Does Facility Based Delivery Reduce Neonatal Mortality? Evidence from Rwanda

Jiwon Park*

August 2018

Abstract

Facility-based childbirth is widely considered to be safer than home birth and to help reduce neonatal mortality rate (NMR). Almost all developing countries have at least one policy to promote safe birth delivery. However, whether the institutional delivery policies reduce neonatal mortality rate is an empirical question that is less addressed in the literature. This paper examines whether facility-based delivery (FBD) reduces NMR, exploiting a policy intervention in Rwanda. To measure the effect of the policy, I use a difference-in-difference strategy exploiting the heterogeneous response to the policy intervention based on the household's SES and birth characteristics. There is a rapid and large increase in facility delivery rate in the high risk population compared to low risk after the policy implementation, however, this is not accompanied by a reduction of NMR. Interestingly, the disparity between high and low risk mothers in cesarean section rate becomes even larger after 2006. To supplement these findings, I also show that other policies, such as expansion of health facilities, universal health insurance scheme, and performance-base financing policies, help maximize the effect on FBD and reduce the disparity in c-section.

Keywords: Facility-based delivery, Neonatal Mortality Rate, Rwanda, Cesarean Section

JEL: I10, I12, J10, J19

*University of Texas at Austin, Email: jiwon.park@utexas.edu

Although the mortality rate for children has declined throughout the last decades in developing countries, it is still high compared to developed counterparts. Reducing the infant and child deaths is one of the most important goals in developing countries, where various policy interventions are designed to curtail such deaths. One of the most prevalent programs is promoting safe births and facility-based delivery (FBD). In fact, the United Nations induce countries to attain universal safe birth—skilled attendant at birth—through setting Millennium Development Goals (MDG) until 2015, followed by Sustainable Development Goals (SDG) until 2030.

Having a skilled attendant during labor undoubtedly reduces the chance of maternal and neonatal deaths if the quantity and quality of the attendants are high enough, proven by sound clinical evidence (De Bernis et al., 2003, De Brouwere, Tonglet and Van Lerberghe, 1998). Most of the developing countries now have some public health programs to increase FBD rate or delivery assisted by formally trained attendants. However, it is not clear whether FBD reduces the mortality in developing countries. There are several reasons FBD could be ineffective. Traveling to facilities could increase the chance of deaths if facilities are too far away or transportation means are not prepared. Also, the quality of health facilities might be poor, or they might lack proficient health assistants equipped with skills to deal with emergencies during labor. Finally, being surrounded by other patients could also cause other infections that lead to death (Graham, Bell and Bullough, 2001). Whether FBD reduces neonatal mortality (NMR) in developing countries is thus an empirical question; however, it is difficult to examine a causal relationship because selection of delivery location is endogenous. On one hand, mothers with higher socioeconomic status (SES) who are healthier in general are more likely to give birth in health facilities in developing countries (Montagu et al., 2011), leading to a negative correlation between FBD and NMR. On the other hand, women who experienced some health problems before or during pregnancy may go to a facility to deliver a child. In this case, the relation between FBD and NMR is biased upward (positive correlation).

This paper examines whether FBD reduces newborn deaths, exploiting a policy intervention in Rwanda. After a series of health-related policies, Rwanda achieved its MDG of safe birth by increasing FBD from 30 percent in 2005 to 96 percent in 2015. The most notable programs relevant to this result are (i) Facility-Based Childbirth Policy, which provides a full package of prenatal care and FBD for all pregnant women free of charge regardless of their insurance status, (ii) Community-Based Health Insurance plan, a universal health insurance in Rwanda that operates in the community level, and (iii) Performance-Based financing, which determines the budget of a facility based on its performance. All policies were implemented or expanded in 2006. A rapid increase of FBD rate follows the policy interventions as panel A of figure 1 shows. Despite the fact that all African countries have at least one policy measure to reduce the number of neonatal and maternal deaths (United Nations, Department of Economics and Social Affairs, 2017), panel B of figure 1 implies that not all countries have experienced such a rapid growth in FBD rate. Rwanda, as well as Burundi (BDI) and Burkina Faso (BFA) is very noticeable.

Despite a large increase in the FBD rate, there is no clear change in the trend of NMR in Rwanda. Figure 2 shows the 3-year moving average of the neonatal mortality rate in Rwanda. A sharp declining trend in NMR is observed after Rwandan genocide in 1994, however, the trend seems to stabilize in the aggregate level after 2006, instead of accelerating. Although there is no noticeable change of the trend in the aggregate data, we cannot conclude that FBD does not affect NMR in the individual level with this figure.

In this paper, I exploit the heterogeneous response to the policy change depending on the baseline characteristics of the household and birth to assess the causal effect of FBD on NMR in Rwanda. Although the policies were implemented or expanded in 2006 nation-wide, figure 4 shows that the magnitude of the effect was not uniform across population: disadvantaged households had a greater potential for change in FBD. I use the Rwandan Demographic and Health Survey (RDHS), which contains rich information of birth history and socioeconomic and demographic information of mothers and households. To identify the heterogeneity of the baseline characteristics, I construct an index encapsulating a variety of SES of the mother and the household and birth characteristics and use it in a difference-in-difference framework. I construct this index by estimating the probability of home delivery using pre-2006 data and calculating the fitted value for the entire data set (from 2000 to 2014). This index proxies the risk of having home delivery assuming no intervention.

As a number of documents show, Rwanda has successfully increased FBD rate since 2006, and the increase is much greater for lower SES mothers. The disadvantaged group almost catches up and closes the gap of the FBD rate across high- and low risk groups. However, there is no evidence that these policy changes have contributed to the reduction of neonatal deaths.

Next, I examine the relation to other public programs like the expansion of health facilities, universal health insurance scheme and performance-based financing. The increase in FBD rate among higher risk mothers is more pronounced in districts where the average travel time to the nearest health center is shorter. Performance-based financing program also plays an important role: high risk mothers in earlier treated districts catch up to low risk mothers in a greater magnitude. This suggests that convergence of FBD rate was possible because of the combination of multiple public programs. Moreover, the effect on NMR was insignificant in all groups of districts except for the earlier PBF treated districts.

The results on cesarean section is very interesting. The disparity in c-section rate across high- and low risk mothers has expanded since 2006 rather than decreased, implying that the quality of the service mothers use is not uniform. The divergence is smaller in the districts where the increase of insurance coverage is greater. The results here imply that high risk mothers, especially with complicated pregnancies, might not have been fully benefiting from the free FBD policy. If lower SES mothers are left behind and still face barriers to care, this could be one of the reasons why there is no reduction in NMR associated with FBD.

Only a few papers have examined the causal relationships between FBD and NMR despite the large literature. Okeke and Chari (2018) use a variation in the delivery time in Nigeria, which is arguably random. They find that a nighttime birth is associated with higher mortality rate and lower incidence of FBD, and this relationship gets weaker if there is a 24-hour facility in the neighborhood. Daysal, Trandafir and Van Ewijk (2015) exploits the exogenous variation of the distance from a mother's residence to the closest hospital and finds that birth in hospital is associated to lower mortality even in Netherlands, which is the only developed country that home birth is widespread.

My contributions to this literature and the advantages of studying Rwanda as follows. First, this paper is one of the few papers studying whether institutional delivery reduces neonatal deaths in Rwanda. Okeke and Chari (2018) suggests a causal effect of FBD on NMR in Nigeria; however, different countries can have different effects because the institutional settings are all different in each country. In fact, increase in FBD might not lead to a reduction in NMR if the quality of facilities is low in Rwanda. Thus, it is important to confirm whether the seemingly successful program has achieved its ultimate goals of reducing mortality since the relationship between two is not easily generalizable. To my knowledge, there is only one other paper studying Rwanda. Chari and Okeke (2014) use the staggered roll-out scheme of performance-based financing program in Rwanda, where the budget of each facility is determined by its performance, and also find no effect of FBD on NMR. My paper uses a different identification strategy, exploiting the convergence of FBD across low and high risk mothers. My paper also attempts to measure the importance of other policies that happened simultaneously. I show that PBF as well as the universal insurance and the expansion of health facilities play an important role unlike Chari and Okeke (2014). This suggests that policy design should be manifold—a single intervention might not be successful.

Second, this paper finds that the SES disparity in c-section use has increased since 2006 in Rwanda. C-section is associated with lower maternal and neonatal mortality up to 10 percent level (Ye et al., 2014). C-section rate in Rwanda is about 10 percent after 2006; however, there is a substantial heterogeneity by SES. This might have prevented following reduction of the neonatal mortality among high risk households. To my knowledge, this paper is the first to show the diverging inequality in c-section use since 2006 in Rwanda.

Third, this paper finds no significant effect of the programs of FBD on NMR, like many other papers assessing policy intervention on FBD in different countries. A notable example is the Janani Suraksha Yojana (JSY) program in India, a conditional cash transfer program that rewards mothers and health providers for institutional delivery. This program has successfully increased access to FBD especially among poor and rural households; however, there is a scarce evidence that it helped reduce NMR (Powell-Jackson, Mazumdar and Mills, 2015, Randive et al., 2014). Studies in other countries tell a similar story, financial incentive program in Nepal (Powell-Jackson et al., 2009) and the ban on the traditional birth attendant in Malawi (Godlonton and Okeke, 2016). Results of my paper supports the previous literature.

