In Vaccines we Trust? The Effects of Anti-vaccine Propaganda on Immunization: Evidence from Pakistan*

Monica Martinez-Bravo
CEMFI

Andreas Stegmann
CEMFI

September 12, 2017

The most updated version of the paper can be found here

Abstract

In July 2011, the Pakistani public unexpectedly learnt that the CIA had conducted a fake vaccination campaign as part of the operations to capture Osama Bin Laden. This episode was extensively used by Taliban groups to discredit the health system and vaccination campaigns. We implement a Difference-in-Differences strategy to document the effect of the disclosure of this information on demand for health services. We use survey data to compare vaccination rates before and after the disclosure of this information, across regions with different levels of electoral support for Islamist groups. Our results suggest that the disclosure of information on the fake vaccination campaign had a substantial negative effect on immunization rates: a one standard deviation increase in support for Islamist groups lead to a 9 to 13% decline in immunization rates over the sample mean. Our results are consistent with the hypothesis that the disclosure of the vaccination ruse eroded the degree of trust in medical services, and consequently, lead parents to actively refuse the use of formal medicine and vaccines, in particular.

*We would like to thank Manuel Arellano, Diego Puga, Nancy Qian, Pascaline Dupas, Nathan Nunn, Guillermo Caruana, Jishnu Das, Michael Callen, and, Pamela Campa for valuable suggestions. We also thank seminar participants at NEUDC-2016, CEMFI PhD workshop, Oxford University, Political Economy of Development Workshop at Warwick University. The present draft is a revised version of the Master's Thesis presented by Andreas Stegmann in partial fulfillment of the 2013-2015 Master in Economics and Finance at CEMFI. Monica gratefully acknowledges financial support from Ramón y Cajal Grant (RYC-2013-14307). Monica Martinez-Bravo; email: mmb@cemfi.es. Andreas Stegmann; email: stegmann@cemfi.edu.es.

1 Introduction

Trust in the medical sector and on medical products is a key determinant of the demand for health care. This is specially relevant for the use of vaccines. Because of herd immunity, it is difficult - if not impossible - to learn about the effectiveness of vaccines based on own experience. Hence, events that discredit the effectiveness of vaccines or the reputation of the medical sector, can have dramatic consequences on immunization rates. A well known example was the publication of an article in 1998 in the medical journal *The Lancet* linking autism to the MMR (measles, mumps, and rubella) vaccine. Media reports have associated this publication with the emergence of the anti-vaccines movement and the recent rise in the number of unvaccinated children in several countries. As a result, infectious diseases that were previously eradicated have reemerged in countries like the UK and the US.[1]

These issues are even more relevant in developing countries, where citizens have lower levels of education and the low quality of remedial medicine can exacerbate the negative consequences of infections. In spite of the importance of these issues, we have very limited empirical evidence on the causal effect of the disclosure of information that damages the reputation of vaccines on immunization rates and on health outcomes.

In this paper, we exploit a sequence of events that took place in the recent history of Pakistan and that severely affected the degree to which citizens trusted formal medicine and vaccines, in particular. As part of the operations to capture Osama Bin Laden in 2011, the CIA launched a fake vaccination campaign in the city of Abbottabad, Pakistan. The objective of this operation was to obtain DNA samples of children living in a compound of Abbottabad where Bin Laden was suspected to hide. This would have allowed the CIA to obtain definite proof that Bin Laden was hiding there. In July 2011, two months after the actual capture of Osama Bin Laden, the British newspaper *The Guardian* published an article reporting on the vaccine ruse and describing the collaboration of a Pakistani doctor with the CIA.[2]

The disclosure of this information caused uproar in Pakistan. The Pakistani Taliban used this information to intensify their discrediting campaign against formal medicine and the polio vaccine, in particular. They issued a number of *fatwas* - religious edicts - in which they accused health workers of regularly conducting espionage activities for the US[3] and relating polio vaccination campaigns to attempts to sterilize the Muslim population[4]. While the Taliban's campaign to discredit vaccinations can be traced back to the early 2000s,

[1] See Alazraki (2011).
[2] See Shah (2011).
[3] See Walsh (2012).
[4] See Roul (2014).

the disclosure of the vaccination ruse and the actual involvements of Pakistani doctors in espionage activities lent credibility to the Talibans' arguments.

We empirically evaluate the effects of the disclosure of the vaccination ruse on immunization rates. We use household-level data from several waves of the Pakistani Social Living Standards Measurement (PSLM) survey. We implement a *Difference-in-Differences* strategy (DID, henceforth) where we compare immunization rates of children born before and after the vaccine ruse was disclosed and, across districts with different levels of support for Islamist political groups. Our underlying assumption is that, on average, parents in districts with higher support for political Islamist groups will be more likely to change their believes about vaccines according to the messages spread by the Taliban. As a measure of support for Islamist groups we use district-level measures of electoral support for *Muttahida Majlis-e-Amal* (MMA), which is a coalition of Islamist parties that ran under a single banner in the 2008 general election.[5]

Our estimates suggest that the disclosure of the vaccine ruse had substantial effects on vaccination rates: a one standard deviation increase in the support for Islamist groups leads to a 9 to 13% larger decline in the likelihood that children have received the first dose of a number of different vaccines.[6]

These results are consistent with the hypothesis that the disclosure of the vaccine ruse damaged the reputation of vaccines, and possibly of the Pakistani formal health system, more generally. As a result, a larger fraction of parents were hesitant about vaccinations or decided to refuse to vaccinate their children. Consequently, immunization rates declined. These effects are stronger in regions where political Islamist groups had higher rates of support. This is consistent with the idea that individuals ideologically close to the Taliban were more likely to receive their messages discrediting vaccines and changed their beliefs accordingly.

There are a number of alternative channels that could also provide an explanation for these results. For instance, the supply of medical services, such as vaccination drives, may have endogenously reacted to the disclosure of the vaccine ruse. Starting in mid-2012 the Taliban carried out attacks and intimidation of health workers.[7] While this is a plausible channel, we believe it cannot account for the entire magnitude of our effects. The intimidation of health workers only took place about a year after the disclosure of the vaccine ruse, while we observe a decline in vaccination rates immediately after the disclosure.

We also provide additional evidence that demand of other health services declined after

[5]The parties that form the MMA coalition have strong ideological and financial connections to the Pakistani Taliban. See section 2 for further details.

[6]In particular the effect is 10.6% for polio vaccine, 9.4% for DPT vaccine, and 12.5% for measles vaccine.

[7]See The Express Tribune (2012).

the disclosure of the vaccination ruse. We implement a similar DID strategy to show that parents are less likely to consult health workers when their children get sick.

Our results are highly robust to alternative specifications. In our baseline estimates on vaccination rates, we include controls for district and month-of-birth fixed effects. The estimates are robust to controlling for age of the children at time of the survey, month when the survey was conducted, and a dummy for whether the child lives in a rural area of the district. We also show that the results are robust to flexibly controlling for baseline level of health and education conditions in the district interacted with cohort fixed effects.

This paper is related to a number of different literatures. First, the paper relates to the recent literature on the demand for health care in developing countries. See Dupas (2011) as well as Banerjee and Duflo (2012) for two literature reviews. These studies document that the poor tend to exhibit low levels of demand for highly effective preventive care, such as vaccines. While the reasons are varied, in some cases the poor seem to have incorrect believes about the effectiveness of preventive treatments. Misconceptions about the effectiveness of vaccines and the concerns over potential side effects are also prevalent in developed countries. However, the problem is exacerbated in developing countries that do not have well-established organizations that certify treatments and that enjoy a good reputation, such as the Food and Drugs Administration in the US or the European Medicines Agency.

In spite of the importance of the role of trust on demand for health services, the empirical evidence documenting the causal effect of events that damage the reputation of the heath care system are scarce. Das and Das (2003) examine the determinants of the demand for vaccination in a case study from one Indian village. In this village, vaccination rates sharply declined after two mothers died while in labor. The authors argue that the deaths of these two mothers lead to a decrease in the level of trust in the local midwife. Since the local midwife is also in charge of delivering vaccines, the authors argue that it is likely that parents started distrusting the midwife's recommendation to vaccinate their children, after the two mothers passed away.

Our study also relates to the recent paper on the effects of the disclosure of the Tuskegee experiment (Alsan and Wanamaker, 2016). For forty years a number of black males in Tuskegee, Alabama were purposely untreated from syphilis with the objective of studying the long-term effects of the disease. The paper documents that the disclosure of the Tuskegee study in 1972 was associated with a decline in medical utilization and with negative health outcomes for black males living in states close to Tuskegee. The authors argue that the effects are driven by the fact that black males identified more closely with the subjects of the Tuskegee experiment and, consequently, developed lower levels of trust in healthcare institutions.

Our paper complements this work and also differs from it in a number of ways. First, our evidence exploits a recent event that damaged the reputation of the healthcare sector in a very different context: contemporaneous Pakistan. Hence, it highlights that the role of trust in the effectiveness of the delivery of health services is a current and pressing issue for developing countries. Second, we focus on the effects on vaccination rates. Given the inherent difficulties in inferring the effectiveness of vaccines based on own-experience, shocks to the reputation of vaccines can be specially damaging. Third, instead of distance to the onset of the event, or demographic characteristics, we exploit ideological proximity to the Taliban. The Taliban had an on-going defamation campaign against vaccination efforts. Hence, it is likely that the cross sectional variation that we exploit is closely connected to exposure to information discrediting vaccination campaigns and to the likelihood that individuals updated their beliefs based on the new information.

This paper is also related to the literature that examines the effect of persuasive communication on behavior. See Della Vigna and Gentzkow (2010) for a literature review. While a large literature has documented the effect of advertising campaigns and media exposure on consumer and voting behavior, to the best of our knowledge, no study has documented the effects of propaganda campaigns against vaccines on immunization rates.

Finally, the paper also relates to the delivery of health services in Pakistan and the determinants of attitudes of Anti-Americanism (Bursztyn et al. 2016; Andreoni et al. 2016)

The remainder of the paper is organized as follows. Section 2 provides background information on the context of political and health system of Pakistan. Section 3 presents the data used in the analysis. Sections 4 presents the empirical strategy. Section 5 discusses the main results. Section 6 discusses evidence on the mechanism. Section 7 concludes.

2 Background

2.1 The Vaccine Ruse

In the summer of 2010, the CIA obtained information that Bin Laden could be hiding in a compound located in the city of Abbottabad, Pakistan. During the following months, the CIA surveilled the compound in a number of different ways, such as via satellite images and from a nearby safe house. Before launching an operation that would entail invading the territory of Pakistan, a critical ally of the US in the region, the CIA wanted to obtain definite proof that Bin Laden was hiding in the compound. For this purpose the CIA organized a fake vaccination campaign. The main objective of the vaccination ruse was to obtain DNA samples of children living in the compound and compare them to the DNA of Bin Laden's sister, who died in Boston in 2010. Obtaining a proof that the children were related to Bin Laden would have been telling evidence that Bin Laden was hiding in the compound (Shah, 2011).

To conduct the fake vaccination campaign, the CIA recruited a senior Pakistani doctor, Dr. Shakil Afridi. The doctor, in turn, hired low-ranked health workers, who were unaware of the CIA involvement in the operation. Bypassing the official Abottabad health services, in March 2011, Dr. Afridi began a vaccination campaign for hepatitis B in a poor neighborhood of the city. In April 2011, the team moved to Bilal Town, a rich suburb of the city, where the suspected compound was located. Allegedly, one of the nurses gained access to the compound. However, whether the operation succeeded in obtaining DNA samples of children in the compound is still unclear.

