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Does Antenatal Care Matter in the Use of Skilled Birth Attendance in Rural Africa: A Multi-country Analysis

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- The effect of antenatal care on skilled birth attendance is biased downward in all four countries if endogeneity is not taken into account;
- We observed also that this effect is mediated by the quality of antenatal care service in Kenya and Uganda but not in Ghana and Tanzania;
- Women's level of education influence both the quality of antenatal care received and the delivery with professional;
- Distance to health facility has negative effect on skilled birth attendance in all countries.

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# Does Antenatal Care Matter in the Use of Skilled Birth Attendance in Rural Africa: A Multi-country Analysis

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**Abstract**

While the importance of antenatal care for maternal and child health continues to be debated, several researchers have documented its impact on intermediate variables affecting survival such as birth weight. These studies have also highlighted the problems of causality that are typically not taken into account when estimating the effects of antenatal care on skilled birth attendance. In this study, we revisit this relation in the rural areas of four countries: Ghana, Kenya, Uganda and Tanzania. Using a structural equation modeling approach that corrects for endogeneity, in all four countries we find that the usual simpler probit (or logit) models tend to underestimate the direct effect of antenatal care on skilled birth attendance. Furthermore, in two of the countries, this estimated effect is mediated by the range of services offered to women during antenatal care. These results suggest that governments and NGOs should place more importance on the role of antenatal care providers and on the services they offer, in efforts to promote skilled birth attendance.

**Keywords**: Antenatal care; skilled birth attendance; quality of care; endogeneity; structural equation modeling; Africa; Ghana; Uganda; Kenya; Tanzania.

## Introduction

The importance of antenatal care (ANC) for the prevention of maternal and infant mortality in developing countries is an ongoing debate (Villar et al., 2001). Beyond its role of detecting malformation problems and other risk factors, antenatal care can also be a means of educating women on the advantages of giving birth in medically-controlled conditions (de Bernis et al., 2003). In areas where skilled birth attendance (SBA) remains uncommon, this second role is far from negligible in importance, as the timely use of qualified personnel reduces the risk of

death for both the mother and newborn (de Bernis et al., 2003; Gabrysch & Campbell, 2009; Say & Raine, 2007). By increasing the use of formal health services at delivery, antenatal care can have an indirect influence on the survival of mothers and children.

The effect of antenatal care on women's decision to seek skilled birth attendance has received less attention by researchers than its impact on maternal and child health outcomes (Guilkey et al., 1989; Jewell & Rous, 2009). The few studies examining this association have revealed a positive effect of the frequency (de Allegri et al., 2011; Gage, 2007; Guliani et al., 2012; Stephenson et al., 2006) and the content/quality (Barber, 2006; Bloom et al., 1999; Nikiema et al., 2009; Rockers et al., 2009) of antenatal visits on births attended by qualified practitioners or occurring in a health center. Three pathways may explain the relationship between antenatal care and skilled birth attendance: through the quality of services provided and the information given to women (Akin et al., 1995; Nikiema et al., 2009); by increasing their familiarity with medical personal and thus reducing the "psychological costs" related to seeking their services (Barber, 2006); and by creating or reinforcing habits to make use of this care (Luszczynska & Schwarzer, 2005; Zerai & Tsui, 2001).

Studies on the topic must deal with difficult measurement issues. The number of consultations – by far the most common indicator used to measure antenatal care – does not differentiate women in terms of differences in the quality or range of services received (Bloom et al., 1999) or of their specific motivations, such as perceiving pregnancy complications that underlie their frequency of visits (Ram & Singh, 2005). By defining a composite indicator relating the frequency of ANC care to its content, Bloom et al. (1999) have shown that urban Uttar Pradesh women in the highest quartile of this indicator, whose use is deemed "adequate", are on average four times more likely to deliver in the presence of trained staff than women in the

lowest quartile. With composite indicators, however, it is not possible to separate out which part of the effect on recourse to skilled birth attendance is due to the frequency rather than to the quality of antenatal care (Barber, 2006; Rockers et al., 2009). Nor can they throw light on the relationship linking the frequency of care visits to the quality of the services (Rani et al., 2008).

Aside from questions of measurement, a major problem with previous studies on the relation between antenatal care and medically assisted childbirth is their failure to take into account possible endogeneity biases (Frick & Lantz, 1996; Rockers et al., 2009). There are several reasons to believe that the decisions to seek antenatal care and qualified help at delivery (or to give birth in a health center) are interrelated. First, various characteristics of women or their households such as schooling attainment or income can explain why women may opt for both types of care. For instance, Nikiema et al. (2009) argue that women wishing to give birth in a health center are also those who make the most use of ANC services. In this case, unless we are able to include all the characteristics influencing the use of both of these services, there will be a simultaneity bias in the estimated effect of antenatal care on skilled birth attendance (Cramer, 1995; Joyce, 1994). Analyzing the influence of antenatal care on birth weight, Joyce (1994) showed that women who receive adequate care are different from other women with regard to certain unobservable factors which, if not taken into account, cause the effects of antenatal care to be underestimated. As a consequence, women are likely to differ in terms of unobservable factors associated not only with the use of ANC care, but also with the quality of services received and their likelihood to use skilled personal for delivery (Nikiema et al., 2009; Rockers et al., 2009).

Concern over possible health problems may also affect both the demand for antenatal care and the likelihood of a skilled birth attendance, acting to bias the estimated impact of ANC on SBA in single equation models (Jewell & Rous, 2009). Thus, women experiencing complications

or worried about health problems may seek both antenatal care and skilled attendance at birth more frequently than other women (Bloom et al., 2001). However, expecting complications may, at times, have the opposite effect: deterring women from seeking formal care at delivery through fear of a caesarean section (Carter, 2010) or to avoid the direct and indirect costs of interrupting their normal activities. Thus, the direction of the bias cannot be known in advance, as it will depend on the dominant effect.

The antenatal care / skilled birth attendance association may also be partly explained by the existence of contextual factors that affect both phenomena simultaneously. This is the case when certain socio-cultural norms discourage women from using maternity services of any kind - antenatal care or skilled assistance at birth (Beninguisse et al., 2005; Sepehri et al., 2008; Stephenson et al., 2006). For instance, Beninguisse et al. (2005) describe cultural practices that restrict access to antenatal consultations during the first months of pregnancy in some contexts in Cameroon, where women have to hide their pregnancy to avoid attracting the attention of "evil spirits." These norms also place a high value on natural, "non-medicalised" childbirth. In contrast, most awareness campaigns promote both antenatal care and skilled birth attendance (Guilkey & Hutchinson, 2011).

Qualitative research has shed some light on the endogenous nature of the antenatal care variable. Women may make antenatal visits to verify how their pregnancy is progressing and, once reassured, they may not necessarily seek skilled help for the birth itself (Amooti-Kaguna & Nuwaha, 2000). A variety of reasons may underlie these decisions, and the researcher is not always aware of them. Some women may be seeking a kind of assurance vis-à-vis their community so as to avoid personal blame should their pregnancy end badly (Carter, 2010). In communities that prize childbirth without medical assistance, women may use these services to

make sure that the pregnancy is progressing without complications. In addition, antenatal visits can be planned ahead of time (for example, coinciding with a trip to a local market), something that is more difficult to do for childbirth. In cases where health care is not easily accessible, a woman may opt for antenatal care so as to reduce the need for SBA. Finally, antenatal care can act as a guarantee of a hospital birth should the need arise, as women will be registered in the health system (Myer & Harrison, 2003).

While these methodological issues have been recognized by many studies, to our knowledge no attempt has been made to address them through the use of appropriate methods applied to cross-sectional data. This study aims to re-examine this relationship by using methods that correct for the effects of unobserved factors that may bias the estimated effect of ANC care on skilled birth attendance. In this paper, we will address both the methodological and substantive limitations of existing studies. From a methodological standpoint, we test for unobserved heterogeneity in the relationship between ANC and SBA using a recursive biprobit model (Babalola & Kincaid, 2009), and we compare the results with those of a simple probit model. A full structural equation modeling (SEM) approach is then used to understand how the services received during ANC visits may explain the relation between ANC care and SBA, again after accounting for the effects of possible endogeneity. By comparing the results, we can assess their robustness and more accurately the true causal effects of ANC care on SBA in a non-experimental design setting.

## Data and methods

### *Data and selected countries*

The study is based on publicly accessible large DHS data sets that passed all ethical reviews and which are carefully designed to ensure the complete confidentiality of respondents.

Data are from four Demographic and Health Surveys (DHS). The DHS apply multi-stage stratified probability based sampling to provide nationally and rural/urban representative samples of women of reproductive age. These surveys used standardized questionnaires that allow for a comparison of results across countries, and collected data on various dimensions of antenatal care and skilled birth attendance, and on women's individual, household and community characteristics. An assessment of DHS data from 1993 to 2003 with respect to child health and antenatal care revealed the data are of high quality with relatively few missing values (Pullum, 2008).