This paper is structured as follows. Section 1 summarizes institutional background relevant to this paper. Section 2 describes the data and descriptive statistics. Section 3 presents the empirical strategy. Section 4 explains the empirical results. I discuss the implications and limitations of this paper in Section 5 and conclude in Section 6.

1 Institutional Background

The Rwandan genocide in 1994 destroyed most of the health facilities and workforce, leading to a surge in all mortality and morbidity rates. Life expectancy at birth dropped to 28 years, and most of the health providers died or escaped during the massacre. At the end of the civil war, the Rwandan government had implemented a variety of policies and public programs, with help from foreign countries and organizations, to improve the health status of people and health facility utilization. Not only the low utilization rate but also discrepancy across population was a big problem. Wealthier, urban and more educated households had much greater propensity to consume healthcare and use FBD. A number of studies have documented that this inequality comes from both financial and physical barriers faced by the disadvantaged population (Comfort, Peterson and Hatt, 2013).

A variety of health policies have been implemented in Rwanda since 1999. There are three notable policies: (1) Community based health insurance scheme which is a universal health insurance plan eligible to the entire population, (2) facility-based child birth policy which provides a full package of maternity care and delivery service free of charge to pregnant women regardless of their insurance possession, and (3) performance-based financing which determines the budget of each facility based on its performance(Bucagu et al., 2012). Note that (1) and (2) are intended to improve access to health service while (3) is intended to improve the quality of care. Table 1 shows the timeline of these events. It is noteworthy that most of the changes occurred together in 2006. Although I am not able to differentiate the effect of each policy, I can assess the combined effect of the various health policies by taking 2006 as the year of starting of the treatment.

As mentioned above, one of the problems with health facility usage was the disproportionate utilization across population: people in the upper quartile of the SES distribution tend to visit health facilities more frequently even though their overall health status is better. To mitigate this inequality, the Ministry of Health made three key changes to the healthcare system. First, the copayment and premium for the health insurance is set to be proportional to the household income. The poorest households are exempt from any copayment and pay a very low premium (Nyandekwe, Nzayirambaho and Kakoma, 2014). Second, maternity care became free regardless of health insurance possession. Third, community health workers were sent to each household to educate people on when and why to use health facilities. They even provide some basic care while present. Importantly, they emphasized the benefits of FBD and suggested pregnant women go to facilities for prenatal checks and delivery. This is considered one of the crucial reasons why Rwanda has shown greater increase in FBD than any other sub-Saharan African countries (Rwanda Ministry of Health, 2017).

The healthcare system in Rwanda reaches from community-level care to the national hospitals. In the most basic level, community workers visit homes and check the health status of each household member and identify healthcare needs. They often give very basic and preventive care. Health posts and centers are the primary care unit. Health posts are smaller than centers, reaching out to the most remote portions of the country. More complicated illnesses that cannot be treated in primary care units are referred to higher level facilities, such as district hospitals (secondary) and provincial and national referral hospitals (tertiary). Child delivery service is provided from the health center level, and complicated pregnancies are referred to the higher levels (Rwanda Ministry of Health, 2017).

2 Data

2.1 Data Sources

The main data I use are the birth history data of Rwandan Demographic and Health Survey (RDHS). I use the 2005, 2010 and 2014 waves of RDHS and stack them according to birth year to create a continuous set of births from 2000 to 2014. Although RDHS asks the entire birth history of each respondent's (woman) life retrospectively, I only include births in the recent 5 years. This is because (1) more specific information such as place of delivery (FBD or HD) is available up to recent five years, (2) I assume that previous births happened in the same location where the respondent currently lives, (3) characteristics of the mother and household are likely to change over time, and (4) to minimize inaccuracies (e.g., recall problems).

I define neonatal death by the standard definition: the neonatal mortality rate is the number of deaths within a month, conditional on being born alive, per 1,000 live births. To match to this definition, I assign 1000 if a baby was born alive but died before reaching her first month, and 0 if she passed the one-month threshold. I exclude the births happening within a month of the interview time, regardless of their status of survival.

Rwanda reformed its administrative areas in 2006 from 12 provinces and 106 districts to 5 provinces and 30 districts. Thus, in the data, I have information about 12 provinces for 2005 data set and 5 provinces and 30 districts for the later surveys. Fortunately, since RDHS includes GPS coordinates of the primary sampling units (PSU, or clusters) from 2005 wave, I can match 2005 clusters to 30 new districts and have a continuous regional code. However, since the DHS displaces the GPS coordinates due to privacy issue, [1] some measurement error still exists.

For additional information on district characteristics, I use the Integrated Household Living Conditions Survey (EICV) of Rwanda, waves 2005 and 2014. This survey provides information on changes in the well-being of the population such as economic conditions, education, health and housing conditions, household consumption, etc. I use it as a supplementary data set to calculate the mean of insurance rate and distance to nearest health facilities (health center and district hospitals) by district and survey year, which are not provided by the RDHS. When calculating the means by district, I restrict the EICV sample to women who are 15-45 years old as the RDHS sample consists of the reproductive-aged women.

2.2 Descriptive Statistics

Table 2 presents the summary statistics of the resulting data. I separate pre- and post-period for comparison. Panel A shows the birth characteristics and B shows the mother's and household's characteristics. For both panels, the unit of observation is a birth, which means some mothers and households are duplicated when the mother had multiple births. The table indicates that there is a large overall decline in neonatal mortality, from 34 per 1,000 live births in the pre-periods to 24 in post-periods. Most of the neonatal deaths are concentrated in the first-week after birth. FBD has increased about 50 percent points between the two periods. Note that the mean of the indicator for prenatal care has not increased much, and the proportion who ever got prenatal care was already very high in the pre-period. This suggests that any change between two periods cannot be attributable to the incidence of prenatal care.

[1] The coordinates are displaced with some error; 0 to 2 kilometers for urban clusters and 0 to 5 kilometers for rural clusters.

The distribution of the wealth quintile is not balanced because poorer households tend to have more children. Mothers' education levels are better in the post-period since younger cohorts are more educated on average. Mothers' partners mostly have agricultural occupations; however, this proportion decreases over time. The proportion of households with a car or truck doesn't change much over time whereas residential electricity coverage has almost tripled. Mothers visit to the health facilities for general purpose is much more frequent after the policy changes, likely because of the health insurance.

3 Empirical Strategy

Figure 4 implies that there is heterogeneity in the magnitude of the response to the policy changes in 2006 depending on mothers' SES. Mothers with lower SES—poorer, rural household and less educated—have experienced a larger increase of FBD rate since 2006. My identification strategy utilizes this heterogeneity. The assumption here is that the series of policies would have been more effective to a certain group of people based on their observable characteristics. To summarize the heterogeneity, I construct an index which is explained in detail below. I implement a difference-in-difference estimation strategy that uses variation across time and observable characteristics.

3.1 Constructing Indexes to Measure the Heterogeneity of the Response to the Policies

In addition to the SES of the household, studies have found that some specific birth characteristics are associated with higher probability of FBD: the sex of the child (male), multiple gestation, maternal age, and birth order (Celik and Hotchkiss, 2000, Tarekegn, Lieberman and Giedraitis, 2014). Exploiting the discrepancy across SES and known factors of birth characteristics, I construct an index that encapsulates observable characteristics. First, I estimate the probability of having a home delivery (HD) with the pre-period sample (2000 to 2005 births) with a Probit model. Next, I estimate the fitted value using the coefficients of this regression with the entire sample. The fitted value represents the magnitude of risk to have a home delivery assuming no policy intervention. Specifically, I estimate:

$$P(HD_{irt} = 1) = 1 - P(FBD_{irt} = 1) = \alpha + X_{irt}\Lambda + B_{irt}\Pi + \tau_r + \tau_t + \eta_{irt} \quad (1)$$

with the pre-2006 sample. HD_{irt} indicates delivery at home for a baby i in district r born in year t. X_{irt} and B_{irt} are a vector of characteristics of the mother and household and birth, respectively. The variables I include are: dummies for household wealth quintile, place of residence (urban or rural), mother's educational level (no education, primary or less, and more), occupation and education level of mother's partner, indicator for possession of automobile, water source, quadratic form of mother's age at birth and the full set of dummies of birth order. Next, I take the coefficient vectors Λ, Π, and τ_r from equation (1) and use them to predict the probability—estimating the fitted value—of HD for the entire data set. This fitted probability proxies the risk of HD for each baby assuming no policy intervention. For interpretation, I separately normalize the fitted value by birth year to have mean of zero and standard deviation of one to know the relative risk in each birth year. For example, the distribution of education year has shifted to the right during the period of interest, making the relative position of a certain level of education different over time. Normalizing separately by birth year mitigates this problem. Since it is a predicted probability of having home delivery, I call it an HD index. Panel (d) of figure 4 plots the FBD rate of higher HD Index mothers (2nd-4th quartile)–high risk– and lower HD Index mothers (1st quartile)—low risk. The index effectively summarizes the SES variables depicted in the three panels of figure 4.

