Peer Effects on Vaccine Take-up among Women: Experimental Evidence from Rural Nigeria

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Abstract

Social networks are important in influencing one's health behaviors. Using experimental data, this paper analyzes the effect of social networks on vaccination behaviors among women in rural Nigeria. Social networks within village, neighborhoods, and among friends all influence one's vaccination decision to a great extent. We find that the effect of a friend getting vaccinated increases the likelihood that one receives a vaccination by 17.8 percentage points. We additionally find that the effect of a friend receiving a vaccine on one's vaccination decision varies by the belief about vaccine safety, by the distance to a health clinic, and by the amount of cash incentives. We find suggestive evidence that social networks matter for one's vaccination decision because peers visit the clinic for vaccination together.

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1 Introduction

The role of social networks in vaccination behaviors among other health behaviors deserves attention because of the potential externalities of the disease within a social network that vaccination can prevent. Theoretically and practically, the effect of peers on one's vaccination decision can be positive or negative due to various mechanisms such as information sharing, cost sharing, imitation, and free-riding (Bodine-Baron, 2013; Philpson, 2000). In the context of developed countries, Rao et al. (2014) find positive peer effects on the perception of vaccine benefits as well as on vaccination behavior by using a random assignment of dormitory rooms among American undergraduates. On the other hand, Ibuka et al. (2014) find that vaccinations are discouraged among peers due to the free-riding problem using a lab experiment in the U.S.[1]

Although the potential role of peers in effective disease control can be crucial, especially in developing countries where disease prevalences are high, there has not been a causal study of peer effect on vaccination in developing countries. This study is the first to causally examine the peer effect on vaccination in Africa, using different definitions of peers.[2] Furthermore, we analyze the differential effect of social networks on vaccination, as well as identifying potential mechanisms through which peers influence one's vaccine behavior.

Measuring the causal effect of social networks has proven challenging because the selection of peers is endogenous (Manski, 1993). However, recent studies have overcome this methodological issue by implementing experiments that can influence peers' behaviors exogenously. For example, Miguel and Kremer (2004) uses the random variation of the distribution of deworming drugs at school level and find that untreated students who are close to treated schools benefit from the spillover of the project in Kenya. Godlonton and Thornton (2012) measures the effect of social networks on learning HIV results by using the exogenous variation of cash incentives offered to individuals in Malawi. They find that when the number of neighbors learning their HIV results increases by 2.4, it increases the probability of one's learning HIV results by 1.1 percentage points.

Identifying mechanisms for peer effects has been important yet difficult in the previous

[1] Many other papers analyze the relationship between social networks and one's vaccination decision in develped countries (for example Nyhan, Reifler, and Richey, 2012; Brunson, 2013), but they are mainly not causal studies as they do not control for the endogeneity of social network formation.

[2] Goldberg (2014) presents the non-causal relationship between social networks and vaccination behavior in Nigeria.

studies. Within non-health field, Cai, De Janvry, and Sadoulet (2015) contributed to social network literature because they identified the mechanisms under which social networks influenced the insurance take-up among farmers in rural China by creating a random variation of information available to farmers about peers' decision to insure. Bursztyn et al (2014) evaluated a field experiment to distinguish between social learning and social utility (utility from owning the same asset with her peers). Within health-related literature, Kremer and Miguel (2007) studied the information sharing about de-worming drugs among school children. Sorensen (2006) found that social learning is important for the choice of health plan in the U.S.

This paper focuses on vaccination behaviors against tetanus among women at child-bearing age. Tetanus is a non-communicable disease; thus, we control for the potential free-riding problem to evaluate the peer effects.[3] Nigeria, the study site, is one of twenty five countries where tetanus remains a major public health problem (WHO, 2013). Tetanus contributes to high neonatal mortality rate, up to 20 percent in Nigeria (Oruamabo, 2007). This is because fatality of neonatal tetanus reaches almost 100 percent without medical treatment, which is difficult to obtain in rural Africa (Blencowe et al, 2010). Neonatal tetanus is typically contracted at the time of delivery when the umbilical cord is cut with a non-sterile instrument, and tetanus-toxoid vaccine is the most effective way to prevent neonatal tetanus. However, the take-up of tetanus vaccines in Nigeria remains low: 52.8 percent (DHS, 2013). Eliminating the possibility of free-riding problem, this paper evaluates if peers encourage an individual's vaccination.

This paper analyzes the effect of various social networks on one's vaccination decision as well as performs analysis on the characteristics of peers who have stronger influence on one's vaccination in rural Nigeria, and evaluates potential mechanisms of the positive peer effects on vaccine decisions. We analyze an experiment that randomized the amount of cash incentives, conditional cash transfer (CCT), to women to receive a tetanus-toxoid vaccination at an assigned clinic. The random allocation of cash incentives to individuals allows the causal study of peer effect on vaccination decision due to the strong positive effect of cash incentives

[3]With other things being equal, we expect to see higher network effects for non-communicable diseases than communicable diseases due to the lack of free-riding problem. So, if network effects are significant for vaccine take-up for communicable diseases, they should also be so for non-communicable diseases. In another word, the estimated effects for non-communicable diseases are considered to be upper bound of network effects on vaccination.

on individual's vaccine take-up.

We find that social networks have a strong influence on vaccine take-up. Social networks among villagers, neighbors, and friends all significantly increase one's vaccine take-up. For example, if a respondent has a friend who has been vaccinated, it increases the likelihood of her vaccination by 17.8 percentage points. Although this is not the first causal study of the social network, our result adds to the literature by methodologically overcoming endogeneity through using a random variation of peers' behavior and by finding very strong peer effects on vaccination.[4]

This paper further evaluates the differential effect of friends' vaccination on one's vaccination behaviors by the amount of CCT, by the belief, by the distance, and by the religion. If a respondent was offered the highest amount of CCT, the effect of her friend's vaccine take-up on her vaccine decision is smaller than when the amount of CCT offered is lower. A respondent's concern about vaccine safety reduces the effect of a friend's vaccination to null. If the distance from a respondent's house to a health clinic is short, the effect of her friend's vaccination behavior on her vaccination decision is smaller than when the distance is long. One's religion does not change any type of friends' effects on own vaccination decision.

We also address the potential mechanism of the positive effect of social networks; social networks enhance vaccination possibly through information sharing or collective decision making. Particularly, we find suggestive evidence that friends' vaccination decision matters because respondents come together with friends, which indicates the potential collective decision making. We provide suggestive evidence for collective decision making by analyzing what kind of respondents attend clinic together with their peers.

Overall, our results suggest important policy implications. Our finding of strong effects of peers as well as cash incentives on vaccine take-up implies that governments should invest more in CCTs for vaccination. Social benefits of investing in CCTs for vaccines are higher if the peer effect is taken into consideration because recipients of CCTs positively influence their

[4]It is important to contrast the difference in the role of social networks that we find on a health behavior and what Miguel and Kremer (2007) find. While they find a negative effect of social networks on deworming pill take-up in Kenya, our study finds a positive effect on vaccination take-up. This contrast can be attributed to the difference in nature of products. Deworming pills benefit the treated people, but they also greatly benefit others in the community. As a result, the take-up of deworming pills might decrease if people free-ride on this public good. On the other hand, tetanus-toxoid vaccines only benefit the vaccinated individuals because tetanus is not transmitted from person to person. Thus the take-up increases once people realize the benefit of the vaccine through their peers.

peers for vaccination.

2 Experiment and Data

2.1 Setting

This study is based on a larger project to measure the relative importance of psychic costs of vaccination as compared to monetary costs as potential barriers to vaccination in rural Nigeria. We conducted the larger study in Jada local government area, which exhibited the lowest tetanus toxoid vaccination rate in Adamawa state, one of the northeastern states.

This project was conducted in March through May, 2013. The sample was drawn from three-stage sampling. First, 10 health clinics were selected in a way that they were geographically spread across Jada local government. There was a total of 11 wards (9 rural wards and 2 urban wards) spanning all the villages in Jada and the study exclusively focused on 9 rural wards with each ward having 1 to 5 public health clinics. We selected the main health clinic from each ward with the exception of one large ward under which we selected 2 clinics, which brought the total to 10 clinics for our study.