The analysis focuses on the rural area of four countries: Ghana (DHS-2003), Kenya (DHS-2003), Uganda (DHS-2006) and Tanzania (DHS-2004/2005). This study is part of a broader project that aims to link DHS and SPA (Service Provision Assessment) data[i] to highlight the importance of supply side variables, and that was an important reason for selecting these specific countries for the analysis. In addition, while the four countries are classified as having high or very high levels of maternal mortality and face similar challenges in terms of health care provision (Rajaratnam et al., 2010; WHO, 2012), their situations are varied in regard to key variables[ii]. Some have experienced continuous and sustained improvements in maternal and child health (Tanzania), while others have experienced reversals in recent years (Kenya). In regard to current levels of maternal and infant mortality, Ghana and Kenya are characterized by relatively better prospects of survival than Uganda and Tanzania. To some degree, these varied contexts reflect the diversity that exists across sub-Saharan Africa, allowing us to better gauge the robustness of our results.

Our analysis focuses on women who had a live birth in the five years preceding the survey, and is restricted to rural areas where the use of health services is relatively low, access to

care more difficult and the consequences of non-use more dramatic. The analysis covers 1814 women in Ghana, 2662 in Kenya, 4223 in Tanzania and 4164 women in Uganda (Table 1).

***Variables***

The independent variables were selected based on a modified version of the Gabrysch and Campbell's (2009) conceptual framework. These authors distinguished four sets of factors related to skilled birth attendance, namely socio-cultural factors (age, marital status, education…), the perceived benefits/needs (quality of care, pregnancy wanted, previous use of health services…), economic accessibility (work status, household wealth…) and physical accessibility (distance to health care, rural/urban). These and similar variables have been shown to influence the use of antenatal care in developing countries (Simkhada et al., 2008).

In addition, three community-level variables were used in the analysis. Service accessibility is measured indirectly by means of a question asking women if the distance to a health center was a barrier to service use (not asked in Kenya's DHS), and the variable used in the regressions is the proportion of women in each survey cluster who judged distance to be a serious problem. We also estimated the proportion of women in each community with at least a secondary schooling (Kravdal, 2002), and the proportion of households with children under five years of age, which serves as a proxy for fertility norms and the persistence of "traditional" practices in the community (Stephenson et al., 2006). Each of these variables was grouped in three quantiles.

Three dependent variables were used in the analysis. First, the skilled birth attendance is measured as whether the delivery took place in presence of qualified personnel: a doctor, nurse, midwife, auxiliary midwife or trained birth attendant. Second, antenatal service use is assessed in terms of the number of ANC visits and the range of services received. The number of visits is

dichotomous, set to 1 if the woman has made four or more antenatal consultations (the WHO recommendation), and 0 otherwise. The content of antenatal care variable was calculated from women's responses to eight questions on the information given to them during consultations (regarding possible complications and the type of assistance in case complications arise) and about the range of services offered (measuring pregnancy weight and height, blood pressure, taking urine and blood samples, and receiving anti-tetanus vaccination). This information was grouped into four categories, from low service content (less than 5 services) to high service content (7 to 8 services). This measure of content of care is related to the perceived quality of care received, in the sense that one cannot attain a high quality of care in a low health service setting. Table 1 summarises the definition of the variables and presents the descriptive statistics.

***Explanatory model***

Three regression models were estimated for each country. The simplest model (model 1) is a single equation probit model to estimate the determinants of SBA, with independent variables including the use of ANC and the set of other covariates described above. This approach does not take into account the potential endogeneity of antenatal care, and is similar to the approach used by many other studies to examine the factors underlying skilled birth attendant use. Model 2 use a recursive biprobit model to estimate simultaneously the determinants of both antenatal care and skilled birth attendance. This approach tests the fact that ANC care may be endogenous and corrects for possible resulting biases. Model 3 adds a third equation to the model to account for the content of antenatal care. This is a structural equations model (SEM) with three equations to assess the mediating effects of the content of antenatal care on SBA and, at the same time, control for possible endogeneity biases. This approach makes it possible to test whether care is offered in different ways depending on a woman's demographic, social or economic status, as other studies

have suggested (Zanconato et al., 2006). For all models, the Huber-White procedure is used to estimate consistent standard errors and thus significance levels, in the context of statistical dependence between individuals residing in the same sample cluster.

Estimating the systems of equations in models 2 and 3 requires imposing the so-called exclusion rule for identification (Maddala, 1983)[iii]. With regard to controlling for the endogeneity of ANC in the case of model 2, the "debut of antenatal care" is a suitable variable to fit the exclusion criteria. Debut of antenatal care affects the number of antenatal visits in the sense that, the later the care begins, the fewer the number of visits that will generally occur during the nine months of pregnancy (Carter, 2010). On the other hand, this variable should not have a direct influence on the decision to seek qualified help for the delivery. In that sense, several authors point out that women in rural areas of Africa are often unaware of the benefits of an early debut of antenatal care (Myer & Harrison, 2003). Table 2 provides a Wald test of exogeneity for this variable and shows that we can reject the null hypothesis that "debut of antenatal care" is a weak instrument for the estimation of model 2, as the minimum eigenvalue statistic far exceeds its critical value of 16.38 in all four countries (Stock & Yogo, 2005).

In Model 3, at least one additional excluded variable is needed to correctly identify the determinants of skilled birth attendance relative to the content of care. The variables related to the provider of ANC care and the location of this service were selected for this purpose. These two variables are likely to influence the content of care without having any direct influence on skilled birth attendance. The relevance of these variables (instruments) are again assessed following the approach adopted by Babalola and Kincaid (2009) and Guilkey and Hutchinson (2011) by testing the significance of the exclusion variables in the reduced form equations. The results show a strong effect of both or one of these variables on the content of care but not on skilled birth

attendance, indicating that the restriction criteria for model 3 are valid. For Ghana, both variables appear to be valid instruments, and using one or the other provided essentially the same results. In the other three countries, only one of the two variables met the exclusion restriction well, and that one was used in the model (for details, see Adjiwanou, 2013, forthcoming or the supplemental tables) [INSERT LINK TO ONLINE FILES].

**Results**

Table 1 presents the descriptive statistics for the analysis sample. The proportion of women in rural areas who had four or more antenatal visits ranges from 46% in Uganda to 63% in Ghana. Skilled birth attendance was consistently lower, ranging from 32% in Ghana to 51% in Tanzania.

***Effects of the frequency and content of antenatal care on SBA***

Table 2 presents regression coefficients and significance levels from the three models for the effect of antenatal care frequency and content on skilled birth attendance in the four countries; the estimates of the effects of the other variables in the regressions are not included in this table. Model 1, the "standard" single equation model that does not control for endogeneity biases, reveals a positive effect of the number of antenatal consultations on SBA – effects that are highly significant in all countries except Tanzania.

Model 2 computes the recursive bivariate probit model that corrects for endogeneity biases with respect to antenatal care. The significance of the rho coefficient (for the correlation between the error terms of the two equations) reveals that external unobservable factors influence the use both of antenatal services and of skilled attendance during childbirth in Kenya and, to a lesser extent, in Tanzania. The estimated coefficients for the effects of antenatal care are always greater in this model than in model 1. Differences are relatively high for Kenya and slightly less

so for Tanzania, suggesting that the standard model considerably underestimates the impact of antenatal care on the decision to seek skilled birth attendance in those countries. Propensity score matching model estimates also show a positive effect of ANC care in Tanzania (results not shown). Similarly, a Rosenbaum Bounds sensitivity analysis performed on our data reveals that the effect in Tanzania may be biased downward (See Adjiwanou, 2013, Forthcoming). In Kenya and in Ghana, the estimated marginal effects indicate that women who have had at least four antenatal consultations are, respectively, 20% or 17% more likely to be delivered by qualified practitioners than women with less frequent care. In the other two countries, differences were on the order of 10%.

The statistics in Table 2 also suggest that the content of antenatal care plays an important role in the decisions women take with regard to type of delivery. In all four countries, content of antenatal care is seen to increase the likelihood of a skilled delivery. Models 1 and 2 consider this effect to be additive to the number of visits. As discussed earlier, it may be that the influence of the content of care depends itself on the number of services women received, and that this content measure may itself thus be somewhat endogenous. In fact, respondents' memory of this information could be affected by both observed and unobserved factors which could act to bias the estimated effects. If true, to obtain correct estimates, the content of antenatal care must be explicitly estimated by the model. The third model does this, taking into account both endogeneity and the mediating effect of the content of antenatal care. The results of this model reveal a very large increase in the estimated effect of antenatal care content in Kenya and less so in Uganda, causing the impact of the frequency of visits to largely disappear there. In contrast, the effect of antenatal care frequency remains significant in Ghana, whereas in Tanzania, neither

the frequency of antenatal care visits nor the content of care has a significant impact on SBA (model 3, table 2).

**[Table 2 here]**

To facilitate the interpretation of these results, simulations were carried out at the level of each individual based on the results of model 3. Table 3 presents the predicted means of the marginal effects arising from this model. The results indicate that if all women had enjoyed a high content of antenatal service (level 4 – almost all services), the probability of skilled birth attendance for the most recent birth would have increased on average by 7% in Ghana (in addition to the 18% due to the frequency of antenatal care), 38% in Kenya, 25% in Uganda and 27% in Tanzania. Considering that the present level of skilled birth attendance exceeds rarely 50% in these countries, this indicates that a remarkable gain could be achieved simply by improving the quality of antenatal care. In all countries but Ghana, the gain far exceeds that estimated for four antenatal consultations by model 2, showing that not only the frequency, but also and to a considerable degree the quality of antenatal care, matters.