Since constructing an index like above is not found in the literature, I create another supplementary index that is more generally used. This index includes only SES characteristics of the mother and household. I use the principle component analysis (PCA), which reduces the number of variables in a data set into a smaller number of dimensions. The components are ordered so that the first component explains the largest possible variation of the original data (Vyas and Kumaranayake, 2006). Following the literature, I keep the first component. I also separately normalize it by year to have mean zero and standard deviation one. For comparison with the HD Index, I construct it to have greater value for lower SES mothers and indicate the riskiness. I call it the SES Index. Lastly, I use the regional variation of FBD utilization rate in the pre-period. The intensity of the effect would have been different across regions because there was large regional variation in

FBD utilization rate in the pre-period: regions with higher HD rate would have been more affected. Using the baseline regional variation for a treatment-control strategy is widely accepted in the literature (Bleakley, 2007, Godlonton and Okeke, 2016). Thus I use it to add more credibility to my main analysis which uses variation across the characteristics of mothers and births. Using GPS coordinates of RDHS, I match clusters (primary sampling units) in the later waves to the closest cluster in 2005. Note that this match is not accurate because the DHS has displaced GPS coordinates with error. Next, I calculate the mean of HD by each cluster in 2005 and standardize the number to make an index with mean zero and standard deviation one. I use variation across clusters instead of 30 districts for more variation; however, the standard error is large because the sample size in each cluster is small. I call this index the Regional Index.

3.2 Effect on FBD and NMR

In the main analysis, I estimate the effect of the programs on FBD and NMR. The estimation equation is:

$$Y_{irt} = \beta_0 + \beta_1 HDIndex_{irt} + \beta_2 HDIndex_{irt} \times Post_t + \theta_r + \theta_t + \varepsilon_{irt}, \tag{2}$$

Y_{irt} is either (1) an indicator whether a baby was born in a health facility or (2) an indicator for neonatal death, born alive but died within a month. Again, I assign 1,000 when the baby died within a month to make the unit of dependent variable per thousand live births. To assess whether the rapid increase in FBD also expand the access to more complicated procedures, I estimate the effect on (3) incidence of cesarean section. No other controls are added because the HD Index summarizes both SES and birth characteristics. When using the SES and Regional Index for the robustness check, however, I add birth characteristics controls and birth and SES controls, respectively. The coefficient of interest is β_2, the difference-in-difference estimate with a continuous treatment variable. I cluster the standard errors at the PSU level.

For some specifications, I include group specific time trends to allow different time trends in different groups. The groups are defined by the index quartiles. The equation is:

$$Y_{irt} = \beta_0 + \beta_1 HDIndex_{irt} + \beta_2 HDIndex_{irt} \times Post_t + \sum_{q=2}^{q=4} \eta_q \times t + \theta_r + \theta_t + \varepsilon_{irt}, \tag{3}$$

where η_q is an indicator for each quartile. Since I define the HD Index to have a greater value when the observation is higher risk, I expect to have positive β_2 when the dependent variable is FBD and negative when NMR, if the policies were effective. The sign when the dependent variable is c-section is ambiguous. If disadvantaged mothers start to have greater access to more complicated procedures as well, the sign of β_2 for c-section should also be positive.

3.3 Validity of the Identification Strategy

The identifying assumption for equation (2) is that the low risk mothers are a good control group in FBD and NMR. Births with higher value of HD Indexes are more disadvantageous by construction. However, this is not a problem as long as the trends are similar for high risk mothers and low risk mothers. The key assumption for the difference-in-difference strategy is a parallel trend of the dependent variable, which implies nothing else has changed differently over time across the groups that would have affected FBD and NMR. Although this exact assumption is untestable, I test whether the pre-trends are parallel to one another across the quartile groups of the HD Index. I regress the variables of interest on an interaction term of the HD Index (as a continuous variable or the full set of indicators for each quartile groups) and time trend using the pre-2006 samples. Not included in the text, the coefficients on the interaction term are never statistically different from zero when the dependent variable is FBD or NMR, which gives more credibility to the parallel pre-trends. However, the group specific time trend matters when the dependent variable is an indicator for c-section, which means that the rate of increase in c-section was different across quartile groups even before the policy interventions.

As a falsification check, I compare some birth and household characteristics across low and high risk mothers. Figure 4 depicts the coefficient of Post $\times$ HD Index with different dependent variables using equation (2). The dependent variable is stated in the vertical axis of the figure. The coefficients of the interaction terms are mostly not statistically different from zero. Three of the exceptions are parental educational attainment and electricity connection. In fact, average schooling level of Rwanda has increased over time, and the result suggests that the average educational attainment increased even for the relatively high risk households. Since the ratio of never educated was higher for higher risk households, the coefficient is negatively significant. Electricity became more common during the period of study; however, the rate of increase was higher for lower risk households, which makes the coefficient negative. Birth characteristics that are considered random, like the sex of the baby and indicator for twins, are not statistically different from zero. The falsification tests imply that birth characteristics cannot be attributed to the changes over time between lower and higher risk households; however, the increase of overall SES among relatively high risk households could drive the main results explained below.

4 Results

4.1 Main Results of FBD and NMR

I begin by presenting the descriptive evidence of the main results. Figure 5 displays trends of three variables of interest, FBD, NMR, and c-section, of low risk (1st quartile of the HD Index, the most advantaged group) and high risk (2nd to 4th quartile) births. I divide the index in this way because figure 4 implies the inequality is notable between the top quartile and others rather than the upper half and the lower half of the SES distribution. The figure shows the mean of each variable by the group with 95-percent confidence intervals. Panel A clearly shows that, although high risk households are still less likely to give birth in health facilities, the gap between high and low risk shrinks after 2006. Interestingly, panel C shows that the rate of babies born by cesarean section does not reflect the increase in FBD in panel A. C-section utilization is increasing in high risk mothers after 2006, however, the rate is slower than low risk mothers and the gap is rather diverging. Panel B shows that there is seemingly no effect on NMR. High risk babies have higher NMR overall; however, the pattern doesn't seem to be different before and after. In fact, the standard errors are large such that NMR is not different between two groups in any year.

To control for birth year fixed effects, trends, and regional differences, I estimate the differential effect of the treatment using equation 2. Table 4 shows the main result of this paper. The coefficient 0.116 of the interaction term means that after 2006, the increase of probability of a mother having FBD is 11.6 percentage points higher than the increase of a mother with one standard deviation lower HD Index (lower risk). As the sum of the interaction term of post indicator and HD Index and HD Index is still negative, the high risk mothers are still less likely to give birth in facilities; however, the gap across high and low risk mothers is reduced. This is precisely what panel A of figure 5 depicts. Column 2 of table 4 uses the binary version of the index; it takes 1 if the HD Index is larger the first quartile, and zero if smaller, as in figure 5. Because the major difference is happening around the bottom of HD index, the sizes of the coefficients are bigger in absolute terms in column 2. When quartile group specific time trends are included, the coefficient gets smaller. This is likely because higher risk mothers experience a steeper increase in FBD overall, and the time trend accounts for this.

Panel B of Table 4 shows the result when the dependent variable is the indicator of neonatal death. As panel (b) of figure 5 depicts, NMR is larger for higher risk mothers overall. The coefficient of the HD Index is positive and statistically significant in column 1. When using binary indicator, this relation is no longer statistically significant, reflecting the noisy confidence intervals in figure 5. Whether the gap in neonatal mortality has reduced is not clear. The coefficient on the interaction term of post and HD Index is negative, which means newborns of high risk households catch up to lower risk households; however, the standard errors are large. This result is not surprising considering the noise in figure 5. The sign of the coefficient even turns positive when the quartile group specific time trend is included.

In table 5, I use two supplementary indexes to check whether the constructed HD Index reflects the differential change across mothers with different SES. The stable coefficients in columns 1 and 2 gives more credibility to the HD Index. Mothers experience a 10 to 11 percentage point bigger increase in FBD relative to the mothers with a one standard deviation lower SES Index. The Regional Index which is more widely used in the literature also supports that there is an overall increase in FBD and that the regions with lower FBD prevalence are more affected by the policy intervention. Both indexes are stable to the inclusion of controls and quartile group specific time trends. Not surprisingly, the effect on NMR is not significant, although the signs of the interaction terms are all negative.

4.2 Relation of Free FBD and Other Policies

As described in table 1, several policy changes take place at the same time. Even though the series of policies have not effectively reduced NMR, it is important to know how Rwanda achieved its MDG of universal FBD. To examine this, I divide the sample into two groups of districts and run separate regressions according to (1) distance to the nearest health center and district hospital in 2014, (2) insurance coverage, and (3) performance-based financing policy.

4.2.1 Travel time to the closest health center and district hospital

Because I do not have information on the facility locations, I cannot estimate the accurate distance to the nearest health facility in the village level. Fortunately, the nearest health facility is available in the EICV. The EICV asks each household the distance and travel time to the nearest health center and district hospital. [2] Using the 2014 round, I estimate the average distance to the closest health center and district hospital by district. I use the distance instead of the travel time because travel time varies by the transportation means, although most of the household reported travel time on foot.

In table 6, I estimate equation 3 for each group defined in the title of the column. In columns 1 and 2, I divide the sample by whether the distance to the closest health center is smaller or greater than 4 km (the median distance is 4.02 km). The interaction term of post indicator and HD Index is positive in both columns, and the size is larger in column 2. The convergence of FBD rate in districts where the average distance to the nearest health facility is greater than 4km is 9.4 percent points while 12.6 percent points in districts where the health centers are closer. The difference is statistically significant. Columns 3 and 4 divides the sample by the distance to the closest district hospital, where more complicated procedures are done. The results are similar to columns 1 and 2, mostly because the two classifications largely overlap. The coefficients are statistically different from each other at the 10 percent level.

