GRIPS Discussion Paper 15-19

The impact of access to health facilities on maternal care use and health status: Evidence from longitudinal data from rural Uganda

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December 2015

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The impact of access to health facilities on maternal care use and health status: Evidence from longitudinal data from rural Uganda

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Abstract

Maternal and child mortality remains high in developing countries. While timely antenatal care and delivery at formal facility are recommended, many mothers do not use them. This paper investigates whether newly established health facilities affect maternal health care utilization as well as the health of mothers and children. In order to deal with possibly endogenous facility placement, we apply the community-level and mother-level fixed effects models to the new, decade-long panel data from rural Uganda. Results demonstrate differential roles played by large facilities and small clinics. Openings of large facilities increase the probability of delivery at formal facility, attended by trained personnel. This is accompanied by an increased use of inexpensive transportation modes such as walking and own bicycle to delivery places. Weak evidence is also found for reduced degree of selective infant survival. New community-level clinics, on the other hand, increase regular antenatal care usage and reduce complications during delivery. These results suggest that accessible clinics help pregnant mothers to avoid preventable problems through early diagnosis of risky cases and/or treatment of existing diseases. Overall, these findings underscore the importance of providing good access to health facilities, in particular to community-level clinics, in order to promote the utilization of maternal care and improve maternal and infant health.

JEL classification: I10 ; I18 ; D12
Keywords: health facility; maternal health; infant health; skilled birth attendance; antenatal care; Uganda

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[‡]This work was supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Number 25101002. We appreciate comments from participants at the International Health Economics Association conference (IHEA), Australian Development Economics Workshop (ADEW), Japan Health Economics Association conference (JHEA), The 85th Meeting of the Osaka Workshop on Economics of Institutions and Organizations: Tokyo Conference, Osaka University Machikaneyama Seminar and a number of anonymous reviewers. Any remaining errors are our own.

1 Introduction

Maternal death poses a serious risk to women of reproductive age. In 2013, 289,000 mothers lost their lives during their pregnancy or within 42 days after that. Ninety-nine percent of these deaths occurred in developing countries and 62 percent in sub-Saharan Africa (WHO, 2014). In order to reduce maternal mortality, it is considered most crucial that women deliver at formal facility, attended by skilled health practitioners such as midwives (Campbell and Graham, 2006; Filippi et al., 2006).[1] Most complications cannot be predicted or prevented (Ronsmans and Graham, 2006), and if a complication happens without the presence of a skilled practitioner, delay in the diagnosis and referral of the complication could result in maternal mortality or morbidity.[2] Reflecting this importance, deliveries attended by a skilled birth attendant (SBA) has been one of the Millennium Development Goal indicators. However, the average rate of utilization is still low in developing countries. Only 53 percent of pregnant women deliver with the help of a skilled attendant (WHO, 1999). One of the major causes of poor use of SBA is physical accessibility to health facilities. They are considered to be too far for mothers to walk to in many Sub-Saharan African countries (Sabine and Oona, 2009; Thaddeus and Maine, 1994).

This paper investigates how improved access to health facilities can affect the utilization of SBA and other maternal care as well as maternal and child health status. As we discuss later, while many studies examine the cross-sectional relationship between these outcomes and access to health facilities, rigorous evidence is lacking for the causal relationship between them. Few available panel

[1] A skilled attendant refers to individuals with midwifery skills who have been trained to manage normal pregnancies, childbirth and the immediate postnatal period, as well as to identify and refer complications in women and newborns. They include a midwife, doctor and nurse (WHO, 2004). While home deliveries attended by a skilled practitioner might be another option (or the only option in some areas), home conditions can be extremely basic and the skilled attendant will not have the support of other skilled practitioners or equipment in the case of complications (Campbell and Graham, 2006).

[2] In addition to antenatal and delivery care, reducing the number of unwanted pregnancies and lowering the costs of safe abortion are alternative ways to improve maternal health because unsafe abortion is one of the causes of maternal deaths. In fact, new clinics offering family planning services are found to have modestly reduced fertility in Iran (Hashemi and Salehi-Isfahani, 2013) and openings of legal abortion centers are shown to have decreased the probability of live birth given conception in Nepal (Valente, 2014). While these services are for women in general or pregnant women who prefer abortion, this paper focuses on services for pregnant women who prefer giving birth.

studies are also based on the data spanning for a relatively short time period. In particular, to our knowledge, no panel study has been conducted for Africa, even though the majority of maternal deaths occur in the continent. Moreover, it is not well understood how health facility of differing types (such as community-based clinics and hospitals covering a whole district) play different roles in influencing maternal and child health. We fill these gaps in the literature by investigating the effect of new openings of health facilities on maternal health care usage and outcomes in Uganda, using the decade-long panel data which distinguish the level and ownership of health facilities. More specifically, we utilize the new panel data on the availability of health facilities between 2002 and 2012. Merging this with the rich panel data on maternal care utilization enables us to investigate how an increase in the availability of health facilities is associated with changes in a range of maternal care use behavior such as SBA use, delivery at a formal facility, and regular antenatal care visits in every trimester. In order to address the endogenous placement of health facilities, we employ the community- and mother-fixed effects models, controlling for the district-level time trends as well as various time-variant characteristics. Furthermore, we also shed light on the mechanism through which better access to health facility improves health investment by looking at the impact on transportation patterns.

Results demonstrate differential roles played by large facilities and small clinics. Openings of facilities of medium to large size, providing comprehensive maternal care, increase delivery with SBA at a facility by 9 percent. This is accompanied by an increased use of inexpensive transportation modes such as walking and own bicycle to delivery places. Weak evidence is also found for reduced degree of selective infant survival. On the other hand, a new lower-level facility, which does not provide delivery care or detailed tests for pregnant women, increases the probability of regularly receiving antenatal care in every trimester, and decreases the number of complications during delivery. These results suggest that lower-level facilities enable early diagnosis and referral of serious cases to

higher-level facilities, or they treat existing diseases through repeated antenatal care visits, thereby helping mothers to avoid preventable problems and generally better prepare for delivery. Overall, these findings underscore the importance of expanding the coverage of health facilities. While both community-based clinics and more equipped facilities play different roles to promote the utilization of maternal care and improve maternal and infant health, they imply that it is crucial to have wide coverage of lower-level health facilities which connect mothers in remote areas with the national health service network.

These results are generally consistent with the findings in the literature on the impact of access to health facilities in general. While we find the expansion of health system increases the demand for health care, it has been found the closure of nearby hospitals and living away from a health facility negatively affect health care utilization and health outcomes. For instance, each additional mile from the health facility is found to be associated with three percent decline in health check up for black children in the U.S. (Currie and Reagan, 2003). Also, communities experiencing an increase in the distance to the nearest facility (due to the closure of some of the public facilities in Los Angeles) exhibit a larger increase in deaths due to heart attacks and unintentional injuries, but not in deaths due to long term chronic diseases such as cancer (Buchmueller et al., 2006). This is likely to be due to the delay in reaching care as found in Wilde (2013), who investigates the impact of response time of emergency medical services on mortality. Hospital closures are also found to increase travel distance for hospital visitors, particularly among a group of pregnant women (Bazzoli et al., 2012). Similar adverse effects on health care usage and health status are found in the study comparing two groups of medical inpatients in hospitals which did and did not close down (Bindman et al., 1990).[3]

However, empirical evidence on the impact of access to health facility is limited for developing

[3]Buchmueller et al. (2006) uses the ZIP code fixed effect model, while Currie and Reagan (2003) employs mother fixed effects model. Wilde (2013) analyzes the impact of the time ambulance takes to respond to accidents on the probability of hospital admission and mortality, using the distance between the incidence and ambulance garage as an instrument.

countries. It is particularly unfortunate that there is paucity of rigorous evidence on the impact on maternal care utilization and maternal health, given that many developing countries suffer from high maternal and infant mortality. While many studies find positive association between the availability of health facilities and maternal care use and maternal health outcomes using cross-sectional data (for example, Do (2009); Gage and Calixte (2006); Overbosch et al. (2004); Yanagisawa et al. (2006)), it is unclear whether their estimates are free from a possible bias due to endogenous placement of health facilities. For example, public facilities might target areas with worse outcomes, which creates a negative bias in the OLS estimates as in Rosenzweig and Wolpin (1982), Pitt et al. (1993) and Frankenberg et al. (2005).[4] On the other hand, remote areas might not be able to attract a health facility due to high construction costs and preferences of health practitioners. If those areas also have individuals of poorer health, OLS estimates are likely to be positively biased.