The coefficient estimates for most of the control variables in Table 3 were of the hypothesized signs and statistically significant, with some little differences between the countries. For example, women with secondary or higher education have a high probability of skilled birth attendance in Kenya and in Uganda, whereas their partner's level of education has a positive and significant influence in Ghana and Uganda. In addition, even after controlling for the educational attainment of the spouses, in all four countries, those residing in areas with higher levels of educational attainment are more likely to seek SBA. We also find that, for women who had given birth previously under medical supervision, the estimated probability that they would seek care from qualified personal at their most recent pregnancy would rise by 39% in Ghana,

23% in Kenya, 38% in Uganda and 41% in Tanzania, compared to women who did not. Finally, sample clusters in which women generally perceived distance to care to be a serious problem were, not surprisingly, those where recourse to skilled birth attendance was lower.

**[Table 3 here]**

***Determinants of antenatal service received***

Table 3 presents the full set of results for model 3. The results provide evidence that the content of antenatal services received by respondents improves as their frequency of antenatal visits increases. More concretely, if all women reached at least four antenatal services consultations, the estimated probability that almost all services would be received would increase by at least 25% in all four countries. This relationship is, however, more complicated than it appears, as the probability of reaching the required number of visits is, itself, influenced by the quality of the service women received during preceding visits (Rani et al., 2008). The signs and significance of the rho statistic between antenatal care frequency and the content of this care for all countries confirm that contention. Lower quality services may incite women to cease seeking out antenatal care altogether, whereas a better quality of care and range of services provided may increase their expectations and enthusiasm for future antenatal visits.

In regard to the characteristics of maternal health care services as perceived by local users, the results indicate that service content is greater when dispensed by a doctor in all countries but Ghana. They also show that the content of antenatal care is significantly associated to the service venue. When care is provided in locations other than health centers, women tend to

report having received fewer services. In addition, the content of antenatal care in Tanzania is significantly higher when provided by the private rather than the public sector.

The impact of socio-demographic variables on antenatal care varies from country to country. In Ghana and Kenya, the effects of age, number of children and birth interval on the content of care are not significant. In Uganda, on the other hand, age has a positive effect and, in Tanzania, high parity women tended to receive a lower content of antenatal care. In all four countries, however, the content of care depends on the woman's level of education or on her economic status. In Ghana, for example, if all women attained secondary schooling, the probability that they receive the whole range of services would rise by 13%, in comparison to women with no schooling, holding all other factors constant. The equivalent increase would be 11% in Uganda, and 10% in Tanzania, while in Kenya, women's schooling appears to have no effect. Women living in wealthier households are more likely to report having received a higher content of ANC services in Ghana, Kenya and Tanzania. However, the overall effect of household economic status is relatively modest, with the largest observed effect occurring in Kenya, where women from the richest households are 9% more likely to enjoy good services compared to those from the poorest households.

**Discussion**

This study aimed to analyse the impact of antenatal care on skilled birth attendance in rural Africa, while attempting to correct for problems of endogeneity in the use of antenatal care. We estimated a structural equations model that separates the effect of the number of visits from that of the content of antenatal care, and delineates the determinants of the content of antenatal care and the decision to seek skilled attendance at birth in the rural areas of four sub-Saharan

African countries. These results are compared with those estimated from simpler models to assess the likely effects of biases when these issues are not taken into account. The results of this study are relevant to maternal health policies and programs in the least developed countries of the world, where maternal health services remain relatively less used and the importance of antenatal services is under debate (Campbell & Graham, 2006).

Our findings point to a significant and positive effect of the number of antenatal consultations on skilled birth attendance in the four countries studied (model 2). In the two countries where results confirm the presence of endogeneity – Kenya and, to a lesser extent, Tanzania – the estimated effects of this variable are larger than those obtained when endogeneity is not taken into account. In Tanzania, for instance, women who had at least four antenatal consultations were estimated to be 11% more likely to give birth with medical assistance after accounting for endogeneity, while the effect was substantially smaller and statistically insignificant when estimated by the simpler model. Clearly, in contexts where endogeneity is important, the true impact of antenatal care on skilled birth attendance cannot be properly measured without addressing its effects. These results corroborate those of other studies that report a similar underestimation of the effect of antenatal care on various health outcomes, when simpler models are used (Guilkey et al., 1989).

Although the endogenous nature of the antenatal care variable has been demonstrated both theoretically and empirically, defining in a justifiable manner the exclusion restrictions that are necessary to adequately model the effects of endogeneity remains a particular challenge. The different approaches adopted in this study aim to provide a meaningful way to better measure the effects of antenatal care on skilled birth attendance. In that sense, the diversity of the results

found here should steer authors to systematically test for endogeneity in their empirical work – something that generally has not been done by previous studies (Hutchinson & Wheeler, 2006).

Several explanations have been put forward to account for the effects of antenatal care on the subsequent decision to give birth in a medically qualified environment. By explicitly testing the mediating effect of the content of antenatal care provided to women, the impact of the number of ANC visits on skilled birth attendance was seen to be largely mediated by the content of antenatal care in both rural Kenya and Uganda. In fact, the estimated effect of frequency of antenatal care *per se* was considerably smaller and lost its significance in those countries. Other studies have similarly reported a loss of statistical significance of the antenatal care effect, once a mediating variable are taken into account (Guilkey et al., 1989; Rockers et al., 2009). For instance, in their study of the Philippines, Guilkey and colleagues (1989) found that the estimated effect of antenatal care on birth weight was no longer significant, once the intermediate variables for birth weight were controlled for.

Findings for Ghana and Tanzania differ from those for the other two countries. In Ghana, the estimated effect of the number of antenatal visits remained important and essentially unchanged after accounting for possible endogeneity, whereas the content of care appears to have no effect on skilled birth attendance. The Rosenbaum sensitivity analysis showed that the effect of antenatal care on SBA was more pronounced in Ghana than in the other three countries. It is possible that other avenues of influence of antenatal care on SBA are more important in this specific context. In Tanzania, neither the estimated effects of frequency nor of content of antenatal care are statistically significant, even though the effect of the latter variable is sizable. This may perhaps be explained by the fact that the health care services in Tanzania are more accessible than in the other three countries (although often of relatively low quality see Musau et

al., 2011), as 90% of women live less than 5 km from a health center (Musau et al., July 2011). In any case, the effects of ANC care are probably even more complicated than those modelled here, and their impact is surely conditioned by the specific contexts that exist in each country. More research is needed to better understand how quality of care influences the frequency of care and decisions to seek SBA in differing policy, service and socioeconomic contexts.

Before concluding, it is important to note a number of methodological limits to this study. First, we were unable to examine the inverse effect of the quality of care on the decision to have at least four antenatal consultations with the data available, although service quality obviously influences the decision to make subsequent visits (Trinh et al., 2007). Second, even if the content of the services received as reported by women can be viewed as a proxy for quality of care, a better measure would be less subjective and take into account the interpersonal relationships between clients and practitioners, as well as the confidentiality of the care provided and the satisfaction of clients (Bruce, 1990). Again, this information was unavailable in our data. Finally, the time-lag between the use of services and the date of the survey may have affected the precision of self-reported information on the content of antenatal care. That said, a study carried out in many African countries comparing the quality of information provided by respondents for different time-lags did not reveal the presence of important recall errors (Nikiema et al., 2009). The fact that the mean duration between the last birth and the survey was less than 24 months in all countries, that the questions were addressed only with regard to the index (last) child and the empirical modelling approach used in this study should act to limit the extent of possible measurement error biases in our results.

Our findings point to two levers which could help improve the use of skilled birth attendance. First, they suggest that it is highly important that the quality of antenatal care be

improved. As other studies carried out in various countries have demonstrated, women are still not being systematically given adequate information during antenatal visits. The service providers who do so typically only cite the benefits of SBA and often make little attempt to understand the cultural practices and the social norms of the area and address women accordingly (Magoma et al., 2010). In addition, a higher priority should be placed on improving the range of services available to women most in need. Unfortunately, those women are often also those who are most disadvantaged when it comes to quality of care (Zanconato et al., 2006). For example, our results indicate that Tanzanian women who have already given birth to many children tend to receive a poorer set of services than others. We also find that women with lower schooling attainment tend to report a significantly lower content of antenatal care services in Ghana, Uganda and Tanzania. That said, compared with less-educated women, well-educated women may have a better recall of the services received, expect and insist on a higher quality of services, and they are more likely to be in a position to pay for good care. The differences in the services received by women's schooling further justifies the importance of estimating a separate equation for the content of care, as those who benefit most from antenatal care are likely to be a relatively select group.

