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COMMUNITY-BASED HEALTH PROGRAMS AND CHILD VACCINATIONS: EVIDENCE FROM MADAGASCAR

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ABSTRACT

Vaccinations are a cost-effective tool to prevent child mortality and morbidity; however, their access and take-up remain low in developing countries. We analyze the effects on child vaccinations of a large-scale community-based health worker program that aimed to reach remote areas distant from public health facilities in Madagascar. We identify these effects using a triple-difference design that leverages the time and geographic variation in the program rollout and the geocoded household distance to the closest health facility. Our findings indicate that, on average, the program did not improve the vaccination uptake in treated areas; however, the community health workers component had an additional effect on children's vaccinations in the most remote areas from the closest health facility. Despite this improvement, we find that mothers' religious affiliation might constitute a barrier for the vaccination uptake of the most remote and vulnerable children.

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Introduction

Vaccinations are one of the most cost-effective strategies to prevent child mortality and infectious diseases (UNICEF, 2018; Ozawa et al., 2016). In Africa, despite recent progress, immunization rates remain low: 1 in 5 children do not receive all the necessary and basic vaccinations, and as a result, over half a million children die from vaccine-preventable diseases annually (WHO, 2019). As preventive investments, childhood vaccinations can have positive ripple economic effects because vaccines improve health outcomes including a reduction in all-cause mortality (Higgins et. al., 2016) and in future costs in terms of medical expenses (Alsan and Eichmeyer, 2021; Newhouse 2021; Summan, et. al., 2022). In addition, beyond improvements in health and reductions in child mortality, vaccinations have other benefits that materialize in the long term, including boosting learning, education, earnings, longevity, and other economic outcomes (Verguet et al., 2013; van der Putten, 2015, Sumnan, et. al., 2022; Atwood and Pearlman, 2022). In fact, there is evidence that achievable improvements to vaccination rates are linked to significant increases in the GDP growth rate that can persist and grow over time (Masia et., al., 2018).[1] All of these arguments support why immunization is directly and indirectly related to several Sustainable Development Goals (Decouttere et. al., 2021) critical to developing countries.

Given the relatively low rates of vaccinations in low-income countries, particularly in Africa, it is important to identify the potential barriers to access to and take-up of child immunization. Recent empirical evidence indicates that demand factors such as parents' lack of knowledge, distance to access points, financial barriers, and mistrust in immunization programs combined with poor health infrastructure constitute the main barriers to vaccination uptake in African countries (see Bangura et al., 2020 for a review). Understanding what type of interventions can mitigate these barriers and increase child vaccination uptake is crucial for the existent and new vaccines, especially in low-income settings (Banerjee et al., 2010). The COVID-19 pandemic underscores the need for this type of evidence not only because of the introduction of new vaccines

[1] Masia et., al., (2018) use diphtheria, tetanus, and pertussis first dose (DTP1) vaccination rate during 1980-2010 as a proxy for the investment in and effectiveness of vaccination in each country. To test whether improved vaccination coverage influences economic growth, they use an extension of the conditional convergence model by Barro and Sala-i-Martin. They find that higher vaccination rates are linked to statistically significant increases in GDP growth between 0.05%-0.08%, which are sustained over time.

but also as lockdowns, misinformation, and diverted resources have been linked to reductions in childhood routine vaccinations (Maltezou et. al., 2022).

This paper analyzes the short-term effects of a *large*-scale community health-based (CHB) intervention on child vaccinations in Madagascar, one of the world's poorest countries.[2] *Santenet2*, as other CHB interventions, mobilized the community to disseminate health information and incentivize healthy behaviors as well as improved the supply and distribution of health commodities. This program was implemented between 2009 and 2011 and reached half of the population of the country. Since 65% of the population lives further than 5 kilometers (km) from the closest health facility in Madagascar (USAID, 2014), one component of *Santenet2* aimed to address the lack of primary health services in remote areas by training two volunteer community health workers (CHWs), one in maternal and other in child health in remote villages, defined as those located more than 5 km away from the closest primary health clinic. The child health worker focused on promoting child preventive health services, including encouragement to obtain vaccinations.

We study the differential effect of the *Santenet2-CHW* component on child immunizations take-up by distance to the closest public health facility. This analysis is relevant for Madagascar, and other low-income contexts, where geographic remoteness and the lack of access to roads and formal clinics are factors explaining the decrease in vaccination rates and the increase in child mortality (Clouston et al., 2014; Karra, Fink & Canning, 2016). In fact, using our data before the program implementation, we observe that the vaccination rate, measured as the total number of required vaccination doses, decreases dramatically with a longer distance to the closest public health clinic (see Figure 1).

<< Insert Figure 1 here>>

Using a nationally representative survey, the Madagascar's Millennium Development Goals Survey 2013-ENSOMD, we analyze the short-term effects of *Santenet2* on children's vaccinations. Our empirical strategy starts by implementing a double difference model that compares the average vaccination outcomes between *Santenet2* and non-*Santenet2* communes

[2] In Madagascar, 77% of the population lives in poverty (World Bank, 2017)

before and after the program rollout. Nevertheless, this model does not measure the differential effect of the CHW component of the program among households living in remote places from the closest health clinic. Therefore, we implement a triple difference model which combines the geographic and time variation of the *Santenet2* commune rollout with a third difference, the exact distance from each household to the closest health facility. Following the program design, we identify remote households targeted by the CHW component as those located more than 5 km from the closest health center by combining household GPS locations with a national administrative census of the public health centers (collected before program implementation). We also estimate models in which we distinguish remote households as those located: i) between 5 and 10 km and ii) 10 or more km from the closest health facility. Furthermore, we conduct several robustness checks and placebo tests that validate our identification strategy, in particular, the validity of the parallel trends and two-way fixed effects assumptions as well as the use of alternative distance variable cut-offs.

Using the difference-in-differences model, we find that there is no *evidence of an overall* effect of *Santenet2* on the average child immunization outcomes. Nevertheless, our findings from the triple difference model indicate that while exposure to *Santenet2* did not change the vaccination uptake for those children living between 0 and 5 km and 5 and 10 km from the closest clinic, the program significantly improved the vaccination uptake among children who live more than 10 km from the closest health facility. This result suggests the positive effects of the CHWs' role in mobilizing households to vaccination campaigns or the nearest health facility among the most remote and vulnerable populations (Clouston et al., 2014). Furthermore, we estimate heterogeneous effects to characterize the households that benefit the most from the CHW in remote areas following what the empirical evidence has recognized as important demand factors for vaccinations in Africa (Bangura et al., 2020; Porth et al., 2020; Tesema et al., 2020). We do not find differential effects of *Santenet2* by mothers' education or poverty in areas more than 10 km away from the closest clinic. However, we do find a differential effect by mothers' religion. While we find that the CHWs' effect is larger among those young children whose mother declares not having a religious affiliation, there is a differential negative and statistically significant effect when the mother's religious affiliation is Catholic or Protestant.

Our paper contributes to the evidence on the effects of CHB interventions on child health in developing countries (Joshi and Schultz, 2013; Barham, 2012; Björkman et al., 2019). Most of

these studies rely on small-scale randomized controlled trials or quasi-experiments in specific areas within a country, and the existent evidence is still inconclusive (Baqui et al., 2009). In particular, there is no consistent evidence regarding the CHWs' role in increasing child immunization rates through promoting vaccinations take-up or providing vaccinations themselves in the context of low-and-middle-income countries (Scott et al., 2018; Oyo-Ita et al., 2016). Therefore, little is known about whether CHB interventions implemented on a *large* scale can improve child immunizations take-up, especially in rural and remote areas where the distance to the primary health facility is a significant households' hassle cost to healthcare access (Adhvaryu and Nyshadham, 2015; Wagner et al., 2017). Moreover, improving vaccination rates is an economic development and policy-relevant outcome as emerging empirical evidence documents the causal effect of immunization campaigns on long-term human capital outcomes including educational attainment, earnings, and long-term health status (Summan, et. al., 2022; Atwood and Pearlman, 2022).

Furthermore, we relate to the set of studies analyzing the barriers to child immunization in Africa (Bangura et al., 2020; Tesema et al., 2020; Lowes and Montero, 2021; Archibong and Annan, 2021). In particular, there is growing empirical evidence that underlines religion as an important demand factor for immunization uptake (Costa et al., 2019; Porth et al., 2020; Archibong and Annan, 2021) and as a mechanism for medical mistrust in vaccinations (Athias and Macina, 2022). We contribute to these studies by providing suggestive evidence that religion can be a key barrier for CHWs to mobilize the most remote and vulnerable households to vaccinate their children. More broadly, our paper also relates to the evidence analyzing the effect of religious practices on child health. For instance, Menon and McQueeney (2020) examine the differences in girls' anthropometric outcomes between Christians and Hindus in India, while Karlsson (2019) studies the differences in child mortality and stunting between Muslims and Christians in West Africa.

The rest of the paper is organized as follows. Section 2 describes the data and the program in the context of Madagascar. Section 3 explains the empirical strategy and Section 4 focuses on the program's results on child immunizations and the robustness checks of our empirical results. Finally, Section 5 presents the discussion and conclusions.

2. Context and Data Description

2.1 The *Santenet*2 Program

The United States Agency for International Development (USAID) -one of the largest bilateral donors to Madagascar- funded the *Santenet2* community health program in 2009, which was implemented by RTI international in collaboration with the national government and local NGOs. This program was a community-based integrated primary health care services intervention that included the deployment of volunteer community health workers in remote areas. *Santenet2*'s primary goals included empowering community participation and accountability in setting and achieving health goals, in particular, reducing maternal, child and infant mortality, the fertility rate, malaria prevalence, and chronic malnutrition in children under age 5.

Santenet2 was rolled out between 2009 and 2011 and implemented in 800 of 1566 communes (smallest administrative unit), corresponding to 16 of 22 regions and 72 of the 119 districts in Madagascar. The program targeted communes where USAID had a strategic development focus and that also met certain criteria such as minimum road infrastructure, a high unmet need for family planning, and a high population density. In the intervention communes, the program reached 5,758 villages (*fokontanys*) located more than five km from the nearest public primary health center, training 13,086 CHWs during this period and benefiting around 11 million people, approximately half of the population of the country (USAID, 2014).

The program had two main components. First, at the treated commune level, the program aimed to generate demand for primary and preventive care through disseminating information about healthy behaviors and practices. For instance, the program used local radio broadcasts as communication channels to cover a range of topics including maternal and child health (i.e., antenatal care, promotion of immunization campaigns, child nutrition and use of insecticide-treated bed nets); reproductive health and family planning; water, sanitation and hygiene; and community engagement. Also, *Santenet2* built community huts where program activities were conducted (awareness raising, care management, and counseling). The huts displayed posters with information about vaccination calendars and other health-related activities (USAID, 2013c). Additionally, at the commune level, the program established community supply points across the commune to ensure a steady, reliable supply of family planning, curative medicines, and other health commodities (including bed nets, family planning products, ORS, etc.). Second, within the

treated communes, the program deployed CHWs to bring basic health care closer to remote villages, identified as those located more than 5 km from the closest public primary health clinic.

The volunteer CHWs were chosen by the community members following eligibility requirements such as having completed primary education, the ability of reading, writing, and counting skills, and being socially accepted by the community (USAID, 2013a). In each community, local committees oversaw and worked closely with the CHWs to: i) assess the community-level health priorities, ii) provide technical support in the activities to mobilize community members, raise awareness, and iii) coordinate health interventions such as vaccination campaigns with the local health clinics and establish supply chains for the distribution of health products.

Each treated remote village in *Santenet2* communes had two volunteer CHWs: one who specialized in maternal and reproductive health services and another who focused on child health. *Santenet2* implemented a comprehensive training program for the CHWs that was designed according to the Ministry of Health standards (USAID, 2014). We have analyzed the effect of CHWs on short-term fertility outcomes in Herrera-Almanza and Rosales-Rueda (2020). In this paper, we focus on examining the effects of CHWs on child immunizations take-up. In particular, the training of the child health CHWs had two levels. In level 1, the CHWs received training in the promotion of the Expanded Program of Immunization (EPI) and disseminated information on the vaccination schedule and immunization campaigns. They were also trained in essential nutrition actions, growth monitoring, and prevention of common diseases (malaria, diarrhea, acute respiratory infections). After three months of service, their performance was assessed and the most qualified CHWs were trained on Community-Based Integrated Management of Childhood Illness (c-IMCI), becoming level 2 child health CHWs (USAID, 2013a).

Santenet2 also employed a system of regular monitoring and supervision of CHW activities and performance by community-level committees. Notably, these workers were *volunteers* and did not receive a stipend for performing these program activities. *Santenet2* lacked a central system of monetary incentives to motivate the CHWs. Many CHWs stated that they were de facto motivated to work for the wellbeing of their communities, which is why they agreed to take on their roles as health promoters (USAID, 2013b). Despite the lack of monetary incentives, external evaluations of the program quantified that the attrition rate of the CHWs was only 8% from the program rollout to 2013, which is favorable compared to other contexts in developing countries (USAID, 2014).

USAID, in collaboration with the Ministry of Health, fully upscaled the *Santenet2* model of health services to the national level from 2013 to the present (USAID, 2015).

2.2 Vaccination Landscape in Madagascar

The expanded program of immunization (EPI) was launched in 1976 in Madagascar, which extended immunization services and established a standardized vaccination schedule. The main strategy to deliver childhood vaccinations (including polio, DTCOQ and measles) is through year-round routine programs at primary-level health facilities. In addition to supporting routine activities, in 2006, the EPI created complementary delivery activities including mass vaccinations campaigns through periodic vaccination weeks (twice a year) and supplementary immunization activities (SIAs) every three years (Rajaonarifara et. al., 2022; Jones et. al., 2021; Mensah, et. al., 2019).