The available rigorous evidence on maternal health and access to health facility includes Frankenberg et al. (2009), which assess the effect of the presence of village midwives in Indonesia, using the panel data with two waves of 1993 and 1997. The government of Indonesia recruited, trained and allocated a large number of midwives to disadvantaged areas in the 1990s. Their findings based on the mother fixed effects model suggest that this midwifery program significantly increased the probability for pregnant mothers of receiving iron tablets during pregnancy. It also increased SBA use, albeit the estimates based on the mother fixed effects are marginally significant. The presence of a village midwife is also shown to have improved the health status of women of reproductive age and children.[5] While these studies inform us of the roles played by midwives, the impact is still unknown of health facility which includes health practitioners, medical supplies, and testing and operating

[4]For instance, Rosenzweig and Wolpin (1982) finds that an additional family planning clinic increased child height by 12 percent in India using the child fixed effect model. However, their 'naive' cross-sectional estimates suggest no significant impact.

[5]Children who are fully exposed to this midwifery program are found to have significantly gained in terms of height-for-age compared to the cohort which was not exposed to the program (Frankenberg et al., 2005). Birth weight and body mass index among women ages 20-45 also significantly increased in those communities which gained midwives (Frankenberg and Thomas, 2001).

equipment.

Another set of evidence is based on the experiment conducted in Matlab, India, where a package of family planning, maternal and child services were provided through home visits by health facilitators. While the results indicate a wide range of improvement (Chaudhuri, 2008), it is likely to be difficult to replicate this type of intensive service package in sparsely populated, remote and low-income areas. On the other hand, the development of public health system, usually consisting of the network of well-equipped hospitals and far-reaching clinics, is a widely shared policy objective. It is therefore of significant importance to quantify the impact of additional health facilities on the health of the population, particularly the most vulnerable such as infants and pregnant mothers. By showing evidence on the impact of health facility of different types, we provide implications which contribute to the policy discussion on the efficient formulation of a national health system.

In addition to the access to health facilities, the affordability of health care is shown to matter in determining its utilization (Basinga et al., 2011; Lagarde et al., 2007; Nguyen et al., 2012; Powell-Jackson and Hanson, 2012).[6] In the case of Uganda, user fees in public health facilities were mostly abolished in 2001.[7] Some preventative care including antenatal visits had been free even before the 2001 reform (Burnham et al., 2004). However, unofficial fees in the public sector has been reported (Ministry of Health, 2010a), and users still pay for transportation and face the opportunity costs for the time taken to reach facility and receive care. In this context, changes in the physical proximity to health facilities are still likely to affect the total cost of health care usage, thereby influencing health care utilization and health outcomes.

The rest of the paper is organized as follows: The next section presents the institutional background and the literature review. Section three describes the data used for this analysis. The

[6]These studies underscore the importance of good access to health facilities as well because the policies they evaluate, such as conditional cash transfers, pay-for-performance schemes, and voucher schemes, have been shown to improve preventative health behavior but require health facility to be implemented.

[7]User fees in public facilities remained in private wings of public hospitals (Ministry of Health, 2010a).

analytical and empirical models are presented in section four. Section five and six presents the findings and the robustness checks. Section seven concludes.

2 Background

Uganda is one of the low income countries with per capita GDP of about $434 in 2014.[8] The country however is growing rapidly. Its average growth rate between 2000 and 2012 was 7.5 percent (World Bank, 2014). During this period, health indicators improved appreciably. Infant mortality decreased from 88 to 54 deaths per 1000 live births, and the maternal mortality ratio declined from 524 to 438 deaths per 100,000 live births between 2000-01 and 2011 (UDHS, 2012). The health system of the country also expanded significantly, following the governmental plans which put forward the improvement of the access to health services as one of the major objectives. The first national health policy of 1999 stipulated that national health infrastructure would be expanded in order to bring health care closer to the public and improve the utilization of health services. For this end, emphasis was placed on the provision of community-based health facilities (Ministry of Health, 1999).[9]

The national health policy also specified the target population size and geographic unit that is to be served by each level of facility. For example, a village is supposed to have Health Center I (HCI), which is to cover 1000 individuals. A parish, which includes several villages, is supposed to have a Health Center II (HCII) covering 5000 individuals. A HCI comprises of a team of community health workers who provide community-based health care services. The health facility of the lowest administration level with physical establishment therefore is a HCII. This level of facility provides simple preventive and curative care as well as outreach services to promote healthy lifestyle. It

[8] Based on the data.worldbank.org and in terms of constant 2005 U.S. dollars.

[9] After the political insecurity during the 1970s and 1980s, the government of Uganda started to base the development of the health sector on the 10-year national health policy plans (Ministry of Health, 1999, 2010b) and the associated five-year sectoral plans (Ministry of Health, 2000, 2005, 2010a). This framework has been formulated within the context of the provisions of the 1995 Constitution and the 1997 Local Governments Act, which decentralised governance and service delivery.

is not supposed to provide delivery care or comprehensive antenatal care, though sometimes HCII may receive emergency cases and provide partial antenatal care which does not require laboratory testing.[10] The lowest level of facility which provides delivery and comprehensive antenatal care is a Health Center III (HCIII), which is expected to serve 20,000 individuals. Every sub-county is supposed to have one HCIII. The facilities of higher levels all provide comprehensive maternal care. They include a Health Center IV which should be built in every county, and a Health Center V (or hospital) for every district, serving 100,000 and 500,000 individuals, respectively. On top of these levels, there are regional referral hospitals which are expected to cover 2 million individuals and the national referral hospital in the capital city (Ministry of Health, 2000). In the analysis, we distinguish HCII and the facilities above HCII as the latter provides comprehensive maternal care. We refer HCII and facilities above HCII as "lower-level facilities" and "higher level facilities", respectively.

These goals for the availability of health services were far from being met initially. For instance, in 1999-2000, there were only 746 HCIIs, while it was considered that 3624 were needed. Accordingly, it was expected that priority would be placed on the construction of lower-level facilities. Since it was recommended that every parish has one HCII and also good access to health facility was considered to be living within 5 km of a facility, priority was placed on locations which did not have a facility initially for establishing new facilities (Ministry of Health, 2000). This means the initial availability of health facilities affects the probability of acquiring a new facility during the analysis period. In order to take this into account, we control for sub-county fixed effects, which allow different localities to have different levels of outcomes such as maternal care use and health status due to sub-county-level time-invariant factors, including the initial availability of health facilities.

[10] HCII does not have a laboratory, and thus cannot conduct the tests required in comprehensive antenatal care such as urine and blood tests. However, health workers at HCII can examine body size, blood pressure, and also provide those with existing diseases with drugs and treatment.

3 Data

Our analysis draws on the Research on Poverty, Environment and Agriculture Technologies (RePEAT) survey for 2003, 2005, 2008 and 2012 as well as the Uganda health facility inventory for 2002, 2004, 2006, 2010, 2011, and 2012.[11] The RePEAT survey is the longitudinal survey of about 900 households from 94 communities in rural Uganda.[12] The communities (or *Local Council 1*) are scattered in three regions (Central, East and West) as shown in Figure 1. In the initial year, ten households were randomly sampled from each of the 94 communities. The attrition rate has been low at 6 percent between 2003 and 2012, leaving 889 out of the original 940 households. The main outcomes for this study, maternal care utilization and maternal health, are based on the retrospective questions on past pregnancies collected in the second (2005) and fourth (2012) waves.

In 2005, each household was asked whether there was a woman who became pregnant in the past five years, including cases of miscarriage, abortion and still births. For those households reporting a pregnancy, detailed questions on care utilization were asked on each pregnancy for each woman. In 2012, the presence of a woman aged 15-56 (women ages 50-56 are included as they were aged 49 or below in 2005) was asked first, then the number of pregnancies was verified for each type (live birth, still birth, miscarriage and abortion). For women who provided pregnancy information in 2005, pregnancy experience between 2005 and 2012 was asked for update, while women who did not provide pregnancy information in 2005 were asked about pregnancy experience between 2001 and 2012. When there were more than two women per household who reported pregnancy in the relevant years, we randomly selected two women and recorded all the pregnancy cases for them. However, there were

[11] The administrative data was collected once in two years between 2002 and 2010, and annually from 2010 onwards. The 2008 inventory data was not found at the Ministry of Health.

