Social Networks and Maternal Health Care Utilisation in Tanzania

Alfred K. Mukong* & Justine Burns†

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Abstract

Social networks are increasingly being recognised as having an important influence on the health market outcomes, as they facilitate the exchange of information on health care related issues. Networks reduce search costs by providing information to peers about the appropriate health care providers and details about the functioning of the health care system. In this paper, we examine the impact of information externalities generated through network membership on maternal health care utilisation in Tanzania. We further propose new approaches for quantifying the size of one's network. We adopt an econometric approach that minimises the problems of omitted variable bias. Using the Demographic and Health Survey data for Tanzania, a country characterised by low levels of maternal health care utilisation we find that social networks may enhance antenatal completion and early antenatal check-up probabilities by an additional 6-35 percent and sometimes up to 59 percent. The results suggest that failure to adequately control for omitted variables would lead to substantial under-estimation of the network effect. Finally, we show that irrespective of the measure of the size of the networks, high quality networks have better outcomes than low quality networks.

Keywords: Maternal healthcare, social networks, Tanzania
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1 Introduction

Uncertainty about health outcomes is a key feature that distinguishes the demand for health services from the demand for standard goods and services in consumer theory. It is due to this uncertainty that individuals demand preventive health care to ensure better health outcomes in the future (Chang, 1996; Dardanoni and Wagstaff, 1990; Picone et al., 1998). Empirical evidence have documented the role of household and community factors on the use of maternal health services in both developed and developing countries (Gage, 2007; Kamal, 2009; Jat et al., 2011). Social networks facilitate information spillovers and learning, transmit norms and values, and may matter in explaining economic and social outcomes

*School of Economics, University of Cape Town, Tel: +27 61 275 8436, Email: kchmuk001@myuct.ac.za
†School of Economics, University of Cape Town, Tel: +27 21 650 3506, Email: justine.burns@uct.ac.za

(Banerjee, 1992; Bikhchandani et al., 1998). In the context of health economics, there are numerous channels through which social networks can influence health care seeking behaviour[1]. While social networks have been shown to significantly influence most individual and economic outcomes (Bertrand et al., 2000; Burns et al., 2010; Webster et al., 2014), little is known about the maternal health care use effect of social networks. The study by Deri (2005) illustrates the association between social networks and health care utilisation. Although this study makes important contribution in this area, the effect of social networks in the care utilisation decision of pregnant women is still relatively unexploited. In addition, very little is known about this link in other parts of the world, most especially in Sub-Saharan Africa. This paper present unique evidence on the effect of social networks on antenatal completion and timing of first antenatal check-up in Tanzania .

It is only in the recent decades that economists have become interested in examining how information spillover through networks and learning between network members can explain individual choices and economic outcomes. Focus has been in the context of labour market decisions (Burns et al., 2010; Oreopoulos, 2003), education (Sacerdote, 2001), welfare participation (Bertrand et al., 2000), and health outcomes (Webster et al., 2014; House et al., 1988) among others[2]. In the context of health care, the pioneer work of Deri (2005) identified that health care utilisation among immigrants in Canada increases with the number of doctors that speak their language in their neighbourhoods. The argument is that contacts may provide more information about the importance of care utilisation than just the availability of health services themselves. Studying social network effects on health care decisions, especially in the context of developing countries is imperative, since most people acquire information through informal sources and cultural values and norms still play a vital role in decision-making.

Arguably, information and norms are the various ways through which individual choices are affected by the behaviour of others. In terms of information, the awareness of an individual depends, to some extent, on the behaviour or how knowledgeable his/her friends or neighbours (contacts) are. With regards to norms, individual preferences may be influenced directly through taste and indirectly through social pressure (Bertrand et al., 2000). While it has been shown that individuals whose neighbourhoods are healthier are more likely to experience better health outcomes and lower exposure to diseases (Ludwig et al., 2001; Katz et al., 2001), much is not known concerning the health care use effects of social networks. Yet reliance on networks to utilise health services reduces patient's uncertainty about physician's action, improves patient and physician relationship, may enhance physician loyalty, and hence service satisfaction[3]. In the absence of the media and other formal sources of information, it is obvious that the patient's awareness about the availability of modern health services is relative to the quality of their contacts. For instance, if one's contacts rely on traditional healers for treatment, the likelihood of being informed about the benefits of modern health services through such contacts reduces, thereby reducing benefits from such contacts.

While health economists have made progress in understanding the supply and demand side of the health

[1] Network reduces search costs as it provides information to peers about the appropriate health care providers and details about the functioning of the national health system. In addition, networks can affect the utilisation of health services through its effects on desirability of the available care (Deri, 2005).

[2] See Case and Katz (1991) who examined the effects of networks on drug use and crime.

[3] Interacting with others that have faced similar health related problems in the past, increases patient's awareness and reduces the chance for physician inducement or exploitation in case of free or subsidised health services.

market, there is limited emphasis on how utilisation varies across social groups. Apart of the fact that empirical studies in Africa have overlooked the effect of social networks on health care use, evidence of the importance of social networks on individual choices and economic outcomes in general is further limited by the measure of network size. In order to correct for omitted variable bias, recent literature relies mostly on language and geography as a measure of network quantity. It should be noted that in a society where everyone speaks the same language or with high degree of inter-tribal marriages, ethnic languages may not be an effective measure of the quantity of one's networks. With the high level of inter-tribal marriages in Tanzania and the fact that one of its official language - Swahili, has dominated and displaced many tribal languages(Yoneda, 2010), makes the use of ethnic languages as a measure of network quantity difficult. Hence, network formation in Tanzania is independent of tribal languages and we suggest alternative approaches for measuring the size of networks in such a system. In context of maternal health care utilisation, female age-marital status, age-fertility cohort and geography are therefore considered to be more appropriate measures of the quantity of networks (see footnote 8 for justification).

A number of studies have established that regular and timely antenatal care visit reduces associated risk, educates women, and ensures better pregnancy outcomes (Overbosch et al., 2004). Consequently, women who initiate antenatal care late and/or have limited number of visits are less likely to deliver in a health facility as opposed to home birth (AbouZahr and Wardlaw, 2003; Bloom et al., 1999). For better pregnancy outcomes, women with uncomplicated pregnancies should visit or consult with a health professional at least four times before childbirth (WHO, 1994). It is evident that most maternal and infant deaths resulting from pregnancy complications can be averted with early and frequent antenatal check-up (Kamal, 2009; Reynolds et al., 2006). While researchers have shown how household and community characteristics determine the decision to utilise these services (Duong et al., 2004), we find that social networks do affect maternal health care utilisation behaviour. Our results show that for high utilising age-marital status or age-fertility groups, living in areas of high concentrations of the age-marital/age-fertility group increases access to antenatal services between 6 to 35 percent and at times up to 59 percent.

Within the context of very low and declining levels of antenatal care utilisation in Tanzania (see Table 1), understanding the effects of social networks on antenatal care use is arguably critical, especially as it influences the amount of medical care consumed. It is also part of the puzzle that the decline utilisation of these services in Tanzania does not synchronise with the targets of government policies[4]. The media is one of the major means or formal channels through which information regarding health care policies among others is disseminated to the general public (Sharma et al., 2007). Using the TDHS, it is rather unfortunate that over 76 percent of the population do not watch television (TV), 30 percent do not listen to radio at all, and 71 percent do not read newspapers. Awareness about the availability of health services and the existing policies towards these services may rely heavily on informal sources (networks).

[4]The government of Tanzania and other international agencies in the post MDGs have put in place policies to improve on the use of maternal health services, with the mandate to enhance maternal and child health. Some of these programs in Tanzania include Health Sector Reforms and the Health Sector Strategic Plan (2003-2007), Maternal Newborn and Child Health Partnership (MNCHP), the Primary Health Service Development Program in 2007 and the Health Sector Support Program III in 2008 to address Maternal, Newborn and Child Health issues(Mwaikambo, 2010). In addition, primary maternal and child health services are made free.

Table 1: Antenatal care utilisation Rates 2004 and 2010

Health Service	Rural		Urban		Total	
	2004	2010	2004	2010	2004	2010
At least one antenatal care visit	94	95	97	99	94	96
At least four antenatal care visits	58.5	39.1	71.4	54.8	62	42.7
Antenatal care within first 16 weeks	13.7	14.3	15.6	19.1	14.5	15.4

Source: Extracted from TDHS 2004 and 2010 reports.