The EPI has contributed to significant improvements in vaccination uptake. However, coverage goals for the recommended vaccines to achieve immunity, which according to the WHO should be around 95%, have not been achieved. For example, in 2015 EPI reached 70% of infants with 3 doses of DTCOQ, an important improvement from 57% in 2000 but still behind the target (van den Ent et. al., 2017). Suboptimal immunization coverage can lead to disease outbreak. In fact, the inadequate coverage for measles vaccines, which was around 80% by 2017, was a driver of the large outbreak in 2018-2019 (Rajaonarifara et. al., 2022; Jones et. al., 2021). Thus, achieving vaccination coverage goals is an important challenge. This issue is more salient in rural areas where the gap in coverage is around 10% with respect to urban areas for all recommended vaccines (Rajaonarifara et. al., 2022; Clouston et. al., 2014). Therefore, health interventions that target rural and remote populations such as *Santenet2* have the potential to address these gaps and help achieve vaccination coverage goals. These facts support the importance and relevance of our study.

2.3 Religion in Madagascar

Religions and churches play an important social and cultural role in Madagascar (Nielssen and Skeie, 2014; Feron and Razakamaharavo, 2019); particularly in the political arena. Indeed, most of the early placements of missionaries in Madagascar were driven by political objectives, following the trend of other African countries. In the late nineteenth and twenty centuries, the

Anglicans on the one hand, and the Catholics, on the other were trying to establish missions to get hold of the Merina elite, the country's rulers (Stifel et al. 2011). Since its arrival throughout the colonial and postcolonial period, Christianity has been associated with building civil society, particularly in education and health. In fact, by leveraging external funding, Christian churches have invested in hospitals, clinics, schools, and educational institutions as well as other types of humanitarian aid and development projects such as agriculture, which have become relevant for the society in the absence of a strong provision of public goods and services (Nielssen and Skeie, 2014). Since the late 1990s, religious stakeholders have been deeply involved in Madagascar's politics and related conflicts and resolutions. For instance, in the most recent 2009 political crisis-around the time of *Santenet2*'s program conception, the Protestant Church supported Ravalomanana (the incumbent president), and the Catholic Church switched sides to back opposition leader Andry Rajoelina, playing a pivotal role in this conflict and its resolution (Feron and Razakamaharavo, 2019).

Despite the growing empirical evidence underlying religion as a key factor in the demand for vaccination uptake in Africa (Costa et al., 2019; Porth et al., 2020; Archibong and Annan, 2021); there is no prior evidence on the role of religion, particularly, of Christian churches in individuals' trust in health systems and health outcomes in Madagascar. However, given the context described above, it is plausible to hypothesize that there is a relationship between the presence of Christianity and vaccination uptake. In fact, a recent study by Lowes and Montero (2021) shows that medical campaigns during the French colonial period in Cameroon are associated with less trust in modern medicine and lower vaccinations today. Moreover, Athias and Macina (2022) find that children from mothers whose ancestors were exposed to the slave trade are less likely to be vaccinated than children living in the same location but with mothers from a slave-free ethnic group in a sample of sub-Saharan African countries. As Christianity has been linked with political turmoil and the provision of health services in Madagascar, it might be that individuals with certain religious affiliations are more or less prone to uptake vaccines. However, the role of religion on health is an empirical question as it can benefit or prevent child health investments. We will explore if *Santenet2* effects on vaccinations are heterogeneous by religious affiliation.

2.4 Data Description

In this paper, we combine administrative information about the rollout of *Santenet2* program with a nationally representative household survey in Madagascar and the geocoded information of the census of public health facilities in the country.

We obtained information on the starting month and year for each commune that participated in *Santenet2.* The program was rolled out in three phases: 1) January 2009-October 2009; 2) November 2009-January 2010; and 3) February 2010-February 2011. Figure 2 shows a map of the phased rollout of *Santenet2*. The *Santenet2* rollout data at the commune level is combined with the 2012-13 Millennium and Development Goals household survey (ENSOMD) using the geographic identifiers for each commune. This large-scale nationally representative survey was conducted by the Madagascar's National Institute of Statistics (INSTAT) among 16,000 households from September 2012 to November 2013 to assess Madagascar's progress towards meeting the Millennium Development Goals. Its design is similar to that of the Demographic Health Surveys-DHS and contains detailed information on women's fertility behaviors and birth history, and most importantly for this paper, for children less than age 5, the ENSOMD collects health-related data including prenatal care use, birth delivery, vaccinations, morbidity, anthropometrics, and other related indicators. We also use the 2008-09 DHS to explore whether vaccinations in *Santenet2* communes had a similar trend to that of non-participating communes before the program rollout.

We then use geocoded data from both households in the ENSOMD and the census of 3309 public health facilities to identify the sample households targeted by the CHWs; i.e., those living in villages located more than 5 km away from the closest health clinic. Geographic information about these clinics was obtained from the health care mapping software of the Madagascar Ministry of Health, which was updated in 2011 with the support of the Japan International Cooperation Agency (JICA). The geographic location of the health facilities is used with the household location information collected in the ENSOMD to calculate the Euclidian distance of each household from the closest health clinic in *Santenet2* and *non-Santenet2* communes. This distance variable allows us to identify the remote households targeted by the CHWs as well as the corresponding counterfactual in non-treated communes.

Our sample consists of children ages 0-5 who have vaccination cards at the time of the survey. We limit our analysis to the data in the vaccination cards and do not use the information

mothers report on their children's immunizations to avoid recall bias on our main outcome variables. Appendix Table B.1 shows that there is no selection into having a vaccination card by *Santenet2* status.

Table 1 shows the summary statistics of socio-demographic characteristics for these sample children, including gender, age in months, maternal education and religion, and household poverty, stratified by distance to the closest public health clinic. Approximately 46% of our sample children live in *Santenet2* communities, and their households are located, on average, 4.85 km from the closest public health clinic. Moreover, 33% of our sample children can be classified as living in remote households as they live further than 5 km from the closest clinic and their average distance to the closest health facility is about 10 km. The mean age of our children sample is 30 months old; these children have taken 4.9 out of 7 required vaccinations, and 14% of them had not received their first vaccine by the time of the survey. The longer the distance to the closest public clinic, the lower the number of vaccinations a child has taken. For instance, the mean of children's required vaccinations is 5.1 if they live between 0 and 5 km from the closest clinic, while this average is 4.1 if they live further than 10 km from the closest clinic. These children come from disadvantaged households; 44% live in poor households, and their mothers have on average 4 years of schooling.[3] We also observe that 20% of the mothers do not report any religious affiliation. The majority of mothers, who have an affiliation, are Catholic (35%) or Protestant (33%). The rest of the sample mothers belong to other religious groups, including Muslims, Traditional, Adventist, and Anglican, among other groups.[4]

As we are particularly interested in the heterogeneous effects of the program by religious affiliation, Figure B.1 shows the baseline vaccination rates for different religious groups using 2008-09 DHS data.[5] The figure shows that for distances shorter than --approximately-- 10 km from

[3] A household is defined as poor if it is in the lowest two quintiles of the asset index distribution. The household asset index was constructed using a principal component analysis and household variables such as dwelling characteristics, including the roof and wall material and type of floor and bathroom, as well as ownership of durable goods (i.e., radio, bicycle).

[4] Although we lack recent census population estimates on religion—the last Malagasy census was in 1993- the distribution of religious affiliation in our sample is in line with estimates from Pew Research Center for 2021 showing that 85.3% of the population is Christian (including any affiliation Catholic, Protestant, Anglicans, Adventist), 3 percent is Muslim, 4.5 adhere to traditional beliefs and 6.9 have no affiliation (International Religious Freedom Report, 2021)

[5] As we discuss later in the empirical strategy, the 2008-09 survey only has available geocoded data for the survey clusters and not for the households; thus, we calculate the distance to the closest clinic accordingly. In addition, these GPS coordinates are displaced randomly.

the closest health clinic, children whose mothers' religious affiliation is Catholic or Protestant, have a higher number of vaccinations than those children whose mothers' affiliation is other religious groups. However, this pattern seems to be reversed for children living further than 10 km from the clinic: Children from Catholic and Protestant groups have a significantly lower number of vaccinations compared with their counterparts whose mothers have a different religious affiliation. These descriptive statistics suggest that vaccine hesitancy might be an issue among children living in Catholic and Protestant households located in remote areas (i.e., further than 10 km from the closest clinic) as we observe lower vaccination rates among these groups before the program implementation.[6]

<< Insert here Table 1>>

3. Empirical Strategy

We start by estimating a difference-in-differences (DD) specification that compares childhood vaccinations in *Santenet2* and non-*Santenet2* communes before and after the program rollout and allows us to measure the average effect of the program on child immunization outcomes. We formally estimate the intent-to-treat effects of *Santenet2* as:

$$Y_{icb} = \alpha + \beta Santenet_c * Bornafter_{icb} + \mathrm{X'_i}\varphi + \delta_b + \theta_c + \varepsilon_{icb} \quad (1)$$

where Y_{icb} denotes the health outcome of interest for child *i* in commune *c* born in year *b*. Immunization outcomes are measured as i) the number of polio vaccine doses (maximum 3), ii) the number of DTCOQ (Diphtheria-Tetanus-Pertussis) doses (maximum 3), iii) an indicator for whether a child received the Rougeole vaccine, and iv) the total number of vaccinations (maximum 7).[7]

The variable $Santenet_c$ is a dummy variable equal to 1 if the child's commune was part of the *Santenet2* program. $Born\_after_{icb}$ is an indicator equal to 1 if child *i* was born after the program rollout date in a *Santenet2* commune. X_i is a vector of children and maternal sociodemographic characteristics that includes the child's gender and birth order, maternal birth

[6] We acknowledge that this figure is descriptively showing the relation between religious affiliation and vaccination outcomes across distance. The socio-demographic composition of families by religion can be different across distances and we examine heterogeneity by other dimensions such as wealth and mother's education. We find stronger heterogeneity impacts of the program by religion and not by those other characteristics.

[7] According to UNICEF– Madagascar, these seven vaccinations should be received during the first year of life.

cohort and education, and a household asset index. δ_b are child's year-of-birth fixed effects, which capture unobserved shocks that affected children born in the same year. θ_c are commune fixed effects that absorb time-invariant unobserved characteristics at the commune level. The standard errors are clustered at the commune level. The coefficient of interest is β, which measures the DD estimate of the average effect of *Santenet2* community-based health intervention on child vaccinations. We test the validity of this identification strategy by i) providing evidence on the parallel trends assumption and ii) evaluating the underlying assumptions of using two-way-fixed effects in our model by implementing recent econometric diagnostic tools (Jakiela, 2021).

First, we rely on the 2008-09 DHS data collected before the program implementation to show that children's vaccinations followed similar trends in places that were exposed and not exposed to *Santenet2* before the program. Figure 3 plots the coefficients of the interaction between being born in a *Santenet2* commune and the year of birth of the child, conditioning on child and mother's socio-demographic characteristics, district, and year-of-birth fixed effects. These estimates capture the differences in the means of child vaccination outcomes by cohort and *Santenet2* status. The results indicate that, before the intervention, immunization outcomes did not differ by *Santenet2* status.[8]

<< Insert here Figure 3>>

Second, although *Santenet2* had a short-term rollout between 2009 and 2011 across different communes, we evaluate the validity of controlling for two-way geographic and time fixed effects. Indeed, recent econometric literature has documented that these DD estimates can be biased and sometimes incorrectly signed when treatment effects change over time within treated units (i.e., Goodman-Bacon 2021; De Chaisemartin and d' Haultfoeuille, 2020; Jakiela 2021). Therefore, in Online Appendix A, we conduct a series of diagnostic tools following Jakiela (2021), to test that the assumptions of the two-way fixed effects are valid in our context. First, we show that negative weighting is only occurring for a small part of our sample (7%) and does not affect the validity of our main results (See Figure A.1 and Table A.2). Second, we also show that treatment heterogeneity is not a concern for our DD models (See Figure A.2 and Table A.1). This test exploits the fact that treatment effect homogeneity implies a linear relationship between

[8] Herrera-Almanza and Rosales-Rueda (2020) provide several robustness checks validating the parallel trends assumption in the context of evaluating the effects of *Santenet2* on women's fertility outcomes.

residualized outcomes and residualized treatment after removing the fixed effects.[9] Online Appendix A provides more details and further discussion. These diagnostic tests give us confidence that our empirical design is not vulnerable to the use of two-fixed effects or misspecification of the comparison group.

Although the difference-in-differences model is informative to get the average treatment effects of the program, it does not allow us to measure the *differential or additional* effect of the CHW component of *Santenet2* that targeted households living in remote areas; i.e. those located further than 5 km from the closest health clinic. Thus, to estimate the effect of the *Santenet2*-CHW component on child immunizations that intended to reach households living in remote areas, our main specification relies on a difference-in-difference-in-differences (DDD) design that exploits three sources of variation: geographic (commune), cohort of birth, and distance. Therefore, our strategy compares the vaccination outcomes for children in places far from the closest health clinic with those in households close to a health facility in *Santenet2* and *not-Santenet2* communes born before and after the program was rolled out. Specifically, we estimate the following equation:

$$Y_{icb} = \alpha + \beta Santenet_c * Bornafter_{icb} * dist_{ic} + \gamma Santenet_c * Bornafter_{icb} +$$

$$\vartheta Santenet_c * dist_{ic} + \rho dist_{ic} + \delta_b + \delta_b * dist_{ic} + \mathrm{X'_i}\varphi + \theta_c + \varepsilon_{icb} \quad (2)$$

Where $dist_{ic}$ is a dummy variable that captures whether a child's household is 5 km or more from the closest health facility; it takes the value of 1 if the household is 5 km or more from the closest clinic and 0 otherwise. We use 5 km as a cut-off to identify remote households following the *Santenet2* program criteria. The rest of the variables in equation (2) are as defined above in the double difference model. In addition, the triple difference model in equation (2) includes distance-time fixed effects that control for time-varying differences between remote and non-remote areas, and *Santenet2*-distance fixed effects that allow distance to have a different effect in treated and comparison areas. In this DDD specification, $\boldsymbol{\beta}$ measures the estimate of the effect of exposure to *Santenet2* CHWs component on the immunization outcomes of children living in remote places, 5 km or more from the health facility, who are the target population of the CHWs. This coefficient captures all variation in child vaccinations specific to remote children (relative to close children)

[9] When treatment effects are homogeneous, negative weighting is not an issue (Jakiela, 2021).

in *Santenet2* communes (relative to non-*Santenet2* communes) before and after the program rollout. In addition, $\boldsymbol{\gamma}$ measures the overall effect of the program on children living close to a health clinic.