[12] It is a subset of a stratified random sample collected for the study on Policies for Improved Land Management by the IFPRI. As its main research goal was to investigate agricultural productivity and livelihoods, strata were defined based on the factors influencing agricultural practices: agro-climate conditions, elevation, access to market and population density. Using these, 32 districts in Southern Uganda were divided into 18 strata, excluding parts of the northern region which had security concerns around 1999. The RePEAT further excluded three districts which had aggravated insecurity when the survey started in 2003 (Ruecker et al., 2003a,b; Yamano et al., 2004).

only seven households bound by this constraint. Out of the original 940 households, 893 remained in the second wave, of which 539 had at least one pregnancy in the past five years reported by 609 women. Seventy-nine percent of these women were re-interviewed in the fourth wave, providing the full pregnancy history between 2001 and 2012. The remainder of women attrit between the second and fourth waves, but their pregnancy histories between 2001 and 2005 are used for our analysis. In addition to these 609 women, in the fourth wave, 339 women who joined the sample households or became of reproductive age reported pregnancies between 2001 and 2012. Altogether, these 948 women reported 2408 pregnancies.

Since data on pregnancy details were collected retrospectively, one might be concerned about possible measurement errors. According to Beckett et al. (2001), there is unlikely to be a large measurement error for important events such as whether pregnancy resulted in a live birth or still birth. However, detailed information such as the choice of antenatal care providers and medical fees could suffer from some measurement errors. In order to address this concern, we use dichotomous indicators for less salient outcomes such as transportation costs (for example, whether she paid for it or not, rather than the actual amount of payment). We also excluded data on pregnancies which were reported after more than 5 years have past, but our results did not change qualitatively. This is likely to reflect the fact that there are few women who provided information on pregnancies which occurred more than 5 years ago because those who were newly interviewed in 2012 (who were supposed to be asked about their pregnancy experience from 2001) were mostly young girls who became 15 years or older or married in.

The health facility inventory is an administrative list of health facilities for the whole Uganda. For each facility, the list indicates its level (such as HCI and HCII), ownership (public, private or non-governmental-not-for-profit organization (NGO)) and status (whether or not it is operational). We count the number of operating facilities for each year and sub-county. A sub-county is likely

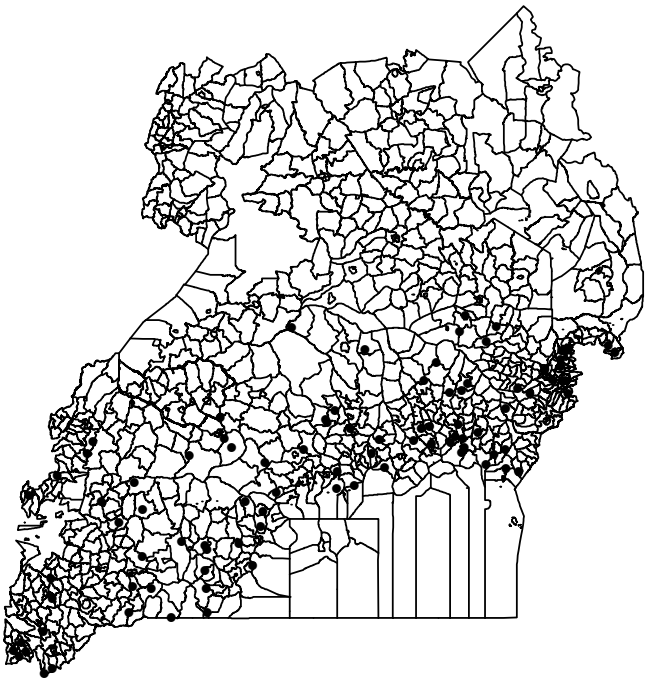


Figure 1: Location of RePEAT survey communities (local council 1) and the 2002 sub-county boundaries in Uganda

Source: Author's elaboration.

to approximate the area individuals travel to antenatal care. As discussed in the previous section, every sub-county is supposed to have one HCIII, which is the most basic level of facility providing comprehensive antenatal care. Also, a sub-county is not too large with the average population size being 25,261 in 2002 (UBOS, 2006). Since there are very few private or NGO facilities, to improve the precision of the estimates, these two types of facilities are combined into one group labeled as "non-public facilities," including both higher-level and lower-level facilities.[13] This health facility inventory data was merged across years using sub-county names as in 2002.[14]

As Figure 2 indicates, there has been a massive increase in the number of health facilities in Uganda. Between 2002 and 2012, the total number of facilities has increased by more than two

[13]In particular, only one sub-county had private health facilities functioning by 2012 in the RePEAT survey areas.

[14]Between the analysis period of 2001-2012, some administrative areas split into multiple new administrative areas, some parishes were promoted to become sub-counties, and some parishes were assigned to new sub-counties. We traced the names of the parishes and their sub-counties over the years, using the crosswalk data provided from the Uganda Bureau of Statistics (UBOS). The resulting data are organized in the way that the same parishes that are identified within one sub-county as in 2002 are contained in that sub-county throughout the analysis period.

folds from about 2500 to 5000. Consistent with the governmental focus on the investment in HCII, the increase has by large been driven by an increase in the number of HCIIs, while the higher-level facilities have also increased. The average annual growth rate was 5 percent for higher-level facilities and 13 percent for HCII.[15] After we divide the number of health facilities by the number of parishes as in 2002,[16] the number of health facilities per parish still shows an increasing trend (Figure 3). The top panel indicates that, while the average number of facilities per parish was about a half in 2002, by 2012 it rose to almost one. The disproportionate increase in the number of lower-level facilities is also confirmed. We examine how this massive investment in health infrastructure has affected a range of maternal care utilization.

Table 1: Reason for choosing a particular place for delivery

Reason	No.	%
Better access	544	39.4
Good quality of service	385	27.9
Less waiting time	196	14.2
Cheaper	140	10.2
No need(was confident that everything was fine)	78	5.7
Harassment by medical personnel	15	1.1
Lack of transport	11	0.8
Medical attendant nearby	10	0.7
Total	1,379	100

Source: RePEAT Study 2012
Notes: This is based on the responses to the following question: "What factors led you to choose this delivery site/attendant?" This was asked only in the 2012 RePEAT, and thus the number of observations is smaller compared to the total sample size used in the analysis of this paper.

This increase in the availability of health facility is likely to have affected maternal care usage. According to our survey data, access to health facilities was the most cited reason for choosing a

[15]There is a slight decline between 2004 and 2006. Our interviews with officials at the Ministry of Health suggest that this was mainly due to the campaign to close private facilities that either failed to renew the permits to operate, or did not have permit to operate at all. Since these facilities were largely located in Kampala, the capital city, once it is excluded, Figure A1 in the appendix shows a consistent upward trend.

[16]Ideally, we would like to adjust our measure of facility availability for population size. However, unfortunately data on population at the sub-county level is unavailable. Since the number of parishes in a sub-county is proportional to the population size of the sub-county, this is likely to approximate the availability of health facilities adjusting for population size at the initial period. We use the initial number of parishes so that the indicator for access captures the availability adjusting for population size, but not affected by population changes motivated by new openings of health facilities.

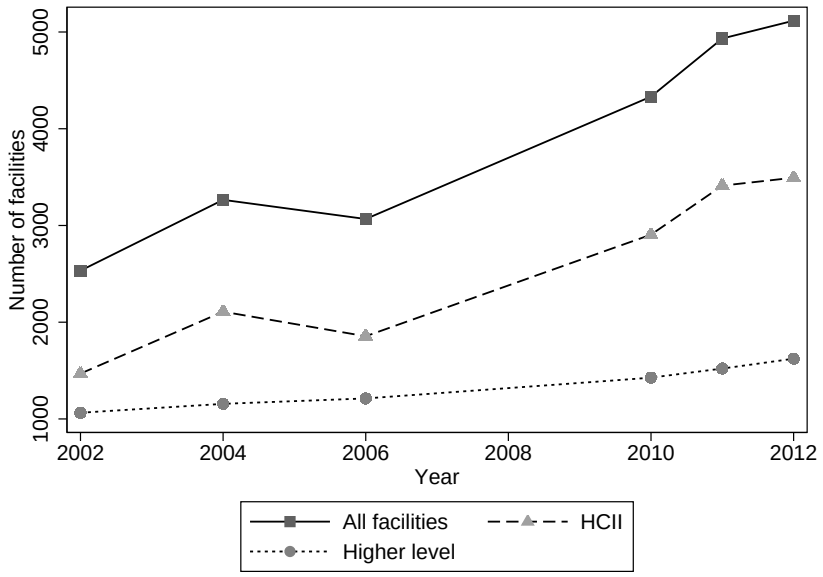


Figure 2: Changes in the total number of health facilities in Uganda by type: 2002-2012