Second, we selected a total of 80 villages which fell within one of the catchment areas of each clinic. Catchment areas of each health clinic were defined by the primary healthcare development agency which was responsible for national immunization campaigns. All the villages within a catchment area of each health clinic were selected if the village had more than 10 households and the total number of villages within a clinic's catchment area did not exceed 15. If it did, the priority was given to villages with the furthest distance from the health clinic.

Third, one eligible woman, who was aged 15 to 35, was selected from each household in each village. The survey team visited all the households in each village to find out if there were any eligible women. A woman was ineligible if she had received a tetanus vaccination in the 6 months prior to the time of the survey so as to avoid overdose; the second dose of the tetanus vaccine should be given to individuals at least 6 months from the first dose. In cases where there was more than one eligible woman in one household, the first priority was given to pregnant women who had not received tetanus-toxoid vaccination in the past 6 months. If there were no eligible pregnant women in the household, then the second priority was given to women who had never received a tetanus vaccination before. If we still did not find any eligible women with a priority, then women who had not receive a tetanus vaccine in the past 6 months were invited to participate in the survey. If there was more than one woman who was eligible under the same priority, then we randomly picked one of the eligible women by selecting the first one in alphabetical order of the first name. On average, each health clinic covered 249 respondents from 9.6 villages in the study.

2.2 Experimental Design

The larger study randomized several factors: the amount of cash incentives, the condition of cash incentives, and the salience of information. We found that a small cash incentive ($2) increased the vaccine take-up by almost 20 percentage points, from 50 percent. On the other hand, two different conditions under which a respondent could receive cash incentives, either clinic attendance or vaccination at the clinic attendance, did not result in difference in the clinic attendance rate. The salient information which emphasized the severity of tetanus did not promote vaccination behavior, either. Thus, this paper focuses only on the random variation in the amount of cash incentives offered to individuals because other factors did not influence one's vaccination decision (Sato and Takasaki, 2015).

We randomly varied the amount of conditional cash transfer (CCT) offered to each respondent. The probability of one being offered each amount of cash incentives was roughly the same in each village. The amount of money offered was randomly assigned to each respondent: either 5 naira (approximately 3.3 US. cents), 300 naira (2 US. dollars) or 800 naira (5.3 US. dollars). As a reference, the average daily earnings per household is approximately 1,000 naira and that per person is 144 naira in the study. The average transportation cost to and from the health clinic is about 250 naira among those who need to pay for the transportation while 50 percent of the sample do not pay for the transportation in our study.

Although we designed the study so that the probability of one being offered each amount of cash incentives is roughly the same in each village, the nature of our study creates a village-level variation of the percentage of respondents who received the highest amount of CCT. This is because the assignment of the amount of CCT to each respondent was randomly determined by interviewers picking a questionnaire in front of each respondent, which indicated a randomly-assigned amount of cash incentives in the middle of the pages of each questionnaire. In other words, the assignment of the amount of CCT to each respondent was not determined beforehand. This variation in the proportion of respondents who were offered the highest amount of CCT in the village becomes critical when we analyze the effect of peers in a village on one's vaccination behavior.

2.3 Data

2.3.1 Social Networks

This study collected information about social networks at the baseline survey. Namely, this study defines villages, neighbors, and friends as social networks. Below describes how we collected the information.

Village

We use the pre-determined unit of the social network, village, to identify the peer effect. The average number of women the study covered in each village was relatively small, the total number of women who were in the study in a village was 50.2 on average. Because the assignment of each treatment was random at an individual level and the nature of the treatment assignment created a variation in the proportion of respondents who received each amount of CCT by village, the peer effect on vaccination behavior is identified using such village-level random variations. The proportion of respondents receiving the highest amount of cash transfer (800 naira) ranges from 18.2 percent to 60 percent with the average of 34.9 percent.

Neighbors

Literature suggests that the village might not be a correct unit in measuring the spillover effect because information might spread only within the neighborhood (Godlonton and Thornton, 2012). This study measured the GPS coordinates of each respondent's house in order to analyze the spillover effect within a closer geographical proximity than within a village. Because the assignment of treatment status to respondents was random at an individual level, the random assignment rule should also apply to their neighbors. This study focuses on the neighbors who lived in the same village and who lived within 100 meters and 700 meters from each respondent. On average, one respondent had about 13.4 and 39.8 neighbors who were also respondents of the study from the same village respectively within 100 meters and withint 700 meters from her house.[5]

Friends

In addition to geographical information, this project collected unique data on friends for each respondent. Each respondent was asked to list the full name of her friends in the same village who fell within the 6 categories: a best friend, a friend whom she admires, a friend whom she talks about health issues with, a friend whom she goes to health clinic together with, a friend whom she visits when the friend is sick and a friend who visits her when she is sick. Respondents were asked to list only one name for each category, but the name could overlap across the different categories.

Data on listed friends was matched to names of respondents in the study. The matching was done manually to increase the precision because misspelling of names was common in the survey and at many times, there was more than one way to correctly spell each name. Furthermore, the total number of participated women in each village to find the match from was not large, which makes the maual coding easier and more accurate.[6]

Among six friend-categories, the matching rate was relatively similar. Approximately 25 percent of the names listed in each category were matched to respondents in our study while 1.5 percent of respondents did not provide any name for each category. The rest of approximately 73.4 percent of respondents who listed the name of friends in each category were not matched with any names of respondents. Reasons why names of friends listed were not matched with any names who were also in the survey include that the friend lived in a household that the survey team did not visit, or that the friend was not eligible. We did not conduct a census of each village covered in the study which would have enabled us to identify the reasons of unmatching.

We use the variation of vaccination behaviors among friends who also participated in the study to evaluate the effect of friend's vaccination status on the likelihood that one receives

[5]We also check the robustness of the analysis by using other distance which ranges from 200 meters to 1000 meters, and only the closest neighbor. Additionally, we also use the alternative definition of neighbors: those who reside within a certain radius, independent of the village border. We find that the main results do not change even with the different definition of neighborhood based on the distance.

[6]We also coded each name of friends to match with respondents' names to check the precision of the manual matching. The manual matching achieves the higher matching rate.

a vaccine. This analysis is possible because the vaccination decisions by friends have been randomly induced by cash incentives. Whenever we analyze the effect of friends using the total sample, we treat friends who are outside of the study or who are not eligible for the study as though they have not received a vaccine, in order to evaluate the lower bound of the effect of friends.

2.3.2 Descriptive Statistics and Balancing Tests

Our analysis of 3 social networks (village, neighborhood, and friends) is based on 2,482 eligible women from a larger study. We exclude respondents who do not have any neighbors within a certain radius (either 100 meters or 700 meters) from the neighbor analysis. On average, slightly more than 70 percent of respondents in a village and in a neighbor (100 meters and 700 meters) received a vaccine, and 34 percent of villagers and neighbors were offered the highest CCT of 800 naira. Around 24 percentage of respondents had at least one friend who received a vaccine and 11.7 percentage of respondents have friends who were offered the highest CCT (Appendix 1 Panel A).

The proportion of villagers and neighbors who were offered the highest amount of CCT was the lowest among respondents who were offered the highest amount of CCT (Appendix 1 Panel A). This is because each village had approximately the equal proportion of respondents with each amount of cash incentives. The proportion of friends who were offered each amount of CCT, on the other hand, is not statistically different by the amount of CCT respondents received. The proportion of villagers who received a vaccine was more among respondents who were offered the highest CCT, while the proportion of vaccinated peer did not change among neighbors and among friends. All the analysis control for own treatment status

Appendix 1 Panel B presents the balance tests of respondents' baseline characteristics. Respondents were on average 25 years old and half of the sample were Muslim. About half of the women did not receive any form of education; 24 percent completed primary school and 26 percent completed secondary school. 15 percent had never been married and 76.5 percent had at least one child. Around 18 percent of respondents were pregnant at the time of baseline survey. Many respondents, 43 percent, had paid work. The majority of respondents, 73.7 percent, had previously visited the health clinic which was assigned to each respondent under this study. Overall, 40.8 percent of women had ever received tetanus-toxoid vaccination at least once. Over 65 percent of respondents thought that vaccine have side effects. The distance to the clinic was on average 1.7 kilometers, and around 47 percent of respondents live within 1.5 km from health clinics.

