'We Are Not Guinea Pigs': The Effects of Negative News on Vaccine Compliance*

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Abstract

In 1996, following an epidemic, Pfizer tested a new drug on 200 children in Muslim Nigeria. 11 children died while others were disabled. We study the effects of negative news on vaccine compliance using evidence from the disclosure of deaths of Muslim children in the Pfizer trials in 2000. Muslim mothers reduced routine vaccination of children born after the 2000 disclosure. The effect was stronger for educated mothers and mothers residing in minority Muslim neighborhoods. The disclosure did not affect other health-seeking behavior of mothers. The results illustrate the potential spillover effects of perceived medical malpractice on future vaccine hesitancy.

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1 Introduction

"We are not guinea pigs"

- South African anti-vaccine protesters, *Reuters, July 1, 2020*

Following a meningitis epidemic in 1996, Pfizer conducted human trials on 200 children in the Muslim state of Kano in Northern Nigeria of an experimental antibiotic, Trovan. 11 children died following the trials, with multiple participants disabled as well. A reporter at the Washington Post (WP) published an exposé alleging Pfizer's fault in the children's death and for unethical medical trials in 2000. The news sent shockwaves throughout Nigeria sparking a series of protests led by Muslim religious leaders alleging that Pfizer and 'the West' were trying to kill Muslims and calling for boycotts of vaccinations among Muslims. The subsequent reduction in routine child vaccination among Muslim mothers set back global polio eradication efforts by over a decade, with negative effects lasting for up to 12 years after the initial disclosure. The event provides evidence to study the effects of negative news about vaccination on vaccine hesitancy and non-compliance.

We assess the effects of the 2000 WP disclosure on child vaccination outcomes using a difference-in-differences strategy comparing differences in child vaccination outcomes across Muslim vs. non-Muslim mothers (first difference), for children born before versus after the Washington Post revelation of the Pfizer drug trials in 2000 (second difference). We focus on Muslim mothers because the victims were Muslim children and the boycotts against vaccination were led by Muslim religious leaders in the aftermath of the drug trial disclosure in 2000. We find that the Washington Post disclosure of the Pfizer trials led to significant reductions in routine vaccination- namely, tuberculosis (BCG), diphtheria, pertussis and tetanus (DPT), polio and measles vaccinations, of children born to Muslim mothers after the disclosure. Muslim mothers reduced BCG, DPT, polio, and measles vaccination rates

by 7.3 percentage points (pp), 8.7 pp, 6.7 pp, and 9.1 pp respectively, equivalent to a 14% to 29% reduction in child vaccination of children born to Muslim mothers relative to the pre-disclosure sample mean. We show that the effects are largely driven by educated Muslim mothers and Muslim mothers residing in minority Muslim neighborhoods with relatively stronger ties to religious networks. The disclosure did not affect other health-seeking behavior of mothers; the reduction effect is specific to child vaccination, not other child health outcomes.

The results provide insight into the drivers of vaccine hesitancy and non-compliance, with over 1.5 million people, many of them children, dying each year from vaccine preventable diseases[1]. We add to several distinct literatures. First our work is related to the recent economics literature on the role of medical malpractice and negative news on long term trust in health institutions and health behavior (Alsan and Wanamaker, 2018; Lowes and Montero, 2020; Martinez-Bravo and Stegmann, 2021; Qian, Chou, and Lai, 2020; Chang, 2018); including work on the effects of the Tuskegee trials on health outcomes of African-American men (Alsan and Wanamaker, 2018), a CIA vaccine ruse on immunization in Pakistan (Martinez-Bravo and Stegmann, 2021), and colonial medical campaigns on mistrust in medicine in Africa (Lowes and Montero, 2020). We complement previous work by examining how mothers choose to vaccinate their children in response to negative news about vaccines. We also show how such responses are driven by the mother's education (Cutler and Lleras-Muney, 2010; Kenkel, 1991; Anderberg, Chevalier, and Wadsworth, 2011).

Our work also adds to the nascent literature on the economics of religion. Past work focused on Christians/churches has linked participation in religious networks to economic development (Iannaccone, 1998; Iyer, 2016), and demand for insurance (Auriol et al., 2020). Here, we provide evidence from Muslim populations, an understudied group in this literature,

[1]Source: Children's Hospital of Philadelphia: https://www.chop.edu/centers-programs/vaccine-education-center/global-immunization/diseases-and-vaccines-world-view

and focus on the important role of religious networks in diffusing information on health, particularly among minority communities where individuals may cleave more strongly to these networks in the absence of neighboring family ties. Past research has shown that these networks can be particularly important ways of spreading information to improve health among minority communities such as African-Americans (Ellison and Sherkat, 1995) and Samoan immigrants in the United States (Levy-Storms and Wallace, 2003). Our paper illustrates how religious networks can reduce health behavior by diffusing negative news about vaccines, with consequences for future vaccine hesitancy.

2 Context: The Pfizer Epidemic Drug Trials in Nigeria

In 1996, Nigeria experienced one of the worst meningitis epidemics in the country's history, with 109,580 cases and 11,717 deaths (Mohammed et al., 2000). Bacterial meningitis is an infection of the lining of the brain that is especially virulent in children, and endemic in northern Nigeria (Archibong and Annan, 2017). Northern Nigeria is also a majority Muslim region, with around 99% of residents in Kano state where the infectious disease hospital was located, identifying as Muslim as shown in the map in Figure 1. At the hospital in Kano, the non-profit Doctors Without Borders treated children with chloramphenicol, a well-known antibiotic endorsed by the World Health Organization (WHO) to treat bacterial meningitis (Perlroth, 2008).

Over the same period, Pfizer, a US pharmaceutical company, was trying to launch its new antibiotic drug, Trovan. While Pfizer had tested the drugs on adults, it had not yet been tested on children (Perlroth, 2008). Additionally, early testing on adults had shown some serious side effects of the drugs, including liver problems and cartilage abnormalities (Perlroth, 2008). After being alerted to the news of the meningitis epidemic in Nigeria, Pfizer decided to use the epidemic as an opportunity to test the efficacy of Trovan in pediatric

settings. Pfizer staff flew to Kano, set up a site beside the Doctor Without Borders testing area and over 2 weeks, selected a sample of 200 children aged between 3 months and 18 years old to participate in drug trials for Trovan. 100 children were given full daily doses of Trovan over the course of a 5 day treatment in the treatment group. The other 100 children in the control group were given ceftriaxone, an antibiotic widely recognized as standard treatment for meningitis. The children in the control group were given a lower than normal dose of ceftriaxone, allegedly only a third of the WHO recommended dose at the time, over 4 of the 5 days of the treatment course (Perlroth, 2008; Ahmad, 2001).

A month later, 11 of the children that had participated in the Pfizer trials were dead. Additionally, numerous parents of children involved in the trials reported disabilities among their children, including paralysis and liver failure. In December 2000, a reporter at the Washington Post broke the story of the Pfizer epidemic drug trials in a series of exposés, alleging Pfizer's fault in the deaths and disabilities of multiple children and accusing Pfizer of conducting unethical experimental trials on children without attaining informed consent of participants (Stephens, 2000; Ezeome and Simon, 2010). A snapshot of the headlines is shown in Figure A1 in the Appendix. Parents alleged that they had not been informed of the experimental nature of the Pfizer trials, with many reporting that they thought they were receiving the standard medication issued in the neighboring Doctors Without Borders area at the hospital site in Kano (Ahmad, 2001; Perlroth, 2008; Wise, 2001)[2].

The disclosure sent shockwaves throughout Nigeria, prompting a series of protests in Muslims states in northern Nigeria in 2001. Protesters, led by Muslim religious leaders, highlighted the death of Muslim children and the fact that the trials had been conducted in a Muslim state as evidence for the claim that Pfizer and its associated 'Western' institutions were targeting and trying to kill Muslims with vaccines (Yahya, 2007). Pfizer denied

[2]After approving Trovan for other uses in 1997, the US Food and Drug Administration (FDA) advised Pfizer to pull the drug citing safety concerns over deaths from Trovan-linked liver injuries (Perlroth, 2008).

any wrongdoing, stating that the children died of meningitis not their drug (Ahmad, 2001; Perlroth, 2008).

2.1 The Aftermath

Following the Washington Post revelation, a panel of experts hired by the Nigerian government conducted its own investigation, and released a report finding Pfizer at fault in the children's death and guilty of conducting human trials without informed consent (Ezeome and Simon, 2010; Lenzer, 2006; Stephens, 2006). The report cited the Washington Post article as how the officials discovered news of the trials, with a snapshot of the report shown in Figure A2. In the following years, a series of lawsuits were filed against Pfizer by parents of children involved in the trials and the Kano state government. An out of court settlement was reached for, allegedly, $75 million to Kano state and $175,000 to four families of dead children in 2009.

The incident heightened distrust among Muslims towards vaccination campaigns led by 'Western' non-profits like the Global Polio Eradication Initiative (GPEI), a consortium including the WHO and the US Center for Disease Control (CDC), aimed at eradicating polio worldwide (with a particular focus on Nigeria where more than 40% of the 677 new polio cases worldwide were recorded in 2002) (Yahya, 2007; Frishman, 2009). Tensions culminated in a 2003 Muslim religious leader-led boycott of the GPEI-led polio mass vaccination campaigns in 5 Muslim Northern States in Nigeria, buoyed by rumors that the vaccination effort was part of an effort by Westerners to spread HIV among Muslims and cause infertility in Muslim girls. In interviews explaining support for the boycott, respondents explicitly cited the Pfizer drug trials, with one respondent stating, "We cannot trust the white man or our federal government because many years ago they were in partnership when they brought medicine to poison our people" (Yahya, 2006; Jegede, 2007).

The boycotts continued for over a year and ended only after federal government officials worked with local religious leaders to demonstrate the safety of the vaccine (Yahya, 2006; Ghinai et al., 2013). The boycott also led to a 30% increase in polio prevalence, setting back global polio eradication efforts by over a decade, with Nigeria becoming one of the last countries in the world to be declared polio free in 2020 (Ghinai et al., 2013; Yahya, 2007). The Pfizer trials remain a point of tension among Muslims in Nigeria, with the spectre of Muslim children's deaths often referenced anytime health authorities attempt to conduct mass vaccination campaigns in the country (Masquelier et al., 2012; Nasiru et al., 2012).

3 Data and Empirical Strategy

3.1 Data

To examine the effects of the 2000 Washington Post news revelation of the Pfizer drug trials on child vaccination outcomes, we use available data from the birth recode (BR) of the Demographic and Health Surveys (DHS) for four rounds of surveys between 1990 and 2013. The dataset documents individual mother's reported vaccination of children born between 1985 and 2013[3]. It also records the mother's religion. The DHS sample reflects the religious composition of Nigeria and is split almost evenly between Muslims (57%) and Christians (41%) (Archibong, 2019)[4], varying geographically by state as shown in Figure 1.

We assemble available information on routine vaccination in the DHS, namely: BCG (tuberculosis), polio, DPT (diphtheria, pertussis and tetanus) and measles vaccination. Our main outcome of interest is an indicator that equals one if the child has received the BCG or measles vaccine or any dose of the DPT or polio vaccines. The recommended schedule

[3]For the BR sample, mothers aged 15-49 are individually interviewed to gather information on every child ever born to the woman. For each of the women interviewed, the BR has one record for every birth. The dataset is missing data on children born between 1991 and 1997 as the DHS only collects responses for children born in the five years prior to the survey.

[4]The remaining 2% of the sample identifies as other/traditional religion adherents.

for routine vaccination of children by WHO standards is at or near birth for BCG, DPT and polio, and at 9 months for measles, with most children receiving recommended vaccines within their year of birth (Organization, 2019). To examine the effects of the 2000 disclosure on mother's own health seeking behavior, we collect data on mother's reported pre-natal care source from the DHS. Other child health outcomes examined include whether the child is currently stunted or underweight[5]. Summary statistics are provided in Table A1 in the Appendix.

To explore links between vaccination rates and cases of disease, we digitized 10 years of available archival data on disease incidence in Nigeria from 1985 to 1995 from the Federal Ministry of Health. Panel A Table A2 in the Appendix shows a significant negative correlation between child vaccination coverage in the prior year, $t-1$ and current year, t, disease incidence. In line with findings from the scientific literature, vaccination coverage of up to 90% in the previous year is needed for herd immunity/positive external benefits of vaccination in reducing the caseload of disease (Chen and Fu, 2019).

Lastly, to explore mechanisms and the potential role of Muslim religious networks in disseminating information around the Pfizer drug trials and intensifying the effects of the news announcement on child vaccination outcomes, we assemble data on religiosity, and perceptions of corruption and trust in religious leaders, neighbors and state officials from available Afrobarometer surveys over 4 rounds from 2003 to 2014. The data appendix and Table A3 in Section A.2 provides further detail on these sources.

