In Vaccines We Trust? The Effects of the CIA's Vaccine Ruse on Immunization in Pakistan*

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Abstract

In July 2011, the Pakistani public learnt that the CIA had used a vaccination campaign as cover to capture Osama Bin Laden. The Taliban leveraged on this information and initiated an anti-vaccine propaganda to discredit vaccines and vaccination workers. We evaluate the effects of these events on immunization by implementing a Difference-in-Differences strategy across cohorts and districts. We find that vaccination rates declined 12 to 20% per standard deviation in support for Islamist parties. These results suggest that the disclosure of information that lends credibility to conspiracy theories about vaccines can have large effects on demand for immunization.

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1 Introduction

Vaccines are responsible for some of the largest improvements in public health in human history.[1] However, vaccine skepticism has increased in recent years and many parents have refused to vaccinate their children. This has led to numerous outbreaks of preventable diseases throughout the world.[2] Vaccine skepticism has been fueled by groups ideologically opposed to vaccines, which have spread multiple rumors and conspiracy theories against vaccines. A strong anti-vaccine movement has emerged in the US and Europe, while religious extremist groups have engaged in anti-vaccine propaganda in countries such as, Nigeria, Afghanistan, or Pakistan.[3]

Confidence in vaccines is particularly vulnerable to rumors and misconceptions. Because of the preventive nature of vaccines and herd immunity, it is difficult—if not impossible—to learn about the effectiveness of vaccines based on own experience. Trust in the medical worker that prescribes vaccinations is key to vaccine acceptance. Hence, information that casts doubts on vaccines or that discredits health workers can have severe effects on parental acceptance of vaccines.

Despite the potential implications for human welfare, we have a limited understanding of how the disclosure of information that discredits vaccines affects immunization rates. In this paper, we exploit a sequence of events that took place in the recent history of Pakistan and that severely affected the population's confidence in vaccines. As part of the operations to capture Osama Bin Laden in 2011, the CIA organized an immunization campaign as cover for their espionage activities. The objective was to obtain DNA samples of children living in a compound in 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 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.[4]

The disclosure of this information caused uproar in Pakistan. Leveraging on the new piece of information, the Pakistani Taliban launched an important anti-vaccine propaganda campaign to discredit medical workers and to cast doubt on vaccines. They accused health

[1] Acemoglu and Johnson (2007).

[2] BBC 2019 "Measles cases quadruple globally in 2019, says UN" https://www.bbc.com/news/health-47940710 (last accessed 07/16/2019).
McNeil Jr., Donald G. 2019. "Measles Outbreak Now at 880 Cases, With Fastest Growth Still in New York" https://nyti.ms/2Enz9sC (last accessed 07/16/2019)

[3] See Kennedy (2016).

[4] Shah, Saeed. 2011. "CIA organized fake vaccination drive to get Osama bin Laden's family DNA". *The Guardian*, July 11. *https://www.theguardian.com/world/2011/jul/11/cia-fake-vaccinations-osama-bin-ladens-dna* (last accessed 07/18/2019).

workers of being CIA spy agents[5] and claimed that the polio vaccination campaigns were a conspiracy to sterilize the Muslim population.[6]

We obtained data on children's immunization records from a large household survey and evaluate how the disclosure of the vaccine ruse affected immunization rates. We implement a *Difference-in-Differences* strategy using detailed data on children's month of birth combined with their district of residency. The cohort variation is indicative of the children's exposure to the new information. In particular, we distinguish between fully-exposed, not-exposed, and partially-exposed cohorts depending on the fraction of their early months in life that happened under the new information scenario. The geographic variation allows us to compare the evolution of immunization rates across regions with different levels of ideological affinity to the Taliban. Parents in districts with higher support for Islamist groups are likely to have been more exposed to the anti-vaccine propaganda campaign. Furthermore, it is likely that parents with an initial ideological affinity to the Taliban accorded greater credibility to their anti-vaccine messages.[7]

Our estimates indicate that the disclosure of the vaccine ruse had substantial negative effects on vaccination rates: one standard deviation increase in the support for Islamist groups led to a 12 to 20% reduction in the immunization rates of fully-exposed with respect to not-exposed cohorts. The results are highly statistically significant and robust to the inclusion of a host of controls, including district and monthly-cohort fixed effects. Furthermore, we provide evidence that supports the absence of pre-existing trends preceding the disclosure of the vaccination ruse.

These results are consistent with the hypothesis that the disclosure of the vaccine ruse damaged the reputation of vaccines and formal medicine, more generally. There is substantial anecdotal evidence suggesting that these events were a key driver of vaccine skepticism. For instance, a reporter for one of the main newspapers in Pakistan describes the following quote from a health worker in Karachi.[8]

> *"Many parents still resist the vaccine, as they believe in many conspiracies. Some think it's a Western conspiracy to sterilise the next generation, while others think that this campaign is a cover for some kind of spy programme. Many Urdu newspapers and magazines publish material to the effect that polio drops are not good*

[5]Walsh, Decan. 2012. "Taliban Block Vaccinations in Pakistan". *The New York Times*, June 18. *https://nyti.ms/2nrYKJM* (last accessed 07/18/2019).

[6]Roul (2014).

[7]This could be the result of confirmation bias (Mullainathan and Shleifer, 2005) or of inference on the quality of the source of the propaganda messages (Gentzkow and Shapiro, 2006). In the appendix, we present a theoretical model to guide the interpretation of our empirical results.

[8]See sections 2.3 and 8.4 for additional anecdotal evidence.

for children, and then religious clerics use these articles to prove their conspiracy theories."[9]

The quote is also informative about the likely mechanism behind our empirical results, which we formalize in the appendix of this paper. Following the disclosure of the vaccine ruse, the Taliban initiated an anti-vaccine propaganda leveraging on the new information. In particular, they claimed that vaccine workers were spy agents and, hence, should not be trusted. It is likely that the disclosure of the vaccine ruse also lent credibility to many of the other anti-vaccine messages spread by the Taliban. Parents with an initial ideological connection to the Taliban may have been more likely to receive these messages and to be persuaded by them.

We provide additional empirical evidence consistent with this channel. First, we show that the negative effect of the disclosure of the vaccine ruse on vaccination rates is larger for girls than for boys. This is important because one of the rumors that the Taliban was spreading was that vaccines were intended to sterilize Muslim girls. Hence, the evidence is consistent with parents granting credibility to this rumor. Second, we present evidence consistent with an increase in the levels of mistrust in formal medicine. We show that other forms of health seeking behavior also experienced important declines. In particular, parents were less likely to consult formal health workers when their children got sick. Third, using data from the South Asia Barometer, we examine the effects on measures of trust on different organizations. We document that, after the disclosure of the vaccine ruse, trust in government organizations experienced larger declines in areas with high support for Islamist groups.

We also examine the empirical relevance of alternative channels. In particular, we explore if the effects are *supply-driven*.[10] We collected administrative data on the number and scope of the vaccination drives that took place during the period of our study. We provide evidence that the number and intensity of vaccination campaigns did not differentially change across districts after the disclosure of the vaccine ruse. Furthermore, our results are fully robust to controlling for a host of measures of supply of health services. We also provide suggestive evidence that the reduction in the demand for vaccines is likely to be driven by the ideological affinity to Islamist groups and not by fear or intimidation of the Taliban.

Finally, we collect data on the number of cases of poliomyelitis diagnosed at the district-level. We implement a *Difference-in-Differences* design across districts and years and document that one standard deviation increase in support for Islamist parties is associated with

[9]Siddiqui, Taha. 2014. "The naysayers' propaganda machinery". *Dawn*, February 23. *https://www.dawn.com/news/print/1088811* (last accessed 07/18/2019).

[10]Starting in mid-2012 the Taliban carried out attacks and intimidation acts against health workers. This could have hindered the immunization drives.

one extra case of poliomyelitis per year, which is equivalent to a 93% increase over the sample mean.

Despite the vulnerability of vaccines to conspiracy theories and misconceptions, there is limited evidence on the drivers of vaccine skepticism. The medical literature has examined the correlates to vaccine hesitancy and has tested a number of interventions to reduce it.[11] Das and Das (2003) examine the determinants of the demand for vaccination in a case study from one Indian village. They show that vaccination rates declined after two mothers died while in labor. The authors argue that these effects could be explained by an increase in mistrust in the midwife's recommendation to vaccinate the children.

This paper is also related to a recent literature that has studied cases of medical malpractice as a negative shock to the levels of confidence in formal medicine.[12] We contribute to this literature by exploiting the disclosure of information that directly damaged the reputation of vaccines and examine immunization rates as our main outcome of interest. Given the inherent difficulties in inferring the effectiveness of vaccines based on own-experience, shocks to the reputation of vaccines can be especially damaging. We differ from previous literature by studying a context where an ideologically-motivated group was actively spreading misconceptions about vaccines. In our empirical design, we exploit the ideological connection to this group and cohort variation as our key drivers of treatment intensity, rather than demographic characteristics or purely cross-sectional factors.

The presence of an active political group trying to discredit the reputation of vaccines links this paper also to the literature that examines the effect of persuasive communication on behavior. See Della Vigna and Gentzkow (2010) and Kamenica (2018) for literature reviews. This literature has mainly focused on the role of media or advertising on consumer and voter behavior. To the best of our knowledge, no study has documented the effects of propaganda campaigns against vaccines—or of information lending credibility to such campaigns—on immunization rates. In order to benchmark our estimates to this literature we compute persuasion rates. Our estimated persuasion rates range from 30.7% to 42.3%, which are among the highest rates in the literature.[13]

[11] See Sadaf et al. (2013) for a literature review.

[12] Alsan and Wanamaker (2017) study the disclosure of the Tuskegee study, in which a number of black males that suffered from syphilis were denied medical treatment in order to investigate the effects of the disease. Th disclosure of this study led to a reduction in demand for health of black men living close to Tuskegee. The authors argue that that group of individuals was more likely to identify with the subjects of the Tuskegee study and, hence, were more affected by it. Lowes and Montero (2018) study the long-run effects of the French colonial campaigns against the sleeping sickness in Central Africa. They exploit cross sectional variation on the location of the colonial campaigns. Gonzalez-Torres and Esposito (2018) show that the attempts to contain the Ebola epidemic generated civil conflict in the areas where mistrust in government was higher.

[13] We follow Della Vigna and Gentzkow (2010) and estimate the persuasion rates for different vaccines as

The paper is also related to the literature that has studied the determinants and implications of anti-Americanism or anti-Western values. See for instance Gentzkow and Shapiro (2004), Beath, Christia and Enikolopov (2017), Cantoni, Yang, Yuchtman, Zhang (2016, 2017), and Bursztyn, et al. (2017). Finally, the nature of the anti-vaccine propaganda connects the paper to the recent literature on the effects and demand of fake news and conspiracy theories.[14] Scholars have noted that true pieces of information are frequently woven into the narratives of conspiracy theories.[15] However, there is limited empirical evidence about how the disclosure of information that may provide seeming proof for a component of a conspiracy theory affects support for such beliefs and subsequent behavior. To the best of our knowledge, this is the first paper to evaluate how the disclosure of information that may lend credibility to a set of rumors—that vaccination workers are spy agents—affects an important type of human behavior: demand for vaccines.

The remainder of the paper is organized as follows. Section 2 provides background information on the political and administrative context of Pakistan. Section 3 summarizes our conceptual framework. Sections 4 and 5 present the data and empirical strategy. Sections 6 and 7 present the main results and robustness checks. Section 8 discusses evidence on the mechanisms. Section 9 concludes.

2 Background

2.1 The Vaccine Ruse

In the summer of 2010, the CIA obtained intelligence 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 ways, such as via satellite images and from a nearby house. Yet, prior to 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 there. To this end, the CIA organized a vaccination ruse with the objective to obtain DNA samples of children living in the compound and compare them to the DNA of Bin Laden's sister, who had died in Boston in 2010. Obtaining proof that the children were related to Bin Laden would have been telling evidence that Bin Laden was

the percentage of individuals that change their vaccination decision among those that were exposed to the information and were not already vaccinating their children. The persuasion rates reported in Della Vigna and Gentzkow (2010), range between 0.7% and 29.7%, with the median persuasion rate being 8%.

[14] See Alcott and Gentzkow (2017) on the effects of fake news on the US 2016 elections and Vosoughi et al. (2018) on the spread of fake news on social media. See also Augenblick, Cunha, Dal Bó and Rao (2016) for unique study in which the strength of belief in conspiracy theories was elicited.

[15] Raab et al. (2013).

hiding in the compound.[16]

To carry out the vaccine ruse, the CIA recruited a senior Pakistani doctor, Dr. Shakil Afridi. The doctor, in turn, hired low-ranked health workers, who were unaware of the motives behind the vaccination campaign and of the CIA involvement in the operation. Without knowledge or consent from the Pakistani health authorities, Dr. Afridi started administrating hepatitis B vaccines to children living in a poor neighborhood of the city in March 2011. A few weeks later, 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.[17] The article described the collaboration of Dr. Afridi with the CIA and the attempts of health workers to obtain DNA samples from children.[18]

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.[19] 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.[20] In response to these critiques the White House announced that the CIA had pledged not to use vaccination programs as a cover to gather intelligence or genetic material.

[16]Shah, Saeed. 2011. Op. cit.

[17]Ibid.

[18]In January 2012, the U.S. Defense Secretary, Leon E. Panetta, confirmed that doctor Shakil Afridi had collaborated with the CIA. Shakil Afridi was arrested by the Pakistani police and accused of conspiracy against the state. Hew was sentenced to serve 33 years in jail on May 2012.
Mazetti, Mark. 2012. "Panetta Credits Pakistani Doctor in Bin Laden Raid". *The New York Times*, January 28. *https://nyti.ms/2yo1VEi* (last accessed 07/18/2019).
Boone, Jon. 2012. "Doctor who helped US in search for Osama Bin Laden jailed for 33 years". *The Guardian*, May 23. *http://www.theguardian.com/world/2012/may/23/doctor-bin-laden-cia-jail* (last accessed 07/18/2019).

[19]For instance, Leslie F. Roberts, Professor of Columbia University's 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. "How the CIA's Fake Vaccination Campaign Endangers Us All". *Scientific American*, May 1. *https://www.scientificamerican.com/article/how-cia-fake-vaccination-campaign-endangers-us-all/* (last accessed 07/18/2019).

[20]Johns Hopkins Bloomberg School of Public Health. 2013. "CIA Vaccination Cover in Pakistan". *Johns Hopkins Bloomberg School of Public Health*, January 8. *https://www.jhsph.edu/news/news-releases/2013/klag-CIA-vaccination-cover-pakistan.html* (last accessed 07/18/2019).

2.2 Political Context in Pakistan

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.[21] Provinces are divided in districts. In the year 2013, the four provinces of Pakistan consisted of 114 districts in total.

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: the Pakistan Peoples Party (PPP)—a center-left political party founded by Zufilkar Ali Bhutto—and the Pakistan Muslim League (N) (PML (N))—a right-wing nationalistic party.

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).[22] This alliance was established in 2002 in direct opposition to Pakistan's support to the US-led invasion of Afghanistan. The parties organized within the MMA are Islamist in nature and strongly emphasize Islamist moral and principles in every day life.[23] They preach a hard-line and traditional Islamic ideology that is shared by many 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.

MMA obtained 11% of votes and 63 seats in the 2002 election for the national legislature. Their vote share declined in the 2008 election, obtaining about 3% of votes and 8 seats for the national legislature. They obtained 26 out of 728 seats in the provincial legislatures. However, as shown in Figure 1, the support for MMA in 2008 exhibits substantial variation across districts. Importantly, MMA did not manage to control any of the local executive governments after the 2008 election.

Several authors have documented the close political, financial, and ideological connec-

[21] 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. 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 12 in the Online Appendix for further details on the data.

[22] The six parties are: Jamiat Ulema-e-Pakistan (JUP), Jamiat Ulema-e-Islam-Fazl (JUI-F), Jamiat Ulema-e-Islam (JUI-S), Jamiat-e-Ahle Hadith, Pakistan Isami Tehrik (ITP) (formerly Tehriq-e-Jafaria (TeJ)) and Jamaat-e-Islami (JI).

[23] This is particularly the case for the three largest parties, JUI-F, JUI-S, and JI. See Norell (2007) for further details.

tions between MMA and the Pakistani-Taliban. For instance, many of the Taliban leaders have been educated in the madrassas run by some of the Islamist parties that form MMA. Also, MMA leaders have been observed attending the funerals of Taliban combatants. Both Taliban and MMA flags were displayed during these funerals (Norell (2007), page 75). While the support of MMA to the Taliban is not official, the electoral support of MMA predominantly consists of individuals that are sympathetic to the Taliban and support their fight in Afghanistan (Norell (2007), page 71).

2.3 The Pakistani Taliban's Anti-Vaccine Propaganda

Occasionally, Islamist extremist groups in Pakistan have tried to discredit formal medicine and vaccines. By discrediting services provided by the state, the Taliban can increase the reliance of the population on non-state actors (Acemoglu et al. 2019). As part of that strategy, Taliban leaders have criticized Western lifestyles and vaccination drives through Friday prayers in radicalized mosques, Urdu newspapers, and through illegal radio shows. For instance, the Taliban leader Maulana Fazlullah claimed during his radio show that the polio eradication campaign was part of a "conspiracy of Jews and Christians to make Muslims impotent and stunt the growth of Muslims" (Roul (2014), page 18).

Islamist groups have also spread a variety of other rumors and misconceptions about vaccines. For instance, they have argued that vaccines should be avoided because they were made out of pig fat—and hence forbidden for Muslims—and because it is un-Islamic to "take a medicine before the disease [is contracted.]"[24] The concern that vaccines are a conspiracy to sterilize Muslim children, girls in particular, has been recurrent.[25]

In this context, the disclosure of the CIA vaccination ruse had the potential to generate a large impact because it lent credibility to many of the Taliban's arguments against vaccines. Several scholars and journalists have made this observation.[26] For instance,

> *"However the ruse has provided seeming proof for a widely held belief in Pakistan, fuelled by religious extremists, that polio drops are a western conspiracy to sterilise the population."*[27]

[24]Nishtar (2009); Siddiqui, Taha. 2014. Op. cit.
Saleem, Sana. 2011. "Muslim scholars fight to dispel polio vaccination myths in Pakistan". *The Guardian*, November 4. *https://www.theguardian.com/commentisfree/belief/2011/nov/04/polio-vaccination-pakistan*, (last accessed 07/18/2019).

[25]Scientific American. 2013. Op. cit.