I argue that districts with smaller average distance have better access to health facilities. Since the number of health facilities has increased substantially after 2006, the distance in 2014 might not fully capture the accessibility of health facilities. However, the increase in health facilities is driven mainly by health posts, where child delivery service is not provided, and private facilities (Rwanda Ministry of Health, n.d.). Although some mothers give birth in private facilities, the fraction is very small (less than 2 percent). The largest increase in the number of health centers from 2008, when the data is first available, to 2014 is 5 in Rusizi and Musanze district. Since this number is non-negligible (as the median number of health centers in each district in 2014 is 16), I estimate the same regression for

[2] In fact, EICV asks distance only in 2014

two groups according to average travel time in 2005 where the results are not included in the text. The result of the regression is very similar: districts with average travel time greater than 68 minutes (the median in 2005) have smaller coefficient on the interaction term (0.1159 (0.014) vs 0.134 (0.01)), although they are not significantly different from each other. The results change little when I use travel time from 2014.

None of the coefficients when the dependent variable is NMR are statistically significant. In fact, the sizes of the absolute value in columns 1-4 are even counter-intuitive: smaller in the even columns, even though it should be larger if there is a correspondence to FBD in the upper row. However, the main results and figures render this result unsurprising.

4.2.2 Community-based Health Insurance

Ministry of Health of Rwanda expanded a universal health insurance scheme between 2006 and 2007. Although the basic delivery care is free without insurance, having health insurance plays an important role in increasing FBD. For instance, it increases hospital visits for general purposes. Visiting facilities more often, women of reproductive age get healthier and learn about the importance of FBD. Health insurance coverage was 30-60 percent in 2005 and reached 60-80 percent in 2014. The RDHS has information on insurance; however, it is not very accurate with a lot of missing data, so I extract the insurance coverage by district in the EICV data. The reason why it did not become "universal" is that the poor refuse to pay the premium, although it was relatively low for them.

To assess whether health insurance helped increase FBD, I first separate the districts by initial insurance coverage in 2005. If the insurance coverage was low in 2005, since the insurance coverage converges to 60-80 in 2014, the jump of insurance coverage would be larger. As expected, the coefficient of the interaction term is larger when the initial insurance coverage was low (0.118 vs 0.108). However, the difference is not statistically different form each other. Columns 7 and 8 compare districts that went through bigger and smaller increase in insurance coverage. The median increase in coverage is about 80 percent (79.6 percent). The results are very similar because the districts overlap a lot and still not statistically different from each other. The coefficients when the dependent variable is NMR are statistically insignificant with no stability.

4.2.3 Performance-based Financing

Performance-based Financing (PBF) started in Rwanda as early as 2001 by some NGOs. It first started in the Cyangugu and Butare provinces as pilot studies. In 2005, the government decided to expand the program nationwide, starting in 2006 after the reorganization of the administrative boundaries. Among the 30 new districts, 11 districts already had PBF in 2006. The program was rolled out to the rest of 19 districts in a staggered approach: 12 in 2006 and 7 in 2008 (Rusa and Fritsche, 2007). PBF is considered to improve the quality of facilities because their performances are assessed and rewarded on a regular basis. Since the staggered roll-out happened in a 2-year interval, I consider all 19 districts as later treated districts.

The earlier treated districts would have better quality facilities because they had PBF longer. If the quality of facilities also affects FBD, the earlier districts should have larger coefficient on the interaction term. Columns 9 and 10 of table 6 run separate regressions over two groups: early implemented and later implemented districts. The effect on FBD is much larger in earlier implemented districts; the convergence of FBD rate in earlier implemented districts are about 3.4 percent points larger than later implemented districts. The difference is statistically significant. This result suggests the quality plays a role in increasing FBD.

The earlier treated districts also have closed the NMR gap across mothers, as column 10 shows. In fact, this coefficient is the only statistically significant coefficient on NMR in this paper. Although it is significant only at the 10% level, this finding is still meaningful. It does not counter Chari and Okeke (2014) because their paper finds is that there is no difference between 2006 and 2008 rollout districts. The model I estimate examines whether there is a convergence in NMR across risk groups over time within same district, not convergence across districts.

4.3 Effect on Cesarean Section

The effect on the cesarean sections is important because it proxies how emergencies during labor are covered. In table 2, 7.6 percent babies were born by c-section between 2000 and 2014. In fact, there is a considerable increase between pre- and post-periods: from 3.1 percent to 10.2 percent. After 2006, the c-section rate in Rwanda meets the WHO recommendation of 10 to 15 percent.

In this subsection, I examine whether the rapid increase of FBD among high risk mothers is also followed by an increase in c-section. C-section is done in a district hospital or above level, as it involves professional skills and equipment. While some women go straight to a district hospital for labor, most women are transferred to a hospital during labor when the birth attendants in the health center (sometime doctors, but mostly nurses and midwives) determine an emergency. Women in labor are transferred to the hospital by ambulance if available, or personal means of transportation arranged by herself (Niyitegeka et al., 2017). In the typical case, when a patient is transferred to an upper level facility by ambulance, the expense is covered by health insurance or completely out of pocket if the patient does not have insurance. C-section is covered mostly by CBHI (Schneider and Hanson, 2006). However, it is not clear whether the facility-based childbirth policy covers the transportation cost and even c-section itself. I could not find any formal documents from the government that exactly refer the transportation and the cost for c-section without insurance. Documents of the facility-based childbirth policy state a full package of prenatal and postnatal care in addition to FBD; however, it is not clear if FBD is restricted to a basic delivery care in a health center. If c-section itself or the transportation cost are not included in the free FBD policy, then poor households who could not afford health insurance are not able to fully benefit from FBD.

What happens to the c-sections after 2006 is estimated in panel C of table 4. Mothers from high risk households are less likely to have a cesarean section overall, and this discrepancy expands after 2006. A mother was 2.6 percentage points less likely to get a c-section compared to another mother with one standard deviation lower HD Index (lower risk) mother before 2006; however, the gap expands to 5.4 percentage points after 2006. Considering the average of c-section rate, which is 7 percent in the entire period, this 5.4 percent gap is huge. The diverging utilization rate of c-section casts doubt on the process of referral and emergency transfer of health centers. Inclusion of the quartile group specific time trend reduces the absolute size of the coefficient of the interaction term. Like panel A, the absolute value of the coefficients get larger when using a binary variable because the difference is happening mostly in the lower quartile of the HD Index (low risk mothers).

When using the SES Index, the interpretation of the coefficient is quite similar to that of the HD Index; however, the index loses statistical significance when using the Regional Index in table 5. This means that utilization of c-section is more associated with SES of the mother and household than the location of residence and the increasing trend of FBD. Regions with lower exposure to FBD stay low in access to c-section, which implies disadvantaged regions remain disadvantaged even after 2006. Taking into account that there is a clear relative increase in FBD in the disadvantaged regions in panel A of columns 3 and 4, it appears that the increase in FBD is not associated with increase in c-sections. The coefficient of the regional index becomes statistically insignificant when time trends are included.

The results captured in table 6 are more interesting. When dividing districts by the average distance to the nearest health center, the coefficient of the interaction term of the post indicator and the HD Index is larger in absolute terms in districts where HC is farther. However, the two coefficients are not statistically different. Distance to health center doesn't matter, in fact, because c-section is not operated in a health center. The results in columns 3 and 4 are almost identical with similar coefficients. There is no clear evidence that the size of the gap is smaller when distance to the district hospital is closer. Distance to district hospitals could matter because high risk households could manage to travel to a hospital for child delivery when the travel distance is short. Perhaps the distance to the district hospital itself is not a barrier to the travel: high risk mothers might not be able to afford it no matter how close it is unless it is in a walkable distance.

With respect to insurance, a difference is observed. If insurance plays an important role in deciding c-section, then high risk women would also get c-section if necessary with health insurance. This will lead to a smaller divergence of c-section utilization across the risk groups, or even a convergence if insurance is truly universal. Columns 5 to 8 show that insurance does play a significant role. There are divergences in both groups of districts; however, the dispersion is smaller in the districts where insurance got more prevalent from 2005 to 2014. The difference is sizable. When comparing districts by their baseline insurance coverage in 2005, the difference in the size of the increase in c-section use between a mother and another mother whose HD Index is one standard deviation lower is 4 percentage points when the initial insurance rate is high, whereas the difference is 2.38 percentage points in the districts with a low baseline coverage rate. Considering the average c-section rate is 7 percent points, this difference is considerable. The results are very similar when I separate the districts by the size of the increase in insurance coverage. There was a smaller divergence in the districts where insurance coverage increases most. In both cases, the coefficients are statistically different from each other. I interpret this result as the districts where there was a greater expansion of the insurance scheme successfully getting low SES or high risk households involved in the insurance scheme. I check this hypothesis with the insurance status variable that is available in the RDHS.[3] Not included in the text, I find that the districts with larger increase in insurance coverage or with lower initial insurance coverage have a smaller negative correlation between the HD Index and insurance status in the post period.

The last two columns of this table assess the effect on c-section according to when the districts implemented PBF. The quality of the facility affects the likelihood of having c-section because better quality facilities are more prepared for emergencies and are more able to transfer women in labor to a hospital. The sign of this relationship, however, is still questionable. Better quality facilities could be better at transferring all mothers with emergencies or only mothers who have insurance. If the latter is true, the divergence across low and high risk mother in terms of c-section use could be rather larger in earlier PBF implemented districts.