On the 2nd of May 2011, U.S. special forces carried out a targeted attack on the compound resulting in the killing of Osama Bin Laden.

A few months later, on July 11th of 2011, the British newspaper *The Guardian* published an article describing the vaccine ruse.[8] The article described the collaboration of Dr. Afridi with the CIA and the attempts of health workers to obtain DNA samples from children living in the suspected compound during the vaccine ruse.[9]

The involvement of health personnel in the operations to capture Osama Bin Laden was intensely criticized, both in the US as well as in other countries.[10] In January 2013, the deans of twelve leading public health schools sent an open letter to President Obama protesting against the use of vaccination programs in espionage activities (Johns Hopkins Bloomberg School of Public Health News, 2013). In response to these critiques, on May 2014, the White House announced that the CIA had pledged not to use vaccination programs to gather intelligence or genetic material.

[8] See Shah (2011).

[9] In January 2012, the U.S. Defense Secretary at that time, Leon E. Panetta, publicly confirmed that the Pakistani doctor Shakil Afridi had collaborated with the CIA to gather intelligence in the city of Abbottabad (Mazetti, 2012). Shakil Afridi was arrested shortly after the operation to kill Bin Laden had been concluded. He was accused of conspiracy against the state and sentenced to serve 33 years in jail on the 23rd of May 2012 (Boone, 2012)

[10] Some of these reactions were described in an article published in 2013 in the Scientific American Magazine. For instance, Leslie F. Roberts, Professor of Columbia University's Mailman School of Public Health argued *"Forevermore, people would say this disease, this crippled child is because the U.S. was so crazy to get Osama bin Laden."* (Scientific American, 2013).

2.2 Pakistan Political Context and Reaction to the Vaccination Ruse

Pakistan is divided into four provinces, three territories, and the capital city of Islamabad. Our study focuses on the four provinces of Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh.[11] Provinces are divided in districts. In the year 2013, the four provinces of Pakistan had 114 districts in total. Districts are themselves subdivided into tehsils.

Pakistan is a federal parliamentary democracy which had held regular election since the end of the Musharraf regime in 2008. Legislative elections take place every five years. Since 2008, two main political forces have been alternating in power: first, the Pakistan Peoples Party (PPP) a center-left political party founded by Zufilkar Ali Bhutto and currently led by Yousaf Gillani; second, the Pakistan Muslim League (N) (PML (N)) a right-wing nationalistic party led by Nawaz Sharif, the current prime minister of Pakistan.

A number of smaller political parties have also contested elections in Pakistan. Foremost among them is an alliance of six Islamist parties known as Muttahida Majlis-e-Amal (MMA).[12] This alliance was established in 2002 in direct opposition to Pakistan's support to the US-led invasion of Afghanistan. All of the parties organized within the MMA are Islamist in nature. The three largest and most influential parties[13] strongly emphasize Islamist moral and principles in every day life. They preach a hard-line and traditional Islamic way of thinking that is shared by the Pashtuns living along the Pakistani-Afghan border. These political groups all have historical and ethnic links with the Afghan Taliban, as they are all Pashtun, which is Afghanistan's largest and Pakistan's second largest ethnic group.[14]

Several authors have documented the close connections between some of the parties that form MMA and the Pakistani-Taliban. Norell (2007) documents a vast amount of political, financial and ideological connections between members of the individual parties contained in the MMA and the Afghan Taliban and other militant groups operating in the FATA where the Pakistani Taliban were founded.

[11] We exclude from the study the Federally Administered Tribal Areas, also known as FATA. This region is semi-autonomous and has never been under the full control of the Pakistani government. We also exclude from the sample the semi-autonomous territories of Gilgit-Baltistan and Azad Kashmir because they experience the long-standing conflict with India for the overall Kashmir region. No data on vaccinations are available for these regions. Finally we exclude the capital city of Islamabad because it constitutes a large city and operates very differently from the rest of the country. The four provinces in our sample cover 96.47% of the current undisputed territory of Pakistan and contain 97.35% of its population. See section 9 in the Online Appendix for further details on the Data.

[12] In particular, the Jamiat Ulema-e-Pakistan (JUP), the Jamiat Ulema-e-Islam-Fazl (JUI-F), the Jamiat Ulema-e-Islam (JUI-S), Jamiat-e-Ahle Hadith, Pakistan Isami Tehrik (ITP) (formerly Tehriq-e-Jafaria (TeJ)) and the Jamaat-e-Islami (JI).

[13] JUI-F, the JUI-S and the JI.

[14] See Norell (2007).

Islamist extremists groups have tried to discredit formal medicine and vaccines on multiple occasions. In Pakistan, the Taliban groups have actively engaged in propaganda campaigns, which questioned the effectiveness and safety of vaccines since the early 2000s. Starting in 2006 the Taliban leader Maulana Fazlullah criticized Western lifestyles and polio vaccination drives during illegal radio shows and Friday prayers in local mosques. He claimed that the polio eradication campaign was part of a "conspiracy of Jews and Christians to make Muslims impotent and stunt the growth of Muslims". Even before the disclosure of the vaccine ruse, the Taliban accused polio-vaccination campaigns of being part of Western espionage against the Muslim community (Roul, 2014). The Taliban have also argued that vaccines should be avoided because they were imported and because it is un-Islamic to "take a medicine before the disease [is contracted.]"[15]

It is likely that the disclosure of the fake vaccination campaign conducted by the CIA during the operations to capture Bin Laden lent credibility to the Taliban's arguments against vaccines. The Taliban took advantage of this by intensifying their propaganda campaign against vaccines after the disclosure. They issued a number of religious edicts (*fatwas*), directly linking the on-going vaccination campaigns to espionage activities. For instance, they claimed that "polio agents could also be spies as we have found in the case of Dr. Shakil Afridi has surfaced. Keeping these things in mind we announce to stop the polio dosage."[16]

The Taliban have also exerted violence against vaccination workers. The first attack happened in July 2012 in the city of Karachi, the capital of Sindh province. In December 2012, coordinated attacks took place in several districts during a national vaccination drive. Between 2012 and 2014, 56 individuals, mostly female health workers were killed while collaborating in vaccination drives (Roul, 2014).

2.3 Immunization in Pakistan

Children in Pakistan typically receive three main vaccines at young age through routine immunization activities: vaccine against poliomyelitis (or polio vaccine), DPT (vaccine against diphtheria, pertussis, and tetanus); and measles vaccine. Pakistan follows the recommended vaccination calendar of the World Health Organization and the first dose of most of these vaccines is supposed to be administered shortly after birth. See Appendix Table 1 for details on the immunization calendar.[17]

[15] See Nishtar (2009).

[16] See Roul (2014).

[17] The official immunization schedule of Pakistan is published by the Expanded Program on Immunization (EPI), Pakistan. See Expanded Program on Immunization (EPI), Pakistan (2017)

The health workers responsible for immunization of children are Lady Health Workers. These workers are assigned to a local health facility and each of them is responsible for, approximately, 1,000 people or 150 homes. They regularly visit households to provide information on family planning and to immunize children according to the vaccination schedule.[18]

The Expanded Program on Immunization of Pakistan (EPI, henceforth) coordinates the procurement and supply of vaccines, syringes, safety boxes and other logistical needs by the provinces and other areas to vaccinate the target populations. These EPI activities are financed by the federal government of Pakistan. Nevertheless, the provinces through respective EPI programme units are themselves responsible to manage the operational cost of the immunization activities at the provincial and district levels.

The supply of polio vaccine plays a special role in the EPI activities. Pakistan is one of the only two countries in the world in which the poliomyelitis virus is still endemic. Immunization against polio is supported by the Global Polio Eradication Initiative (GPEI, henceforth). In conjunction with staff from the WHO, EPI coordinates national as well as subnational immunization days during which vaccinators (typically lady health workers joined by other volunteers recruited from different branches of local government, e.g. the education department) provide the polio vaccine at households' doorstep. These immunization campaigns typically last for 3 days and target all children up to age 5 in the respective district.

3 Data

Our main data source is the Pakistan Social and Living Standards Measurement (PSLM) provided by Pakistan's Bureau of Statistics. These data contain household-level data on vaccination status of each child living in the household. For our main results we focus on waves 2010/11 and 2012/13, which cover the events of interest. In some of the robustness checks we also use the 2008/9 wave.

Our main outcomes correspond to whether a child has received the first dose of the polio, DPT, or measles vaccine. Focusing on the first dosages provides a tighter prediction of how the events described in this paper should have affected children of different cohorts. However, we also present results for full immunization rates — i.e., receiving all dosages of each vaccine. We record a successful vaccination if the immunization was recorded in the vaccine card. In order to minimize the scope for misreporting we do not rely on recall

[18] The Lady Health Worker program was established in 1994 by the federal government. Since 2010, the provision of health public goods is a provincial responsibility. In 2014, there were, approximately, 110,000 lady health workers in Pakistan.

measures of vaccinations.[19]

Our baseline sample records the vaccination status of 22,346 children born between 2010 and 2012 that were up to 24 months old at the time of the interview. These children are distributed through the 114 districts that conform the four provinces that are part of our study. See Appendix Table 2 for descriptive statistics of the main sample.

As a measure of support for political Islamist groups, we collect electoral data from the legislative elections of 2008 provided by the Election Commission of Pakistan. In particular, we obtain constituency-level electoral results for the provincial assembly. Electoral constituencies are smaller than districts. Hence, we aggregate the results at the district level. Our main measure of support for Islamists groups is the population-weighted share of votes obtained by an alliance of Islamist parties, the *Muttahida Majlis-e-Amal* (MMA), across all constituencies within a given district. See the Data Appendix in Section 9 for further details. Figure 1 represents the geographic distribution of support for MMA.

We also use some additional data sources that we describe as they become relevant. For an exhaustive description of the data used in this paper see section 9 of the Online Appendix.

4 Empirical Strategy and Basic Results

Our objective is to evaluate the effect of the disclosure of information about the vaccine ruse and the subsequent anti-vaccine propaganda campaign on immunization rates. Our main outcomes of interest are dummies that take value 1 if a particular child has received the first dose of polio, DPT, or measles vaccine. The date of birth and the district of residence jointly set an individual child's exposure to the shock induced by the disclosure of the vaccine ruse.

Children born after July 2011 were fully exposed to the disclosure of the vaccine ruse, since their entire childhood took place after the information had been disclosed. Children born much earlier were not exposed to the disclosure of information, since they reached older ages before the information about the vaccine ruse was disclosed. Children born shortly before July 2011, were partially exposed, since part of their early months of life took place under the new information scenario.

In order to identify the partially exposed children and the non-exposed children, we empirically examine the age profiles of the three vaccines. The official immunization schedule—presented in Appendix Table 1—is not perfectly enforced. Hence, it is important to document how the likelihood of obtaining each vaccine changes as children get older.

[19] Vaccination status based on recall has been shown to be subject to a large extent of measurement error (Research and Development Solutions (2012); Sheikh et al (2011)). See section 9 of the Appendix for further details on the construction of our main outcome variables.