[26]Saleem, Sana. 2011. Op. cit.; Roul (2014)
Shah, Saeed. 2012. "CIA tactics to trap Bin Laden linked with polio crisis, say aid groups". *The Guardian*, March 2. *https://www.theguardian.com/world/2012/mar/02/aid-groups-cia-osama-bin-laden-polio-crisis* (last accessed 07/18/2019).

[27]Shah, Saeed. 2012. Op. cit.

While the disclosure of the CIA vaccine ruse may only have provided evidence in support of the rumors linking vaccination drives to espionage activities, it is likely that all other claims made by the Taliban gained credibility as well.

The Taliban reacted to the disclosure of the vaccination ruse by intensifying their propaganda campaign against vaccines. They leveraged on the new credibility of their claims and issued a number of religious edicts (*fatwas*), directly linking the on-going vaccination campaigns to espionage activities by the CIA.

> *"The CIA's actions likely made the Taliban leadership in Pakistan all the more suspicious about the vaccination programs, and it contributed to a renewed armed backlash against polio immunization workers in the country.*
>
> *According to a Taliban fatwa issued in June 2012, "polio agents could also be spies as we have found in the case of Dr. Shakil Afridi* [Pakistani doctor involved in the CIA vaccination ruse] *has surfaced. Keeping these things in mind we announce to stop the polio dosage.""*[28]

This propaganda campaign was spread through illegal radio shows, extremist religious leaders, and through right-wing newspapers.[29]

> *"Many parents still resist the vaccine, as they believe in many conspiracies. Some think it's a Western conspiracy to sterilise the next generation, while others think that this campaign is a cover for some kind of spy programme. Many Urdu newspapers and magazines publish material to the effect that polio drops are not good for children, and then religious clerics use these articles to prove their conspiracy theories."* (Siddiqui (2014), quoting a campaigner in Karachi polio vaccination team.)[30]

The Taliban have also exerted violence against vaccination workers. Seventy health workers had been killed during this campaign of violence, which started in July 2012.[31] Taliban leaders also boycotted immunization campaigns by banning immunization drives. These boycotts and most of the attacks to health workers took place in the FATA region, which is not included in our study sample. Furthermore, our main analysis focuses on children born

[28]Roul (2014), page 18.

[29]Siddiqui, Taha. 2014. Op. cit.

[30]Ibid.

[31]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 (Roul (2014)). BBC. 2015. "Four kidnapped polio workers are found dead in Pakistan". *BBC*, February 17. *https://www.bbc.com/news/world-asia-31507217* (last accessed 07/18/2019).

between January 2010 and July 2012, hence, before the violence campaign against vaccination workers started. Nevertheless, later in the paper we discuss the intimidation to health workers as an alternative channel for our effects on vaccination rates.

In April 2013, the Pakistani Taliban issued a statement declaring that they will not interfere with the polio vaccination drives as long as the drives were not used by the United States as a cover for espionage and as long as the vaccine was manufactured in accordance with Islamic laws.[32] However, the conflict between the Taliban, the Pakistani government, and the United States has continued to affect the immunization campaigns, predominantly in the FATA region (Ahmad et al. (2015)).

Since mid-2012, vaccination campaigns have also aimed at addressing misconceptions about vaccines by engaging local community and religious leaders during vaccination drives. Vaccinators have been equipped with fatawa (religious) books and videos on their mobile phones that describe vaccines as being safe and in accordance with Islamic precepts. Immunization workers show these materials to parents that hesitate to vaccinate their children because of religious concerns.[33]

2.4 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.[34]

Lady Health Workers are the health workers responsible for child immunization. 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.[35]

The Expanded Program on Immunization of Pakistan (EPI, henceforth) coordinates the

[32]Roul (2014).

[33]Khan, Taimur. 2017. "How Pakistan got to near zero on polio". *www.devex.com*, November 14. *https://www.devex.com/news/how-pakistan-got-to-near-zero-on-polio-91521* (last accessed 07/18/2019). Khan et al. (2017).

[34]Expanded Program on Immunization, Pakistan. 2019. "Immunization Schedule". *http://www.epi.gov.pk/immunisation-schedule/* (last accessed 07/18/2019).

[35]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. See Andreoni et al. 2016 for additional details and for the effects of improvement in the monitoring technology on their activities.

procurement and supply of vaccines, syringes, safety boxes and other vaccination-related logistical needs of health providers. 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.[36]

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.[37] Immunization against polio is supported by the Global Polio Eradication Initiative. In conjunction with staff from the World Health Organization, EPI coordinates national as well as subnational immunization days during which vaccinators (typically lady health workers joined by other volunteers) provide the polio vaccine at households' doorstep. These immunization campaigns take place every month in most districts. They typically last for 3 days and target all children up to age 5 in the respective district.

3 Conceptual Framework

In section 11 of the Online Appendix, we present a simple model of Bayesian updating that provides a conceptual framework for our empirical exercise. In this section, we describe the main insights that the model provides.

Consider a setting where parents take a one-time decision about whether to vaccinate their children. There are two possible states of the world. One where vaccines are good for children and health-workers are trustworthy and another where the opposite is true. Parents have a common prior about the state of the world and they update their prior based on new information.

Two pieces of information get revealed before parents take their vaccination decisions. First, a public signal is revealed. We interpret the disclosure of the CIA vaccine ruse as a negative realization of this public signal: it suggests that vaccines and health-workers are not trustworthy. Note that this is not incompatible with the state of the world being one where vaccines are good and with the public signal being informative. In a counterfactual world were the CIA vaccine ruse had not happened, the realization of the public signal could have indicated that vaccines were good: for instance a celebrity endorsing vaccines, or good news about vaccines leading to the eradication of a disease. In other words, we interpret the CIA vaccine ruse as an (ex-ante unlikely) negative realization of an informative public

[36]Note that Islamist parties, did not control any of the local executive governments during the study period. Hence, it is unlikely that they could affect the spending decisions of government-sponsored vaccination programs.

[37]The other country where polio is still endemic is Afghanistan.

signal, in a context where the state of the world is one were vaccines are good.[38]

The second piece of information that gets disclosed is a message sent by the Taliban. We assume that the Taliban get a private signal and decide what message to send to parents. There are two types of Taliban: 'honest' Taliban always truthfully report their private signal to parents. In contrast, 'dishonest' or 'ideological' Taliban always send a message reporting that vaccines are bad and health-workers not trustworthy.

We introduce two sources of heterogeneity across parents. First, we assume that parents in districts with higher levels of support for Islamist parties have a higher probability to receive the message sent by the Taliban. This captures the notion that the network of distribution of Taliban propaganda is more developed in areas where the Taliban had more support. For instance, areas with high support for Islamist parties tend to have a larger density of mosques led by radicalized clerics (Roul, 2014). Second, we assume that parents with a higher ideological affinity to the Taliban are more likely to trust the messages sent by the Taliban. This could be driven by the presence of confirmation bias (Lord et al. 1979, Mullainathan and Shleifer, 2005) or by the possibility that parents judge the source of information as being of higher quality when it conforms with their priors (Gentzkow and Shapiro 2006). We introduce these notions in a reduced form way, by assuming that parents with a stronger ideological affinity with the Taliban assign a higher probability to the possibility that the Taliban are honest.

We interpret the sequence of events that we study in this paper as follows: nature choose a state of the world where vaccines are good for children. Then parents observe a negative realization of the public signal–i.e., the CIA vaccine ruse. Parents update their prior about the state of the world. Then some parents observe the message sent by the Taliban. We interpret the anti-vaccine propaganda campaign that followed the disclosure of the vaccine ruse as the Taliban sending a message that vaccines are bad. The parents that receive the Taliban message further update their posterior about the state of the world. Parents decide whether to vaccinate or not their children.

This simple framework generates a number of predictions that guide our empirical analysis. The disclosure of the CIA vaccine ruse and the subsequent anti-vaccine propaganda

[38]It is important to point out that the CIA vaccine ruse was a quite unlikely event. To the best of our knowledge, this was the only time when the CIA had used vaccination campaigns or other forms of health-related activities as a cover for espionage operations in the context of Pakistan. We conducted extensive searches in the CIA's Freedom of Information Act Electronic Reading Room as well as supplementary web searches and we could not identify any additional incident. Hence, despite the occurrence of the vaccine ruse, we believe the most accurate depiction of the state of the world is one were parents' decisions to vaccinate their children is largely beneficial for them. This is particularly true for the context of Pakistan, where diseases like poliomyelitis—which mainly affects children and can lead to paralysis—is still endemic. See for instance McNeil. 2019. "Polio Cases Surge in Pakistan and Afghanistan". https://nyti.ms/2XKX695 (last accessed 07/16/2019).

campaign of the Taliban make parents update downwards their prior that the state of the world is one where vaccines are good. The downward updating is greater in regions where a larger fraction of parents have an ideological affinity with the Taliban. This is driven by those regions having (i) a larger fraction of parents that receive the anti-vaccine propaganda messages or by (ii) a larger fraction of parents assigning greater credibility to the messages of the Taliban.

Given these two sources of heterogeneity across parents and districts, we expect that districts with greater ideological support for the Taliban will experience larger declines in the demand for immunization after the disclosure of the CIA vaccine ruse and the subsequent anti-vaccine propaganda campaign. Hence, these predictions guide our *Difference-in-Differences* empirical strategy.

4 Data

Our main data source is the Pakistan Social and Living Standards Measurement (PSLM) provided by Pakistan's Bureau of Statistics. These data contain individual-level data on the 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 baseline sample records the vaccination status of 18,650 children born between January 2010 and July 2012 that were up to 24 months old at the time of the interview. Our main outcomes correspond to whether a child has received the first dose of the polio, DPT, or measles vaccine, respectively. Restricting the sample to young children and focusing on the first dosages provides a tighter prediction of how the events described in this paper affected children's vaccination status. However, we also present results for full immunization rates — i.e., receiving all dosages of each vaccine.

The survey records vaccination status with one of the following three options: 1) yes (as verified on the vaccination card by the enumerator); 2) yes, based on parent's recall; 3) no. In order to minimize the scope for misreporting we do not rely on recall measures of vaccinations. 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)). Hence, our main outcome variable is an indicator variable that takes value one if the enumerator was able to verify that the vaccine was provided in the vaccination card, and

zero otherwise.[39,40]

The children in our sample are distributed through the 114 districts included in the four provinces that are part of our study. A few districts have experienced divisions during our study period. Hence, we cluster the standard errors at the level of the 109 districts in existence in 2008. See Appendix Table 2 for descriptive statistics and Appendix Table 3 for a tabulation of the cohorts included in our baseline sample.[41]

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. The 2008 election was the closest in time that preceded the disclosure of the vaccine ruse. In particular, we obtain constituency-level electoral results for the provincial assembly. Electoral constituencies are smaller than districts.[42] Hence, we aggregate the results at the district level in order to merge the electoral data with our main outcome variables. Our main measure of support for Islamist groups is average vote share of MMA across all constituencies within a given district. To compute this average, we weight each constituency by population to increase the representativeness of our measure. Figure 1 presents the geographic distribution of the district-level vote shares for MMA in the 2008 election.

For the purpose of this project, we also collected administrative data on the polio vaccination campaigns that were conducted between 2008 and 2013 throughout Pakistan.[43] These data contain district-month measures of whether a polio vaccination campaign was conducted, the type of campaign—national or subnational immunization days—, and the number of children targeted.

We use some additional datasets that we describe as they become relevant. For an exhaustive description of the data used in this paper see section 12 of the Online Appendix.

[39]By focusing on verifiable vaccination status we mitigate the concerns of measurement error due to over-reporting of vaccination status. However, it is possible that we are still subject to under-reporting. Parents may say they do not have the vaccination card if they want to hide that they vaccinated their children. However, we believe it is unlikely that under-reporting affects our results: the percentage of parents that self-reported not to have vaccinated their children against polio is low—3.6%—and was even lower in the 2012/3 wave. This suggests that over-reporting is a more relevant issue than under-reporting. See section section 7 for further discussion.

[40]In the case of the polio vaccine the survey contains an additional possible answer: "4) yes, during polio campaign". This option is self-reported by parents and, hence, equivalent to option (2) above.

[41]For some of the robustness checks we also use data from the Demographic Health Survey (DHS, henceforth) (NIPS, 2008, 2013). The two DHS waves closest in time to the vaccine ruse and 2006 and 2012. The resulting sample size of the DHS is smaller: 6,234 children. Hence, our baseline results are estimated using the PSLM survey.

[42]In particular, districts typically contain multiple electoral constituencies. Electoral constituencies rarely cross district boundaries.

[43]These data was kindly provided by the internal monitoring and surveillance unit at the National Emergency Operations Centre within the Expanded Program on Immunization in Pakistan.

5 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 on immunization rates. Our main outcomes of interest are indicators for whether a child has received the first dose of polio, DPT, or measles vaccine. Our working assumption is that the date of birth and the district of residence jointly determine children's exposure to the shock induced by the disclosure of the vaccine ruse.[44]

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 available. By the time the information is disclosed, the parents of these children had already taken the decision of whether to administer or not the first dose of each vaccine. 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 distinguish between the partially-exposed and the non-exposed cohorts, we examine the age profiles of the three vaccines. Figure 2 presents the results. These figures show the fraction of children that received the first dose of each vaccine as a function of their age at the time of interview. We restrict the sample to the pre-treatment period, so that the age profiles are not confounded by the effects of the disclosure of information on the vaccine ruse.[45] 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. For the measles vaccine, the probability of receiving the first dose rapidly increases after the 9th month and reaches a plateau after the first year of life. These patterns have two implications: (i) There is imperfect compliance with the official calendar: the first doses are supposed to be administered at birth, in the 6th week, and 9th month for polio, DTP, and measles, respectively. Hence, the empirical age profiles are key to differentiate between not-exposed and partially-exposed cohorts. (ii) The fact that the three age profiles exhibit a plateau indicates that after a certain age, the decision of whether to take the first dose of the vaccine has already been reached. Hence, we consider children that have reached the plateau by the time the vaccine ruse is disclosed as part of not-exposed cohorts.[46]

[44]Note that the survey does not record the date when the vaccine was provided to the child. We only observe whether a child has been previously administered the vaccine at the time of the interview. Furthermore, the survey does not record the district of birth of the household head. See section 7 for robustness checks for selective migration, including the analysis of alternative data sources which contain the district of birth of the child.

[45]In particular, we restrict the sample to PSLM waves 2008/09 and 2010/11. The latter wave was fielded before June 2011.

[46]Note that the *non-exposed* cohorts are not a pure control group since they can always get vaccinated

Hence, when considering immunization status of polio and DPT, we will regard children born in the three months prior to July 2011 as partially treated. Similarly, when considering the measles vaccine, we will consider children born in the year prior to July 2011 as partially treated.

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 districts that have different levels of support for Islamist parties. In order to provide a visual representation of the sources of identifying variation, 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.[47] The left-hand side figures 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.

In districts with low support for Islamist parties, the age profiles are similar before and after the disclosure of the vaccine ruse. In contrast, in regions with high support for Islamist groups, the age profile shifts downward, indicating a decline in the likelihood of vaccination at different ages. This result is consistent with the hypothesis that, in regions with high levels of support for Islamist groups, a larger fraction of parents were exposed to the anti-vaccine propaganda spread by the Taliban or were more persuaded by it. As a result, a larger fraction of parents became skeptical about vaccination, and decided not to vaccinate their children.[48,49]

Regression Framework

While the previous results are illustrative of the main source of variation, it could be subject to district- or cohort-level confounders. Next, we estimate a more demanding econometric specification that allows for the inclusion of controls:

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at later ages. The fact that the vaccination age profiles reach a plateau mitigates this potential concern. After reaching a certain age, *non-exposed* do not experience further increases in their likelihood of getting vaccinated. Hence, they represent a good approximation to a control group.

[47] The age profiles labeled as "pre-period" use information from children observed in the 2008/09 and 2010/11 waves of the PSLM. All of them are born before June 2011. The age profiles labeled as "post-period" use information from children observed in the 2012/13 wave of the PSLM that are born after July 2011. Hence, all these children are *fully-exposed* to the information treatment.

[48] Note that the decline in vaccination rates seems to be higher for older children. The reason is that the old children in the post-treatment age profile are born at a time closer to the disclosure event—July 2011. (The post-treatment survey was conducted towards the end of 2012.) As we show later in the paper, the effects are the largest for the children born shortly after the disclosure of the vaccine ruse. See Appendix Figure 1 for the distribution of dates of interview in the different waves of the PSLM survey.

[49] The age profiles are similar when we consider multiple doses of the same vaccine. See Appendix Figures 2 and 3 and section 13 in the Online Appendix for further details.

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

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 of support for Islamist 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_k are month-year 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 an indicator for rural regions). The omitted category corresponds to the last cohort of the non-exposed cohorts (i.e., February 2011 for polio and DPT and June 2010 for measles). Standard errors are clustered at the district level.[50]

This specification allows for a fully flexible pattern of treatment effects by cohort. Cohort fixed effects control for all factors that are common for all individuals in a cohort, such as nation-wide economic growth or improvements in health and nutrition over time. District fixed effects control for time-invariant factors such as geography, climate, or religiosity. Hence, the coefficients β_k are the cohort-specific *Difference-in-Differences* estimates that are identified out of within-cohort-variation across districts with different levels of support for Islamist groups. For not-exposed cohorts, we expect $\hat{\beta}_k \approx 0$. For fully-exposed cohorts, we expect $\hat{\beta}_k < 0$, and possibly for the partially treated cohorts as well.

Figure 4 plots the estimates of the different cohort-specific treatment effects. The shaded horizontal lines capture the predicted pattern of coefficients. Consistent with what we expected, the estimates for not-exposed cohorts fluctuate around 0 and do not follow any specific trend. This is consistent with the lack of pre-treatment differences in the evolution of vaccination rates. This supports our main identification assumption of a lack of pre-existing trends. The estimates for fully-exposed cohorts are negative and large in magnitude. They indicate a reduction in the likelihood of immunization between 4 and 12 percentage points. The estimates corresponding to the partially exposed cohorts are also negative. For the measles vaccines, for which we have a larger set of partially treated cohorts, we observe a clear downward trend in the treatment effects of partially treated cohorts. This is consistent with stronger negative effects for the partially treated cohorts that are exposed to the new information for a longer period of time during the first months of life.

[50]We focus on the treatment effects for cohorts born in the months before and after of the disclosure of the vaccine ruse. See Appendix Figures 7 and 8 for similar graphs including more pre- and post-treatment cohorts. See also the discussion in section 13 of the Online Appendix.

Overall, the pattern of cohort-specific treatment effects is consistent with our predicted effects and with the notion that the information disclosed in July 2011 affected the parental acceptance rates of vaccines.