Figure 1 shows differences between mothers' outcomes and child vaccination rates for Muslim vs non-Muslim mothers of children born between 1985 and 2013. Muslim mothers have lower education attainment, marry earlier and report lower vaccination and child health outcomes for children. We examine the differences in mean vaccination outcomes for Muslim

[5]A child is considered underweight by WHO standards if they have a weight for age z-score (WFA z) of less than -2.0 while a child is considered stunted with a height for age z-score (HFA z) of less than -2.0

versus non-Muslim mothers for children born pre and post the 2000 WP disclosure of the Pfizer drug trials in Table A1. Muslim mothers in the sample report significantly lower child vaccination rates on average than their non-Muslim counterparts. The results from the unconditional means show that Muslim mothers decreased vaccination rates of children born after the 2000 announcement by 12.5 pp from 43% to 31% for BCG vaccination, by 10.9 pp from 41% to 30% for DPT vaccination, and by 7 pp from 32% to 25% for measles vaccination. In contrast, non-Muslim mothers increased vaccination rates across all vaccines between the pre-2000 and post-2000 birth samples, with over 70% of children born to non-Muslim mothers post 2000 vaccinated for BCG, DPT and polio.

3.2 Empirical Strategy

Our aim is to assess the effect of negative news about the Pfizer drug trials on Muslim children on child vaccination outcomes. We assume that the year of birth and mother's religious identity jointly determine a child's exposure to the shock induced by news of the Pfizer drug trials[6]. Since the Pfizer drug trials occurred in 1996, it is plausible that news about the trials may have already begun diffusing among Muslims through religious "whisper networks" as has been documented in other settings (Martinez-Bravo and Stegmann, 2021). Given information diffusion among these networks, we adapt the strategy from Martinez-Bravo and Stegmann (2021), and consider children born between 1996 and the 2000 WP disclosure year as *partially exposed* to the news about the Pfizer trials. Children born after the 2000 disclosure, after the information about the trials is fully revealed, are considered *fully exposed* to the news. Children born before the trials in 1996 are considered *non-exposed*.

Our main specification in an interacted difference-in-differences (DD) model comparing differences in child vaccination outcomes across Muslim vs non-Muslim mothers (first dif-

[6]In contrast with Martinez-Bravo and Stegmann (2021), we do not have complete information on exact dates of child vaccination, so we use the recorded years here.

ference), for non-exposed and fully exposed cohorts of children born before versus after the Washington Post revelation of the Pfizer drug trials in 2000 respectively (second difference). To produce a distinct comparison, we exclude partially exposed cohorts from the sample (Martinez-Bravo and Stegmann, 2021).

We estimate panel regressions linking child vaccination outcomes for child i born in year r and located in district d and state s at survey year t to a measure of post 2000 birth year assignment, Post 2000_r, that is interacted with the religion of the child's mother Muslim_{idst}:

$$y_{idsrt} = \gamma \underbrace{\text{Post } 2000_r \times \text{Muslim}_{idst}}_{} + \beta \text{Muslim}_{idst} + X'_{idsrt}\theta + \mu_d + \delta_t + \delta_r + \phi_{sr} + \epsilon_{idsrt} \quad (1)$$

Post 2000_r and Muslim_{idst} are binary indicators for children born post the 2000 news revelation and for mother's reported Muslim religious identity respectively. This specification includes district fixed effects μ_d which capture unobserved differences that are fixed across districts or local government areas (LGAs), the smallest administrative neighborhood unit in Nigeria[7]. It also includes birth year fixed effects, δ_r, that control for potential life cycle changes across cohorts, and survey year fixed effects, δ_t, that control for potential changes across survey collection practices over time. The state-by-year fixed effects, ϕ_{sr}, control for time-varying changes to vaccination outcomes that are common across states, e.g. differences in health policies and infrastructure across states; such relevant policies are generally taken at the state level in Nigeria (Khemani, 2006). The specification includes controls for the mother's age at birth and level of education, X_{idsrt}.

Our key parameter of interest, γ, captures the post-2000 birth year effect of being

[7]Nigeria is a federation with 36 states, a capital at the Federal Capital Territory in Abuja and 776 local government areas (LGAs). See Archibong (2019) for institutional details on the country.

a Muslim mother relative to non-Muslim mothers on child vaccination outcomes for fully-exposed versus non-exposed cohorts, controlling for differences in the Muslim-Non-Muslim mother child vaccination rates in each district (β).

Without pre-existing trends in vaccination rates that correlate with the mother's Muslim identity, we expect to find no effects for non-exposed cohorts, i.e. $\gamma \approx 0$. For fully exposed cohorts, we expect $\gamma < 0$ as exposure to the WP news in 2000 and the subsequent anti-vaccine rhetoric and vaccine boycotts led by Muslim religious leaders make Muslim mothers hesitant to vaccinate their children. For partially exposed cohorts, we also expect negative effects, as their vaccination years occur under the early diffusion of news about the Pfizer trials among Muslim networks.

To test that the effects of the 2000 disclosure on child vaccination outcomes of Muslim mothers, γ, will be stronger among mothers with more information on vaccination, as discussed in Section 1, we conduct heterogeneity analysis, estimating Equation 1 in the split sample among educated mothers, with non-zero years of schooling. To test that γ will be stronger among Muslim mothers living in minority Muslim neighborhoods with relatively stronger religious networks, as discussed in Section 1, we estimate Equation 1 in the split sample among mothers living in minority Muslim neighborhoods, defined relative to a 50% threshold.

3.2.1 Validity of Design

Our empirical strategy requires a primary identifying assumption, namely that in the absence of news about the Pfizer trials, vaccination rates across birth cohorts would have been similar for children born to Muslim and non-Muslim mothers. The evidence shown in the event study coefficients in Figure 2 supports this assumption. The estimates for the non-exposed birth cohorts fluctuate around zero. Additionally, we show that the Muslim-non-

Muslim child vaccination gap was generally not systematically different prior to the 2000 disclosure in Table A2 in the Appendix. The estimates for the fully exposed cohorts shown in Figure 2 are negative, in line with the predictions in Section 3.2. There is a sharp drop in vaccination for children born to Muslim mothers after the 2000 news disclosure, with vaccination rates reaching their lowest levels in 2001 for all vaccination outcomes except polio, where vaccination rates decline past 2001, and reach their lowest level in 2002.

The DD strategy outlined in Equation 1 also requires that the estimates of γ reflect the effect of the Pfizer drug trials news disclosure on the child vaccination outcomes of Muslim mothers as long as there are no other structured shocks to Muslim mothers that affected health access or health-seeking behavior, that were correlated with the timing of the disclosure. The fixed effects and controls included in Equation 1, flexibly control for the pre-disclosure Muslim-Non-Muslim mother child vaccination gap and for time-varying threats to identification such as national trends in vaccination campaigns that affected Muslim women.

Comparably, although access to health care, including the numbers of health personnel and quality of health infrastructure differs and has historically differed for residents in poorer, northern Muslim states from their richer, southern, less Muslim counterparts[8], any time-invariant geographic difference in these factors are absorbed by the district fixed effects. State-year effects net out any time-varying health benefits or costs associated with location that affected the general population and might confute interpretation of our results. If our attempts to control for any changes in health investments that affected Muslim mothers differentially are insufficient, most policy changes coinciding with the timing of the 2000 news disclosure were aimed towards improving access for Muslim populations, and would likely bias our estimates toward zero[9].

[8]Figure A6 and Figure A7 in the Appendix, provide a snapshot of access to and quality of health care by state in Nigeria from a comprehensive 2012 survey of health facilities. See (Archibong, 2019) for data details.

[9]We find increases in the share of nurses/midwives in health personnel in majority Muslim states between

4 Effects of the 2000 Washington Post Disclosure of Pfizer Drug Trials on Child Vaccination Outcomes

4.1 Main Estimates

Table 1 reports estimates of the effects of the 2000 Washington Post (WP) disclosure of the Pfizer epidemic drug trials on child vaccination outcomes[10]. Our main results are in column (1) across four panels A, B, C and D for whether or not the child received the BCG, any dose of the DPT, any dose of the polio vaccine or the measles vaccine respectively. Across all vaccination outcomes, the 2000 WP revelation of the Pfizer drug trials reduced child vaccination outcomes for children born to Muslim mothers after the disclosure year; the interaction estimates are negative and strongly significant at conventional levels. The 2000 WP disclosure led to a significant reduction in BCG vaccination rates for children born to Muslim mothers after the disclosure by 9.1 percentage points (pp)- approximately 21% of the pre-disclosure Muslim mother sample mean.

Estimates of the effect of the 2000 WP disclosure on DPT vaccination in column (1) of Panel B, show that Muslim mothers reduced DPT vaccination rates by 8.9 pp- about 22% of the pre-disclosure Muslim mother sample mean. Results for the effects of the disclosure on polio vaccination rates are shown in column C, with Muslim mothers reducing vaccination rates of children born after the 2000 revelation by 5.1 pp- approximately 11% of the pre-disclosure Muslim mother sample mean. Results for the effects of the disclosure on measles vaccination rates are shown in column D, with Muslim mothers reducing vaccination rates of children born after the 2000 revelation by 8.6 pp- approximately 27% of the pre-disclosure Muslim mother sample mean.

1991 and 2012 in line with increases in health investments in these areas, with results shown in Table A10.

[10]Results with β estimates from Equation 1 are provided in Table A4 and overall effects are summarized in Figure A4 in the Appendix.

4.2 Heterogeneous Effects by Education and Neighborhood Religious Composition

In column (2) to column (5) of Table 1, we explore heterogeneous effects by splitting the sample by education and district or neighborhood religious composition. First, we explore the role of education by dividing the sample into educated (with non-zero years of education) and non-educated (with zero years of education) mothers in columns (2) and (3) respectively. The educated and non-educated samples are roughly equally sized as shown in Table 1. In contrast to results in Alsan and Wanamaker (2018), here we hypothesize that the effects of the 2000 Pfizer drug trial disclosure should be stronger for educated mothers, who would have access to more information, be literate and hence more likely to have read the news and be more informed on health practices as shown in previous literature linking education and news consumption in Nigeria (Larreguy and Marshall, 2017).

The results show that the effects of the 2000 WP disclosure on vaccination of children born to Muslim mothers are driven by educated mothers across all vaccination outcomes. Educated Muslim mothers reduce BCG, DPT, polio, and measles vaccination of their children by 7.3 pp, 8.7 pp, 6.7 pp, and 9.1 pp respectively, an approximately 17%, 21%, 14%, and 29% reduction in vaccination relative to the pre-disclosure Muslim mother sample means. There is no significant effect of the 2000 WP disclosure on the vaccination outcomes of non-educated Muslim mothers as shown in column (3) of Table 1.

Following the literature on minority group cleavage to own social networks where, for example, religious individuals may cleave more strongly to religious networks in areas where they are the minority and far from neighboring family ties, described in the Introduction, we hypothesize that the effects of the 2000 Pfizer drug trial disclosure may be stronger for Muslim mothers residing in Muslim minority neighborhoods than those in majority Muslim neighborhoods. These individuals may be relatively less trusting of their out-group neighbors

and consequently adhere more strongly to religious networks and hence would be more exposed to anti-vaccine messaging from religious leaders. Using DHS averages on the share of Muslim mothers in each district over the entire 1990-2013 survey, we divide the sample into Muslim minority districts or neighborhoods where Muslims make up less than or equal to 50% of the neighborhood and Muslim majority districts where Muslims make up over 50% of the neighborhood. The majority Muslim sample has more observations than the minority Muslim sample. The results are shown in columns (4) and (5) of Table 1 for the Muslim minority and Muslim majority neighborhood samples respectively.

The effects of the 2000 WP disclosure of the Pfizer drug trials on child vaccination outcomes of Muslim mothers are significantly distinct for Muslim mothers residing in minority Muslim neighborhoods from majority Muslim neighborhoods at, at least, the 5% level. Across all child vaccination outcomes, Muslim mothers in minority Muslim neighborhoods significantly decrease their vaccination outcomes for children born after the 2000 disclosure by between 6.3 pp (BCG) to 99 pp (DPT); the point estimate for the effect of the disclosure on child vaccination outcomes for Muslim mothers in majority Muslim neighborhoods is essentially 0 as shown in column (5) of Table 1.

4.3 Effects on Health Seeking Behavior and Other Child Health Outcomes

To evaluate whether the 2000 WP revelation of the Pfizer drug trials affected health behavior and parent's investments in children's health more generally or just child vaccination behavior of Muslim mothers, we estimate Equation 1 with mother's pre-natal care source (own health-seeking behavior) and other child health outcomes (stunting and underweight). The results are shown in Table 2. There is no change in Muslim mother's use of nurses/midwives (nurses) or traditional birth attendants post 2000 as shown in Panel A. The only difference is a significant decrease (-5.7 pp) in the use of doctors for pre-natal care in column (1) of Panel A, driven entirely by reductions among non-educated mothers as shown in column

(3). The decrease in the use of doctors among poorer, non-educated mothers is in line with previous literature highlighting an exodus of doctors from poorer regions in the Muslim north to richer regions in the less Muslim south or out of the country(Doctor et al., 2012). Table A10 in the appendix shows this decrease in the share of doctors in health personnel in majority Muslim areas in the post-2000 period.

Panel B of Table 2 shows no changes in underweight or infant mortality outcomes for children born to Muslim mothers post the 2000 WP disclosure in columns (4) and (7). If anything, children born to Muslim mothers post 2000 are healthier, as measured by the lowered stunting outcomes in column (1), with outcomes driven entirely by reductions in child stunting among children born to non-educated, Muslim mothers in column (3).