Randomization check in Appendix 1 (Panel B) finds very few differences by the amount of CCT offered. For all the demographic variables listed above, we could not reject the equality of means between each treatment except age and concern about side effects . On the other hand, age is positively correlated and concerns are negatively correlated with the amount of CCT offered.

Table 1 presents the balance tests by the proportion of villagers (Panel A), neighbors (Panel B), and friends (Panel C), who were offered the highest CCT. The higher proportion of villagers who were offered the highest CCT was correlated with one's religion (less likely to be Muslim), with one's education level (more likely to have secondary education or more), with pregnancy (less likely to be pregnant), and with clinic use (less likely to use clinic before). The proportion of neighbors within 100 meters who were offered the highest CCT was negatively correlated with one's likelihood to have used the clinic before, while the higher proportion of neighbors within 700 meters who were offered the highest CCT was correlated with one's religion, education level, pregnancy, and the clinic use. The treatment status of friends are not significantly correlated with any of observable characteristics (Table 1 Panel C). Because several variables are correlated with the proportion of peers who received the highest CCT, all the analysis control for all the baseline characteristics.

3 Peer Effects

In this section, we evaluate the effect of various social networks on vaccination take-up. The units of social networks we use in this study are village, neighborhood, and friend network. We overcome the methodological challenge of measuring the effect of social networks by using the exogenous variation of the amount of cash incentives offered to each peer which affected peers' vaccination decision. We find that peers' vaccination behaviors within all the social networks causally increases one's vaccination take-up to a great extent.

3.1 Specification

We estimate the peer effect on one's vaccination take-up with the following regression:

$$Y_{ij} = \alpha + \beta_1 PeerVaccinated_{ij} + \beta_2 NumberWomen_{ij} + X_{ij}{}'\mu + \epsilon_{ij} \tag{1}$$

where $PeerVaccinated_{ij}$ is the proportion of peers who received a vaccine in a village or within a neighborhood, or a dummy variable which takes 1 if any of a respondent's friend received a vaccine, and $NumberWomen_{ij}$ is the total number of women in the social network. X_{ij} is a set of covariates which include individual-level variables such as age, age squared, education level, religion (Muslim or not), marital status, pregnancy status, whether she has a child, whether she has a paid work, distance to a health clinic, past utilization of the assigned health clinic, and past tetanus-vaccine experience as well as the treatment status of each respondent.

Because the independent variable $PeerVaccinated_{ij}$ is endogenous, we use an instrumental variables strategy to causally measure the peer effect on vaccination, relying on the fact that peers were randomly offered the different amount of CCT and that the amount of CCT strongly affect one's vaccination decision. We instrument $PeerVaccinated_{ij}$ in (1) with the proportion of peers who received the highest amount of CCT within a village where a respondent belongs, or within a neighborhood. For estimating the effect of a friend's vaccine behavior, we instrument $PeerVaccinated_{ij}$ in (1) with a dummy variable which takes 1 if a friend was offered the highest amount of CCT. The first stage to evaluate peer effects among villagers and among neighbors is

$$PeerVaccinated_{ij} = \alpha + \beta_1 PeerCCT800_{ij} + X_{ij}{}'\mu + \epsilon_{ij} \tag{2}$$

where $PeerCCT800_{ij}$ is the proportion of respondents who were offered the highest amount of CCT (800 naira) in a village, or within a neighborhood (100 meters or 700 meters radius). This does not include the amount of own CCT. We only use the highest amount of CCT because this amount has the strongest effect on vaccine take-up.

The first stage to evaluate peer effects among friends is

$$PeerVaccinated_{ij} = \alpha + \beta_1 FriendCCT800_{ij} + X_{ij}{}'\mu + \epsilon_{ij} \quad (3)$$

where $FriendCCT800_{ij}$ indicates if any friend of a respondent was offered the highest amount of CCT (800 naira).

3.2 Strong Effect of Social Networks

Because we use IV estimator to identify social networks, we first describe the strong result of the first stage. There is a large and strong effect of the highest amount of CCT on the vaccination take-up among the social networks (Appendix 2 Panel A). Specifically, one percent increase of peer in a village offered the highest amount of CCT increases the proportion of respondents receiving a vaccine in the village by 2.3 percent. Similarly, one percent increase in neighbors residing within 100 meters with the highest CCT increases the proportion of respondents receiving a vaccine in the neighborhood by 0.77 percentage points, and it increases by 1.02 percent among neighbors living within 700 meters. If any of a respondent's friend is offered the highest CCT, it increases the likelihood of friends receiving the vaccination by 32 percentage points. Among respondents who have friends who are also respondents, any friend offered the highest CCT increases her likelihood of receiving the vaccine by 22.0 to 24.4 percentage points. These results, that peers with higher cash incentives increases their likelihood of vaccination within any of the three social networks (village, neighbors, and friends), are important first stage estimates in order for the instrument variable strategy to be valid.

Using IV regressions, we find strong evidence of positive peer effects on vaccination take-up (Table 2 Panel B).[7] If the proportion of women receiving a vaccination increases by one percent in one's village, then a respondent is more likely to receive a vaccine by 0.84 percentage points (Table 2 column 8). Similarly, if the proportion of women who received a vaccination increases by one percent in one's neighborhood within 100 meters and 700 meters, then the probability that a respondent receives a vaccine increases by 0.29 (column 9) and 0.76 percentage points (column 10) respectively. Finally, if any friend that a respondent has received a vaccination,

[7] OLS regressions reveal the consistent results with IV regressions (Table 2 Panel A). OLS estimators are biased because peers' vaccine take-up is endogenous, unless it is driven by the cash incentives that were randomly given to peers. We also evaluate the reduced form result (Appendix 2 Panel B). Generally, we find the consistent results with IV results: higher proportion of peers (villagers, neighbors, and friends) offered the highest CCT, more likely that one receives a vaccine.

it increases one's vaccination take-up by 17.8 percentage points (column 11). The analysis among friends using village fixed effect gets weaker, but still consistent with the one with health facility fixed effect (column 12).

Note the similarity between the effect of the proportion of villagers vaccinated and the effect of the proportion of neighbors within 700 meters vaccinated, and the similarity between the effect of the proportion of neighbors within 100 meters vaccinated and the effect of any friend vaccinated. This is because many of neighbors within 700 meters overlap with villagers, and close neighborhoods (100m) significantly overlap friend networks. Most of one's friend (68 percent) live within 100 meters from a respondent (Figure 1).

We evaluate the effect of friend's vaccine take-up on one's vaccine decision, restricting the sample into women who have at least one friend who is also in the survey. First, we check if there are differences in characteristics between women who do not have friends in the survey and women who have. We did not find any significant differences by the proportion of villagers and neighbors who were vaccinated (Appendix 7), as well as by other observable characteristics (Table not shown). Among respondents who have friends in the sample, the effect size is 18.6 to 26.4 percentage points (column 13 and 14).