Yet, until relatively in the recent decade, the Tanzanian literature on health care has focused on the demand for health care due to illnesses or injuries with limited attention to the reproductive health aspects. Although attempts have been made to explore the determinants of maternal health care utilisation in Tanzania[5], and other developing countries, a comprehensive explanation of the importance of social networks to the demand for health services, particularly antenatal care is lacking. This has been exacerbated by the fact that in Tanzania, most of these studies had limited coverage of the health care system. While Sahn et al. (2003) and Kowalewski et al. (2002) focused on rural Tanzania, Gross et al. (2012) focused on adolescent women. This leaves a huge gap in the literature which must be addressed in order to provide a broader picture of the health care situation in Tanzania. Furthermore, most of these studies adopted a descriptive approach which failed to show the relative impact of the considered factors on health care use.

This paper empirically close this gap by identifying the importance of social networks on antenatal completion and timing of antenatal visits in Tanzania. In so doing, we add to the sparse literature on health care use effects of social networks from developing countries, particularly Sub-Saharan Africa where data quality has hampered research on this topic. Besides having one of the lowest physician density in the world, the health delivery system in Tanzania has been characterised by state domination and failure to provide for the basic health needs of the population. The independent government of Tanzania in 1961 inherited a health system that was characterised by mainly traditional healers, a few clinics, and missionary health centres (Gilson et al., 1994). The main objective of the government was universal access to care, and by 1978, about 90 percent of all Tanzanians lived within 10km of a health facility (Dominicus, 1989). To achieve this, the government ensured free access to care in public health facilities and actively discouraged, and banned the activities of for-profit private sector in 1977 (Tibandebage et al., 2001). The worsening economic performance, particularly in the 1980s, that led to fiscal crisis reduced the ability of the health sector to deliver basic health services to the majority of the population. This adversely affected health outcomes and prompted the need for policy reforms, not only at the macroeconomic policy level, but inclusive of the health sector in the early 1990s (Gilson et al., 1994).

In early 1993, the implementation of user fees became a centrepiece of the health sector reform process. This reform was intended to ensure financial sustainability in the health sector and to improve the quality of care. In order to ensure that this policy does not negatively affect the poorest and the vulnerable groups in accessing basic health care, an exemption system was introduced (Lambert and Sahn, 2002).

[5]Health care demand studies in the context of Tanzania include (Gross et al., 2012; Sahn et al., 2003; Kowalewski et al., 2002; Boller et al., 2003; Mpembeni et al., 2007; Mrisho et al., 2009).

In response to government policy change, primarily the removal of the ban on private for-profit practice in 1991, the size of the private health sector has increased tremendously over the past decades (White et al., 2002). Currently, the public and private health sectors are the main components of the Tanzanian health system. Both the public and private health sector comprises of non-for-profit and for-profit entities distributed throughout the country. Over 70 percent of all the health facilities are publicly owned. Urban areas have a good network of hospitals and referral facilities, while primary level facilities are predominant in rural areas (Mtei et al., 2012). While household out-of-pocket payments, medical schemes, and private health insurance are the major sources of private expenditure on health care; general taxes and donor funds are the main sources for public expenditure on health care. The rest of the paper is structured as follows; Section 2. presents the empirical strategy. Data and descriptive statistics are reported in Section 3. The empirical results are presented in Section 4 and conclusions in Section 5.

2 Empirical Strategy

The probability that a pregnant woman completed the required number of antenatal care visits and/or initiated antenatal care early is represented as:

$$Pr\left(Use_{ijk}\right) = Netw_{ijk}\alpha^{*} + X_{i}^{*}\beta^{*} + Y_{i}^{*}\delta^{*} + Z_{i}^{*}\tau^{*} + \varepsilon_{ijk} \tag{1}$$

Where i represents individuals, j represents geography (clusters), and k is age-marital status or age-fertility cohort. Use_{ijk} is a dummy variable equivalent to one, if the individual utilised the required number of antenatal visits, and zero otherwise. $Netw_{ijk}$ is a measure of information the pregnant woman receives from her female contacts; X is a set of observed and unobserved individual and household characteristics; Y is a set of observed and unobserved characteristics from her locality (for instance, urban areas may have abundant health care facilities that increase accessibility and may increase the probability of utilisation); and Z is a set of observed and unobserved age-marital status or age-fertility cohort characteristics.

Several empirical studies have shown that individual outcomes are directly associated with friends, neighbours and ethnic group outcomes. Before the identification of the 'reflection problem[6] by Manski (1993), the average neighbourhood outcome was the basis for measuring social network (Jencks and Mayer, 1990). Bertrand et al. (2000) developed a methodological approach for handling such hurdles. Social network studies in the recent periods have made use of this approach (Burns et al., 2010; Deri, 2005). This paper adopts this methodological approach to identify the effects of social network to antenatal care utilisation in Tanzania. The estimation of this model is difficult given that actual information concerning individual's contacts and the extent of her network hardly exist in many datasets.

[6] Manski (1993) highlighted that causal statements between social networks and individual outcomes cannot be established due to two related omitted variable biases. First, omitted individual characteristics could be correlated with average group outcome. For instance, individuals residing where the incidence of care use is low may be less motivated to demand care services. Second, omitted neighbourhood characteristics may be correlated with mean incidence of non-user of health services in that locality. For instance, urban areas may have abundant health care facilities that increase accessibility and may increase the probability of health service utilisation. Even if information on actual contacts existed, individuals select their contacts. Individuals with many contacts may be qualitatively different from those with few contacts. Estimates derived in this manner may suffer from omitted variable bias.

In the recent literature, Bertrand et al. (2000) and Deri (2005) used language while Burns et al. (2010) used age-language cohort as a way of defining social networks. The idea is that speaking a mutual language is an essential channel for information externalities and individuals around the same age cohort in a given geographic area are more likely to spend time together and obtain information from each other. As highlighted earlier, this study argues that in Tanzania, language may not be a good measure for network quantity as one of its official languages - Swahili along with the degree of inter-tribal marriages have dominated and displaced most ethnic languages (Mekacha et al., 1993; Yoneda, 2010). It is evident that social networks can be categorised in the dimensions of race, ethnicity, age, and religion (Waldinger, 1999; Lin and Westcott, 1991; Albeck and Kaydar, 2002). Consequently, Arai (2007) showed that beside relatives, other forms of socialisation are important determinants of fertility. High fertility enhances experience about the available and important use of reproductive health services and can be viewed as a source of information spill over about the importance of these services to pregnant women. The analysis in this paper follows Bertrand et al. (2000) methodological approach, but proposes some new plausible measure for the size of network[7].

This paper uses age-marital status and age-fertility cohorts as proxies for network size for women of reproductive age within a given cluster[8]. Because there is no information on the number of pregnancies, the number of children ever born is considered as a measure of fertility. The fertility levels are categorised as follows: 0-3 children, 4-6 children, and 7+ children. The age brackets ranges from 15–24, 25-34, 35-44, and 45-54. The span of 9 years in the age bracket are large enough to reduce the bias that may result from social ties (see Burns et al., 2010). The age-fertility cohorts consider all the likely age-fertility combinations that may result from these two variables. For age-marital status, women are grouped into the various age groups and into their respective marital status. For example, all women between the age of 15 and 24 who are married and live within a particular geographical area are regarded as members of the same network. Such network would be distinct from that of women aged 15 − 24 who are unmarried or divorced but reside in the same area. The number of women in one's locality who are of the same age-marital status cohort measures the quantity of contacts available. Consequently, a woman who resides in an area with more women of her age-marital status category will have a large number of available contacts. The number of women in one's contact group that uses antenatal services measures the quality of that network. As there is no explicit information about peer network, this network proxy should be viewed

[7]Given the peculiarity of language set up in Tanzania and the fact that our data limits the use of other highlighted measures of social network, age-marital status and age-fertility cohort are the most plausible and available measures of network in this case. The use of these two approaches is to ensure robustness of network effects.

[8]The argument is that, in the context of developing countries, especially in Africa, networks of couples during marriage are based on ties with other couples and in most cases with the husband's network. The wife's friendships in her single days rarely develop into a relationship with both partners or are maintained during marriage (Rands, 1988; Albeck and Kaydar, 2002). The social bridges that exist during marriage collapses in periods of divorce. Women, in particular lose a significant percentage of the network of shared friends (Duffy, 1993; Wilcox, 1986). Again, in periods of divorce, women's constellation of friendships may collapse entirely within a very short time (Rands, 1988; Duffy, 1993). The damage of her social network is extensive if she depended heavily on her husband's network (Gerstel et al., 1985; Wallerstein, 1986; Daniels-Mohring and Berger, 1984). Even the friends she had before and during the marriage may dissolve due to conflict of loyalty Rands (1988), social norms that project negative attitudes towards divorced women, and the absence of recognised social behavioural codes towards divorced (D'Abate, 1994; Wiseman, 1975; Gerstel, 1987). Finally, the social status of married women depends on their husbands' status and the social activity of married women differ considerably from unmarried and divorced women, but fits better with the activity of other married women (Albeck and Kaydar, 2002; Duffy, 1993). Given this argument, and the fact that all women in our analysis have given birth, a woman's age-marital status cohort is used as a possible measure for quantity of contacts.

as potential rather than actual contacts. In order to minimise biases resulting from omitted variable bias at the geographic area and age-marital status, the area fixed effects as well as age-marital status fixed effects are included.