Figure 2 presents the monthly age profiles of the main vaccines. We restrict the sample to the pre-treatment period, so that the age profiles are not confounded with the disclosure of information on the vaccine ruse.[20] As we can see, the likelihood of obtaining the first dose of the polio and DPT vaccines increases during the first three months of life and remains constant thereafter. This is consistent with the first dose of these vaccines being received during regular visits of Lady Health Workers or during vaccination drives in the first months of life. This evidence also illustrates the imperfect compliance with the official calendar: the first dose of polio is supposed to be received at birth and the first dose of DPT in the 6th week of life. The last panel of the figure shows the age profile of the measles vaccine, which is supposed to be administered in the 9th month of life. As we can see, the probability of receiving the first dose of polio rapidly increases after the 9th month of life and reaches a plateau after the first year of life.

When considering immunization status of polio and DPT, we will consider children born in the three months prior to July 2011 as partially treated: the information on the vaccine ruse is disclosed at a time when their likelihood of receiving the vaccine was rapidly increasing. Similarly, when considering the measles vaccine, we will consider children born in the year prior to July 2011 as partially treated.

Note that the probability of receiving the first dose of these vaccines tends to increase during the first months of life. However, in each of the three cases, it reaches a plateau suggesting that a substantial fraction of children remains unvaccinated. This is consistent with certain families being isolated from vaccination (either because of lack of demand or lack of supply) and inconsistent with erratic or irregular supply of vaccines. In the latter case, we would expect a continuous increase in the probability of the receiving the vaccines as children get older.

Our main empirical strategy consists of comparing vaccination rates across cohorts of children with different levels of exposure to information on the vaccine ruse, and across regions that have different levels of support for Islamist parties. The underlying assumption is that parents in districts, in which higher support for political Islamist groups prevails, were more likely to change their believes about vaccines according to the messages spread by the Taliban.

In order to provide a visual representation of the variation used in this empirical design, Figure 3 presents the age profiles of children observed before and after the disclosure of information and across regions with different levels of support for Islamist parties. The

[20] In particular, we restrict the sample to PSLM waves 2008/9 and 2010/11. The latter wave was fielded before June 2011. We consider the vaccination status and the age of the child at the time they are surveyed. Hence, the vaccination status of all children is observed *before* the disclosure of the vaccine ruse.

figures on the left panel restrict the sample to districts in the first quartile of the distribution of support for Islamist parties. The figures on the right show the age profiles for districts in the top quartile of the distribution of support for Islamist parties.

The figures show that, in regions with low support for Islamist parties, the immunization age profiles are similar before and after the disclosure of information on the vaccine ruse. In contrast, the right figures show that, in regions with high support for Islamist groups, vaccination rates experienced a substantial decline after the disclosure of information on the vaccination ruse. This result is consistent with the hypothesis that, in regions with high levels of support for Islamist groups, a larger proportion of parents were influenced by the anti-vaccine propaganda spread by the Taliban, became more skeptical about vaccination, and actively decided not to vaccinate their children.[21]

In Appendix Figures 1 and 2, we examine the age profiles for complete immunization. The PSLM survey only records the first three doses of polio and DPT, as well as the first dose of measles. Hence, we consider a child completely immunized against each disease if she received all dosages recorded in the survey. Similarly, we consider children "completely immunized" once they have received all dosages of all vaccines documented in the survey. See section 9 in the Appendix for further details.

Appendix Figure 1 shows the age profiles for full immunization of polio and DPT. Note that since we only have data on one dose of the measles vaccine, the corresponding figure would be equivalent to the one presented in Figure 2. The third panel of Appendix Figure 1 shows the age profile of full immunization for the three vaccines. The figures show a steady increase in the likelihood that children are fully immunized during the first 14 months of life. Hence, when the outcome is full immunization, we will consider children born between May 2010 and July 2011 as partially treated.

Appendix Figure 2 presents the age profiles for full immunization, before and after the disclosure of information and across regions with different levels of support for Islamist parties. The results are similar to the ones documented for the first doses of each vaccine. In regions with low support for Islamist groups there are no differences in the age profiles. However, regions with high support for Islamist parties experience a decline of full immunization rates after the information on the vaccine ruse was disclosed.

[21] Note that the decline in vaccination rates seems to be higher for children older than six months. However, it is important to keep in mind that differences across cohorts and differences on the intensity of the treatment over time could generate a differential impact on children observed with different ages. We provide a more detailed examination of the dynamic effects across cohorts in the econometric analysis.

Regression Framework

Despite the fact that the previous results provide suggestive evidence on the effects, we were not controlling by cohort or district fixed effects. Next, we estimate the following econometric model to allow for the inclusion of controls.

$$Y_{ikaj} = \gamma_0 + \gamma_k + \gamma_j + \gamma_a + \sum_k \beta_k D_k I_j + \delta c_i + \epsilon_{ikaj} \quad (1)$$

where Y_{ikaj} is a dummy that captures the vaccination status of child i, born in month-year k, interviewed at age a, and living in district j. D_k is a dummy indicating whether the child belongs to month-year cohort k. I_j is the district-specific measure of treatment intensity, i.e. our proxy for support for Islamists parties. We define this measure in terms of standard deviations of the electoral support for Islamist parties, in order to facilitate the interpretation of the magnitudes. γ_0 is a constant. γ_k are monthly cohort fixed effects. γ_j are district fixed effect. γ_a are monthly age-at-interview fixed effects. c_i represents individual-level controls (in particular, month-of-interview fixed effects to control for seasonality and a dummy that takes value 1 for rural regions in the district).[22] The sample includes children born between 2010 and 2012. The omitted category corresponds to the cohort born in January 2010 and standard errors are clustered at the parent district level.[23]

This specification allows a fully flexible pattern of treatment effect estimates per cohort. We expect β_k to take negative values for the fully exposed cohorts—born after July 2011—and possibly for the partially treated cohorts—born in the months leading to July 2011. Cohort fixed effects control for all factors that are common across cohorts, such as nation-wide economic growth or improvements in health and nutrition over cohorts. District fixed effects control for all time (or cohort) invariant factors such as geography, climate, or religiosity. Hence, the coefficients β_k are identified out of within cohort variation across districts with different levels of support for Islamist groups.

Figure 4 plots the β_k estimates and 90% confidence intervals for different monthly cohorts. Consistent with what we expected, the estimates corresponding to cohorts fully exposed to the disclosure of the vaccination ruse—i.e. those born after July 2011— are negative. This is specially the case for those born in the year after the disclosure of the information. Hence, the results are consistent with a drop in the demand of vaccines, possibly generated by an

[22]The figures are very similar when including only cohort and district fixed effects as controls. They are presented in Figure 4 of the Online Appendix.

[23]During the sample period some districts experienced divisions. We cluster the standard error at the level of districts in existence in 2008. Our measure of support for Islamist parties and district fixed effects are defined according to their boundaries in 2012. See Appendix section 9 for details on the construction of the data.

increase in distrust in formal medicine and vaccines in particular.

In contrast, the estimates for cohorts born much earlier than July 2011 fluctuate around 0 and are not statistically significant. This is consistent with the lack of differences in the evolution of vaccination rates across cohorts between districts with different levels of support for Islamist parties. In other words, it supports the lack of pre-trends and, hence, our main identification assumption.

Consistent with the evidence on the age profiles, we also observe declines in vaccination rates for cohorts partially affected by the disclosure of the vaccination ruse. Children born 3 to 4 months prior to July 2011 experience drops in the likelihood of having received the polio or the DPT vaccines, whereas those born 8 months prior to July 2011 experience declines in the likelihood of the vaccination of measles.[24] The fact that the pattern of vaccination rates of partially treated children is consistent with the evidence obtained from the age profile of the different vaccines is reassuring and consistent with the notion that the information disclosed in July 2011 affected the administration of these vaccines.

Appendix Figure 3 shows similar estimates for complete immunization of polio, DPT, and the three vaccines. We observe significant drops in immunization rates for fully exposed cohorts. Consistent with the age profiles of full immunization, we observe steady declines in immunization rates for those cohorts that were partially affected by the disclosure of information on the vaccine ruse.

In Appendix Figure 5, we incorporate data from an earlier wave of the PSLM survey to show a longer sequence of pre-treatment coefficients. We report this results for our main outcomes: receiving the first dose of each vaccine. The results on full immunization are similar and available upon request. While the pre-treatment coefficients are more noisily estimated, they fluctuate around zero and confirm the absence of pre-trends.[25]

5 Main Regression Estimates

In this section, we present the main regression estimates to assess the magnitude and significance of the decline in vaccination rates. To provide a stark comparison, we compare vaccination rates between cohorts fully exposed to cohorts not-exposed to the new infor-

[24]The age profiles of the polio and DPT suggest that the likelihood of receiving the first dose of these vaccines reaches a plateau in the third month of life. However, we also observe declines in the fourth month prior to the treatment. This is likely to be driven by measurement errors on the date of birth, with some children partially affected reporting dates of birth in the prior month.

[25]Appendix Figure 5 includes children born between 2007 and 2012. The omitted category corresponds to children born in 2007.

mation environment. Hence, we exclude from the sample the partially treated cohorts.[26] We then investigate how this difference varies across regions with different levels of Islamist groups. In other words, we implement the following *Difference-in-Differences* (DID, henceforth) empirical strategy:

$$Y_{ikaj} = \gamma_0 + \gamma_k + \gamma_j + \gamma_a + \beta Post_k I_j + \delta c_i + \epsilon_{ikaj} \tag{2}$$

where $Post_k$ takes value 1 for cohorts of children fully exposed to the disclosure of the vaccine ruse—that is, children born after July 2011—, and takes value 0 for not-exposed cohorts. The other variables are defined as in equation (1). Standard errors are clustered at the parent district level.

Panel A of Table 1 presents the main DID estimates, β, for indicators of having received the first dose of different vaccines. As we can see, all the estimates are negative and statistically significant: a one standard deviation increase in the support for Islamist groups is associated with declines of 4.5, 4.3, and 2.9 percentage points in the vaccination rates of polio, DPT, and measles, after the disclosure of information on the vaccine ruse.[27] These declines in vaccination rates represent a 9 - 13% decline in vaccination rates over the sample mean. Note that, if one were to take into account the externalities that vaccinations generate, the decline on herd immunity of these declines in immunization rates will be much larger.

Panel B of Table 1 presents the results on receiving all dosages of each vaccine. In column 4, we present the results on complete immunization defined by receiving all dosages of the three vaccines. The effects are similar in magnitude to those for the first dosage. For instance, one standard deviation increase in support for Islamist groups is associated to a 11% decline in full immunization rates. Since the results are similar, in the rest of the paper we focus on the results on obtaining the first dosage of each vaccines.

These effects are consistent with the hypothesis that the disclosure of information on the vaccine ruse generated an increase in distrust towards formal medicine, which made parents become more hesitant about vaccines, and lead some of them to actively refuse vaccines. It is likely that this increase in distrust was larger in regions with high support for Islamist groups, either because these regions were more exposed to the anti-vaccine propaganda campaigns by the Taliban, or because a larger fraction of the population was prone to trust the anti-vaccine messages spread by the Taliban. In section 6 we provide further discussion on the potential mechanisms behind this results and provide additional supporting evidence for a

[26]See Table notes for details on the excluded cohorts.