4.4 Cost Estimates

Being unvaccinated increases an individual's risk of infection from the disease (Yahya, 2006). The costs of treatment of these illnesses can be significant and incur large financial burdens on households (Archibong and Annan, 2017). The objective of this section is to conduct simple back of the envelope calculations on the potential costs of treatment from an increased number of unvaccinated Muslim children as a result of negative news about the Pfizer drug trials. We assemble data on direct medical costs of treatment of the four diseases in Nigeria from the scientific literature, and calculate lower bound estimates of the costs of treatment if 20% of unvaccinated Muslim children born each year from 2001 to 2013 had fallen ill. We compare these cost figures to the counterfactual scenario if the Pfizer trials disclosure had not occurred, using the regression estimates from Section 4.1. The results are shown in Figure A8 and Figure A9, along with a detailed description of the methodology in Appendix A.5. Using our most conservative estimates of direct medical costs only, and without factoring in any potential deaths from disease, the reduced vaccination of Muslim children in the aftermath of the Pfizer drug trials incurred a total potential cost of treatment of $94,128,449 over the

counterfactual scenario. This cost is over $19 million higher than the Pfizer settlement to the Nigerian government of $75 million.

5 Mechanisms

The results presented in Section 4, along with the historical context presented in Section 2 are consistent with the hypothesis that the reduction in vaccination outcomes among Muslim mothers post the 2000 WP revelation of the Pfizer drug trials was driven by decreased demand from Muslim mothers with more information and relatively stronger ties to religious networks. These mothers were more educated and more likely to reside in minority Muslim neighborhoods, farther away from family networks and with relatively lower trust in neighbors, and hence more likely to exhibit stronger cleavage to religious networks.

To test the hypothesis on the role of stronger ties to religious networks among Muslims in explaining the results, we assemble Afrobarometer data on religious identity of respondents and reported religiosity and trust in religious leaders, neighbors and state officials. The Afrobarometer data only includes this data post 2000, with four rounds of surveys from 2003 to 2014, so we conduct a cohort study to examine the effects of Muslim religious identity on religiosity and trust attitudes for individuals who would have been adults, and hence more cognizant of the news disclosure in 2000.

In the cohort study analysis, we investigate whether there is a Muslim-Non-Muslim religious gap in trust and religiosity outcomes for individuals a born in year r residing in district d and state s at survey year t and estimate equations of the following form, limiting the sample to adults, aged 18 or older, as of the time of the WP news disclosure in 2000:

$$\text{Trust}_{ardst} = \eta \text{Muslim}_{ardst} + X'_{ardst}\theta + \mu_d + \delta_t + \delta_r + \phi_{st} + \epsilon_{ardst} \tag{2}$$

where Trust_{ardst} is the trust or religiosity outcome of interest and $Muslim$ is an indicator that equals one if the respondent indicates that she is Muslim. We include vectors of individual level covariates X'_{adt}, including controls for the gender and educational level of the respondent[11]. All regressions include year of birth (δ_r), survey year ($\delta_r t$), district (μ_d) and state by year (ϕ_{st}) fixed effects with standard errors are clustered at the district level, following the specification in Equation 1.

Our key parameter of interest, η, captures the effect of being a Muslim relative to non-Muslims on religiosity and trust outcomes for respondents who were adults as of the time of the 2000 WP news disclosure of the Pfizer drug trials. The religious outcomes we focus on are reported religiosity, or how often the respondent reports attending religious services and the respondent's perception of how many religious leaders are engaged in corruption, a "revealed preference" measure of trust[12]. We also examine respondents' reported levels of trust in neighbors, relatives and perceptions of corruption of police and elected local governing council members; these outcomes have been shown in previous research to be results of long-term historical processes like the slave trade (Nunn and Wantchekon, 2011) and colonial prison labor (Archibong and Obikili, 2020).

To test that there were no effects of the 2000 disclosure on religiosity and trust outcomes of Muslims, we examine differences in attitudes for adult Muslim cohorts in 2000 versus non-adult cohorts at the time of the disclosure. We estimate equations of the following form:

$$\text{Trust}_{ardst} = \gamma \underbrace{\text{Post 2000 Adult}_r \times \text{Muslim}_{ardst}}_{} + \beta \text{Muslim}_{ardst} + X'_{ardst}\theta + \mu_d + \delta_t + \delta_r + \phi_{st} + \epsilon_{ardst} \tag{3}$$

[11]Data is described in detail in Appendix.

[12]There is a significant negative correlation between reported trust in religious leaders and the corruption perception measure, with the correlation equal to -0.28 ($p < 0.001$). The results are similar using the trust and corruption perception measures.

where Post 2000 Adult$_r$ is a binary indicator for adults as of the time of the 2000 WP news disclosure and all other variables are as in Equation 2. If there are no differences in adult-non-adult/child cohort as of 2000 disclosure religiosity and trust attitudes, then γ will be insignificant in Equation 3.

In Panel A of Table 3, columns (1), (2) and (3) report results on religiosity, corruption perceptions of religious leaders, and trust in neighbors outcomes respectively for the adult cohort in 2000 (Equation 2); columns (4) to (6) shows cohort differences as described in Equation 3. Adult Muslims as of the time of the 2000 disclosure report higher levels of religiosity than non-Muslims, an effect size of 4% relative to the sample mean. The effect is stronger for adult cohorts in 2000 who would have been more cognizant of the Pfizer news and anti-vaccine messaging from religious leaders as shown by the significant interaction term in column (4). Adult Muslims as of the 2000 disclosure are 13% less likely to report their religious leaders are corrupt as shown in column (2) of Table 3, with no significant differences between adult and child cohorts in column (5). Adult Muslims as of the 2000 disclosure also report higher trust in neighbors (11%) than their non-Muslim counterparts in column (3), with no significant differences by cohort in column (6).

We examine heterogeneous effects by the neighborhood religious composition, splitting the adult cohort in 2000 sample by residence into Muslim minority and Muslim majority neighborhoods. The results in Panel B show that adult Muslim respondents as of the time of the WP disclosure in 2000 living in Muslim minority neighborhoods are significantly more religious than their non-Muslim counterparts, an increase of 6% relative to the sample mean as shown in column (1). They are also 16% less likely to report beliefs that their religious leaders are corrupt as shown in column (2). There is no significant effect of Muslim identity on trust in neighbors for respondents in minority Muslim neighborhoods as shown in column (3) and Panel B of Table 3. In contrast, adult Muslim respondents as of the time of the 2000

WP disclosure residing in majority Muslim neighborhoods report no significant differential behavior for religiosity (column (4)) or perceptions of corruption of their religious leaders (column (5)).

The higher trust in neighbors results for Muslims reported in Panel A is almost entirely driven by Muslims residing in majority Muslim neighborhoods as shown in column (6) of Panel B. The results are summarized in Figure A5 and robust to changes in the majority-minority Muslim neighborhood cutoffs as shown in Table A6 in the Appendix[13]. There is no significant difference between Muslim and non-Muslim corruption perceptions of police and elected local governing councils and trust in relatives for adults at the time of the 2000 WP disclosure as shown in columns (1), (2), (3) of Panel C. The evidence of higher religiosity and trust in religious leaders among Muslim respondents supports the hypothesis that the reduction in vaccination outcomes for children born to Muslim mothers post the disclosure was linked to information spread among Muslim mothers with stronger religious networks.

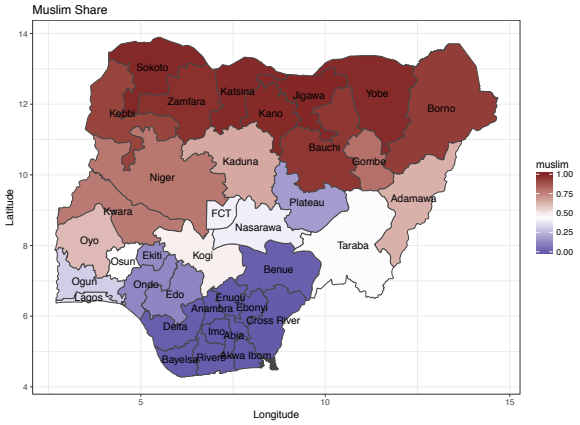
6 Conclusion

The 1996 Pfizer epidemic drug trials remain a point of tension and source of vaccine hesitancy for Muslims in Nigeria, over a decade over the initial news disclosure in 2000, with the specter of the trials evoked with every new mass vaccination campaign (Yahya, 2006). Our results show significant reductions in routine vaccination of children born to Muslim mothers after the disclosure of the trials in 2000. The effects are driven by educated mothers and mothers living in Muslim minority neighborhoods with relatively lower trust/weaker ties to their neighborhoods/local communities and relatively stronger ties to religious networks. The reduction effect is specific to child vaccination outcomes with generally no reductions in

[13]We provide suggestive evidence that the long-term effects of the WP disclosure on child vaccination outcomes are stronger for children born to Muslim mothers living in neighborhoods with higher religiosity and trust in religious leaders in Table A8.

Muslim mother's pre-natal care behavior and other child health outcomes.

These findings highlight the importance of both careful, ethical and transparent practices in vaccination efforts, and institutional and local community network trust in vaccine compliance. The negative externalities from reduced vaccination have global consequences for the resurgence of epidemics of infectious diseases that can persist for years after the initial event and disclosure.



	Muslim Mothers			Non-Muslim Mothers		
Variable	N	Mean	St. Dev.	N	Mean	St. Dev.
Age at first marriage	135,004	15.572	3.478	101,429	18.703	4.548
Educated	135,116	0.232	0.422	103,251	0.783	0.412
Level of education	135,116	0.343	0.693	103,251	1.286	0.900
BCG child vaccination	37,362	0.326	0.469	28,881	0.732	0.443
DPT child vaccination	37,126	0.318	0.466	28,626	0.706	0.456
Polio child vaccination	36,705	0.578	0.494	28,646	0.774	0.418
Measles child vaccination	37,164	0.256	0.436	28,701	0.538	0.499
Doctor pre-natal care	27,481	0.166	0.372	21,748	0.368	0.482
Nurse/Midwife pre-natal care	27,481	0.349	0.477	21,750	0.568	0.495
Traditional pre-natal care	27,481	0.015	0.121	21,751	0.042	0.201
Stunted	28,989	0.444	0.497	24,054	0.252	0.434
Underweight	28,989	0.395	0.489	24,054	0.191	0.393

Figure 1: Muslim population shares by state with Kano drug trial state labelled (top) and summary statistics by Muslim mother status in DHS sample for children born between 1985-2013 (bottom)

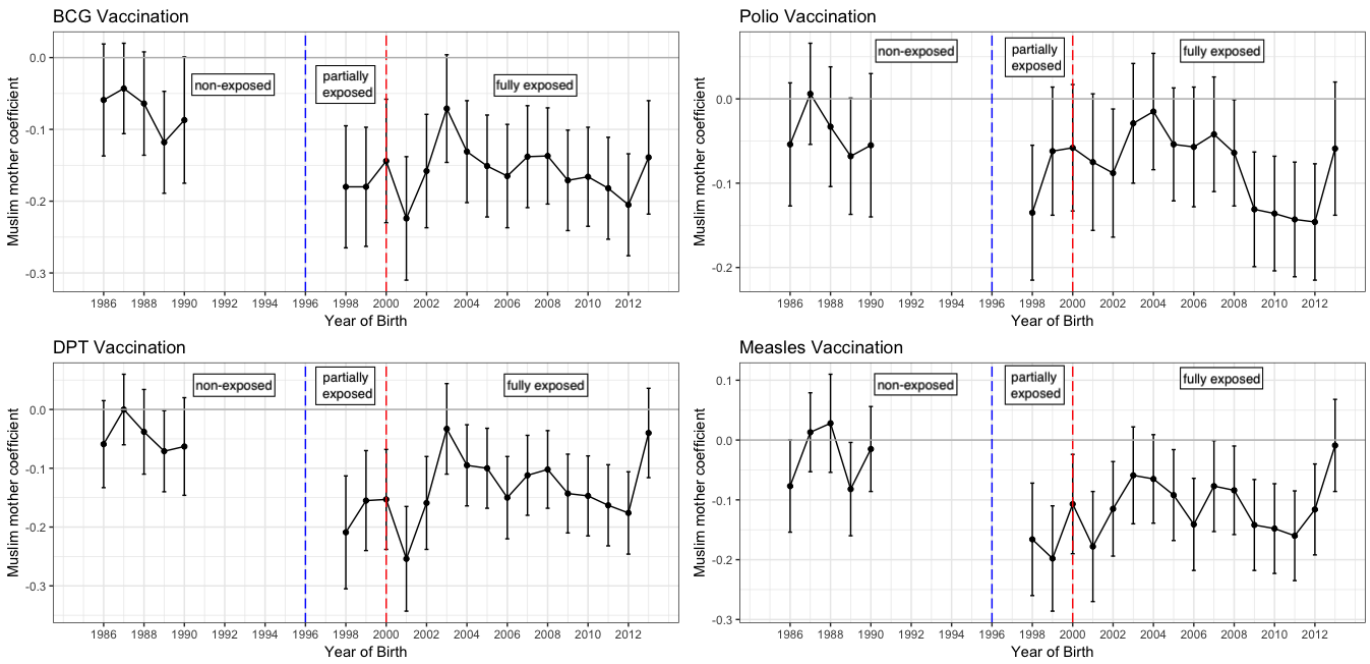


Figure 2: Event study coefficients (with error bars shown) of the effect of Muslim mother status on child vaccination outcomes by child's year of birth. Pfizer drug trial year (1996) and WP news disclosure year (2000) highlighted. (Note: Missing data between 1991-1997).