The results imply that better quality facilities do not benefit all women in the district. Both groups of districts have experienced an increasing divergence of c-section use across population; however, the magnitude is not markedly smaller in the early treated districts. The size of the coefficient is smaller in column 10 in absolute terms; however, the difference is not statistically significant. The results are probable if c-sections are not fully covered by the facility-based child birth policy. Even if the quality of facilities is better, the highest risk mothers cannot benefit from it without full access.

The results are credible only when having a c-section is chosen mainly by the medical professionals due to pregnancy complication, not by mothers' preference. A survey in Burkina Faso finds that women are not only afraid of c-section but also feel guilty about it (Harrison and Goldenberg, 2016). Rwanda might not be the same; however, I believe Rwandan women would not also prefer a c-section if they can have a natural delivery.

5 Discussion

Facility-based childbirth policy and a series of other programs seem to be very successful at increasing FBD. The success is quite meaningful in the sense that very low SES mothers

[3] Again, this variable has a lot of missing values, especially in 2010 wave.

start to go to facilities to give birth. However, the increase in FBD is not reflected in NMR, one of the most important markers of the overall health of a society. There are a lot of possible explanations for this. First, the quality of the facilities or the care provided might not be high enough to have a meaningful effect on the mortality. Very basic causes of death could be prevented by basic cares in a health facility; however, more knowledge and equipment are necessary as it becomes more complicated. In fact, about 84 percent of health centers did not have any ambulance in 2014. The majority of health centers own a motorcycle as the main means of transportation, which is not appropriate for patient transfer. Almost none of health centers have an X-ray or anesthesia machine. Even in the provincial and district hospitals, 15 percent did not own anesthesia machine (Rwanda Ministry of Health, 2014). Although both devices might have little to do with safe delivery (especially X-rays), it gives a sense of how low the overall qualities of the health facilities in Rwanda is. One way to rigorously address this issue is to assess whether there is a heterogeneous effect between better quality facilities and worse facilities. If the quality is a major driving force in reducing NMR, the fewer deaths should be observed in the regions with better facilities. Unfortunately, this analysis is not possible currently due to data limitation. Column 10 of table 6, however, suggests that quality of the institutions matters.

Second, it is possible that the reduction of NMR is not observed because FBD and other prenatal cares made high risk mothers more likely to successfully deliver a live birth. Health insurance also plays an important role by enhancing overall health of women. For instance, marginal babies that would have been spontaneously aborted or born dead could be born alive as women become healthier. Or, a marginal woman who could not have conceived a baby in the pre-period gets more likely to have a baby as she gets healthier. These high-risk mothers and newborns are more associated with neonatal deaths, so as a result, no change in NMR is observed. To examine this hypothesis, I plot the fertility trend of each quartile group of HD Index. If the births from the 2nd-4th quartile are increasing after 2006, then the speculation that higher risk babies make NMR remain stable would be more convincing. Although not included in the text, the pattern of the composition of births does not support this. There is no significant change in the composition of births before and after 2006, although there is a declining trend for the 2nd quartile after 2010. I also assess whether average birth order in each quartile group has changed after 2006.

If there is a large increase in births in the upper quartile, the average birth order should increase because women who would not have been pregnant would give more births. The trend of average birth order is very stable. The average birth order of the top quartile group is always the greatest, demonstrating that low SES households have more children in average. The two trends indicate that the change in the composition of newborns is less likely to explain the large increase of FBD is not followed by a large drop of NMR.

The experience of Rwanda is unique. As figure 1 shows, most of the countries in Africa have experienced moderate increases in FBD. Although other countries have at least one program to promote safe birth deliveries, the magnitude of their effects is different across countries. Results of this paper imply that the success of Rwanda in terms of promoting FBD was not coming from a single program. The government's effort to improve the physical access to health facilities and to reduce financial barrier with an insurance scheme played a crucial role. Efforts to enhance the quality of facilities cannot be overstated. The government's success to bring women out to the facilities is not done by a single intervention. This is why the effect of these kind of public programs is not easily generalizable; different countries have different backgrounds.

Institutional delivery is crucial to maternal health as wealth as neonatal. When both the mother and the fetus are in danger, the skilled attendants put the mother's survival as their priority. Although maternal mortality is as important as neonatal and infant mortality, there are few rigorous examinations on the relationship between FBD and maternal mortality in Rwanda and other developing countries. Descriptive evidence indicates there is a reduction in maternal mortality in Rwanda, however, the relevance to institutional delivery is not clear. Further studies are necessary to assess the true benefit of the interventions.

6 Conclusion

Today, still more than 2.5 million babies die within a month after birth every year. Governments and NGOs have taken enormous efforts during last thirty years,but premature deaths are still far from eradication. Some causes of deaths could be readily treated by a health professional during labor. The importance of safe birth delivery or facility-based delivery cannot be overstated as it could save millions of lives. The quality of care and birth attendants are believed to be higher in formal sectors and therefore lead to a reduction in mortality. However, several empirical studies counter this hypothesis. This paper examines the effect of policy interventions in Rwanda that increased FBD in a great magnitude during less than five years. The experience in Rwanda is unique in that only few countries went through such rapid surge in FBD.

In 2006, a series of policy change happened at almost the same time. The government launched facility-based child policy and made basic pre- and postnatal care free of charge including facility-based delivery. Additionally, community-based health insurance scheme and performance-based financing were expanded nationwide to improve access to and quality of health services. People immediately reacted to this series of policies; however, the intensity varies by their initial use of health service which is highly correlated with the SES and birth characteristics: higher risk mothers' FBD rate catches up to their lower risk counterparts. Exploiting the heterogeneous response to the policy based on SES of mothers and birth characteristics, I find that the rapid increase in FBD was not followed by a reduction in NMR. Interestingly, I find that the c-section rates are diverging even across high and low risk mothers after 2006. This implies that the quality of medical service is unequal across SES groups and shed light on why rapid increase in FBD did not lead to reduction in NMR.

I assess the relation to other various policies by dividing 30 districts according to the intensity of the policy implementation. There was a larger convergence of SES disparities in FBD in the districts where the average distance to the nearest facility is shorter and where PBF was implemented earlier. For c-sections, the size of divergence was smaller in the districts where the increase in insurance coverage from 2005 to 2014 is greater. This leads to an important interpretation: the free FBD program was not universal enough to remove all financial and physical barriers to more complicated procedures during labor; however, the universal insurance scheme partially compensates.

The relatively small increase in FBD rate in different countries with similar social programs regarding safe birth delivery implies that the effect of a program varies by country. Such successful increase in FBD rate in Rwanda was the result of a synergy of multiple health programs. However, such success in FBD did not lead to reduction of newborn deaths. Studies like Okeke and Chari (2018) suggest that facility delivery helps reduce neonatal deaths in developing countries, and Godlonton and Okeke (2016) find that the institutional intervention is effective when the quality of the facility is sufficiently high.

This study also shows that there was a reduction in SES disparities in NMR in the districts where PBF was implemented earlier. Health insurance clearly matters not only to FBD itself, but to c-sections. The coverage of the CBHI is 79 percent in 2016, which is high but not enough to reach to the lowest quartile of SES. While Rwanda is one of the few countries that attained the MDGs in maternal and child mortality, there is still ways to go. For a country like Rwanda, where quantitative success is widely known, it is time to seek qualitative improvement as well in the health sector.

References

Bleakley, H. 2007. "Disease and Development: Evidence from Hookworm Eradication in the American South." *The Quarterly Journal of Economics*, 122(1): 73–117.

Bucagu, Maurice, Jean M. Kagubare, Paulin Basinga, Fidèle Ngabo, Barbara K. Timmons, and Angela C. Lee. 2012. "Impact of health systems strengthening on coverage of maternal health services in Rwanda, 2000-2010: A systematic review." *Reproductive Health Matters*, 20(39): 50–61.

Celik, Yusuf, and David R. Hotchkiss. 2000. "The socio-economic determinants of maternal health care utilization in Turkey." *Social Science and Medicine*, 50(12): 1797–1806.

Chari, Amalavoyal V., and Edward N. Okeke. 2014. "Can Institutional Deliveries Reduce Newborn Mortality? Evidence from Rwanda."

Comfort, Alison B., Lauren A. Peterson, and Laurel E. Hatt. 2013. "Effect of health insurance on the use and provision of maternal health services and maternal and neonatal health outcomes: A systematic review." *Journal of Health, Population and Nutrition*, 31(4 SUPPL.2).

Daysal, N. Meltem, Mircea Trandafir, and Reyn Van Ewijk. 2015. "Saving lives at birth: The impact of home births on infant outcomes." *American Economic Journal: Applied Economics*, 7(3): 28–50.

De Bernis, Luc, Della R. Sherratt, Carla AbouZahr, and Wim Van Lerberghe. 2003. "Skilled attendants for pregnancy, childbirth and postnatal care." *British Medical Bulletin*, 67(July): 39–57.

De Brouwere, Vincent, Rene Tonglet, and Wim Van Lerberghe. 1998. "Strategies for reducing maternal mortality in developing countries: what can we learn from the history of the industrialized West?" *Tropical Medicine and International Health*, 3(10): 771–782.