Second, governments should place more priority on providing maternal health care services closer to the populations in need. Too often, care is difficult to access (Gabrysch & Campbell, 2009), and the lack of a strong association between antenatal care and skilled birth attendance may be partly explained by distance. Whereas antenatal care can be given in any circumstance and at any time, delivery may begin unexpectedly and distance from health care services may prevent women from seeking trained assistance, even when they want and can afford it. Policies targeting the demand for services alone may not suffice and guarantee the

desired decline in maternal and infant mortality (de Bernis et al., 2003). Improvements in maternal and child health in recent years could be attributed in large part to the improvement of the supply of care in the four countries studied, and the changes in the health policies with a greater decentralization in services in many countries since 2004.

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**Table 1: Means (SD) for analysis sample in Ghana (2003), Kenya (2003), Uganda (2006) and Tanzania (2004/05)**

| Variables Name | Remarks | Ghana | Kenya | Uganda | Tanzania |
|---|---|---|---|---|---|
| **DEPENDENT VARIABLES** | | | | | |
| Skill birth attendance° | | .323 (.019) | .370 (.018) | .399 (.014) | .506 (.016) |
| At least four antenatal visits ° | | .626 (.018) | .499 (.013) | .455 (.012) | .598 (.012) |
| Antenatal care starts the first trimester° | | .411 (.016) | .093 (.008) | .163 (.008) | .133 (.008) |
| Content of care - Low - less than 5 | Measure from: information on complication and recourse, women weight and height measured, blood pressure, urine and blood sample taken and anti-tetanic injection received. | .228 (.015) | .553 (.017) | .247 (.012) | .510 (.016) |
| 5 services received | | .106 (.009) | .192 (.009) | .205 (.009) | .146 (.007) |
| 6 services received | | .328 (.013) | .110 (.008) | .212 (.009) | .153 (.007) |
| High content - >=7 services received | | .339 (.018) | .145 (.010) | .336 (.012) | .191 (.012) |
| **INDEPENDENT VARIABLES** | | | | | |
| **SOCIOCULTURAL FACTORS** | | | | | |
| Women age at pregnancy - (*15-19 y*) | | .109 (.009) | .160 (.008) | .142 (.006) | .183 (.007) |
| 20-24 y | | .217 (.012) | .284 (.009) | .264 (.008) | .271 (.008) |
| 25-29 y | | .237 (.011) | .237 (.009) | .238 (.008) | .235 (.008) |
| 30-34 y | | .196 (.011) | .166 (.008) | .179 (.007) | .161 (.006) |
| 35-49 y | | .240 (.012) | .153 (.008) | .178 (.006) | .150 (.007) |
| Living with partner ° | | .896 (.009) | .832 (.009) | .838 (.007) | .866 (.008) |
| Number of living children before the index child–(*0*) | | .225 (.011) | .238 (.010) | .175 (.006) | .225 (.008) |
| 1 or 2 | | .344 (.013) | .359 (.010) | .316 (.009) | .372 (.009) |
| 3 or 4 | | .248 (.011) | .223 (.008) | .252 (.007) | .223 (.007) |
| 5 or more | | .184 (.011) | .180 (.009) | .257 (.008) | .180 (.009) |
| Previous birth interval - (*24-36 months*) | If the women had only one birth, they are put in the category "only one child" | .266 (.011) | .301 (.010) | .373 (.009) | .326 (.010) |
| Less than 24 months | | .094 (.009) | .157 (.008) | .192 (.007) | .122 (.007) |
| 36 months or more | | .451 (.014) | .336 (.011) | .291 (.008) | .370 (.011) |
| Only one child | | .190 (.010) | .206 (.010) | .143 (.006) | .182 (.007) |
| Religion –(*Catholics*) | In Kenya, others are put together with Muslims | .285 (.017) | .249 (.017) | .458 (.016) | .289 (.019) |
| Other Christians | | .406 (.021) | .645 (.020) | .346 (.013) | .304 (.020) |
| Muslims | | .170 (.021) | .106 (.015) | .095 (.010) | .230 (.021) |
| Others | | .139 (.016) | | .102 (.007) | .177 (.025) |
| Women Education - (*No education*) | | .469 (.025) | .146 (.017) | .239 (.012) | .288 (.017) |
| Primary | | .238 (.014) | .667 (.016) | .647 (.011) | .690 (.016) |
| Secondary and more | | .293 (.018) | .187 (.013) | .114 (.008) | .022 (.003) |
| Spouse education – (*primary or less*) | | .461 (.026) | | | |
| Middle | | .347 (.020) | | | |
| Secondary and more | | .102 (.010) | | | |
| Other, don't know or no partner | | .090 (.009) | | | |
| (*No education*) | | | .107 (.014) | .095 (.007) | .194 (.018) |
| Primary | | | .513 (.016) | .614 (.011) | .706 (.016) |
| Secondary and more | | | .287 (.014) | .228 (.010) | .049 (.005) |
| Other, don't know or no partner | | | .093 (.008) | .062 (.005) | .051 (.005) |
| **PERCEIVED BENEFIT/NEED** | | | | | |
| Antenatal care provider – Doctor | In Tanzania, doctor, nurse and midwife put together | .116 (.321) | .175 (.380) | .070 (.255) | .702 (.457) |
| Nurse. midwife | | .768 (.422) | .662 (.473) | .860 (.347 | |
| Others | | .115 (.319) | .163 (.369) | .069 (.254) | .298 (.457) |

| | | | | | |
|---|---|---|---|---|---|
| Venue of antenatal care - Public sector | In Tanzania, private and other put together | .806 (.396) | .620 (.486) | .748 (.434) | .851 (.356) |
| Private sector | | .076 (.265) | .220 (.414) | .183 (.387) | .148 (.456) |
| Others | | .118 (.323) | .160 (.367) | .069 (.253) | |
| Skilled attendance for previous birth (*No*) | The information is available for the last 5 years. | .281 (.015) | .306 (.014) | .385 (.011) | .254 (.014) |
| Yes | | .104 (.009) | .145 (.008) | .201 (.010) | .224 (.011) |
| Only one child in last 5 years | | .615 (.015) | .549 (.013) | .414 (.009) | .522 (.013) |
| Death of any previous child ° | 1 if number of living children < number of children. | .323 (.013) | .283 (.013) | .445 (.009) | .353 (.010) |
| Experiencing blindness during pregnancy° | 1 if difficulty with daylight vision or night blindness. | .210 (.015) | | .226 (.011) | .085 (.007) |
| Wanted pregnancy – (*wanted then*) | | .555 (.018) | .496 (.013) | .488 (.011) | .767 (.010) |
| Wanted later | | .263 (.014) | .261 (.010) | .340 (.010) | .175 (.009) |
| Wanted no more | | .181 (.013) | .243 (.011) | .173 (.008) | .058 (.005) |
| Exposure to radio - (*Never*) | | .186 (.016) | .191 (.014) | .218 (.010) | .310 (.014) |
| Sometimes | | .400 (.016) | .253 (.011) | .284 (.009) | .344 (.010) |
| Everyday | | .414 (.018) | .556 (.015) | .497 (.014) | .346 (.013) |
| **ECONOMIC ACCESSIBILITY** | | | | | |
| Women Employment - (*Agriculture*) | | .577 (.020) | .450 (.020) | .810 (.014) | .885 (.012) |
| Sales/services | | .211 (.014) | .167 (.010) | .087 (.008) | .012 (.002) |
| Others | | .124 (.010) | .064 (.006) | .049 (.004) | .048 (.007) |
| No employment | | .089 (.009) | .318 (.019) | .054 (.007) | .055 (.006) |
| Spouse employment – (*Agriculture or no employment*) | | .727 (.018) | .491 (.016) | .674 (.012) | .861 (.012) |
| Sales or services | | .105 (.010) | .246 (.011) | .178 (.008) | .047 (.005) |
| Skilled manual | | .168 (.014) | .262 (.014) | .148 (.008) | .093 (.009) |
| Wealth quintile – (*Lowest*) | Re-categorized from DHS wealth quintile measure. In Ghana, Middle is quintile>=3 | .367 (.023) | .258 (.018) | .245 (.016) | .256 (.015) |
| Second | | .309 (.019) | .256 (.013) | .242 (.011) | .257 (.012) |
| Middle | | .324 (.023) | .233 (.013) | .218 (.011) | .239 (.012) |
| Fourth and highest | | | .253 (.019) | .295 (.016) | .248 (.017) |
| **CONTEXTUAL VARIABLES** | | | | | |
| Proportion of women in each community with at least a secondary level of education | For women older than 20 years old. | .286 (.246) | .194 (.180) | .132 (.135 | .078 (.142) |
| Proportion of households with children under five years of age > rural mean | | .410 (.195) | .365 (.173) | .497 (.152) | .431 (.195) |
| Proportion of women who judged distance to be a serious problem for them to reach care | Question not addressed in Kenya. | .540 (.318) | | .623 (.252) | .446 (.286) |
| **N** | | **1814** | **2662** | **4164** | **4223** |