Table 1: Effects of 2000 Pfizer trial announcement on child vaccination outcomes

	Panel A: Child Vaccination Outcomes: BCG				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.091***	−0.073***	−0.068	−0.070**	−0.059
	(0.025)	(0.027)	(0.044)	(0.032)	(0.043)
Mean of outcome	0.503	0.745	0.246	0.748	0.311
Observations	63,876	32,724	31,152	27,861	36,015
Clusters	710	687	619	380	330
	Panel B: Child Vaccination Outcomes: DPT				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.089***	−0.087***	−0.058	−0.099***	−0.025
	(0.025)	(0.029)	(0.044)	(0.031)	(0.047)
Mean of outcome	0.488	0.716	0.248	0.722	0.307
Observations	63,410	32,479	30,931	27,604	35,806
Clusters	710	687	619	380	330
	Panel C: Child Vaccination Outcomes: Polio				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.051**	−0.067**	−0.025	−0.063**	−0.013
	(0.024)	(0.027)	(0.044)	(0.030)	(0.045)
Mean of outcome	0.660	0.790	0.524	0.778	0.568
Observations	62,995	32,418	30,557	27,626	35,369
Clusters	710	687	619	380	330
	Panel D: Child Vaccination Outcomes: Measles				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.086***	−0.091***	−0.054	−0.098***	−0.042
	(0.022)	(0.030)	(0.034)	(0.029)	(0.042)
Mean of outcome	0.376	0.544	0.199	0.542	0.247
Observations	63,528	32,512	31,016	27,696	35,832
Clusters	710	687	620	380	330
Mother's controls	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs) in Nigeria. Dependent variables are child vaccination outcomes for tuberculosis (BCG), diphtheria, pertussis and tetanus (DPT) and polio and measles as described in text. Sample is split between respondents living in districts that are over 50% muslim or Muslim Majority and respondents living in districts with <= 50% muslims or Muslim Minority districts in labeled columns. Post 2000 is an indicator that equals 1 if the child's year of birth is after the 2000 drug trial announcement. Muslim is an indicator that equals one if the mother reports that she is Muslim. Mother's controls include mother's age at birth and level of education, and drops education in non-educated (Education=0) subsamples. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table 2: Effects of 2000 Pfizer trial announcement on mother's health-seeking behavior (pre-natal care) and other child health outcomes

	Panel A: Mother's Pre-Natal Care: Doctor, Nurse/Midwife, Traditional								
Outcome:	**Doctor**			**Nurse**			**Traditional**		
Sample Within:	All	Educated	Non-Educated	All	Educated	Non-Educated	All	Educated	Non-Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post 2000 x Muslim	−0.057**	−0.033	−0.116***	−0.005	0.032	0.022	−0.011	−0.016	−0.005
	(0.025)	(0.026)	(0.043)	(0.035)	(0.047)	(0.044)	(0.010)	(0.016)	(0.015)
Mean of outcome	0.255	0.394	0.113	0.444	0.614	0.268	0.027	0.034	0.019
Observations	48,300	24,561	23,739	48,302	24,563	23,739	48,303	24,564	23,379
Clusters	710	688	624	710	688	624	710	688	624
	Panel B: Child Health Outcomes: Stunting, Underweight and Infant Mortality								
Outcome:	**Stunted**			**Underweight**			**Mortality**		
Sample Within:	All	Educated	Non-Educated	All	Educated	Non-Educated	All	Educated	Non-Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post 2000 x Muslim	−0.050**	−0.047	−0.084**	−0.030	−0.030	−0.050	−0.018	−0.033	−0.008
	(0.023)	(0.032)	(0.038)	(0.023)	(0.028)	(0.042)	(0.025)	(0.036)	(0.037)
Mean of outcome	0.355	0.257	0.467	0.304	0.207	0.414	0.412	0.477	0.380
Observations	51,101	27,304	23,797	51,101	27,304	23,797	31,695	10,680	21,015
Clusters	710	683	616	710	683	616	705	661	588
Mother's controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs) in Nigeria. Dependent variables are mother's reported pre-natal care source: doctors, nurses/midwives or traditional healers, in Panel A; In Panel B, dependent variables are current child health outcomes for stunting and underweight in columns (1) to (6). A child is considered underweight by WHO standards if they have a weight for age z-score (WFA z) of less than -2.0 while a child is considered stunted with a height for age z-score (HFA z) of less than -2.0. Infant mortality is the outcome in columns (7) to (9) of Panel B. Post 2000 is an indicator that equals 1 if the child's year of birth is after the 2000 drug trial announcement. Muslim is an indicator that equals one if the mother reports that she is Muslim. Mother's controls include mother's age at birth and level of education in columns (1), (2), (4), (5), (7) and (8) and drops education in non-educated subsamples. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table 3: Religiosity and trust among Muslims by post 2000 adult cohort status

	Panel A: Muslim respondents, religiosity and trust in neighbor outcomes					
Outcome:	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**
Sample Within:	Adult (>= 18 years) Cohort in 2000			All Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	0.166**	−0.140**	0.157**	0.047	−0.152**	0.184***
	(0.072)	(0.057)	(0.064)	(0.082)	(0.061)	(0.062)
Post 2000 Adult x Muslim				0.156**	0.050	−0.038
				(0.076)	(0.058)	(0.060)
Mean of outcome	3.996	1.076	1.414	4.069	1.101	1.364
Observations	4,516	2,750	2,904	6,882	4,481	4,643
Clusters	374	290	325	381	299	326
	Panel B: Muslim respondents and trust outcomes by minority (<= 50%) and majority (> 50%) status					
Outcome:	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**
Sample Within:	Muslim Minority (Adult Cohort in 2000)			Muslim Majority (Adult Cohort in 2000)		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	0.229**	−0.185**	0.078	0.031	−0.072	0.202**
	(0.091)	(0.082)	(0.095)	(0.134)	(0.083)	(0.099)
Mean of outcome	4.012	1.165	1.196	3.931	0.942	1.740
Observations	2,663	1,636	1,645	1,651	977	1,112
Clusters	209	163	172	141	109	130
	Panel C: Muslim respondents and other trust outcomes					
Outcome:	**Corrupt Police**	**Corrupt Local Gov.**	**Trust Relatives**	**Corrupt Police**	**Corrupt Local Gov.**	**Trust Relatives**
Sample Within:	Adult (>= 18 years) Cohort in 2000			All Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	−0.005	0.006	0.111	−0.053	−0.042	0.182***
	(0.044)	(0.041)	(0.073)	(0.044)	(0.042)	(0.066)
Post 2000 Adult x Muslim				0.060	0.049	−0.054
				(0.037)	(0.041)	(0.061)
Mean of outcome	2.071	1.755	1.979	2.083	1.760	1.967
Observations	5,805	5,727	2,581	9,022	8,887	4,564
Clusters	481	481	358	484	484	360
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs). Dependent variables are religiosity, trust in religious leaders and trust in neighbors from the Afrobarometer surveys from 2003-2014 where data available. Trust outcomes are reported trust levels on a scale of 0-3, where "Not at all"= "0", "Just a little"="1", "Somewhat"="2", "A lot"="3"; Religiosity is reported frequency of religious service attendance, excluding weddings and funerals, where "Never"="0", "About once a year or less"="1", "About once every several months"="2", "About once a month"="3", "About once a week"="4", "More than once a week"="5". Corruption outcomes are respondents' beliefs about how many people are involved in corruption where "None"="0", "Some of them"="1", "Most of them"="2", "All of them"="3". Individual controls include respondent level of education and gender or an indicator that equals one if the respondent is female. Muslim is an indicator that equals one if the respondent is Muslim; Post 2000 Adult is an indicator that equals one if the respondent was an adult, aged >= 18 years, in 2000. State x Year FE are included in all specifications except for Corrupt Religious outcomes, which have only one year of data available. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

References

Ahmad, Khabir. 2001. "Drug company sued over research trial in Nigeria." *The Lancet* 358 (9284): 815.

Alsan, Marcella, and Marianne Wanamaker. 2018. "Tuskegee and the health of black men." *Quarterly Journal of Economics* 133 (1): 407–455.

Anderberg, Dan, Arnaud Chevalier, and Jonathan Wadsworth. 2011. "Anatomy of a health scare: education, income and the MMR controversy in the UK." *Journal of Health Economics* 30 (3): 515–530.

Archibong, Belinda. 2019. "Explaining divergence in the long-term effects of precolonial centralization on access to public infrastructure services in Nigeria." *World Development* 121: 123–140.

Archibong, Belinda, and Francis Annan. 2017. "Disease and Gender Gaps in Human Capital Investment: Evidence from Niger's 1986 Meningitis Epidemic." *American Economic Review* 107 (5): 530–35.

Archibong, Belinda, and Nonso Obikili. 2020. "Prison labor: The price of prisons and the lasting effects of incarceration." *African Economic History Working Paper Series* (52).

Auriol, Emmanuelle, Julie Lassebie, Amma Panin, Eva Raiber, and Paul Seabright. 2020. "God insures those who pay? Formal insurance and religious offerings in Ghana." *Quarterly Journal of Economics* .

Chang, Lenisa V. 2018. "Information, education, and health behaviors: Evidence from the MMR vaccine autism controversy." *Health Economics* 27 (7): 1043–1062.

Chen, Xingru, and Feng Fu. 2019. "Imperfect vaccine and hysteresis." *Proceedings of the royal society B* 286 (1894): 20182406.

Cutler, David M, and Adriana Lleras-Muney. 2010. "Understanding differences in health behaviors by education." *Journal of Health Economics* 29 (1): 1–28.

Doctor, Henry V, Sally E Findley, Alastair Ager, Giorgio Cometto, Godwin Y Afenyadu, Fatima Adamu, and Cathy Green. 2012. "Using community-based research to shape the design and delivery of maternal health services in Northern Nigeria." *Reproductive Health Matters* 20 (39): 104–112.

Ellison, Christopher G, and Darren E Sherkat. 1995. "The "semi-involuntary institution" revisited: Regional variations in church participation among black Americans." *Social Forces* 73 (4): 1415–1437.

Ezeome, Emmanuel R, and Christian Simon. 2010. "Ethical problems in conducting research in acute epidemics: the Pfizer meningitis study in Nigeria as an illustration." *Developing World Bioethics* 10 (1): 1–10.

Frishman, Alan. 2009. "Major reason for Nigerian boycott of polio vaccine." *Health Affairs* 28 (6): 1860–1861.

Ghinai, Isaac, Chris Willott, Ibrahim Dadari, and Heidi J Larson. 2013. "Listening to the rumours: What the northern Nigeria polio vaccine boycott can tell us ten years on." *Global Public Health* 8 (10): 1138–1150.

Iannaccone, Laurence R. 1998. "Introduction to the Economics of Religion." *Journal of Economic Literature* 36 (3): 1465–1495.

Iyer, Sriya. 2016. "The new economics of religion." *Journal of Economic Literature* 54 (2): 395–441.

Jegede, Ayodele Samuel. 2007. "What led to the Nigerian boycott of the polio vaccination campaign?" *PLoS Med* 4 (3): e73.

Kenkel, Donald S. 1991. "Health Behavior, Health Knowledge, and Schooling." *Journal of Political Economy* pp. 287–305.

Khemani, Stuti. 2006. "Local government accountability for health service delivery in Nigeria." *Journal of African Economies* 15 (2): 285–312.

Larreguy, Horacio, and John Marshall. 2017. "The effect of education on civic and political engagement in nonconsolidated democracies: Evidence from Nigeria." *Review of Economics and Statistics* 99 (3): 387–401.

Lenzer, Jeanne. 2006. "Secret report surfaces showing that Pfizer was at fault in Nigerian drug tests." *British Medical Journal* 332 (7552): 1233.

Levy-Storms, Lene, and Steven P Wallace. 2003. "Use of mammography screening among older Samoan women in Los Angeles county: a diffusion network approach." *Social Science & Medicine* 57 (6): 987–1000.

Lowes, Sara Rachel, and Eduardo Montero. 2020. "The legacy of colonial medicine in Central Africa." *CEPR Discussion Paper No. DP12772, Conditionally accepted at American Economic Review* .

Makinde, Olusesan Ayodeji, Abayomi Sule, Olayinka Ayankogbe, and David Boone. 2018. "Distribution of health facilities in Nigeria: implications and options for universal health coverage." *The International journal of health planning and management* 33 (4): e1179–e1192.

Martinez-Bravo, Monica, and Andreas Stegmann. 2021. "In Vaccines We Trust? The Ef-

fects of the CIA's Vaccine Ruse on Immunization in Pakistan." *Journal of the European Economic Association* .

Masquelier, Adeline, H Dilger, A Kane, and S Langwick. 2012. "Public health or public threat? Polio eradication campaigns, Islamic revival, and the materialization of state power in Niger." *Medicine, Mobility, and Power in Global Africa* pp. 213–40.

Mohammed, Idris, Abdussalam Nasidi, AS Alkali, MA Garbati, EK Ajayi-Obe, Kudi A Audu, Abdulmumini Usman, and Suleiman Abdullahi. 2000. "A severe epidemic of meningococcal meningitis in Nigeria, 1996." *Transactions of the Royal Society of Tropical Medicine and Hygiene* 94 (3): 265–270.