Godlonton, Susan, and Edward N. Okeke. 2016. “Does a ban on informal health providers save lives? Evidence from Malawi.” *Journal of Development Economics*, 118: 112–132.

Graham, Wendy J, Jacqueline S Bell, and Colin H W Bullough. 2001. “Can skilled attendance at delivery reduce maternal mortality in developing countries ?” *Studies in HSO&P*, 17: 97–129.

Harrison, Margo S., and Robert L. Goldenberg. 2016. “Cesarean section in sub-Saharan Africa.” *Maternal Health, Neonatology and Perinatology*, 2(1): 6.

Montagu, Dominic, Gavin Yamey, Adam Visconti, April Harding, and Joanne Yoong. 2011. “Where do poor women in developing countries give birth? a multi-country analysis of Demographic and health survey data.” *PLoS ONE*, 6(2).

Niyitegeka, Joseph, Georges Nshimirimana, Allison Silverstein, Jackline Odhiambo, Yihan Lin, Theoneste Nkurunziza, Robert Riviello, Stephen Rulisa, Paulin Banguti, Hema Magge, Martin Macharia, Regis Habimana, and Bethany Hedt-Gauthier. 2017. “Longer travel time to district hospital worsens neonatal outcomes: A retrospective cross-sectional study of the effect of delays in receiving emergency cesarean section in Rwanda.” *BMC Pregnancy and Childbirth*, 17(1): 1–10.

Nyandekwe, Médard, Manassé Nzayirambaho, and Jean Baptiste Kakoma. 2014. “Universal health coverage in Rwanda: Dream or reality.” *Pan African Medical Journal*, 17(232).

Okeke, Edward N., and A. V. Chari. 2018. “Health care at birth and infant mortality: Evidence from nighttime deliveries in Nigeria.” *Social Science and Medicine*, 196: 86–95.

Powell-Jackson, T, B D Neupane, S Tiwari, K Tumbahangphe, D Manandhar, and A M Costello. 2009. “The impact of Nepal’s national incentive progamme to promote safe delivery in the district of Makwanpur.” In *Innovations in health system finance in developing and transitional economies.* , ed. D Chernichovsky and K Hanson. Bingley:Emerald.

Powell-Jackson, Timothy, Sumit Mazumdar, and Anne Mills. 2015. "Financial incentives in health: New evidence from India's Janani Suraksha Yojana." *Journal of Health Economics*, 43: 154–169.

Randive, Bharat, Miguel San Sebastian, Ayesha De Costa, and Lars Lindholm. 2014. "Inequalities in institutional delivery uptake and maternal mortality reduction in the context of cash incentive program, Janani Suraksha Yojana: Results from nine states in India." *Social Science and Medicine*, 123: 1–6.

Rusa, Louis, and Gyuri Fritsche. 2007. "Rwanda: Performance-Based Financing in Health." *Tropical Medicine*, 105–115.

Rwanda Ministry of Health. 2017. "Health Service Packages for Public Health Facilities in Rwanda." Ministry of Health, Republic of Rwanda January.

Rwanda Ministry of Health. n.d.. "Rwanda Health Statistical Booklet."

Schneider, Pia, and Kara Hanson. 2006. "Horizontal equity in utilisation of care and fairness of health financing: A comparison of micro-health insurance and user fees in Rwanda." *Health Economics*, 15(1): 19–31.

Tarekegn, Shegaw M., Leslie S. Lieberman, and Vincentas Giedraitis. 2014. "Determinants of maternal health service utilization in Ethiopia: Analysis of the 2011 Ethiopian Demographic and Health Survey." *BMC Pregnancy and Childbirth*, 14(1): 161.

United Nations, Department of Economics and Social Affairs, Population Division. 2017. "Reproductive Health Policies 2017: Data Booklet (ST/ESA/ SER.A/396)." United Nations, Department of Economics and Social Affairs, Population Division.

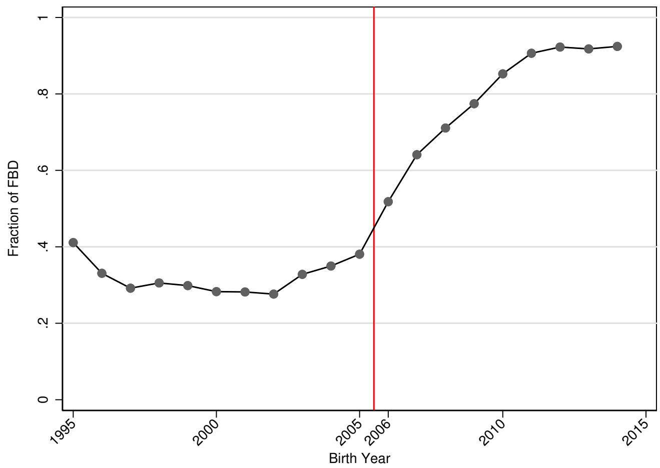
Vyas, Seema, and Lilani Kumaranayake. 2006. "Constructing socio-economic status indices: How to use principal components analysis." *Health Policy and Planning*, 21(6): 459–468.

Ye, Jiangfeng, Ana P.ilar Betrán, Miguel Guerrero Vela, Joäo Paulo Souza, and Jun Zhang. 2014. "Searching for the optimal rate of medically necessary cesarean delivery." *Birth (Berkeley, Calif.)*, 41(3): 237–244.