[27]The results are similar if we only include cohort and district fixed effects, as in the most basic DID model. These results are presented in Appendix Table 3.

potential distrust channel.

Heterogeneous Effects

Next, we explore whether the effects are heterogenous depending on the gender of the child. Islamist extremists have recurrently claimed that polio vaccinations are a complot to sterilize Muslim children, girls in particular.[28] If the disclosure of the vaccination ruse lent higher credibility to this rumor, we would expect the results to be larger when the child is a female.

In Table 2, we present results that include a triple interaction with a dummy that takes value 1 if the child is a female. The triple interaction is negative and statistically significant for polio and DPT, suggesting that girls were differentially less likely to be vaccinated after the vaccine ruse was disclosed. These results are consistent with parents becoming even more skeptical of vaccinations when they had to vaccinate a girl. Hence, this is consistent with parents lending higher credibility to defamation messages of the Taliban groups. Note that the interaction of a post dummy variable and support for Islamist groups is negative for the three vaccines. This suggests that the effect of the disclosure of the vaccine on boys was also negative, but lower in magnitude than the effect on girls.

Robustness Checks

The main identifying assumption behind our empirical strategy is that, in the absence of the disclosure of information on the vaccine ruse, the across-cohorts evolution of vaccination rates would have been similar in districts with different levels of support for Islamist groups.

Note that the results presented in Figure 4 document the lack of differential trends across districts prior to the disclosure of the vaccine ruse. The point estimates fluctuate around zero and do not follow any specific pattern. The p-values of joint-significance of the pre-treatment coefficients are 0.69, 0.21, and 0.19 for the polio, DPT, and measles, respectively. Appendix Figure 5 shows the same figures with a longer pre-trend. While the point estimates in the pre-period are more noisy, they fluctuate around zero and do not show any systematic pattern, consistent with the absence of pre-trends.

In order to address remaining concerns, Table 3 presents a number of additional robustness checks. Column 1 reproduces our main results for comparison. Column 2 incorporates as controls pre-treatment measures of access to health services interacted with yearly-cohort fixed effects. In particular, we control for the share of women that had received tetanus

[28]See Scientific American (2013)

immunization, pre-natal care, and post-natal care during pregnancy. We measure these controls in the 2008/09 wave of the PSLM survey. In column 3 we include as controls the share of mothers with no formal schooling interacted with cohort fixed effects. The estimates are highly robust to the addition of these controls. These results mitigate the concern that the results could be driven by more underdeveloped districts experiencing a differential evolution of vaccination rates over time (or over cohorts).

Column 4 adds flexible controls for natural disasters. In 2010, a number of districts in Pakistan were affected by severe monsoon floods. To control for their effect we incorporate as controls an indicator for flood affectedness interacted with cohort fixed effects. The results are highly robust to the addition of these controls.

In column 5, we explore the possibility that our results are confounded by endogenous fertility decisions: if the disclosure of information on the vaccine ruse affected optimal fertility decisions our sample may be selected on parents that decided not to postpone having children because of the disclosure of information. Note that this selection pattern would only affect our estimates if there is a correlation between the number of parents whose fertility decisions was affected and support for Islamist groups. Furthermore, we believe that the shock is unlikely to have had affected the fertility decisions of a substantial fraction of the population since higher levels of distrust in vaccines is unlikely to make parents modify their decision of when to have children. Nevertheless, we empirically explore this possibility. Column 5 reports the results when we restrict the sample to children born before May 2012. Hence, we are effectively focusing on children conceived before the disclosure of the vaccine ruse. The results are negative and highly statistically significant. Note that the effects increase in magnitude. This is driven by the effects of the disclosure of the vaccination ruse being mitigated over time. This can also be observed in Figure 4. It is possible that over time the vaccine ruse became a less salient issue among the population. However, it is also possible that the mitigating effect was driven by an endogenous supply reaction. We further discuss this possibility in section 6.

Finally, column 6 drops the district of Abbottabad, where the operations to capture Bin Laden took place. The results are robust, suggesting that the evolution of vaccination rates in this district are not driving the results.

In Table 4, we assess the robustness of our results to non-linear specifications of support for Islamist parties. In Panel A, we show the results for above the median level of support for Islamist parties, whereas in Panel B we examine the effects by terciles. The panels are consistent with our baseline specification. The results indicate that the effects are monotonically increasing in the magnitude of support for Islamist groups. This is not affected by the particular functional form that we use for the support for Islamist parties.

Another potential concern is that the treatment may have induced differential migration across districts. This may have lead to a differential household composition across districts with different levels of support for Islamist groups. Changes in household composition could affect immunization rates. Unfortunately, the PSLM data does not contain information on migration or on parent's place of birth. We can nevertheless, verify that household characteristics do not change as a result of the treatment variable. We explore this in Table 5 by using child and household characteristics as dependent variables in our baseline specification. The dependent variable in column 1 is a dummy indicating whether a child is male. In column 2 and 3, the dependent variables are the mother's education level and age, respectively. Column 4 relies on a dummy that assumes value 1 if the household is residing in a rural area as a dependent variable. In columns 5 and 6, we use as outcomes dummy variables to indicate whether a household owns either a radio or a television set, respectively. Lastly, columns 7 and 8 treat the number of household members as well as the number of rooms available to the household in its residential dwelling as dependent variables. The results show that all estimated interaction coefficients are close to zero and statistically insignificant. This supports the notion that there were no differential changes in the sample composition across repeated cross-sections that could possibly confound the baseline results.

6 Mechanisms

The results presented in this paper are consistent with the hypothesis that the disclosure of the vaccine ruse eroded the population's trust in vaccine and towards formal medicine. The disclosure of this information lent credibility to the ongoing anti-vaccine propaganda of the Taliban. Naturally, the Taliban used this opportunity to increase their efforts to discredit vaccines by increasing the number of anti-vaccine messages. We believe our treatment is explained by the combination of the disclosure of the information of the vaccine ruse and the increase in the intensity in the anti-vaccine propaganda of the Taliban.

It is possible that these events affected vaccination rates through different channels. It is useful to decompose these set of mechanisms in two groups: supply and demand channels.

One possible demand channel relates to the increase in distrust in vaccines among the population. As a result, a larger fraction of parents became more skeptical about vaccines and started actively refusing to vaccinate their children. We believe this mechanism is likely to have played an important role and we provide further supporting evidence below.

A second demand channel may relate to Taliban intimidation. Even if the level of distrust on vaccines was not affected, parents may have increasingly perceived vaccinating their children as an action in opposition to the Taliban's directives. In a context, where there was extensive Taliban intimidation this may have dissuaded some parents to vaccinate their children.

Third, the supply of vaccines may have been reduced as a result of intensified anti-vaccine propaganda of the Taliban. As reported in section 2, the Taliban attacked polio vaccination workers starting in mid-2012.

While these three channels may have played some role, we believe that the trust-demand channel is quantitatively important. Next, we present some evidence consistent with the relevance of the trust-demand mechanism.

If the disclosure of information eroded the level of trust in vaccines and in the medical sector, we may expect that households also reduced their demand for other health services. In Table 6, we investigate whether parents decided to consult a medical worker if their children got sick. We modify the empirical specification from a cohort to a time dimension.

$$Y_{itaj} = \gamma_0 + \gamma_t + \gamma_j + \beta Post_t I_j + \delta c_i + \epsilon_{itaj} \tag{3}$$

Y_{itaj} corresponds to a health seeking behavior measure related to child i, whose parents were interviewed in date t, at age a, and in district j; γ_t are quarter-year of interview fixed effects; γ_j are district fixed effects; $Post_t$ is a dummy that takes value 1 if the household was interviewed after July 2011; I_j is electoral support for Islamist parties in standard deviations; c_i contains individual-level controls: dummy for rural region and monthly age of children i. We focus on the same sample of children, younger than 24 months old to facilitate the comparison across results.[29]

The outcome variable in column 1 of Table 6 is an indicator for whether the child was sick in the two weeks prior to the date at which the survey took place. The results show that the likelihood of children getting sick was differentially higher in areas with higher support for Islamist parties. This suggests that the lower vaccination rates and demand of formal medicine might have made children more vulnerable to diseases.

In columns 2 to 4, we restrict the sample to children that reported being sick in the last two weeks. The dependent variable in column 2 is a dummy that takes on value 1 if the parents of a sick child indicated that they consulted anyone for the sickness of their child. We estimate a negative and significant effect, suggesting that parents were less likely to seek for help in the event of sickness. In the survey, parents are asked specifically which type of health care provider they consulted. In columns 3 to 4, we divide the answers among two

[29]Note, however, that we do not eliminate from the sample partially treated children in a cohort-sense. When we redefine the variation from a cohort to a time dimension, all health seeking behavior observed after July 2011 is subject to the new information scenario, while all behavior observed before July 2011 is not affected by the new information.

different possibilities. We find that the negative effect on demand for consultation is driven by asking for help in the formal medical sector — hospital, basic health units and lady health workers. In contrast, there is a positive effect, albeit not significant, in consulting non-formal medicine — spiritualist, homeopath, chemist, hakeem, or other. Hence, consistent with the demand channel, we find that parents in districts with higher Islamist sentiments reduced their demand for formal medicine after the disclosure or information about the vaccine ruse.

An alternative channel that could also provide an explanation for our main results could be that the supply of medical services, such as vaccination drives, may have endogenously reacted to the disclosure of the vaccine ruse. Starting in mid-2012 the Taliban carried out attacks and intimidation of health workers. While this is a plausible channel, we believe it cannot account for the entire magnitude of our effects. The intimidation of health workers only started to take place about a year after the disclosure of the vaccine ruse, while we observe a decline in vaccination rates immediately after the disclosure. Furthermore, our analysis focuses on the period 2010-2012, when the attacks and intimidation to health workers were rare.

Furthermore, note that the evidence presented in panel A of Table 2 is not fully consistent with the results being entirely driven by a supply channel. We observe that the decline in vaccination rates was higher for girls than for boys. This is consistent with the rumors spread by the Taliban that vaccinations were a conspiracy to sterilize Muslim girls. However, the supply of vaccines is unlikely to be differential between boys and girls, since Lady Health Workers and EPI have a mandate to vaccinate and treat all children equally regardless of their gender.

7 Conclusion

In this paper, we provide empirical evidence on the causal effect of the disclosure of information that damages the reputation of vaccines or health system on immunization rates. We exploit a sequence of events that took place in the recent history of Pakistan and that severely affected the degree to which citizens trusted formal medicine and vaccines, in particular. As part of the operations to capture Osama Bin Laden in 2011, the CIA launched a fake vaccination campaign in the city of Abbottabad, Pakistan. The disclosure of this information caused uproar in Pakistan. The Pakistani Taliban used this information to intensify their discrediting campaign against formal medicine and polio vaccination, in particular.

We empirically evaluate the effects of the disclosure of the vaccination ruse on immunization rates. We use household-level data from several waves of the Pakistani Social Living Standards Measurement (PSLM) survey to implement a *Difference-in-Differences* strategy

(DID, henceforth) where we compare immunization rates of children born before and after the vaccine ruse was disclosed and, across districts, depending on the extent of support for Islamist groups. Our underlying assumption is that, on average, parents in districts with higher support for political Islamist groups will be more likely to change their believes about vaccines according to the messages spread by the Taliban. As a measure of support for Islamist groups we use district-level measures of electoral support for *Muttahida Majlis-e-Amal* (MMA), which is a coalition of Islamist parties that ran under a single banner in the 2008 general election.