Source: The Health Facility Inventory 2002, 2004, 2006, 2010, and 2012

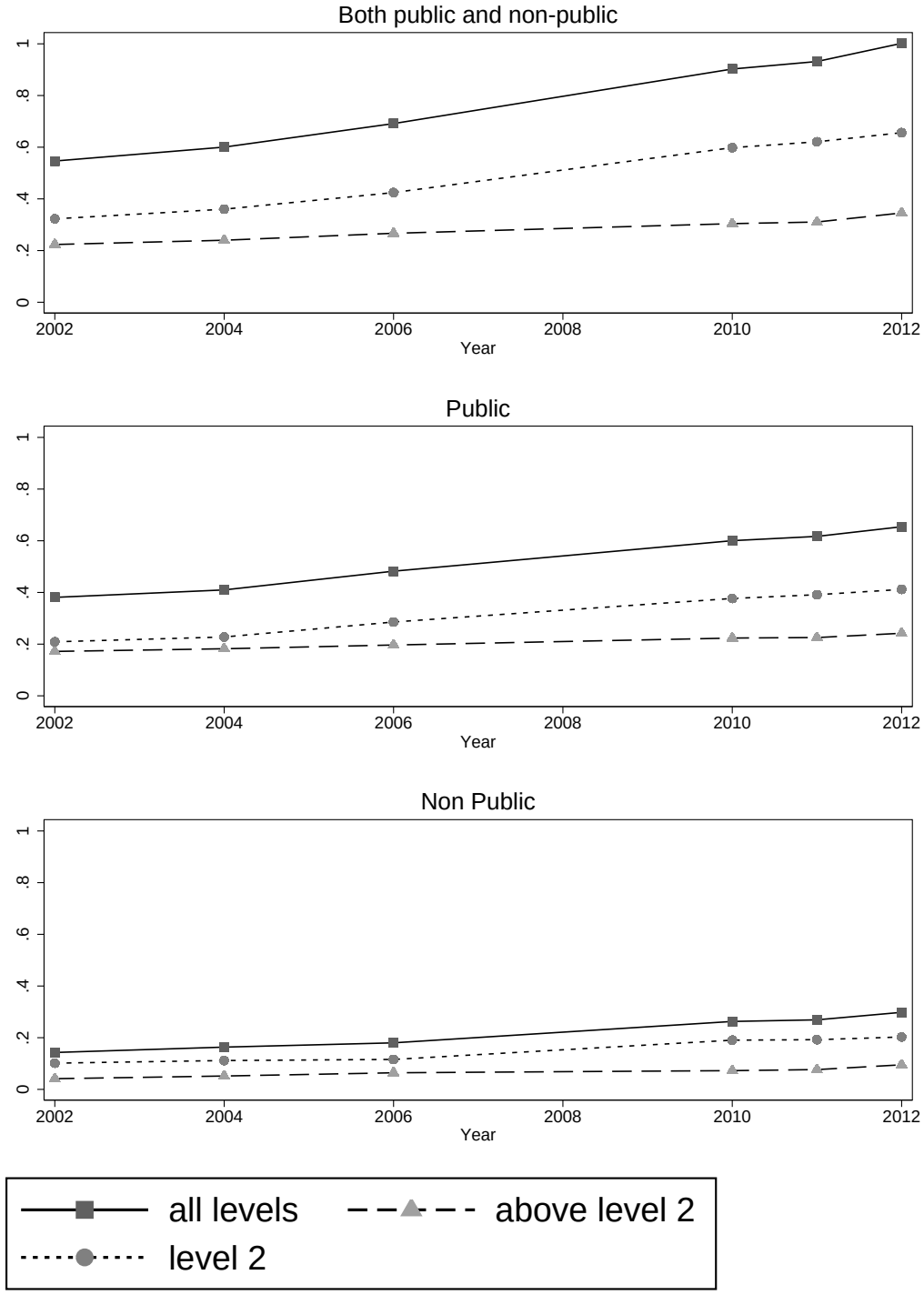
Notes: Facilities are divided into Health Center II (HCII) and the rest of the facilities including Health Centers III, IV, and V. HCII is expected to cover a parish, while HCIII is to cover a sub-county. HCIV and HCV cover a county and district, respectively. While HCII does not provide full maternity care, all the other types of HCs provide it.

particular facility for delivery, followed by quality of care (Table 1). Indeed, the increase in the availability of health facilities was accompanied by the increase in the number of the sample mothers in the RePEAT delivering at facility using SBA (Figure 4). The SBA indicates deliveries attended by a skilled attendant both inside and outside of formal health facility, while facility delivery refers to deliveries taking place at a health facility regardless of who attended delivery. Both increased from about 40% to 68 percent between 2000 and 2012.[17]. Antenatal care utilization remains high around 95 percent throughout the period. However, regular antenatal care usage, which refers to pregnancy cases in which the mother made at least one antenatal care visit in every trimester,[18] is much lower averaging 43 percent. There is also no indication of improvement over time. Data on infant and

[17]A small proportion of mothers reached health facilities but were not assisted by skilled attendants. Thus, we also created the indicator for skilled birth attendance at formal facility (SBA at a facility). It averages 53 percent - three percentage points lower than the proportion of all deliveries which took place in the facilities. While facility delivery only reflects the demand-side behavior, the difference between facility delivery and SBA at a facility is likely to be due to the absence of health practitioners. SBA at a facility is not included in Figure 4 because its trend almost coincides with the trends of SBA and facility delivery.

[18]Regular antenatal care is recommended by WHO and the Ministry of Health of Uganda. This variable can be defined only for pregnancies terminated in 2005-2012.

Figure 3: Number of facilities per parish by level and ownership in the RePEAT Study areas

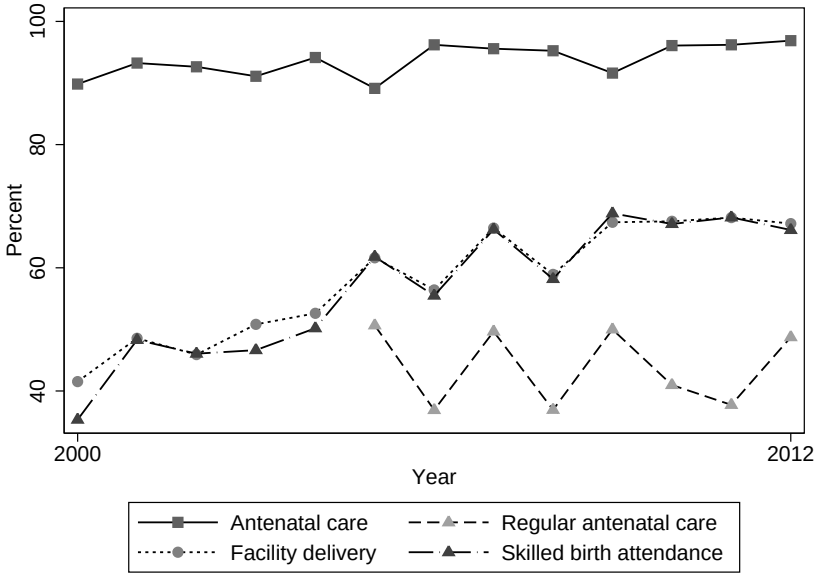


Source:Author, computed from inventory data.

Source: Health Facility Inventory Data
Notes: The figures shows the number of Health Center (HC) II and all the other types of health centers (HCIII, IV, and V) within the areas covered by the RePEAT study, separately for governmental facilities and either private or not-for-profit facilities.

maternal deaths are available, but unfortunately sample size is too small to conduct a reliable study on the impact of access to health facilities on them.

Figure 4: Maternal care utilization



Source: RePEAT Study 2005 and 2012.
Notes: A formal facility includes both governmental and private facilities. Delivery at home or attended by a traditional birth attendant (TBA) is not included in the delivery at facility. Skilled birth attendants include a midwife, nurse, or doctor, but excludes a TBA, relative, or Village Health Team (VHT, or HCI). Regular care refers to receiving antenatal care at least once in every trimester.

In order to merge the RePEAT data and the facility data for each sub-county and year, we filled missing values in the facility data mostly using the information on pre-determined availability. That is, since data on facility are unavailable for 2007-2009, the availability as in 2006 was assigned to observations (pregnancy cases) between those years. The availability in 2002 and 2004 were assigned to observations in 2003 and 2005, respectively. Only for observations before 2002, the availability in 2002 was assigned because pre-2002 facility data are unavailable. Excluding the observations before 2002 from the analysis does not alter the main findings, most likely because the many new health centers were constructed after 2002. The number of planned construction of HCII was 20 and 65 for 2001 and 2002, but 250, 250, and 300 for 2003, 2004 and 2005 (Ministry of Health, 2000). See the

Appendix for the summary statistics.