4 Differential Effects

The previous section reveals the strong peer effects on vaccination decision. This section performs the analysis of differential effects of peers. First, we analyze the substitution between the effect of CCT a respondent receives and the peer effect. We then move on to the differential effect analysis. We focus on three categories; (1) perceptions about vaccine, (2) access to health clinic, and (3) socioeconomic characteristics. Particularly, we report the differential effect of peers by belief about vaccine safety (concerns about side effects) for (1), distance from a respondent's house to a health clinic for (2), and religion for (3) in this section. We also analyze several other differential effects for each category, for example by belief that vaccines give some diseases for (1), and by past tetanus vaccine take-up, education level, and pregnancy status for (3) and find the similar results as the one we show in this section (Table not shown).[8]

We evaluate the differential effect of friend's vaccination on one's vaccine take-up decision

[8]The analysis of differential effects in this section focuses on friends. We do not show the differential effects among villagers and neighbors because there are no differential effects by these variables.

in the following regression framework:

$$Y_{ij} = \alpha + \beta_1 FriendVaccinated_{ij} + \beta_2 H_{ij} + \beta_3 (FriendVaccinated * H)_{ij} + X_{ij}'\mu + \epsilon_{ij} \tag{4}$$

where $FriendVaccinated_{ij}$ is a dummy variable which takes 1 if any of a respondent's friend received a vaccine, H_{ij} is a variable which potentially changes the average effect of the peers' vaccination decision (the amount of CCT, belief about vaccine side effects, the distance to the health clinic, and a respondent's religion; whether Muslim or not). Appendix 3 and 4 presents the result of first stage and of reduced form respectively to show that the IV estimator is valid and consistent.

4.1 Substitution between CCT and Peer effects

Table 3 (column 1 and 2) show the substitution of the effect of the amount of CCT a respondent's received and peers' vaccination. The result shows suggestive evidence that the effect of CCT on vaccine take-up substituted the effect of a friend's vaccination decision. Especially, if a respondent offered the highest amount of CCT (800 naira), the effect of a friend's vaccine take-up on one's vaccination decision was lower by 6.8 to 8.6 percentage points than when she was offered the lowest amount of CCT.

4.2 Concern about Vaccine Safety

Perceptions greatly influence vaccination behaviors across the globe (Larson et al., 2014). One's perception might mitigate the effect of social networks if her belief is difficult to be influenced by peers. We examine if one's risk perception of vaccine (concern about side effects) diminishes the effectiveness of peers' vaccine behavior on one's vaccination decision.

Table 3 (column 3 and 4) show the differential effect of villagers' vaccination on one's likelihood of receiving a vaccine by respondents' belief about vaccine safety. The positive effect of any friend who received a vaccine on one's vaccine behavior is mitigated by the respondent's concern about side effects by 8.5 to 11.9 percentage points. Although the interaction term is insignificant using health facility fixed effect, this result of the differential effect of side effects is reinforced with a robustness check using villages fixed effect. This result indicates that if a respondent has a safety concern over vaccines, her friend's vaccination decision is less likely to influence her vaccine take-up. In other words, one's belief is difficult to be changed by peers.

4.3 Distance to Health Clinic

The distance to a health clinic is one of the major reasons for low health service utilization (Thornton, 2008). While the long distance prevents one from attending a clinic, peers might help one overcome costs of traveling long distance. On the other hand, a woman might not need her peers if she has an easy access to a health clinic because the cost of attending the clinic is already not large. We construct a dummy variable to indicate the distance to a health clinic, and the cut-off of the distance variable we use is 1.5 km, which is about the median distance to health clinics.

Table 3 (column 5) shows that if a respondent lives 1.5 km or less from the health clinic, the effect of a friend's vaccination is reduced by 11.0 percentage points. The friend networks influence one's vaccination decision especially when the distance to the clinic is far.

This result suggests that the long distance to a health clinic might increase one's barriers to receive a vaccine at the clinic, either due to financial costs or psychological costs, but friends help mitigate such costs. If the health clinic is far, one might have stronger incentives to visit the clinic together with her peers so that they share the transportation cost. Peers might also help mitigate her psychological costs to visit a health clinic when it is far if she travels together with her peers.

4.4 Muslim

Muslim is often argued to have distrusts against western medicines, including vaccines. For example, polio vaccine boycott was initiated by Muslim leasers in northern Nigeria in 2003 (Jegede, 2007). Muslim leaders claimed that polio vaccines contains viruses that would make women infertile. If Muslim respondents hold similar distrusts against tetanus vaccine (especially because tetanus vaccine is highly linked with pregnancy), being Muslim might hinder a effect of peer effects on vaccine decision.

Contrary to the hypothesis, being Muslim does not have any differential peer effect among villagers nor among friends (Table 3 column 6 and 7). However, it is important to note that being Muslim significantly reduces one's likelihood of getting vaccinated by 10.4 to 13.3

percentage points. This result implies that the vaccine take-up among Muslim can greatly improve with the help of their peers.

5 Mechanism of Peer Effect

Here we examine possible channels through which social networks may affect a vaccination behavior, with a focus on information sharing and collective decision making.

First, information sharing might not be a strong mechanism in this setting because all the respondents have received some information about the vaccine. However, there is suggestive evidence that knowledge about tetanus and vaccine is promoted among respondents through peers, especially friends. Appendix 5 shows that respondents are more likely to correctly state the causes and symptoms of tetanus (column 19 and 25) and are more likely to have higher perception of vaccine efficacy (column 12, 24, and 30) if they have more neighbors or a friend who received a vaccine beforehand .

5.1 Mechanism: Coming to Clinic Together

We also consider the possibility that the vaccination decision is made collectively among peers. Particularly, we hypothesize that respondents gather together after they receive the intervention, decide if they would receive a vaccine, and then visit a clinic together. We analyze this possibility further below by analyzing who visited a clinic together with their peers among respondents who visited a clinic.

As we found in the previous section, the high amount of CCT, the concern about side effects, and the closer distance to a health clinic reduce the effect of friend's vaccination, while they do not influence the effect of peers among villagers. Assume that the main mechanism of the positive peer effect is that peers visit clinic together. Then we should observe that, among respondents who visited a clinic, those who have the concern about side effect are less likely to visit the clinic together with their friends. Similarly, we should expect that respondents who live closer to health clinics as well as respondents who were offered the high amount of CCT are less likely to come to clinic together with their friends. On the other hand, because we did not find any differential effect of peers by beliefs about vaccine safety, by distance to health clinic, by religion among villagers, nor by the amount of CCT, we should expect that these variables should not be correlated with a likelihood that a respondent visit the clinic together with anyone in the village.

To test the mechanism of "coming together", it is ideal to analyze and compare who visited a clinic with any villagers except friends and who visited a clinic with friends, using the total sample. However, doing so is not possible because not all the respondents have friends who were also in the survey. Thus, we do the similar analysis, limiting the sample to those who have at least one friend in the survey.

Table 4 shows the correlation between variables (concern about side effect, distance to health clinic, and religion) and whether a respondent visits a clinic together with any villagers except friends (left half of the table), or with any friend (right half of the table), among respondents who attended a clinic and who also have at least one friend in the survey (472 observations).

Our data does not have a direct observation about people with whom a respondent visited a clinic together. However, we have data on the order with which each respondent came to each health clinic, and the time of the day (as well as the date) when each respondent was interviewed at a health clinic. Respondents who came to clinic was interviewed immediately and the interview was implemented in the order of their visit. Thus we use two criteria to define if a respondent came to a clinic together with other respondents ("coming together"): (1) if a respondent arrived at a clinic right before and right after her peer (consecutive visit) and (2) if the time lag between the initiation time of the interview for the respondent and the initiation time for her peer's interview is less than a certain minute (particularly we use 10 minutes, 5 minutes, 4 minutes, and 3 minutes).

The outcome variable of the left half of Table 4 is "coming together" with any peers from a village where a respondent belongs except friends (any villagers except friends), and the outcome variable of the right half of Table 4 is "coming together" with any friend that a respondent has in the village. Although insignificant, the concern about side effects reduces the likelihood that a respondent comes together with her friend in a consistent manner, no matter which definition used (column 5 to 8) while the concern does not reduce the likelihood of "coming together" with any villagers except friends (column 1 to 4). This pattern is consistent with the result of the differential effect; that a concern about side effects reduces the effect of friend's vaccine decision on one's vaccine take-up, but the effect of villagers' vaccine decisions is not mitigated by one's concern about side effects (Table 3 column 3 and 4). If a respondent has a concern about side effects, her friend is less likely to influence her vaccine decision because she tends to avoid visiting a clinic together with her friends.