Our estimates suggest that the disclosure of the vaccine ruse had substantial effects on vaccination rates: a one standard deviation increase in the support for Islamist groups leads to approximately an 9 to 13% larger decline in the likelihood that children have received the first dose of a number of different vaccines.

These results are consistent with the hypothesis that the disclosure of the vaccine ruse damaged the reputation of vaccines. As a result, a larger fraction of parents were hesitant about vaccinations or decided to actively refuse to vaccinate their children. Consequently, immunization rates declined. These effects are stronger in regions where political Islamist groups had higher rates of support. This is consistent with the idea that individuals ideologically close to the Taliban were more likely to receive their messages discrediting vaccines and changed their beliefs accordingly.

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Figure 1: Distribution of Electoral Support for MMA

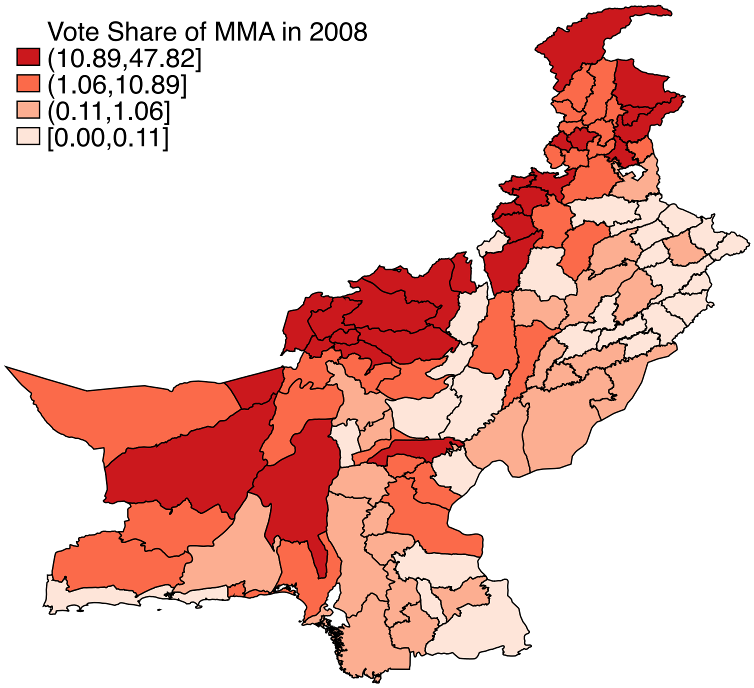


Figure 2: Age Profiles of Vaccines (Pre-Treatment Period)

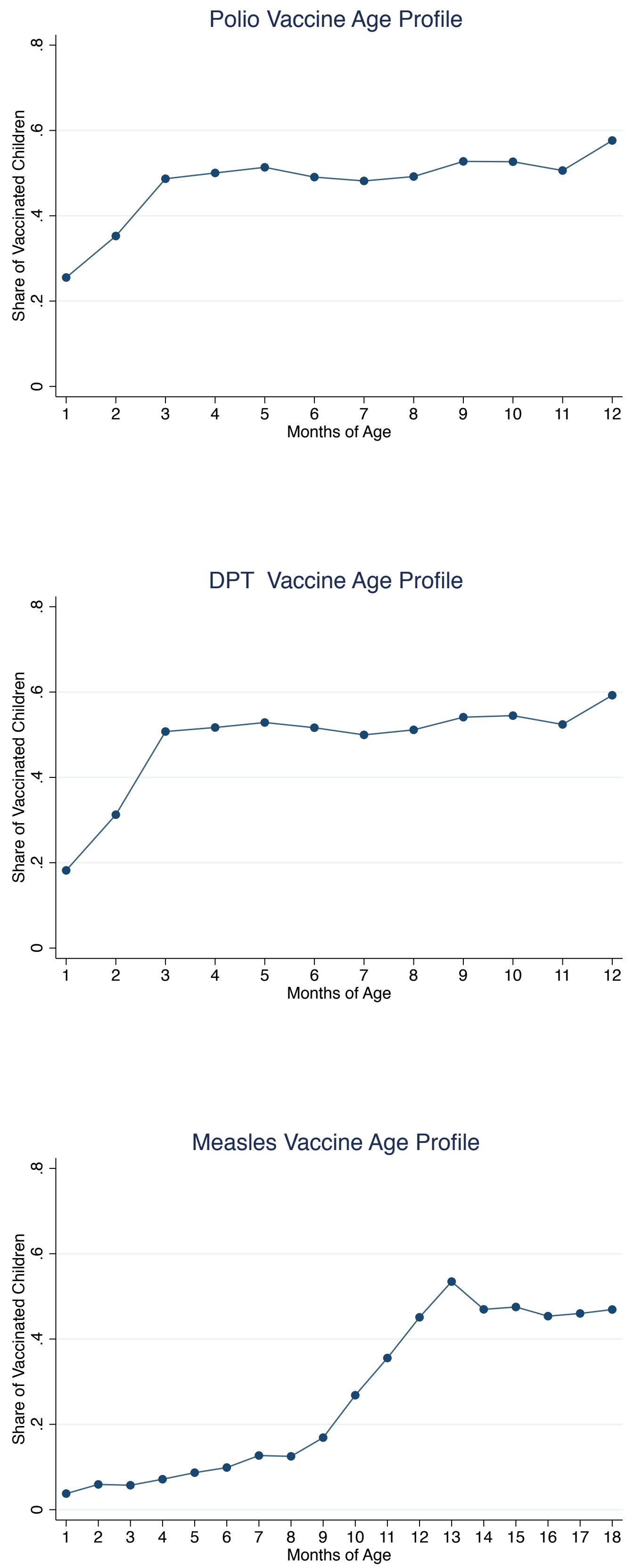


Figure 3: Age Profiles of Vaccines. Before & After Treatment. By level of Islamist Support

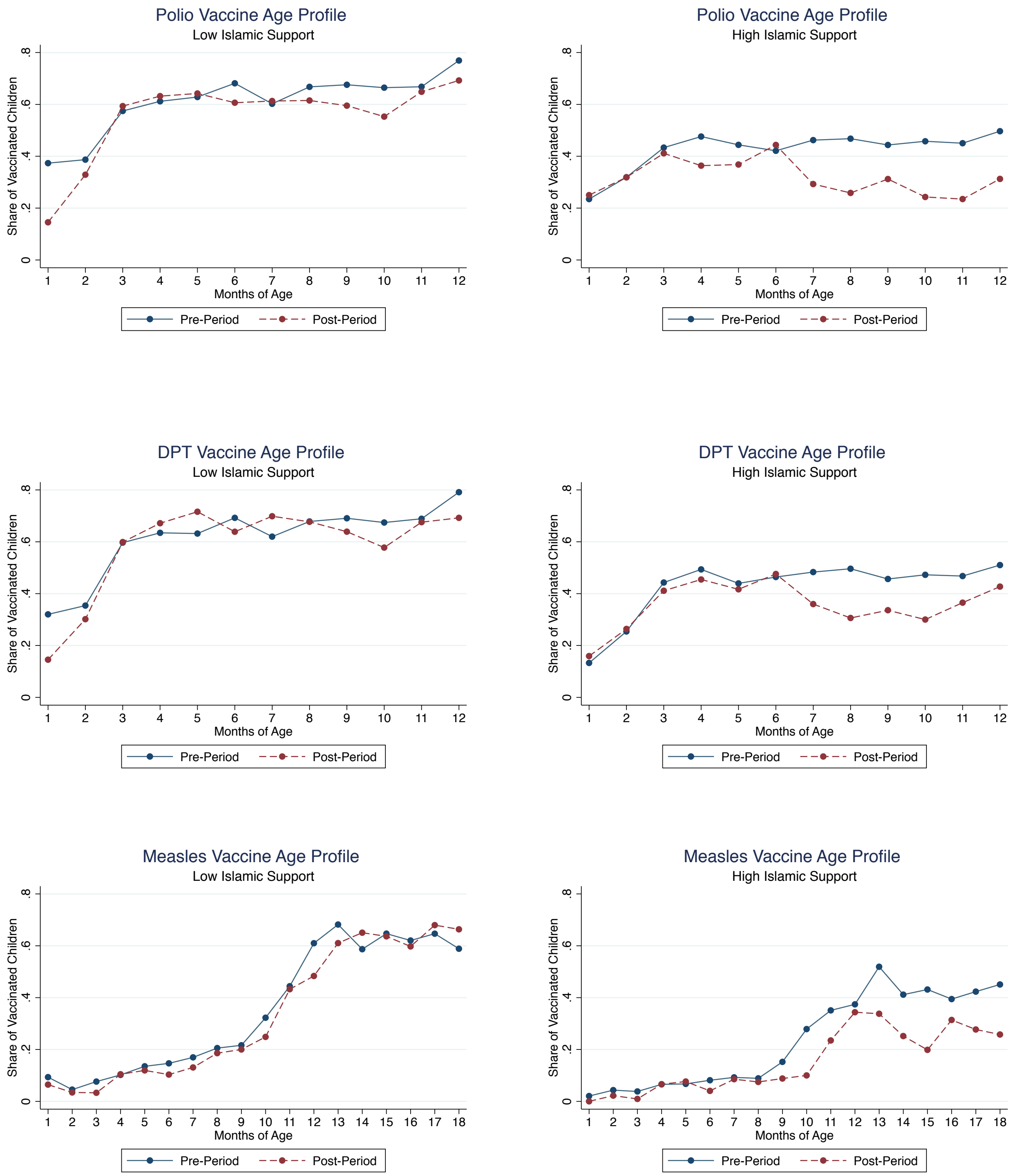
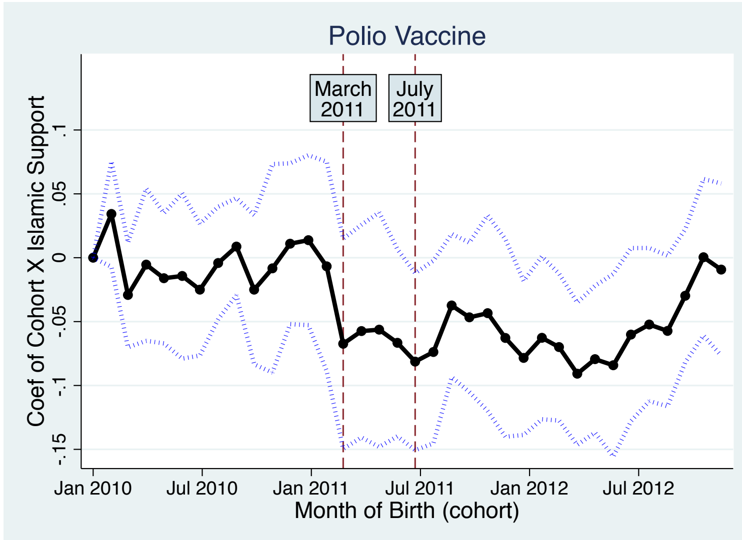
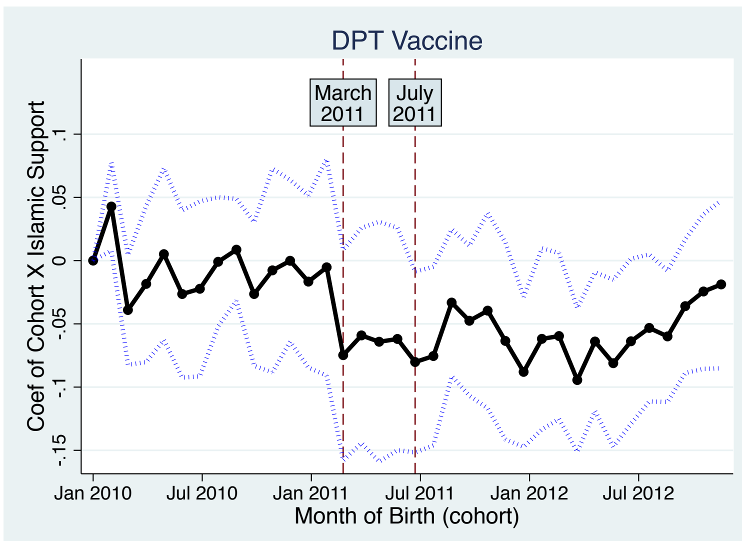
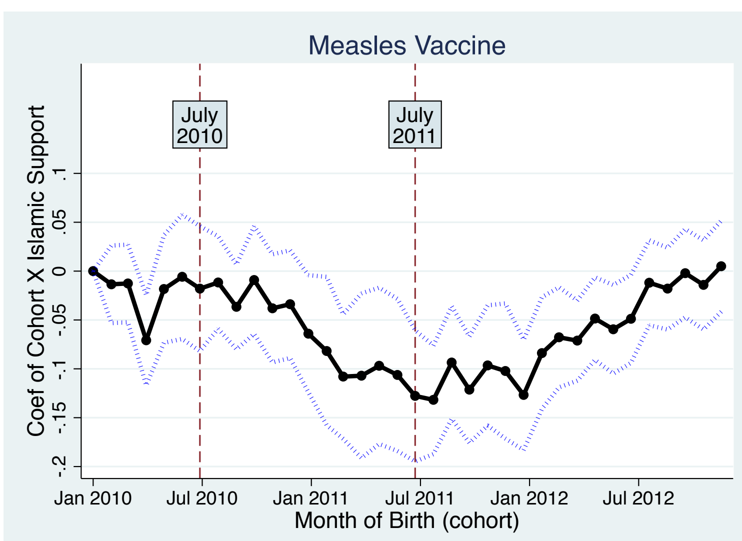