4 Empirical model

The increasing trends in both access to health facility and maternal care usage suggest that maternal health investment might be partly explained by the improvement in access to facility. In order to more rigorously investigate this possibility, we employ sub-county fixed effects model and mother fixed effects model. First, sub-county fixed effects model is formalized as follows:

$$M_{ijhkt} = \beta_1 * Access_{kt} + \beta_2 * Z_{jhkt} + \mu_k + \lambda_{rt} + \nu_{ijhkt} \tag{4.1}$$

M_{ijhkt} indicates the outcome of interest for pregnancy i of woman j in household h, living in sub-county k in region r, in year t. $Access_{kt}$ is the vector of three variables which indicate the per-parish availability of the three types of health facilities (public higher-level, public lower-level, and non-public) within sub-county k in year t. μ_k are unobserved time-invariant characteristics of sub-county k. These characteristics include the initial availability of health facilities. According to the governmental plan, sub-counties with many parishes which did not have HCII were more likely to receive a new HCII. While sub-counties with many and few such parishes might be different in terms of unobserved characteristics which affect health investment behavior and outcomes, sub-county fixed effects take into account any additive differences in those outcomes. Also, sub-counties in remote and rugged areas are less likely to receive a health facility, and might also have residents suffering from poor health. However, to the extent such unobserved characteristics do not change in the short run, it is likely to be captured by the sub-county fixed effects. They also control for differentials across districts due to varying levels of public investment in health as most of the districts have only one

sub-county covered by the RePEAT Study.

λ_{rt} is a set of dummy variables defined for each region (Central, Eastern and Western) and year (year dummies and district-year interactions) which controls for the annual nation- and region-wide shocks/events that might have affected the availability of health facilities and utilization of health care. These include natural calamities such as floods and outbreak of diseases. Also, they include possible changes in the average awareness of women, which might have happened due to increased information exposure to younger cohorts.

In addition to these region-specific time trends, a set of control variables, Z_{jhkt}, is included. These consist of: maternal age at delivery, the age squared, a set of three dummy variables indicating parity, log of per capita household land size and the three dummy variables indicating quartiles in terms of assets (livestock and durables). Furthermore, we control for the condition of the road connecting between the community and the nearest district town, distinguishing those that are passable under all types of weather and those that are passable only in dry seasons. Good roads to a district town are likely to make many goods and services accessible including health care, and also reduces the cost of establishing a new facility in the village. By controlling for such changes in road conditions, our measures for the access to health facilities are likely to specifically capture the impact of improved access to health care. When we estimate the OLS model for comparison, the altitude of the household location and three dummy variables indicating maternal education are additionally controlled. The Appendix contains the summary statistics for these and outcome variables. Finally, ν_{ijhkt} is the idiosyncratic standard errors clustered at the sub-county level. Clustering corrects the standard errors for potential correlation of outcomes for women within the sub-county over time, including those with repeated births (Bertrand et al., 2001).

The sub-county fixed effects assumes that, controlling for the region-specific year effects, individual-, household- and village-level characteristics, there is no unobserved heterogeneity that affect growth

in outcomes and changes in access to health facility. However, the composition of mothers could change over time within a sub-county. For instance, mothers who delivered in later years in the analysis period might have been more aware of the importance of maternal care than mothers who delivered in earlier years. If this tendency is particularly strong in areas that gained a new facility, it could positively bias the impact of the availability of health facilities on the utilization of SBA and facility delivery.

In order to assess whether this issue matters, we also utilize the mother fixed effects model, which replaces the sub-county fixed effects with mother fixed effects. It controls for the mother-specific unobserved characteristics such as innate health and preferences towards health care. Thus, the mother fixed effect model is our preferred specification. This model assumes that, controlling for the district-specific year effects, maternal time-invariant differences, individual-, household- and village-level time-variant characteristics, there is no unobserved change that affects growth in outcomes and a new opening of a health facility. That is, pregnant women in sub-counties which gain a health facility would not have changed unobserved factors disproportionately compared to pregnant women in other sub-counties which experience no change in access to health facility. This is likely to hold as we allow general attitudinal changes affecting the outcomes at the regional level, and also control for the effect of the village road condition, which often influences the general modernization of rural villages.

The linear probability model (LPM) is used to estimate equation 4.1. While some of the outcome variables are discrete, the fixed effects logit model does not allow the estimation of the partial effects on the response probabilities without making assumptions on the values of the fixed effects. As the results based on the fixed effects logit model are generally similar to the findings based on the LPM, in this paper we mainly discuss the LPM results.

5 Results

5.1 Impact on maternal health care use

Table 2 reports for maternal care utilization. For comparison, the OLS estimates are reported in the first four columns. They suggest that sub-counties with relatively many more non-public facilities have more pregnant women who deliver at formal facilities, attended by skilled birth attendants. On the other hand, sub-counties with few and many public facilities do not differ much in terms of the use of delivery care (Columns 2, 3, and 4). The only exception is that areas with many more lower-level facilities are more likely to have women who regularly receive antenatal care in every trimester (Column 1). These results are quite different from those based on the sub-county fixed effects model. Areas experiencing a gain in access to public higher-level facilities exhibit an increase in the probability of facility delivery and SBA (Columns 6-8). These results suggest the OLS estimates largely underestimate the impact of access to public higher-level health facilities on the utilization of facility delivery and SBA. This is consistent with the previous studies which do not find significant effect of health programs in cross sectional estimates but do find a significant impact in community fixed effects models (Frankenberg et al., 2005; Pitt et al., 1993; Rosenzweig and Wolpin, 1982). It is likely that the government's guideline to target unserved areas causes a downward bias in the OLS estimates. On the other hand, the OLS estimates overestimate the impact of public higher-level facilities on regular antenatal care visits. An explanation for this might be that sub-counties which already had a public high-level facility (which are usually local towns and are less likely to gain a new facility) had women who were more likely to regularly take antenatal care, compared to more remote sub-counties.

The sub-county fixed effects results however may still be biased if the composition of mothers changed within sob-counties. Once mother fixed effects are taken into account, the results in Column

10-12 indicate no significant relationship between non-public facilities and delivery care. This suggests the sub-county fixed effects estimates for the impact of non-public facilities are overestimated, probably reflecting the tendency of for-profit and NGO facilities to operate in areas with growing demand and lowering costs of operation. As a small number of the RePEAT villages became urban towards the end of the analysis period, it is likely that, in those areas, women who became pregnant later in the analysis period became to utilize delivery care at non-public facilities compared to those who became pregnant in earlier periods.

Instead, the results for public, higher-level facilities are robust. That is, given the same woman, a delivery which occurred after the opening of a new higher-level facility is more likely to happen at a formal facility with SBA (Columns 11 and 12). The estimated coefficient for the use of SBA at facility implies that, an additional higher-level facility in a sub-county induces a 10-percentage-point increase in the probability of SBA at facility. This is equivalent to an 9-percent increment compared to the mean.[19]

Interestingly, the mother fixed effects results also show that improved access to public *lower-level* facilities increases regular antenatal care, though such basic facilities do not provide full maternal care. The estimates imply that an additional public lower-level facility leads to a 7-percent increase in regular antenatal care. A possible explanation for the differences between the sub-county and mother fixed effects models is that relatively developed sub-counties which are unlikely to have gained lower-level facility experienced disproportionate changes in unobserved factors affecting regular antenatal care, such as willingness to deliver at formal facility, possibly due to the exposure of young cohorts to media. If such improvement in awareness happened due to cohort changes only in areas not gaining access to facilities, while both young and old women kept traditional attitude in more rural areas, it

[19] A new high-level facility somewhere in a sub-county is equivalent to about a one-sixth increase in the number of that facility per parish, as there are about six parishes on average. This can be a newly established facility or upgrading of an existing lower-level facility. It leads to a $1/6 \times 0.30 = 5$-percentage-point increase in the outcome, or a 9-percent increase relative to the mean ($0.05 \div 0.53$).