Column 9 to 16 of Table 4 presents the correlation between the distance to clinic and "coming together". The closer distance to clinic reduces the likelihood of "coming together" with friends (column 13 to 16), but it does not affect the likelihood of "coming together" with any villagers except friends (column 9 to 12). This result is consistent with Table 3 (column 5). The close distance to the health clinic reduces the effect of friend's vaccine decision on one's vaccine behavior, but it does not influence the peer effect among villagers. If one lives nearby to a clinic, her friend is less likely to influence her vaccine decision because it is not necessary for her to attend a clinic together with her friend.[9]

Table 4 (column 17 to 24) shows that there is no clear correlation between religion and "coming together" neither with villagers nor with friends. This result is consistent with Table 3 (column 6 and 7): religion does not have any differentiate the peer effect on vaccine behavior. Although insignificant, signs of differential effects (Table 3) are consistent with that for the analysis for "coming together". Among villagers except friends, being Muslim weakly reduces the peer effect on one's vaccine take-up (table not shown), and this religion is also weakly negatively correlated with the likelihood of "coming together". Among friends, being Muslim weakly increases the peer effect (Table 3 column 6 and 7), and this religion is also weakly positively correlated with the likelihood of "coming together".

Because Table 4 uses the restricted sample of respondents who have at least one friend who were also in the survey, we would like to confirm how this restricted sample is comparable with the total sample. Appendix 6 shows the comparison of the correlation between characteristics and the likelihood of "coming together" with villagers using the total sample (left half of the table), and using the restricted sample (right half of the table). Because our analysis for differential effects suggests that any characteristics (concern about side effects, distance, and religion) do not have differential effect on peer effects by villagers (Table not shown), all the correlation should be insignificant. This hypothesis is consistent with the result for side effect

[9]Similar to the concern about side effects and the close distance to health clinic, we find that the highest amount of CCT offered to a respondent weakly reduces the likelihood of "coming together" with friends (table not shown), but this pattern does not hold with villagers. This result is weakly consistent with the differential effect of peer effects by the amount of CCT a respondent was offered (Table 3 column 1 and 2).

and being Muslim. Although the close distance to clinic is negatively correlated with the likelihood of "coming together" with villagers, using the total sample (Appendix 6 column 9 to 12), we confirm that this comes from friends among other villagers in Appendix 6 (column 13 to 16).

Overall, we find consistent results that respondents come to clinic together with their friends, which can be one mechanism for why peers' vaccination decision positively affects one's vaccine take-up.[10]

6 Conclusion

Although the role of social networks in health behaviors received increasing attentions in the literature, it is important to evaluate if there are differential effects of peers depending on their characteristics. This paper examines the effect of various social networks as well as the differential effect of peers' vaccination on one's vaccination decision. We also identify the potential mechanism of the positive peer effects.

We find that peers' vaccination behavior increases one's vaccine take-up significantly among villagers, neighbors, and friends. However, the influence of peers' vaccination decisions on one's vaccine take-up significantly drops if the respondent was offered the highest amount of CCT, if one has a concern about vaccine safety (side effects), and if one resides less than 1.5 km from the health clinic Own religion (being Muslim) does not alter the effect of peers' vaccination behavior. We identify that social networks influence one's vaccine take-up positively at least partly because they attend the clinic together.

Past studies have emphasized the importance of peers in promoting health behaviors without detailed examinations on what kind of peers has more influence than others, and why peers matter. We contribute to social network literature because this is the first study in measuring the causal effect of social networks on vaccination in Africa and identify the potential mechanism of peer effects. Results imply that group interventions to promote vaccination among peers might be effective than individual interventions.

[10] We also analyze the correlation between other perceptions measures than concerns about side effects and "coming together", such as the belief that vaccines give HIV, and that vaccines give diseases. Consistent with insignificant results of differential effects (Table not shown), The likelihood of "coming together" is not associated with these belief measures.

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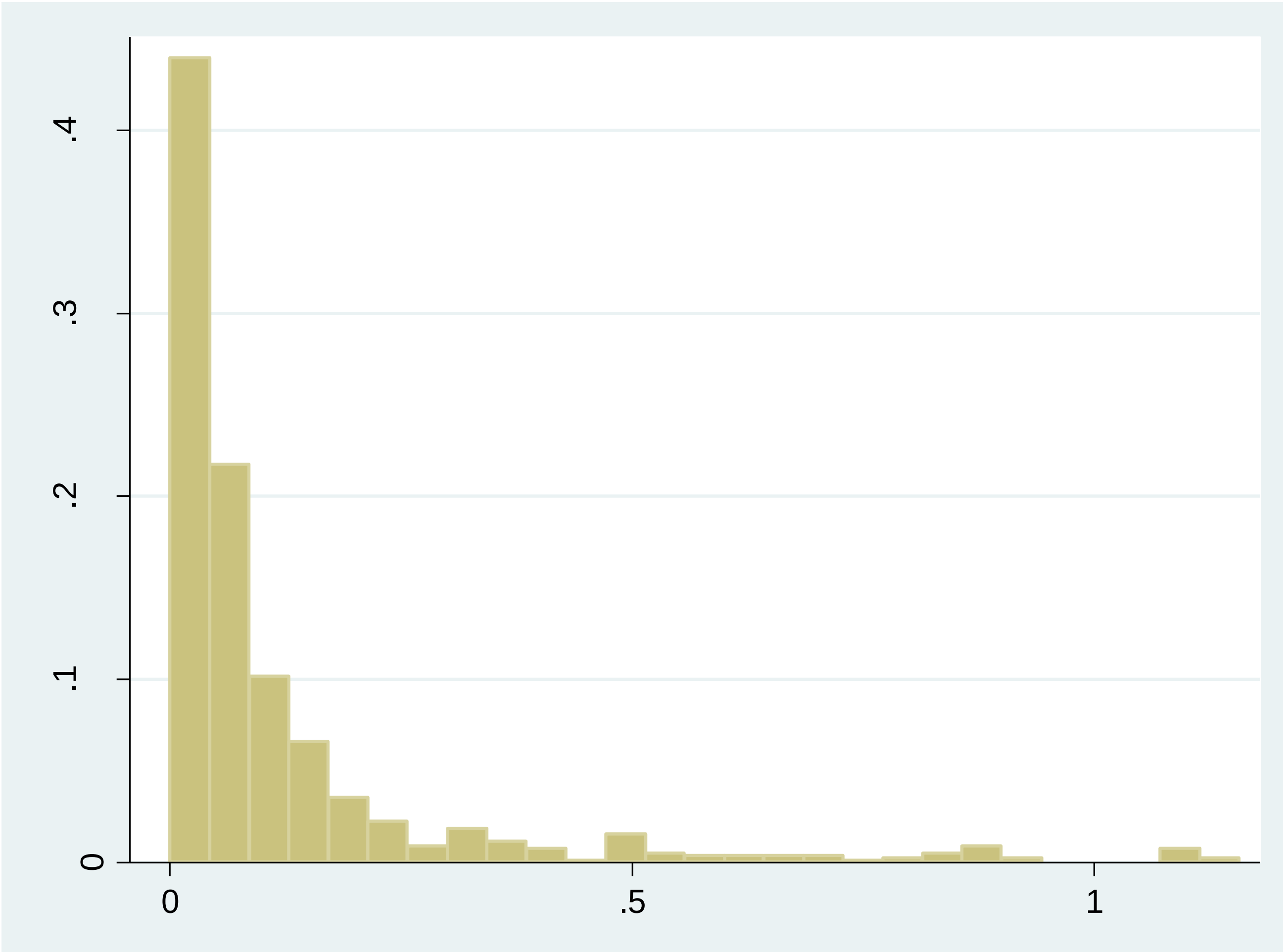

Figure 1: Distance between a respondent's house and her friend's house (km)