Appendix Figure 4 presents the results showing 90% confidence intervals. Appendix Figure 5 shows the estimates when including only cohort and district fixed effects as controls. Finally, Appendix Figure 6 presents similar estimates for complete immunization of polio, DPT, and the three vaccines all together. 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.

6 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 fully-exposed and not-exposed cohorts. Hence, we exclude the partially treated cohorts from the sample. More specifically, we implement the following *Difference-in-Differences* (DID, henceforth) empirical strategy:

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

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).[51] Standard errors are clustered at the district level.

Panel A of Table 1 presents the main DID estimates, $\hat{\beta}$, when the outcome variables are indicators of having received the first dose of different vaccines. All the estimates are negative and statistically significant at the 1% level: a one standard deviation increase in the support for Islamist groups is associated with declines of 6, 5.5, and 5.6 percentage points in the vaccination rates of polio, DPT, and measles, respectively. These declines are large in magnitude they represent a 12% to 20% decline in vaccination rates over the corresponding sample mean. Column 4 shows that exposed cohorts are 5.8 percentage points less likely to have received the first dose of the three vaccines. This effect represents a 23% decline over the sample mean. Note that, the declines in effective protection against these diseases

[51] See the notes of Table 1 for details on the set of cohorts included in the specification.

are likely to be even larger since these estimates do not take into account the externalities generated by individual decisions to refuse vaccination.

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. However, the sample size is smaller because there are more partially treated cohorts when we examine full immunization. Hence, we focus on the results on first dosages as our baseline estimates for the rest of the paper and present results for all dosages in the Online Appendix.[52]

These results are consistent with the hypothesis that the disclosure of information on the vaccine ruse and the subsequent anti-vaccine propaganda, led to a reduction of parental confidence in vaccines and health workers. In section 8 we provide further discussion on the potential mechanisms and provide additional supporting evidence for this channel.

7 Robustness Checks

No Evidence of Pre-Existing Trends

The main identifying assumption behind our empirical strategy is that, in the absence of the disclosure of 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 support this assumption. The point estimates of non-exposed cohorts fluctuate around zero and do not follow any specific pattern. The p-values of joint-significance of the coefficients of non-exposed cohorts are 0.69, 0.21, and 0.19 for the polio, DPT, and measles vaccines, respectively. In Appendix Figure 7, we incorporate data from an earlier wave of the PSLM survey to show a longer sequence of pre-treatment coefficients. While the pre-treatment coefficients more distant from the vaccine ruse are more noisily estimated, they fluctuate around zero and do not follow any systematic pattern.

Additional Controls for Differential Trends

Table 2 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

[52]We verify the validity of these estimates by conducting a similar exercise using a different dataset: the Demographic Health Survey (DHS). The results are presented in Appendix Table 4 and show estimates within the same order of magnitude albeit less precisely estimated given the smaller sample size. See section 12 in the Appendix for details on the construction of the sample and measures. The DHS also reports the immunization record for the Hepatitis B vaccine. We find a negative and significant effect for this vaccine as well. This outcome is of particular interest since the CIA vaccination ruse consisted of a Hepatitis B vaccination campaign.

to health services interacted with yearly-cohort fixed effects. In particular, we control for the share of women that had received tetanus 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 yearly-cohort fixed effects. In column 4 we incorporate as controls the average value of the dependent variable for the non-exposed cohorts, interacted with cohort fixed effects. All the resulting estimates are similar to the baseline estimate. This suggests that our main estimates are unlikely to be driven by poor districts experiencing a differential evolution of vaccination rates over cohorts or by mean reversion.

Column 5 controls for the monsoon floods that took place in 2010 and that severely affected some regions (Fair et al. (2017); Masera and Yousaf (2018)). Our results are robust to include as controls an indicator for the districts affected interacted with cohort fixed effects.[53]

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 is not driving the results.

In columns 7 and 8 we explore whether incidence of conflict affects our results. We construct different measures of the number of violent incidents based on the Armed Conflict Location & Event Data Project (ACLED). In column 7, we control for a the number of conflict events that occurred in a child's district of residence during her first year of life. In column 8, we construct a measure of pre-treatment conflict and interact it with yearly-cohort fixed effects. The results are highly robust to both set of tests.[54]

Under-reporting of Vaccination Status

In order to minimize measurement error in our measure of vaccination status, we code successful vaccinations only if the enumerator was able to verify the information on children's vaccination card. Vaccination rates based on recall have been shown to be subject to a large extent of measurement error, mainly due to over-reporting of vaccination status (Sheikh et al (2011); Research and Development Solutions (2012)).

A potential concern in our context is that our measure suffers from under-reporting of vaccination status. For instance, parents may destroy or hide the vaccination report card to conceal that they vaccinated their children. Under-reporting may be more prevalent if parents were concerned about Taliban violence or intimidation.

[53]See section 12 in the Appendix for details on the construction of the flood affectedness measure.

[54]The measures of conflict contain battles, violence by non-state actors, violence against civilians, among others. See section 12 in the Appendix for details. Our results are robust to using measures of conflict that involve the Taliban as an actor. These results are available upon request.

However, we would expect that parents that wanted to under-report their children's vaccination status to comply with the Taliban directives would report *not* having vaccinated their children. In contrast, only 3.6% of parents report not having vaccinated their children against polio.[55] Furthermore, the fraction of parents that indicate not having vaccinated their children declines after the disclosure of the vaccine ruse and this decline is not differential across regions with different levels of support for Islamist parties. Appendix Figure 9 shows these results. While the fraction of parents that report not having vaccinated their children fluctuates over time, it is not differential across regions with high and low levels of Islamist support and it is always below 10%. If parents were strategically destroying or hiding the vaccine card to conform with the views of the Taliban, we would expect a higher fraction of self-reported lack of vaccination in areas with high Islamist support for partially- and fully-exposed cohorts. To set these numbers in perspective, we also report in the same graph the evolution of our measure of vaccination status—as verified in the report card—by level of Islamist support. As we can see, the evolution of these rates is similar across regions for the unaffected cohorts but starts differing for the partially- and fully- affected cohorts.

This evidence also mitigates the concern that social desirability of vaccination changed upon the disclosure of the vaccination ruse. Social image concerns have been shown to have important implications for multiple areas of human behavior,[56] including vaccination decisions.[57] If vaccinating children became less socially desirable in areas with high Islamist support, we would have expected a differential increase in the self-reported lack of vaccination, relative to areas with low Islamist support.

Selective Migration

Another potential concern is that the treatment may have induced differential migration across districts. If parents that are complying with (or intent to comply with) the vaccination schedule out-migrate in greater proportions from districts with high Islamist support, our results may be downward biased—i.e., biased towards finding a negative effect. Unfortunately, the PSLM data do not contain information on families' migration history or on parent's place of birth. Hence, in our baseline specification we assign children to the districts they are residing at the time of interview.

We conduct a number of tests to check whether selective migration could confound our estimates. First, we empirically investigate whether the composition of households changed

[55] 55% of parents report having vaccinated their children based on recall measures. The remaining 42% report successful vaccinations based on the vaccination card.

[56] See Bursztyn and Jensen (2017) for a literature review.

[57] See Karing (2018).

differentially for districts with different levels of support for Islamist parties. We explore this in Appendix Table 5 by using child and household characteristics as dependent variables. Most of the estimates are small and insignificant, suggesting there are no large changes in the sample composition across districts.

Second, we conduct additional analyses using information from the Demographic Health Survey (DHS, henceforth). In the 2012 wave, the survey contains information on the migration history of households. We use these data to construct district-specific rates of in-migration and out-migration.[58] The average in-migration rate is 2.5%, the average out migration rate is 3.9%.[59] Given that the fraction of migrants is low, it is unlikely that selective migration could have large effects on our estimates.

In Panel A of Appendix Table 6, we control for the district-specific in- and out-migration rates interacted with a full set of cohort fixed effects. This addresses the concern that districts with different propensities to experience migration may have underlying different trends. The results are very similar to the baseline estimates.

In Panel B, we conduct an exercise to obtain a lower bound on the magnitude of our estimates assuming the most unfavorable scenario of potential selective migration. For each district, we compute the net out-migration rate.[60] We assume that districts with positive out-migration estimates have fewer observations in the post period, relative to a counterfactual scenario where the treatment—disclosure of the vaccine ruse—did not happen. Hence, we add "constructed" observations to those districts equal to the corresponding share of net out-migration.[61] In particular, the "constructed observations" are assigned to the post-treatment cohorts. In order to construct the most unfavorable scenario, we impute successful vaccination outcomes in districts where the level of support for Islamist groups exceeds the median in the sample, whereas we impute unsuccessful vaccination outcomes in districts, where the level of support for Islamist groups lies below the median in the sample. For districts where we estimate negative net out-migration rates, we proceed to drop observations. In particular, we drop observations with a successful vaccination outcome if the level of support for Islamist groups is below the median level in the sample, whereas we drop observations with an unsuccessful vaccination outcomes in districts where the level of support for Islamist groups exceeds the median in the sample.[62] Despite the extreme assumptions on the nature of selective migration, our estimates remain negative, large in magnitude and

[58] See section 12 for further details on the construction of these measures.

[59] The maximum rates of in- and out- migration are 11% and 22%, respectively.

[60] The net out-migration rate is equal to the out-migration rate minus the in-migration rate.

[61] We assume that these observations have characteristics equal to the average in that district among the post-treatment cohorts.

[62] The observations dropped are selected at random among the observations that have the specified vaccination status.

statistically significant, with the only exception of the measles vaccine, which is no longer statistically significant. These estimates constitute a lower bound on the negative effect of the vaccine ruse on vaccination rates. The fact that this lower bound is still large in magnitude is reassuring. In other words, it is unlikely that selective migration could entirely account for our estimates.

In Panel C, we use the fact that for the DHS sample we do have data on the district of origin of households observed in the post period. We estimate our effects when assigning households observed in the post period to their district of origin, instead of to their district of residence. The results are very similar to the baseline effects when using the DHS sample, which are presented in Appendix Table 4.

Additional Results and Robustness Checks

We provide a number of additional results and robustness checks in the Appendix. Appendix Table 7 shows our main estimates are similar in a parsimonious specification where we only include cohort and district fixed effects as controls. In Appendix Table 8, we explore potential non-monotoncity in the treatment effects. Columns 2, 5, and 8 present the results where we interact the *Post* dummy for fully-exposed cohorts with an indicator for districts above the median support for MMA—instead, of our baseline measure of vote share of MMA in standard deviations. The results are highly significant and large in magnitude. In columns 3, 6, and 9, we interact the fully-exposed cohort dummy with indicators for the quintiles of support for Islamist parties. Districts with support for Islamist parties above the 60th percentile are the ones experiencing the largest declines in vaccination rates, relative to districts below the 20th percentile.[63]

Appendix Table 9, we examine the effects on the number of cases of poliomyelitis that were registered in Pakistan. We obtained district-level data on the cases of polio for the years 2009, 2010, 2011, and 2014.[64] We implement a *Difference-in-Differences* strategy where the dependent variable is the number of cases of poliomyelitis in the district-year. Our main

[63]Note that districts with support for Islamist parties between the 60th and the 80th percentile have a somewhat larger effect (in magnitude) relative to districts with support above the 80th percentile. One potential interpretation is that the districts between the 60th and 80th percentiles may have had a larger fraction of parents that before the vaccine ruse were *on the margin* on their decision of whether to vaccinate their children. Instead, districts with support for Islamist parties above the 80th percentile may have had a large fraction of parents that were already opposed to vaccination before the vaccine ruse. While this could provide a plausible interpretation for the pattern of coefficients, the differences in the point estimates are not statistically significant. Hence, this interpretation should be taken with caution.

[64]We obtained district-level data on polio incidences for the year 2014 from the website http://www.endpolio.com.pk (last accessed 07/18/2019), which is maintained from the Expanded Program of Immunizaton. We then complemented this dataset with information on polio cases for the years 2009, 2010, and 2011 by digitizing and geo-referencing polio incidences using maps provided in the annual reports of the Global Polio Eradication Initiative. We could not obtain information on the timing of the cases of po-

regressor of interest is the interaction between the vote share of Islamist parties interacted and an indicator for the periods after the disclosure of the vaccine ruse. We include as controls district fixed effects and year fixed effects. In column 1 we define the *post* dummy to take value one for the years 2011 and 2014. Ideally, this dummy would take value one only after July 2011 but, unfortunately, we do not have data on cases of poliomyelitis at the month level. However there is evidence that suggests that most of the cases of poliomyelitis in 2011 took place in the second half of the year.[65] The results presented in column 1 indicate that one standard deviation increase in support for Islamist parties is associated with a 93% increase in the number of cases of polio detected over the sample mean. In column 2 we decompose the effect by year. The omitted category is 2009. We observe no differential increase in the number of polio cases in 2010—before the disclosure of the vaccine ruse. However, both in the years 2011 and 2014, we observe a differential increase in the number of cases of poliomyelitis for the districts with high support for Islamist parties.

These results suggest that the fall in immunization rates in areas with high support for Islamist groups may have generated breeding ground for the disease to reproduce and spread. While poliomyelitis cases are relatively infrequent, the magnitude of the increase in polio cases suggest that the decline in immunization rates may have had serious health consequences for a highly vulnerable population.

Finally, we examine the evolution of the effects for subsequent cohorts. Appendix Figure 8 extends our analysis to a larger set of fully-exposed cohorts. The results indicate that, while cohorts born around the time of the disclosure of the vaccine ruse show persistent lower vaccination rates, those born after mid-2012 experience a mitigation of the negative effects. One possible explanation is the fact that, starting in mid-2012, vaccination workers have directly attempted to address misconceptions by involving religious leaders that endorsed the usage of vaccines.[66] It is possible that this made parents regain confidence in vaccines and, that this in turn mitigated the negative effects on immunization rates.[67]

liomyelitis. However, supplemental sources suggest that most of the recorded cases for 2011 took place in the second half of the year. See Center for Disease Control and Prevention, Weekly, Vol. 62 No.17, May 2013. https://www.cdc.gov/mmwr/pdf/wk/mm6217.pdf Figure in page 337 (last accessed 07/05/2019). Hence, we consider the cases registered in 2011 as part of the post-treatment period.

[65]See Center for Disease Control and Prevention, Weekly, Vol. 62 No.17, May 2013. https://www.cdc.gov/mmwr/pdf/wk/mm6217.pdf Figure in page 337 (last accessed 07/05/2019)

[66]Khan, Taimur. 2017. "How Pakistan got to near zero on polio". *www.devex.com*, November 14. *https://www.devex.com/news/how-pakistan-got-to-near-zero-on-polio-91521* (last accessed 07/18/2019). Khan et al. (2017).

[67]See section 9 for further discussion.

8 Mechanisms

The results presented in this paper are consistent with the hypothesis that the disclosure of the vaccine ruse, and the subsequent Taliban anti-vaccine propaganda campaign, eroded the population's degree of confidence in vaccines and in health workers. In this section, we provide further evidence supporting this mechanism and we evaluate the validity of competing explanations.

8.1 Heterogenous Effects by Gender of the Child

First, we examine whether our baseline results are heterogenous as a function of the gender of the child. This is relevant because some of the rumors spread by Islamist groups claimed that vaccines were a conspiracy to sterilize Muslim children, girls in particular.[68] If parents accord credibility to this specific rumor, we would expect a larger decline in vaccination rates for girls than for boys.

The results presented in Table 3 indicate that this was indeed the case. The triple interaction of *Post*×*Islamist_support*×*female* is negative for all vaccines and statistically significant for polio and DPT. This indicates that girls' vaccination rates declined by 3 additional percentage points, relative to the vaccination rate of boys. Note that the double interaction of a *Post*×*Islamist_support* is negative for the three vaccines. This indicates that boys were also negatively affected by the disclosure of the vaccine ruse, but to a lesser extent than girls.

Overall, these results are consistent with parents granting credibility to the rumors of the Taliban and modifying their vaccination decisions accordingly.

8.2 Effects on Health Seeking Behavior

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 order to examine this, we modify the empirical specification by substituting the cohort with the time dimension.

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

Y_{itj} corresponds to a health seeking behavior measure related to child i, whose parents were interviewed in date t, in district j; $Post_t$ is a dummy that takes value 1 if the household

[68] Scientific American. 2013. Op. cit.

was interviewed after July 2011; I_j is electoral support for Islamist parties in standard deviations; γ_t are quarter-year of interview fixed effects; γ_j are district fixed effects; c_i contains individual-level controls: dummy for rural region and monthly age of child i. We focus on the same sample of children, younger than 24 months old to facilitate the comparison with the immunization results.[69]

Note that with this approach we lose our rich detailed cohort variation. Nevertheless, the evidence is still suggestive of a parental behavioral response for the periods after the disclosure of the vaccine ruse.

Table 4 presents the results. In column 1, the outcome variable 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 indicate that there is a slight differential increase in the probability that children are sick in the areas with high support for Islamist parties. However, what is more noteworthy is the type of assistance parents sought when their children fell sick. In columns 2 and 3, we restrict the sample to children that reported being sick in the last two weeks. Column 2 shows that parents in areas with high Islamist support became less likely to consult someone regarding the sickness of their child. Column 3 indicates that this was driven by a lower likelihood to consult formal medical workers. Instead, parents became more likely to consult non-formal medical workers, such as spiritualists, homeopaths, chemists, hakeem, or other.

This decline in the rate at which parents consulted formal doctors is consistent with a decrease in the demand for health services and with a potential decline in the level of confidence in formal medicine after the disclosure of the vaccine ruse.[70]

8.3 Effects on Trust Measures

Next, we examine the effects on a range of measures of trust using data from the South Asia Barometer. These data report individual-level measures of trust in different organizations for a large sample of individuals. We use the two waves of this survey in closest temporal proximity to the vaccine ruse—waves 2005 and 2013.

Unfortunately, the survey does not explicitly record trust on formal medicine or in health organizations. The closest proxy of trust in the health sector is trust in the civil service. Furthermore, the survey does not have information on the district of residence of individu-

[69]Note, that we do not eliminate from the sample partially treated children in a cohort-sense. Since the outcome relates to the sickness of the child in the previous two weeks, we consider all behavior observed after July 2011 as exposed to the new information scenario, while all behavior observed before July 2011 as not exposed. The results are similar if we drop children partially treated in a cohort-sense.

[70]In Appendix Table 10 we show robustness of these results to data from the DHS survey. While the results are less precisely estimated, the overall evidence indicates that parents in regions with high support for Islamist groups became less likely to consult formal medical workers.

als. Respondents are geocoded at the provincial level. We estimate a simple *Difference-in-Differences* model comparing measures of trust in the wave before and after the disclosure of information, and across provinces with above or below the median support for Islamist groups. Hence, these results should be interpreted with caution.