The underlying identifying assumption of our triple difference coefficient, $\boldsymbol{\beta}$, is that in the absence of the *Santenet2*-CHW intervention, the relative change over time in the difference in vaccination rates between children living in non-remote areas (i.e., less than 5km) and children in remote areas (i.e., more than 5km) from a health facility would have been the same in the *Santenet2* and non-*Santenet2* communes, after controlling for the socioeconomic characteristics and other geographic and time fixed effects included in equation (2).[10] We test this parallel trend assumption by providing some suggestive evidence using the DHS 2008-09 pre-program data (acknowledging some limitations). These survey data only have available geocoded data for the survey clusters and not for the households. In addition, these GPS coordinates are displaced randomly[11] and the magnitude of the displacement may misclassify clusters as remote (and, therefore, the targeted population by the CHWs component). Despite these issues, using the geocoded data from the survey clusters, we calculate the distance to the closest health clinic in the commune and estimate our triple-difference model. Figure 4 shows the triple interaction coefficients of a version of equation (2) for the pre-program data. Results indicate no statistically significant evidence of a differential trend for households located further than 5 km in treated and non-treated communes (relative to close areas) before the program implementation in terms of children vaccination outcomes. As an additional test, we define *remote* using a cutoff of 10km and the interaction coefficients are small and not statistically significant either (see Appendix Figure B.2). To complement these exercises, in the Robustness Checks Section, we also provide some placebo tests that alleviate concerns regarding the potential nonrandom selection of treatment communes in our DDD models (see Table B.8).

[10] In other words, following Olden and Moen (2022) language, this assumption implies that the relative vaccination outcomes of remote and non-remote areas in a treatment commune would have follow the same trend as the relative outcome of remote and non-remote places in a comparison commune in the absence of the program after controlling for all the other covariates in equation (2).

[11] Clusters GPS coordinates in the DHS might be displaced by 5km or more.

Overall, we provide evidence supporting the identification assumptions of both DD and DDD models as well as the validity of TWFE in our setting, which reassure the validity of our empirical strategy.[12]

As mentioned before, our main triple difference model in equation (2) defines remote areas, following the *Santenet*2 programmatic criteria, as those areas located further than 5 km from the closest health clinic within the commune. In addition, we are interested in exploring if the CHWs mobilization component has a differential effect on children's vaccinations at different distances more than 5 km from the closest health facility. Thus, we change the variable $Dist_{ic}$ in equation (2) to a categorical variable of the distance between a child's household and her closest health facility as follows: i) strictly less than 5 km; ii) between 5 and 10 km and iii) equal to or more than 10 km. We chose these cut-offs based on the distribution of the children sample in Table 1 that allows us to maximize the power of our DDD estimates. We also consider that the average distance to the closest health facility is 10 km among our sample households defined as remote by the *Santenet2* criteria (i.e., 5 km or more from the closest clinic). Moreover, we follow other empirical evidence in rural Africa that use similar distance cut-offs to limit areas of influence of health programs-- administered in rural clinics-- on women and children's health outcomes (i.e., Lucas and Wilson, 2018; Lucas et al., 2019 and Friedman, 2018).[13] In any case, in the Robustness Section, we conduct a sensitivity analysis showing that our DDD results using different distance cut-offs are consistent with the proposed distance categories. In addition, we also check that our models are consistent with alternative definitions of the distance variable.

4. Results

We start by presenting the results of *Santenet2* effects on childhood vaccinations using the double-difference model. Column 1 of Table 2 shows that the program did not have an *overall* effect on the number of child immunizations. Consistently, using the same DD specification, we

[12] In addition to the evidence provided here, in Online Appendix A, we show that our triple difference results are robust to excluding the observations with negative weights.

[13] Using triple difference models, Lucas and Wilson (2018) measure the effect of antiretroviral therapy (ART) for the treatment of HIV/AIDS on women's anthropometric outcomes in Zambia, while in the same setting, Lucas, Chidhote and Wilson (2019) analyze the effect of ART on children's education outcomes. Friedman (2018), using a variety of difference-in-differences models, investigates the effects of the ART introduction on sexual behavior and pregnancy rates among 15-18-year-olds in Kenya.

do not find an overall effect of the program on any of the other vaccination outcomes such as Polio, DTCOQ and Measles doses (see these results in Table B.2).

Next, we show in Table 2 the results of the DDD specification. As described in our empirical strategy, our interest is to capture the *differential* effect of the *Santenet2*-CHWs component on child vaccinations in remote areas. Column 3 shows that there are no statistically significant effects of the CHW component (proxied by the triple interaction *Santenet*Born after*Dist5km*) on the number of total vaccinations among children living in areas further than 5 km from the closest health facility. Furthermore, Appendix Table B.2 shows that this is the case for any of our measures of immunization records. Nevertheless, in Columns 3-6 of Table 2, when we analyze the DDD models that differentiate remote households living between 5 km and 10 km and more than 10 km from the closest health facility within the commune, we find that the CHW component of *Santenet2* had a sizable positive and statistically significant effect on all our measures of immunization status for children in the most remote areas. Children in *Santenet2* communes living in very remote households (more than 10 km from the closest health facility) relative to children in close households in *Santenet2* communes relative to those in non-*Santenet2* communes experienced an increase in the number of Polio doses, DTCOQ doses, Measles dose and total vaccinations by 0.57, 0.49, 0.16 and 1.2 doses, respectively. These effects are large in magnitude. For instance, the increase in the total doses of vaccinations represents an improvement of 25% with respect to the outcome mean. It is worth mentioning that the positive results of the *Santenet2*-CHW component among children living further than 10 km are robust to a sensitivity analysis of this cut-off as well as different distance specifications as discussed in the Robustness Section (see Figure 5).

Previous empirical evidence has shown that the lack of access to roads and formal clinics is a barrier to increasing immunization coverage, especially among remote and vulnerable population in Madagascar (Clouston et al., 2014). Thus, our results suggest that the *Santenet2* CHWs promoted vaccination uptake among households with young children living in the most remote places from the closest health facility, and who probably needed the most: in our sample data, the average total number of vaccinations among children under age 5 living in households within 5 km from the nearest health facility is 5.11, whereas this measure is 4.19 in households more than 10 km away.

As discussed in the background section, despite the significant improvements, Madagascar is still lagging behind in achieving the optimal goal of vaccination coverage, which is worse in rural and remote areas. In this landscape, our findings highlight the potential of community-based health interventions that target remote populations. We show that children living in remote areas exposed to the *Santenet2* program experience a sizable increase in vaccination uptake. The magnitude of the program effect suggests that *Santenet2* could help close the gap in vaccination coverage between close (0-5km) and remote areas (10 plus).[14] Despite still being behind the goal, this finding is relevant.

<< Insert Table 2 here >>

4.2 Heterogeneous Effects

We estimate heterogeneous effects of our main triple difference model in equation (2) to characterize the households that the CHWs helped mobilize to vaccinate their children. We analyze these effects by socio-economic variables recognized as important demand factors for immunization in developing countries, particularly in Africa, such as parents' or caregiver's education, wealth, and religion (Bangura et al., 2020; Porth et al., 2020; Tesema et al., 2020).

We estimate these heterogeneous effects by adding an interaction term between our main triple difference interaction ($Santenet_c * Bornafter_{icb} * dist_{ic}$) and each of the following variables separately: i) mothers' education, defined as a dummy variable for whether a mother has at least 4 years of education; ii) mother's poverty, defined as a dummy variable for whether the households' asset index is in the lowest two quintiles of the asset distribution; and iii) mother's religious affiliation.[15] For the latter, we present two set of estimations. First, we specify mothers' religion as a dummy variable equals to one if a woman has no religious affiliation. Second, we focus on women with a religious affiliation and specify a categorical variable for whether a mother identifies as Catholic, Protestant (these two are the main religions in the country), or with other religious groups. Although our focus is on the heterogenous effects of the CHWs program by

[14] The size of the program effect on the total number of vaccination (1.2 doses) suggests that the CHWs component closed the gap between children in close versus remote areas as the average number in comparison communes in 2013 in close areas was 5.1 doses versus 4.2 in remote areas.

[15] All the lower-level interactions between the main triple difference and the variable of interest are also included in the models.

religion, we also analyze the effects by mothers' education and household poverty to assess whether sorting or composition of the households by these socio-economic characteristics across distance to the clinic drives the heterogeneous results by religion.

<< Insert Table 3 here>>

We observe in Table 3, Columns 1 and 2, that while that there are no differential effects of the CHW component on the total number of vaccinations by mother's education and poverty status among households living 10 km from the closest health clinic, we find interesting differential effects by mother's religion. First, in Column 3, we find that the CHWs effect is larger among those young children whose mother declares not having a religious affiliation. Although this differential effect is statistically significant at the 10 percent level, it is relevant considering that 20% of our sample mothers do not declare a religious affiliation, as shown in Table 1. This result is consistent with recent evidence from Ethiopia showing that religion was associated with a child being unvaccinated (Porth et al., 2020). Furthermore, conditional on reporting any religious affiliation, Column 4 shows a differential negative and statistically significant effect when the mother is Catholic or Protestant, compared to other religious groups.[16] It is worth noting that the main DDD coefficient that measures the effect of *Santenet2* on child vaccinations in areas more than 10km from the clinic for other religious groups is statistically significant; and the differential negative effect of Catholicism is relatively large compared to this effect. In Table 4, we also confirm that the negative differential effect of the mother being Catholic or Protestant is found for all three types of vaccination counts, Polio, DCTQ and Measles, among children living in areas 10 km or further from the closest clinic. We do not find any differential effect of the program by religion between 0-5 km or 5-10 km from the clinic. Our results seem to suggest that mothers' religion is a barrier to vaccination uptake in the most remote areas from the clinic, which might deter the role of the CHWs in promoting immunizations.[17]

[16] The number of observations in Column 4 of Table 3 is smaller as we exclude the children whose mothers do not have a religious affiliation.

[17] In Figure B.3 in the Online Appendix B, we illustrate the heterogeneous effects of the *Santenet2*- CHWs component by religious affiliation across distance to the clinic. The figure plots the estimated average number of vaccine doses received with and without the intervention for children in each of the religious groups.

One interpretation of these results is that different religions might have different attitudes and values towards child vaccinations. Being affiliated with a particular religious group can increase or release the peer pressure to child vaccination, and more broadly, to health care-seeking behavior (Porth et al., 2020; Costa et al., 2019). Another alternative hypothesis is that religious affiliation is correlated with medical mistrust over vaccines, as previously shown in the African region. Indeed, Athias and Macina (2022) show that children from mothers whose ancestors were exposed to the slave trade are less likely to be currently vaccinated against Measles, and religion is an important mechanism of medical mistrust. Also, recent evidence from Lowes and Montero (2021) shows that in Central Africa, exposure to French Colonial medical campaigns to treat and prevent sleepiness sickness reduces present-vaccination rates and trust in medicine, as measured by willingness to consent to a blood test. We cannot disentangle which are the underlying mechanisms through which Catholic or Protestant affiliations are barriers for CHWs to promote vaccination uptake. Future research should analyze the differential role of religion by distance to the closest health clinic in vaccination uptake, and more generally, in health-seeking behavior.

<< Insert Table 4 here >>

One potential concern with this heterogeneity analysis is the presence of simultaneous inference. Therefore, we show that our results in Tables 3 and 4 are robust to correcting inference by multiple hypothesis testing. We do so by using the Clarke-Romano-Wolf (2020) correction method, which controls for the Family Wise Error Rate (i.e., the probability of rejecting at least one true null hypothesis among a family hypothesis under test). This method is a more stringent test than other corrections as it incorporates the dependence structure of the test statistics by resampling from the original data. Appendix Table B.3 shows the p-values for our main triple difference model as well as those generated by Clarke-Romano-Wolf for the main coefficients of the triple difference model and their interactions with mothers' education, poverty status, and religion for the vaccine count outcome reported in Table 3 and Table 4. Appendix Table B.4 displays the corresponding p-values for all vaccine types by mothers' religion, as reported in Table 4. When comparing the p-values of our original triple difference models and those corresponding to the multiple hypotheses testing correction, we can validate our heterogeneity analysis: While mothers' education and poverty status do not have a differential effect on the number of

vaccinations among children living in areas further than 10 km from the clinic, mothers' religious affiliation to Catholic or Protestant does have an adverse differential effect on vaccination uptake.[18]

4.3 Additional Robustness Checks

We conduct different econometric exercises to validate estimates of the *Santenet2* CHW effects on children's immunizations outcomes. First, we allow for differential time trends by education levels in remote places to our models in equation (2) by adding interactions of the mother's education and birth cohort and the distance variable.[19] Appendix Table B.5 indicates that our results are robust to this alternative specification.

Second, we present a sensitivity analysis of our triple difference models using distance as a continuous variable and different cut-offs of the distance variable. Column 1 of Appendix Table B.6 shows that our results are consistent with a model specification that includes distance as a continuous variable. In addition, Columns 3 to 7 display the results for different distance cut-offs to the closest health facility. Given the *Santenet2-CHW* program criteria to target remote households (i.e., those living further than 5 km from the closest health clinic), we analyze the effects of the CHW component across different distance cut-offs further than 5 km. Figure 5 illustrates the effect sizes for some of these specifications shown in Appendix Table B.6. Both Table B.6 and Figure 5 show that our original triple difference results are consistent if we marginally move the cut-off of 10 km or further to the left (9 km plus) or the right (11 km plus) along the distance to the closest clinic as well as with more granular distance cut-offs (i.e., 9-11 km; 11-13 km; 13-15 km and 15 km plus). Overall, this sensitivity analysis supports the categories chosen in the main specification as 0-5 km, 5-10 km, and 10 km plus.