In order to resolve the biases resulting from omitted neighbourhoods and age-marital status or age-fertility cohort characteristics, the network measure is the interaction between 'quantity' (the number of people in one's cohort) and 'quality' (the attitude and knowledge of these people towards the use of antenatal services)[9]. That is, $Netw_{ijk} = V_{jk} * \overline{Use_k}$ where V_{jk} represents the density of age-marital status group k residing in area j a measure of potential number of contacts available to an individual (quantity)[10], $\overline{Use_{ijk}}$ is the mean frequency of antenatal care users from age-marital status group k in the population. This provides a measure of the level of service utilisation in one's network (quality)[11]. The estimated equation is then written as:

$$Pr\left(use_{ijk}\right) = \left(V_{jk} * \overline{Use_k}\right)\varphi + X_i\beta + \pi_j + \omega_k + dist_{jk}\theta + reloc_{jk}\delta + V_{jk}\gamma + \mu_{ijk} \tag{2}$$

Where π_j and ω_k are respective fixed effects for geography and age-marital status cohort. Their inclusion captures any unobserved differences between regions, such as availability of health care facilities and age-marital status group effects; X_i is individual and household level characteristics; $dist_{jk}$ is distance to a health facility (supply side influence); and $reloc_{jk}$ is a relocation variable that indicates whether or not an individual relocated away from her network[12]. To deal with biases resulting from any omitted individual characteristics correlated with V_{jk}, the variable V_{jk} is included as an independent variable in the regression. This would appear as an estimate of γ which does not affect φ. Since the age-marital group fixed effects, ω_k is included in the equation, the direct effect of $\overline{use_k}$ is therefore excluded. The potential exogenous and endogenous biases are accommodated in equation 7 [13]. The remaining potential bias may result from the correlation between omitted individual characteristics and the network variable $V_{jk} * \overline{use_k}$. This arises if people self-select away from their age-marital cohort. The idea is that individuals

[9] See (Bertrand et al., 2000; Deri, 2005; Burns et al., 2010)

[10] Based on Bertrand et al. (2000), V_{jk} is the proportion of individuals in area j that are in age-marital status cohort k as a ratio of the proportion of individuals from Tanzania in that group. The available measure for contact is therefore $\ln\left(\frac{V_{jk}/A_j}{L_k/T}\right)$, where V_{jk} measures the number of individuals in area j in the age-marital status group k; A_j is the number of individuals who reside in area j; L_k is the total number of individuals in Tanzania belonging to the same age-marital status group; and T is the total number of women of reproductive age. It is the case that small groups will have small available contacts even if there is full concentration and the fact that individuals self-segregate could be misleading. Using proportions resolve these problems and prevent the underweighting of small age-marital status groups.

[11] Using the frequency of care use from age-marital group k in cluster j, excluding individual i as a measure of use_k introduces bias, since it may reflect the unobserved characteristics this individual has in common with others from the same age-marital group living in the same cluster. To avoid such biases, the mean care users of the age-marital group in the entire population is used. Precisely, it is measured as the mean deviation the group's level of care use relative to the mean care use of the entire sample used in the analysis (Bertrand et al., 2000).

[12] DHS dataset is collected after every five years but they are not panels. It provides information on maternal and child health outcomes during five years prior to each of the surveys. Concerning the relocation variable, individuals are asked how long they have lived in their current place of residence. Those who indicated to have been five years or less in their cuurent place of residence are considered to have relocated in the intervening period, otherwise they have not.

[13] The fixed differences in utilisation resulting from differences in service availability between areas are removed by geography fixed effects and the age-marital group specific differences in utilisation such as differing levels of experience and beliefs are eliminated by age-marital status fixed effects. The omitted reasons for individuals choosing to reside in high/low density area of their age-marital group are eliminated by the direct effect of the density of age-marital group in her locality.

living in areas of high density of their age-marital group are different in some unobserved way from those living in low density areas.

Differential selection biases the estimates because leaving from a group with low level of utilisation to a group with high level of service use might increase the care use for that individual and vice versa. Bertrand et al. (2000) and Deri (2005) showed that the network effect cannot be completely explained by differential selection. In addition, Burns et al. (2010) argued that this might not be a significant source of bias given the high level of aggregation in districts and further proposed the use of a relocation variable. A variable equivalent to whether or not an individual relocated is therefore included to control for the probability of individuals moving away from their network, in the intervening periods. We employ a Linear Probability Model (LPM) to identify the effects of social network on the probability of completing the required number of antenatal visits and timing of antenatal care.

There are two potential limitations of the LPM. First, the predicted probabilities from the LPM regression are not bounded on the unit interval and second, the existence of heteroscedasticity.A standard remedy points to the use of the conventional probit or logit that bound the maximum likelihood estimated probabilities on the unit interval (Horrace and Oaxaca, 2006). However, results estimated by probit can be inconsistent when fixed effects are includedBaltagi (2008). The use of the LPM is not entirely problematic, since robust standard errors can commonly be used (Paxton, 1999). The unboundedness of the of estimated probabilities on the unit interval is considered the serious problem that may results in biased and inconsistent estimates of the LPM. The potential bias increases with the relative proportion of LPM predicted probabilities that fall outside the unit interval. Conversely, Horrace and Oaxaca (2006) argued that if no few predicted probabilities lie outside the unit interval, the LPM is expected to be largely unbiased and consistent. In this paper we find that the proportion of LPM predicted probabilities that lie outside the unit interval ranges from 0.00 to 2.22 percent for all specifications. So it appears that according to Horrace and Oaxaca, our LPM estimates are unbiased and consistent. In this case,, the LPM is preferred to the probit model, since the latter suffers computational difficulties in the presence of fixed effects (Bertrand et al., 2000; Deri, 2005; Burns et al., 2010)[14] . For sensitivity, we estimate a logit model and compared the estimates to those obtained from the LPM.

3 Data and Descriptive Statistics

The data used in the analysis is the 2010 Tanzanian Demographic and Health Survey (TDHS) conducted by the Tanzania National Bureau of Statistics (TNBS). The TDHS is a nationally representative cross-sectional survey. The sample is limited to women aged 15–49 years. In order to obtain the social network variable, women are categorised into their respective age-fertility or age-marital status cohort and geography. Notably, the entire sample of women is used to construct the contact availability (quantity of contact) variable. The mean utilisation (quality of contacts) by age-fertility or age-marital status cohort

[14]Adding fixed effects to any binary outcome model that is based on maximum likelihood estimation induces bias in the coefficient and standard errors (incidental parameter bias). In addition, it is near certainty that any probit estimation incorporating a nontrivial number of fixed effects will produce bias results (Baltagi, 2008). For the use of fixed effects in social sciences, there have been a switch from a standard normal probit to a logit model. The logit fixed effects is not dissimilar to multiple linear regression in that it filters out the fixed effects (Baltagi, 2008).

is also based on the entire sample. This is because excluding women who did not give birth within the period of the survey, but who had done so before, may underestimate the potential quantity or quality of contacts available to each individual woman. Getting the direct costs (user charge for supplies) for health services is difficult and has made the use of prices in health care demand literature limited (Sahn et al., 2003). The empirical analysis is limited only to women who gave birth during the survey period. The available sampling weight for this dataset is used to correct for the over and under representation of certain households.

Table 2 reports summary statistics for the sample by antenatal care use[15], revealing the interesting differences between early antenatal check-up and antenatal completion. Individuals residing in the southern highlands, the lake, the central and the western zones have a lower percentage of those who attended at least four antenatal visits relative to their share of the sample. In contrast, individuals from the northern, southern and eastern have a higher proportion of those with at least four visits. While the eastern zone records the highest proportion of individuals that completed the number of visits, Zanzibar has the lowest. Individuals in lower wealth quintiles have a higher proportion of those with incomplete antenatal care. The converse holds true for those in the upper wealth quintiles. These results are consistent with the timing of antenatal check-up.

Another difference between those who completed the number of visits and those who did not lies in their potential educational attainment and health knowledge. Individuals with primary and secondary education have higher proportion of those with complete number of visits and early antenatal check-up relative to their share in the sample. The contrary holds for those with less than primary education and those with no health knowledge. Over 70 percent of women who completed the required number of visits had their first birth between the ages 20–34 years and over 72 percent of women who initiated antenatal care early had their first birth between the ages 20–34 years. These percentages are far higher than their relative share in the sample. This suggest that women who gave birth at an adolescent age (15–19 years) and at an older age (35–49 years) are less likely to initiate for early care, or complete the required number of antenatal visits. Adolescent mothers have the lowest rate of utilising antenatal services.