Figure 4: Treatment Effects by Monthly Cohort







8 Tables

Table 1. Effects of the Disclosure on Vaccination Rates. Main Results

	Dependent Variables:			
	Polio	DPT	Measles	All Vaccines
	(1)	(2)	(3)	(4)
	Panel A. 1st Dose of Each Vaccine			
Mean Dep. Var.	*0.422*	*0.455*	*0.231*	
Post × IslSup	-0.045**	-0.043**	-0.029**	
	(0.019)	(0.017)	(0.014)	
Observations	20,350	20,350	16,175	
R-squared	0.269	0.251	0.253	
Number of Clusters	109	109	109	
	Panel B. All Doses of Each Vaccine			
Mean Dep. Var.	*0.338*	*0.371*	*0.231*	*0.213*
Post × IslSup	-0.042**	-0.042**	-0.029**	-0.025*
	(0.017)	(0.017)	(0.014)	(0.014)
Observations	14,901	14,901	16,175	14,901
R-squared	0.279	0.260	0.253	0.263
Number of Clusters	109	109	109	109

Notes: Standard errors clustered at the parent district-level in parentheses. There are 114 districts in the sample. The unit of observation is the child level. The sample consists of children born between 2010 and 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. In particular, for both the first dose of Polio and DPT, we exclude children born between March and June 2011. In the case of Measles, we exclude children born between July 2010 and June 2011. For the receipt each dose of Polio, DPT as well as for all vaccines, we exclude children born between May 2010 and June 2011. All regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions. The dependent variables in Panel A take value 1 if the first dose of each vaccine was received, 0 otherwise. The dependent variables in Panel B take value 1 if a child has received all doses of a given vaccine, 0 otherwise. In particular, for Polio and DPT, we require that the child has received the first 3 shots of vaccine and for measles we require that the child has received the first dose of measles vaccine. The outcome for all vaccines combines all of these requirements. *** p<0.01, ** p<0.05, *p<0.1.

Table 2. Heterogenous Effects by Child or Household Characteristics

	Dependent Variable: Dummy for 1st Dose of each Vaccine		
	Polio	DPT	Measles
	(1)	(2)	(3)
Post × IslSup	-0.031*	-0.030*	-0.018
	(0.018)	(0.018)	(0.014)
Post × IslSup × Female	-0.029**	-0.029**	-0.024
	(0.012)	(0.013)	(0.016)
Observations	20,350	20,350	16,175
R-squared	0.269	0.251	0.253

Notes: Standard errors clustered at the district-level in parentheses. The unit of observation is the child level. All regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions. All regressions include all the double interactions: post x female, IslSup x female. *** p<0.01, ** p<0.05, *p<0.1.

Table 3. Robustness Checks

	Baseline	Initial Health x Cohort FE	Initial Education x Cohort FE	Flood-Affected x Cohort FE	Dropping children born after May 2012	Drop District of Abottabad
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. First Dose of Polio Vaccine					
Post × IslSup	-0.045**	-0.036**	-0.032*	-0.039**	-0.058***	-0.042**
	(0.019)	(0.016)	(0.019)	(0.017)	(0.020)	(0.018)
Observations	20,350	20,350	20,350	20,350	14,526	20,171
R-squared	0.269	0.271	0.269	0.271	0.253	0.271
	Panel B. First Dose of DPT Vaccine					
Post × IslSup	-0.043**	-0.039***	-0.045**	-0.042**	-0.056***	-0.040**
	(0.017)	(0.015)	(0.018)	(0.017)	(0.019)	(0.016)
Observations	20,350	20,350	20,350	20,350	14,526	20,171
R-squared	0.251	0.254	0.251	0.251	0.234	0.253
	Panel C. First Dose of Measles Vaccine					
Post × IslSup	-0.029**	-0.028**	-0.034**	-0.029**	-0.065***	-0.027**
	(0.014)	(0.014)	(0.015)	(0.014)	(0.018)	(0.013)
Observations	16,175	16,175	16,175	16,175	10,351	16,038
R-squared	0.253	0.257	0.257	0.254	0.255	0.254

Notes: Standard errors clustered at the district-level in parentheses. The unit of observation is the child level. All regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions Column 2 adds controls for district-level measures of access to health services as reported in the 2008/9 PSLM share, respectively interacted with yearly cohort fixed effects. The health measures are the share of mothers that received pre-natal care, post-natal care, and tetanus vaccine during previous pregnancy. Column 3 adds controls for share of mothers that had no formal education in 2008/9 interacted with yearly cohort fixed effects. Column 4 adds as controls a dummy for whether the district was severely affected by floods in 2010 interacted with yearly cohort fixed effects. Column 5 drops children born after May 2012. Column 6 drops the district where Abottabad is located. *** p<0.01, ** p<0.05, *p<0.1.

Table 4. Robustness Checks. Alternative Specifications of Support for Islamist Groups

	Dependent Variable: Dummy for Receipt of 1 Vaccine Dose		
	Polio	DPT	Measles
	(1)	(2)	(3)
Mean Dep. Var.	*0.422*	*0.455*	*0.231*
	Panel A. Cutoff-Level: Median		
Post × 1(IslSup>P50)	-0.117***	-0.104***	-0.049**
	(0.033)	(0.031)	(0.023)
Observations	20,350	20,350	16,175
R-squared	0.271	0.252	0.253
	Panel B. Cutoff-Levels: Terciles		
Post × 1(IslSup>P33 & IslSup<P66)	-0.097**	-0.074**	-0.033
	(0.040)	(0.037)	(0.024)
Post × 1(IslSup>P66)	-0.140***	-0.133***	-0.075**
	(0.037)	(0.037)	(0.032)
Observations	20,350	20,350	16,175
R-squared	0.271	0.253	0.253

Notes: Standard errors clustered at the district-level in parentheses. The unit of observation is the child level. All regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions. *** p<0.01, ** p<0.05, *p<0.1.

Table 5. Robustness Checks. Lack of Household Compositional Changes

	Dependent Variables:							
	Dummy for Male Child	Mother's Education	Mother's Age	Dummy for Rural Region	Dummy for Radio Ownership	Dummy for Television Ownership	Number of Household Members	Number of Rooms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean Dep. Var.	*0.514*	*3.528*	*27.930*	*0.658*	*0.223*	*0.581*	*8.268*	*2.637*
Post July2011 × IslSup	-0.006	0.012	-0.087	-0.004	-0.003	-0.018	0.065	0.063
	(0.008)	(0.061)	(0.147)	(0.009)	(0.017)	(0.017)	(0.083)	(0.044)
Observations	22,346	22,346	22,346	22,346	22,346	22,346	22,346	22,346
R-squared	0.008	0.261	0.027	0.190	0.145	0.230	0.094	0.112

Notes: Standard errors clustered at the district-level in parentheses. The unit of observation is the child level. All regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions (except for the specification displayed in column 4). *** p<0.01, ** p<0.05, *p<0.1.

Table 6. Effect on Health Seeking Behavior

	Dependent Variables:			
	Dummy for Illness in Last 2 Weeks	Dummy for Consulted Anyone	Dummy for Consulted Formal Medical Sector	Dummy for Consulted Informal Medical Sector
	(1)	(2)	(3)	(4)
Mean Dep. Var.	*0.191*	*0.981*	*0.926*	*0.055*
Post July2011 × IslSup	0.032**	-0.018*	-0.040*	0.021
	(0.013)	(0.010)	(0.022)	(0.018)
Observations	22,346	4,260	4,260	4,260
R-squared	0.063	0.063	0.144	0.139

Notes: Standard errors clustered at the district-level in parentheses. The unit of observation is the child level. All regressions include district fixed effects, quarter of interview fixed effects, monthly age, and a dummy for rural regions. In column 3, formal medical sector corresponds to hospital, basic health units and lady health workers. In column 4, informal medical sector corresponds to spiritualist, homeopath, chemist, hakeem, or other. *** p<0.01, ** p<0.05, *p<0.1.

Online Appendix

9 Data Appendix

Data Sources

Pakistan Social and Living Standards Measurement (PSLM)

The PSLM Project is designed to provide social & economic indicators at district levels. It is implemented by the Pakistan Bureau of Statistics. We use the PSLM survey waves implemented in 2010/11 and 2012/13 for our main analysis. For robustness, we further complement the analysis with data from the survey wave implemented in 2008/09. We construct the following outcomes of interest from survey responses in the Vaccination Diarrhea module of the PSLM survey.

Firstly, we construct indicators for the receipt of different doses of vaccines. In particular, we consider and construct indicators for polio, DPT, as well as, measles vaccines. Enumerators for the PSLM surveys could choose among the following options in order to record a child's vaccination status: 1) yes (based on vaccination card); 2) yes (based on recall); 3) no; 4) yes (polio campaign). We focus only on the first choice as a measure of immunization. Vaccination status measures based on recall have been shown to be prone to suffer from severe measurement error (Research and Development Solutions (2012); Sheikh et al (2011)). Hence, when constructing the outcome variable "received one shot of *vaccine type*", we code answers based on recall as 0.