<< Insert Figure 5 here>>

Furthermore, our triple difference results are robust to using a different specification of the distance variable that identifies a household's remoteness. Appendix Table B.7 shows that our

[18] In Tables B.3 and B.4, we also present an alternative multiple hypothesis testing correction formulated by Benjamin and Hochberg (1995), which controls for the false discovery rate (FDR). It is re-assuring that our heterogeneous analysis is robust to either of these corrections.

[19] Our findings are also robust to controlling for the interaction of the mother's education, child's birth year, and distance variable. These results are available upon request.

results are robust to using the Euclidian distance from the centroid of the village to the closest health facility within the commune instead of the household distance.

Third, we perform placebo regressions on outcomes that should not be affected by the program in the short term. In particular, we validate whether the child vaccinations results are explained by unobserved factors that are not captured in our triple difference specifications. Appendix Table B.8 shows that the *Santenet2* program did not have a statistically significant effect on the households' per-capita consumption or on the households' probability of being poor. These results validate our specification, as we do not expect that the program should affect consumption and poverty levels in the short term.

Fourth, one potential concern is vaccination uptake for older cohorts or catch up. The EPI emphasizes following the recommended vaccination schedule within the first year of life. This motivated us to define the cohort treatment variation as born after *Santenet2* rollout (whether a child aged 0 to 5 in 2013 was born after the program rollout), which corresponds to an intent-to-treat approach. However, it is possible that children born right before the program could be misclassified as comparison cohorts if they caught up with the vaccinations after the program rollout. However, it is important to acknowledge that the decision to catch up can be endogenous, which motivates our preference for an intent-to-treat approach. Therefore, if some comparison children received the treatment, that implies that our estimates would correspond to a lower bound effect of *Santenet2* on vaccinations. To explore this, we performed some robustness checks where we exclude from the comparison cohorts those children who were less than 9, 12, and 24 months of age when *Santenet2* was implemented in a commune. Appendix Table B.9 shows that these results are similar and somewhat larger than our main results, corroborating that our approach is conservative. [20]

Finally, one might be concerned about selective migration affecting our vaccination results. Herrera-Almanza and Rosales-Rueda (2020), using the rollout of *Santenet2,* find no effects of the program on women's change of residence.

[20] It is worth noting that vaccination catch-up is not substantially large in our context. Mensah, et. al., (2019) document that between 2013 and 2019, among vaccinated children, 80% of them got their measles vaccine on time. For immunizations that entail multiple dosages like the Diphtheria-Tetanus-Pertussis (3 doses), Jones et. al (2021) found that timely take-up is very high for the first dose (91%) and decreases subsequently for each of the consecutive two doses (81%, and 72% respectively).

5. Discussion and Conclusions

Africa has the highest child mortality rate worldwide, accounting for 40% of the total deaths under-age of 5 (Bangura et al., 2020); vaccine-preventable diseases are one of the major leading causes of child mortality.[21] Thus, it is imperative to understand the effectiveness of programs in increasing child immunization rates in the region. We study the effects of a *large-scale* community-based health delivery program, *Santenet2*, on child vaccinations in Madagascar. In particular, this intervention aimed to increase the provision and use of primary healthcare in remote areas by training two members of the community in maternal and child primary health care services in villages located more than 5 km from the nearest primary health clinic. We study the *differential* effect of the CHWs component of *Santenet2* on vaccination rates by distance to the closest public health clinic.

Although *Santenet2* did not have an *overall* average effect on vaccination rates among children under age of 5 in treated areas, we do find that the CHW component of the program improved vaccination uptake among children living more than 10 km from the closest health facility. This result suggests a positive effect of the CHWs' role on mobilizing households to vaccination campaigns or the nearest health facility to get their children immunized. We also characterize the households targeted by CHWs by analyzing heterogeneous effects of the program by the mother's socioeconomic status. Despite the success of *Santenet2* in areas located more than 10 km from the closest public clinic, we find a negative differential effect of the program among children whose mother's religion is Catholic or Protestant.

Overall, these findings underline the importance of CHWs in reaching the most vulnerable population to increase child immunization in remote areas. Nevertheless, our heterogeneous results show that mothers' religious affiliation might be a factor that undermines the CHWs' efforts to promote vaccination uptake. This is surprising as *Santenet2* selected workers from the same community to gain trust in their community members to facilitate the dissemination of health information. We are not able to disentangle the mechanisms through which religion lessens the effects of the program on child vaccination rates; it might be medical mistrust, as other literature has shown in the region (Lowes and Montero, 2021; Athias and Macina, 2022); but it also can be the effect of the religious networks on preventive health care use (Archibong and Annan, 2021;

[21] According to IHME (2019), the major causes for child mortality in sub-Saharan Africa were communicable maternal and neonatal diseases; enteric infectious, respiratory infections and TB, and Malaria.

Porth et al., 2020). Further research should disentangle these mechanisms as they can inform the design of policies to improve and promote vaccination rates in the region.

More broadly, the analysis of a large-scale program such as *Santenet2* is informative for other low-income countries that incorporate community-based health interventions in their health systems. Due to the lack of developed infrastructure of health facilities and health personnel, community health workers have become key stakeholders to provide primary health services in low-income settings.

Although our paper is one of the few empirical studies in analyzing the effects of a large-scale community-based health program such as *Santenet2* in Sub-Sahara Africa using nationally representative data and precise household geocoded data, it presents some limitations. First, we lack data on the CHWs' socioeconomic characteristics and their performance, which can potentially explain the differential effects of this program component on childhood immunization across distance to the closest health facility. Second, it is also worth noting that our results capture only short-term effects of the program; future research should examine the long-term effects of this type of intervention in light of dynamic circumstances such as the COVID-19 pandemic. However, the findings of this paper are relevant to the current efforts to deter the spread of COVID-19 through vaccination campaigns in Africa, where vaccine hesitancy has been a concern (Adepoju, 2021; Nachega et al., 2021).

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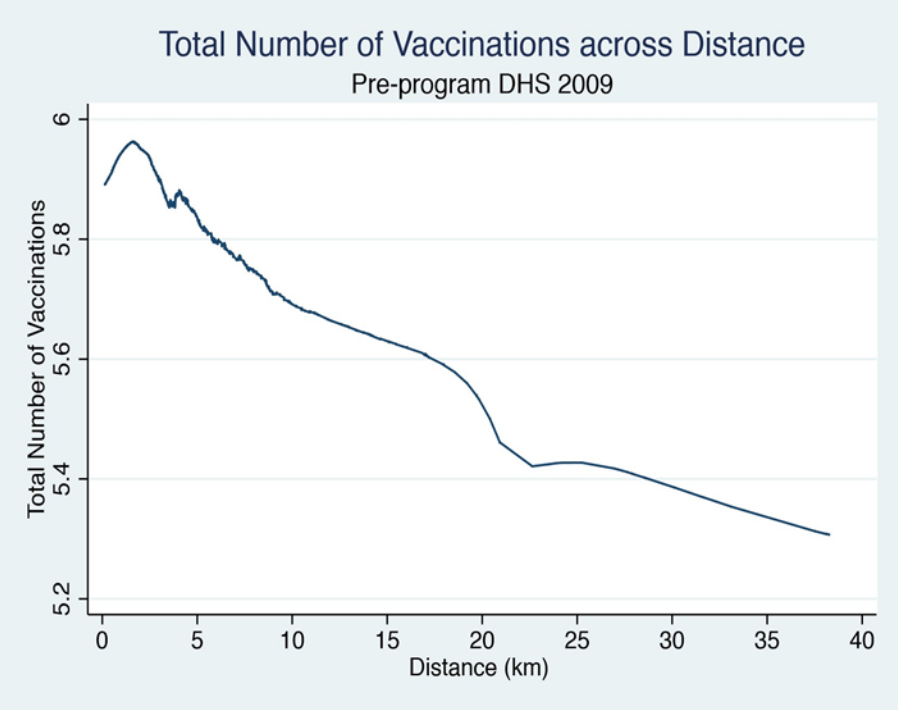
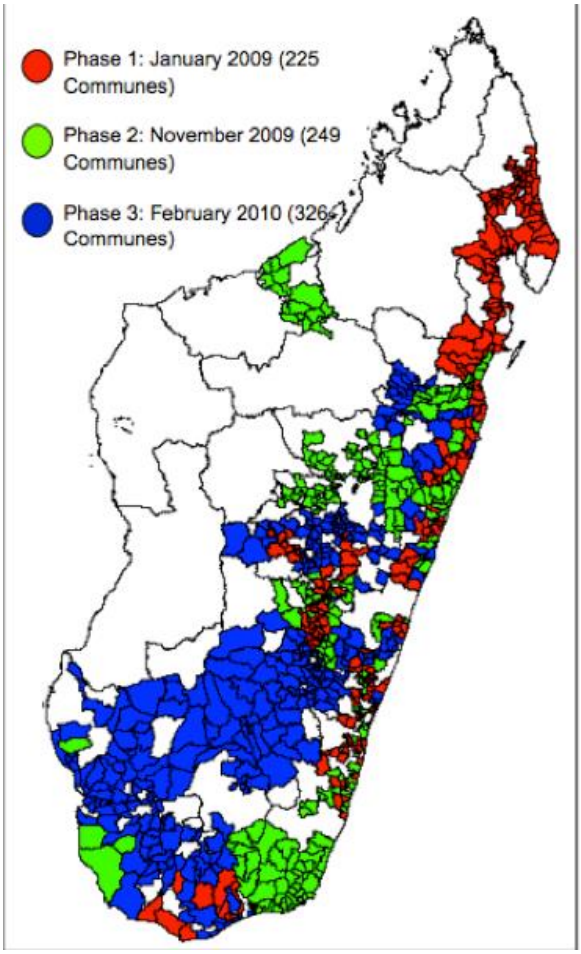
TABLES AND FIGURES

Figure 1: Vaccination Rate before Program Implementation



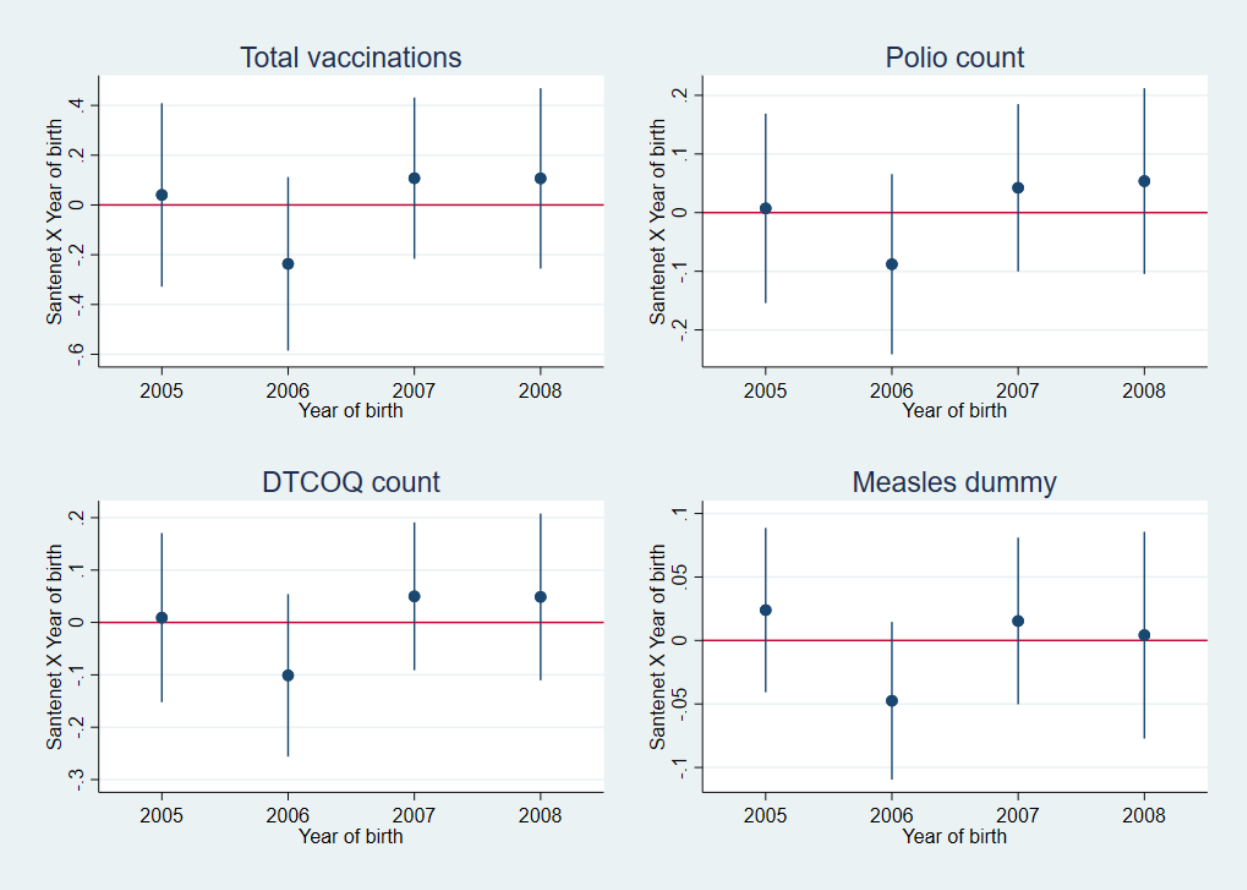
Notes: The figure depicts the non-parametric local regression of the total number of vaccinations on the distance to the closest health facility using data from children less than age 5 in the Demographic and Health Survey (DHS) 2009. This distance is the Euclidian distance between the DHS geocoded coordinates of the cluster, where the household is located, and the geocoded location of the closest health facility.

Figure 2: Rollout of the *Santenet2* Program.