Nasiru, Sani-Gwarzo, Gambo G Aliyu, Alex Gasasira, Muktar H Aliyu, Mahmud Zubair, Sunusi U Mandawari, Hassana Waziri, Abdulsalami Nasidi, and Samer S El-Kamary. 2012. "Breaking community barriers to polio vaccination in Northern Nigeria: the impact of a grass roots mobilization campaign (Majigi)." *Pathogens and Global Health* 106 (3): 166–171.

Nunn, Nathan, and Leonard Wantchekon. 2011. "The slave trade and the origins of mistrust in Africa." *American Economic Review* 101 (7): 3221–52.

Organization, World Health. 2019. "WHO recommendations for routine immunizations summary tables.".

Perlroth, Nicole. 2008. "Pfizer's Nigerian Nightmare." *Forbes* .

Qian, Mengcen, Shin-Yi Chou, and Ernest K Lai. 2020. "Confirmatory bias in health decisions: Evidence from the MMR-autism controversy." *Journal of health economics* 70: 102284.

Stephens, Joe. 2000. "Where profits and lives hang in balance." *The Washington Post* .

Stephens, Joe. 2006. "Panel faults Pfizer in'96 clinical trial in Nigeria." *The Washington Post* pp. A1–A21.

Wise, Jacqui. 2001. "Pfizer accused of testing new drug without ethical approval." *British Medical Journal* .

Yahya, Maryam. 2006. "Polio vaccines: difficult to swallow: the story of a controversy in northern Nigeria." *Institute of Development Studies Working Paper 261* .

Yahya, Maryam. 2007. "Polio vaccines "no thank you!" Barriers to polio eradication in Northern Nigeria." *African Affairs* 106 (423): 185–204.

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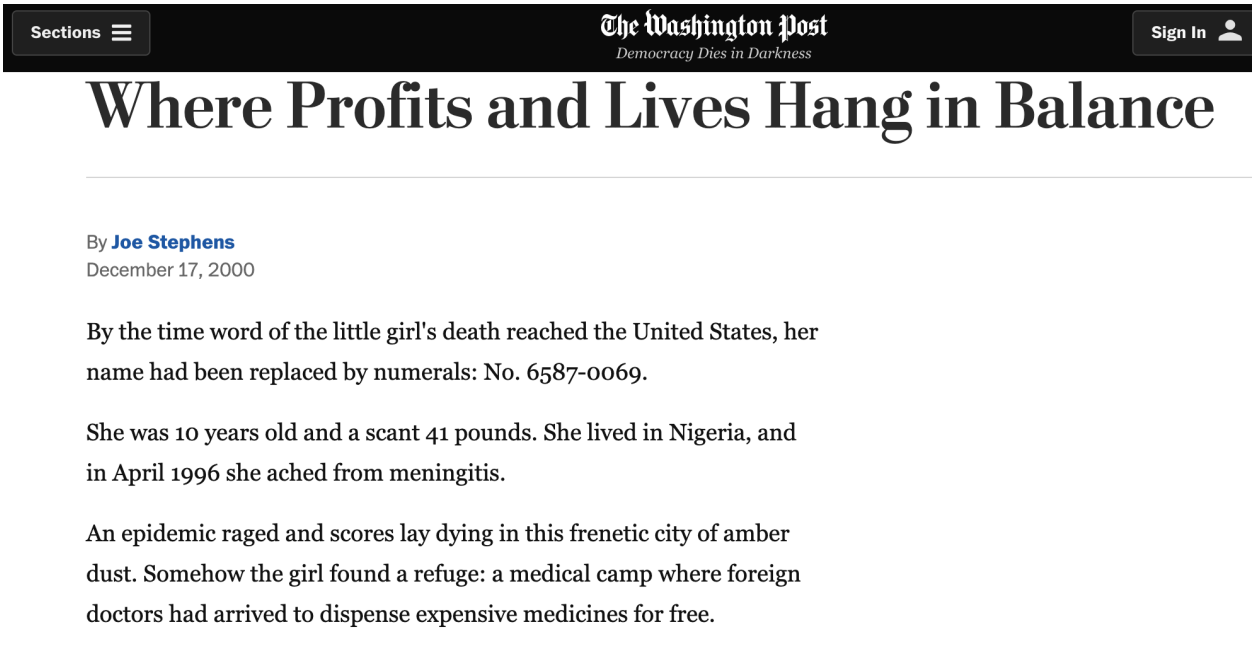
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A.1 2000 WP Disclosure and Ex-Post Government Report



Sections

The Washington Post
Democracy Dies in Darkness

Sign In

Where Profits and Lives Hang in Balance

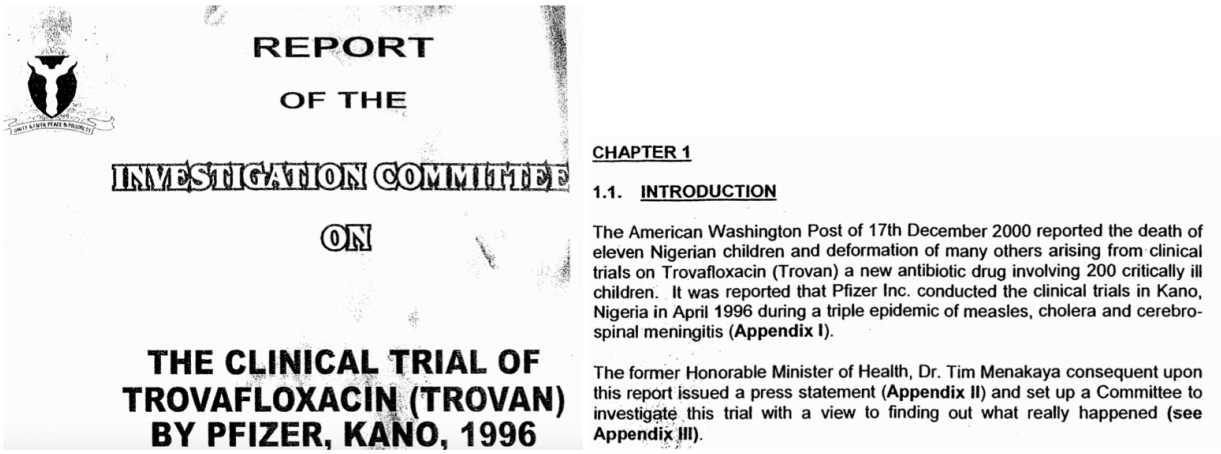
By **Joe Stephens**
December 17, 2000

By the time word of the little girl's death reached the United States, her name had been replaced by numerals: No. 6587-0069.

She was 10 years old and a scant 41 pounds. She lived in Nigeria, and in April 1996 she ached from meningitis.

An epidemic raged and scores lay dying in this frenetic city of amber dust. Somehow the girl found a refuge: a medical camp where foreign doctors had arrived to dispense expensive medicines for free.

Figure A1: The Washington Post Revelation



REPORT
OF THE
INVESTIGATION COMMITTEE
ON
THE CLINICAL TRIAL OF TROVAFLOXACIN (TROVAN) BY PFIZER, KANO, 1996

CHAPTER 1

1.1. INTRODUCTION

The American Washington Post of 17th December 2000 reported the death of eleven Nigerian children and deformation of many others arising from clinical trials on Trovafloxacin (Trovan) a new antibiotic drug involving 200 critically ill children. It was reported that Pfizer Inc. conducted the clinical trials in Kano, Nigeria in April 1996 during a triple epidemic of measles, cholera and cerebro-spinal meningitis (**Appendix I**).

The former Honorable Minister of Health, Dr. Tim Menakaya consequent upon this report issued a press statement (**Appendix II**) and set up a Committee to investigate this trial with a view to finding out what really happened (**see Appendix III**).

Figure A2: Government Report highlighting Pfizer misconduct and role of Washington Post news

A.2 Data Appendix

A.2.1 Data and Variable Descriptions

- Demographic and Health Survey (DHS) Birth Recode (BR) data from 1990-2013 for 1985-2013 birth years. Including child vaccination outcomes for tuberculosis (BCG), diphtheria, pertussis and tetanus (DPT), measles and polio. Child health outcomes for stunting and underweight. Mother's health seeking behavior or reported pre-natal care source.

- Annual Abstract of Statistics for cases of infectious disease by state from 1985-1995. Health personnel statistics by state in 1991. Health statistics from 2012 from Nigeria Millennium Development Goals (MDG) Information System survey dataset: https://qsel.columbia.edu
up-initiative/

- Afrobarometer data from 2003-2014 surveys. Trust outcomes are reported trust levels on a scale of 0-3, where "Not at all"= "0", "Just a little"="1", "Somewhat"="2", "A lot"="3"; Religiosity is reported frequency of religious service attendance, excluding weddings and funerals, where "Never"="0", "About once a year or less"="1", "About once every several months"="2", "About once a month"="3", "About once a week"="4", "More than once a week"="5". Corruption outcomes are respondents' beliefs about how many people are involved in corruption where "None"="0", "Some of them"="1", "Most of them"="2", "All of them"="3".

Table A1: Summary Statistics, DHS

	Pre-2000 Births				Post-2000 Births			
Variable	Mean (Non-Muslim)	Mean (Muslim)	t-stat	p-val	Mean (Non-Muslim)	Mean (Muslim)	t-stat	p-val
BCG child vaccination	0.685	0.433	24.997	0	0.739	0.308	111.960	0
DPT child vaccination	0.659	0.413	23.951	0	0.714	0.304	105.250	0
Polio child vaccination	0.684	0.473	20.482	0	0.787	0.591	49.962	0
Measles child vaccination	0.509	0.315	19.148	0	0.542	0.245	75.340	0
Doctor pre-natal care	0.458	0.312	13.643	0	0.349	0.139	51.446	0
Nurse/Midwife pre-natal care	0.565	0.308	24.279	0	0.568	0.356	43.350	0
Traditional pre-natal care	0.048	0.029	4.509	0	0.040	0.012	18.412	0
Stunted	0.330	0.483	−12.714	0	0.238	0.437	−45.240	0
Underweight	0.251	0.390	−12.173	0	0.181	0.396	−51.245	0

Notes: DHS data from BR dataset includes outcomes for birth years from 1985-2013 and survey years from 1990-2013.

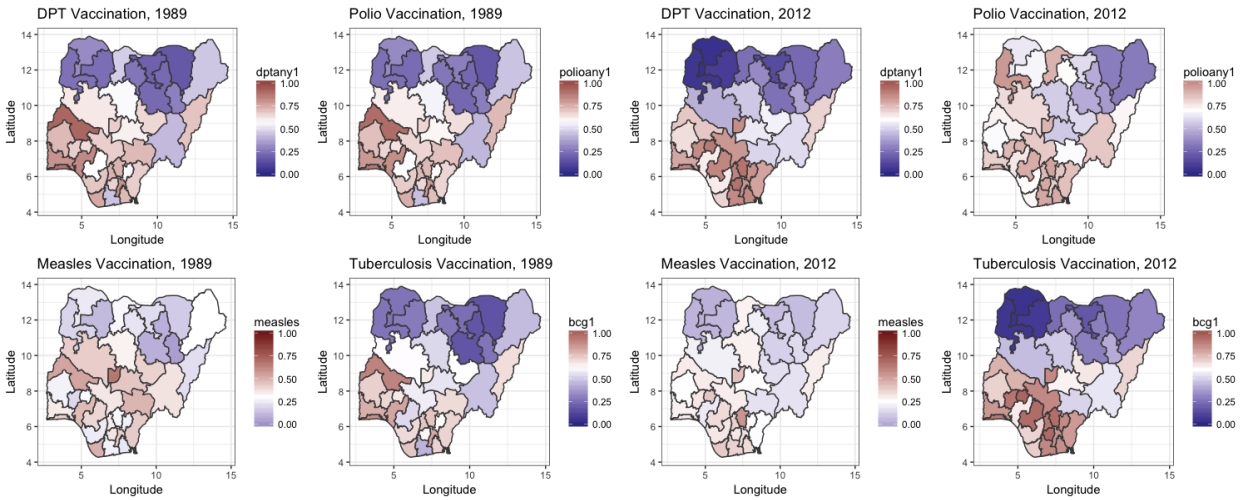


Figure A3: Share of children born in 1989 and 2012 with vaccinations recorded in Nigeria by state. Source: DHS

Table A2: Reduced form relationship between prior year, t-1, child vaccination coverage and disease incidence in year t (Panel A) and between Muslim mother status and child vaccination outcomes (Panel B) pre 2000

	Panel A: Vaccination Coverage and Disease Incidence, 1985-1990			
Outcome:	**BCG Cases, t**		**Measles Cases, t**	
Vaccination rate, t-1:	(BCG 90%)	(BCG 50%)	(Measles 90%)	(Measles 50%)
	(1)	(2)	(3)	(4)
Vaccination rate, t-1 (%)	−16.796***	5.815	−93.484**	17.374
	(6.277)	(11.125)	(46.704)	(23.994)
Mean of outcome	35.100	35.100	176.700	176.700
Observations	192	192	192	193
Clusters	35	35	35	35
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
	Panel B: Muslim Mothers and Child Vaccination Outcomes, 1985-1999			
Outcome:	**BCG**	**DPT**	**Polio**	**Measles**
	(1)	(2)	(3)	(4)
Muslim	0.020	0.024	0.028	0.018
	(0.020)	(0.020)	(0.020)	(0.021)
Mean of outcome	0.550	0.527	0.571	0.405
Observations	9,167	8,863	8,872	9,095
Clusters	375	374	375	373
Mother's controls	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes

Notes: OLS regressions. In Panel A, observations are individual states from 1985-1990 years of available data and robust standard errors in parentheses are clustered by state. In Panel A, dependent variables are cases per 100,000 population of tuberculosis (BCG) and measles in year t. Each column denotes a separate regression. Vaccination rate, t-1 is an indicator that equals one if the share of children born in a given year, t-1, and vaccinated in the state for BCG or measles is above x% in the previous year t-1, where the percentage is donated in the parentheses. In Panel B, observations are individual mother responses from 1985-1999, and robust standard errors in parentheses are clustered by district. Districts are local government areas (LGAs) in Nigeria. Dependent variables are child vaccination outcomes for tuberculosis (BCG), diphtheria, pertussis and tetanus (DPT) and polio and measles as described in text. Mother's controls include mother's age at birth and level of education. Muslim is an indicator that equals one if the mother reports that she is Muslim. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table A3: Summary Statistics including Afrobarometer outcomes

Variable	Mean (Non-Muslim)	Mean (Muslim)	t-stat	p-val
DHS Survey Outcomes, 1985-2013				
Age at first marriage	18.70	15.57	189.68	0
Educated	0.78	0.23	319.08	0
Level of Education	1.29	0.34	289.01	0
BCG child vaccination	0.73	0.33	113.21	0
DPT child vaccination	0.71	0.32	106.84	0
Polio child vaccination	0.77	0.58	53.76	0
Measles child vaccination	0.54	0.26	77.40	0
Doctor pre-natal care	0.37	0.17	55.56	0
Nurse/Midwife pre-natal care	0.57	0.35	49.89	0
Traditional pre-natal care	0.04	0.01	18.56	0
Stunted	0.25	0.44	−46.79	0
Underweight	0.19	0.40	−52.35	0
Afrobarometer Trust and Religiosity Outcomes, 2003-2014				
Religiosity	4.059	4.086	−0.803	0.422
Trust Neighbors	1.143	1.679	−18.816	0
Trust Relatives	1.791	2.219	−14.223	0
Trust Religious	1.702	1.913	−4.905	0
Trust Police	0.596	0.838	−14.842	0
Trust Local Gov.	0.805	1.129	−17.596	0
Corrupt Religious	1.201	0.943	10.357	0
Corrupt Police	2.130	2.010	6.586	0
Corrupt Local Gov.	1.813	1.678	7.652	0

Notes: DHS data from BR dataset includes outcomes for birth years from 1985-2013 and survey years from 1990-2013. Trust variables are from the Afrobarometer samples over 2003 to 2014. Trust outcomes are reported trust levels on a scale of 0-3, where "Not at all"= "0", "Just a little"="1", "Somewhat"="2", "A lot"="3". Corruption outcomes are respondents' beliefs about how many people are involved in corruption where "None"="0", "Some of them"="1", "Most of them"="2", "All of them"="3". Religiosity is reported frequency of religious service attendance, excluding weddings and funerals, where "Never"="0", "About once a year or less"="1", "About once every several months"="2", "About once a month"="3", "About once a week"="4", "More than once a week"="5".

A.3 Robustness

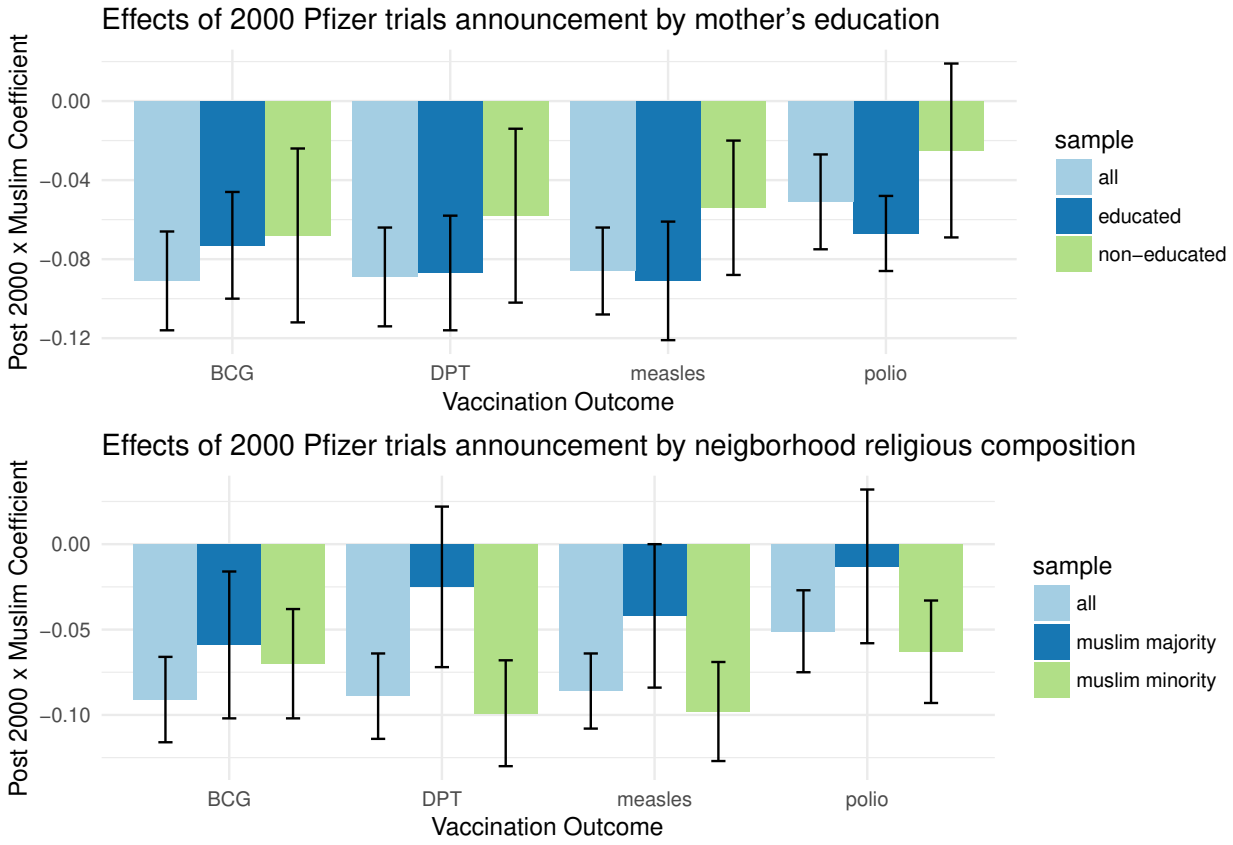


Figure A4: Effect of 2000 Pfizer trials announcement by mother's education and neighborhood religious composition

Table A4: Effects of 2000 Pfizer trial announcement on child vaccination outcomes, showing main effects

	Panel A: Child Vaccination Outcomes: BCG				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Muslim	0.068***	0.070***	0.042	0.052*	0.036
	(0.023)	(0.018)	(0.038)	(0.028)	(0.038)
Post 2000 x Muslim	−0.091***	−0.073***	−0.068	−0.070**	−0.059
	(0.025)	(0.027)	(0.044)	(0.032)	(0.043)
Mean of outcome	0.503	0.745	0.246	0.748	0.311
Observations	63,876	32,724	31,152	27,861	36,015
Clusters	710	687	619	380	330
	Panel B: Child Vaccination Outcomes: DPT				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Muslim	0.063***	0.068**	0.045	0.062**	0.009
	(0.022)	(0.026)	(0.038)	(0.027)	(0.043)
Post 2000 x Muslim	−0.089***	−0.087***	−0.058	−0.099***	−0.025
	(0.025)	(0.029)	(0.044)	(0.031)	(0.047)
Mean of outcome	0.488	0.716	0.248	0.722	0.307
Observations	63,410	32,479	30,931	27,604	35,806
Clusters	710	687	619	380	330
	Panel C: Child Vaccination Outcomes: Polio				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Muslim	0.046**	0.062**	0.035	0.055**	0.007
	(0.021)	(0.025)	(0.038)	(0.027)	(0.041)
Post 2000 x Muslim	−0.051**	−0.067**	−0.025	−0.063**	−0.013
	(0.024)	(0.027)	(0.044)	(0.030)	(0.045)
Mean of outcome	0.660	0.790	0.524	0.778	0.568
Observations	62,995	32,418	30,557	27,626	35,369
Clusters	710	687	619	380	330
	Panel D: Child Vaccination Outcomes: Measles				
Sample Within:	All	Educated	Non-Educated	Minority Muslim	Majority Muslim
	(1)	(2)	(3)	(4)	(5)
Muslim	0.053***	0.055*	0.059**	0.069**	0.009
	(0.020)	(0.028)	(0.030)	(0.028)	(0.036)
Post 2000 x Muslim	−0.086***	−0.091***	−0.054	−0.098***	−0.042
	(0.022)	(0.030)	(0.034)	(0.029)	(0.042)
Mean of outcome	0.376	0.544	0.199	0.542	0.247
Observations	63,528	32,512	31,016	27,696	35,832
Clusters	710	687	620	380	330
Mother's controls	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs) in Nigeria. Dependent variables are child vaccination outcomes for tuberculosis (BCG), diphtheria, pertussis and tetanus (DPT) and polio and measles as described in text. Sample is split between respondents living in districts that are over 50% muslim or Muslim Majority and respondents living in districts with <= 50% muslims or Muslim Minority districts in labeled columns. Post 2000 is an indicator that equals 1 if the child's year of birth is after the 2000 drug trial announcement. Muslim is an indicator that equals one if the mother reports that she is Muslim. Mother's controls include mother's age at birth and level of education, and drops education in non-educated (Education=0) subsamples. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

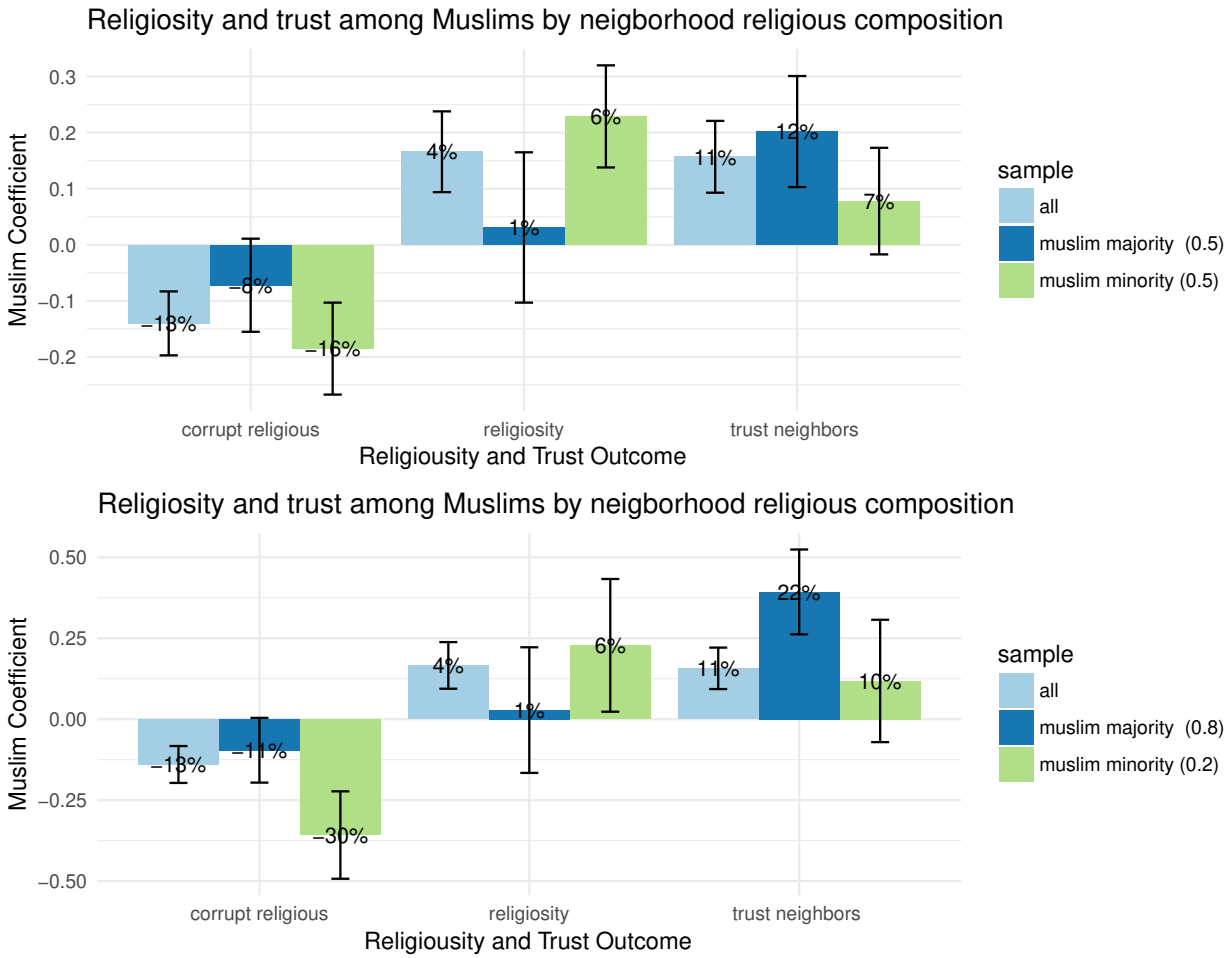


Figure A5: Religiosity and trust among Muslims by neighborhood religious composition