Panel A in Table 5 presents the results. Column 1 shows the effects on trust in civil service. Provinces with high support for Islamist groups experienced a 7.6 percentage points decline in trust in the civil service after the disclosure of the vaccine ruse. This effect represents a 16% decline over the sample mean. Columns 2 to 9 show the effects on trust in other organizations. With a couple of the exceptions, most of the effects are negative and significant. Column 10 uses as dependent variable a z-score for the different measures of trust. We find that there was an overall decline in trust of 0.08 standard deviations.

Given the coarseness in the geographic measure of support for Islamist groups, we enrich our empirical strategy by examining an individual-level predictor of sympathies for Islamist groups. In particular we add a triple interaction with a dummy that takes value 1 for individuals that do not own a TV. The Taliban have discouraged ownership of TV with the argument that that type of entertainment is contrary to the ultra-conservative lifestyle they advocate for.[71] The results, presented in Panel B, suggest that the decline in trust is driven by individuals that do not own a TV. The triple interaction is negative, large in magnitude, and typically statistically significant. Hence, these results suggest that the effects are driven by those individuals that are more likely to hold views aligned with Islamist groups.[72,73]

8.4 Alternative Channels: Changes in Supply of Health Services

An alternative explanation for our main results is that the supply of medical services may have endogenously reacted to the disclosure of the vaccine ruse. Starting in mid-2012 the Taliban carried out attacks against health workers. Hence, vaccination campaigns may have been more difficult to conduct in regions with higher Islamist support. However, a supply reaction is unlikely to fully account for the estimates presented in this paper, mainly for two reasons. First, our sample period precedes the campaign of violence against health workers: our main results include cohorts born up to July 2012.[74] Second, the region that suffered the most intense violence against health workers—i.e., the FATA region—is not part

[71] Roul (2014).

[72] In Appendix Table 11 we present the coefficients of the post dummy, the "no TV" dummy, and the binary interactions of each of these variables.

[73] The results are robust to including measures of wealth of the individual, such as indicators for ownership of other items such as a car, phone, or fridge. The results are available upon request.

[74] Furthermore, the effects for cohorts born after July 2012 seem to be lower in magnitude—i.e., less negative—and, hence, not fully supportive of a *decline* in supply of vaccines after July 2012. See section 7 and Appendix Figure 7 for details.

of our estimating sample. Nevertheless, we conduct a number of tests to assess the empirical relevance of a supply mechanism.

First, we examine the effects on different measures of ease of access to health facilities. The dependent variables in columns 1 and 2 of Appendix Table 12 correspond to the time required to travel to the nearest health clinic and basic health unit, respectively. [75] The interaction coefficients are small and statistically insignificant. Columns 3 and 4 examine the effects on the intensity of vaccination campaigns. To conduct this test, we collected administrative data from the Expandend Program on Immunization in Pakistan on the number of polio vaccination drives conducted in each district between 2008 and 2013.[76] The unit of observation in these specifications is the month-district. The results indicate that there is no evidence that the frequency of vaccination drives or the intensity of vaccination efforts differentially changed across regions with different levels of Islamist support.

Next, we verify that our main estimates are robust to controlling for measures of supply. The results are presented in Table 6. Column 1 presents the baseline results for comparison. Column 2 controls for travel distance to the closest health clinic and basic health unit. In columns 3 to 6 we incorporate controls for the number of immunization campaigns and the number of targeted children per capita. For each child in our sample, we construct the corresponding average measure of supply of vaccines during her first three months of life or during her first month of life in his or her district. The results are highly robust to controlling for these measures of supply of health services.

Finally, note that the heterogenous effects by gender are not fully consistent with a supply channel. It is unlikely that vaccination workers had a differential propensity to vaccinate girls versus boys. Hence, the stronger negative effects on girls are more supportive of the hypothesis that the decline in vaccination rates was driven by a drop in demand.

8.5 Unbundling Demand: Changes in Beliefs or Intimidation

There are different reasons why the demand of vaccines may have changed as a response to the disclosure of the vaccine ruse. First, parents may have updated their beliefs according to the messages spread by the Taliban and, hence, may have become more skeptical about the benefits of vaccination.

There is substantial anecdotal evidence supporting this particular demand channel. For

[75] This information was reported by parents in the PSLM survey. Hence, we have information at the child level. About 5% of the observations have missing values for distance to health facilities. In order to show results for our baseline sample, we fill in the missing values with the average distance to health facilities for children in the same district and year of interview. The results are similar when we do not conduct this imputation.

[76] See the section 12 in the Online Appendix for details.

instance, an article under the title "We Believed Our Cleric" narrates the heartbreaking story of a father that did not vaccinate his son in 2012 and who later became paralyzed from poliomyelitis.[77]

> *"Hamid Aziz says he listened to the advice of a cleric in his village, who announced over loudspeakers of the madrasah, a local Islamic religious school, that the vaccine was "not good" for children's health, and prevented it from being administered to any of his sons.*
>
> *(...) Nooran Afridi, a pediatrician at a private clinic in Pakistan's Khyber tribal region, says one of the biggest obstacles to eradicating polio in Pakistan has been 'refusals' stemming from 'antipolio propaganda' spread by conservative Islamic clerics in 'backward areas.' "*[78]

Interestingly, this article also describes the CIA vaccine ruse and anti-vaccine propaganda as a contributing factors to parental skepticism about vaccines.

> *"Antipolio propaganda also has been fueled by distrust in Western governments who fund vaccine programs—particularly after the CIA staged a fake hepatitis vaccination campaign in 2011 to confirm the location of Al-Qaeda leader Osama bin Laden in Abbottabad, Pakistan."* [79]

An alternative channel that could have generated a decline in the demand for vaccination is intimidation by the Taliban or their supporters. Parents may have increasingly perceived vaccinating their children as an action in opposition to the Taliban's directives and may have feared that vaccination could have led to reprisals by Islamist groups.

This alternative mechanism is unlikely to fully account for our results. The main reason is that the regions with greater presence of the Taliban and more affected by conflict—FATA, Gilgit-Baltistan and Azad Kashmir—are not part of our estimating sample.

Nevertheless we empirically assess the relevance of this alternative channel. We obtain measures of conflict where the Taliban were a relevant actor from the ACLED data. There were 266 instances of conflict involving the Taliban in 2010 and 631 instances during the 2010-2013 period. Most of these events of conflict are classified as battles between the

[77] Synovitz, Ron and Ahmad Ullah. 2017. "'We Believed Our Cleric': Pakistani Polio Victim's Regretful Father Urges Others To Use Vaccine". *Radio Free Europe Radio Liberty*, December 12. *https://www.rferl.org/a/pakistan-polio-vaccination-regretful-father-paralyzed-son/28912188.html* (last accessed 07/18/2019).

[78] Ibid.

[79] Ibid.

Pakistani security forces and the Taliban that did not result in an actual change of territory, incidences of remote violence, and violence against civilians.

In Appendix Table 13 we do a horse-race between these two different hypothesis. We estimate our baseline specification including simultaneously interactions of the post-vaccine ruse indicator with our measure of Islamist support and with the number of conflict events that involved the Taliban. Our estimates of the interaction *Post*×*Islamist_support* are unaffected by the inclusion of the interaction term *Post*×*Conflict*. Furthermore, the latter interaction is small and typically statistically insignificant across specifications.[80] Hence, this suggests that ideological proximity to Islamist groups is more closely related to the declines of vaccines than the violence exerted by the Taliban. This evidence is suggestive that the changes in attitudes is a more likely explanation for the decline in vaccination rates than the threat of violence or reprisals from the Taliban.

9 Conclusion

In this paper, we estimate the effects of the disclosure of information that damages the reputation of vaccines on immunization rates. We exploit the disclosure of information on the vaccine ruse that the CIA carried out in 2011 as part of the operations to locate and capture Osama Bin Laden. Following the disclosure of this information, the Taliban launched an intense anti-vaccine propaganda to raise suspicion about vaccines and health workers. It is likely that these factors eroded the parental confidence in vaccines and health workers. There is substantial anecdotal evidence that suggests this was indeed the case.

Using detailed cohort variation in exposure and district-level variation in ideological affinity to Islamist groups, we estimate the effects of these events on immunization rates. Our estimates are large in magnitude: one standard deviation increase in support for Islamist parties is associated with 12 to 20% declines in vaccination rates. These effects correspond to persuasion rates of 31 to 42%, which are among the highest estimated in the literature (see Della Vigna and Gentzkow (2010)).

We provide additional empirical evidence that suggests that these effects are likely to be driven by a reduction in the demand for vaccines. First, we find stronger declines in vaccination rates for girls than for boys. This is consistent with parents believing some of the rumors spread by Islamist groups that linked vaccines to attempts to sterilize Muslim girls. Second, we show that other forms of health seeking behavior were also negatively affected. Third, we provide suggestive evidence that trust in public services declined. Fourth, we

[80]Note that this is not due to lack of variation in our measure of conflict. If we only include the interaction *Post*×*Conflict* the estimates are negative and significant.

show that our results are fully robust to measures of supply of health services and intensity of vaccination drives. Finally, we show that our results are robust to controlling for the presence of the Taliban and the incidence of Taliban attacks. While we cannot entirely rule out that fear to the Taliban played some role, the overall evidence suggests that increase in vaccine skepticism is likely to be an importan driver of our estimated effects.

Our findings have implications for at least two areas that deserve further investigation. First, an important and open question is whether trust can be regained. Studies that exploit cases of medical malpractice find that the negative effects on demand for health persist over multiple generations.[81] In contrast, recent experimental evidence suggests that individuals can increase their levels of trust in government providers upon receiving good news about state-effectiveness (Acemoglu et al. 2019).[82] Our findings are consistent with the notion that trust can be regained: while we find lower vaccination rates for the children born in the year after the disclosure of the vaccine ruse, subsequent cohorts exhibit a mitigation of these negative effects. One explanation for this pattern could be the efforts of vaccination workers to directly address misconceptions by involving religious leaders that endorsed the usage of vaccines.

Second, our results support the observation that conspiracy theories are fueled by pieces of true information. Research in social psychology have noted that conspiracy theory narratives combine true with wrongful information.[83] The existence of the former could lent credibility to the entire narrative. To the best of our knowledge, this is the first paper to evaluate how the disclosure of information lending credibility to conspiracy theories affects an important type of human behavior: demand for vaccines. The study of how the disclosure of different types of information can affect the credibility and the evolution of conspiracy theories seems a fruitful area for further research.

[81] Alsan and Wanamaker 2017, Lowes and Montero, 2018.
[82] See also Andrabi and Das (2017).
[83] Raab et al. (2013).

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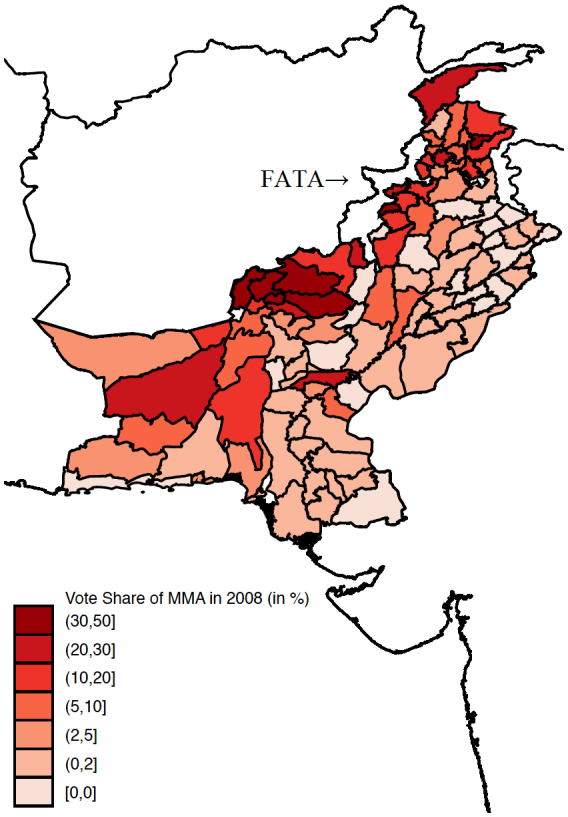
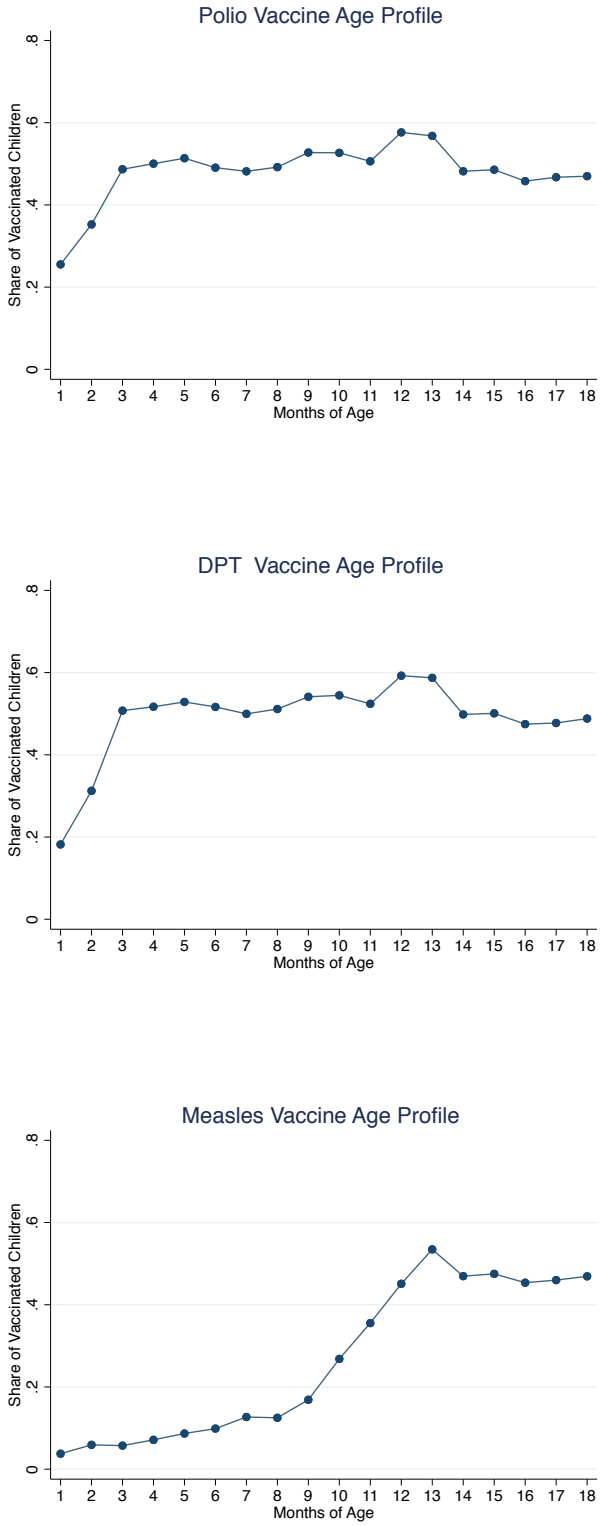
Figure 1: Distribution of Electoral Support for MMA



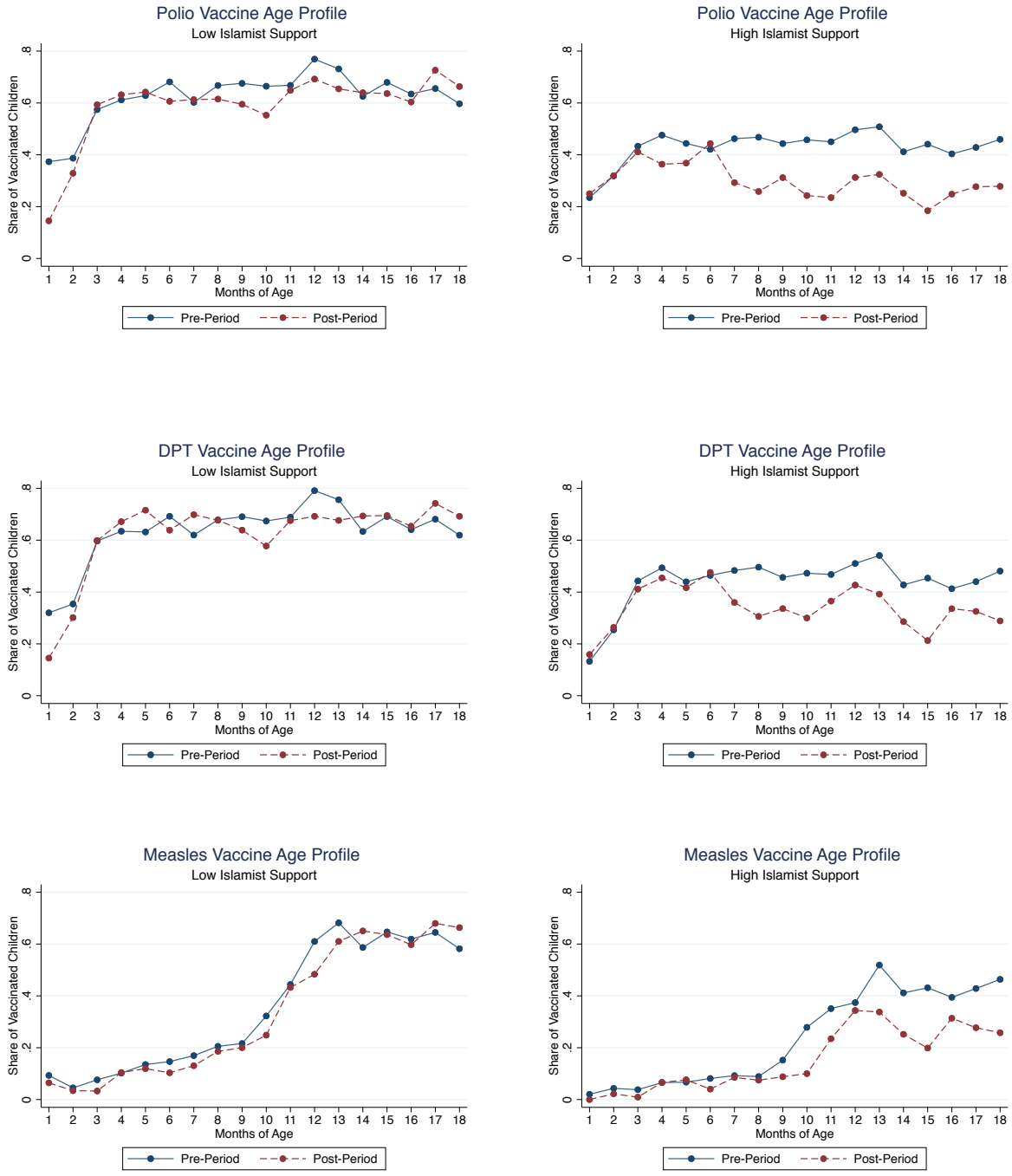
Notes: Map of Pakistan showing the geographic distribution of district-level vote shares for MMA in the 2008 legislative election.