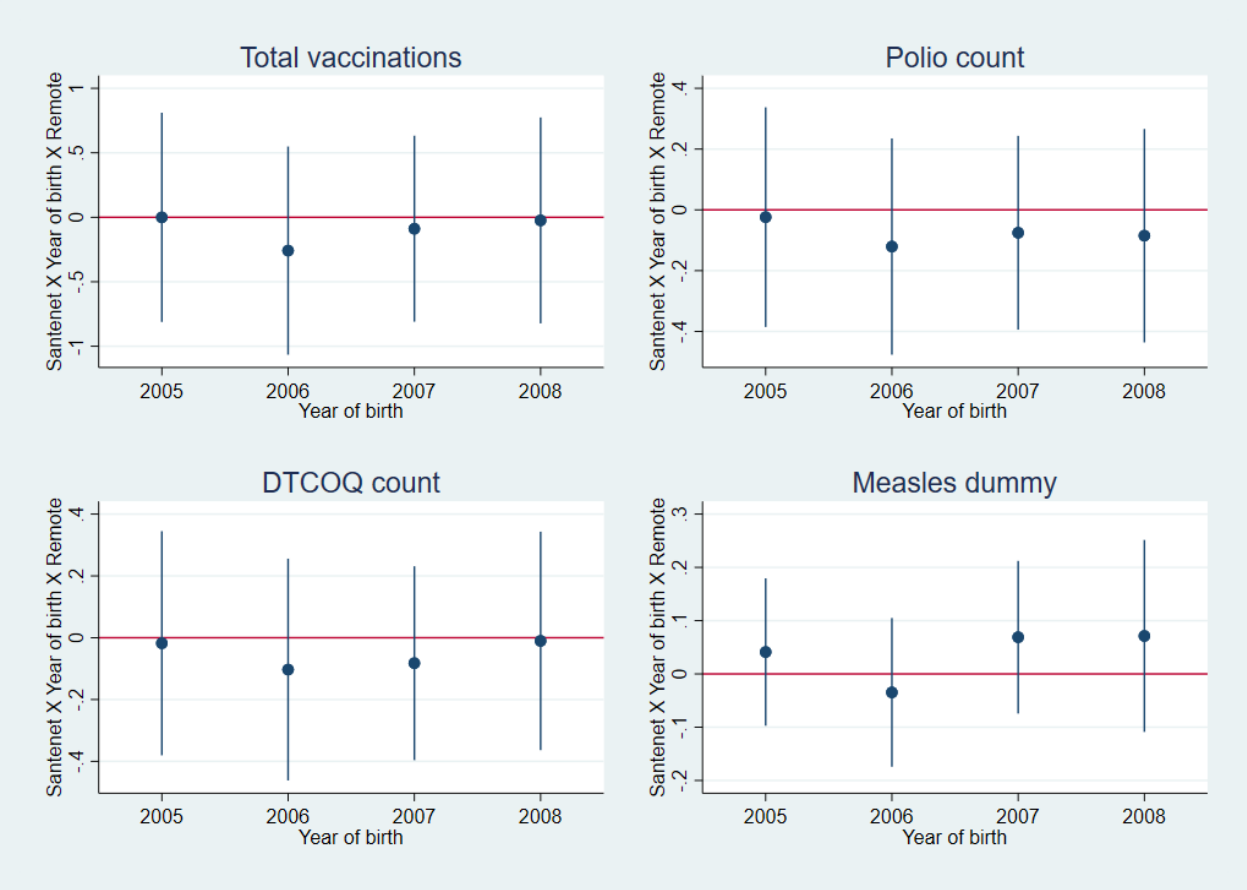
Source: USAID (2013b) in Herrera-Almanza and Rosales-Rueda (2020)

Figure 3: Parallel Trends Pre-*Santenet2* using 2008-09 DHS-
Child Vaccination Outcomes



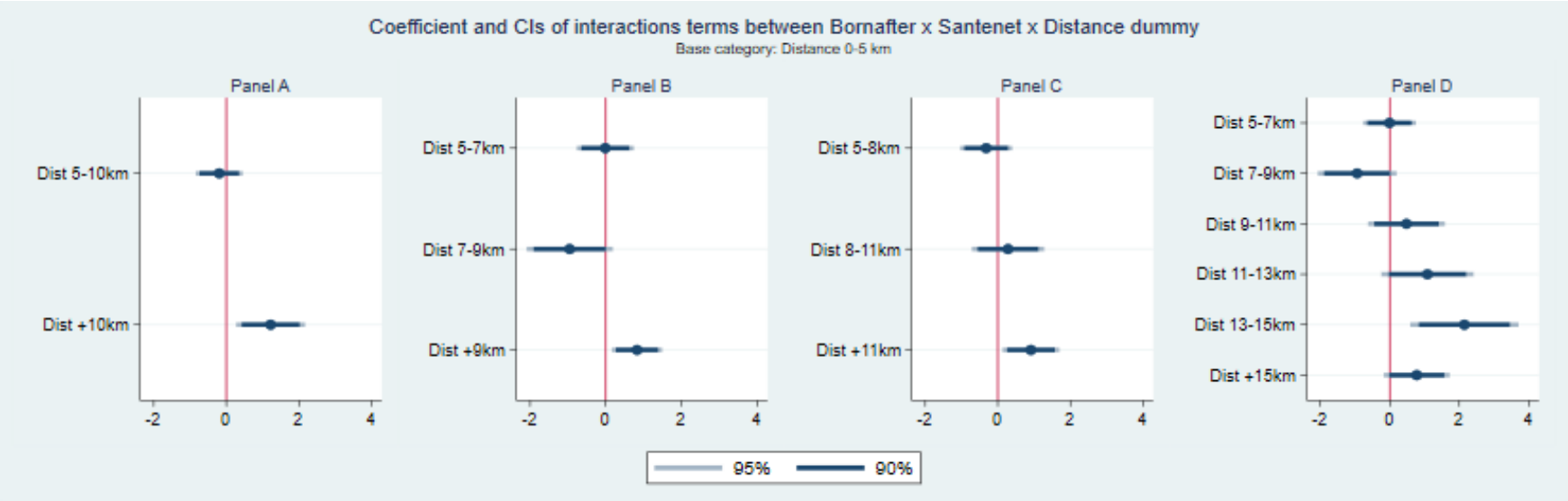
Notes: Figure 3 depicts the coefficients of the interaction between being born in a *Santenet2* commune and the year of birth of the child controlling for child's gender and birth order and mother's socio-demographic characteristics (i.e., mother's education, birth cohort and household asset index), district and year-of-birth fixed effects. The omitted birth cohort is 2004. 95% confidence intervals are shown.

Figure 4: Parallel Trends in Remote Areas Pre-*Santenet2* using 2008-09 DHS-Child Vaccination Outcomes



Notes: Figure 4 depicts the coefficients of the interaction of being born in a *Santenet2* commune, the child's year of birth and living in a remote village defined as those located further than 5 km from the closest health clinic. We acknowledge that when using the DHS, the distance variable suffers from displacement of the GPS coordinates of cluster locations. The models of Figure 4 control for child's gender and birth order and mother's socio-demographic characteristics (i.e., mother's education, birth cohort and household asset index), district and year-of-birth fixed effects. The omitted birth cohort is 2004. 95% confidence intervals are shown.

Figure 5: Triple Difference Coefficients across Different Distance Thresholds



Notes: The figure depicts the coefficient and the 95% and 90% confidence intervals for the interaction terms between different distance variables with *Santanet2* **Bornafter* after estimating our main triple difference specification in equation (2). The base category of each dummy variable corresponds to the 0-5 km threshold. Panel A through D are independent regressions that show different specifications of distance thresholds displayed in Appendix Table B.6. All panel regressions control for child's gender, birth order, mother's cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. All models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance. Robust standard errors are clustered at the commune level.

Table 1: Summary Statistics of the Children's Sample by Distance to the Closest Public Health Clinic.

	Total Sample			0-5 km			5-10 km			10 km or plus		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Program Variables												
Born After Santenet	0.269	0.443	4685	0.271	0.444	3145	0.268	0.443	1056	0.258	0.438	484
Distance to the closest clinic	4.847	6.679	4685	2.036	1.428	3145	6.875	1.400	1056	18.692	12.747	484
Santenet (%)	0.459	0.498	4685	0.459	0.498	3145	0.480	0.500	1056	0.415	0.493	484
Child Characteristics												
Boy	0.503	0.500	4685	0.509	0.500	3145	0.489	0.500	1056	0.494	0.500	484
Child age in months	29.736	19.836	4685	29.982	19.885	3145	29.680	19.689	1056	28.264	19.811	484
Polio Doses	2.194	1.162	4685	2.278	1.137	3145	2.079	1.177	1056	1.901	1.222	484
No. DTCOQ doses	2.165	1.182	4685	2.253	1.157	3145	2.045	1.193	1056	1.853	1.243	484
Measles doses	0.542	0.498	4685	0.577	0.494	3145	0.487	0.500	1056	0.438	0.497	484
Vaccine Count (max 7 doses)	4.901	2.600	4685	5.107	2.548	3145	4.610	2.625	1056	4.192	2.698	484
Mother's Characteristics												
Mother's Age	28.815	7.276	4681	29.110	7.150	3145	28.414	7.509	1056	27.765	7.453	480
Years of Schooling	3.978	3.487	4667	4.570	3.705	3133	2.828	2.645	1055	2.633	2.511	479
Household is poor (Y=1)	0.441	0.497	4685	0.362	0.481	3145	0.592	0.492	1056	0.626	0.484	484
No Religion Affiliation (%)	0.203	0.402	4656	0.152	0.359	3121	0.275	0.447	1052	0.381	0.486	483
Catholic (%)	0.351	0.477	4656	0.374	0.484	3121	0.315	0.465	1052	0.280	0.449	483
Protestant (%)	0.330	0.470	4656	0.358	0.480	3121	0.288	0.453	1052	0.238	0.426	483
Other Religion (%)	0.117	0.320	4656	0.117	0.320	3121	0.123	0.329	1052	0.102	0.302	483

Notes: This sample consists of children under the age of 5 who have a vaccination card. DTCOQ is the Diphtheria-Tetanus-Pertussis. A household is defined as poor if it is in the lowest two quintiles of the asset index distribution. Other religions include Muslim, Traditional, Adventist, Anglican, and other religious affiliations.

Table 2: Double Difference and Triple Difference Estimates of *Santenet2* Effects on Child Vaccinations

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Vaccinations			Polio count	DTCOQ count	Measles dummy
Santenet*Bornafter	-0.0472	-0.109	-0.113	-0.0366	-0.0500	-0.0263
	(0.147)	(0.186)	(0.186)	(0.0817)	(0.0814)	(0.0358)
Santenet*Bornafter*Dist 5km+		0.182				
		(0.301)				
Santenet*Bornafter*Dist5-10km			-0.194	-0.0685	-0.106	-0.0200
			(0.329)	(0.153)	(0.155)	(0.0569)
Santenet*Bornafter*Dist10km+			1.222**	0.569***	0.493**	0.160*
			(0.484)	(0.216)	(0.220)	(0.0902)
Outcome Mean	4.906	4.899	4.899	2.193	2.164	0.543
Observations	4830	4612	4612	4612	4612	4612

Notes: Robust standard errors are clustered at the commune level and appear in parenthesis. Asterisks denote significance: * p<0.10; ** p<0.05; *** p<0.01. All columns control for child's gender, birth order, mother's age cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. Triple difference models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance.

Table 3: Heterogeneous Effects by Mothers' Socioeconomic Status

	(1)	(2)	(3)	(4)
	Outcome: Vaccine Count			
Santenet*Bornafter	-0.159	-0.0148	0.0121	-0.466
	(0.220)	(0.209)	(0.194)	(0.348)
Santenet*Born after*Dist5-10km	-0.166	-0.449	-0.309	0.101
	(0.355)	(0.407)	(0.356)	(0.678)
Santenet*Born after*Dis10km+	1.075**	1.174*	0.904	3.858***
	(0.510)	(0.699)	(0.556)	(0.952)
Santenet*Bornafter*Mom4yrsch	0.103			
	(0.221)			
Santenet*Bornafter*Dist5-10km*Mom4schoolyrs	-0.0461			
	(0.481)			
Santenet*Bornafter*Dist10km*Mom4schoolyrs	0.397			
	(0.607)			
Santenet*Bornafter*HHpoor		-0.186		
		(0.222)		
Santenet*Born after*Dist5-10km*HHpoor		0.450		
		(0.427)		
Santenet*Bornafter*Dist10km*HHpoor		0.150		
		(0.645)		
Santenet*Bornafter*Noreligion			-0.567*	
			(0.337)	
Santenet*Bornafter*Dist5-10km*Noreligion			0.634	
			(0.522)	
Santenet*Bornafter* Dist10km*Noreligion			1.117*	
			(0.662)	
Santenet *Bornafter*Catholic				0.540
				(0.361)
Santenet*Bornafter*Protestant				0.439
				(0.373)
Santenet*Bornafter*Dist5-10km*Catholic				-0.814
				(0.774)
Santenet*Bornafter*Dist5-10km*Protestant				-0.414
				(0.702)
Santenet*Bornafter*Dist10km*Catholic				-3.546***
				(0.888)
Santenet*Bornafter*Dist10km*Protestant				-2.532**
				(1.017)
N	4612	4612	4584	3676

Notes: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for the child's gender and birth order, mother's cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. All models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance. *Mom4schoolyrs* is a dummy variable for whether a mother has completed at least 4 years of schooling. *HHpoor* is a dummy variable for whether a household is poor (i.e., it is in the lowest two quintiles of the asset distribution). *Noreligion* is a dummy variable for whether a mother reports no religious affiliation. *Religion* is a categorical variable where the omitted group is other religious affiliation different from Catholic or Protestant. All the lower-level interactions between the main triple difference variable and the variable of interest (religion, poverty, and mother's education) are also included in the models but not shown in the table.