To some extent, the difference in care use may reflect an age-fertility cohort difference. First, only 27 percent of the sample have between 0-3 children, but over 57 percent of all women within this fertility cohort completed the number of antenatal visits. In fact, to put it more starkly, over 34 percent of all women in the sample have at least seven children, but only 13 percent of all women with complete check-up are from within this fertility cohort. Similarly, women with 4 to 6 children have a lower proportion of those with complete antenatal check-up, compared to their share in the sample. Intuitively, this indicates that women gain experience that is likely to reduce their utilisation rates in subsequent births. Considering the respective fertility levels, it is identified that the probability of early antenatal check-up, and antenatal care completion reduces with fertility rate (see Table 12). The difference in early care check-up and antenatal completion may also reflect an age cohort difference. Just about 2 percent of women in the age group 45 and 54 years who gave birth within this period completed the required number of visits.

[15] An individual is considered to have completed the required number of antenatal care visits if she indicated to have had at least four visits for every childbirth between 2005 and 2010. An individual is considered to have initiated antenatal care late if her antenatal care visit for every childbirth is not within the first four months of pregnancy. In the regression analysis, we control for number of children ever born to deal with learning.

Table 2: Mean statistics for sample by antenatal care visit

Variables	All		At least four visits		Less than four visits		Early care check-up	
Household size	7.14	(4.05)	6.57	(3.87)	7.27*	(4.46)	6.09	(3.33)
Number of under-five children per woman	1.13	(0.91)	1.37	(0.56)	1.56*	(0.65)	1.34	(0.54)
Number of children ever born	5.44	(2.65)	3.56	(2.37)	3.91*	(2.46)	3.26	(2.11)
First wealth quintile	0.21	(0.41)	0.17	(0.38)	0.22*	(0.41)	0.17	(0.37)
Second wealth quintile	0.23	(0.42)	0.18	(0.38)	0.25*	(0.44)	0.18	(0.39)
Third Wealth quintile	0.22	(0.42)	0.2	(0.40)	0.22*	(0.42)	0.19	(0.39)
Fourth wealth quintile	0.2	(0.40)	0.22	(0.42)	0.19*	(0.39)	0.21	(0.41)
Fifth wealth quintile	0.14	(0.35)	0.23	(0.42)	0.12*	(0.33)	0.25	(0.43)
Individual years of schooling	4.82	(3.43)	5.68	(3.44)	4.73*	(3.33)	5.88	(3.42)
Individual has no formal education	0.27	(0.44)	0.19	(0.40)	0.27*	(0.44)	0.17	(0.37)
Individual completed primary	0.68	(0.47)	0.7	(0.46)	0.68	(0.47)	0.71	(0.45)
Individual completed at least secondary	0.05	(0.22)	0.11	(0.32)	0.05*	(0.21)	0.12	(0.32)
Age at first birth (15 – 19 years)	0.01	(0.12)	0.06	(0.23)	0.08‡	(0.27)	0.06	(0.25)
Age at first birth (20 – 34 years)	0.42	(0.49)	0.7	(0.46)	0.66†	(0.47)	0.72	(0.45)
Age at first birth (35 – 49 years)	0.57	(0.50)	0.24	(0.43)	0.26‡	(0.44)	0.22	(0.42)
Individual lives in the northern zone	0.14	(0.35)	0.17	(0.37)	0.12*	(0.33)	0.13	(0.34)
Individual lives in the central zone	0.1	(0.30)	0.09	(0.28)	0.09	(0.29)	0.09	(0.28)
Individual lives in the southern highland zone	0.14	(0.35)	0.1	(0.29)	0.17*	(0.38)	0.15	(0.36)
Individual lives in the lake zone	0.19	(0.40)	0.18	(0.39)	0.19	(0.39)	0.12	(0.32)
Individual lives in the Eastern zone	0.12	(0.33)	0.2	(0.40)	0.09*	(0.28)	0.21	(0.41)
Individual lives in the Zanzibar zone	0.03	(0.17)	0.03	(0.17)	0.02*	(0.15)	0.03	(0.17)
Individual lives in the southern zone	0.09	(0.29)	0.1	(0.29)	0.09	(0.29)	0.16	(0.36)
Individual lives in the western zone	0.19	(0.39)	0.15	(0.35)	0.22*	(0.42)	0.12	(0.32)
Age bracket 1: 15 – 24 years	0.11	(0.31)	0.3	(0.46)	0.32‡	(0.47)	0.3	(0.46)
Age bracket 2: 25 – 34 years	0.33	(0.47)	0.45	(0.50)	0.42*	(0.49)	0.47	(0.50)
Age bracket 3: 35 – 44 years	0.4	(0.49)	0.22	(0.42)	0.24	(0.43)	0.21	(0.40)
Age bracket 4: 45 – 54 years	0.16	(0.37)	0.02	(0.15)	0.02	(0.15)	0.02	(0.13)
Fertility cohort 1: 0 – 3 children	0.27	(0.44)	0.57	(0.49)	0.52*	(0.50)	0.63	(0.48)
Fertility cohort 2: 4 – 6 children	0.39	(0.49)	0.29	(0.45)	0.33*	(0.47)	0.29	(0.45)
Fertility cohort 3: 7+ children	0.34	(0.48)	0.13	(0.33)	0.16*	(0.37)	0.08	(0.28)
Distance to facility is problematic	0.46	(0.50)	0.39	(0.48)	0.46*	(0.50)	0.36	(0.48)
Male headed households	0.78	(0.41)	0.82	(0.40)	0.80*	(0.38)	0.82	(0.37)
Individual relocated between 2005 and 2010	0.12	(0.32)	0.16	(0.37)	0.12*	(0.32)	0.14	(0.35)
Participated in health care decision	0.62	(0.49)	0.64	(0.48)	0.56*	(0.50)	0.64	(0.48)
knowledge of pregnancy complication	0.54	(0.50)	0.6	(0.49)	0.51*	(0.50)	0.65	(0.48)

Notes: Standard deviation in parentheses. ‡, † and * indicates that the difference in characteristics between those who completed and those who did not complete the number of antenatal visits is statistically significant at 10%, 5% and 1% respectively, otherwise they are not significant.

It is interesting that the majority (64 percent) of individuals that completed or went for early antenatal care live in household where both partners cooperate in decision-making towards care use, relative to 56 percent for those with less than required number of visits. Those from male headed households are significantly more likely to complete the number of visit. For those living further away from health facilities, only about 39 percent completed the number of visits and 36 percent went for early antenatal check-up. Approximately 16 percent of those with complete care and 14 percent of those with early care check-up had relocated in the intervening period. On average, there are about 8 persons per household, and about 2 under-five children per woman. Finally, the fertility rate (average number of children ever born) is 6.

Since the network variable used in this study defines contact availability in terms of age-fertility and age-marital status cohorts, Table 3 and 4 present antenatal care utilisation figures by age cohorts, fertility and marital status grouping. These statistics are quite similar to the results in Table 2. More than half of the individuals in all the respective fertility and age cohorts (Table 3) underutilise antenatal services and the incidence of underutilisation is high amongst those in (4 to 6) and 7+ fertility cohorts. Except for widows, over half of all individuals in the respective marital status used less than the recommended number of visits (Table 3).

Table 3: Mean statistics for fertility, age and marital status cohorts by antenatal care visit

Fertility/age group	At least four visits	Less than four visits	Early care check-up
0 - 3 children	46.16	53.84	17.57
4 - 6 children	40.09	59.91	14.56
7+ children	37.56	62.44	09.00
15 - 24 years	41.64	58.36	14.98
25 - 34 years	44.77	55.23	16.85
35 - 44 years	41.49	58.51	13.61
45 - 54 years	45.02	54.98	12.28
Never married	44.83	55.17	18.03
Married	42.02	57.98	14.57
Living together	48.28	51.72	21.11
Widow	53.54	46.46	17.73
Divorced	43.31	56.69	16.27
Separated	45.91	54.09	16.44

Table 4 categorised women into their respective age-fertility and age-marital status cohorts, and identify their respective utilisation rates. These are women who all gave birth in the last five years before the survey. On average, underutilisation rates varies significantly across the various age cohorts. For example, over 76 percent of all individuals between the ages 15 and 24 who are in the 4 to 6 fertility cohort, and over 73 percent of all individuals between the ages 45 and 54 in 0 to 3 fertility cohort, attended less than four antenatal visits. This incidence is however not consistent across all fertility and marital status cohorts. For instance, younger individuals (15-24 years) in the 0 to 3 fertility cohort have the lowest underutilisation rate, whereas oldest individuals (45-54 years) have the highest utilisation rate in the 4 to 6 fertility cohort. Similar statistics are obtained for marital status (see Table 4).