Table 2: Impact of access to health facilities on maternal care utilization in rural Uganda: 2001-2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		OLS				Sub-county FE				Mother FE		
Outcome = 1 if ...	regular antenatal care	facility delivery	SBA at facility	SBA	regular antenatal care	facility delivery	SBA at facility	SBA	regular antenatal care	facility delivery	SBA at facility	SBA
Number of higher level facility per parish(Public)	0.32***	-0.05	0.04	0.01	0.15	0.19	0.26**	0.26**	0.20	0.22	0.30*	0.30*
	(2.74)	(-0.37)	(0.40)	(0.11)	(0.72)	(1.44)	(2.29)	(2.20)	(1.22)	(1.34)	(1.98)	(1.98)
Number of level 2 facility per parish(Public)	0.07	-0.06	-0.06	-0.06	0.06	-0.01	-0.04	-0.04	0.23**	0.11	0.08	0.08
	(1.20)	(-0.76)	(-0.91)	(-0.97)	(1.11)	(-0.11)	(-0.71)	(-0.67)	(2.40)	(1.33)	(1.01)	(1.03)
Number of facilities per parish (Non Public)	0.07	0.34***	0.31**	0.28**	0.19	0.25*	0.27*	0.26*	-0.18	0.14	0.18	0.13
	(0.65)	(2.72)	(2.62)	(2.45)	(0.91)	(1.66)	(1.85)	(1.86)	(-0.95)	(0.79)	(0.99)	(0.75)
Observations	1,106	2,210	2,168	2,175	1,122	2,239	2,197	2,204	923	1,935	1,903	1,910
Number of Sub-counties					86	87	87	87				
Number of Mothers									453	784	784	781
R-squared	0.10	0.34	0.32	0.32	0.09	0.26	0.26	0.26	0.07	0.44	0.45	0.46
Subcounty FE					Yes	Yes	Yes	Yes				
Mother FE									Yes	Yes	Yes	Yes

Notes:
1). Robust t-statistics in parentheses
2). Significance level: *** p<0.01, ** p<0.05, * p<0.1
3). Standard errors clustered at sub-county level.
4). All regressions control for age, age squared, parity dummies, log of household land size and indicators for poverty quartiles. The OLS and sub-county fixed effects models also control for the three dummies for maternal education and altitude of the household location.
4). Regressions for the regular care use include region-year interactions because of the limited sample size. The regressions for the remaining outcomes include year-district interactions.

can cause an underestimation of the impact of access to health care.

The estimated coefficients for the control variables (not shown) suggest the usage of SBA and facility delivery is associated with economic status. For example, the results based on the mother fixed effects model suggest that mothers in the richest two quartiles are about 10 percentage points more likely to use facility for delivery compared to those in the poorest quartile. Under the sub-county fixed effects model, it is found that women of higher parities are less likely to use facility or be attended by SBA, while richer women are more likely to use those services. In terms of time-invariant correlates, higher altitude is correlated with more limited use of delivery care and the level of education does not indicate a systematic association.

5.2 Impact on maternal and child health

The analyses thus far suggest that improved access to health infrastructure promotes regular antenatal care visits and delivery at a formal facility with a skilled birth attendant. A natural next question is whether this increase in maternal care utilization also influences maternal and child health outcomes. In order to address this issue, we now examine the impact on the incidence of complications mothers experience during delivery, as well as the birth weight of their children. The 2012 RePEAT asked whether a woman experienced any complication or health problems during child birth, and some problems happened for 16 percent of the pregnancies. Common responses include severe bleeding and being labor for more than a day.[20] The 2012 RePEAT also asked mothers whether they think their babies are bigger, smaller, or similar in size compared to other infants, whether their weights were measured right after birth, and if so, how many kilogram they were.

The results for these outcomes are shown in Table 3 based on the sub-county fixed effects model (Panel A) and mother fixed effects model (Panel B). Starting from the incidence of complications

[20]The common complications that can be life-threatening include severe bleeding and infections (particularly after childbirth), high blood pressure during pregnancy (which can lead to pre-eclampsia and eclampsia), and other indirect causes due to worsening medical disorders.

during delivery (Column 1), the opening of the lower-level public health facility, which does not have a maternity ward, is accompanied by a reduced risk of complications for mothers during childbirth (Panel B). Though lower-level health facilities are not supposed to provide comprehensive maternal care, they examine whether expecting mothers have general health problems. Combined with their positive impact on regular antenatal care (Table 2), these lower-level facilities might have expedited the diagnosis and referral of possibly serious cases to higher-level health facilities. This would help pregnant women with some problems to deliver at higher-level facilities with qualified staff and emergency equipment, thereby lowering the probability of preventable problems developing into a serious complications due to delay in reaching care. These results suggest the rapid expansion of lower-level facilities have contributed to a reduction in the incidence of maternal complication.

On the other hand, the results for child health outcomes provide more nuanced evidence. An increase in the number of higher-level public facilities leads to a reduction in the birth weight among those who were weighed (Column 3), though not to the significance increase in the incidence of low birth weight infants (less than 2.5kg). Nevertheless, such a negative effect is not found in the subjective size of children, which was evaluated by their mothers regardless of whether they were weighed or not (Column 5). One possible explanation might be selective survival. That is, the opening of higher-level facilities saves more newborn lives who develop medical complications, and those who would not have survived without facilities tend to have small sizes. While one might expect this to occur with an increase in the probability for babies of being weighted, that is not found (Column 2). This might be due to the failure of facility or mothers to follow the protocol of postnatal care.[21] These results provide weak evidence that improvement in access to higher-level facilities saves small babies who might not have survived without them.

[21]The RePEAT asks whether a child was weighed immediately after birth, but 16 percent of babies delivered at facility were not immediately weighted after birth. Also, 7 percent of cases answered that their babies were immediately weighted after birth even though they were born outside facility.

Table 3: Impact of access to health facility on maternal and child health outcomes in rural Uganda: 2001-2012

Panel A: Sub-county fixed effects model	(1) 1 if complication during delivery	(2) 1 if baby weight was measured	(3) Birth weight (Kg)	(4) 1 if birth weight < 2.5Kg	(5) 1 if mother thinks baby is big
Number of public higher-level facility per parish	0.21	0.06	-1.06***	0.35	-0.22
	(1.30)	(0.32)	(-3.24)	(1.46)	(-1.53)
Number of public lower-level facility per parish	-0.03	-0.07	-0.22	0.13	-0.12
	(-0.38)	(-1.04)	(-1.14)	(1.07)	(-1.57)
Number of non-public facilities per parish	-0.17	-0.33	-0.45	0.01	-0.14
	(-0.78)	(-1.49)	(-1.16)	(0.05)	(-0.59)
Observations	1,172	1,167	597	597	1,109
R-squared	0.04	0.07	0.07	0.08	0.03
Number of sub-counties	86	86	80	80	86
Panel B: mother fixed effects model	(1) 1 if complication during delivery	(2) 1 if baby weight was measured	(3) Birth weight (Kg)	(4) 1 if birth weight < 2.5Kg	(5) 1 if mother thinks baby is big
Number of public higher-level facility per parish	0.04	0.06	-1.43**	0.42	-0.12
	(0.37)	(0.25)	(-2.51)	(1.40)	(-0.53)
Number of public lower-level facility per parish	-0.12**	-0.05	-0.05	0.20	-0.01
	(-2.00)	(-0.61)	(-0.14)	(1.24)	(-0.13)
Number of non-public facilities per parish	0.04	-0.06	0.23	-0.09	0.14
	(0.16)	(-0.22)	(0.40)	(-0.47)	(0.41)
Observations	962	960	495	495	907
R-squared	0.05	0.10	0.14	0.10	0.05
Number of mothers	467	470	294	294	456

Notes:
1). Robust t-statistics in parentheses
2). Significance level: *** p<0.01, ** p<0.05, * p<0.1
3). Standard errors clustered at sub-county level.
4). All regressions include controls for age, age squared, parity dummies, log of household land size, indicators for poverty quartiles, region-specific year effects.

5.3 Impact on travel and expenditure patterns

Thus far, we have demonstrated the improvement of the access to health facility promotes maternal health utilization as well as infant and maternal health. In order to see if these advantages are in fact due to better access to health facilities, we now examine the effects on travel mode, time and expenses. On one hand, if a new facility reduces the distance to the nearest facility, this can reduce the time to reach facility and transportation costs, given the mode of transportation remains unchanged. On the other hand, one might stop using a relatively expensive mode of transportation such as a motorcycle or bus, and start using a less expensive mode such as walking. In this case, transportation time will increase while transportation costs decline. The data on the major transportation mode, total travelling time and transportation costs are available in the 2005 and 2012 RePEAT survey for mothers who used some antenatal care or delivery care.[22] We focus on the results for transportation mode and travel time as transportation costs variable contains a larger number of missing values.

The results in Table 4, Panel A are based on the sub-county fixed effects model. They suggest that a new lower-level public facility in every parish (which increases our measure of per-parish availability by one) reduces the time taken to get to antenatal and delivery care by 12-15 minutes (Columns 2 and 4). Among those who answered the transportation expenses, openings of lower-level facilities lower the probability of paying for transportation for both antenatal and delivery care (Column 3 and 6).[23] However, these results are not robustly found in the mother fixed effects specification (Panel B).