Table 1: Randomization Check by peers' CCT

	Age	Muslim	Highest education = primary	Highest education = secondary and more	Not married	Have children	Pregnant	Have paid work	Used clinic before	Received tetanus vaccine before	Vaccines have side effects	Distance to clinic (1.5km or less)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(14)
Panel A: Villagers												
% villagers offered CCT800	1.468	-2.270***	0.075	0.818**	-0.014	0.206	-0.368**	0.469	-0.876**	-0.224	-0.071	-0.653
	(2.231)	(0.588)	(0.251)	(0.325)	(0.177)	(0.171)	(0.158)	(0.339)	(0.426)	(0.426)	(0.373)	(0.933)
Mean of dependent var	24.333	1.280	0.227	-0.076	0.144	0.695	0.306	0.236	1.016	0.439	0.717	0.436
Panel B: Neighbors												
% neighbors (100m) within	0.614	-0.142	-0.017	0.033	0.030	0.015	-0.024	0.099	-0.148**	-0.029	0.039	-0.089
village offered CCT800	(0.698)	(0.096)	(0.057)	(0.056)	(0.047)	(0.057)	(0.051)	(0.076)	(0.067)	(0.075)	(0.058)	(0.117)
Mean of dependent var	24.587	0.529	0.273	0.182	0.149	0.719	0.190	0.306	0.595	0.380	0.653	0.463
% neighbors (700m) within	2.680*	-0.968**	0.089	0.427**	-0.053	0.192	-0.318***	0.019	-0.459*	-0.057	-0.027	-0.210
village offered CCT800	(1.540)	(0.427)	(0.149)	(0.195)	(0.132)	(0.144)	(0.109)	(0.231)	(0.253)	(0.222)	(0.210)	(0.499)
Mean of dependent var	26.833	0.167	0.167	0.167	0.333	0.500	0.500	0.500	0.500	0.167	0.500	0.167
Panel C: Friends												
Any friend offered CCT800	0.142	-0.100***	-0.020	0.028	0.002	0.001	0.011	0.022	-0.017	-0.021	-0.015	0.049
	(0.446)	(0.034)	(0.035)	(0.031)	(0.032)	(0.031)	(0.027)	(0.036)	(0.026)	(0.034)	(0.040)	(0.037)
Mean of dependent var	24.851	0.512	0.237	0.258	0.155	0.757	0.179	0.428	0.718	0.412	0.690	0.497

Notes: Sample used here is the total sample of 2,482 women. Robust standard errors clustered by village are presented. Covariates include the number of peers (villagers, neighbors, and friends in each specification) and CCT800. 150 naira = $1 approximately. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Effect of Social Networks

Dependent variable:	Received vaccine						
Panel A: Specification: OLS	(1)	(2)	(3)	(4)	(5)	(6)	(7)
% villagers vaccinated	0.825***						
	(0.049)						
% neighbors (100m) within village vaccinated		0.637***					
		(0.062)					
% neighbors (700m) within village vaccinated			0.782***				
			(0.052)				
Any friend vaccinated				0.206***	0.099**	0.273***	0.108**
				(0.049)	(0.036)	(0.063)	(0.049)
Observations	2482	2409	2457	2482	2482	775	775
R-squared	0.249	0.254	0.252	0.147	0.115	0.224	0.115
Mean of dependent var among control	0.035	0.181	0.068	0.694	0.694	0.464	0.464
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X	X	X	X		X	
Fixed effect (village)					X		X
Panel B: Specification: IV	(8)	(9)	(10)	(11)	(12)	(13)	(14)
% villagers vaccinated	0.839***						
	(0.065)						
% neighbors (100m) within village vaccinated		0.290*					
		(0.166)					
% neighbors (700m) within village vaccinated			0.763***				
			(0.104)				
Any friend vaccinated				0.178**	0.112	0.264**	0.186*
				(0.072)	(0.070)	(0.103)	(0.110)
Observations	2482	2409	2457	2482	2482	775	774
R-squared	0.305	0.277	0.307	0.211	0.115	0.282	0.126
F-statistic of instruments in first stage	15.448	34.833	16.251	153.346	154.021	65.31	51.179
Mean of dependent var among control	0.035	0.181	0.068	0.694	0.694	0.464	0.464
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X	X	X	X		X	
Fixed effect (village)					X		X

Notes: Sample used in column 1-5, 8-12 is the main sample of 2,482 women and the sample in column 6,7,13,14 is the restricted sample of 775 women who have friends in the survey. Robust standard errors clustered by villages are presented. The instrument used in each IV regression is % villagers (column 4), % neighbors (column 5), or any friend (column 6) received the highest CCT (CCT800). Neighbors are villagers who reside within 100 meters from the respondent. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Differential Effect among Friends

Dependent variables:	Received vaccine (IV)						
	CCT800		Side Effect		Distance	Religion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CCT800	0.310***	0.293***					
	(0.027)	(0.029)					
Side effect			0.002	0.024			
			(0.023)	(0.023)			
Distance to clinic (1.5km or less)					0.140***		
					(0.039)		
Muslim						-0.133***	-0.104***
						(0.039)	(0.037)
Any friend vaccinated	0.211***	0.138*	0.232***	0.188**	0.233***	0.149*	0.084
	(0.077)	(0.075)	(0.079)	(0.075)	(0.086)	(0.077)	(0.074)
Any friend vaccinated * CCT800	-0.086*	-0.068					
	(0.048)	(0.047)					
Any friend vaccinated * Side effect			-0.085	-0.119**			
			(0.053)	(0.051)			
Any friend vaccinated * Distance to clinic (1.5km or less)					-0.110*		
					(0.060)		
Any friend vaccinated * Muslim						0.087	0.089
						(0.064)	(0.065)
Observations	2482	2482	2482	2482	2482	2482	2482
R-squared	0.211	0.115	0.210	0.113	0.213	0.208	0.113
F-statistic of instruments in 1st stage	77.552	77.647	76.608	77.277	61.332	76.542	77.800
F-stats for 1st stage	80.83	78.81	77.92	78.18	86.01	77.20	78.70
F-stats for 1st stage (interaction)	338.37	330.23	347.30	351.29	699.41	374.17	316.32
p-value for t-test (***)=0	0.080	0.306	0.053	0.366	0.086	0.004	0.033
Mean of dependent var among control	0.620	0.620	0.712	0.712	0.679	0.738	0.738
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X		X		X	X	
Fixed effect (village)		X		X			X

Notes: Sample used here is the main sample of 2,482 women. Robust standard errors clustered by villages are presented. The instrument used in each IV regression is any friend (column 3) received the highest CCT (CCT800). Side effect takes 1 if the respondents believs that vaccine gives side effects. t-test tests if peer vaccinated+peer vaccinated*(CCT800, side effect, distance, or religion)=0. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Mechanism: Collective Decision Making (Coming to Clinic Together)

	Consecutive visit **with any villagers except friends** & Time lag **with any villagers except friends** <				Consecutive visit **with friends** & Time lag **with friends** <			
	10 min	5 min	4 min	3 min	10 min	5 min	4 min	3 min
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Side effect	0.057	0.051	0.072	-0.030	-0.070	-0.065	-0.052	-0.055
	(0.059)	(0.057)	(0.056)	(0.062)	(0.052)	(0.052)	(0.044)	(0.037)
R-squared	0.032	0.028	0.017	0.022	0.055	0.050	0.053	0.043
Fixed effect (village)	X	X	X	X	X	X	X	X
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Distance to clinic (1.5km or less)	0.056	0.044	0.029	-0.013	-0.081***	-0.090***	-0.063**	-0.037
	(0.061)	(0.061)	(0.061)	(0.058)	(0.031)	(0.031)	(0.029)	(0.025)
R-squared	0.029	0.026	0.014	0.021	0.049	0.051	0.054	0.031
Fixed effect (health facility)	X	X	X	X	X	X	X	X
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Muslim	-0.022	-0.015	-0.049	-0.053	0.063	0.048	0.040	0.011
	(0.066)	(0.063)	(0.068)	(0.076)	(0.068)	(0.067)	(0.064)	(0.060)
R-squared	0.029	0.026	0.013	0.023	0.052	0.045	0.050	0.037
Fixed effect (village)	X	X	X	X	X	X	X	X
Observations	472	472	472	472	472	472	472	472
Mean of dependent var	0.659	0.642	0.602	0.498	0.186	0.176	0.161	0.112
Covariates	X	X	X	X	X	X	X	X