Table 4: Mean statistics for age-fertility and age-marital status cohorts by antenatal care visits

Fertility/marital status	Age cohort	At least four visits	less than four visits	Early care check-up
0 - 3 Children	15 - 24 years	42.32	47.68	15.09
	25 - 34 years	50.83	49.17	20.40
	35 - 44 years	51.51	48.49	22.05
	45 - 54 years	26.81	73.19	23.19
4 - 6 Children	15 - 24 years	23.47	76.53	12.03
	25 - 34 years	38.41	61.59	13.75
	35 - 44 years	44.06	55.94	16.22
	45 - 54 years	61.39	38.61	16.26
7+ Children	15 - 24 years			
	25 - 34 years	36.23	63.77	04.76
	35 - 44 years	37.15	63.85	09.46
	45 - 54 years	41.30	48.70	10.66
Never married	15 - 24 years	43.92	56.08	16.39
	25 - 34 years	48.47	51.53	20.87
	35 - 44 years	41.22	58.78	25.34
	45 - 54 years			
Married	15 - 24 years	39.76	60.24	13.18
	25 - 34 years	44.24	55.76	16.25
	35 - 44 years	40.76	59.24	13.07
	45 - 54 years	40.75	59.25	15.25
Living together	15 - 24 years	53.31	46.69	28.38
	25 - 34 years	46.09	53.91	18.10
	35 - 44 years	42.89	57.11	17.13
	45 - 54 years			
Widow	15 - 24 years	38.82	61.18	05.16
	25 - 34 years	43.70	56.30	34.83
	35 - 44 years	60.68	39.32	12.27
	45 - 54 years	68.44	31.56	
Divorced	15 - 24 years	44.59	55.41	17.30
	25 - 34 years	44.44	55.56	14.46
	35 - 44 years	39.57	60.43	19.11
	45 - 54 years	50.60	49.40	
Separated	15 - 24 years	47.45	52.55	22.31
	25 - 34 years	50.11	49.89	18.47
	35 - 44 years	34.93	65.07	08.67
	45 - 54 years	49.53	50.47	

4 Empirical Results

In Table 5 and 6, we present the network estimates from the baseline regressions, demonstrating the changes in coefficient estimates as the various fixed effects are included. In Table 5, age-fertility is used as a measure of network quantity, while in Table 6 age-marital status is used as a measure of network quantity. The use of these two measures is to check for robustness of the effect of network quality. For the antenatal completion regressions, the network coefficient increases from 0.39 when no fixed effects are included to 0.74 once the age-fertility cohort fixed effects and cluster fixed effects are included. Interestingly, the network coefficient remains highly significant. The increase is less dramatic in the regression estimating the probability that a pregnant woman is likely to initiate antenatal care early as opposed to late initiation. This clearly indicates that failure to control for omitted variable bias through the inclusion of fixed effects would lead to a substantial under-estimation of the network coefficient. Deri (2005) and Devillanova (2008) also identified that the effect of networks on health care utilisation are under-estimated if group and location fixed effects are not included. Similar results are obtained when age-marital status is used (see Table 6). The inclusion of distance in the baseline regression is to net out biases resulting from differences in the supply of services across regions. The relocation variable is included at this stage to control for the probability that an individual relocated away from her network within the intervening period and the number of children ever born is included to account for experience.

Table 5: Regression estimates of network coefficient as additional fixed effects are included

	Probability of antenatal care completion			Probability of early antenatal check-up		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Contact availability	-0.10***	-0.19***	-0.22***	-0.14***	-0.17***	-0.16***
	(0.02)	(0.03)	(0.04)	(0.01)	(0.01)	(0.01)
Network effects	0.39***	0.65***	0.74***	1.27***	1.36***	1.36***
	(0.07)	(0.09)	(0.10)	(0.09)	(0.09)	(0.10)
Individual relocated between 2005 and 2010	0.13***	0.13***	0.12***	-0.01	-0.00	-0.01
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Distance to health facility is problematic	-0.05*	-0.04*	-0.02	-0.03**	-0.03**	-0.01
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Number of children ever born	-0.00	-0.03***	-0.02**	0.00	-0.02***	-0.02***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Constant	0.43***	0.40***	0.32***	0.15***	0.14***	0.02
	(0.02)	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Observations	**5,310**	**5,310**	**5,310**	**5,249**	**5,249**	**5,249**
R-squared	**0.02**	**0.04**	**0.20**	**0.19**	**0.21**	**0.33**
Age-fertility cohort fixed effects	No	Yes	Yes	No	Yes	Yes
Cluster fixed effects	No	No	Yes	No	No	Yes

Notes: Significance *** 1%, ** 5%, * 10%, Robust standard errors in parentheses. The contact availability variable is V_{jk} and the network variable is defined as $Netw_{ijk} = V_{jk} * \overline{use_k}$. Age- fertility cohort is a measure of the quantity of one's contact

Table 6 looks at an alternative source of information externalities, by classifying individual women according to their age-marital status cohort. The results reveal that irrespective of the various ways of social groupings, individuals with high quality of contacts are more likely to utilise antenatal services, relative to their counterparts with low quality of contacts[16]. The probability of antenatal care use decline with distance to health facilities. Interestingly, individuals who relocated away from their network significantly increased the probability of antenatal completion. The positive effect of relocation is possible if the quality of their new network is higher than the quality of their previous network, or if they relocated to areas where health services are more readily available. The negative coefficient for contact availability indicates that the positive effect of social networks are mainly due to quality of networks. The negative effect of number of children ever born shows that antenatal care utilisation declines significantly with maternal experience. The results obtained from the logit model are presented in Table 13 and Table 14 of the appendix and are similar to results obtained from the LPM.

[16]'High quality' refers to groups with high utilisation rates and 'low quality' refers to groups with low utilisation rates

Table 6: Regression estimates of network coefficient as additional fixed effects are included

	Probability of antenatal care completion			Probability of early antenatal check-up		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Contact availability	-0.06***	-0.29***	-0.29***	-0.09***	-0.10***	-0.09***
	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)
Network effects	0.19***	0.86***	0.85***	0.52***	0.67***	0.66***
	(0.04)	(0.07)	(0.08)	(0.03)	(0.04)	(0.04)
Individual relocated between 2005 and 2010	0.13***	0.12***	0.11***	-0.02	0.02	0.01
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Distance to health facility is problematic	-0.06**	-0.05*	-0.02	-0.04***	-0.03***	-0.02
	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Number of children ever born	-0.01*	-0.03***	-0.01**	-0.00	-0.02***	-0.02***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Constant	0.45***	-0.00	-0.18***	0.17***	0.05**	-0.08***
	(0.02)	(0.05)	(0.06)	(0.01)	(0.02)	(0.02)
Observations	**5,310**	**5,310**	**5,310**	**5,231**	**5,231**	**5,231**
R-squared	**0.02**	**0.06**	**0.22**	**0.16**	**0.21**	**0.32**
Age-marital status cohort fixed effects	No	Yes	Yes	No	Yes	Yes
Cluster fixed effects	No	No	Yes	No	No	Yes

Notes: Significance *** 1%, ** 5%, * 10%, Robust standard errors in parentheses. The contact availability variable is V_{jk} and the network variable is defined as $Netw_{ijk} = V_{jk} * \overline{use_k}$. Age- marital status is a measure of the quantity of one's contact

Table 7 presents regression estimates of network effects after controlling for individual and household characteristics. There are no major changes in the magnitude of network effects on the probability of antenatal care use after controlling for individual and household characteristics (compare the network coefficient in column 3 of Table 5 to the network coefficient in column 1 of Table 7 and the coefficient in column 3 of Table 6 to the coefficient in column 4 of Table 7). Once we control for early antenatal care[17] in the antenatal completion regressions, the network effects reduces significantly (see the network effect in column 1 and column 2 of Table 7 for comparison and column 4 and column 5 of Table 7 for comparison). Including these additional controls to the early antenatal care specification have no major effect on the magnitude of network estimates and the significant level is unaltered (see the estimates of network in column 6 of Table 5 and 6 and the one in column 3 and 6 of Table 7 for comparison). The coefficient estimates of network remain positive and highly significant after controlling for other explanatory variables and the likely biases. This suggests that social interaction among women of reproductive age is an important source of information externalities regarding the use of reproductive health services.

[17]Women who initiate antenatal care early are most likely to complete the number of visits. It is therefore important to identify the effect of early care seeking on care completion and how the effect of networks changes after controlling for early care seeking.

