3)	(4)
IV				
11PM - 5AM	-0.0624	-0.0624**		
	(0.0388)	(0.0275)		
5AM-9AM	-0.0550	-0.0550		
	(0.0372)	(0.0385)		
5PM-11PM	-0.109***	-0.109***		
	(0.0332)	(0.0351)		
5PM-9AM (Combined)			-0.0818***	-0.0818***
			(0.0290)	(0.0288)
Observations	1,307	1,307	1,307	1,307
Group Village FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes
Clustered	Mother	GVH	Mother	GVH

IV	MDHS	EDHS
Distance*Rainfall dummy	-0.0650***	-0.0754***
	(0.017)	(0.009)
Observations	11832	11,493
R-squared	0.036	0.266
Cohort FE	Yes	Yes
Month of Birth FE	Yes	Yes
Clustered	GVH	GVH

Robust standard errors are in the parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: The second stage result: The effect of hospital births on infant survival

	(1)	(2)	(3)
	7 days	28 days	1 year
Chimutu			
IV: Timing			
Facility delivery	0.0810**	0.0950*	0.359**
	(0.0361)	(0.0546)	(0.161)
Observations	1,307	1,307	1,307
Group Village FE	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes
First stage F	8.077	8.077	8.077
MDHS			
IV: Distance*rainfall			
Facility delivery	0.1655**	0.1314	-0.0000
	(0.0785)	(0.0846)	(0.1052)
Observations	11,832	11,832	11,832
Cohort FE	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes
First stage F	15.46	15.46	15.46
EDHS			
IV: Distance*rainfall			
Facility delivery	0.124*	0.146*	0.0617
	(0.0684)	(0.0769)	(0.0859)
Observations	11,493	11,493	11,493
Cohort FE	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes
First stage F	64.97	64.97	64.97

Standard errors are clustered at the group village level.
*** p<0.01, ** p<0.05, * p<0.1

Table 4: OLS: The effect of hospital births on infant survival

	(1)	(2)	(3)
	7 days	28 days	1 year
Chimutu			
Facility delivery	0.00284	-0.00200	-0.00647
	(0.00758)	(0.00708)	(0.0131)
Observations	1,307	1,307	1,307
Group Village FE	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes
MDHS			
Facility delivery	-0.0004	0.0002	0.0013
	(0.0037)	(0.0043)	(0.0060)
Observations	11,832	11,832	11,832
Cohort FE	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes
EDHS			
Facility delivery	-0.0272***	-0.0293***	-0.0323***
	(0.00913)	(0.0102)	(0.0119)
Observations	11,493	11,493	11,493
Cohort FE	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes

Standard errors are clustered at the group village level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Suggestive mechanism

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	First Checkup	Polio1	Polio2	Polio3	DPT1	DPT2	DPT3	Measles
MDHS								
Facility delivery	0.358*	-0.198	-0.234	-0.203	-0.146	-0.229	-0.123	-0.104
	(0.200)	(0.121)	(0.152)	(0.202)	(0.110)	(0.140)	(0.165)	(0.134)
Observations	11,832	10,963	10,962	10,962	10,954	10,949	10,949	10,938
R-squared	0.241	0.031	0.117	0.126	0.087	0.128	0.250	0.492
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered	GVH	GVH	GVH	GVH	GVH	GVH	GVH	GVH
EDHS								
Facility delivery	0.513***	0.0884	0.366*	0.720***	0.413**	0.818***	1.155***	0.580***
	(0.0802)	(0.173)	(0.192)	(0.203)	(0.207)	(0.226)	(0.211)	(0.198)
Observations	11,493	10,650	10,627	10,627	10,562	10,554	10,554	10,540
R-squared	0.341	0.154	0.175	0.037	0.099	0.010	-0.160	0.142
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at the group village level. *** p<0.01, ** p<0.05, * p<0.1

Table 6: The heterogeneity effect of hospital births by wealth

	(1)	(2)	(3)	(4)	(5)	(6)
	7-days	28-days	1-year	7-days	28-days	1-year
Lower than median wealth						
Facility delivery	0.0741	0.0606	-0.0904	2.182	2.116	1.522
	(0.0717)	(0.0769)	(0.1217)	(2.262)	(2.246)	(1.862)
Observations	5,915	5,915	5,915	5,747	5,747	5,747
First stage F	9.126	9.126	9.126	1.124	1.124	1.124
Higher than median wealth						
Facility delivery	0.3480*	0.2794	0.1672	0.0155	0.0396	-0.0868
	(0.1784)	(0.1821)	(0.2118)	(0.0545)	(0.0640)	(0.0800)
Observations	5,917	5,917	5,917	5,746	5,746	5,746
First stage F	7.873	7.873	7.873	45.72	45.72	45.72
Data	MDHS	MDHS	MDHS	EDHS	EDHS	EDHS
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Ethnicity FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at the group village level. *** p<0.01, ** p<0.05, * p<0.1