Notes: Sample used here is women whose friends also visited clinic (472). Robust standard errors clustered by villages are presented. Neighbors are villagers who reside within 100 meters from the respondent. Side effect takes 1 if the respondents believs that vaccine gives side effects. Dependent variables are dummy variables which indicate if the time lag between a respondent's clinic visit and a villager (friend)'s clinic visit is less than 10 (5,4,3) minutes. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 1: Summary Statistics and Randomization Check by CCT

	CCT5 or CCT300	CCT800	p-value
	(1)	(2)	(3)
Panel A: Summary Stats on Peers			
% villagers vaccinated	0.706	0.710	0.000
% villagers offered CCT800	0.349	0.317	0.000
% neighbors (100m) within village vaccinated	0.704	0.711	0.516
% neighbors (100m) within village offered CCT800	0.339	0.320	0.056
% neighbors (700m) within village vaccinated	0.715	0.726	0.100
% neighbors (700m) within village offered CCT800	0.352	0.331	0.000
Any friend vaccinated	0.238	0.246	0.618
Any friend offered CCT800	0.116	0.121	0.705
Panel B: Respondent's characteristics			
Age	24.894	25.505	0.023
Muslim	0.503	0.482	0.202
Highest education = primary	0.242	0.235	0.727
Highest education = secondary and more	0.268	0.289	0.284
Not married	0.155	0.148	0.623
Have children	0.762	0.769	0.616
Pregnant	0.171	0.196	0.138
Have paid work	0.439	0.428	0.554
Used clinic before	0.727	0.714	0.437
Received tetanus vaccine before	0.397	0.401	0.851
Vaccines have side effects	0.670	0.643	0.080
Distance to clinic (1.5km or less)	0.481	0.472	0.464

Notes: Sample used here is the total sample of 2,482 women. Panel A with village fixed effect, and Panel B with health facility fixed effect. Robust standard errors clustered by village are presented. 150 naira = $1 approximately. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 2: Effect of Social Networks (First Stage and Reduced Form)

Panel A: First Stage

Dependent variable:	% villagers vaccinated	% neighbors (100m) within village vaccinated	% neighbors (700m) within village vaccinated	Any friend vaccinated			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
% villagers offered CCT800	2.289***						
	(0.504)						
% neighbors (100m) within village offered CCT800		0.765***					
		(0.135)					
% neighbors (700m) within village offered CCT800			1.015***				
			(0.252)				
Any friend offered CCT800				0.323***	0.317***	0.244***	0.220***
				(0.026)	(0.026)	(0.030)	(0.031)
Observations	2482	2409	2457	2482	2482	775	774
R-squared	0.971	0.916	0.948	0.706	0.698	0.241	0.134
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X	X	X	X		X	
Fixed effect (village)					X		X

Panel B: Reduced Form

Dependent variable:	Received vaccine						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
% villagers offered CCT800	1.492***						
	(0.464)						
% neighbors (100m) within village offered CCT800		0.104					
		(0.077)					
% neighbors (700m) within village offered CCT800			0.774**				
			(0.269)				
Any friend offered CCT800				0.058**	0.036	0.064**	0.041
				(0.025)	(0.023)	(0.027)	(0.025)
Observations	2482	2409	2457	2482	2482	775	774
R-squared	0.219	0.322	0.211	0.199	0.112	0.229	0.124
Mean of dependent var among control	0.035	0.181	0.068	0.694	0.694		
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X	X	X	X		X	
Fixed effect (village)					X		X

Notes: Sample used in column 1-5 is the main sample of 2,482 women and the sample in column 6,7 is the restricted sample of 775 women who have friends in the survey. Robust standard errors clustered by villages are presented. Neighbors are villagers who reside within 100 meters from the respondent. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 3: Differential Effects (First stage)

Panel A: Dependent variable:	Any friend vaccinated						
	CCT800		Side Effect		Distance	Religion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Any friend offered CCT800	0.318***	0.311***	0.300***	0.297***	0.286***	0.332***	0.322***
	(0.025)	(0.026)	(0.036)	(0.035)	(0.039)	(0.032)	(0.032)
Any friend offered CCT800 * CCT800	0.013	0.014					
	(0.029)	(0.028)					
Any friend offered CCT800 * Side effect			0.037	0.032			
			(0.039)	(0.038)			
Any friend offered CCT800 * Distance to clinic (1.5km or less)					0.079*		
					(0.045)		
Any friend offered CCT800 * Muslim						-0.024	-0.014
						(0.037)	(0.036)
Observations	2482	2482	2482	2482	2482	2482	2482
R-squared	0.706	0.698	0.706	0.699	0.705	0.706	0.698
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X		X		X	X	
Fixed effect (village)		X		X			X

Panel B: Dependent variable:	Any friend vaccinated * var						
	CCT800		Side Effect		Distance	Religion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Any friend offered CCT800	-0.159***	-0.164***	-0.289***	-0.292***	-0.202***	-0.211***	-0.211***
	(0.014)	(0.015)	(0.025)	(0.025)	(0.023)	(0.027)	(0.027)
Any friend offered CCT800 * CCT800	0.779***	0.780***					
	(0.033)	(0.033)					
Any friend offered CCT800 * Side effect			0.795***	0.790***			
			(0.030)	(0.030)			
Any friend offered CCT800 * Distance to clinic (1.5km or less)					0.812***		
					(0.023)		
Any friend offered CCT800 * Muslim						0.759***	0.754***
						(0.030)	(0.032)
Observations	2482	2482	2482	2482	2482	2482	2482
R-squared	0.559	0.551	0.600	0.595	0.618	0.584	0.529
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X		X		X	X	
Fixed effect (village)		X		X			X

Notes: Sample used here is the main sample of 2,482 women. Robust standard errors clustered by villages are presented. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 4: Differential Effects (Reduced form)

Dependent variable:	Received vaccine						
	CCT800		Side Effect		Distance	Religion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Any friend offered CCT800	0.081***	0.054*	0.094***	0.090***	0.089**	0.031	0.008
	(0.030)	(0.028)	(0.035)	(0.031)	(0.036)	(0.035)	(0.032)
Any friend offered CCT800 * CCT800	-0.064*	-0.051					
	(0.038)	(0.036)					
Any friend offered CCT800 * Side effect			-0.059	-0.088**			
			(0.044)	(0.041)			
Any friend offered CCT800 * Distance to clinic (1.5km or less)					-0.071		
					(0.049)		
Any friend offered CCT800 * Muslim						0.063	0.066
						(0.050)	(0.050)
CCT800	0.297***	0.281***					
	(0.025)	(0.027)					
Side effect			-0.013	0.004			
			(0.020)	(0.018)			
Distance to clinic (1.5km or less)					0.128***		
					(0.038)		
Muslim						-0.128***	-0.094***
						(0.035)	(0.034)
Observations	2482	2482	2482	2482	2482	2482	2482
R-squared	0.199	0.111	0.200	0.113	0.198	0.198	0.110
p-value for t-test (***)=0	0.606	0.915	0.259	0.931	0.600	0.010	0.040
Mean of dependent var among control	0.620	0.620	0.712	0.712	0.679	0.738	0.738
Covariates	X	X	X	X	X	X	X
Fixed effect (health facility)	X		X		X	X	
Fixed effect (village)		X		X			X

Notes: Sample used here is the main sample of 2,482 women. Robust standard errors clustered by villages are presented. t-test tests if peer vaccinated+peer vaccinated*(CCT800, side effect, distance, or religion)=0. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 5: Mechanism: Information Sharing