We also construct indicators for full immunization. The PSLM survey only records the first three doses of polio and DPT, as well as the first dose of measles.[30] Hence, we consider children fully immunized against polio or DPT if the three doses reported in the survey have been provided and registered in the vaccination card.[31] Similarly, the survey only recorded information regarding the first dose of the measles vaccine. Hence, we cannot assess full immunization for measles. We also combine information on the three vaccines to create a measure of *"complete immunization"*. We consider a child to be completely immunized if all doses of polio, DPT vaccine, and measles, were recorded in the survey.

Secondly, the vaccination & diarrhea module of the PSLM survey also contains some information on general measures of health seeking behavior. The available information allows us to construct the following measures:

[30] In 2009/10 the World Health Organization began recommending a first dose of the polio vaccine at birth in high endemic regions, as well as a second dose of the measles vaccine at 15 months of age (see World Health Organization 2010). The reason why the PSLM survey differs from the official vaccination calendar is probably that the survey was not updated after these changes in the official vaccination calendar.

[31] See Appendix Table 1 for the official vaccination calendar.

- *Dummy for Illness in Last 2 Weeks:* Survey respondents are asked in the survey - for each child separately - whether a child was ill or injured in the two weeks prior to the survey. We use this information to construct a dummy variable that has value 1 if the respondent states that a given child was ill or injured in the two weeks prior to the survey, 0 otherwise.

- *Dummy for Consulted Anyone:* For each child which was reported as had been ill or injured in the two weeks prior to the survey, the survey respondent was then asked whether anyone was consulted regarding the reported illness or injury. We use this information to construct a dummy variable that assumes value 1 if the respondent states that someone had been consulted regarding the illness or injury, 0 otherwise.

- *Dummy for Consulted Formal Medical Sector:* If a respondent reported that a child had been ill or injured in the two weeks prior to the survey and also stated that someone had been consulted regarding the illness or injury, the survey enumerators also elicited which part of the medical sector in Pakistan had been consulted. This allows us to construct a dummy variable that assumes value 1 if the respondent states that the formal medical sector in Pakistan was consulted regarding the illness or injury. In particular, we consider the answer choices *"Private Dispensary/Hospital"*, *"Government Hospital"*, *"Rural Health Clinic/Basic Health Unit"* and *"Lady Health Worker"* as representing the formal medical sector.

- *Dummy for Consulted Informal Medical Sector:* If a respondent reported that a child had been ill or injured in the two weeks prior to the survey and also stated that someone had been consulted regarding the illness or injury, the survey enumerators also elicited which part of the medical sector in Pakistan had been consulted. This allows us to construct a dummy variable that assumes value 1 if the respondent states that the informal medical sector in Pakistan was consulted regarding the illness or injury. In particular, we consider the answer choices *"spiritualist"*, *"homeopath"*, *"chemist"*, *"hakeem"* and *"other"* as representing the informal medical sector.

Electoral Data Provinces elect provincial assemblies as their legislature. The members of these provincial assemblies are directly elected during general elections and serve 5-year terms.

We obtained constituency-level data for the general election to the provincial assembly of 2008. We obtained the names of all the contesting candidates, their political parties, and the number of votes obtained by each candidate. We use the official delimitation of 2002 and the amendments of 2008 published in the *Gazette of Pakistan* to locate constituencies within the districts of Pakistan.

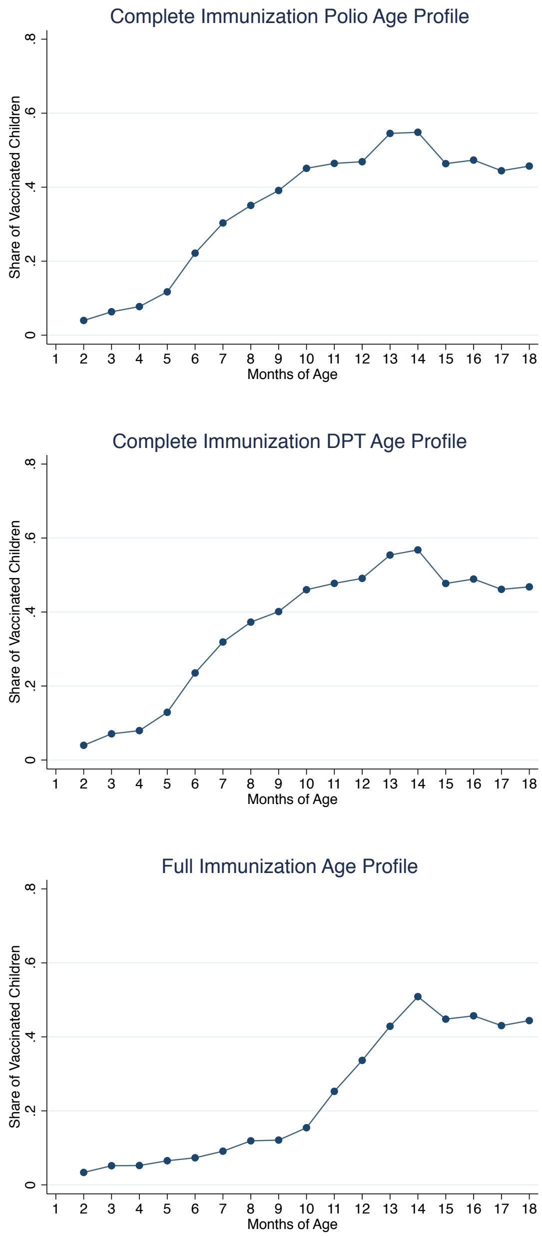
Since electoral constituencies are smaller than districts, we construct a district-level measure of support for different parties. In particular, we calculate the population-weighted average share of votes across all constituencies of a district. The weights correspond to the share of the population living in the respective constituency relative to the overall district population. In the absence of population data, we use number of total votes as a proxy for population numbers. Hence, our main measure of Islamist sentiments is the population-weighted share of votes obtained by the Islamist parties alliance MMA, across all constituencies within a given district in the 2008 provincial legislative election. The spatial distribution of this measure of support for Islamist political parties across the districts of Pakistan is presented in Figure 1.

Construction of the Dataset We combine datasets from multiple sources to conduct our analysis. The different datasets are matched by district and time period (month and year). The matching is performed by current district of residence as well as month and year of child birth.

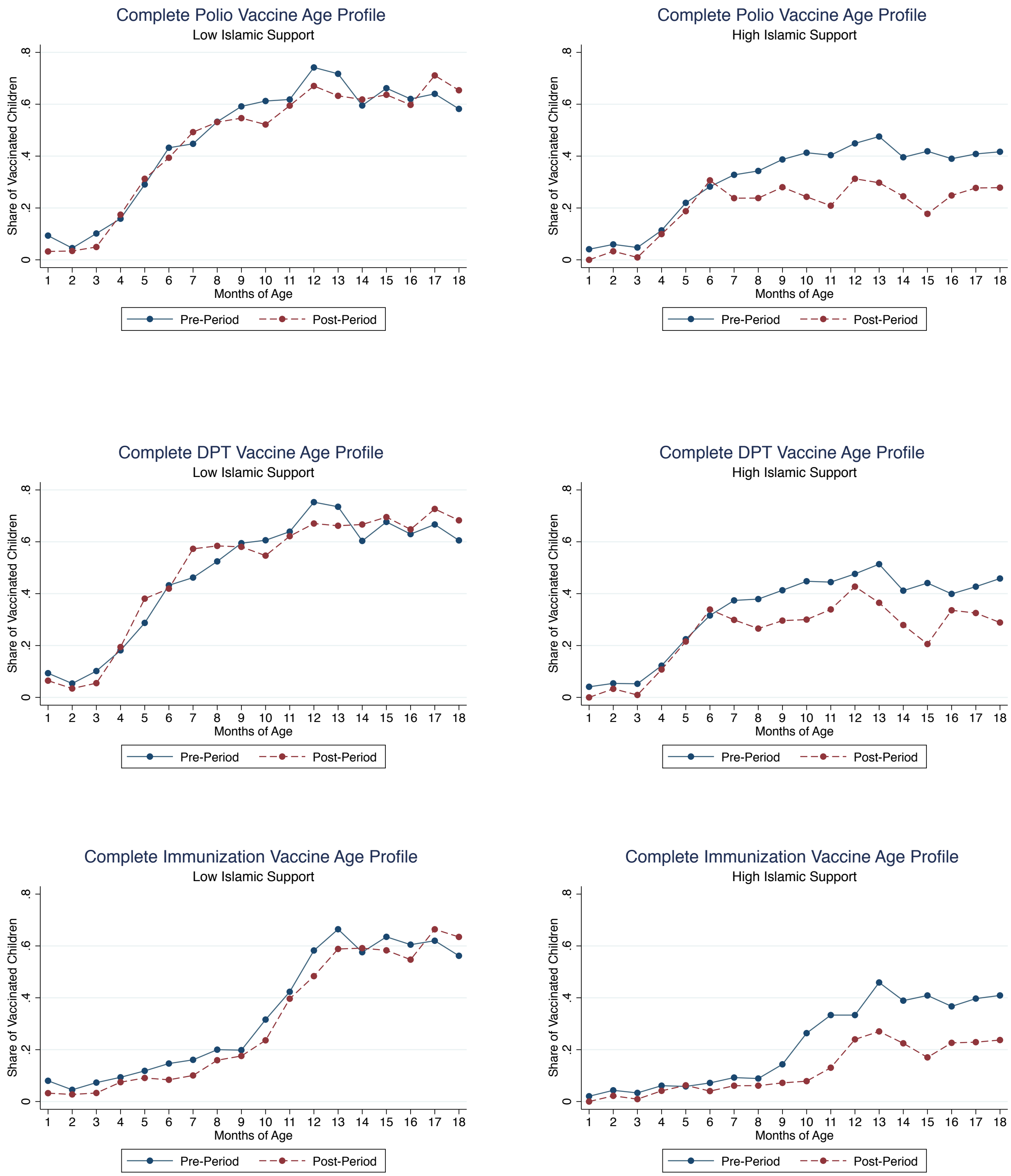
Over the course of our sample period, Pakistan experienced a mild process of district splitting. In particular, the number of districts in our study provinces increased from 109 to 114 between 2008 and 2012. We refer to the former set of districts as the *parent* districts and to the later set of districts are labeled *current* districts. Given the lower level of aggregation of our electoral data, we are able to calculate our measure of support for Islamist political parties at the level of current districts. Moreover, all regressions use district fixed effects at the current district level. However, in our analysis, we cluster standard errors at the level of parent districts to allow for potentially correlated errors across current districts that originated from the same parent district.