Table 7: Regression estimates of network coefficient including individual and household characteristics

	Using age-fertility cohort			Using age-marital status cohort		
	Antenatal Completion	Antenatal Completion	Antenatal care early	Antenatal Completion	Antenatal Completion	Antenatal care early
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Contact availability	-0.22***	-0.21***	-0.16***	-0.28***	-0.24***	-0.09***
	(0.04)	(0.04)	(0.01)	(0.03)	(0.03)	(0.01)
Network effects	0.74***	0.69***	1.36***	0.85***	0.72***	0.66***
	(0.10)	(0.10)	(0.10)	(0.07)	(0.07)	(0.04)
Early antenatal check-up		0.37***			0.35***	
		(0.02)			(0.02)	
Individual characteristics						
Individual relocated between 2005 and 2010	0.11**	0.12***	-0.00	0.10*	0.11***	-0.01
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)
Individual age at first birth (20 – 34 years)	0.08**	0.08**	-0.01	0.08**	0.08**	0.01
	(0.04)	(0.04)	(0.02)	(0.04)	(0.04)	(0.02)
Individual age at first birth (35 – 49 years)	0.36	0.55***	0.16	2.12***	1.90***	0.41***
	(0.23)	(0.13)	(0.11)	(0.15)	(0.14)	(0.09)
Individual years of schooling	0.01***	0.01***	0.00	0.01**	0.01***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Knowledge of pregnancy complication	0.05***	0.04**	0.03**	0.05***	0.04**	0.02*
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Distance to health facility is problematic	-0.01	-0.00	-0.01	-0.02	-0.01	-0.02
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Number of children ever born	-0.00	0.00	-0.01	-0.00	0.00	-0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Number of under-five children per woman	-0.08***	-0.07***	-0.03***	-0.08***	-0.07***	-0.03***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Household Characteristics						
Getting money for care is problematic	-0.06*	-0.05*	-0.02	-0.05*	-0.05*	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Male headed household	0.04*	0.04**	-0.02	0.05*	0.05**	-0.01
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
Household asset index	0.05***	0.04**	0.01	0.05**	0.04**	0.03*
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Household size	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual lives in the central zone	0.21***	0.27***	-0.01	0.11***	0.16***	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Individual lives in the southern highlands zone	0.57***	0.64***	0.03	0.40**	0.48***	-0.05**
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
Individual lives in the lake zone	-0.01	0.12***	0.11***	-0.07***	0.00	0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
Individual lives in the eastern zone	0.60***	0.64***	-0.03*	0.54***	0.58***	-0.05***
	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)
Individual lives in the Zanzibar zone	0.18***	0.26***	-0.07***	0.15***	0.23***	0.10***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Individual lives in the southern zone	0.03	0.41***	0.36***	-0.15***	0.28***	0.46***
	(0.053)	(0.03)	(0.02)	(0.03)	(0.04)	(0.01)
Individual lives in the western zone	0.23***	0.29***	-0.00	0.16***	0.22***	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Constant	0.14***	0.06	0.08*	-0.25***	-0.27***	-0.03
	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.04)
Observations	**5,147**	**5,146**	**5,162**	**5,147**	**5,146**	**5,144**
R-squared	**0.22**	**0.28**	**0.33**	**0.24**	**0.29**	**0.33**

Notes: Significance *** 1%, ** 5%, * 10%, Robust standard errors in parentheses. The contact availability variable is V_{jk} and the network variable is defined as $Netw_{ijk} = V_{jk} * \overline{use_k}$. All regressions include district fixed effects age-fertility and age-marital status cohort fixed effect Column 1, 2, 4 and 5 are for antenatal care completion regression, column 3 and 6 are estimates for timing of antenatal visit. In column 2 and 5 timing of antenatal check-up is included, since women who initiate antenatal care early are likely to complete the number of visits.

The interpretation of the actual magnitude of the network estimates from these specifications is not straightforward, given the way the network variable is computed. According to Bertrand et al. (2000), it is possible to arrive at a measure of the magnitude of the network effects, by asking to what extent social interaction would broaden a policy shock affecting the probability of antenatal care use[18]. The argument is based on the assumption that the policy shock is linear and the remaining marginal change after the policy shock is removed from the equilibrium outcome is attributed solely to social networks $\left(\frac{1}{(1-\varphi \bar{V_k})} - 1\right)$. The indirect network impact on the probability of antenatal completion as well as early antenatal care by age-fertility and age-marital status cohort are presented in Table 8 and Table 9 respectively. Antenatal care completion prospects, owing to social networks only, range between 6 and 35 percent (see panel A of Table 8). In contrast, the influence of social networks on early antenatal prospects are much larger, increasing early care use by 8 to 54 percent (see Table 8). It is interesting to observe that the network impact for different groups is consistent across the various measures of antenatal care utilisation. For instance, the highest network effects for both antenatal completion and early care are observed among women aged 35–44 years with fertility rates of at least 7 children and the lowest among aged 15-24 years with 4 to 6 children.

Table 8: Indirect network impact on completing and timing of antenatal care visits (using age-fertility cohort)

Panel A: Indirect network effects on antenatal completion				
All	0.241 (0.006)			
	15 - 24 years	25 34 years	35 - 44 years	45 - 54 years
1 - 3 Children	0.160 (0.009)	0.227 (0.017)	0.118 (0.009)	0.061 (0.006)
4 - 6 Children	0.060 (0.005)	0.243 (0.011)	0.249 (0.011)	0.166 (0.015)
7+ Children		0.108 (0.011)	0.354 (0.023)	0.230 (0.011)
Panel B: Indirect network effects on seeking care early				
All	0.351 (0.013)			
	15 - 24 years	25 34 years	35 - 44 years	45 - 54 years
1 - 3 Children	0.225 (0.016)	0.352 (0.052)	0.160 (0.014)	0.080 (0.008)
4 - 6 Children	0.079 (0.007)	0.343 (0.019)	0.355 (0.018)	0.231 (0.023)
7+ Children		0.144 (0.015)	0.540 (0.045)	0.325 (0.017)

Table 9 reports the indirect network impact on antenatal services when age-marital status cohorts are considered as the bases for forming social groups. The impact of networks on antenatal care use prospects ranges between 3 and 59 percent (see panel A of Table 9). The network impact on the probability of early antenatal care ranges between 3 and 38 percent (see panel B of Table 9). The highest effect is observed

[18] We adopt the experimental approach, as specified in Bertrand et al. (2000) to identify the actual magnitude of network on antenatal care utilisation. First, it assumes a policy η which linearly affect antenatal care utilisation outcomes. The policy variable is included in the estimation, with the assumption that in the absence of network effect, this variable is scaled such that a one percentage point rise in η will leads to a one percentage point rise in the probability of antenatal care use $use_{ijk} = \eta + (V_{jk} * \overline{use_k})\varphi + X_i\beta + \pi_j + \omega_k + dist_{jk}\theta + reloc_{jk}\delta + V_{jk\gamma} + \mu_{ijk}$. Inclusion of the network variable generate a multiplier effect, such that in equilibrium, the increase care use probability owing to the rise in η is higher. To illustrate this, we take the mean on both sides of the equation for each age-fertility cohort and each age-marital status cohort and differentiate with respect to η. In so doing we have, $\frac{d\overline{use_k}}{d\eta} = 1 + V_k * \frac{d\overline{use_k}}{d\eta}\varphi$ where $\bar{V_k}$ is the average number of contact (V_{jk}) in each age-fertility/age-marital status cohort. The responsiveness of each age-fertility cohort's probability to the utilisation of antenatal care services, owing to the policy change, can be obtained by solving the derivation above for $\frac{d\overline{use_k}}{d\eta}$. In order to obtain the marginal change, resulting purely from social interaction, we net out the direct effects of the policy change (note that it is equal to one). Hence, the actual magnitude of social networks is given by $\frac{1}{(1-\varphi \bar{V_k})} - 1$. Where $\frac{1}{(1-\varphi \bar{V_k})} - 1$ is used to compute the indirect network effect for each age-fertility/age-marital status cohort, and φ represent the respective network estimated coefficients in row 2 of Table 7. It should be noted that we had already controlled for the fixed effects and the possible observable characteristics.

among married women of age 35-44 years and the lowest is among divorced women of age 15–24 years. Compared to the results in Table 8, it is clear that irrespective of the bases for forming social groups, individuals with high quality contacts are more likely to fully utilise antenatal services in Tanzania.