The results are also different between sub-county and mother fixed effects models for the impact of

[22]If more than one transport modes were used, the mode and cost for the most expensive one were asked. This is likely to underestimate the total cost for individuals who travel a long distance. To the extent those individuals are more likely to experience improved access to health facilities, its estimated impact is likely to be underestimated, there by serving as a lower bound.

[23]We prefer to use the dummy variable for paying for transportation rather than the actual amount of expense because it is known that a measurement error issue is less severe in the dichotomous variable citepBeckett˙etal2001. The estimated effects on the actual amount of transport expenses are also negative, and the effect on transport spending for antenatal care is significant.

Table 4: Impact of access to health facilities on travel time and transport fees in rural Uganda for 2001-2012

Panel A: sub-county fixed effects model	(1) 1 if walk or cycle for antenatal	(2) Travel time for antenatal	(3) 1 if paid for transport for antenatal	(4) 1 if walk or cycle for delivery	(5) Travel time for delivery	(6) 1 if paid for transport for delivery
Number of higher level facility per parish(Public)	-0.23*	-17.40	-0.01	0.21	-4.41	-0.43**
	(-1.71)	(-0.99)	(-0.06)	(1.14)	(-0.35)	(-2.00)
Number of level 2 facility per parish(Public)	0.02	-12.42	-0.14**	0.04	-14.61*	-0.14*
	(0.31)	(-1.57)	(-2.10)	(0.40)	(-1.67)	(-1.90)
Number of facilities per parish (Non Public)	0.27	-22.94	0.01	0.24	-15.99	-0.07
	(1.59)	(-1.38)	(0.04)	(1.20)	(-0.91)	(-0.36)
Observations	2,143	2,133	1,400	1,262	1,259	983
R-squared	0.08	0.07	0.10	0.09	0.08	0.09
Number of scocode	87	87	87	87	87	86
Panel B: mother fixed effects model	(1) 1 if walk or cycle for antenatal	(2) Travel time for antenatal	(3) 1 if paid for transport for antenatal	(4) 1 if walk or cycle for delivery	(5) Travel time for delivery	(6) 1 if paid for transport for delivery
Number of higher level facility per parish(Public)	0.11	13.18	-0.23	0.34*	20.61	-0.83***
	(0.88)	(0.90)	(-1.59)	(1.69)	(0.98)	(-3.59)
Number of level 2 facility per parish(Public)	-0.06	2.30	-0.08	0.04	-2.56	-0.02
	(-0.86)	(0.38)	(-1.28)	(0.31)	(-0.27)	(-0.19)
Number of facilities per parish (Non Public)	0.52***	-12.23	-0.17	0.15	22.88	-0.01
	(3.15)	(-0.78)	(-1.10)	(0.67)	(0.87)	(-0.05)
Observations	1,063	1,846	1,142	1,071	1,068	802
R-squared	0.18	0.07	0.13	0.12	0.10	0.19
Number of PID	516	753	543	521	519	411

Notes:
1). Robust t-statistics in parentheses
2). Significance level: *** p<0.01, ** p<0.05, * p<0.1
3). Standard errors clustered at sub-county level.
4). Panel A shows the results of sub-county fixed effects and Panel B shows the results of mother fixed effects estimation. All regressions include region-specific year effects, age, age-squared, parity dummies, log of household land size, and indicators for poverty quartiles.

access to public, higher-level facility. We therefore focus on the results based on our preferred model, the mother fixed effects specification. Panel B indicates that pregnant women became more likely to either walk to or use bicycle to the place of delivery care after the opening of a new higher-level public facility (Column 4). At the same time, the proportion of women paying for transportation for delivery is reduced (Column 6), and the associated increase in transportation time is not significant (Column 5). This is likely to be because mothers who used to take more expensive transportation means in the previous pregnancy quit using those means as the facility became closer to home. In sum, these results provide weak evidence suggesting the improvement of access to health facility, particularly of higher-level, made it easier for mothers to visit it for delivery care.

5.4 Heterogeneity in the impact of access to health facility

The analysis so far has assumed the impact of access to health facility is homogeneous across all the groups of different characteristics. However, take-up behavior of opportunities can vary depending on the constraints which restrict maternal care use. This section explores the heterogeneity in the impact of access to health facility by the condition of the road connecting from a local village to the district town. We have also investigated heterogeneity by maternal education and household poverty levels, but no heterogeneity is found by these characteristics (results not shown). It is possible that a new facility benefits communities with good road conditions particularly for the higher-level facilities because they are usually located in towns. As discussed earlier, HCIII is supposed to be built for every sub-county, HCVI for every county and a hospital (HC V) for every district. For many of the villages, the road leading to the district town also include the road to the sub-county town and other towns. Thus, the condition of the road to the district town roughly measures whether individuals living in a village can reach a new higher-level facility if it is built within the sub-county. If the local road is not passable, even if a new higher-level facility is built in the adjacent town, women in the village may not be able to use it.

Table 5 shows the results of estimating the original mother fixed effects model, which is augmented by further including the interaction terms between the three indicators for access to health facilities and the dummy variable indicating whether the road to the nearest district town is passable under all weather conditions or passable only in dry seasons.[24] The results show that the positive impact of higher-level facilities on facility delivery, which was found in Table 2, are concentrated in communities which have good all-weather roads leading to the nearest district town (Column 2). Those communities which do not have such good roads on the other hand fail to benefit from an improved health system, as indicated by the insignificant coefficient for the uninteracted indicator

[24] Unfortunately, the results for the other outcomes do not provide significant results most likely due to small sample sizes.

for access to higher-level health facility. The results for SBA (Column 4) indicate a similar tendency, though of marginal significance due to a small sample size. These results suggest that neither having a good road nor gaining a new facility achieves the increase in maternal care utilization, and thus road infrastructure and health facility network have an important complementary effect on maternal care demand.

However, no such heterogeneous effect is found for the lower-level facility. The estimated impact of the uninteracted indicator for the access to lower-level health facility is significantly positive, suggesting that basic clinics can promote regular antenatal care even if the village does not have good road connection to the nearest district town (Column 1). This makes sense as these basic clinics are likely to be built in every parish, which can be reached on foot in many cases. These results suggest that the condition of road infrastructure is less likely to matter in enhancing the use of antenatal care by expanding the community-level basic-type health facilities.

Lastly, we have examined the long-term impact of having a new health facility on maternal care use in later years using the lagged variables of the three measures of access to health facility. More specifically, we have attempted to estimate the impact of the lagged availability measures of health facilities by adding a set of one-year lags for the three access measures, a set of three-year lags and a set of five-year lags, and so on. The results however indicate that demand responds quite sharply once a new facility opens up, and thus no lagged take-up increase is observed (results not shown).

6 Conclusion

At the turn of the 21st century, the world leaders pledged to reduce the maternal mortality ratio by three quarters of the 1990 level by 2015, and the efforts will continue as the new Sustainable Development Goals have been set for 2030. However, successful stories have been limited, and the goal was not met by the majority of Sub-Saharan countries. This paper has investigated the roles

Table 5: Impact of improving access to health facilities-Road quality heterogeneity: Mother fixed effects model

	(1) 1 if regular antenatal care	(2) 1 if facility delivery	(3) 1 if SBA at a facility	(4) 1 if SBA
Number of public higher-level facility per parish	0.19	-0.18	0.02	-0.08
	(0.87)	(-0.59)	(0.06)	(-0.23)
All-whether road × Number of public higher-level facility per parish	0.02	0.42*	0.29	0.40
	(0.11)	(1.72)	(1.00)	(1.47)
Number of public lower-level facility per parish	0.21*	0.02	0.02	0.00
	(1.87)	(0.13)	(0.13)	(0.02)
All-whether road × Number of public lower-level facility per parish	0.02	0.10	0.07	0.09
	(0.18)	(0.76)	(0.62)	(0.76)
Number of non-public facilities per parish	-0.31	0.29	0.38	0.29
	(-1.03)	(1.27)	(1.47)	(1.13)
All-whether road × Number of non-public facilities per parish	0.17	-0.18	-0.26	-0.21
	(0.72)	(-1.03)	(-1.16)	(-0.96)
Observations	923	1,935	1,935	1,910
R-squared	0.07	0.44	0.45	0.46
Number of Mothers	453	784	784	781
P value: joint significance for road dummy and its interaction with higher-level public facility	0.826	0.0865	0.0336	0.0407
P value: joint significance for the higher-level public facility the interaction term	0.491	0.0134	0.00188	0.00308

Notes:
1). Robust t-statistics in parentheses
2). Significance level: *** p<0.01, ** p<0.05, * p<0.1
3). Standard errors clustered at sub-county level. All regressions include a constant term.
4). Regression for Column 1 includes region-year interactions because of limited sample size. The regressions for the reaming outcomes include year-district interactions. Road condition takes one if the road to the nearest district town is passable in all types of wether.
5). All regressions include age at pregnancy, its squared term, a set of dummies indicating parity, log of per capita landholding, three dummies indicating poverty quartiles based on household assets and durables.

played by the expansion of a national health facility network in improving maternal care utilization as well as infant and maternal health. We have also analyzed how the patterns of transportation to maternal care places have changed.