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



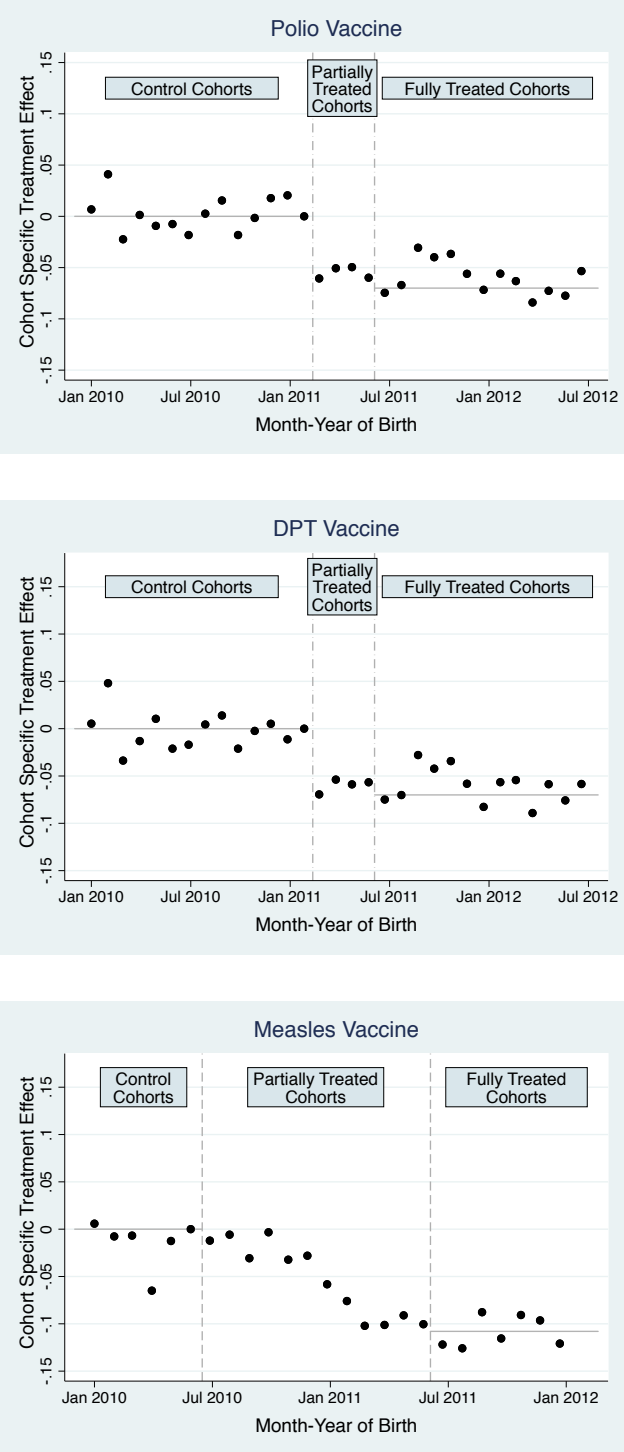
Notes: These figures show the fraction of children that received the first dose of each vaccine by their age at the time of interview. Only the pre-treatment waves of the survey (2008/9 and 2010/11) are used.

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



Notes: These figures show the fraction of children that received the first dose of each vaccine by their age at the time of interview. The figures on the left (right) hand side restrict the sample to districts in the bottom (top) quartile of vote shares for Islamist parties. The solid-blue age profiles are obtained from the pre-treatment waves of the survey, 2008/9 and 2010/11. The dashed-red age profiles are obtained from the post-treatment wave, 2012/13.

Figure 4: Treatment Effects by Monthly Cohort



Notes: These figures show cohort-specific treatment effects by month of birth. In particular they show the coefficients on the interaction of Islamist support with the corresponding cohort indicator. The omitted category corresponds to the last cohort of the non-exposed cohorts, i.e., children born in February 2011 for polio and DPT and children born in June 2010 for measles.

10 Tables

Table 1. Effects of the Disclosure of the Vaccine Ruse 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.	*0.420*	*0.453*	*0.279*	*0.250*
Post × Islamist Support	-0.060***	-0.056***	-0.055***	-0.058***
	(0.020)	(0.018)	(0.016)	(0.016)
Observations	16,654	16,654	12,479	12,479
R-squared	0.262	0.241	0.253	0.259
Number of Clusters	109	109	109	109
	Panel B. All Doses of Each Vaccine			
Mean Dep. Var.	*0.381*	*0.419*	*0.279*	*0.264*
Post × Islamist Support	-0.064***	-0.061***	-0.055***	-0.050***
	(0.019)	(0.018)	(0.016)	(0.015)
Observations	11,205	11,205	12,479	11,205
R-squared	0.277	0.247	0.253	0.272
Number of Clusters	109	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 July 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children: for the first dose of Polio and DPT, we exclude children born between March and June 2011; for first dose of measles and the first dose of all vaccines, we exclude children born between July 2010 and June 2011. In panel B (with the exception of the results for measles in column 3), 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. The outcome for *all vaccines* takes value 1 if the child has obtained the corresponding dosage of the three vaccines.

Table 2. Main Robustness Checks

	Baseline	Initial Health x Cohort FE	Initial Education x Cohort FE	Mean of Dep Var Pre-Treatment x Cohort FE	Flood-Affected x Cohort FE	Drop District of Abottabad	Conflict Events in the First Year of Life	Conflict Events in 2010 x Cohort FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. First Dose of Polio Vaccine							
Post × Islamist Support	-0.060***	-0.052***	-0.044**	-0.061***	-0.055***	-0.058***	-0.060***	-0.060***
	(0.020)	(0.018)	(0.020)	(0.020)	(0.018)	(0.020)	(0.020)	(0.020)
Observations	16,654	16,654	16,654	16,654	16,654	16,500	16,624	16,624
R-squared	0.262	0.264	0.263	0.262	0.265	0.264	0.262	0.263
	Panel B. First Dose of DPT Vaccine							
Post × Islamist Support	-0.056***	-0.054***	-0.056***	-0.058***	-0.055***	-0.054***	-0.057***	-0.056***
	(0.018)	(0.016)	(0.019)	(0.019)	(0.018)	(0.018)	(0.017)	(0.018)
Observations	16,654	16,654	16,654	16,654	16,654	16,500	16,624	16,624
R-squared	0.241	0.244	0.241	0.242	0.242	0.243	0.242	0.243
	Panel C. First Dose of Measles Vaccine							
Post × Islamist Support	-0.055***	-0.046***	-0.049***	-0.053***	-0.053***	-0.053***	-0.055***	-0.054***
	(0.016)	(0.015)	(0.018)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Observations	12,479	12,479	12,479	12,341	12,479	12,367	12,459	12,459
R-squared	0.253	0.256	0.254	0.254	0.253	0.254	0.252	0.253
	Panel D. All Vaccines							
Post × Islamist Support	-0.058***	-0.046***	-0.040**	-0.056***	-0.054***	-0.057***	-0.058***	-0.058***
	(0.016)	(0.016)	(0.017)	(0.016)	(0.015)	(0.016)	(0.016)	(0.016)
Observations	12,479	12,479	12,479	12,341	12,479	12,367	12,459	12,459
R-squared	0.259	0.263	0.263	0.261	0.262	0.260	0.258	0.259

Notes: Standard errors clustered at the district-level in parentheses. There are 109 parent districts in the baseline sample. 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 survey, 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 the mean of the dependent variable for the non-exposed cohorts interacted with cohort fixed effects. Column 5 adds as controls a dummy for whether the district was severely affected by floods in 2010 interacted with yearly cohort fixed effects. Column 6 drops the district where Abottabad is located. Column 7 adds as a time-varying control the number of conflict events in the first year of life (excluding protests and riots). Column 8 adds controls for the number of conflict events in 2010 interacted with yearly cohort fixed effects.

Table 3. Heterogenous Effects by Child's Gender

	Dependent Variables:			
	Polio	DPT	Measles	All Vaccines
	(1)	(2)	(3)	(4)
	Panel A. 1st Dose of Each Vaccine			
Mean Dep. Var.	*0.420*	*0.453*	*0.279*	*0.250*
Mean Dep. Var. for Males	*0.414*	*0.447*	*0.274*	*0.244*
Mean Dep. Var. for Females	*0.428*	*0.459*	*0.284*	*0.256*
Post × Islamist Support	-0.047**	-0.041**	-0.043**	-0.044***
	(0.020)	(0.019)	(0.017)	(0.017)
Post × Islamist Support x Female	-0.028**	-0.032**	-0.024	-0.029
	(0.013)	(0.016)	(0.018)	(0.018)
Observations	16,654	16,654	12,479	12,479
R-squared	0.263	0.242	0.253	0.259
Number of Clusters	109	109	109	109
	Panel B. All Doses of Each Vaccine			
Mean Dep. Var.	*0.381*	*0.419*	*0.279*	*0.264*
Mean Dep. Var. for Males	*0.374*	*0.413*	*0.274*	*0.259*
Mean Dep. Var. for Females	*0.388*	*0.425*	*0.284*	*0.269*
Post × Islamist Support	-0.037*	-0.038*	-0.043**	-0.036**
	(0.019)	(0.020)	(0.017)	(0.016)
Post × Islamist Support x Female	-0.057**	-0.049*	-0.024	-0.029
	(0.024)	(0.026)	(0.018)	(0.019)
Observations	11,205	11,205	12,479	11,205
R-squared	0.278	0.248	0.253	0.273
Number of Clusters	109	109	109	109

Notes: Standard errors clustered at the district-level in parentheses. The sample consists of children born between January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. 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. 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. The outcome for all vaccines takes value 1 if the child has obtained the corresponding dosage of the three vaccines.

Table 4. Effects on Health Seeking Behavior

	Dependent Variables:		
	Dummy for Illness in Last 2 Weeks	Dummy for Consulted Anyone	Dummy for Consulted Formal Medical Sector
	(1)	(2)	(3)
Mean Dep. Var.	*0.191*	*0.980*	*0.923*
Post July 2011 × Islamist Support	0.025*	-0.019	-0.052**
	(0.014)	(0.012)	(0.026)
Observations	18,650	3,558	3,558
R-squared	0.064	0.076	0.151

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. The formal medical sector corresponds to hospital, basic health units and lady health workers.

Table 5. Effects on Trust Measures

	Dependent variables. Trust in:									
	Civil Service	Police	The Courts	Parliament	Political Parties	Army	Central Government	Provincial Government	Local Government	z-score
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean Dep. Var.	*0.46*	*0.53*	*0.49*	*0.47*	*0.58*	*0.50*	*0.53*	*0.50*	*0.58*	*0.00*
	Panel A. Effects on Trust									
Post x (Islamist Support > Average)	-0.076**	-0.135***	-0.063	-0.094**	-0.190***	0.144***	-0.052	0.012	0.089**	-0.081*
	(0.039)	(0.036)	(0.039)	(0.039)	(0.036)	(0.035)	(0.039)	(0.039)	(0.039)	(0.049)
Observations	3,252	3,252	3,252	3,252	3,252	3,252	3,252	3,252	3,252	3,252
R-squared	0.054	0.208	0.029	0.054	0.215	0.204	0.050	0.041	0.055	0.069
	Panel B. Effects on Trust by Ownership of TV									
Post x (Islamist Support > Average)	0.04	-0.100**	-0.031	-0.03	-0.099**	0.158***	0.003	0.107**	0.153***	0.045
	(0.050)	(0.045)	(0.051)	(0.050)	(0.047)	(0.042)	(0.050)	(0.050)	(0.050)	(0.063)
Post x (Isl. Support > Average) x No TV	-0.271**	-0.218**	-0.12	-0.154	-0.305***	0.109	-0.236**	-0.268**	-0.084	-0.345**
	(0.108)	(0.098)	(0.103)	(0.106)	(0.096)	(0.096)	(0.105)	(0.107)	(0.103)	(0.136)
Observations	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212
R-squared	0.054	0.209	0.034	0.056	0.222	0.215	0.052	0.045	0.058	0.071

Notes: Robust standard errors in parentheses. The unit of observation is the individual. The dependent variables are indicators for whether the respondent reported trusting the different organizations "a great deal" or "quite a lot". In Panel A, the regressor of interest is the interaction of an indicator for the 2013 wave of the South Asia Barometer and an indicator for provinces with support for MMA above the average (i.e., Khyber Pakhtunkhwa, Balochistan, Sindh). All regressions include as controls: province fixed effects, wave fixed effects, age, gender, years of schooling, and type of locality indicators. In Panel B also include interactions for the 2013 wave and province fixed effects with an indicator for TV ownership.

Table 6. Robustness to Controlling for Supply of Health Services

		Additional Controls:				
	Baseline	Travel Distance to Health Facilities	Number of Immunization Campaigns		Number of Targeted Children per Capita in Immunization Campaigns	
			First 3 months of life	First year of life	First 3 months of life	First year of life
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. 1st Dose of Polio Vaccine					
Post × Islamist Support	-0.060***	-0.061***	-0.060***	-0.060***	-0.061***	-0.062***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Observations	16,654	16,647	16,654	16,654	16,612	16,612
R-squared	0.262	0.264	0.262	0.263	0.261	0.261
Number of Clusters	109	109	109	109	109	109
	Panel B. 1st Dose of DPT Vaccine					
Post × Islamist Support	-0.056***	-0.057***	-0.056***	-0.056***	-0.056***	-0.059***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Observations	16,654	16,647	16,654	16,654	16,612	16,612
R-squared	0.241	0.243	0.241	0.242	0.240	0.240
Number of Clusters	109	109	109	109	109	109
	Panel C. 1st Dose of Measles Vaccine					
Post × Islamist Support	-0.055***	-0.056***	-0.055***	-0.055***	-0.054***	-0.058***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.017)
Observations	12,479	12,472	12,479	12,479	12,437	12,437
R-squared	0.253	0.254	0.253	0.253	0.252	0.252
Number of Clusters	109	109	109	109	109	109
	Panel D. Full Immunization					
Post × Islamist Support	-0.058***	-0.059***	-0.058***	-0.058***	-0.058***	-0.062***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.017)
Observations	12,479	12,472	12,479	12,479	12,437	12,437
R-squared	0.259	0.259	0.259	0.260	0.258	0.259
Number of Clusters	109	109	109	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 January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. 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 travel distance to basic health facilities. Column 3 and 4 add controls for the number of polio vaccination campaigns conducted in the district of residence in the first three months of life and in the first year of life, respectively. Columns 5 and 6 add similar controls for number of targeted children during polio vaccination campaigns. The number of observations is slightly lower because of missing information on the number of targeted children for some periods. The dependent variable in Panels A, B and C take value 1 if the first dose of the respective vaccine (Polio, DPT, Measles) was received, 0 otherwise. The dependent variables in Panel D take value 1 if a child has received all doses of a given vaccine, 0 otherwise.

APPENDIX (For Online Publication Only)

11 Theoretical Model

In this section, we present a formal model of Bayesian updating that provides a conceptual framework for our analysis.

We assume that parents take a one-time decision about whether to vaccinate or not their children. There are two possible states of the world $\omega \in \{0, 1\}$. If $\omega = 1$ vaccines are safe and beneficial for children and health workers are trustworthy. If $\omega = 0$ vaccines are harmful and health workers do not care for the well being of children. We assume that parents obtain a positive utility payoff if they vaccinate their children when $\omega = 1$ and the same negative payoff when $\omega = 0$. Hence, parents will vaccinate their children when the posterior probability of $\omega = 1$ is larger than $1/2$. Parents have a common prior, θ, that the state of the world is such that vaccines are safe.

Parents may observe two pieces of information before taking the vaccination decision. The first one is the realization of a public signal, $\lambda \in \{0, 1\}$, which is observed by everyone. The signal is informative. In particular we assume: $Pr(\lambda = 1|\omega = 1) = Pr(\lambda = 0|\omega = 0) = \delta > 1/2$. We interpret the disclosure of the CIA vaccine ruse as a realization of this public signal (i.e., $\hat{\lambda} = 0$).

The second piece of information that gets disclosed is a message sent by the Taliban. We assume that the Taliban get a private signal, $x \in \{0, 1\}$, and decide what message m to send to parents. The Taliban's private signal is informative. We assume:
$Pr(x = 1|\omega = 1) = Pr(x = 0|\omega = 0) = \delta_T > 1/2$. There are two types of Taliban: honest Taliban always truthfully report their private signal to parents, $m = x$. In contrast, dishonest Taliban want parents to believe that vaccines are bad for children. Hence, they always send message $m = 0$. Parent's perception of the probability that the Taliban is honest is denoted by q.

We assume that only a fraction e of the population receives the signal of the Taliban. This could capture that in certain regions the Taliban have a better system to diffuse their message, such as through a network of radicalized mosques.

The timing of events is as follows:

1. Nature chooses the state of the world ω.

2. The public signal λ is disclosed.

3. Parents update their prior about the state of the world.

4. The Taliban receive a private signal and report message m. A fraction e of parents receive this message.

5. Those parents that receive the message from the Taliban further update their posterior probability of the state of the world.

6. All parents decide whether to vaccinate their children.

Updating after the public signal

We conceptualize the CIA vaccine ruse as the realization of a negative signal $\hat{\lambda} = 0$. Hence, we focus on this case. Parents will decide to vaccinate their children if the ratio of posteriors of $\omega = 1$ relative to $\omega = 0$ is larger than 1. Parents that have only observed the public signal at the time of vaccination will decide to vaccinate as long as the following equation holds:

$$\frac{Pr(\omega = 1|\lambda = 0)}{Pr(\omega = 0|\lambda = 0)} = \frac{Pr(\lambda = 0|\omega = 1)Pr(\omega = 1)}{Pr(\lambda = 0|\omega = 0)Pr(\omega = 0)} = \frac{1-\delta}{\delta}\frac{\theta}{1-\theta} \geq 1 \tag{4}$$

The second ratio follows from applying Bayes rule and by the fact the terms $1/Pr(\lambda = 0)$ in the numerator and the denominator cancel out. Note that, by our assumption that the public signal is informative about the state of the world, the term $\frac{1-\delta}{\delta}$ takes value lower than one. This means that the disclosure of the CIA vaccine ruse has a negative effect on parents's posterior probability of the adequacy of vaccines.