Table A5: Effects of 2000 Pfizer trial announcement on child vaccination outcomes, heterogeneity tests by minority status of Muslims in district

		Panel A: Child Vaccination Outcomes: BCG			
Sample Within:	All	Minority (<= 20%) Muslim	Majority (> 80%) Muslim	Minority (<= 50%) Muslim	Majority (> 50%) Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.091***	−0.050	−0.004	−0.070**	−0.059
	(0.025)	(0.091)	(0.070)	(0.032)	(0.043)
Observations	63,876	19,995	30,829	27,861	36,015
Clusters	710	293	275	380	330
		Panel B: Child Vaccination Outcomes: DPT			
Sample Within:	All	Minority (<= 20%) Muslim	Majority (> 80%) Muslim	Minority (<= 50%) Muslim	Majority (> 50%) Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.089***	−0.131	0.040	−0.099***	−0.025
	(0.025)	(0.084)	(0.074)	(0.031)	(0.047)
Observations	63,410	19,812	30,665	27,604	35,806
Clusters	710	293	275	380	330
		Panel C: Child Vaccination Outcomes: Polio			
Sample Within:	All	Minority (<= 20%) Muslim	Majority (> 80%) Muslim	Minority (<= 50%) Muslim	Majority (> 50%) Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.051**	−0.112	0.058	−0.063**	−0.013
	(0.024)	(0.087)	(0.073)	(0.030)	(0.045)
Observations	62,995	19,828	30,243	27,626	35,369
Clusters	710	293	275	380	330
		Panel D: Child Vaccination Outcomes: Measles			
Sample Within:	All	Minority (<= 20%) Muslim	Majority (> 80%) Muslim	Minority (<= 50%) Muslim	Majority (> 50%) Muslim
	(1)	(2)	(3)	(4)	(5)
Post 2000 x Muslim	−0.086***	−0.091	0.079	−0.098***	−0.042
	(0.022)	(0.057)	(0.048)	(0.029)	(0.042)
Observations	65,865	20,607	31,841	27,696	35,832
Clusters	710	293	275	380	330
Mother's controls	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs) in Nigeria. Dependent variables are child vaccination outcomes for tuberculosis (BCG), diphtheria, pertussis and tetanus (DPT) and polio and measles as described in text. Sample is split between respondents living in districts that are over 50% or 80% muslim or Muslim Majority and respondents living in districts with <= 50% or <= 20% muslims or Muslim Minority districts in labeled columns. Post 2000 is an indicator that equals 1 if the child's year of birth is after the 2000 drug trial announcement. Muslim is an indicator that equals one if the mother reports that she is Muslim. Mother's controls include mother's age at birth and level of education, and drops education in non-educated (Education=0) subsamples. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table A6: Religiosity and trust among Muslims by post 2000 adult cohort status, robustness to marginal changes in age cutoff

	Panel A: Muslim respondents, religiosity and trust by Adult (>=17 years) cohort					
Outcome:	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**
Sample Within:	Adult (>= 17 years) Cohort in 2000			All Cohorts		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	0.164**	−0.134**	0.165**	0.082	−0.176***	0.208***
	(0.074)	(0.054)	(0.061)	(0.081)	(0.062)	(0.068)
Post 2000 Adult x Muslim				0.099	0.079	−0.072
				(0.074)	(0.059)	(0.064)
Observations	4,852	2,971	3,092	6,882	4,481	4,643
Clusters	375	292	325	381	299	326
	Panel B: Muslim respondents, religiosity and trust by Adult (>= 19 years) cohort					
Outcome:	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**
Sample Within:	Adult (>= 19 years) Cohort in 2000			All Cohorts		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	0.154**	−0.137**	0.156**	0.051	−0.146**	0.168***
	(0.075)	(0.060)	(0.066)	(0.079)	(0.059)	(0.059)
Post 2000 Adult x Muslim				0.165**	0.041	−0.014
				(0.076)	(0.057)	(0.061)
Observations	4,184	2,539	2,634	6,882	4,481	4,643
Clusters	373	289	325	381	299	326
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs). Dependent variables are religiosity, trust in religious leaders and trust in neighbors from the Afrobarometer surveys from 2003-2014 where data available. Trust outcomes are reported trust levels on a scale of 0-3, where "Not at all"= "0", "Just a little"="1", "Somewhat"="2", "A lot"="3"; Religiosity is reported frequency of religious service attendance, excluding weddings and funerals, where "Never"="0", "About once a year or less"="1", "About once every several months"="2", "About once a month"="3", "About once a week"="4", "More than once a week"="5". Corruption outcomes are respondents' beliefs about how many people are involved in corruption where "None"="0", "Some of them"="1", "Most of them"="2", "All of them"="3". Individual controls include respondent level of education and gender or an indicator that equals one if the respondent is female. Muslim is an indicator that equals one if the respondent is Muslim; Post 2000 Adult is an indicator that equals one if the respondent was an adult, aged >= 17 (Panel A) or 20 years (Panel B), in 2000. State x Year FE are included in all specifications except for Corrupt Religious outcomes, which have only one year of data available. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table A7: Religiosity and trust among Muslims by post 2000 adult cohort and minority status of Muslims in districts

	Panel A: Muslim respondents and trust outcomes by minority (<= 50%) and majority (> 50%) status					
Outcome:	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**
Sample Within:	Muslim Minority (Adult (>= 18 years) Cohort in 2000)			Muslim Majority (Adult Cohort in 2000)		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	0.229**	−0.185**	0.078	0.031	−0.072	0.202**
	(0.091)	(0.082)	(0.095)	(0.134)	(0.083)	(0.099)
Mean of outcome	4.012	1.165	1.196	3.931	0.942	1.740
Observations	2,663	1,636	1,645	1,651	977	1,112
Clusters	209	163	172	141	109	130
	Panel B: Muslim respondents and trust outcomes by minority (<= 20%) and majority (> 80%) status					
Outcome:	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**	**Religiosity**	**Corrupt Religious**	**Trust Neighbors**
Sample Within:	Muslim Minority (Adult (>= 18 years) Cohort in 2000)			Muslim Majority (Adult Cohort in 2000)		
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim	0.228	−0.358***	0.118	0.028	−0.096	0.393***
	(0.205)	(0.135)	(0.189)	(0.194)	(0.100)	(0.131)
Mean of outcome	3.848	1.196	1.235	3.863	0.908	1.784
Observations	1,862	1,130	1,137	1,299	779	882
Clusters	156	115	130	112	87	101
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs). Dependent variables are religiosity, trust in religious leaders and trust in neighbors from the Afrobarometer surveys from 2003-2014 where data available. Trust outcomes are reported trust levels on a scale of 0-3, where "Not at all"= "0", "Just a little"="1", "Somewhat"="2", "A lot"="3"; Religiosity is reported frequency of religious service attendance, excluding weddings and funerals, where "Never"="0", "About once a year or less"="1", "About once every several months"="2", "About once a month"="3", "About once a week"="4", "More than once a week"="5". Corruption outcomes are respondents' beliefs about how many people are involved in corruption where "None"="0", "Some of them"="1", "Most of them"="2", "All of them"="3". Individual controls include respondent level of education and gender or an indicator that equals one if the respondent is female. Muslim is an indicator that equals one if the respondent is Muslim; post 2000 is an indicator that equals one if the respondent was an adult, aged >= 18 years, in 2000. State x Year FE are included in all specifications except for Corrupt Religious outcomes, which have only one year of data available. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table A8: Trust in religious leaders and child vaccination outcomes in 2012

Covariate:	**Panel: Trust in religious leaders and child vaccination outcomes in 2012**			
	Muslim x Trust Religious D	Muslim x Religiosity D	Muslim x Trust Neighbors D	Muslim x Trust Police D
	(1)	(2)	(3)	(4)
BCG	−0.161***	−0.042	−0.046	−0.095
	(0.059)	(0.057)	(0.078)	(0.084)
Mean of outcome	0.614	0.614	0.608	0.614
DPT	−0.133***	−0.111*	−0.005	−0.068
	(0.048)	(0.058)	(0.077)	(0.081)
Mean of outcome	0.591	0.591	0.579	0.591
Polio	−0.038	−0.135**	−0.035	−0.059
	(0.047)	(0.065)	(0.081)	(0.122)
Mean of outcome	0.766	0.766	0.730	0.766
Measles	−0.092*	−0.047	0.013	−0.036
	(0.054)	(0.052)	(0.077)	(0.078)
Mean of outcome	0.256	0.256	0.279	0.256
Mother's controls	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs). Dependent variables are child vaccination outcomes from the DHS for children born in 2012. Covariates are Muslim x Trust D variables with trust variables from the Afrobarometer survey in 2012 (and closest year 2014 for religious data where 2012 data is not available). Trust D variables are indicators that equal one if trust is greater than 1; Religiosity D is an indicator that equals 1 if religiosity measure is greater than the sample median 4.7. Mother's controls include mother's age at birth and level of education. Muslim is an indicator that equals one if the respondent is Muslim. State FE are included in all specifications. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

Table A9: Effects of 2000 Pfizer trial announcement on mother's health-seeking behavior (pre-natal care) and other child health outcomes

	Panel A: Mother's Pre-Natal Care: Doctor, Nurse/Midwife, Traditional								
Outcome:		**Doctor**			**Nurse**			**Traditional**	
Sample Within:	All	Educated	Non-Educated	All	Educated	Non-Educated	All	Educated	Non-Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Muslim	0.080***	0.059**	0.119***	0.018	−0.010	−0.005	0.015	0.022	0.010
	(0.022)	(0.024)	(0.041)	(0.034)	(0.046)	(0.040)	(0.010)	(0.015)	(0.014)
Post 2000 x Muslim	−0.057**	−0.033	−0.116***	−0.005	0.032	0.022	−0.011	−0.016	−0.005
	(0.025)	(0.026)	(0.043)	(0.035)	(0.047)	(0.044)	(0.010)	(0.016)	(0.015)
Mean of outcome	0.255	0.394	0.113	0.444	0.614	0.268	0.027	0.034	0.019
Observations	48,300	24,561	23,739	48,302	24,563	23,739	48,303	24,564	23,379
Clusters	710	688	624	710	688	624	710	688	624
	Panel B: Child Health Outcomes: Stunting, Underweight and Infant Mortality								
Outcome:		**Stunted**			**Underweight**			**Mortality**	
Sample Within:	All	Educated	Non-Educated	All	Educated	Non-Educated	All	Educated	Non-Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Muslim	0.045**	0.052*	0.054	0.028	0.039	0.023	0.009	0.007	0.016
	(0.022)	(0.030)	(0.035)	(0.023)	(0.028)	(0.039)	(0.019)	(0.028)	(0.028)
Post 2000 x Muslim	−0.050**	−0.047	−0.084**	−0.030	−0.030	−0.050	−0.018	−0.033	−0.008
	(0.023)	(0.032)	(0.038)	(0.023)	(0.028)	(0.042)	(0.025)	(0.036)	(0.037)
Mean of outcome	0.355	0.257	0.467	0.304	0.207	0.414	0.412	0.477	0.380
Observations	51,101	27,304	23,797	51,101	27,304	23,797	31,695	10,680	21,015
Clusters	710	683	616	710	683	616	705	661	588
Mother's controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by district. Districts are local government areas (LGAs) in Nigeria. Dependent variables are mother's reported pre-natal care source: doctors, nurses/midwives or traditional healers, in Panel A; In Panel B, dependent variables are current child health outcomes for stunting and underweight in columns (1) to (6). A child is considered underweight by WHO standards if they have a weight for age z-score (WFA z) of less than -2.0 while a child is considered stunted with a height for age z-score (HFA z) of less than -2.0. Infant mortality is the outcome in columns (7) to (9) of Panel B. Post 2000 is an indicator that equals 1 if the child's year of birth is after the 2000 drug trial announcement. Muslim is an indicator that equals one if the mother reports that she is Muslim. Mother's controls include mother's age at birth and level of education in columns (1), (2), (4), (5), (7) and (8) and drops education in non-educated subsamples. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

A.4 Health Facility Statistics

Below are health infrastructure quality measures by state from a 2012 health facility dataset in Nigeria. The health facility dataset comes from an effort spearheaded by the Nigerian government and researchers from the country's Office of the Senior Special Assistant to the President on MDGs (OSSAP), in collaboration with the Sustainable Engineering Lab at Columbia University who conducted extensive, comprehensive surveys of schools and health facilities at local government areas (LGAs) in Nigeria. According to the Federal Ministry of Health, Nigeria had 34,423 health facilities as of 2013 (Makinde et al., 2018). Thus, the health facility sample represents about 70% of the universe of health facilities in Nigeria. The health quality infrastructure index is an average of 8 public services reported available at the health facility in each LGA and state in Nigeria, namely: the share of facilities with ante-natal services, family planning services, emergency transport, a freezer for vaccines, vaccines at the facility, caesarian services, improved water supply and grid power access.