Table 4: Heterogeneous Effects by Mothers' Religion in all Vaccine Types

	(1)	(2)	(3)	(4)	(5)	(6)
	Polio count (max=3)	DTCOQ count (max=3)	Measles Dummy	Polio count (max=3)	DTCOQ count(max=3)	Measles Dummy
Santenet*Bornafter	0.0214	0.00256	-0.0119	-0.219	-0.223	-0.0239
	(0.0850)	(0.0847)	(0.0375)	(0.155)	(0.156)	(0.0705)
Santenet*Bornafter*Dist5-10km	-0.132	-0.186	0.00940	0.0671	-0.00297	0.0366
	(0.163)	(0.166)	(0.0595)	(0.315)	(0.311)	(0.141)
Santenet*Born after*Dis10km+	0.373	0.341	0.190**	1.620***	1.556***	0.683***
	(0.245)	(0.256)	(0.0961)	(0.396)	(0.405)	(0.239)
Santenet*Bornafter*Noreligion	-0.266*	-0.219	-0.0819			
	(0.155)	(0.157)	(0.0521)			
Santenet*Bornafter*Dist5-10km*Noreligion	0.326	0.350	-0.0418			
	(0.244)	(0.250)	(0.0757)			
Santenet*Bornafter*Dist10km*Noreligion	0.648**	0.503*	-0.0344			
	(0.289)	(0.302)	(0.126)			
Santenet *Bornafter*Catholic				0.273*	0.235	0.0326
				(0.158)	(0.161)	(0.0731)
Santenet *Bornafter*Protestant				0.213	0.225	0.000458
				(0.169)	(0.167)	(0.0708)
Santenet *Bornafter*Dist5-10km*Catholic				-0.437	-0.319	-0.0578
				(0.350)	(0.349)	(0.158)
Santenet *Bornafter*Dist5-10km*Protestant				-0.209	-0.227	0.0220
				(0.316)	(0.320)	(0.155)
Santenet *Bornafter*Dist10km*Catholic				-1.536***	-1.516***	-0.494**
				(0.397)	(0.393)	(0.226)
Santenet *Bornafter*Dist10km*Protestant				-1.038**	-0.996**	-0.498**
				(0.437)	(0.442)	(0.234)
N	4584	4584	4584	3676	3676	3676

Notes: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for the child's gender and birth order, mother's cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. All models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance. *Noreligion* is a dummy variable for whether a mother reports no religious affiliation. *Religion* is a categorical variable where the omitted group is other religious affiliation different from Catholic or Protestant. All the lower-level interactions between the main triple difference variable and the variable of interest (i.e., religion) are also included in the models but not shown in the Table.

Online Appendix of "Community-Based Health Programs and Child Vaccinations: Evidence from Madagascar"

Appendix A: Diagnostic Tools for Two-Way Fixed Effects

Emerging econometric literature has shown potential issues with the difference-in differences (DD) estimates when these models use two-way fixed effects (TWFE), and there is variation in the timing of the program rollout across treated units (i.e., Goodman-Bacon 2021; De Chaisemartin and d' Haultfoeuille, 2020; Jakiela 2021). Indeed, this literature argues that in the presence of treatment effect heterogeneity and the differential timing of the treatment—when some units treated are used as controls- TWFE could lead to bias in the DD estimates. Even though *Santenet2* was rolled out during a short time frame --between January 2009 and February 2011-- we investigate if the negative weighting and heterogeneous treatment effects will threaten the validity of our DD estimates.

Following Jakiela (2021), we conducted a series of diagnostic tests to assess the validity of two-way fixed effects (TWFE) in the context of *Santenet2*. We mainly address two questions: i) do any treated units receive negative weights in the calculation of our DD estimates that use TWFE, and if so will this proportion of negative units be a potential issue,? and ii) can we reject the hypothesis that treatment effects are homogenous.? To answer these questions, we conduct the following tests. First, we graphically illustrate the distribution of the weights used to calculate the TWFE estimates of the *Santenet2 effect* on children's vaccination outcomes. When the common trends assumption is satisfied, the TWFE is a linear combination of the treatment effects across treated units; however, when most or all units are treated in later periods some treated observations may receive negative weight in the calculation of the estimated treatment effect. As Jakiela (2021) points out, these weights are proportional to the residuals from a regression of the treatment on the fixed effects. Second, we examine graphically the association between the residualized outcome (i.e., vaccine outcomes) and the residualized treatment (i.e., *Santenet2*) to show the extent to which treatment effects are homogenous across time and place. Under the validity of the common trends assumption, if the treatment effects are homogenous, it would be demonstrated by a linear relationship between the residualized outcome and the residualized treatment variable. This

homogeneity assumption can be checked more formally by regressing the residualized outcome variable on the residualized treatment variable, the treatment itself and an interaction between the latter two variables. If this interaction is statistically significant, that will indicate a violation of the linearity, and thus, heterogeneity in the treatment will be present.

<< Insert Figure A.1>>

Figure A.1 displays the first diagnostic test illustrating the proportion of negative weights for our estimation sample. This Figure depicts a minor concern for our DD estimates as negative weights represent approximately 7 percent of the sample across the vaccination outcomes. Jakiela (2021) argues that having negative weights on the treated observations could bias the DD estimates only under the presence of heterogeneous treatment effects. Despite the small proportion of negative weights in our estimation sample, we next test whether treatment effect heterogeneity is a concern in our DD estimates. As explained before, Figure A.2 shows the graphical test of heterogeneity while Table A.1 presents the regression test sugested by Jakiela (2021). Figure A.2 shows that the slope of the linear relationship between the residualized outcome and residualized treatment is similar across treatment and control groups, providing evidence that the homogeneity assumption seems to hold. Furthermore, the results of Figure A.2 are confirmed by the lack of statistical significance in the interaction coefficient between residualized *Santenet2* and *Santenet2* presented in Table A.1.

<< Insert here Figure A.2>>

<< Insert here Table A.1>>

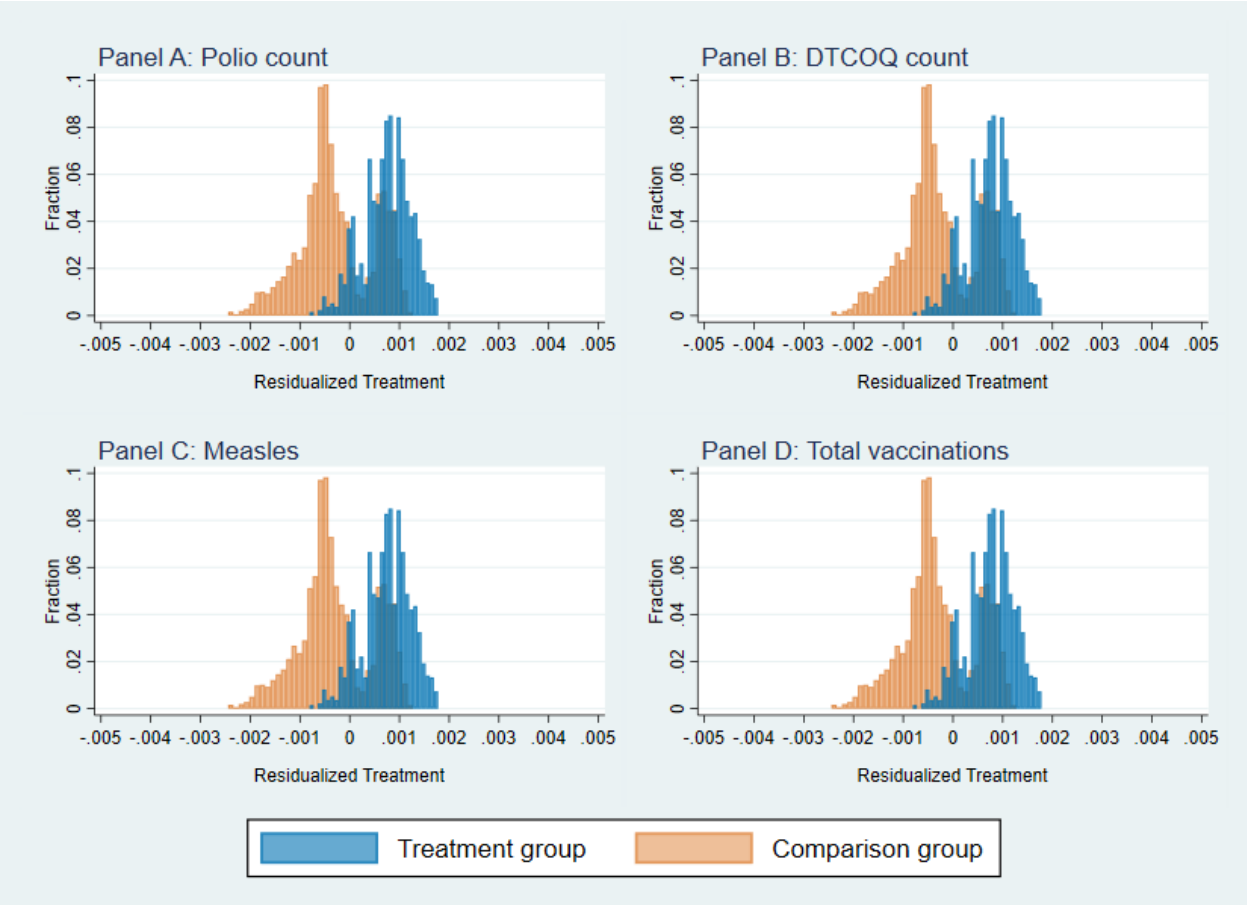
To further confirm that the proportion of negative weights is not an issue in our models, we conduct two additional exercises. First, following Jakiela (2021), we estimate our main DD and DDD models in Table A.2, excluding the observations with negative weights, and show that our main results on vaccination outcomes are robust to this sample exclusion. Second, we use an alternative diagnostic tool for negative weights in staggered treatment timing proposed by De Chaisemartin and d'Haultfoeuille (2020). These authors show that the TWFE estimator can be decomposed as a weighted average of several average treatment effects (LATE), which might be heterogeneous across groups and periods. If the comparison group is treated in consecutive periods, the treatment effect at the second period gets differenced out by the DD generating negative weights that might cause the TWFE to be negative even if all LATE are positive. Using the authors' stata code *twowayfeweights*, we diagnose the presence of negative weights in our DD

models. The results report that under the common trends, treatment monotonicity, and if groups' treatment effect does not change over time, our DD main coefficient is estimated by a weighted sum of 158 LATEs, 157 LATEs receive a positive weight, and 1 receives a negative weight.

<< Insert Table A.2 here >>

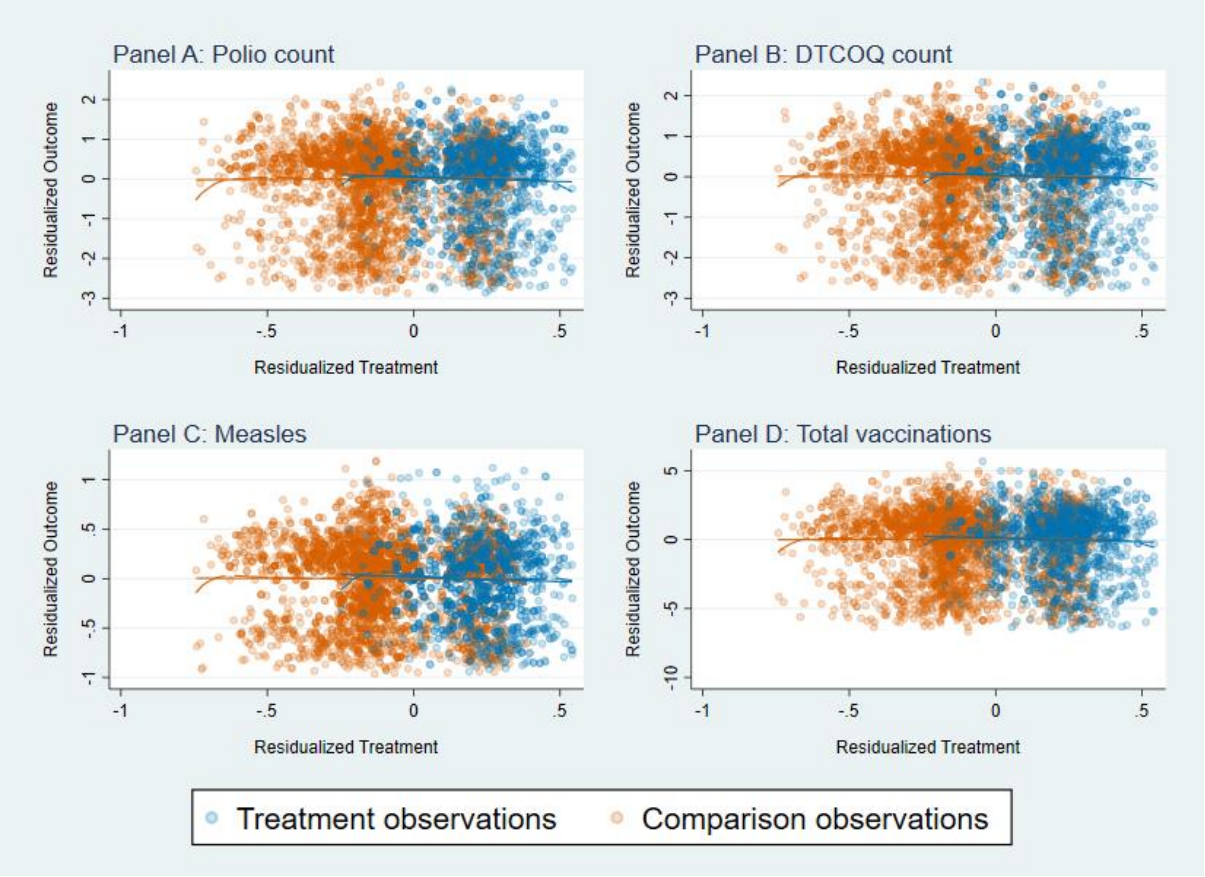
Taken together, the results of these diagnostic tools show that our DD and DDD models that use TWFE are no subject to bias issues due to the potential negative weighting and heterogeneity of the treatment effects.