Dependent variables:	# of correct answers	Number of people who die of tetanus	Very worried about Tetanus	Tetanus is very bad	Very important to be protected from tetanus	Vaccine efficacy
Panel A: Village	(1)	(2)	(3)	(4)	(5)	(6)
% villagers vaccinated before one's intervention	0.044	-2.698*	0.015	0.070**	0.025	1.029
	(0.091)	(1.615)	(0.030)	(0.035)	(0.042)	(1.762)
Observations	2460	2455	2460	2460	2460	2457
R-squared	0.027	0.020	0.064	0.042	0.050	0.016
Fixed effect (health facility)	X	X	X	X	X	X
Panel B: Neighborhood	(7)	(8)	(9)	(10)	(11)	(12)
% neighbors (100m) vaccinated before one's intervention	0.130	0.335	-0.022	-0.008	-0.016	3.342**
	(0.092)	(1.313)	(0.032)	(0.032)	(0.037)	(1.389)
Observations	2417	2412	2417	2417	2417	2414
R-squared	0.031	0.017	0.066	0.043	0.052	0.018
Fixed effect (health facility)	X	X	X	X	X	X
	(13)	(14)	(15)	(16)	(17)	(18)
% neighbors (700m) vaccinated before one's intervention	0.023	-1.943	0.005	0.049	0.006	1.840
	(0.113)	(1.680)	(0.039)	(0.042)	(0.050)	(1.821)
Observations	2468	2463	2468	2468	2468	2465
R-squared	0.032	0.018	0.067	0.045	0.053	0.017
Fixed effect (health facility)	X	X	X	X	X	X
Panel C: Friends	(19)	(20)	(21)	(22)	(23)	(24)
Any friends vaccinated before one's intervention	0.192**	0.486	0.008	0.001	-0.009	3.165*
	(0.079)	(1.302)	(0.033)	(0.037)	(0.030)	(1.695)
Observations	2460	2455	2460	2460	2460	2457
R-squared	0.029	0.019	0.064	0.048	0.056	0.020
Fixed effect (health facility)	X	X	X	X	X	X
	(25)	(26)	(27)	(28)	(29)	(30)
Any friends vaccinated before one's intervention	0.202**	1.225	0.010	0.010	0.001	3.663**
	(0.079)	(1.235)	(0.031)	(0.036)	(0.030)	(1.782)
Observations	2460	2455	2460	2460	2460	2457
R-squared	0.029	0.013	0.044	0.029	0.032	0.019
Fixed effect (village)	X	X	X	X	X	X
Mean of dependent var	3.513	30.151	0.356	0.434	0.495	22.254
Covariates	X	X	X	X	X	X

Notes: Sample used here is the main sample of 2,482 women. % villagers vaccinated before one's intervention" represents the percentage of women in a village who received the tetanus vaccine before the respondent. "% neighbors vaccinated before one's intervention" represents the percentage of women within 100 meters from a respondent's house who received the tetanus vaccine after the respondent. "Any friends vaccinated before one's intervention" is the dummy variable which takes 1 if any of respondent's friends received tetanus vaccine before the respondent. "Friends" are defined as someone whom each respondent listed in either one of 6 categories: a best friend, a friend whom they admire, a friend whom they talk about health issues with, a friend whom they go to health clinic together with, a friend whom they visit if she is sick, a friend who visits them when they are sick. Robust standard errors clustered by villages (80 villages) are presented. The average number of women in one village is 31.235. The average number of women in 100 meters is 13.547. The average number of friends one lists who were also in the study is 0.36. Conditioned on having at least 1 friend, the number of friends a respondents lists who were in the study is 1.15. All the dependent variables indicate the measurement before the flipcharts intervention. "# of correct answers" counts the number of questions that the respondent answered correctly about tetanus. "Number of people who die of tetanus" is a number of people out of 100 a respondent provided to a question "Once they have Tetanus, how many people do you think would die because of Tetanus?". "Very worried about tetanus" is a binary variable which takes 1 if a respondent answers "very worried" to the question "How worried are you that you might get tetanus? Very worried, worried, not too worried, not worried at all?". "Tetanus is very bad" is a binary variable which takes 1 is a respondent answers "very bad" to the question "How bad would it be if you get tetanus? Very bad, bad, not too bad, not bad at all?". "Very important to be protected from tetanus" is a binary variable which takes 1 is a respondent answers "very important" to the question "How important is it for you to make sure that you are protected from tetanus? Very important, important, not too important, not important at all?" "Vaccine efficacy" is the difference between hypothetical number of unvaccinated people who get tetanus and number of vaccinated people who get tetanus. "Correct # of answers" is the number of answers about sympstoms and causes of tetanus.The total number of questions is 6. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, total number of respondents in the village in panela A, total number respondents within 100 meters in panel B, or total number of friends listed in panel C, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 6: Mechanism: Collective Decision Making (Coming to Clinic Together)

Sample:	Total				Have friends in the sample			
Dependent variables:	Consecutive visit **with any villagers** & Time lag **with any villagers** <							
	10 min	5 min	4 min	3 min	10 min	5 min	4 min	3 min
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Side effect	0.039	0.031	0.035	0.011	-0.004	-0.000	0.020	-0.072
	(0.029)	(0.026)	(0.027)	(0.025)	(0.056)	(0.052)	(0.051)	(0.062)
R-squared	0.011	0.008	0.009	0.010	0.016	0.012	0.012	0.023
Fixed effect (village)	X	X	X	X	X	X	X	X
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Distance to clinic (1.5km or less)	-0.054	-0.071*	-0.080**	-0.075*	0.049	0.030	0.019	-0.012
	(0.036)	(0.037)	(0.036)	(0.040)	(0.060)	(0.060)	(0.057)	(0.058)
R-squared	0.009	0.009	0.011	0.010	0.016	0.013	0.008	0.014
Fixed effect (health facility)	X	X	X	X	X	X	X	X
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Muslim	-0.038	-0.031	-0.061*	-0.059	-0.017	-0.026	-0.061	-0.088
	(0.032)	(0.036)	(0.034)	(0.039)	(0.066)	(0.063)	(0.071)	(0.076)
R-squared	0.010	0.008	0.010	0.012	0.017	0.013	0.014	0.022
Fixed effect (village)	X	X	X	X	X	X	X	X
Observations	1721	1721	1721	1721	472	472	472	472
Mean of dependent var	0.701	0.670	0.635	0.517	0.758	0.735	0.699	0.581
Covariates	X	X	X	X	X	X	X	X

Notes: Sample used here is women who visited a clinic (1,721) in left half, and women whose friends also visited clinic (472) in righ half. Robust standard errors clustered by villages are presented. Neighbors are villagers who reside within 100 meters from the respondent. Side effect takes 1 if the respondents believs that vaccine gives side effects. Dependent variables are dummy variables which indicate if the time lag between a respondent's clinic visit and a villager (friend)'s clinic visit is less than 10 (5,4,3) minutes. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 7: Selection

	Any friend is in the Sample					
	(1)	(2)	(3)	(4)	(5)	(6)
CCT800	0.002	-0.006	0.005	0.002	0.006	-0.006
	(0.020)	(0.040)	(0.019)	(0.039)	(0.019)	(0.040)
% villagers vaccinated	-0.120	-0.312				
	(0.245)	(0.252)				
% neighbors (100m) within village vaccinated			-0.005	-0.022		
			(0.053)	(0.052)		
% neighbors (700m) within village vaccinated					0.048	0.186
					(0.132)	(0.168)
Observations	2482	2482	2482	2482	2482	2482
R-squared	0.000	0.012	0.000	0.014	0.000	0.013
Covariates		X		X		X
Fixed effect (health facility)	X	X	X	X	X	X

Notes: Sample used here is the main sample of 2,482 women. Robust standard errors clustered by villages are presented. Covariates include own treatment status (Clinic CCT, Vaccine CCT & Fear, CCT300, CCT800), interaction term between Clinic CCT and each CCT dummy, and between Vaccine CCT & Fear and each CCT dummy, age, education level, marital status, religion, if received tetanus vaccine before, if has paid work, if ever used the clinic before, and distance to the clinic, if has any children, if pregnant. * significant at 10%; ** significant at 5%; *** significant at 1%