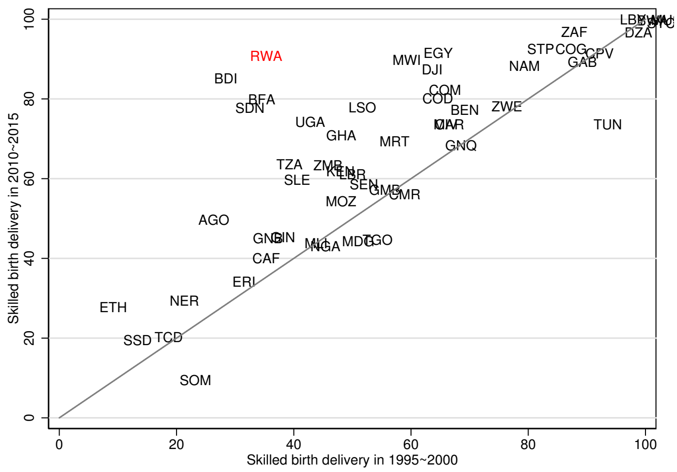
Figures

Figure 1: Facility-based Delivery in Rwanda and Other African Countries

(a) Facility Based Delivery in Rwanda

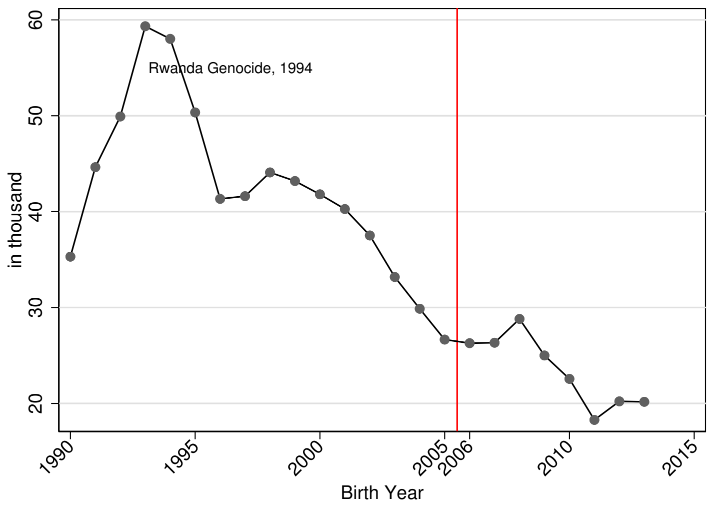


(b) Skilled Birth Delivery in African Countries



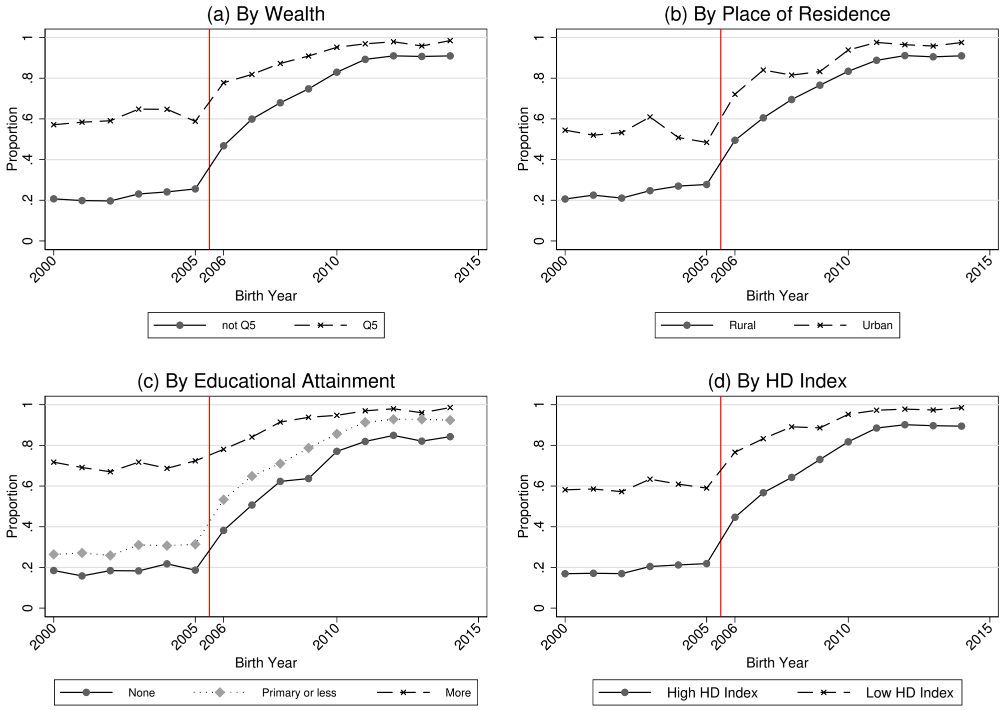
Note: In Panel (a), I plot the proportion of facility based delivery using multiple rounds of Rwandan Demographic and Health Survey. In Panel (b), I compare proportion of delivery assisted by a skilled attendant(Skilled Birth Delivery–SBD) over time in African countries. Data is compiled by UNICEF. The definition of SBD varies across countries–some countries include home birth with a skilled (traditional) birth attendant. I only include countries with more than two surveys containing information on location of delivery, and choose two surveys–one conducted between 1995 and 2000, and the other conducted between 2010 and 2015. Most of them are coming from either Demographic and Health Surveys, Multiple Indicator Cluster Surveys, or Department of Statistics of each country. I try to use same surveys in both period. Each survey contains birth information upto recent 5 years. Thus, the SBD rate is average of the births of the recent years. The horizontal axis and vertical axis represents SBD rates in a survey conducted earlier and later, respectively. Rwanda is marked red for comparison to other countries.

Figure 2: Neonatal Mortality Rate in Rwanda



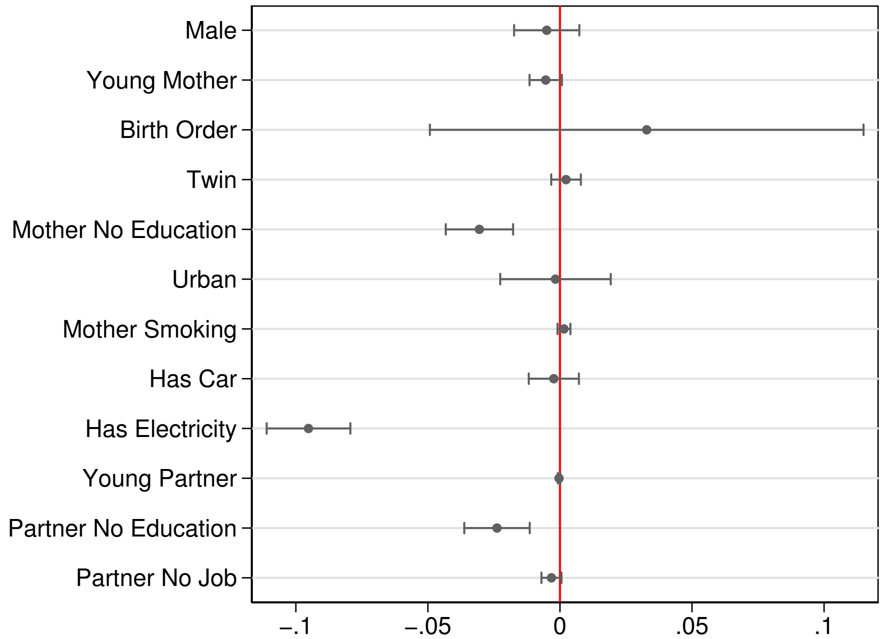
Note: NMR calculated in 3 year moving average. Data source from RDHS 2000-2014 waves. Births from 1990 to 1999 are coming from RDHS 2000. In other waves, I take the recent five years of biths.

Figure 3: Facility Based Delivery Rate by SES



Note: Q5 in panel (a) indicates whether the household is in the fifth quintile (the richest). In panel (d), individuals with HD Index above the first quantile are classified as High HD Index. Data source from RDHS 2005-2014 waves.

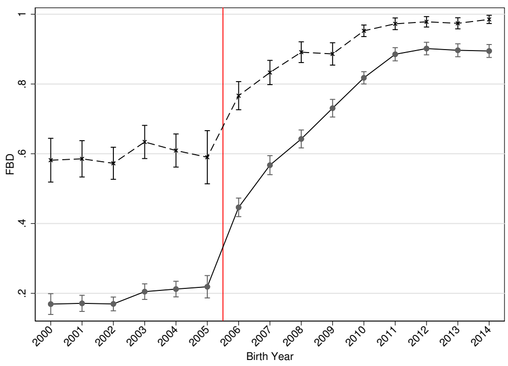
Figure 4: Falsification Test



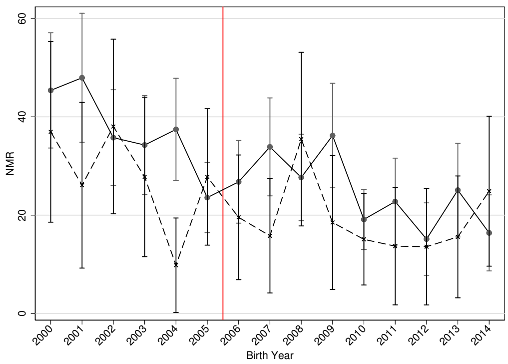
Note: I estimate equation (3) with different dependent variables for this figure. The figure denotes the value of coefficient of the interaction term of post indicator and HD Index and its 95 percent confidence interval. Dependent variables are indicated in the vertical axis.

Figure 5: FBD, NMR and C-section rate by HD Index in Rwanda

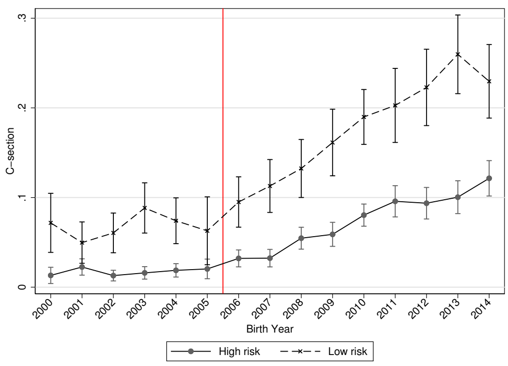
(a) FBD by HD Index



(b) NMR by HD Index

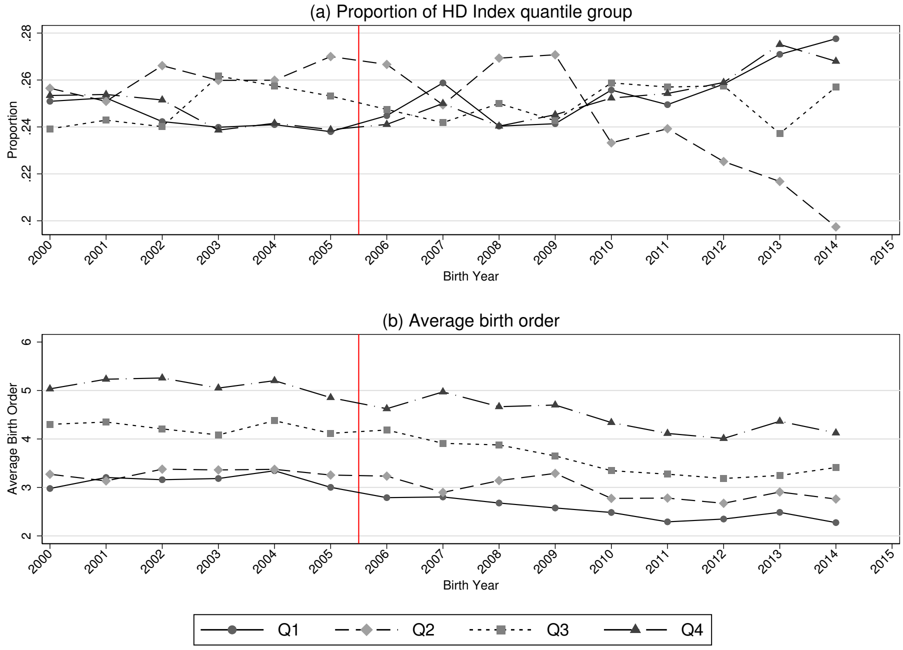


(c) C-section by HD Index



Note: The mean and its 95 percent confident intervals are depicted in this figure. High and low HD Index are defined as same in figure 3.

Figure 6: Trend of Fertility



Note: Q1-Q4 denotes the quantile group of HD Index just as defined in the text. Panel (a) shows the distribution of the quantile groups of all births in each year. It simply calculates the proportion for which each quantile group account in each birth year. Panel (b) shows the average birth order of each group in each year.