Figure A.1: Proportion of Negative Weights for Two-Way Fixed-Effects by Treatment Status.



Notes: This figure displays histograms of the weights used to calculate the two-way fixed effects of *Santenet2* on different vaccination outcomes. The weights are the residuals from a regression of the treatment variable on the fixed effects, scaled by the sum of the squared residuals across all observations. See Jakiela (2021) for further details on the diagnostics tool implementation.

Figure A.2: Association between Vaccine Residualized Outcomes and Residualized Treatment



Notes: This figure plots the relationship between the residualized treatment and residualized outcome. The line of best fit and a local linear regression of residuals for the control group are shown in orange; the line of best fit and a local linear regression of residuals for the treatment group are shown in blue. See Jakiela (2021) for further details on the diagnostics tool implementation.

Table A.1: Testing Relationship between Vaccine Residualized Outcomes and Residualized Treatment.

	(1)	(2)	(3)	(4)
	Polio Count	DTCOQ count	Measles Dummy	Total vaccinations
Treatment	0.0457	0.0311	0.0168	0.0936
	(0.0545)	(0.0552)	(0.0212)	(0.119)
Residualized treatment	0.0296	-0.00877	-0.00414	0.0167
	(0.0759)	(0.0767)	(0.0295)	(0.166)
Treatment x Residualized Treatment	-0.250	-0.170	-0.0916	-0.511
	(0.207)	(0.209)	(0.0803)	(0.452)
N	4903	4903	4903	4903

Note: The dependent variable on each column is the residualized outcome (i.e., residual from a regression of the outcome presented in the title, on the fixed effects). The residualized treatment is the residual from a regression of the treatment variable (*Santenet2)* on the fixed effects. See Jakiela (2021) for further details. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Double and Triple Difference Estimates of *Santenet2* on Total Vaccine Count Excluding Observations with Negative Weights

	(1)	(2)	(3)	(4)	(5)	(6)
	All Sample	Sample with Weights>0	All Sample	Sample with Weights>0	All sample	Sample with Weights>0
Santenet*Bornafter	-0.0472	-0.0314	-0.109	-0.111	-0.113	-0.113
	(0.147)	(0.147)	(0.186)	(0.186)	(0.186)	(0.186)
Santenet*Bornafter*Dist 5km+			0.182	0.244		
			(0.301)	(0.305)		
Santenet*Bornafter*Dist5-10km					-0.194	-0.131
					(0.329)	(0.337)
Santenet*Bornafter*Dist10km+					1.222**	1.270***
					(0.484)	(0.490)
Mean of Y	4.906	4.908	4.899	4.899	4.899	4.899
Observations	4830	4729	4612	4517	4612	4517

Notes: Asterisks denote significance: * p<0.10; ** p<0.05; *** p<0.01. Columns (1), (3), and (5) present the regressions that include the original estimation sample without excluding observations that receive negative weights. Columns (2), (4), and (6) present the regressions using the subsample that exclude observations with negative weights. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for child's gender, birth order, mother's cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. Triple difference models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance.

Appendix B: Additional Tables and Figures

Table B.1: Effects of *Santenet2* on Having a Health Card Vaccination.

	(1)	(2)
	Outcome: Health Card Seen (Y=1)	
Santenet*Bornafter	0.0107	0.0108
	(0.0226)	(0.0226)
Santenet*Bornafter*Dist5kmplus	-0.0230	
	(0.0300)	
Santenet*Bornafter*Dist5-10km		-0.0266
		(0.0352)
Santenet*Bornafter*Dist10km+		-0.0185
		(0.0348)
Outcome Mean	0.377	0.377
N	12218	12218

Notes: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All models control for child gender, birth order, mother's cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. All models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance.

Table B.2: Double Difference and Triple Difference Estimates of *Santenet2* Effects on Child Vaccinations

	(1)	(2)	(3)	(4)	(5)	(6)
	Polio count	Polio count	DTCOQ count	DTCOQ count	Measles dummy	Measles dummy
Santenet*Bornafter	-0.00427	-0.0349	-0.0285	-0.0485	-0.0144	-0.0260
	(0.0649)	(0.0815)	(0.0650)	(0.0812)	(0.0284)	(0.0357)
Santenet*Bornafter*Dist 5km+		0.101		0.0539		0.0271
		(0.137)		(0.139)		(0.0528)
Outcome Mean	2.194	2.193	2.166	2.164	0.545	0.543
Observations	4830	4612	4830	4612	4830	4612

Notes: Robust standard errors are clustered at the commune level and appear in parenthesis. Asterisks denote significance: * p<0.10; ** p<0.05; *** p<0.01. All columns control for child's gender, birth order, mother's age cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. Triple difference models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance.

Table B.3: Multiple Hypothesis Correction for Heterogeneous Effects: Main Triple Difference Coefficients in Table 3.

Outcome	Variable	Original Model	Romano-Wolf FWER	Benjamin & Hochberg FDR
		(1)	(2)	(3)
Total Vaccinations	Born after x Santenet x Dist 5-10 km x Mom school 4 yrs	0.924	0.945	0.924
	Born after x Santenet x Dist +10 km x Mom school 4 yrs	0.513	0.855	0.694
	Born after x Santenet x Dist 5-10 km x Poor	0.293	0.609	0.489
	Born after x Santenet x Dist +10 km x Poor	0.816	0.945	0.907
	Born after x Santenet x Dist 5-10 km x No Religion	0.225	0.500	0.489
	Born after x Santenet x Dist +10 km x No Religion	0.092	0.193	0.308
	Born after x Santenet x Dist 5-10 km x Catholic	0.293	0.609	0.489
	Born after x Santenet x Dist 5-10 km x Protestant	0.555	0.855	0.694
	Born after x Santenet x Dist +10 km x Catholic	0.000	0.001	0.001
	Born after x Santenet x Dist +10 km x Protestant	0.013	0.024	0.066

Notes: Column (1) presents the original p-values associated to the coefficients in Table 3 and 4. Column (2) and (3) show the p-values corrected by a Family Wise Error Rate-FWER (Romano-Wolf) and False Discovery Rate-FDR (Benjamin & Hocheberg), respectively. The Romano-Wolf correction that follows resampling and stepdown procedures is obtained by 1,000 replications using the Stata command *rwolf2* (Clarke, Romano, and Wolf, 2020). The Benjamin & Hochberg correction is a step-up method that controls for the false discovery rate-FDR, it is calculated using the Stata command *qqvalue* (Newson, 2010).

Table B.4: Multiple Hypothesis Correction for Heterogeneous Effects by Religion: Main Triple Difference Coefficients in Table 4.

Outcome	Variable	(1) Original Model	(1) Romano-Wolf FWER	(3) Benjamin &Hochberg-FDR
Polio	Born after x Santenet x Dist 5-10 km x No Religion	0.182	0.367	0.328
	Born after x Santenet x Dist +10 km x No Religion	0.025	0.101	0.086
DTCOQ	Born after x Santenet x Dist 5-10 km x No Religion	0.163	0.338	0.326
	Born after x Santenet x Dist +10 km x No Religion	0.097	0.207	0.218
Measles	Born after x Santenet x Dist 5-10 km x No Religion	0.581	0.884	0.697
	Born after x Santenet x Dist +10 km x No Religion	0.785	0.919	0.831
Polio	Born after x Santenet x Dist 5-10 km x Catholic	0.212	0.415	0.348
	Born after x Santenet x Dist 5-10 km x Protestant	0.508	0.880	0.653
	Born after x Santenet x Dist +10 km x Catholic	0.000	0.007	0.001
	Born after x Santenet x Dist +10 km x Protestant	0.018	0.072	0.086
DTCOQ	Born after x Santenet x Dist 5-10 km x Catholic	0.362	0.734	0.543
	Born after x Santenet x Dist 5-10 km x Protestant	0.479	0.862	0.653
	Born after x Santenet x Dist +10 km x Catholic	0.000	0.007	0.001
	Born after x Santenet x Dist +10 km x Protestant	0.025	0.101	0.086
Measles	Born after x Santenet x Dist 5-10 km x Catholic	0.715	0.919	0.805
	Born after x Santenet x Dist 5-10 km x Protestant	0.887	0.919	0.887
	Born after x Santenet x Dist +10 km x Catholic	0.029	0.101	0.086
	Born after x Santenet x Dist +10 km x Protestant	0.034	0.101	0.086

Notes: Column (1) presents the original p-values associated to the coefficients in Table 4. Column (2) and (3) show the p-values corrected by a Family Wise Error Rate-FWER (Romano-Wolf) and False Discovery Rate-FDR (Benjamin & Hocheberg), respectively. The Romano-Wolf correction that follows resampling and stepdown procedures is obtained by 1,000 replications using the Stata command *rwolf2* (Clarke, Romano, and Wolf, 2020). The Benjamin & Hochberg correction is a step-up method that controls for the false discovery rate-FDR, it is calculated using the Stata command *qqvalue* (Newson, 2010).

Table B.5: Adding Education Trends Specific to Remote Areas using Main Triple Difference Models

Panel A:

	Polio Count (max=3)	DTCOQ Count (max=3)	Measles Dummy	Total Vaccinations (max=7)
	(1)	(2)	(3)	(4)
Santenet*Bornafter	-0.0346	-0.0475	-0.0252	-0.107
	(0.0807)	(0.0806)	(0.0357)	(0.184)
Santenet* Bornafter*Dist 5km+	0.0876	0.0471	0.0205	0.155
	(0.138)	(0.139)	(0.0526)	(0.301)
Mean of Y	2.193	2.164	0.543	4.899
Observations	4612	4612	4612	4612

Panel B:

	Polio Count (max=3)	DTCOQ Count (max=3)	Measles Dummy	Total Vaccinations (max=7)
	(1)	(2)	(3)	(4)
Santenet* Bornafter	-0.0367	-0.0493	-0.0255	-0.112
	(0.0811)	(0.0809)	(0.0359)	(0.185)
Santenet* Bornafter*Dist.5-10km	-0.0704	-0.103	-0.0225	-0.196
	(0.153)	(0.154)	(0.0576)	(0.330)
Santenet* Bornafter* Dist10km+	0.550**	0.479**	0.169*	1.197**
	(0.220)	(0.223)	(0.0915)	(0.488)
Outcome Mean	2.193	2.164	0.543	4.899
N	4612	4612	4612	4612

Notes: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for child's gender and birth order, mother's cohort dummies and education level, household asset index quintiles, childbirth year dummies, and commune fixed effects. These models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of childbirth year dummies and distance. All of these specifications additionally control for mother's cohort*mother's education*distance fixed effects (these lower-level interactions are not shown in the Table). Results controlling for the interaction of the mother's education and child's birth year are available upon request.

Table B.6: Sensitivity Analysis of Distance: Triple Difference Model for Total Vaccinations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Santenet*Bornafter	-0.218	-0.113	-0.115	-0.116	-0.114	-0.111	-0.112
	(0.175)	(0.186)	(0.186)	(0.186)	(0.186)	(0.172)	(0.173)
Santenet*Bornafter*Distance (km)	0.0354**						
	(0.0172)						
Santenet*Bornafter*Distance(km)^2	-0.0000494						
	(0.0000331)						
Santenet*Bornafter*Dist 5-10km		-0.194					
		(0.329)					
Santenet*Bornafter*Dist 10km+		1.222**					
		(0.484)					
Santenet*Bornafter*Dist 5-7km			-0.0130		-0.00751		
			(0.384)		(0.385)		
Santenet*Bornafter*Dist 7-9km			-0.953		-0.941		
			(0.579)		(0.578)		
Santenet*Bornafter*Dist 9km+			0.825**				
			(0.340)				
Santenet*Bornafter*Dist 5-8km				-0.319			
				(0.365)			
Santenet*Bornafter*Dist 8-11km				0.281			
				(0.508)			
Santenet*Bornafter*Dist +11km				0.913**			
				(0.400)			
Santenet*Bornafter*Dist 9-11km					0.480		
					(0.564)		
Santenet*Bornafter*Dist 11-13km					1.085		
					(0.676)		
Santenet*Bornafter*Dist 13-15km					2.148***		
					(0.794)		
Santenet*Bornafter*Dist +15km					0.776		
					(0.482)		
Santenet*Bornafter*Dist 5-6km						-0.172	-0.179
						(0.634)	(0.634)
Santenet*Bornafter*Dist 6-7km						-1.188*	-1.196*
						(0.720)	(0.723)
Santenet*Bornafter*Dist 7-8km						-0.635	-0.647
						(0.897)	(0.896)
Santenet*Bornafter*Dist 8-9km						0.823	0.812
						(0.737)	(0.731)
Santenet*Bornafter*Dist 9-10km						0.108	0.0955
						(0.943)	(0.944)
Santenet*Bornafter*Dist 10-11km						0.467	0.482
						(0.829)	(0.849)
Santenet*Bornafter*Dist 11-12km						2.583**	2.997***
						(1.029)	(1.002)
Santenet*Bornafter*Dist 12-13km						3.888***	3.839***
						(1.282)	(1.253)
Santenet*Bornafter*Dist 13+						0.801*	
						(0.456)	
Santenet*Bornafter*Dist 13-15km							0.0467
							(1.372)
Santenet*Bornafter*Dist 15-17km							7.557***
							(1.193)
Santenet*Bornafter*Dist 17km+							0.598
							(0.497)
Mean of Y	4.898	4.899	4.906	4.906	4.906	4.906	4.906
Observations	4623	4612	4830	4830	4830	4830	4830

Notes: Asterisks denote significance: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors clustered at the commune level appear in parenthesis. All columns control for child's gender, birth order, mother's cohort dummies and education level, child's birth year dummies, and commune fixed effects. These models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance. The base category for categorical distance variables is distance 0-5km.