Applying the sub-county and mother fixed effects models to the decade-long panel data from Uganda, we have demonstrated the improvement in access to public health facility leads to more maternal care use and better maternal and infant health. In particular, an additional higher-level public health facility in a sub-county brings about a 9-percent increase in delivery with SBA at a formal facility. This is accompanied by an increase in the proportion of mothers who walk or ride bicycles to delivery places, without spending on transportation for delivery. There is weak evidence that newly opened higher-level facilities save relatively small babies who would not have survived without them, therefore lowering the birth weight of newborns.

Another major finding is that an additional lower-level public health facility raises the probability of regular antenatal care in every trimester, and also decreases the incidence of complications during delivery. An additional lower-level facility per parish reduces the incidence by 12 percentage points, which are equivalent to a 75-percent improvement. Since the lower-level facility is not supposed to handle delivery or provide comprehensive antenatal care, these results indicate that regular checkup enables early diagnosis and referral of risky cases, which in turn helps mothers to avoid serious complications.

While these benefits of lower-level clinics are enjoyed by all the villages which gain access to them, the effects of higher-level facilities are limited to villages with good road connections to the nearest district towns. This contrast implies the complementary impact of transportation infrastructure and higher-level health facilities. Overall, the estimates imply that 32 percent of the actual decrease in the incidence of maternal complications and 9 percent of the actual increase in the proportion of pregnancies taken place in formal facilities with SBA are explained by the improvements in access to

lower-level and higher-level facilities, respectively.[25]

These findings demonstrate differential roles played by community-based clinics and more equipped facilities. They crucially highlight the roles played by accessible community-level facilities which induce pregnant women to have regular contact with health practitioners and mitigate preventable maternal problems. Accessible higher-level facilities on the other hand increases the utilization of professional delivery services, which is likely to reduce maternal mortality and morbidity. These results underscore the importance of widening the coverage of the health system, and particularly that of lower-level health facilities which connect mothers in remote areas with the national health service network.

[25]Per-parish availability of lower-level facilities increased by 0.06 between 2005 and 2011. The mother fixed effects estimates predict the incidence of complications fall by 0.78 percentage points. Compared to the actual reduction achieved between these years, 2.42 percentage points, the impact of improved access to lower-level facilities explain 32 percent of the actual decrease in the number of complications. Similarly, higher-level health facilities increased by 0.07 between 2001 and 2011 and the proportion of pregnancies delivered at formal facilities with SBA increased by 24 percentage points from the initial 42 percent. A similar calculation indicates that 9 percent of the actual increase in this maternal care investment (or 2.2 percentage points) is accounted by the improved access to higher-level facilities.

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Appendix

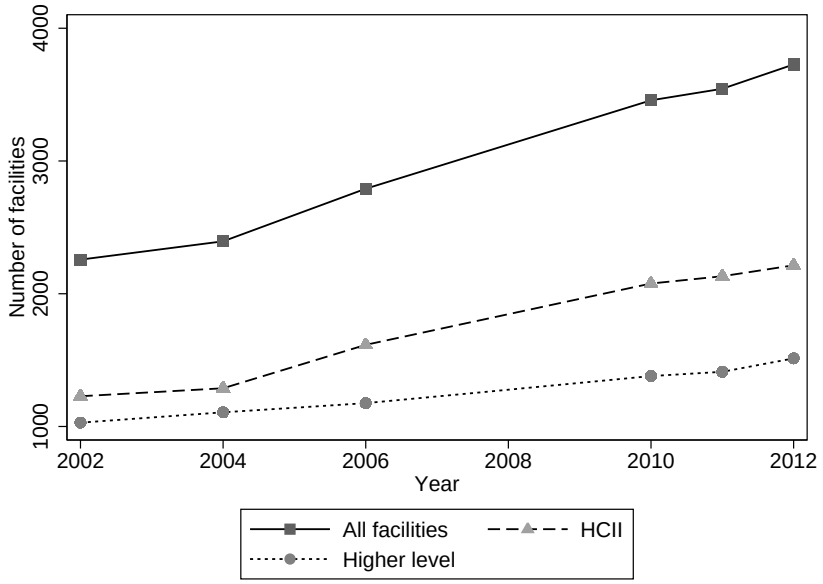

Figure A1: The total number of health facilities in Uganda except for the capital city (Kampala): 2002-2012

Source: The Health Facility Inventory 2002, 2004, 2006, 2010, and 2012

Notes: Facilities are divided into Health Center II (HCII) and the rest of the facilities including Health Centers III, IV, and V. HCII is expected to cover a parish, while HCIII is to cover a sub-county. HCIV and HCV cover a county and district, respectively. While HCII does not provide full maternity care, all the other types of HCs provide it.

Table A1: Summary statistics: sub-county-level data

Variable	Obs	Mean	Std. Dev.
Number of public higher-level facilities per parish	938	.22	.15
Number of public lower-level facility per parish	938	.27	.29
Number of private facilities per parish	938	.16	.17

Source: Uganda health facility inventory data.

Notes:

Theoretically, the number of observations can be 87 sub-counties * 13 years (2000-2012)=1131. However, the number of observations above is smaller than that because some sub-counties do not provide pregnancy observations in each year. Nevertheless, the mean and standard deviation do not differ from the case where we include all the 1131 observations except for private facilities whose mean and standard deviation are 0.17 and 0.22 in that case.

Table A2: Summary statistics: individual- and household-level data

Variable	Obs	Mean	Std. Dev.
A. Outcome variables			
1 if at least one antenatal care visit	2397	.93	.25
1 if at least one antenatal care visit in every trimester (regular antenatal care)	1299	.43	.5
1 if delivered at facility	2334	.57	.5
1 if delivery was attended by skilled birth attendant (SBA)	2293	.56	.5
1 if delivered at facility with SBA	2286	.54	.5
1 if complication happened during delivery	1365	.16	.37
1 if baby weight was measured	1358	.56	.5
Baby's birth weight (Kg)	701	3.44	.81
1 if birth weight < 2.5Kg	701	.08	.26
1 if baby was perceived to be bigger than others by mother	1301	.48	.5
1 if walked or used own bicycle to the place for antenatal care	2353	.65	.48
1 if walked or used own bicycle to the place for delivery	1472	.44	.5
Travel time for antenatal care (minutes)	2237	50.41	43.66
Travel time for delivery (minutes)	1338	38.5	42.95
Transportation fee for antenatal care (Shillings)	1452	1276.27	2863.49
Transportation fee for delivery (Shillings)	1121	3337.42	7755.46
1 if paid for transport for antenatal care	1452	.5	.5
1 if paid for transport for delivery)	1121	.63	.48
B. Mother and household characteristics			
Age at pregnancy	2399	28.09	7.34
Parity	2343	5.04	3.03
Completed years (grades) of education	2374	4.9	3.28
1 if no formal education	2374	.16	.37
1 if some primary education	2374	.51	.5
1 if completed primary education	2374	.18	.39
1 if more than primary education	2374	.15	.35
1 if household falls in the 1th quartile	2406	.26	.44
1 if household falls in the 2th quartile	2406	.27	.44
1 if household falls in the 3th quartile	2406	.24	.43
1 if household falls in the 4th quartile (richest)	2406	.23	.42
Altitude of household location (1000 meters)	2404	1.31	.28
log household land size (per capita acres)	2385	-1.08	.95
1 if roads between the village and the nearest district town can be used under all types of weather	2385	.84	.37

Source: The RePEAT study 2003, 2005, 2009 and 2012.

Notes:

1) A formal facility includes both governmental and private facilities. Delivery at home or attended by a traditional birth attendant (TBA) is not included in the delivery at facility.

2) Skilled birth attendants include a midwife, nurse, or doctor, but excludes a TBA, relative, or Village Health Team (VHT, or HCI).

3) Regular care refers to receiving antenatal care at least once in every trimester.

4) The quartile poverty indicators are computed based on the value of assets and livestock owned at the time of the survey. The value observed in the most current previous wave is assigned to each year.

5) Information on household land size is available for each year because the RePEAT asked the year in which each of the household land parcels was purchased or sold. We use this information to construct household land size in each year.