Table 9: Indirect network impact on completing and timing of antenatal care visits (using age-marital status cohort)

Panel A: Indirect network effects on antenatal completion				
All	0.359 (0.012)			
	15 - 24 years	25 - 34 years	35 - 44 years	45 - 54 years
Never married	0.076 (0.018)	0.059 (0.007)	0.075 (0.007)	0.089 (0.012)
Married	0.139 (0.008)	0.407 (0.018)	0.588 (0.029)	0.248 (0.012)
Living together	0.050 (0.006)	0.133 (0.017)	0.178 (0.039)	0.149 (0.015)
Widow	0.036 (0.008)	0.060 (0.004)	0.129 (0.013)	0.149 (0.016)
Divorced	0.033 (0.003)	0.081 (0.006)	0.138 (0.017)	0.164 (0.022)
Separated	0.053 (0.012)	0.094 (0.015)	0.096 (0.009)	0.126 (0.012)
Panel B: Indirect network effects on seeking care early				
All	0.243 (0.007)			
	15 - 24 years	25 - 34 years	35 - 44 years	45 - 54 years
Never married	0.050 (0.008)	0.044 (0.004)	0.056 (0.005)	0.068 (0.009)
Married	0.102 (0.006)	0.278 (0.009)	0.384 (0.016)	0.177 (0.008)
Living together	0.038 (0.005)	0.097 (0.012)	0.129 (0.026)	0.110 (0.011)
Widow	0.027 (0.006)	0.046 (0.003)	0.095 (0.009)	0.110 (0.012)
Divorced	0.025 (0.002)	0.061 (0.004)	0.102 (0.012)	0.119 (0.015)
Separated	0.040 (0.009)	0.070 (0.011)	0.072 (0.006)	0.094 (0.009)

Table 10 reports the direct and the indirect impact of network on the probabilities of antenatal completion and early antenatal initiation for specific groups. The results are based on age-fertility cohort as a measure of the quantity of one's contact or quantity of network. The estimates on antenatal care completion are presented in column 1 and 2, while the estimates on timing of visit are in column 3 and 4. The indirect network effects suggest that social networks increase antenatal care utilisation for male headed households than in female headed households. The network estimate for employed women is greater than that of unemployed women, with the indirect effect indicating that network raises antenatal care use prospects for employed women by 13 percent relative to 10 percent for unemployed women. The network estimates for urban individuals are greater than that for rural individuals, with the indirect impact for urban dwellers almost four times higher than for rural dwellers.

Interestingly, antenatal completion prospects due to social networks for those with no education increased by 5 percent and those with secondary education by 8 percent compared to 12 percent for those with primary education. The network estimate for those who relocated within the intervening period almost double that for those who did not relocate. The completion prospects for those who relocated increased by 17 percent relative to 9 percent for those who did not relocate. Finally, the social network estimate on antenatal completion increases with the level of household asset index. The indirect effect suggests that social network would improve utilisation prospects for those in the lower wealth quintile by 3 percent and 8 percent for those in the middle quintile compared to 13 percent for those in the upper wealth quintile.

Table 10: Estimates of network and indirect network impacts on completion and timing of antenatal care (age-fertility)

Specification by group	Probability of care completion	Indirect effects on completion	Probability of early care	Indirect effects on early care
Variables	φ		φ	
Male headed household	0.371*** (0.052)	0.103 (0.002)	1.057*** (0.044)	0.462 (0.044)
Female headed household	0.355** (0.115)	0.094 (0.002)	0.876*** (0.091)	0.288 (0.009)
Household asset index below average	0.137 (0.116)	0.034 (0.001)	0.868*** (0.075)	0.299 (0.014)
Household asset index is average	0.299*** (0.109)	0.078 (0.003)	0.809*** (0.109)	0.269 (0.018)
Household asset index above average	0.448*** (0.071)	0.129 (0.003)	1.133*** (0.053)	0.399 (0.083)
Individual has no formal education	0.204** (0.097)	0.052 (0.001)	0.741*** (0.095)	0.234 (0.010)
Individual has completed primary	0.408*** (0.059)	0.115 (0.002)	1.123*** (0.048)	0.031 (0.001)
Individual has completed secondary	0.300*** (0.132)	0.080 (0.010)	0.804*** (0.105)	0.276 (0.023)
Individual is employed	0.457*** (0.112)	0.133 (0.005)	1.058*** (0.045)	0.438 (0.029)
Individual is unemployed	0.351*** (0.053)	0.096 (0.002)	0.900*** (0.081)	0.334 (0.020)
Individual lives in rural area	0.177*** (0.057)	0.045 (0.001)	0.782*** (0.054)	0.252 (0.008)
Individual lives in urban areas	0.604*** (0.089)	0.201 (0.009)	1.339*** (0.056)	0.770 (0.175)
Individual relocated	0.582*** (0.121)	0.165 (0.010)	0.797*** (0.084)	0.248 (0.012)
Individual did not relocate	0.324*** (0.051)	0.088 (0.002)	1.099*** (0.045)	0.307 (0.152)

Robust standard errors in parentheses, significance: *** p¡0.01, ** p¡0.05, * p¡0.1

In contrast, the results for the impact of social networks on the timing of antenatal check-up are much stronger than those of antenatal completion. It is evident from Table 10 that the estimated network coefficients and the magnitude of its impact are higher on timing rather than on antenatal completion probability. While the impact of network on antenatal completion ranges from 3 percent for those from poor households to 20 percent for those in urban areas, the impact on the timing of antenatal visit ranges from 3 percent to 77 percent. In Table 11, the age-marital status cohort is used as a measure of the quantity of one's network, to illustrate how the impacts of network for specific groups vary with the criteria of measuring the quantity of one's contacts. While the magnitude of the network effects vary significantly with the criteria of network formation, it is important to note that the direction of causation is independent on measure of network formation but on the quality of one's contacts.

Table 11: Estimates of network and indirect network impacts on completion and timing of antenatal care

Specification by group	Probability of care completion	Indirect effects on completion	Probability of early care	Indirect effects on early care
Variables	φ		φ	
Male headed household	0.305*** (0.041)	0.103 (0.003)	0.575*** (0.033)	0.186 (0.019)
Female headed households	0.125* (0.049)	0.023 (0.001)	0.499*** (0.023)	0.127 (0.013)
Household asset index below average	0.104 (0.080)	0.029 (0.001)	0.508*** (0.043)	0.170 (0.014)
Household asset index is average	0.104*** (0.029)	0.030 (0.003)	0.518*** (0.041)	0.282 (0.019)
Household asset index above average	0.219*** (0.072)	0.066 (0.002)	0.723*** (0.052)	0.180 (0.065)
Individual has no formal education	0.130* (0.075)	0.037 (0.004)	0.454*** (0.048)	0.238 (0.017)
Individual has completed primary	0.201*** (0.039)	0.060 (0.001)	0.644*** (0.054)	0.177 (0.016)
Individual has completed secondary	0.193** (0.076)	0.052 (0.003)	0.515*** (0.022)	0.137 (0.016)
Individual is employed	0.259*** (0.074)	0.086 (0.003)	0.533*** (0.021)	0.174 (0.037)
Individual is unemployed	0.210*** (0.034)	0.061 (0.002)	0.469*** (0.037)	0.181 (0.015)
Individual lives in rural areas	0.154*** (0.038)	0.045 (0.001)	0.450*** (0.028)	0.148 (0.013)
Individual lives in urban areas	0.241*** (0.054)	0.072 (0.003)	0.580*** (0.025)	0.206 (0.083)
Individual relocated	0.210*** (0.077)	0.062 (0.003)	0.499*** (0.020)	0.172 (0.023)
Individual did not relocate	0.208*** (0.033)	0.055 (0.002)	0.623*** (0.049)	0.196 (0.041)

Robust standard errors in parentheses, significance: *** p¡0.01, ** p¡0.05, * p¡0.1

5 Conclusion

In this paper, we have presented estimates of the magnitude of social networks on antenatal completion probabilities and early antenatal check-up, controlling for the various sources of omitted variable bias as possible. The results suggest the need of properly controlling for omitted variable bias in such an analysis, since failure to do so results in an understatement of the impact of social networks. The network coefficients remain significant after controlling for various fixed effects and controls for individual and household characteristics, although the increase in the impact is less dramatic in the regression estimating the probability of early antenatal initiation than they do affect antenatal completion probabilities. In order to identify whether or not the impact of networks varies with the way social groups are formed, we adopt two approaches for quantifying the size of networks. The results from these approaches reveal that irrespective of the various ways of social groupings, individuals with high quality of contacts are more likely to utilise antenatal services. This implies, what matters is the quality of one's contacts and not just the quantity or bases under which these contacts are formed.

Secondly, while it is clear that information externalities generated through other users of antenatal services are important for enhanced antenatal completion prospects, the effects acquired through these contacts are sensitive to the timing of first antenatal visit. While network effects increase after controlling for various fixed effects and controls for personal and household characteristics, there is a dramatic decline in network effects after including timing of first antenatal visit as a control. This suggests that the probability of antenatal completion depends significantly on the time the individual initiate the first visit, an indication of the importance of physician's information. However, this is a phenomenon worthy of further investigation. The results confirm that the impact of social networks on antenatal completion probabilities and in affecting the timing of antenatal initiation varies demographically. Social networks significantly enhance antenatal completion and early antenatal care prospects for male headed households, affluent households, employed and educated women. In addition, networks significantly enhance antenatal completion and early antenatal care probabilities for individuals living in urban areas and those who relocated within the intervening period.