Updating after the Taliban message

After the disclosure of the public signal, the Taliban receive a private signal and send message m. A fraction e of parents receive the message. Parents that do not receive the Taliban message remain with posterior likelihood ratio as in (4). In contrast, parents that receive the Taliban's message further update their posterior likelihood ratio. We focus on the case where parents observe the Taliban message $m = 0$, which is consistent with the anti-vaccine propaganda that followed the disclosure of the vaccine ruse.

$$\frac{Pr(\omega = 1|\lambda = 0, m = 0)}{Pr(\omega = 0|\lambda = 0, m = 0)} = \frac{Pr(m = 0|\lambda = 0, \omega = 1)}{Pr(m = 0|\lambda = 0, \omega = 0)}\frac{Pr(\omega = 1|\lambda = 0)}{Pr(\omega = 0|\lambda = 0)} \geq 1 \tag{5}$$

The second ratio corresponds to the posterior likelihood ratio derived in (4). The first ratio is given by:

$$\begin{aligned} Pr(m = 0|\lambda = 0, \omega = 1) &= q(1 - \delta_T) + (1 - q) \\ Pr(m = 0|\lambda = 0, \omega = 0) &= q\delta_T + (1 - q) \end{aligned}$$

The first expression captures that, if the state of the world is $\omega = 1$, a Taliban message $m = 0$ could be generated by an honest Taliban that gets an incorrect signal $x = 0$, or from a dishonest Taliban. The second expression is derived in a similar way.

Plugging these expressions on the posterior likelihood we obtain:

$$\frac{Pr(\omega = 1|\lambda = 0, m = 0)}{Pr(\omega = 0|\lambda = 0, m = 0)} = \frac{1 - q\delta_T}{1 - q(1 - \delta_T)} \frac{1 - \delta}{\delta} \frac{\theta}{1 - \theta} \geq 1 \tag{6}$$

Note that, given our assumptions that $\delta_T > 1/2$, the first ratio takes value lower than 1. This suggests that the Taliban's message $m = 0$ makes parents update downward their posterior probability that vaccines are good. Since parents assign a positive probability to the possibility that the Taliban are honest, the Taliban's message contains information to form their posteriors. Hence, parents update their posterior accordingly.

A fraction e of parents will update their posterior according to expression (4), while fraction $1 - e$ will derive their posterior according to (6). The following expression captures the "average" posterior likelihood across parents in a given region. This expression is informative about how parents, on average, will change their behavior after receiving the new information.

$$E\Big(\frac{Pr(\omega{=}1|\lambda{=}0, \{m{=}0 \ or \ m{=}\varnothing\}}{Pr(\omega{=}0|\lambda{=}0, \{m{=}0 \ or \ m{=}\varnothing\}}\Big) = \Big[(1\text{-}e) + e\frac{1 - q\delta_T}{1 - q(1\text{-}\delta_T)}\Big] \frac{1 - \delta}{\delta} \frac{\theta}{1 - \theta} \tag{7}$$

Comparative Statics

Expression (7) comprises the multiplication of three different ratios. The last one represents the ratios of prior probabilities. The first two ratios correspond of the effects of the updating that takes place upon receiving the Taliban's message $m = 0$ and the public signal $\lambda = 0$, respectively. Both ratios take value lower than one, indicating that the new information lowers parents' assessed probability of vaccines and health-workers being trustworthy. Hence, we expect that parents lower their willingness to vaccinate their children. This is not surprising given that we focus on the realization of signals or messages that indicate that vaccines are not good. However, it is likely that the magnitude of the downward updating is heterogenous across parents and regions. Next, we describe how the posterior likelihood depends on a number of parameters and the potential sources of heterogeneity in these parameters.

1. **The more precise signals, the larger downward updating.** The larger δ and δ_T, the more informative are the public and the Taliban signals about the true state of the

world. Hence, the larger the downward updating in the presence of negative signals or messages.

2. **The larger the perceived probability that the Taliban are honest, the larger downward updating.** The higher the perceived probability that the Taliban are honest, q, the larger is the information content of the Taliban's negative message m. Hence, parents will update downward their priors to a greater extent.

3. **The larger the fraction of the population that receives the Taliban's message, the larger downward updating.** The higher e the larger the fraction of parents that will update downward their posterior likelihood ratio according to the messages sent by the Taliban.

There are two parameters that are likely to be heterogenous across parents and regions. First, we assume that parents in districts with higher levels of support for Islamist parties have a higher probability to receive the message sent by the Taliban, i.e. e_i, where the i subindex captures differences across districts. This captures the notion that the network of distribution of information by the Taliban is more developed in areas were the Taliban had more support. For instance, areas with high support for Islamist parties tend to have a larger density of mosques with radicalized clerics that can diffuse some of the messages of the Taliban (Roul, 2014). Second, parents with a higher ideological affinity to the Taliban may be more likely to trust the messages sent by the Taliban. This could be driven by the presence of confirmation bias (Lord et al. 1979, Mullainathan and Shleifer, 2005) or by the possibility that parents judge the source of information as being of higher quality when it conforms with their priors (Gentzkow and Shapiro 2006). We introduce these notions in a reduced form way, by assuming that parents with a stronger ideological affinity with the Taliban assign a higher probability to the possibility that the Taliban are honest, i.e. q_i.

Given these two different sources of heterogeneity across parents and districts, we expect that districts with greater ideological support for the Taliban will experience larger declines in the demand for immunization after the disclosure of the CIA vaccine ruse and the subsequent anti-vaccine propaganda campaign. Hence, this theoretical predictions guide the interpretation of the results we find in the *Difference-in-Differences* empirical framework.

12 Data Appendix

12.1 Data Sources

Pakistan Social and Living Standards Measurement (PSLM)

The PSLM Project is designed to provide social and economic indicators at the district level. 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. The 2008/09 was fielded between August 2008 and June 2009. The 2010/11 was fielded between June 2010 and June 2011. The 2012/13 was fielded between October 2012 and June 2013.

We construct the following outcomes of interest from survey responses in the Vaccination 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). The last option is selected when households report having received the vaccine during regular polio vaccination campaigns. This option is also based on recall. 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)). In order to minimize the concern of misreporting, we focus on immunization status that can be verified in the vaccination card. In particular, our outcome variable take value one the child received a given vaccine as shown in his/her vaccination card, and 0 otherwise. Hence, the immunization rates reported in this study should be considered as a lower bound of immunization rates in this context.

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.[84] 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.[86] 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

[84]Three doses of polio and DPT and one dose of measles, were the World Health Organization (WHO, henceforth) recommended dosages prior to 2009. In that year, the WHO updated their guidelines by recommending to administer an additional dose of the polio vaccine at birth, and an additional dose of the measles vaccine at 15 months.[85] However, the PSLM survey did not update their questionnaire according to the new WHO guidelines. That is the reason why only three doses of polio and one dose of measles are recorded in the data.

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

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:

- *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 to have 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. The categories that correspond to the non-formal medical sector are: *"spiritualist"*, *"homeopath"*, *"chemist"*, *"hakeem"* and *"other"*.

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 respective party affiliations, 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 (The Gazette of Pakistan (2002)).

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 of 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.

Data on 2010 Floods

Pakistan suffered from floods in 2010, which had a severe negative impact on the population and the distribution of health services in particular.[87]

In order to verify robustness of our results to potentially confounding effects, we construct an indicator variable that equals 1 if a district was regarded as severely flood-affected by the FAO in a detailed livelihood assessment of 2012, 0 otherwise. (Food and Agriculture Organization of the United Nations (2012)). There are a total of 28 districts in our sample that were classified as severely flood-affected.

Demographic Health Surveys

We rely on data from two waves of the Demographic Health Surveys (DHS) in Pakistan to obtain further measures of immunization and health-seeking behavior. In particular, we rely on the 2006/07 DHS survey to obtain measures prior to the disclosure of the vaccine ruse, as well as the 2012/13 DHS survey to study outcomes after the vaccine ruse had been disclosed.

In order to make the DHS sample as comparable as possible to the PSLM sample from which we derive our main estimates, we impose the same sample restrictions. In particular, we focus on children that were at most 24 months of age at the time of interview. Thus the sample consists of children born in the years 2004 to 2007 and 2010 to July 2012. Paralleling the restrictions applied to the PSLM sample, we exclude partially treated children. In particular, for both the first dose of Polio, DPT and HBV, we exclude children born between March and June 2011. In the case of Measles, we exclude children born between July 2010 and June 2011. This yields a final sample size of 5,782 children.

[87]Statistics obtained from Pakistan Disaster Knowledge Network. *http://www.saarc-sadkn.org/countries/pakistan/disaster_profile.aspx* (accessed 14.06.2015)

We construct indicators for the receipt of different doses of vaccines analog to the procedure applied in the PSLM survey. In particular, we consider and construct indicators for Polio, DPT, HBV, as well as, measles vaccines. Enumerators for the DHS surveys could choose among the following options in order to record a child's vaccination status: 1) yes (vaccination date marked on the vaccination card); 2) yes (vaccination marked on the vaccination card); 3) yes (based on mother's recall); 4) no. Analog to the procedure applied in the PSLM data, we focus only on the first two choices as a measure of immunization. Hence, in the outcome variable "received one shot of *vaccine type*", we code answers based on recall as 0.

The 2012/13 wave of the DHS also contains detailed information on the migration status of survey respondents. In particular, for each household member, the survey elicits whether the individual was born in the current district of residence. If the respondent denies this, he is subsequently asked about the district of origin, that is the district where he lived prior to moving to the current district of residence. Moreover, respondents are also asked about the year in which this movement took place. We use this migration data in a series of robustness checks. In particular, we use the available information to calculate approximate in- and out-migration rates in the period after the vaccine ruse disclosure for each district in the sample.

To this end, we classify households as migrant households if at least one member migrated to the current district of residence in the years 2011 or 2012. To calculate the in-migration rate, we count the number of migrant households within a given district and divide this number by the total number of households included in the 2012/13 DHS survey that currently reside in the district of interest. To calculate the out-migration rate, for each district, we count the number of migrant households that are currently observed in a different location and report that at least one family member migrated to this place from the district of interest in the years 2011 or 2012. We then divide this number by the total number of households included in the 2012/13 DHS survey that still reside in the district of interest.

The DHS survey also provides information on morbidity outcomes and individuals' health seeking behavior. In particular, the survey inquires whether children in suffered from diarrhea or fever and cough in the two-week period prior to the interview. If so, follow-up information on health-seeking behavior and the course of medical treatment is elicited. This information enables us to construct the following two indicators: First, we generate a dummy which equals one if any treatment was sought out to treat the respective illness, zero otherwise. Second, we generate an indicator which equals one if a child received formal, medical treatment to treat the respective illness, zero otherwise. In particular, we consider a child to have received formal medical treatment either if the parents declared that the child received

medical treatment or if they visited a public, medical facility in order to receive treatment for their child.

South Asia Barometer Data

We use two rounds of the South Asia Barometer (SAB) data to examine trust outcomes before and after the disclosure of the vaccine ruse in Pakistan. The South Asia Barometer data was provided by the Asian Barometer office, located within the Department of Political Science at the National Taiwan University.

In particular, we rely on a first wave of the SAB that was fielded in 2005 in order to obtain trust measures prior to the vaccine ruse disclosure and a second wave of the SAB that was conducted in 2013 to obtain trust measures after the vaccine ruse disclosure. Both datasets are geo-referenced to the province level within Pakistan. Overall, the SAB data provides us with 3,252 observations in the pre- and post-treatment period for which we observe complete trust measures.

Individual can express 4 different levels of trust towards a given institution in the SAB survey. In particular, the available answer choices are: 1) A great deal of trust; 2) some trust; 3) not very much trust; 4) no trust at all. We construct indicators for trust towards a given institution that equal 1 if individuals express that they have either *"A great deal of trust"* or *"some trust"* towards a given institution, 0 otherwise.

Expanded Program on Immunization Data

The Expanded Program on Immunization in Pakistan was established in 1978 and aims to vaccinate children aged 0 to 11 months against nine target diseases, one of which is poliomyelitis. To this end, provincial EPI cells conduct regular immunization activities which take the form of vaccination campaigns. During these campaigns, teams of vaccinators distribute oral polio vaccine to eligible children in a specific target area. While these activities are implemented by the provincial EPI cells, the role of federal cell is restricted to the provision of policy and technical guidelines, coordination for international assistance, surveillance and monitoring.

We obtained administrative data on the polio immunization activities carried out in the period between 2008 and 2013 from the EPI's internal monitoring and surveillance system. This enables us to construct the following measures to control for the supply of polio immunization activities in the districts of the 4 main provinces of Pakistan across the study period of interest: First, we construct measures that record the number of monthly immunization campaigns carried out in a child's district of residence during the first 3 and 12 months of her life, respectively. Moreover, the administrative data also contains the number of children

that were targeted during a monthly immunization drive in a given district. We combine this information with district-level population estimates in 2011 from the Pakistan Bureau of Statistics to record the per-capita number of targeted children during the first 3 and 12 months of a child's life, respectively.

ACLED Data

We use the data from the Armed Conflict Location & Event Data Project (ACLED) to account for potential impacts of conflict. This dataset collects the dates, actors, types of violence, locations, and fatalities of all reported political violence and protest events in Pakistan starting from January 2010. In particular, the dataset records information on the following types of conflict events: a) battles, in which the government regains territory b) battles, from which no change of territory resulted c) battles, in which a non-state actor overtakes territory d) events where a headquarter or a base were established e) non-violent transfers of territory f) remote violence g) riots/protests h) strategic development i) violence against civilians.

Given our focus on conflict and violence, we focus on all events except for riots and protests. In particular, we construct a time-varying control which counts the number of conflict events that occurred in a child's district of residence in the first twelve month of her life. In addition to this time-varying control, we also generate a pre-determined measure of conflict and violence by constructing a measure that records the total number of conflict events in the year 2010. In a series of robustness checks, this pre-determined measure is then interacted with cohort fixed effects.

The fact, that the ACLED dataset also provides information on the actors involved in a particular conflict event, allows us to also construct measures of conflict that are directly linked to Taliban activity. In particular, we construct district-specific measures of the number of conflict events associated with the Taliban in the year 2010 as well as in the time period 2010 to 2013.

Data on Cases of Poliomyelitis

We obtained district-level data on polio incidences for the year 2014 from the website http://www.endpolio.com.pk (last accessed 07/18/2019), which is published by the Expanded Program on Immunization of Pakistan. We then complemented this dataset with information on polio cases in the years 2009, 2010 and 2011 by digitizing and geo-referencing polio incidences using maps provided in the annual reports of the Global Polio Eradication Initiative.

12.2 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. Since the two district measures are almost equivalent and to minimize confusion, we describe these standard errors as "clustered at the district level" in the text and table notes.

13 Additional Results

Full Immunization Results

In Appendix Figures 2 and 3, 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 documented in the survey for the vaccines. See section 12 in the Online Appendix for further details.

The first two panels of Appendix Figure 2 show the age profiles for full immunization of polio and DPT. The last panel shows the age profile of full immunization for the three vaccines.[88] 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 3 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

[88]Note that we only have information on one dose of the measles vaccine. Hence, the "full immunization" figure for DPT would be equivalent to the one presented in Figure 2.

before and after the treatment. In contrast, regions with high support for Islamist parties experience a decline of full immunization rates after the information on the vaccine ruse was disclosed.

14 Estimation of Persuasion Rates

Following DellaVigna and Gentzkow (2010), we calculate "persuasion rates" as suggested by DellaVigna and Kaplan (2007). These rates estimate the percentage of individuals that change their vaccination behavior among those that receive the vaccine ruse message and are not already persuaded, i.e. did not already vaccinate their children.

In a setting with a binary behavioral outcome such as immunization status, a treatment group T, and a control group C, the persuasion rate f (in percent terms) is defined as

$$f = 100 * \frac{y_T - y_C}{e_T - e_C} \frac{1}{1 - y_0}$$

where e_i is the share of group i receiving the message, y_i is the share of group i adopting the behavior of interest, and y_0 is the share that would adopt if there were no message. The persuasion rate thus captures the effect of the treatment on the relevant behavior $(y_T - y_C)$, adjusting for exposure to the message $(e_T - e_C)$ and for the size of the population left to be convinced $(1 - y_0)$.

In our setting, we define the outcome of interest as *not* vaccinating the children, since that is in accordance to the anti-vaccine propaganda messages. We derive estimates for $y_T - y_C$ from a specification that compares the vaccination outcomes for children in districts with above and below median levels of support for Islamist groups. These estimates are presented in Appendix Table 8. We multiply those estimates by -1 in order to be able to interpret the estimates as the increase in likelihood that children *do not* receive the respective vaccine doses.

Given that the information on the vaccine ruse was very salient in Pakistan, we assume that the entire population was exposed to the message after July 2011, while no one was exposed to the message prior to that. Hence, we assume $e_T - e_C = 100\%$. This approach follows the assumptions made in DellaVigna and Gentzkow (2010) to compute persuasion rates.[89] Note that if exposure to the news of the vaccine ruse were indeed lower, the resulting persuasion rate would be larger. Hence, the reported persuasion rate can be considered as a lower bound.

[89]For instance the assume $e_T - e_C = 100\%$ when computing the persuasion rate of newspaper endorsements estimated in Chiang and Knight (2011). The reason is that the sample only contains newspaper readers and, hence, all individuals are subject to the information on newspaper endorsements.

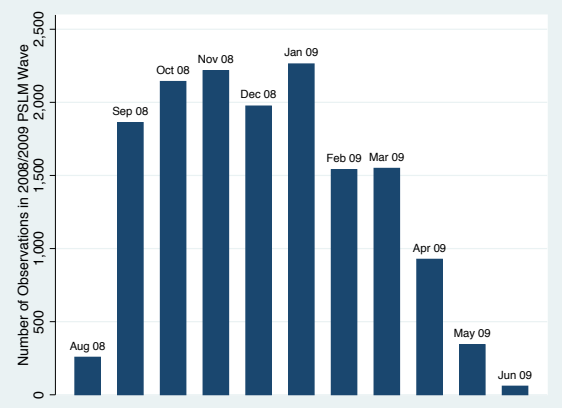
Lastly, we proxy the share of the population that would adopt, i.e. not vaccinate their children even in the absence of any messages, y_0, by calculating the share of the children in our baseline sample that are observed in the pre-treatment survey wave and did not receive the respective vaccine doses.

Our calculations of the persuasion rate for the polio vaccine are as follows: $\widehat{y_T - y_C} = 0.153$ as obtained from Appendix Table 8; $\widehat{e_T - e_C} = 1$; and $\widehat{1 - y_0} = 0.43$, which corresponds to the polio vaccination rate for unexposed cohorts—i.e., those observed in the pre-treatment survey wave. The resulting persuasion rate for the polio vaccine is 35.6%; for the dpt vaccine, it is 30.7%; and for the measles vaccine, it is 42.3%.