**Table 2: Coefficients and marginal effects of ANC care and content of care on skilled delivery by type of statistical model used and by country**

| Country | Model and description | Rho for ANC and SBA | Regression Coefficient | | | | Test for the instrument "debut ANC care"• |
|---|---|---|---|---|---|---|---|
| | | | At least four antenatal care (ANC) | Content of antenatal care | | | |
| | | | | 5 services received (Content 2) | 6 services received (Content 3) | 7 or 8 services received (High content) | Minimum eigenvalue statistic |
| **Ghana** | Model 1: Probit | | 0.66*** | 0.24 | 0.23* | 0.32** | |
| | Model 2 : Recursive biprobit | -0.00 | 0.67** [0,17] | 0.26 | 0.24* | 0.33** | 193,73$^{++}$ |
| | Model 3 : Structural equation model (3 eqn's) | | 0.70* | 0.24 | 0.21 | 0.27 | |
| **Kenya** | Model 1 Probit | | 0.26*** | 0.20* | 0.37*** | 0.44*** | |
| | Model 2 Recursive bi-probit | -0.30** | 0.72*** [0,20] | 0.20* | 0.35*** | 0.42*** | 124,39$^{++}$ |
| | Model 3 Struct equation model | | 0.13 | 0.61* | 0.98** | 1.39** | |
| **Uganda** | Model 1 Probit | | 0.32*** | 0.17* | 0.19** | 0.31*** | |
| | Model 2 Recursive bi-probit | 0.00 | 0.32* [0,10] | 0.17* | 0.19** | 0.31*** | 325.40$^{++}$ |
| | Model 3 Struct equation model | | 0.10 | 0.29 | 0.46 | 0.81 | |
| **Tanzania** | Model 1 Probit | | 0.06 | 0.17* | 0.11 | 0.35*** | |
| | Model 2 Recursive bi-probit | -0.18 | 0.34 [0,11] | 0.16* | 0.11 | 0.34*** | 230.32$^{++}$ |
| | Model 3 Struct equation model | | 0,19 | 0.41 | 0.45 | 0.90 | |

• Wald test of exogeneity; $^{++}$ statistics greater than the limit of 16,38; marginal effects in bracket. Significance at *p<.05, ** p<.01 and *** p<.001. All models controlled for independent variables.

**Table 3: Coefficients and marginal effects of SEM of respondent having had a skilled delivery and high ANC content, by selected countries, Final Model**

| Independent Variables | Ghana | | Kenya | | Uganda | | Tanzania | |
|---|---|---|---|---|---|---|---|---|
| | **ANC content** | **SBA** | **ANC content** | **SBA** | **ANC content** | **SBA** | **ANC content** | **SBA** |
| At least four antenatal visits + | 0.83*** [0.28] | 0.70* [0.18] | 0.99*** [0.29] | 0.13 | 0.71*** [0.26] | 0.10 | 1.00*** [0.35] | 0.19 [0.06] |
| Antenatal care provider – nurse. midwife (*Doctor*) | -0.13 [-0.04] | | -0.21** [-0.04] | | -0.20** [-0.06] | | | |
| Others | -1.42*** [-0.12] | | -0.78* [-0.08] | | -1.36*** [-0.14] | | | |
| Venue of antenatal care - private sector (*Public sector*) | -0.12 [-0.04] | | -0.03 | 0.20** [0.05] | -0.07 | 0.11 | | |
| Others | -1.21*** [-0.14] | | -1.50*** [-0.05] | -0.36* [-0.09] | -0.81*** [-0.16] | -0.37 [-0.10] | | |
| Antenatal care provider – (Doctor, nurse. midwife) Others | | | | | | | -0.29*** [-0.07] | -0.14 [-0.04] |
| Venue of antenatal care - (*Public sector*) Private sector or Other | | | | | | | 0.19** [0.05] | |
| Content of care - 5 services received (*Low - less than 5*) | | 0.24 [0.06] | | 0.61* [0.16] | | 0.29 [0.08] | | 0.41 [0.12] |
| 6 services received | | 0.21 [0.06] | | 0.98** [0.26] | | 0.46 [0.14] | | 0.45 [0.14] |
| High content - 7 services received | | 0.27 [0.07] | | 1.39** [0.38] | | 0.81 [0.25] | | 0.90 [0.27] |
| **SOCIOCULTURAL FACTORS** | | | | | | | | |
| Women age at pregnancy - 20-24 y (*15-19 y*) | 0.11 | | 0.04 | | 0.02 | | -0.02 | |
| 25-29 y | 0.01 | | 0.15 | | 0.21** [0.07] | | -0.01 | |
| 30-34 y | -0.04 | | 0.20* [0.05] | | 0.19* [0.07] | | -0.02 | |
| 35-49 y | 0.03 | | 0.20 [0.05] | | 0.31** [0.11] | | 0.03 | |
| Living with partner + | -0.02 | | -0.04 | | -0.08 | | -0.05 | |
| Number of living children – 1 or 2 (*0*) | 0.03 | 0.05 | -0.15 | -0.01 | 0.08 | 0.19 [0.06] | -0.19* [-0.05] | 0.07 |
| 3 or 4 | 0.09 | 0.07 | -0.17 | -0.19 [-0.05] | -0.17 [-0.05] | 0.08 | -0.23* [-0.05] | -0.02 |
| 5 or more | 0.22 [0.07] | 0.11 | -0.13 | -0.22 [-0.05] | -0.24 [-0.07] | 0.07 | -0.23* [-0.05] | 0.01 |
| Previous birth interval - less than 24 m (*24-36 months*) | -0.11 | 0.15 [0.04] | 0.08 | 0.11 | 0.07 | 0.06 | 0.06 | 0.01 |
| 36 months or more | -0.08 | 0.06 | 0.08 | 0.06 | 0.05 | 0.15* [0.05] | 0.23*** [0.07] | -0.06 |
| Only one child | -0.13 [-0.04] | 0.32 [0.08] | 0.06 | 0.49** [0.13] | 0.07 | 0.62*** [0.19] | 0.06 | 0.36** [0.11] |
| Religion – Other Christians (*Catholics*) | | 0.08 | | -0.08 | | 0.08 | | -0.06 |
| Muslims | | -0.10 | | -0.11 | | 0.32** [0.10] | | -0.09 |
| Others | | -0.17 [-0.04] | | | | 0.17 [0.05] | | -0.22* [-0.07] |
| Women Education - Primary (*No education*) | 0.19* [0.06] | -0.17 [-0.04] | -0.11 | 0.19 [0.05] | 0.05 | 0.02 | 0.20*** [0.05] | 0.04 |
| Secondary and more | 0.41*** [0.13] | -0.02 | 0.02 | 0.33* [0.09] | 0.33*** [0.11) | 0.29** [0.09] | 0.32** [0.10] | 0.14 [0.04] |
| Spouse education – Middle (*primary or less*) | | 0.21* [0.06] | | | | | | |
| Secondary and more | | 0.34* [0.09] | | | | | | |
| Other. don't know or no partner | | 0.05 | | | | | | |
| Primary (*No education*) | | | | -0.01 | | 0.14 [0.04] | | 0.02 |
| Secondary and more | | | | 0.15 [0.04] | | 0.24* [0.07] | | 0.16 [0.05] |
| Other. don't know or no partner | | | | 0.13 | | 0.19 [0.06] | | -0.17 [-0.05] |
| **PERCEIVED BENEFIT/NEED** | | | | | | | | |
| Skilled attendance for previous birth - Yes (*No*) | | 1.32*** [0.39] | | 0.88*** [0.23] | | 1.19*** [0.38] | | 1.45*** [0.41] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Only one child in last 5 years | | 0.61*** [0.15] | | 0.52*** [0.13] | | 0.42*** [0.12] | | 0.88*** [0.26] |
| Death of any previous child + | | 0.18* [0.05] | | 0.04 | | -0.07 | | 0.15** [0.05] |
| Experiencing blindness during pregnancy+ | | -0.03 | | | | 0.09 | | 0.06 |
| Wanted pregnancy – wanted later ( *wanted then*) | | -0.02 | | 0.02 | | 0.06 | | 0.06 |
| Wanted no more | | -0.00 | | -0.01 | | 0.15* [0.04] | | -0.22* [-0.07] |
| Exposure to radio - Sometimes (*Never*) | | -0.12 | | 0.14 | | 0.16 [0.05] | | 0.11 |
| Everyday | | -0.02 | | 0.14 | | 0.10 | | 0.02 |
| **ECONOMIC ACCESSIBILITY** | | | | | | | | |
| Women Employment - Sales/services (*Agriculture*) | | 0.23* [0.06] | | -0.03 | | 0.12 [0.04] | | 0.30 [0.09] |
| Others | | 0.03 | | -0.11 | | 0.01 | | 0.26* [0.08] |
| No employment | | 0.06 | | -0.12 | | 0.29** [0.09] | | 0.16 [0.05] |
| Spouse employment – Sales or services (*agriculture or no employment*) | | 0.11 | | 0.13 | | 0.08 | | 0.00 |
| Skilled manual | | 0.02 | | 0.11 | | 0.06 | | 0.04 |
| Wealth quintile – Second (*Lowest*) | 0.19* [0.06] | 0.02 | 0.11 [0.02] | 0.02 | 0.01 | -0.04 | -0.03 | 0.16* [0.05] |
| Middle | 0.25** [0.08] | 0.16 [0.04] | 0.05 [0.01] | 0.08 | -0.06 | -0.08 | -0.08 | 0.14* [0.04] |
| Fourth and highest | | | 0.35*** [0.09] | 0.19 [0.05] | 0.02 | 0.17* [0.05] | 0.13* [0.04] | 0.21* [0.04] |
| **CONTEXTUAL VARIABLES** | | | | | | | | |
| Proportion of women in each community with at least a secondary level of education – middle (*low*) | | 0.31* [0.08] | | 0.18 [0.05] | | 0.19* [0.06] | | 0.02 |
| High | | 0.29 [0.08] | | 0.44*** [0.12] | | 0.30*** [0.09] | | 0.24 [0.07] |
| Proportion of households with children under five years of age > rural mean – Middle (*low*) | | -0.10 | | -0.08 | | -0.09 | | -0.11 |
| High | | -0.10 | | -0.33** [-0.08] | | -0.02 | | -0.06 |
| Proportion of women who judged distance to be a serious problem for them to reach care - Middle (*low*) | | -0.29* [-0.08] | | | | -0.21** [-0.06] | | -0.07 |
| High | | -0.43*** [-0.11] | | | | -0.23** [-0.07] | | -0.17* [-0.05] |
| Rho for ANC and Content | | -0.25* | | -0.45** | | -0.27** | | -0.53*** |
| Rho for ANC and SBA | | -0.02 | | -0.05 | | 0.08 | | -0.11 |
| Rho for SBA and Content | | 0.03 | | -0.41 | | -0.26 | | -0.20 |
| cut_2_1 | | -0.32 | | 0.39 | | -0.63*** | | 0.64*** |
| cut_2_2 | | 0.12 | | 0.96*** | | 0.01 | | 1.02*** |
| cut_2_3 | | 1.13*** | | 1.38*** | | 0.60*** | | 1.49*** |
| N | | 1814 | | 2662 | | 4164 | | 4223 |
| Ll | | -3786.19 | | -5550.35 | | -10082.51 | | -9860.95 |