Tables

Table 1: Rwanda Health Policy Events, 1999-2010

Year	Policy Description
1999	Pilot project on community based health insurance (CBHI)
2001	Performance-based financing contracts (PBFC) pilot projects
2005	Rwanda Health Sector Policy (including Sexual and Reproductive Health)
2006	**Facility-based childbirth policy** PBFC introduced in all districts **CBHI mandatory** National family planing policy
2007	Government declares family planning a development priority
2008	Health facilities made autonomous Community health program enhanced Maternal death reviews institutionalized

Source: Bucagu et al. (2012)

Table 2: Summary Statistics

	Pre-period 2000-2005		Post-period 2006-2014		Total 2000-2014	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Panel A. Birth Characteristics						
Neonatal deaths in a month (NMR)	34.22	181.789	23.856	152.606	27.977	164.911
Neonatal deaths on the birth day	13.72	116.34	7.574	86.703	10.020	99.600
Neonatal deaths in a week	27.9	164.681	19.860	139.525	23.057	150.087
FBD	0.298	0.4574	0.793	0.405	0.623	0.485
Prenatal care	0.943	0.23111	0.983	0.130	0.971	0.169
Caeserean Section	0.031	0.17466	0.102	0.303	0.078	0.268
Male	0.502	0.50002	0.510	0.500	0.507	0.500
Birth order number	3.844	2.46057	3.228	2.220	3.473	2.338
Twin	0.026	0.15833	0.029	0.168	0.028	0.164
Mother's age at birth	28.76	6.67362	28.394	6.341	28.540	6.478
Panel B. Mother and Household Characteristics						
Wealth Quintile						
Q1	0.21	0.40751	0.236	0.425	0.226	0.418
Q2	0.199	0.39945	0.210	0.407	0.206	0.404
Q3	0.194	0.39566	0.193	0.394	0.193	0.395
Q4	0.202	0.4012	0.178	0.382	0.187	0.390
Q5	0.195	0.39594	0.184	0.387	0.188	0.391
Urban	0.185	0.38859	0.175	0.380	0.179	0.383
Education						
No educaiton	0.269	0.443	0.170	0.375	0.209	0.407
Primary or less	0.639	0.480	0.715	0.451	0.685	0.465
More	0.092	0.289	0.115	0.319	0.106	0.308
Literacy	0.577	0.494	0.658	0.474	0.626	0.484
Partner's Education						
No education	0.265	0.441	0.185	0.388	0.218	0.41256
Primary or less	0.606	0.489	0.693	0.461	0.658	0.47445
More	0.129	0.336	0.122	0.327	0.125	0.33035
Partner's Occupation						
No job	0.005	0.070	0.009	0.096	0.008	0.087
Agriculture	0.740	0.439	0.670	0.470	0.698	0.459
Professional	0.039	0.194	0.047	0.212	0.044	0.205
Clerical/Sales/Skilled Manual/Army	0.155	0.362	0.219	0.414	0.193	0.395
Others	0.061	0.239	0.055	0.228	0.057	0.233
Has car/truck	0.009	0.097	0.012	0.109	0.011	0.104
Has electricity	0.057	0.23119	0.158	0.36432	0.117	0.32184
Number of alive children	3.629	2.023	3.117	1.871	3.321	1.949
Visited health facility in last 12m	0.499	0.500	0.752	0.432	0.652	0.476
Observations	11077		16767		27844	

Note: Q1-5 indicates the wealth quintile of the household. Q1 is the poorest and Q5 is the richest. Panel A shows the characteristics of birth and B shows mother and household. The unit of observation is birth for both panel.

Table 3: Pre-Trend of Dependent Variables

	(1) FBD	(2) FBD	(3) NMR	(4) NMR	(5) C-section	(6) C-section
HD Index	-0.197***	-0.202***	0.462	3.554	-0.0346***	-0.0355***
	(0.0121)	(0.00899)	(3.503)	(3.054)	(0.00833)	(0.00666)
HD Index × Time trend	0.00174		-0.746		-0.00297	
	(0.00264)		(0.943)		(0.00208)	
Time trend × HD Index Q=2		0.00330		0.433		-0.00459+
		(0.00547)		(1.977)		(0.00247)
Time trend × HD Index Q=3		0.00479		-0.753		-0.00786*
		(0.00578)		(2.254)		(0.00316)
Time trend × HD Index Q=4		-0.000524		1.336		-0.00985**
		(0.00616)		(2.519)		(0.00366)
Observations	8024	8024	10363	10363	8001	8001

Note: + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors in the parentheses are clustered in the psu level of the survey. All regressions include the district fixed effect. Odd columns include the interaction term of continuous HD Index and time trend. Even columns include the interaction term of the quantile indicators and time trend. Q1 is the omitted category. The title of each column denotes the dependent variable.

Table 4: Main Effect on FBD, NMR and C-section

	(1)	(2)	(3)
Panel A. Dependent Variable: FBD			
Post × HD Index	0.116***	0.249***	0.0633***
	(0.00684)	(0.0195)	(0.00876)
HD Index	-0.208***	-0.385***	-0.184***
	(0.00616)	(0.0186)	(0.00637)
Panel B. Dependent Variable: Neonatal Mortality			
Post × HD Index	-1.828	-3.518	0.588
	(2.051)	(5.263)	(2.926)
HD Index	4.018*	6.080	2.944
	(1.912)	(4.564)	(2.010)
Panel C. Dependent Variable: Cesarean Section			
Post × HD Index	-0.0284***	-0.0485***	-0.0172*
	(0.00530)	(0.0109)	(0.00876)
HD Index	-0.0264***	-0.0346***	-0.0316***
	(0.00369)	(0.00692)	(0.00501)
Binary Index	No	Yes	No
Time trend	No	No	Yes
Observations	23052	23052	23052

Note: $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors are clustered at the PSU level and are in the parentheses. The title of each panel indicates the dependent variable. Column 1 estimates equation 2. Column 2 uses the binary version of the HD Index, whether it is high or low, defined in figure 3. Column 3 includes quartile group specific time trend and uses equation 3.

Table 5: Effect Using Different Indexes

	(1) SES	(2) SES	(3) Regional	(4) Regional
Panel A. Dependent Variable: Facility-Based Delivery (FBD)				
Post × Index	0.106***	0.112***	0.191***	0.180***
	(0.00760)	(0.00737)	(0.00576)	(0.00589)
Index	-0.175***	-0.184***	-0.232***	-0.199***
	(0.00729)	(0.00927)	(0.00297)	(0.0101)
Panel B. Dependent Variable: Neonatal Mortality (NMR)				
Post × Index	-3.484	-3.103	-2.029	-0.763
	(2.138)	(2.099)	(2.228)	(2.279)
Index	5.919**	2.300	3.106	-0.662
	(1.993)	(3.078)	(2.043)	(3.625)
Panel C. Dependent Variable: Cesarean Section				
Post × Index	-0.0311***	-0.0283***	0.00555	-0.00302
	(0.00514)	(0.00502)	(0.00497)	(0.00495)
Index	-0.0207***	-0.0452***	-0.0206***	0.00101
	(0.00333)	(0.00666)	(0.00391)	(0.00857)
Birth Char Control	No	Yes	No	Yes
SES Control	No	No	No	Yes
Time trend	No	Yes	No	Yes
Observations	23450	23450	25211	23456

Note: The title of each column indicates the alternative index used. Columns 1 and 3 estimate equation 2 while columns 2 and 4 estimate equation 3. Birth controls and birth and SES controls are included when using the SES Index and the Regional Index, respectively. Standard errors are clustered at the PSU level in column 1 and 2 and at the matched cluster in 2005 level in column 3 and 4. All other details are same as table 3.

Table 6: Effect by travel time to HC, insurance rate,and PBF

	(1)	(2)	(3)	(4)
	Distance to HC in 2014		Distance to DH in 2014	
Dependent Variables	>4 km	<4 km	>14 km	<14 km
Facility-based delivery	0.0941***	0.126***	0.0994***	0.123***
	(0.0128)	(0.00799)	(0.0135)	(0.00828)
Neonatal Mortality	-3.226	-0.625	-2.647	0.208
	(3.625)	(2.527)	(3.939)	(2.485)
C-section	-0.0282***	-0.0326***	-0.0255**	-0.0331***
	(0.00753)	(0.00730)	(0.00802)	(0.00706)
Time Trend	Yes	Yes	Yes	Yes
Observation	12962	10190	12602	10550

Table 6–(Continued)

	(5)	(6)	(7)	(8)	(9)	(10)
	Insurance rate in 2005		Change in Insurance rate between 2005 and 2014		Performance-based financing implemented	
Dependent Variables	>0.4	<0.4	<80%	>80%	2006	2001 2005
Facility-based delivery	0.105***	0.122***	0.108***	0.118***	0.103***	0.137***
	(0.0126)	(0.00773)	(0.0139)	(0.00743)	(0.0119)	(0.00881)
Neonatal Mortality	-2.564	-1.896	-0.548	-2.952	0.526	-4.505+
	(3.332)	(2.754)	(3.747)	(2.546)	(3.584)	(2.702)
C-section	-0.0399***	-0.0238***	-0.0403***	-0.0258***	-0.0300***	-0.0270**
	(0.00793)	(0.00708)	(0.00858)	(0.00669)	(0.00708)	(0.00820)
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Observation	13669	9483	11127	12025	14866	8286

Note: This table indicates β_2 of equation (3) for three different dependent variables. Dependent variables are stated in the row. How I separate the districts is explained in the top of the table. Column (1)-(2) divides the 30 districts by the median distance to the nearest health center in 2014, using EICV data. The median distance is 4.02 km. Column (3)-(4) does with median distance to health district, which is 14.5 km. Column (5) and (6) are divided by the baseline coverage of health insurance in 2005. Column (9) and (10) are divided by the timing of PBF implement. All other details are same as table 3.