10 Appendix Figures

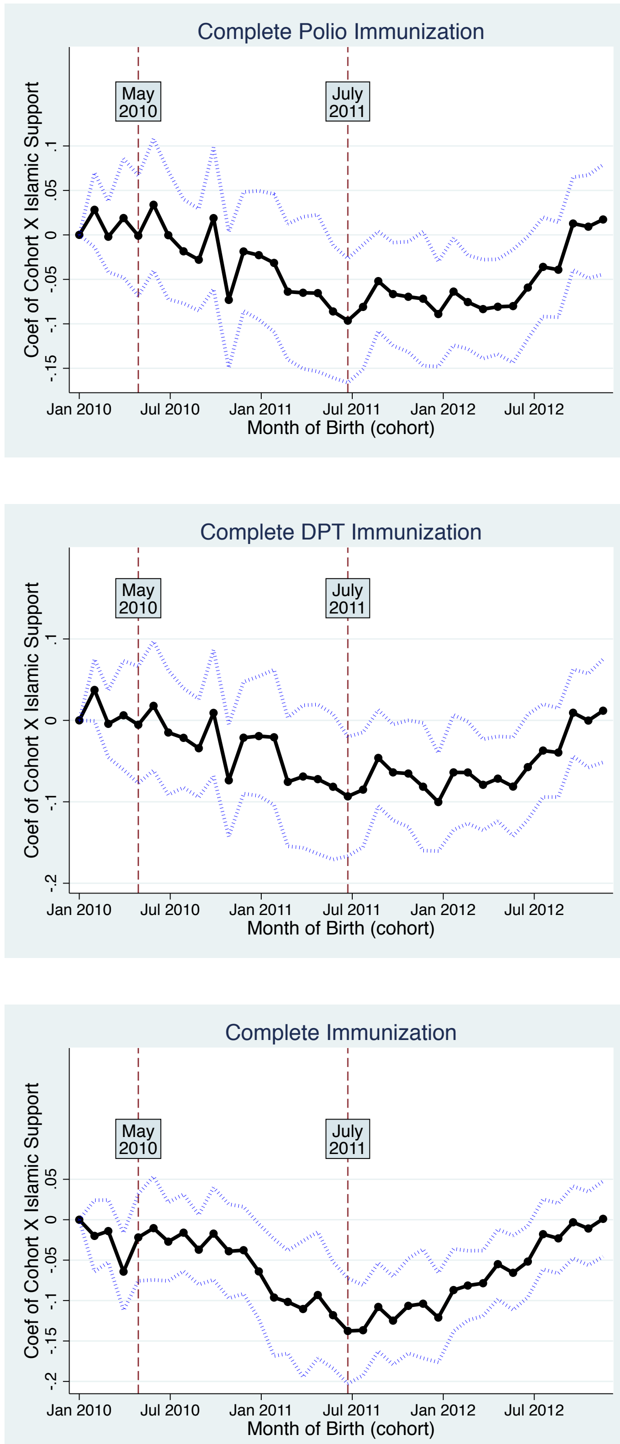
Appendix Figure 1. Age Profile for All Doses of Vaccines. Pre-Treatment Period



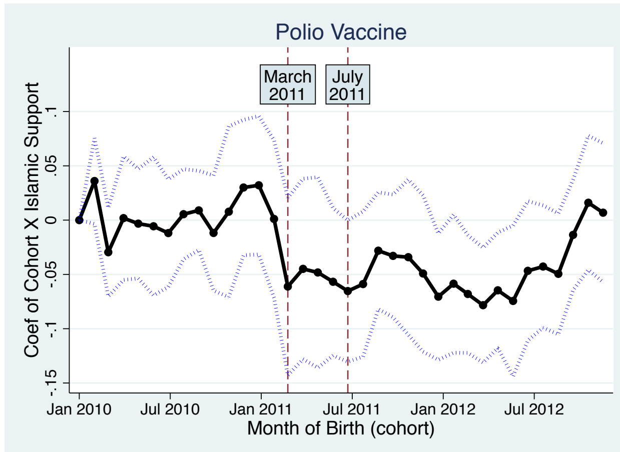
Appendix Figure 2. Age Profile for All Doses of Vaccines. Before & After Treatment. By Level of Islamist Support

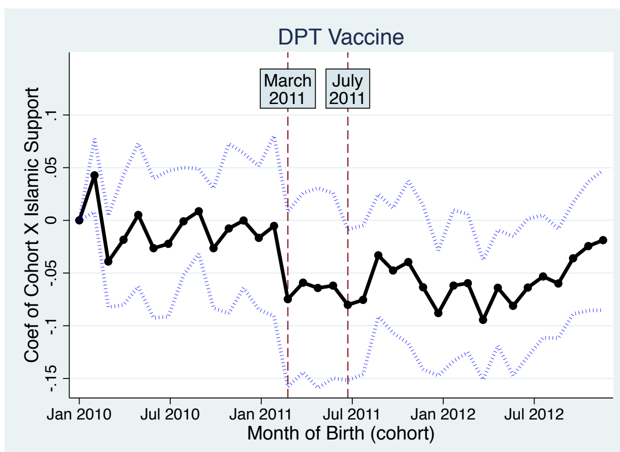


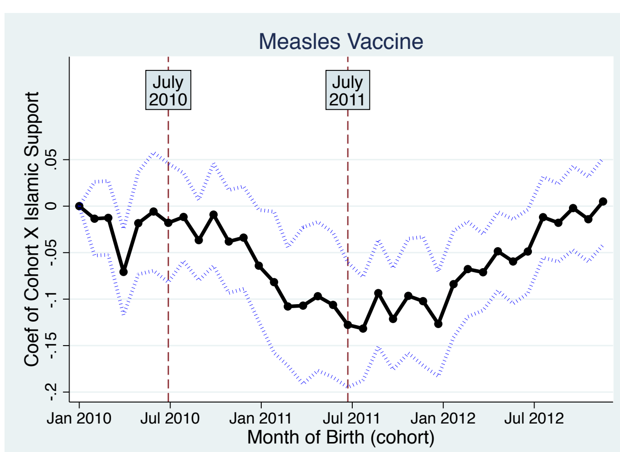
Appendix Figure 3. Treatment Effects by Monthly Cohort. Full Immunization



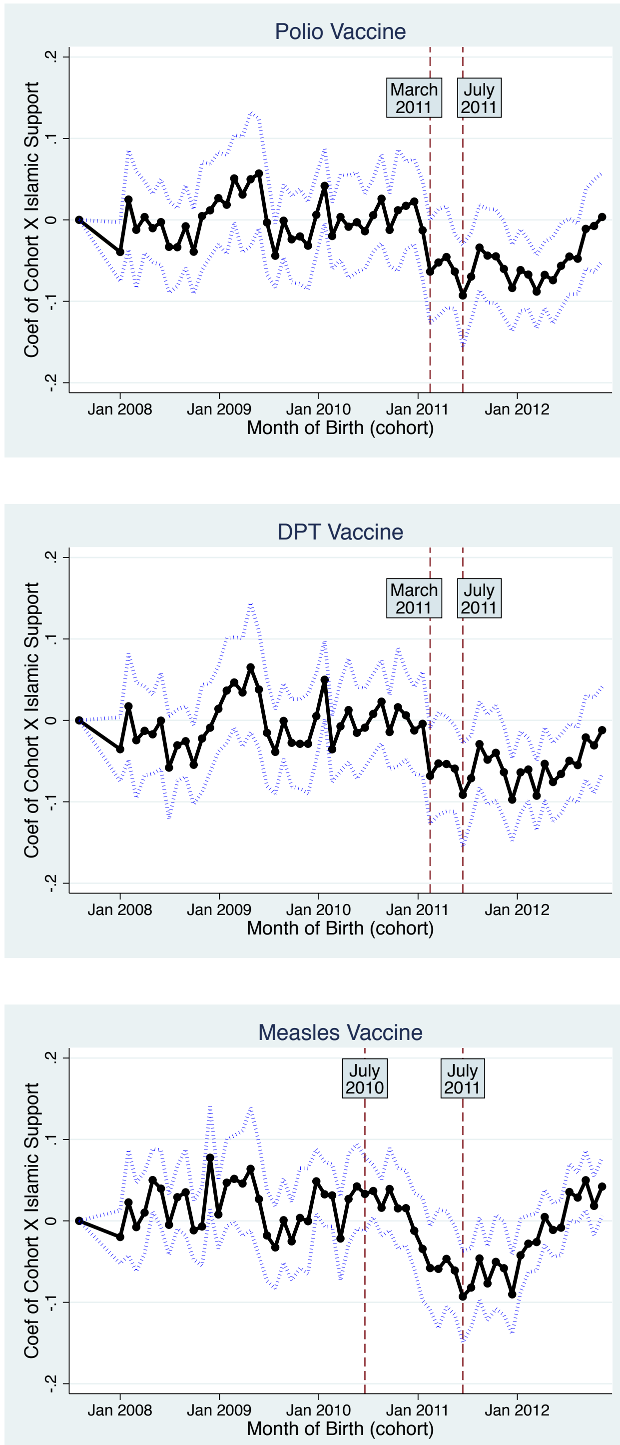
Appendix Figure 4. Treatment Effects by Monthly Cohort. Only Controlling for Montly-Cohort and District Fixed Effects







Appendix Figure 5. Treatment Effects by Monthly Cohort. Longer Pre-Treatment Period.



11 Appendix Tables

Appendix Table 1. Immunization Calendar of Pakistan

Vaccine	First Dose	Second Dose	Third Dose	Fourth Dose
Polio	At birth	6 Weeks	10 Weeks	14 Weeks
DPT	6 Weeks	10 Weeks	14 Weeks	
Measles	9 Months	15 Months		

Notes: Official immunization schedule of Pakistan for the main three vaccines. Published by the Expanded Program on Immunization (EPI), Pakistan http://epi.gov.pk/?page_id=139 (last accessed April 18th, 2017)

Appendix Table 2. Descriptive Statistics

	Observations (1)	Mean (2)	Std. Dev. (3)
	Panel A. Child Characteristics		
Received one dose of Polio vaccine	22,346	0.420	0.494
Received one dose of DPT vaccine	22,346	0.453	0.498
Received one dose of Measles vaccine	22,346	0.226	0.418
Received three doses of Polio vaccine	22,346	0.313	0.464
Received three doses of DPT vaccine	22,346	0.341	0.474
Received all vaccines	22,346	0.202	0.401
Illness or injury (two weeks prior to interview)	22,346	0.191	0.393
Age (in months)	22,346	9.910	6.358
Male	22,346	0.514	0.500
	Panel B. Mother Characteristics		
Mother's education level	22,346	3.538	4.369
Mother's age	22,346	27.926	6.049
	Panel C. Household Characteristics		
Rural region	22,346	0.658	0.474
Radio ownership	22,346	0.223	0.416
Television ownership	22,346	0.581	0.493
Number of household members	22,346	2.637	1.558
Number of rooms	22,346	8.268	3.891

Notes: The unit of observation is the child level. The sample consists of children born between 2010 and 2012 that are less than 24 months of age at the time of interview.

Appendix Table 3. Only Controlling for District and Cohort Fixed Effects

	Dependent Variable: Dummy for Receipt of 1 Vaccine Dose		
	Polio	DPT	Measles
	(1)	(2)	(3)
Mean Dep. Var.	*0.422*	*0.455*	*0.231*
Post × IslSup	-0.042**	-0.041**	-0.041**
	(0.019)	(0.018)	(0.016)
Observations	20,350	20,350	16,175
R-squared	0.257	0.235	0.230
Number of Clusters	109	109	109

Notes: Standard errors clustered at the district-level in parentheses. The unit of observation is the child level. The sample consists of children born between 2010 and 2012 that are less than 24 months of age at the time of interview. We exclude children partially treated. All regressions include district and monthly cohort fixed effects. *** p<0.01, ** p<0.05, *p<0.1.