Significance at * p<.05, ** p<.01 and *** p<.001. Reported marginal effects (ME) [in bracketed] are averages of individual marginal effects. For the oprobit model, marginal effects are calculated for the last category. Only ME higher in absolute value than .03 are shown. Reference's modalities are in brackets and in italics (first column). + = dummy variables. The results of the determinants of frequency of antenatal care are not shown.

## End note

[i] SPA data related to Maternal and Child Health (MCH) are available for six countries in sub-Sahara Africa (SSA). Data from Rwanda and Namibia are excluded due to problems of missing variables; they are also less typical of much of SSA than the other four countries.

[ii] For more details on the differing demographic, health and health provision contexts in these four countries, see (Adjiwanou, forthcoming in 2013) and Table S1 in the supplemental tables.

[iii] Even when the functional form of the system of equations can make them automatically identifiable (see Wilde, J. (2000). Identification of Multiple Equation Probit Models With Endegenous Dummy Regressors. *Economics Letters,* 69, 309-312), it is always preferable to have at least one exclusion variable, especially in cases of possible misspecification. See Monfardini, C., & Radice, R. (2008). Testing Exogeneity in the Bivariate Probit Model: A Monte Carlo Study. *Oxford Bulletin of Economics and Statistics,* 70, 271-282.; and Roodman, D. (2011). Fitting Fully Observed Recursive Mixed-Process Nodels with cmp. *Stata Journal,* 11, 159-206.

**Supplemental Tables**

**Different models estimated:**

**Model 1: Probit Model**

$$SBA_i = 1(ANC_i\pi_1 + Q_{ANC_i}\delta_1 + X_{1i}\beta_1 + \varepsilon_{1i} \geq 0) \quad \text{(Equation 1)}$$

**Model 2: Recursive Biprobip**

$$SBA_i = 1(ANC_i\pi_1 + Q_{ANC_i}\delta_1 + X_{1i}\beta_1 + \varepsilon_{1i} \geq 0) \quad \text{(Equation 1)}$$

$$ANC_i = 1(\beta_{31}ANC_{debut_{31i}} + X_{3i}\beta_3 + \varepsilon_{3i} \geq 0) \quad \text{(Equation 3)}$$

$(\varepsilon_{1i}, \varepsilon_{3i})$ follows a multinomial normal distribution N(0,0,∑), ∑=corr$(\varepsilon_{1i}, \varepsilon_{3i})$

**Model 3: System of Three Equations**

$$SBA_i = 1(ANC_i\pi_1 + Q_{ANC_i}\delta_1 + X_{1i}\beta_1 + \varepsilon_{1i} \geq 0) \quad \text{(Equation 1)}$$

$$\begin{cases} Q_iANC_i = 1 & \text{if } (ANC_i\gamma_{12} + Z_{1i}\theta_{12} + X_{12i}\beta_{12} + \varepsilon_{12i}) < \alpha_{11} \\ Q_iANC_i = 2 & \text{if } \alpha_{11} \leq (ANC_i\gamma_{12} + Z_{1i}\theta_{12} + X_{12i}\beta_{12} + \varepsilon_{12i}) < \alpha_{12} \\ Q_iANC_i = 3 & \text{if } \alpha_{12} \leq (ANC_i\gamma_{12} + Z_{1i}\theta_{12} + X_{12i}\beta_{12} + \varepsilon_{12i}) \end{cases} \quad \text{(Equation 2)}$$

$$ANC_i = 1(\beta_{31}ANC_{debut_{31i}} + X_{32i}\beta_{32} + \varepsilon_{3i} \geq 0) \quad \text{(Equation 3)}$$

$(\varepsilon_{1i}, \varepsilon_{2i}, \varepsilon_{3i})$ follows a multinomial normal distribution N(0,0,0,∑),

$$\sum = \begin{bmatrix} var(\epsilon_{1i}) & & \\ corr(\epsilon_{1i}, \epsilon_{2i}) & var(\epsilon_{2i}) & \\ corr(\epsilon_{1i}, \epsilon_{3i}) & corr(\epsilon_{2i}, \epsilon_{3i}) & var(\epsilon_{3i}) \end{bmatrix}$$

$Z_2$ = ANC provider and/or ANC location

**Table S1: Trend of selected health and fertility indicator by country**

| Indicators | Ghana | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1988 | | 1993 | | 1998 | | 2003 | | 2008 | |
| | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural |
| Current modern contraceptive use | 6.6 | 3.1 | 15.8 | 7.4 | 17.4 | 11.4 | 24.2 | 14.9 | 18.6 | 15.1 |
| Infant mortality rate (1q0) | 66 | 87 | 55 | 82 | 43 | 67 | 55 | 70 | 49 | 56 |
| Total Fertility Rate (TFR) | 5.3 | 7 | 3.7 | 6 | 3 | 5.3 | 3.1 | 5.6 | 3.1 | 4.9 |
| | Kenya | | | | | | | | | |
| | 1989 | | 1993 | | 1998 | | 2003 | | 2008-2009 | |
| | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural |
| Current modern contraceptive use | 25.5 | 16.4 | 37.9 | 25.4 | 41 | 29 | 39.9 | 29.2 | 46.6 | 37.2 |
| Infant mortality rate (1q0) | 57 | 59 | 46 | 65 | 55 | 74 | 61 | 79 | 63 | 58 |
| Total Fertility Rate (TFR) | 4.5 | 7.1 | 3.4 | 5.8 | 3.1 | 5.2 | 3.3 | 5.4 | 2.9 | 5.2 |
| | Uganda | | | | | | | | | |
| | 1988-89 | | 1995 | | 2000-2001 | | 2006 | | | |
| | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural | | |
| Current modern contraceptive use | 12.2 | 1.5 | 28 | 5.1 | 41.6 | 14.7 | 36.1 | 15.1 | | |
| Infant mortality rate (1q0) | 104 | 106 | 74 | 88 | 54 | 94 | 68 | 85 | | |
| Total Fertility Rate (TFR) | 5.7 | 7.6 | 5 | 7.2 | 4 | 7.4 | 4.4 | 7.1 | | |
| | Tanzania | | | | | | | | | |
| | 1991-92 | | 1996 | | 1999 | | 2004-05 | | 2010 | |
| | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural |
| Current modern contraceptive use | 14 | 4.5 | 26.6 | 9.8 | 32.8 | 12 | 34.3 | 15.5 | 34.1 | 25.2 |
| Infant mortality rate (1q0) | 108 | 97 | 82 | 97 | 87 | 113 | 73 | 85 | 63 | 60 |
| Total Fertility Rate (TFR) | 5.1 | 6.6 | 4.1 | 6.3 | 3.2 | 6.5 | 3.6 | 6.5 | 3.7 | 6.1 |