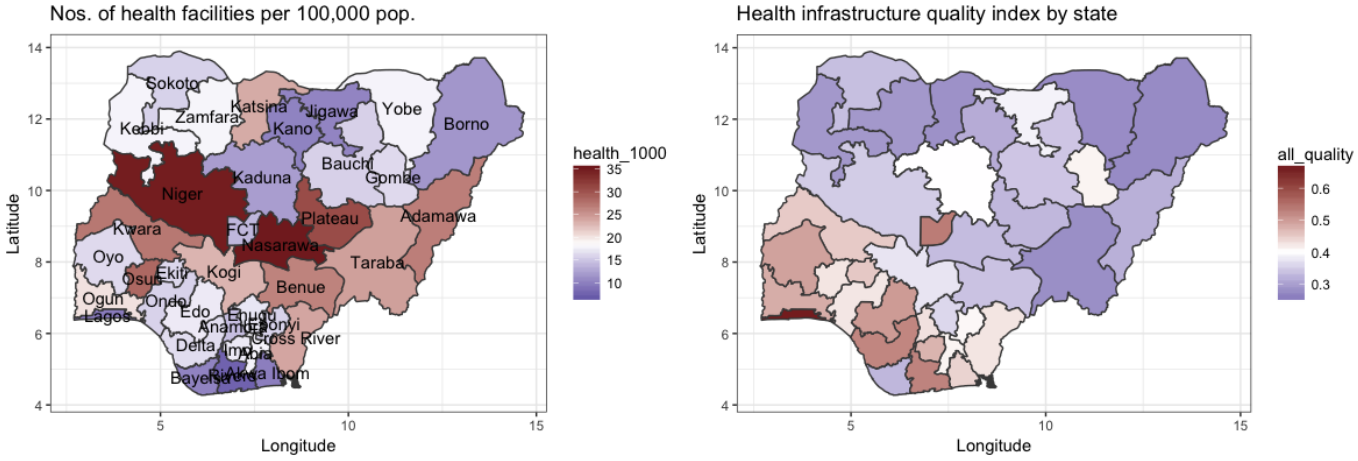


Figure A6: Number of health facilities per 100,000 population and health infrastructure quality index by state, 2012. Source: OSSAP survey

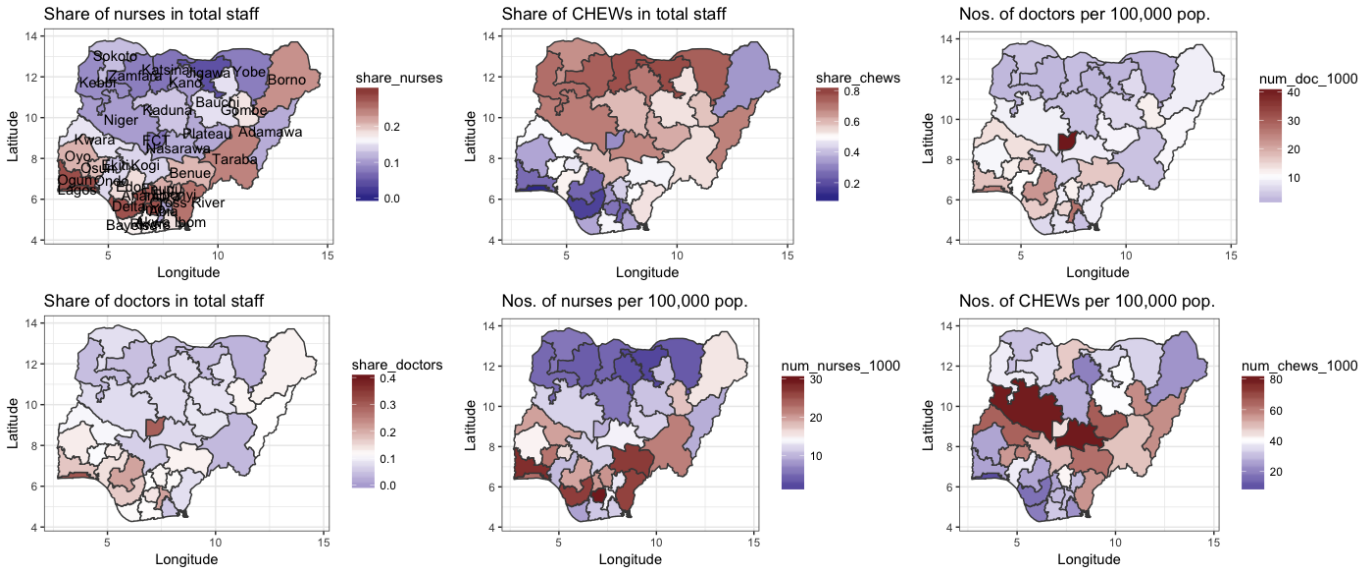


Figure A7: Staff availability at health facilities by state, 2012. Source: OSSAP survey

Table A10: Increase in share of nurse/midwives in total health personnel by Muslim state status post 2000

Covariate:	Muslim Share Continuous			Muslim Majority Indicator		
Outcome:	**Share Nurse**	**Share Doctor**	**Share CHEW**	**Share Nurse**	**Share Doctor**	**Share CHEW**
	(1)	(2)	(3)	(4)	(5)	(6)
Muslim Share	0.034	0.155**	−0.163*	−0.033	0.027	0.020
	(0.074)	(0.071)	(0.095)	(0.061)	(0.020)	(0.074)
Post 2000 x Muslim Share	0.058**	−0.024	0.067*	0.048**	−0.029*	0.053
	(0.026)	(0.017)	(0.041)	(0.021)	(0.017)	(0.035)
Mean of outcome	0.428	0.099	0.387	0.428	0.099	0.387
Observations	71	71	71	71	71	71
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Regressions estimated by OLS. Robust standard errors in parentheses clustered by state. State and year fixed effects included in all specifications. Dependent variables are share nurse/midwives, share doctors and share community health extension workers (CHEWs) in total health personnel (where total health personnel is sum of nurses/midwives, doctors and CHEWs) in 1991 and 2012 datasets. Muslim Share is the share of respondents in a state who are muslim in the 1990 and 2013 DHS for 1991 and 2012 respectively. The Muslim Majority Indicator an indicator that equals 1 if the share muslim is greater than 50% in a state. ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level.

A.5 Cost Estimates

Being unvaccinated increases an individual's risk of infection from the disease (Yahya, 2006). The costs of treatment of these illnesses can be significant and incur large financial burdens on households (Archibong and Annan, 2017). The objective of this section is to conduct simple back of the envelope calculations on the potential costs of treatment from an increased number of unvaccinated Muslim children as a result of negative news about the Pfizer drug trials. We assemble data on direct medical costs of treatment of the four diseases in Nigeria from the scientific literature, and calculate lower bound estimates of the costs of treatment if 20% of unvaccinated Muslim children born each year from 2001 to 2013 had fallen ill. We compare these cost figures to the counterfactual scenario if the Pfizer trials disclosure had not occurred, using the regression estimates from Section 4.1. The results are shown in Figure A8 and Figure A9. Using our most conservative estimates of direct medical costs only, and without factoring in any potential deaths from disease, the reduced vaccination of Muslim children in the aftermath of the Pfizer drug trials incurred a total potential cost of treatment of $94,128,449 over the counterfactual scenario. This cost is over $19 million higher than the Pfizer settlement to the Nigerian government of $75 million. Under different scenarios, like the scenario in which 50% of unvaccinated Muslim children fall ill, the difference in costs is even higher, rising to up to over $235 million as shown in Figure A8 and Figure A9.

Disease	cost of treatment (2010 USD)	Year of data	Source	Description of costs							
Tuberculosis (BCG)	28.42	2013	Ukwaja et al, 2013	direct medical treatment							
Diphtheria, Pertussis, and Tetanus (DPT)	10.2	2001	Salako et al, 2001	direct medical cost of antibiotics							
Polio	0.71	2010	Qadar, 2014	cost of polio vaccination							
Measles	16.44	2018	Zimmermann et al, 2019	direct medical treatment							
actual year outcomes	disease	average population under 1 year old each year (births)	average muslim pop under 1 year each year (births)	unvaccinated	at risk	20% sick	50% sick	cost of treatment (2010 USD)	total costs per year if 20% sick	**total costs over 12 years if 20% sick**	total costs per year if 50% sick	**total costs over 12 years if 50% sick**
2001-2013	DPT	6,115,890	3,486,057	0.70	2,426,296	485,259	1,213,148	10.20	4,949,644	59,395,723	12,374,109	148,489,308
2001-2013	BCG	6,115,890	3,486,057	0.69	2,412,352	482,470	1,206,176	28.42	13,711,807	164,541,681	34,279,517	411,354,204
2001-2013	measles	6,115,890	3,486,057	0.76	2,631,973	526,395	1,315,987	11.00	5,790,341	69,484,094	14,475,853	173,710,235
2001-2013	polio	6,115,890	3,486,057	0.41	1,425,797	285,159	712,899	0.71	202,463	2,429,559	506,158	6,073,897
	all								24,654,255	**295,851,058**	61,635,637	**739,627,644**
counterfactual year outcomes	disease	average population under 1 year old each year (births)	average muslim pop under 1 year each year (births)	unvaccinated	at risk	20% sick	50% sick	cost of treatment (2010 USD)	total costs per year if 20% sick	**total costs over 12 years if 20% sick**	total costs per year if 50% sick	**total costs over 12 years if 50% sick**
2001-2013	DPT	6,115,890	3,486,057	0.48	1,675,063	335,013	837,532	10.20	3,417,129	41,005,547	8,542,822	102,513,867
2001-2013	BCG	6,115,890	3,486,057	0.48	1,679,716	335,943	839,858	28.42	9,547,506	114,570,073	23,868,765	286,425,181
2001-2013	measles	6,115,890	3,486,057	0.48	1,680,224	336,045	840,112	11.00	3,696,493	44,357,921	9,241,234	110,894,803
2001-2013	polio	6,115,890	3,486,057	0.30	1,049,922	209,984	524,961	0.71	149,089	1,789,068	372,722	4,472,669
	all								16,810,217	**201,722,608**	42,025,543	**504,306,521**
difference between actual vs counterfactual costs of treatment										**94,128,449**		**235,321,123**

Figure A8: Back of the envelope cost of treatment estimates over 2001-2013. Population figures from Knoema World Data Atlas database

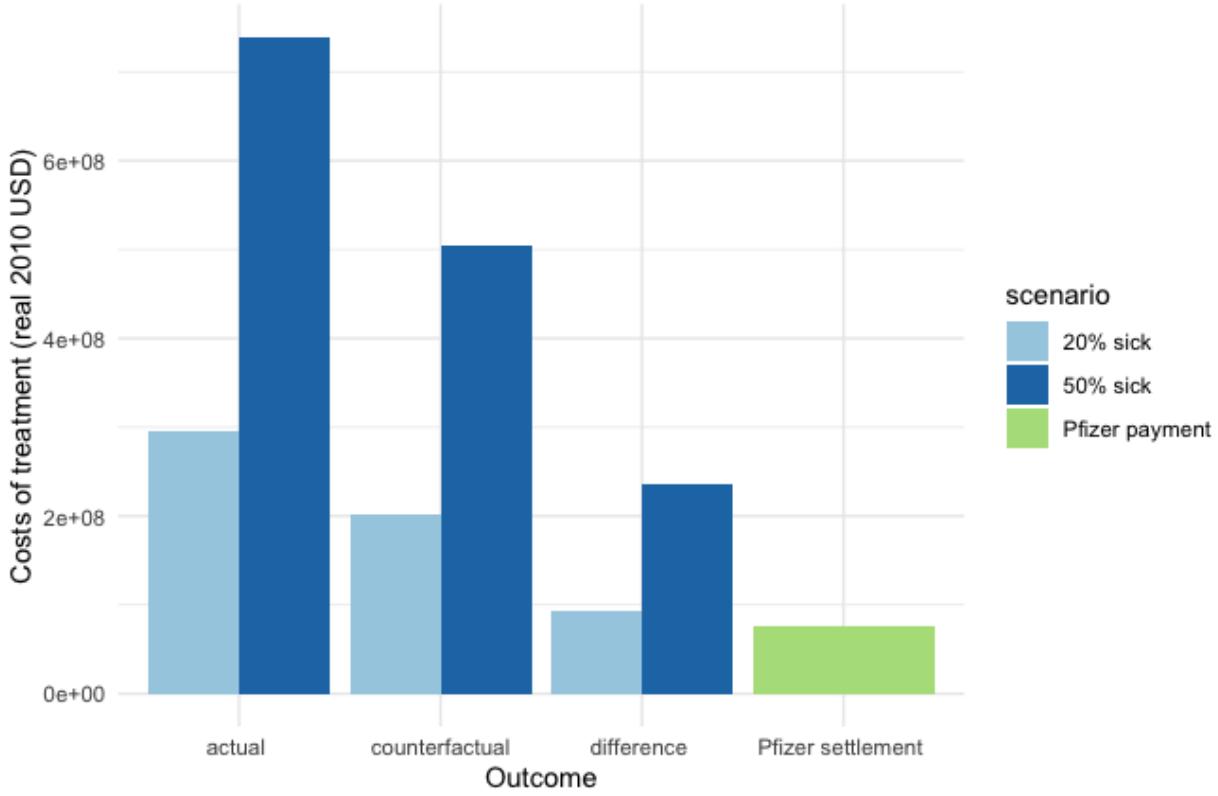


Figure A9: Back of the envelope cost of treatment estimates under different scenarios over 2001-2013, with Pfizer settlement amount shown