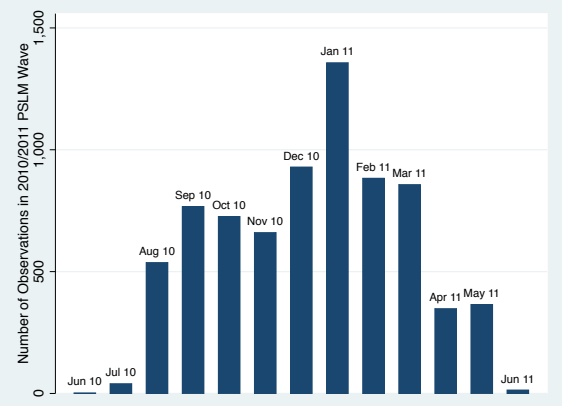
15 Appendix Figures

Appendix Figure 1. Timing of Surveys of the PSLM waves

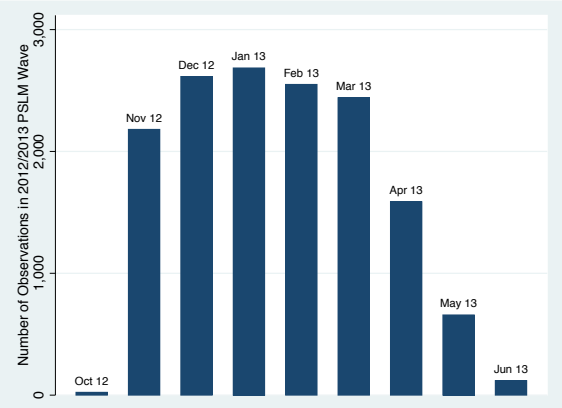
2008/09 PSLM Wave



2010/11 PSLM Wave

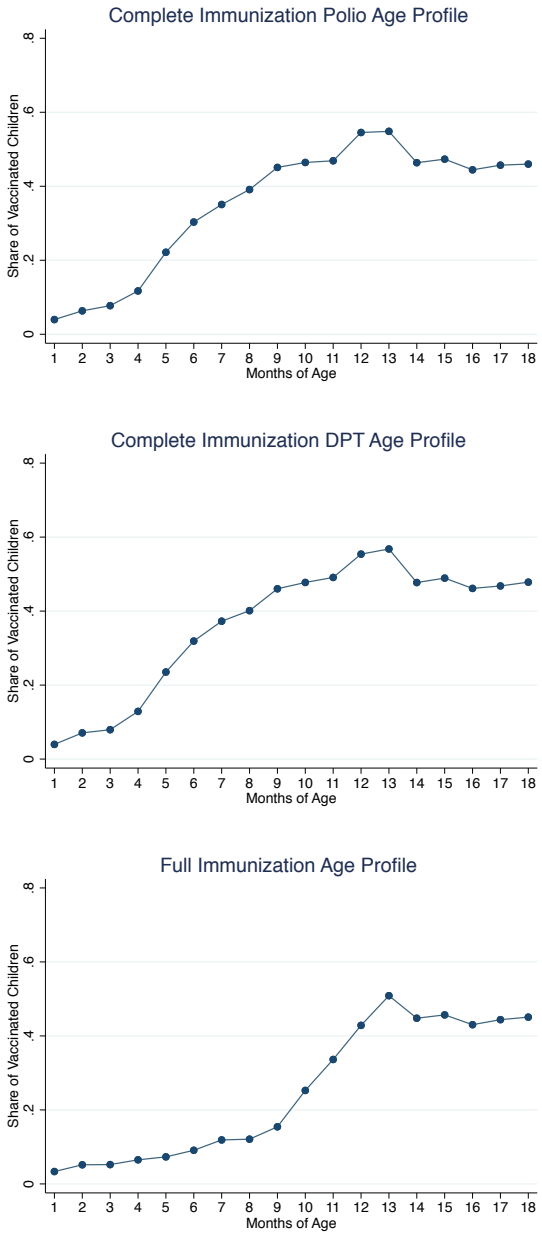


2012/13 PSLM Wave



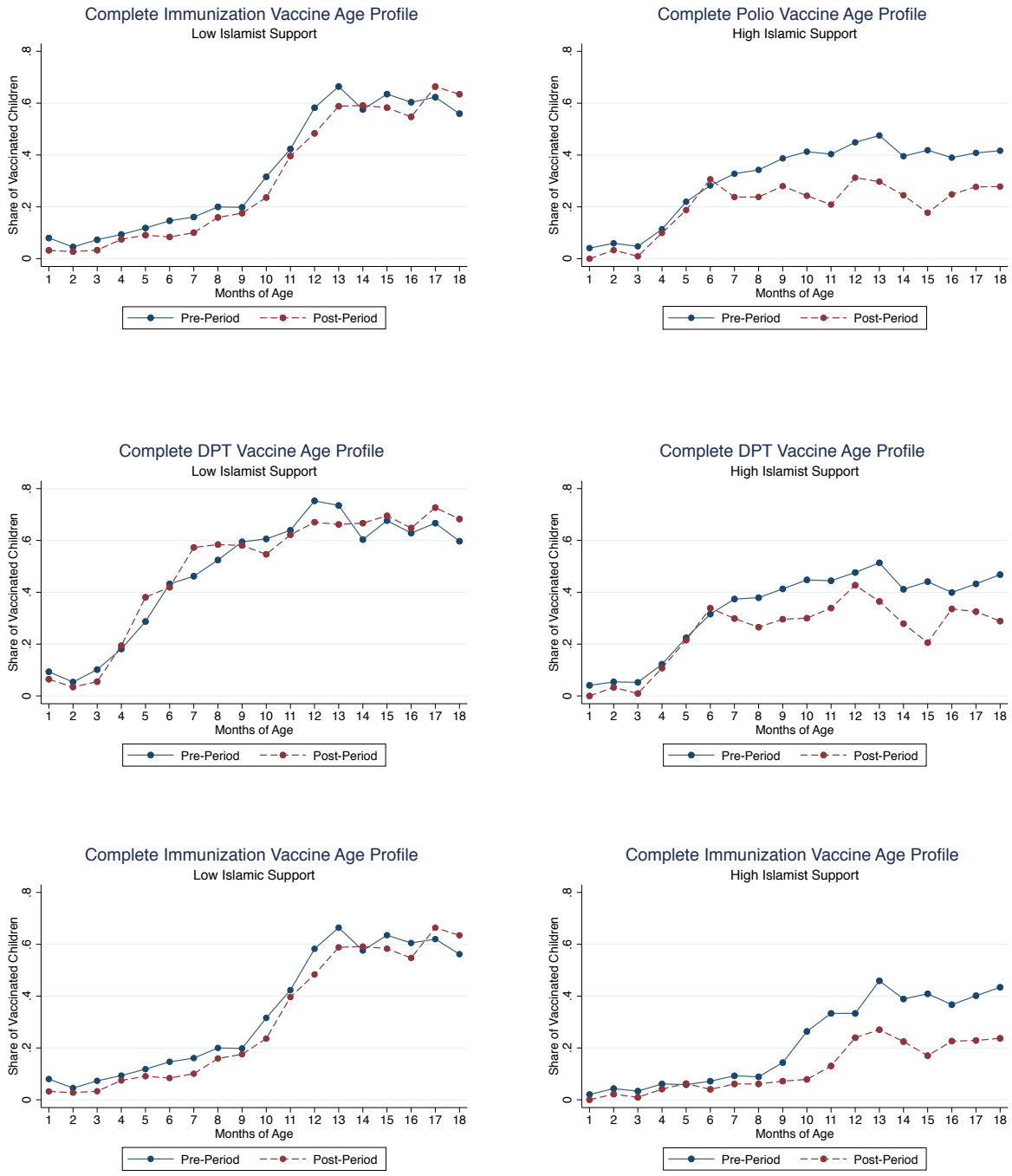
Notes: Distribution of months of interview for the children in our sample by wave of the PSLM survey.

Appendix Figure 2. Age Profile for All Doses of Vaccines. Pre-Treatment Period



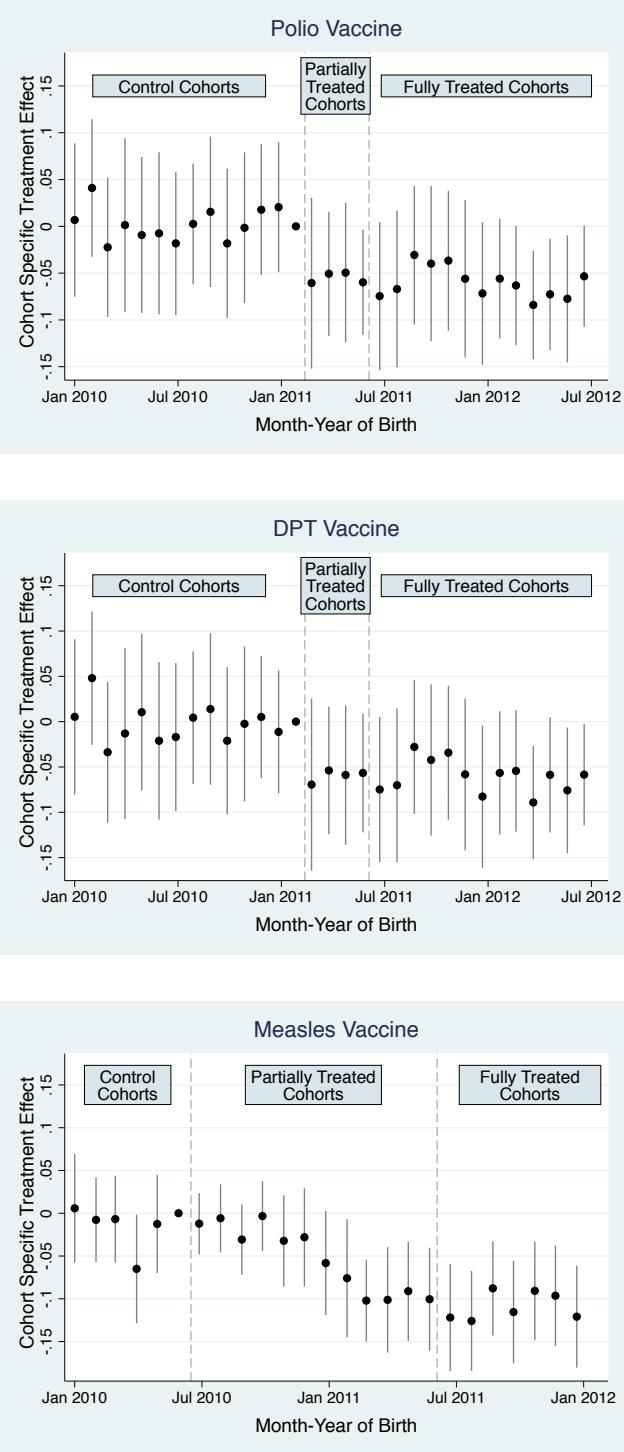
Notes: These figures show the fraction of children that received all the doses of each vaccine by their age at the time of interview. Only the pre-treatment waves of the survey (2008/9 and 2010/11) are used.

Appendix Figure 3. Age Profile for All Doses of Vaccines. Before & After Treatment. By Level of Islamist Support



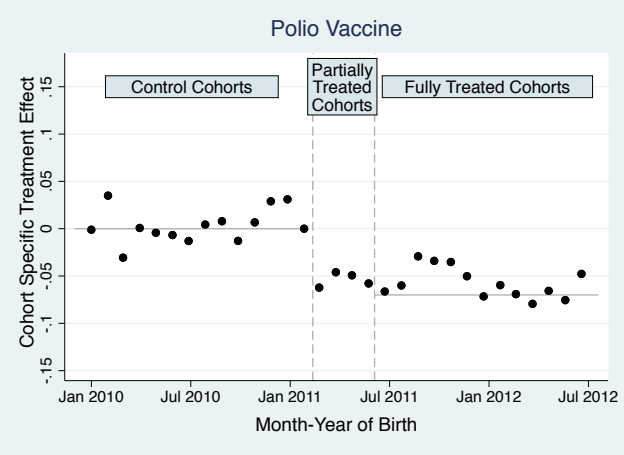
Notes: These figures show the fraction of children that received all the doses of each vaccine by their age at the time of interview. The figures on the left (right) hand side restrict the sample to districts in the bottom (top) quartile of vote shares for Islamist parties. The solid-blue age profiles are obtained from the pre-treatment waves of the survey, 2008/9 and 2010/11. The dashed-red age profiles are obtained from the post-treatment wave, 2012/13.

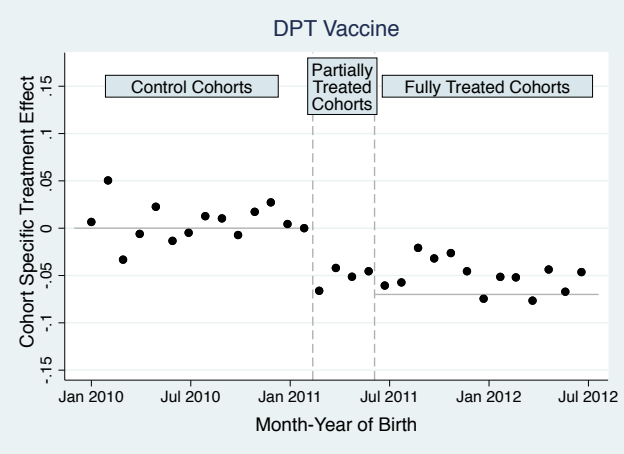
Appendix Figure 4. Treatment Effects by Monthly Cohort (With Confidence Intervals)

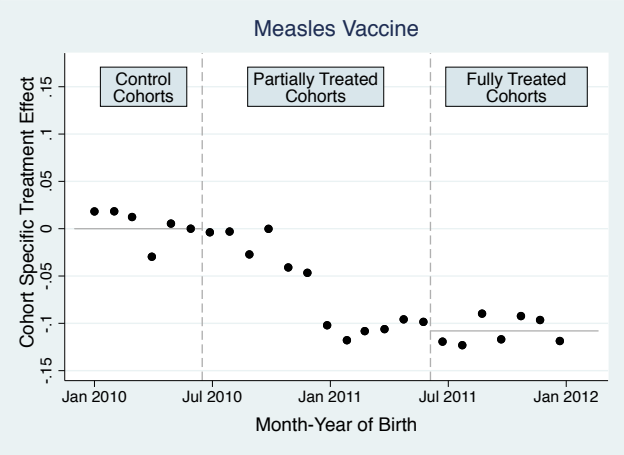


Notes: These figures show cohort-specific treatment effects by month of birth. In particular they show the coefficients on the interaction of Islamist support with the corresponding cohort indicator. The omitted category corresponds to the last cohort of the non-exposed cohorts, i.e., children born in February 2011 for polio and DPT and children born in June 2010 for measles. The vertical lines associated with each point estimate correspond to the 90% confidence intervals.

Appendix Figure 5. Treatment Effects by Monthly Cohort. Only Controlling for Monthly-Cohort and District Fixed Effects

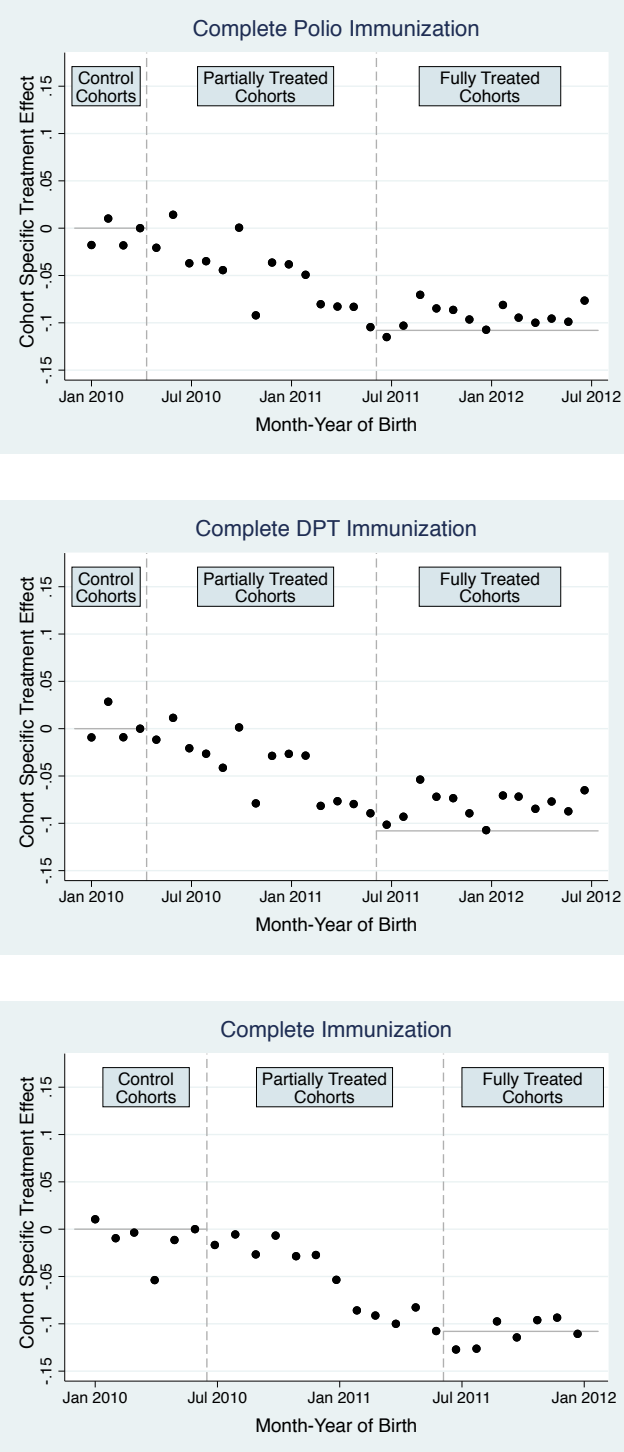






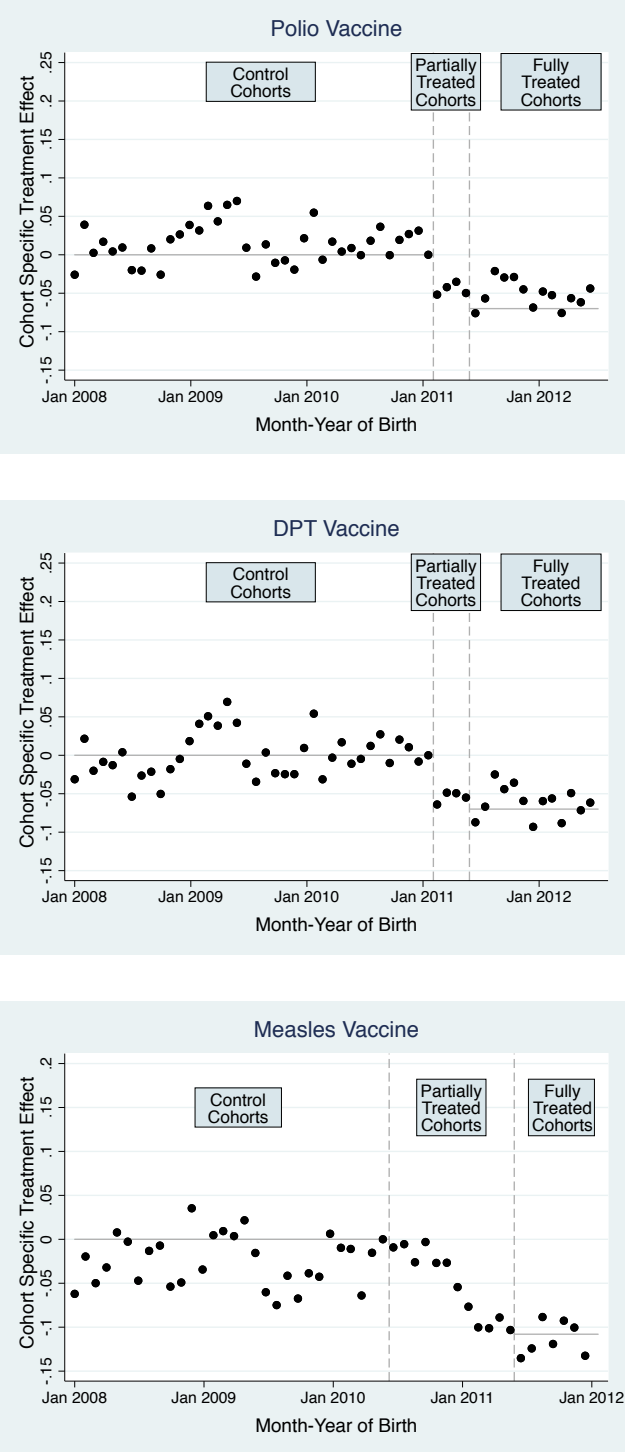
Notes: These figures show cohort-specific treatment effects by month of birth. In particular they show the coefficients on the interaction of Islamist support with the corresponding cohort indicator. The omitted category corresponds to the last cohort of the non-exposed cohorts, i.e., children born in February 2011 for polio and DPT and children born in June 2010 for measles.