*Source: computed by authors from StatCompiler*

## Table S2: Coefficient of probit regression on reduced form equation of ANC content and SBA in Ghana and Kenya (to be continuous)

| Variables Name | Ghana | | | | Kenya | | | |
|---|---|---|---|---|---|---|---|---|
| | Content of care | | SBA | | Content of care | | SBA | |
| At least four prenatal visits [++] | 0.88*** | 0.50*** | 0.66*** | 0.63*** | 0.36*** | 0.34*** | 0.18** | 0.18** |
| Prenatal care provider – nurse. midwife (*Doctor*) | | -0.14° | | -0.11 | | -0.24*** | | -0.00 |
| Prenatal care provider – Others | | -1.45*** | | 0.11 | | -0.85** | | -0.24 |
| Venue of prenatal care - private sector (*Public sector*) | | -0.12 | | 0.06 | 0.00 | -0.01 | 0.22** | 0.22** |
| Venue of prenatal care – Others | | -1.26*** | | -0.37 | -2.19*** | -1.61*** | -0.62*** | -0.39 |
| Content of care - Low - less than 5 | | | | | | | | |
| 5 services received | | | 0.26° | 0.21 | | | 0.13 | 0.13 |
| 6 services received | | | 0.24* | 0.20 | | | 0.28** | 0.27** |
| High content - 7 services received | | | 0.33** | 0.29* | | | 0.36*** | 0.35*** |
| **INDEPENDENT VARIABLES** | | | | | | | | |
| **SOCIOCULTURAL FACTORS** | | | | | | | | |
| Women age at pregnancy - (*15-19 y*) | | | | | | | | |
| 20-24 y | 0.13 | 0.11 | | | 0.03 | 0.03 | | |
| 25-29 y | 0.02 | 0.03 | | | 0.15 | 0.14 | | |
| 30-34 y | 0.01 | -0.01 | | | 0.15 | 0.14 | | |
| 35-49 y | 0.02 | 0.04 | | | 0.17 | 0.18 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Living with partner ++ | 0.04 | -0.01 | | | 0.02 | 0.01 | | |
| Number of living children –(*0*) | | | | | | | | |
| 1 or 2 | 0.11 | 0.03 | 0.05 | 0.04 | -0.11 | -0.09 | -0.05 | -0.05 |
| 3 or 4 | 0.12 | 0.08 | 0.07 | 0.06 | -0.15 | -0.11 | -0.22 | -0.22 |
| 5 or more | 0.26 | 0.19 | 0.10 | 0.10 | -0.13 | -0.09 | -0.23 | -0.23 |
| Previous birth interval - (*24-36 months*) | | | | | | | | |
| Less than 24 months | -0.09 | -0.08 | 0.15 | 0.14 | 0.06 | 0.06 | 0.15 | 0.15 |
| 36 months or more | -0.02 | -0.05 | 0.06 | 0.05 | 0.11° | 0.11° | 0.09 | 0.09 |
| Only one child | 0.01 | -0.10 | 0.32 | 0.31 | 0.09 | 0.12 | 0.53* | 0.53* |
| Religion –(*Catholics*) | | | | | | | | |
| Other Christians | | | 0.08 | 0.07 | | | -0.09 | -0.09 |
| Muslims | | | -0.10 | -0.09 | | | -0.13 | -0.13 |
| Others | | | -0.17 | -0.17 | | | | |
| Women Education - (*No education*) | | | | | | | | |
| Primary | 0.29*** | 0.21** | -0.16 | -0.17 | -0.02 | -0.01 | 0.18 | 0.18 |
| Secondary and more | 0.57*** | 0.46*** | -0.02 | -0.03 | 0.21* | 0.22* | 0.42** | 0.42** |
| Spouse education – (*primary or less*) | | | | | | | | |
| Middle | | | 0.21* | 0.21* | | | | |
| Secondary and more | | | 0.34* | 0.33* | | | | |
| Other, don't know or no partner | | | 0.05 | 0.04 | | | | |
| (*No education*) Primary | | | | | | | | |
| Secondary and more | | | | | | | -0.02 | -0.02 |
| Other, don't know or no partner | | | | | | | 0.17 | 0.17 |
| **PERCEIVED BENEFIT/NEED** | | | | | | | 0.09 | 0.09 |
| Skilled attendance for previous birth (*No*) | | | | | | | | |
| Yes | | | 1.32*** | 1.32*** | | | 0.99*** | 0.99*** |
| Only one child in last 5 years | | | 0.61*** | 0.62*** | | | 0.61*** | 0.61*** |
| Death of any previous child ++ | | | 0.18* | 0.18* | | | 0.03 | 0.03 |
| Experiencing blindness during pregnancy° | | | -0.03 | -0.04 | | | | |
| Wanted pregnancy – (*wanted then*) | | | | | | | | |
| Wanted later | | | -0.02 | -0.01 | | | 0.01 | 0.01 |
| Wanted no more | | | -0.00 | -0.00 | | | -0.06 | -0.06 |
| Exposure to radio - (*Never*) | | | | | | | | |
| Sometimes | | | -0.12 | -0.12 | | | 0.19° | 0.18° |
| Everyday | | | -0.02 | 0.02 | | | 0.19* | 0.19* |
| **ECONOMIC ACCESSIBILITY** | | | | | | | | |
| Women Employment - (*Agriculture*) | | | | | | | | |
| Sales/services | | | 0.23* | 0.23* | | | -0.02 | -0.02 |
| Others | | | 0.02 | 0.02 | | | -0.07 | -0.07 |
| No employment | | | 0.06 | 0.06 | | | -0.16* | -0.16* |
| Spouse employment – (*agriculture or no employment*) | | | | | | | | |
| Sales or services | | | 0.12 | 0.12 | | | 0.17* | 0.17* |
| Skilled manual | | | 0.02 | 0.02 | | | 0.12 | 0.12 |
| Wealth quintile – (*Lowest*) | | | | | | | | |
| Second | 0.25*** | 0.20** | 0.02 | 0.02 | 0.11 | 0.13° | 0.05 | 0.05 |
| Middle | 0.33*** | 0.27*** | 0.16 | 0.16 | 0.10 | 0.11 | 0.10 | 0.10 |
| Fourth and highest | | | | | 0.44*** | 0.45*** | 0.35*** | 0.35*** |
| **CONTEXTUAL VARIABLES** | | | | | | | | |
| Proportion of women in each community with at least a secondary level of education – middle (*low*) | | | 0.31** | **0.30**** | | | **0.20*** | **0.20*** |
| High | | | 0.29* | 0.27* | | | 0.48*** | 0.48*** |
| Proportion of households with children under five years of age > rural mean – Middle (*low*) | | | -0.10 | -0.10 | | | -0.11 | -0.11 |
| High | | | -0.10 | -0.10 | | | -0.39*** | -0.39*** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Proportion of women who judged distance to be a serious problem for them to reach care - Middle (*low*) | | | -0.30** | -0.31** | | | | |
| High | | | -0.43*** | -0.43*** | | | | |
| Cut1 | 0.33 | -0.50 | | | 0.44s | 0.27 | | |
| Cut2 | 0.71s | -0.05 | | | 1.03s | 0.87s | | |
| Cut3 | 1.6s | 0.97s | | | 1.48s | 1.31s | | |
| LR chi2(4) | 342.48 | | 2.73 | | 22.47 | | 0.61 | |
| Prob > chi2 | 0.0000 | | 0.6033 | | 0.0000 | | 0.7380 | |
| **N** | **1814** | | | | **2662** | | | |

s: significance; Significance at 10% (°), 5% (*), 1% (**) and 0.1% (***);[++] dummy variables

## Table S2: Coefficient of probit regression on reduced form equation of ANC content and SBA in Uganda and Tanzania (continuous)