Table 7: The heterogeneity effect of hospital births by education

	(1)	(2)	(3)	(4)	(5)	(6)
	7-days	28-days	1-year	7-days	28-days	1-year
Less than Primary						
Facility delivery	0.0949	0.0615	-0.0322	0.172*	0.197*	0.0385
	(0.0623)	(0.0714)	(0.0983)	(0.0951)	(0.105)	(0.114)
Observations	9,219	9,219	9,219	10,680	10,680	10,680
First stage F	14.44	14.44	14.44	39.97	39.97	39.97
Primary and above						
Facility delivery	0.6286	0.5844	0.2906	-0.0557	-0.0932	-0.121
	(0.4449)	(0.4290)	(0.3698)	(0.0797)	(0.0869)	(0.0890)
Observations	2,613	2,613	2,613	813	813	813
First stage F	2.908	2.908	2.908	20.85	20.85	20.85
Data	MDHS	MDHS	MDHS	EDHS	EDHS	EDHS
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Ethnicity FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at the group village level. *** p<0.01, ** p<0.05, * p<0.1

Table 8: The effect on infant survival using only the last born birth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	7-days	28-days	1-year	7-days	28-days	1-year	7-days	28-days	1-year
Facility delivery	0.1578	0.2998	-0.3698	0.0663	0.0254	-0.0615	0.124	-0.00313	0.825
	(0.2574)	(0.3078)	(0.4343)	(0.0913)	(0.0986)	(0.109)	(0.132)	(0.143)	(0.593)
Data	MDHS	MDHS	MDHS	EDHS	EDHS	EDHS	Chimutu	Chimutu	Chimutu
Observations	1,055	1,055	1,055	2,262	2,262	2,262	593	593	593
District FE	No	No	No	No	No	No	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered	GVH	GVH	GVH	GVH	GVH	GVH	GVH	GVH	GVH
First stage F	2.397	2.397	2.397	37.38	37.38	37.38	1.508	1.508	1.508

Standard errors are clustered at the group village level. *** p<0.01, ** p<0.05, * p<0.1

Table 9: The effect of hospital births on infant survival controlling for ethnicity

	(1)	(2)	(3)	(4)	(5)	(6)
	7-days	28-days	1-year	7-days	28-days	1-year
Facility delivery	0.1665**	0.1314	0.0156	0.122	0.138*	0.0113
	(0.0761)	(0.0817)	(0.1031)	(0.0753)	(0.0829)	(0.0923)
Data	MDHS	MDHS	MDHS	EDHS	EDHS	EDHS
Observations	11,832	11,832	11,832	11,493	11,493	11,493
District FE	No	No	No	No	No	No
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Ethnicity FE	Yes	Yes	Yes	Yes	Yes	Yes
Clustered	GVH	GVH	GVH	GVH	GVH	GVH
First stage F	15.79	15.79	15.79	58.64	58.64	58.64

Standard errors are clustered at the group village level.
*** p<0.01, ** p<0.05, * p<0.1

Table 10: The effect of hospital births on infant survival after controlling for ethnicity and prenatal care

	(1)	(2)	(3)	(4)	(5)	(6)
	7-days	28-days	1-year	7-days	28-days	1-year
Facility delivery	0.0935	0.0455	-0.0431	0.0924	0.106	0.0136
	(0.0792)	(0.0822)	(0.1146)	(0.0667)	(0.0768)	(0.0891)
Prenatal care (number)	-0.0041	-0.0024	0.0030	-0.00570*	-0.00685*	-0.00218
	(0.0039)	(0.0041)	(0.0055)	(0.00339)	(0.00394)	(0.00455)
Data	MDHS	MDHS	MDHS	EDHS	EDHS	EDHS
Observations	7,719	7,719	7,719	7,642	7,642	7,642
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Ethnicity FE	Yes	Yes	Yes	Yes	Yes	Yes
First stage F	12.15	12.15	12.15	48.17	48.17	48.17

Standard errors are clustered at the group village level. *** p<0.01, ** p<0.05, * p<0.1

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