Table B.7: Alternative Distance Measure: Village Centroid to the Closest Public Health Clinic

Panel A:

	Polio Count (max=3)	DTCOQ Count (max=3)	Measles Dummy	Total Vaccinations (max=7)
	(1)	(2)	(3)	(4)
Santenet*Bornafter	-0.0560	-0.0678	-0.0194	-0.143
	(0.0814)	(0.0810)	(0.0362)	(0.186)
Santenet*Bornafter*Dist 5km+	0.143	0.102	0.0181	0.263
	(0.132)	(0.134)	(0.0569)	(0.294)
Mean of Y	2.195	2.167	0.546	4.908
Observations	4738	4738	4738	4738

Panel B:

	Polio Count (max=3)	DTCOQ Count (max=3)	Measles Dummy	Total Vaccinations (max=7)
	(1)	(2)	(3)	(4)
Santenet* Bornafter	-0.0575	-0.0694	-0.0198	-0.147
	(0.0815)	(0.0811)	(0.0363)	(0.186)
Santenet* Bornafter*Dist5-10km	-0.0102	-0.0403	-0.0667	-0.117
	(0.153)	(0.155)	(0.0639)	(0.336)
Santenet* Bornafter *Dist10km+	0.520***	0.449**	0.194**	1.163***
	(0.181)	(0.177)	(0.0828)	(0.398)
Outcome Mean	2.195	2.167	0.546	4.908
N	4738	4738	4738	4738

Notes: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for child's gender and birth order, mother's cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects All models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of child's birth year dummies and distance.

Table B.8: Placebo Test, *Santenet2* Effects on Per-capita Consumption and Poverty

	Per-capita Consumption		Poor Household (Y=1)	
	(1)	(2)	(3)	(4)
Santenet*Bornafter	14668.0	14710.6	-0.519	-0.441
	(16035.7)	(16117.4)	(1.646)	(1.645)
Santenet*Bornafter*Dist5km+	-19144.9		1.102	
	(20104.7)		(2.168)	
Santenet*Born after*Dist5-10km		-20872.5		2.036
		(23985.4)		(2.430)
Santenet*Born after*Dist10km+		-16063.9		-0.285
		(18591.4)		(2.415)
Outcome Mean	398038.2	398243.9	79.38	79.35
N	9863	9831	9863	9831

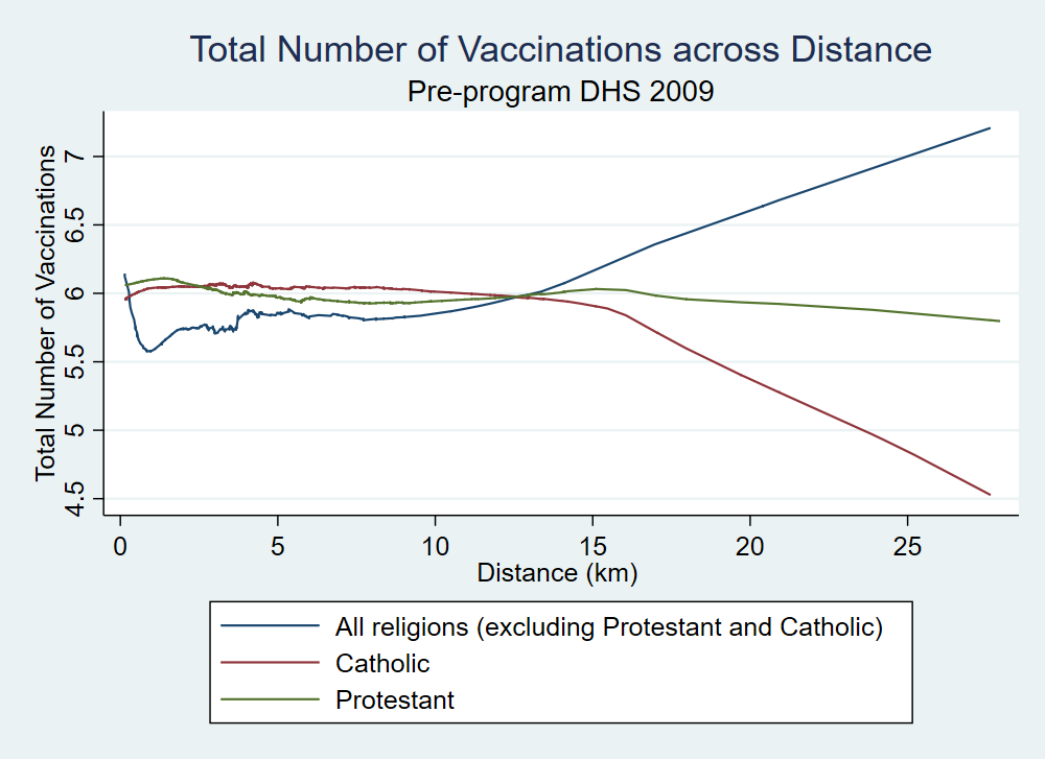
Notes: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for child's gender and birth order, mother's cohort dummies and education level, childbirth year dummies and commune fixed effects. All models also include lower-level interactions (not shown) of *Santenet2* and distance as well as of childbirth year dummies and distance.

Table B.9: Robustness Check, Excluding Potentially Exposed Children in *Santenet2* Communes

		Drop children <=9, 12 and 24 months in *Santenet2* communes		
	Main specification	<=9 months	<=12 months	<=24 months
	(1)	(2)	(3)	(5)
Outcome: Vaccine count				
Santenet*Born after	-0.113	-0.0132	0.0102	0.161
	(0.186)	(0.223)	(0.228)	(0.289)
Santenet*Born after*Dist5-10km	-0.194	-0.406	-0.149	-0.861
	(0.329)	(0.413)	(0.426)	(0.556)
Santenet*Born after*Dist10km+	1.222**	1.223**	1.489**	1.766**
	(0.484)	(0.597)	(0.617)	(0.698)
Outcome Mean	4.899	4.883	4.873	4.865
Observations	4612	4336	4267	4022

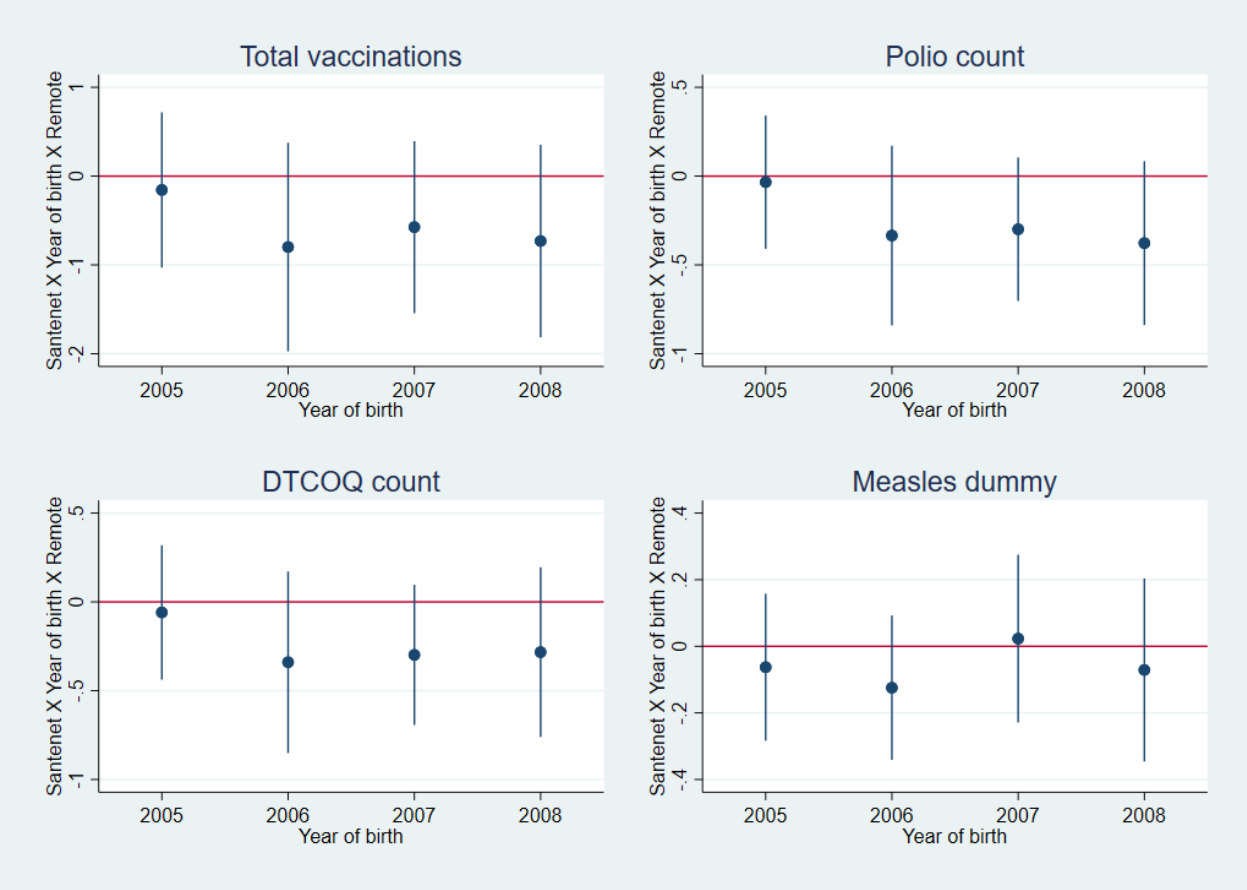
Notes: Asterisks denote significance: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors are clustered at the commune level and appear in parenthesis. All columns control for child's gender, birth order, mother's age cohort dummies and education level, household asset index quintiles, child's birth year dummies, and commune fixed effects. Columns also include lower-level interactions (not shown) of Santenet2 and distance as well as of child's birth year dummies and distance.

Figure B.1: Pre-Program Vaccination Rates by Main Religious Groups



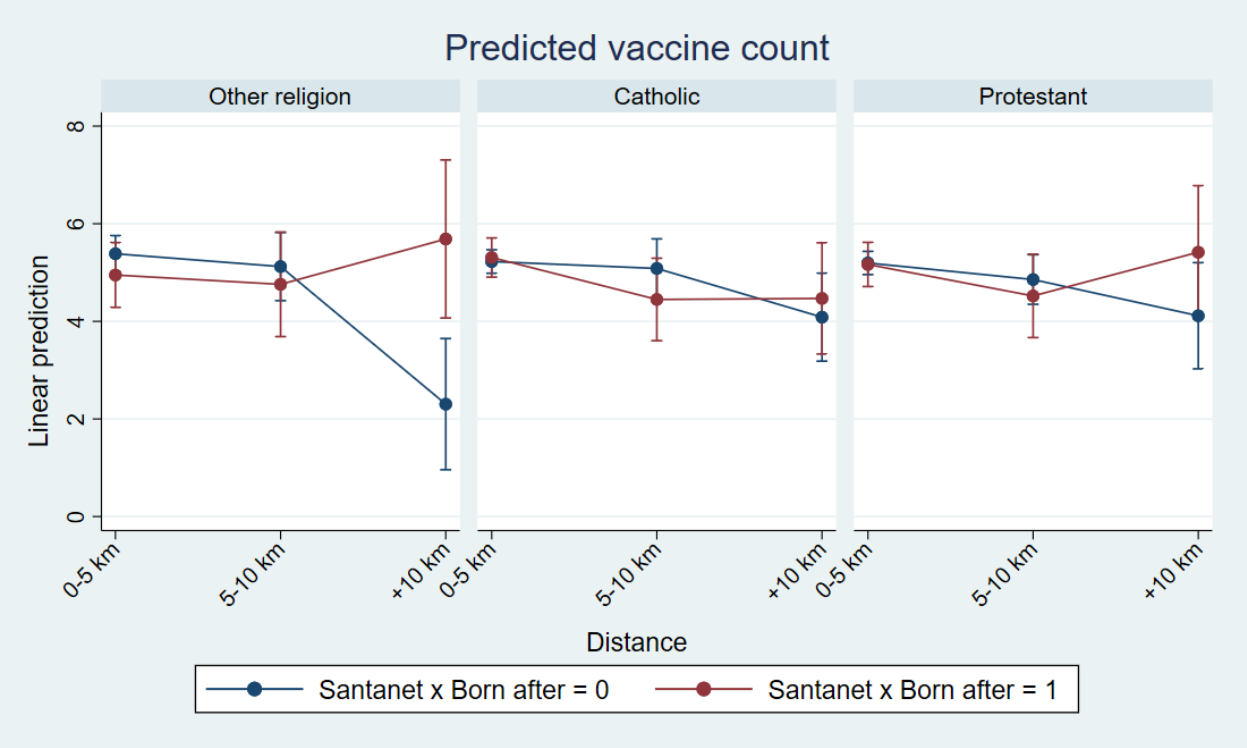
Notes: The figure depicts the non-parametric local regression of the outcome on the distance to the closest health facility across different religions. The distance variable corresponds to the Euclidian distance between the DHS geocoded coordinates of the cluster, where the household is located, and the geocoded location of the closest health facility.

Figure B.2: Parallel Trends Pre-*Santenet2* for Vaccination Outcomes across Remote Areas using 2008-2009 DHS and 10 km Distance Cut-off



Notes: Figure B.2 depicts the coefficients of the interaction of being born in a *Santenet2* commune, the child's year of birth and living in a remote village defined as those located further than 10 km from the closest health clinic. We acknowledge that when using the DHS, the distance variable suffers from displacement of the GPS coordinates of cluster locations. The models of the figure control for child's gender and birth order and mother's socio-demographic characteristics (i.e., mothers' education, birth cohort and household asset index), district and year-of-birth fixed effects. Omitted birth cohort is 2004. 95% confidence intervals are shown.

Figure B.3: Estimated Number of Vaccines by Main Religious Groups Across Distance to the Closest Health Facility



Notes: Figure B.3 depicts the linear prediction of total vaccine count across religion and distance, for both the group of children born in *Santenet2* communes and the group born in non-*Santenet2* communes after estimating our main triple difference model depicted in equation (2). This figure is obtained using the command *margins* in Stata. 95% confidence intervals are shown.

References

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