| Variables Name | Uganda | | | | Tanzania | | | |
|---|---|---|---|---|---|---|---|---|
| | Content of care | | SBA | | Content of care | | SBA | |
| At least four prenatal visits ++ | 0.33*** | 0.32*** | 0.29*** | 0.29*** | 0.23*** | 0.24*** | 0.06 | 0.06 |
| **Prenatal care provider – nurse. midwife (*Doctor*)** | | -0.20** | | -0.11 | | | | |
| **Prenatal care provider – Others** | | -1.38*** | | -0.30 | | | | |
| Venue of prenatal care - private sector (*Public sector*) | -0.07 | -0.07 | 0.10° | 0.09 | | | | |
| Venue of prenatal care – Others | -1.66*** | -0.83*** | -0.64*** | -0.48** | | | | |
| Prenatal care provider – (*Doctor, nurse. midwife* ) | | | | | | | | |
| Prenatal care provider – Others | | | | | -0.34*** | -0.33*** | -0.20*** | -0.20*** |
| **Venue of prenatal care - (*Public sector*)** | | | | | | | | |
| **Venue of prenatal care – Private sector Others** | | | | | | 0.19*** | | 0.02 |
| Content of care - Low - less than 5 | | | | | | | | |
| 5 services received | | | 0.06 | 0.05 | | | 0.15* | 0.15* |
| 6 services received | | | 0.09 | 0.08 | | | 0.09 | 0.09 |
| High content - 7 services received | | | 0.20** | 0.19** | | | 0.33*** | 0.33*** |
| **INDEPENDENT VARIABLES** | | | | | | | | |
| **SOCIOCULTURAL FACTORS** | | | | | | | | |
| Women age at pregnancy - (*15-19 y*) | | | | | | | | |
| 20-24 y | 0.05 | 0.03 | | | -0.03 | -0.03 | | |
| 25-29 y | 0.21** | 0.21* | | | -0.02 | -0.02 | | |
| 30-34 y | 0.24** | 0.23* | | | -0.01 | -0.02 | | |
| 35-49 y | 0.37*** | 0.35*** | | | 0.06 | 0.05 | | |
| Living with partner ++ | -0.10* | -0.10* | | | -0.03 | -0.03 | | |
| Number of living children –(*0*) | | | | | | | | |
| 1 or 2 | 0.04 | 0.06 | 0.23° | 0.23° | -0.19* | -0.19* | 0.03 | 0.03 |
| 3 or 4 | -0.21° | -0.19° | 0.08 | 0.09 | -0.27* | -0.26* | -0.07 | -0.07 |
| 5 or more | -0.30* | -0.29* | 0.07 | 0.07 | -0.33** | -0.32** | -0.05 | -0.05 |
| Previous birth interval - (*24-36 months*) | | | | | | | | |
| Less than 24 m | 0.07 | 0.07 | 0.08 | 0.08 | 0.01 | 0.01 | 0.01 | 0.01 |
| 36 months or more | 0.05 | 0.06 | 0.18** | 0.18** | 0.30*** | 0.30*** | -0.01 | -0.01 |
| Only one child | 0.07 | 0.08 | 0.65*** | 0.65*** | 0.08 | 0.08 | 0.38** | 0.38** |
| Religion –(*Catholics*) | | | | | | | | |
| Other Christians | | | **0.09°** | **0.09°** | | | -0.06 | -0.06 |
| Muslims | | | **0.33*** ** | **0.33*** ** | | | -0.09 | -0.09 |
| Others | | | **0.17*** | **0.17*** | | | -0.25** | -0.25** |
| Women Education - (*No education*) | | | | | | | | |
| Primary | 0.06 | 0.06 | 0.03 | 0.03 | 0.27*** | 0.26*** | 0.08 | 0.08 |
| Secondary and more | 0.38*** | 0.38*** | 0.36*** | 0.36*** | 0.47*** | 0.48*** | 0.22° | 0.22° |
| Spouse education – | | | | | | | | |
| (*No education*) | | | | | | | | |
| Primary | | | 0.15° | 0.14° | | | 0.03 | 0.03 |
| Secondary and more | | | 0.24** | 0.24* | | | 0.20° | 0.20° |
| Other, don't know or no partner | | | 0.21° | 0.21° | | | -0.20° | -0.20° |
| **PERCEIVED BENEFIT/NEED** | | | | | | | | |
| Skilled attendance for previous birth (*No*) | | | | | | | | |
| Yes | | | 1.23*** | 1.22*** | | | 1.52*** | 1.52*** |
| Only one child in last 5 years | | | 0.43*** | 0.43*** | | | 0.95*** | 0.95*** |
| Death of any previous child ++ | | | -0.07 | -0.07 | | | 0.15** | 0.15** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Experiencing blindness during pregnancy[++] | | | 0.09° | 0.09° | | | 0.06 | 0.06 |
| Wanted pregnancy – ( *wanted then*) | | | | | | | | |
| Wanted later | | | 0.06 | 0.06 | | | 0.06 | 0.06 |
| Wanted no more | | | 0.16* | 0.16* | | | -0.23* | -0.23* |
| Exposure to radio - (*Never*) | | | | | | | | |
| Sometimes | | | 0.16* | 0.16** | | | 0.11° | 0.11° |
| Everyday | | | 0.10 | 0.10 | | | 0.04 | 0.04 |
| **ECONOMIC ACCESSIBILITY** | | | | | | | | |
| Women Employment - (*Agriculture*) | | | | | | | | |
| Sales/services | | | 0.12 | 0.12 | | | 0.32 | 0.32 |
| Others | | | 0.01 | 0.01 | | | 0.28** | 0.28** |
| No employment | | | 0.29** | 0.29** | | | 0.13 | 0.13° |
| Spouse employment – (*agriculture or no employment*) | | | | | | | | |
| Sales or services | | | 0.08 | 0.08 | | | 0.03 | 0.02 |
| Skilled manual | | | 0.07 | 0.07 | | | 0.06 | 0.06 |
| Wealth quintile – (*Lowest*) | | | | | | | | |
| Second | -0.00 | -0.01 | -0.04 | -0.04 | 0.00 | 0.01 | 0.17** | 0.17** |
| Middle | -0.06 | -0.07 | -0.09 | -0.09 | -0.04 | -0.03 | 0.13* | 0.13* |
| Fourth and highest | 0.04 | 0.03 | 0.18* | 0.18* | 0.22*** | 0.23*** | 0.24*** | 0.25*** |
| **CONTEXTUAL VARIABLES** | | | | | | | | |
| Proportion of women in each community with at least a secondary level of education – middle (*low*) | | | 0.20** | **0.20**** | | | **0.05** | **0.05** |
| High | | | 0.30*** | 0.30*** | | | 0.27*** | 0.27*** |
| Proportion of households with children under five years of age > rural mean – Middle (*low*) | | | -0.09 | -0.09 | | | -0.13* | -0.13* |
| High | | | -0.02 | -0.02 | | | -0.09 | -0.09 |
| Proportion of women who judged distance to be a serious problem for them to reach care - Middle (*low*) | | | -0.22*** | -0.22*** | | | -0.07 | -0.07 |
| High | | | -0.23*** | -0.24*** | | | -0.18** | -0.18** |
| Cut1 | -0.63s | -0.84s | | | 0.24 | 0.27s | | |
| Cut2 | 0.01 | -0.19 | | | 0.66s | 0.69s | | |
| Cut3 | 0.61s | 0.41s | | | 1.15s | 1.19s | | |
| LR chi2(4) | 98.30 | | 2.77 | | 14.07 | | 0.10 | |
| Prob > chi2 | 0.0000 | | 0.2506 | | 0.0002 | | 0.7577 | |
| **N** | **4164** | | | | **4223** | | | |

s: significance; Significance at 10% (°), 5% (*), 1% (**) and 0.1% (***);[++] dummy variables

## Table S3: Average treatment Effect on the Treat (ATT) of four or more ANC care on SBA, by country

| Country | Treated | Control | ATT | Std. Err. | t |
|---|---|---|---|---|---|
| Ghana | 1148 | 435 | **0.253** | 0.031 | 8.265 |
| Kenya | 1292 | 958 | **0.095** | 0.025 | 3.816 |
| Uganda | 1938 | 1232 | **0.125** | 0.019 | 6.454 |
| Tanzania | 2594 | 1224 | **0.042** | 0.019 | 2.173 |

ATT estimation with Nearest Neighbor Matching method

**Table S4: Rosenbaum Bounds Sensitivity Analysis for Four ANC Care Effects on SBA, by country**

| Γ | Ghana | | Kenya | | Uganda | | Tanzania | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Q_mh+ | p_mh+ | Q_mh+ | p_mh+ | Q_mh+ | p_mh+ | Q_mh+ | Q_mh- | p_mh+ | p_mh- |
| 1 | 7.429 | <0.0001 | 3.057 | .0011 | 5.014 | <0.0001 | 1.401 | 1.401 | .0801 | .0805 |
| 1.1 | 6.864 | <0.0001 | 2.325 | .0100 | 3.971 | <0.0001 | .4373 | 2.367 | .3309 | .0089 |
| 1.2 | 6.350 | <0.0001 | 1.657 | .0487 | 3.019 | .001264 | .3442 | 3.250 | .3653 | .0005 |
| 1.3 | 5.882 | <0.0001 | 1.043 | .1483 | 2.146 | .015936 | 1.154 | 4.063 | .1241 | <0.0001 |
| 1.4 | 5.453 | <0.0001 | .4753 | .3172 | 1.337 | .090483 | 1.904 | 4.817 | .0284 | <0.0001 |
| 1.5 | 5.056 | <0.0001 | -.0536 | .5212 | .5858 | .279002 | 2.603 | 5.521 | .0046 | <0.0001 |
| 1.6 | 4.688 | <0.0001 | | | .0256 | .489775 | | | | |
| 1.7 | 4.344 | <0.0001 | | | .6860 | .246335 | | | | |
| 1.8 | 4.022 | <0.0001 | | | 1.308 | .095284 | | | | |
| 1.9 | 3.718 | .0001 | | | 1.898 | .028827 | | | | |
| 2 | 3.431 | .0003 | | | 2.457 | .006988 | | | | |
| 2.1 | 3.160 | .000788 | | | | | | | | |
| 2.2 | 2.902 | .001854 | | | | | | | | |
| 2.3 | 2.656 | .003953 | | | | | | | | |
| 2.4 | 2.421 | .007734 | | | | | | | | |
| 2.5 | 2.196 | .014028 | | | | | | | | |
| 2.6 | 1.981 | .023793 | | | | | | | | |
| 2.7 | 1.774 | **.038024** | | | | | | | | |
| 2.8 | 1.574 | **.05763** | | | | | | | | |
| 2.9 | 1.383 | .083313 | | | | | | | | |
| 3 | 1.197 | .11546 | | | | | | | | |

Gamma (Γ) : odds of differential assignment due to unobserved factors
Q_mh+ : Mantel-Haenszel statistic (assumption: overestimation of treatment effect)
Q_mh- : Mantel-Haenszel statistic (assumption: underestimation of treatment effect)
p_mh+ : significance level (assumption: overestimation of treatment effect)
p_mh- : significance level (assumption: underestimation of treatment effect)