It is also the case that the characteristics of health care providers will determine to some extent the level care utilisation. In some cases, care users' characteristics may be easily observable, while in others, recommendations from existing users may be especially essential and valuable. Under these circumstances, the strength of the network effects will vary. In addition, care users may vary in terms of their contact availability and in terms of the quality of their networks. This implies, the impact of the social networks on individual outcomes depends not only on the quantity and quality of the network, but also on whether the individual is able to access the network effectively. For example, individuals who relocated may have difficulty accessing the network since they are new in the area. It is therefore acknowledged that the effectiveness of social networks is contingent on differences in the characteristics of care users, the characteristics of their contacts, or their relationship with their contacts and the nature of the health care system. It should be noted that in this paper, we do not ascertain the various channels through which the effectiveness of networks is contingent on. It simply illustrates the actuality of the social network effects for respective social clusters.

Justification as to why the magnitude of network effects varies significantly across groups remain difficult, unless there is more detailed information on the functioning of the health care system, relationship between health care users and their contacts, and the patient-physician relationship. A further understanding of the dynamics and complexities of social networks in the Tanzanian health care system hinge critically on a robust data set on social networks, possibly on actual rather than potential contact. We therefore recommend that as governments design policies to promote health care use, there is need to sensitise the population not only through the media, but through other channels that reaches community groups or religious centres directly. This will have a multiplier type effect, as it affects the behaviour of people that receive the information directly, and many others in their network are more likely to benefit indirectly.

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Appendix

Table 12: Mean statistics for sample by antenatal care visit

Number of children	All	At least four visits	Less than four visits	Early care check-up
1	0.05	0.21	0.17	0.22
2	0.10	0.20	0.18	0.23
3	0.13	0.17	0.16	0.17
4	0.14	0.12	0.14	0.14
5	0.13	0.09	0.10	0.09
6	0.12	0.07	0.08	0.06
7+	0.34	0.13	0.16	0.08

Note: the table illustrates how the level of antenatal care use decline with fertility rate

Table 13: Marginal effects estimates of network as additional fixed effects are included

	Probability of antenatal care completion			Probability of early antenatal check-up		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Contact availability	-0.10***	-0.19***	-0.22***	-0.13***	-0.13***	-0.16***
	(0.02)	(0.03)	(0.04)	(0.01)	(0.01)	(0.01)
Network effects	0.39***	0.66***	0.75***	1.06***	1.09***	1.22***
	(0.07)	(0.09)	(0.10)	(0.08)	(0.08)	(0.11)
Individual relocated between 2005 and 2010	0.13***	0.13***	0.12***	-0.01	-0.01	-0.01
	(0.04)	(0.04)	(0.04)	(0.02)	(0.02)	(0.03)
Distance to health facility is problematic	-0.05**	-0.04*	-0.02	-0.03**	-0.03**	-0.02
	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)
Number of children ever born	-0.00	-0.03***	-0.02**	0.00*	-0.02***	-0.02**
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Observations	**5,310**	**5,310**	**5,181**	**5,249**	**5,249**	**4,038**
Age-fertility cohort fixed effects	No	Yes	Yes	No	Yes	Yes
Cluster fixed effects	No	No	Yes	No	No	Yes

Notes: Significance *** 1%, ** 5%, * 10%, Robust standard errors in parentheses. The contact availability variable is V_{jk} and the network variable is defined as $Netw_{ijk} = V_{jk} * \overline{use_k}$ Age- marital cohort is a measure of the quantity of one's contacts

Table 14: Marginal effects estimates of network as additional fixed effects are included

	Probability of antenatal care completion			Probability of early antenatal check-up		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Contact availability	-0.06***	-0.31***	-0.31***	-0.16***	-0.14***	-0.17***
	(0.02)	(0.04)	(0.03)	(0.01)	(0.01)	(0.02)
Network effects	0.19***	0.95***	0.97***	0.94***	1.24***	1.43***
	(0.04)	(0.09)	(0.09)	(0.07)	(0.11)	(0.12)
Individual relocated between 2005 and 2010	0.13***	0.12***	0.11*	-0.01	-0.00	-0.01
	(0.04)	(0.04)	(0.04)	(0.03)	(0.02)	(0.03)
Distance to health facility is problematic	-0.06**	-0.05**	-0.02	-0.03***	-0.03**	-0.03
	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Number of children ever born	-0.01*	-0.03***	-0.01**	0.00	-0.02***	-0.02***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Observations	5,310	5,308	5,179	5,231	5,231	4,026
Age-marital status cohort fixed effects	No	Yes	Yes	No	Yes	Yes
Cluster fixed effects	No	No	Yes	No	No	Yes

Notes: Significance *** 1%, ** 5%, * 10%, Robust standard errors in parentheses. The contact availability variable is V_{jk} and the network variable is defined as $Netw_{ijk} = V_{jk} * \overline{use_k}$ Age- fertility cohort is a measure of the quantity of one's contacts

Table 15: Marginal effects of networks including individual and household characteristics

	Using age-fertility cohort			Using marital status cohort		
	Antenatal completion	Antenatal completion	Antenatal care early	Antenatal completion	Antenatal completion	Antenatal care early
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Contact availability	-0.14***	-0.20***	-0.16***	-0.31***	-0.26***	-0.17***
	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)	(0.02)
Network effects	0.56***	0.69***	1.21***	0.96***	0.81***	1.42***
	(0.09)	(0.10)	(0.11)	(0.09)	(0.09)	(0.12)
Early antenatal check-up		0.38***			0.36***	
		(0.03)			(0.03)	
Individual characteristics						
Individual relocated between 2005 and 2010	0.11**	0.11***	-0.01	0.10**	0.10**	0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Individual age at birth (20 – 34 years)	0.09**	0.09**	-0.01	0.08**	0.08**	0.01
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)
Individual age at birth (35 – 49 years)	0.50*	0.24**	0.13	1.77***	1.55***	0.56***
	(0.29)	(0.10)	(0.09)	(0.27)	(0.26)	(0.11)
Individual years of schooling	0.01**	0.01***	0.00	0.01***	0.01**	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Knowledge of pregnancy complication	0.05***	0.04**	0.03**	0.05***	0.04**	0.03*
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Distance to health facility is problematic	-0.01	-0.00	-0.02	-0.02	-0.01	-0.02
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Number of children ever born	-0.00	0.00	-0.01	0.00	0.00	-0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Number of under-five children per woman	-0.07***	-0.07***	-0.04***	-0.09***	-0.08***	-0.03***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Household characteristics						
Getting money for care is problematic	-0.06**	-0.05*	-0.02	-0.05*	-0.05	-0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Male headed household	0.05*	0.04**	-0.02	0.05*	0.05**	-0.02
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
Household asset index	0.05***	0.05***	0.01	0.05**	0.04**	0.03**
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Household size	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual lives in the central zone	-0.02	0.07**	-1.35***	-0.09**	-0.04	-1.25***
	(0.04)	(0.03)	(0.13)	(0.04)	(0.04)	(0.11)
Individual lives in the southern highlands zone	-0.20***	-0.15***	0.03	-0.21***	-0.15***	0.10***
	(0.04)	(0.03)	(0.02)	(0.04)	(0.04)	(0.02)
Individual lives in the lake zone	0.13***	0.09***	0.06***	0.07*	0.07*	-0.13***
	(0.04)	(0.02)	(0.02)	(0.04)	(0.04)	(0.03)
Individual lives in the eastern zone	0.21***	0.07**	0.19***	0.06*	-0.03	0.20***
	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.02)
Individual lives in the Zanzibar zone	0.07*	0.08***	0.00	0.02	0.03	0.00
	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.02)
Individual lives in the southern zone	-0.28***	-0.27***	-0.11	-0.38***	-0.37***	-0.01
	(0.04)	(0.09)	(0.11)	(0.04)	(0.04)	(0.02)
Individual lives in the western zone	-0.05	-0.14***	0.02	-0.13***	-0.18***	0.01
	(0.05)	(0.04)	(0.03)	(0.05)	(0.05)	(0.03)
Observations	5,016	5,017	3,986	5,016	5,015	3,973

Notes: Significance *** 1%, ** 5%, * 10%, Robust standard errors in parentheses. The contact availability variable is V_{jk} and the network variable is defined as $Netw_{ijk} = V_{jk} * \overline{use_k}$. All regressions include cluster fixed effects for age-marital status cohort fixed effect Column 1, 2, 4, 5 are for antenatal care use regression, column 3 and 6 are estimates for timing of antenatal visit