Appendix Figure 6. Treatment Effects by Monthly Cohort. Full Immunization



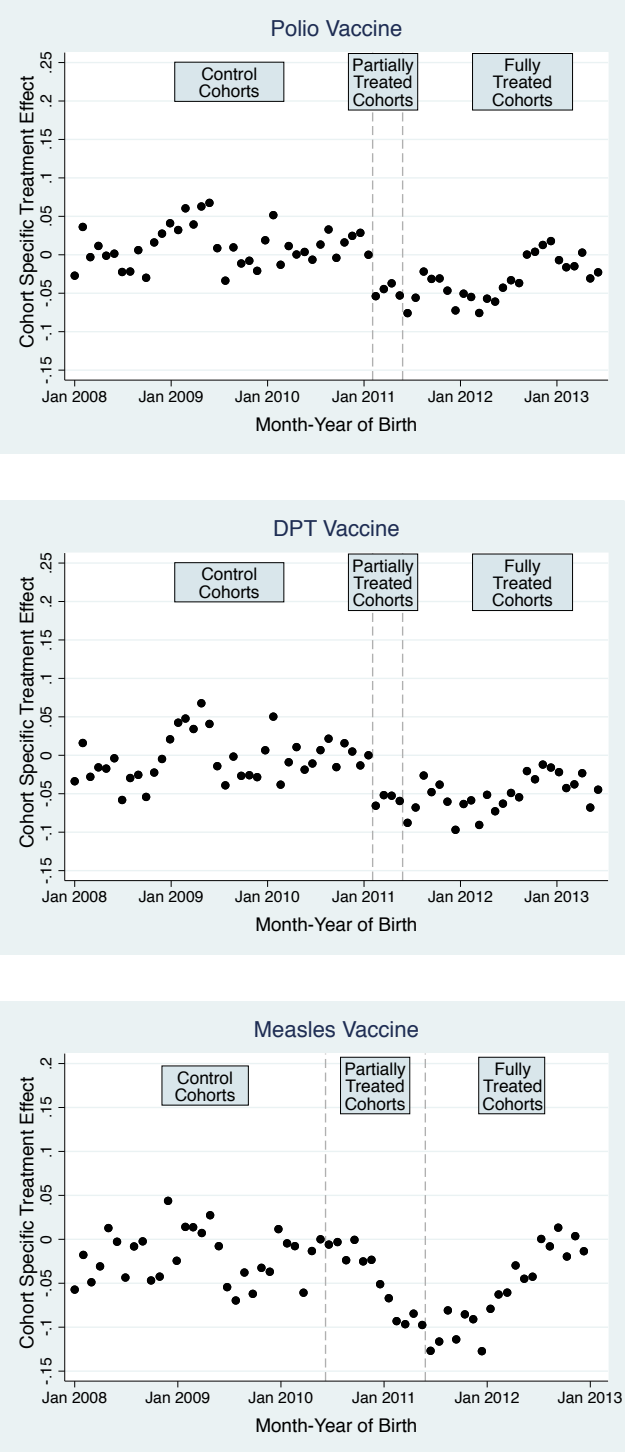
Notes: These figures show cohort-specific treatment effects by month of birth. In particular they show the coefficients on the interaction of Islamist support with the corresponding cohort indicator. The omitted category corresponds to the last cohort of the non-exposed cohorts, i.e., children born in April 2010 for polio and DPT and children born in June 2010 for the complete immunization outcome.

Appendix Figure 7. Treatment Effects by Monthly Cohort. Longer Pre-Treatment Period.



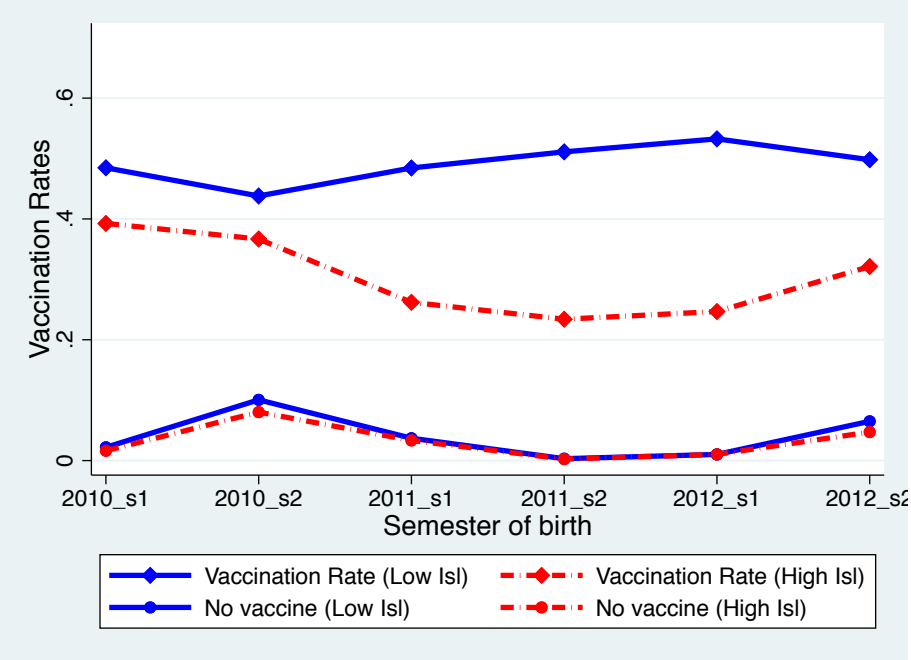
Notes: These figures show cohort-specific treatment effects by month of birth. In particular they show the coefficients on the interaction of Islamist support with the corresponding cohort indicator. The omitted category corresponds to the last cohort of the non-exposed cohorts, i.e., children born in February 2011 for polio and DPT and children born in June 2010 for measles.

Appendix Figure 8. Treatment Effects by Monthly Cohort. Medium-Run Effects.



Notes: These figures show cohort-specific treatment effects by month of birth. In particular they show the coefficients on the interaction of Islamist support with the corresponding cohort indicator. The omitted category corresponds to the last cohort of the non-exposed cohorts, i.e., children born in February 2011 for polio and DPT and children born in June 2010 for measles.

Appendix Figure 9. Evolution of Polio Vaccination Rates



Notes: Diamond-connected lines correspond to the fraction of parents that have vaccinated their children against polio—as verified in the vaccination card—, by semester of birth of the child. Circle-connected lines correspond to the fraction of parents that report not having vaccinated their children against polio. The difference between the sum of these lines and 1 corresponds to the fraction of parents that self-report having vaccinated their children, but no proof of such vaccinations was obtained by the enumerators. Solid-blue lines restrict the sample to districts below the median support for Islamist parties. Dashed-red lines restrict the sample to districts above the median support for Islamist parties.

16 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://www.epi.gov.pk/immunisation-schedule/ (last accessed July1st, 2019)

Appendix Table 2. Descriptive Statistics

	Observations (1)	Mean (2)	Std. Dev. (3)
	Panel A. Child Characteristics		
Received one dose of Polio vaccine	18,650	0.418	0.493
Received one dose of DPT vaccine	18,650	0.451	0.498
Received one dose of Measles vaccine	18,650	0.257	0.437
Received three doses of Polio vaccine	18,650	0.334	0.472
Received three doses of DPT vaccine	18,650	0.363	0.481
Received all vaccines	18,650	0.231	0.421
Illness or injury (two weeks prior to interview)	18,650	0.191	0.393
Age (in months)	18,650	11.051	6.298
Male	18,650	0.513	0.500
	Panel B. Mother Characteristics		
Mother's education level	18,650	3.504	4.359
Mother's age	18,650	27.981	6.038
	Panel C. Household Characteristics		
Rural region	18,650	0.657	0.475
Radio ownership	18,650	0.229	0.420
Television ownership	18,650	0.578	0.494
Number of rooms	18,650	2.632	1.555
Number of household members	18,650	8.237	3.885
	Panel D. District Characteristics		
Vote Share MMA	114	0.073	0.113
Vote Share PPP	114	0.261	0.204
Vote Share PML (N)	114	0.105	0.140

Notes: In Panel A, B and C, the unit of observation is the child level. The sample consists of children born between January 2010 and July 2012 that are less than 24 months of age at the time of interview. In Panel D, the unit of observation is the district.

Appendix Table 3. Tabulation of Cohorts in the Baseline Sample

Survey Wave	Cohort	Number of Observations	Share of the Sample
2010/11	2010/01	725	3.89
	2010/02	721	3.87
	2010/03	561	3.01
	2010/04	518	2.78
	2010/05	588	3.15
	2010/06	686	3.68
	2010/07	721	3.87
	2010/08	793	4.25
	2010/09	582	3.12
2010/11 & 2012/13	2010/10	444	2.38
	2010/11	427	2.29
	2010/12	457	2.45
	2011/01	447	2.4
	2011/02	304	1.63
	2011/03	398	2.13
	2011/04	410	2.2
	2011/05	515	2.76
2012/13	2011/06	673	3.61
	2011/07	731	3.92
	2011/08	717	3.84
	2011/09	705	3.78
	2011/10	752	4.03
	2011/11	628	3.37
	2011/12	550	2.95
	2012/01	670	3.59
	2012/02	649	3.48
	2012/03	558	2.99
	2012/04	592	3.17
	2012/05	582	3.12
	2012/06	766	4.11
	2012/07	780	4.18

Appendix Table 4. DHS Immunization Outcomes

	Dependent Variables: Received 1st Dose of Each Vaccine:				
	Polio	DPT	Measles	HBV	All Vaccines
	(1)	(2)	(3)	(4)	(5)
Mean Dep. Var.	*0.286*	*0.291*	*0.133*	*0.277*	*0.127*
Post × Islamist Support	-0.042**	-0.037**	-0.009	-0.055**	-0.016
	(0.018)	(0.018)	(0.015)	(0.023)	(0.017)
Observations	5,782	5,699	5,297	5,643	5,235
R-squared	0.186	0.184	0.164	0.172	0.156
Number of Clusters	112	112	112	112	112

Notes: Standard errors clustered at the district-level in parentheses. There are 112 districts in the sample. The unit of observation is the child level. The sample consists of children born in the years 2004 to 2007 and 2010 to 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. All regressions include district, monthly cohort, monthly age, and a dummy for rural regions. The dependent variables take value 1 if the first dose of each vaccine was received, 0 otherwise.

Appendix Table 5. Robustness Checks. Lack of Changes in Household Composition

	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 July 2011 × Islamist Support	-0.005	-0.025	-0.131	-0.007	-0.005	-0.019	0.124*	0.052
	(0.010)	(0.059)	(0.140)	(0.009)	(0.015)	(0.016)	(0.072)	(0.045)
Observations	18,650	18,650	18,650	18,650	18,650	18,650	18,650	18,650
R-squared	0.010	0.263	0.029	0.192	0.143	0.228	0.096	0.109

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 January 2010 and July 2012 that are less than 24 months of age at the time of interview. 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).

Appendix Table 6. Robustness Checks Selective Migration

	Dependent Variables:			
	Polio	DPT	Measles	All Vaccines
	(1)	(2)	(3)	(4)
	Panel A. Controlling for In- and Out-migration Rates			
Mean Dep. Var.	*0.426*	*0.459*	*0.233*	*0.208*
Post × Islamist Support	-0.060***	-0.055***	-0.054***	-0.058***
	(0.021)	(0.020)	(0.017)	(0.017)
Observations	16,491	16,491	12,349	12,349
R-squared	0.262	0.240	0.254	0.261
Number of Clusters	104	104	104	104
	Panel B. Lower Bound (in Magnitude) if Most Unfavorable Selective Migration			
Mean Dep. Var.	*0.422*	*0.456*	*0.278*	*0.248*
Post × Islamist Support	-0.052**	-0.048**	-0.047***	-0.050***
	(0.021)	(0.019)	(0.017)	(0.017)
Observations	16,345	16,345	12,203	12,203
Number of Modified Observations	613	613	613	613
R-squared	0.261	0.238	0.252	0.259
Number of Clusters	104	104	104	104
	Panel C. Assigning Households to District of Origin (DHS sample)			
Mean Dep. Var.	*0.281*	*0.286*	*0.117*	*0.111*
Post × Islamist Support	-0.041**	-0.038**	-0.010	-0.016
	(0.018)	(0.018)	(0.015)	(0.017)
Observations	5,782	5,699	5,297	5,235
Number of Reassigned Observations	340	340	340	340
R-squared	0.187	0.184	0.164	0.156
Number of Clusters	112	112	112	112

Notes: Standard errors clustered at the district-level are shown in parentheses. The unit of observation is the child level. In Panels A and B, the sample consists of children born between January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. In Panel B, we modify a number of observations in a bounding exercise. In particular, while we drop 146 observations in districts with negative net outmigration rates (as calculated from DHS data), we add 467 observations in districts with positive net outmigration rates. In particular, we drop observations with a successful vaccination outcome if the level of support for Islamist groups is below the median level in the sample. In contrast, we drop observations with an unsuccessful vaccination outcomes in districts where the level of support for Islamist groups exceeds the median in the sample. When adding additional observations, we impute successful vaccination outcomes in districts where the level of support for Islamist groups exceeds the median in the sample. In contrast, we impute unsuccessful vaccination outcomes in districts, where the level of support for Islamist groups lies below the median in the sample. In Panel C, the sample consists of children born in the years 2004 to 2007 and 2010 to July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children (same as in Panels A and B). In Panels A and B, all regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions. In Panel C, all regressions include district, monthly cohort, monthly age, and a dummy for rural regions. The dependent variables take value 1 if the first dose of each vaccine was received, 0 otherwise. The outcome for all vaccines combines all of these requirements.

Appendix Table 7. Only Controlling for District and Cohort Fixed Effects

	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*	*0.207*
Post × Islamist Support	-0.057***	-0.054***	-0.065***	-0.067***
	(0.021)	(0.019)	(0.018)	(0.018)
Observations	16,654	16,654	12,479	12,479
R-squared	0.251	0.227	0.227	0.236
Number of Clusters	109	109	109	109
	Panel B. All Doses of Each Vaccine			
Mean Dep. Var.	*0.338*	*0.371*	*0.231*	*0.213*
Post × Islamist Support	-0.062***	-0.061***	-0.065***	-0.062***
	(0.020)	(0.019)	(0.018)	(0.018)
Observations	11,205	11,205	12,479	11,205
R-squared	0.267	0.237	0.227	0.250
Number of Clusters	109	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 January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. All regressions include district and monthly cohort fixed effects. 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. The outcome for all vaccines takes value 1 if the child has obtained the corresponding dosage of the three vaccines.

Appendix Table 8. Non-Monotonicity of Treatment Effects

	Dependent Variables: Dummy for Receipt of 1 Vaccine Dose								
	Polio			DPT			Measles		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mean Dep. Var.	*0.422*	*0.422*	*0.422*	*0.455*	*0.455*	*0.455*	*0.231*	*0.231*	*0.231*
Post × Islamist Support	-0.060***			-0.056***			-0.055***		
	(0.020)			(0.018)			(0.016)		
Post × 1(IslSup>P50)		-0.153***			-0.135***			-0.093***	
		(0.032)			(0.031)			(0.026)	
Post × Isl Support in 20th - 40th			0.023			0.044			-0.011
			(0.047)			(0.039)			(0.043)
Post × Isl Support in 40th - 60th			-0.013			-0.023			-0.080**
			(0.060)			(0.059)			(0.040)
Post × Isl Support in 60th - 80th			-0.162***			-0.135***			-0.121***
			(0.048)			(0.046)			(0.043)
Post × Isl Support in 80th - 100th			-0.134***			-0.118***			-0.127***
			(0.038)			(0.036)			(0.039)
Observations	16,654	16,654	16,654	16,654	16,654	16,654	12,479	12,479	12,479
R-squared	0.262	0.266	0.266	0.241	0.244	0.244	0.253	0.253	0.254

Notes: Standard errors clustered at the district-level in parentheses. The sample consists of children born between January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. 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.

Appendix Table 9. Effects on Cases of Poliomyelitis

	Dependent Variable: Number of Cases of Poliomyelitis	
	(1)	(2)
Mean Dep. Var.	*0.890*	*0.890*
Post × Islamist Support	0.831**	
	(0.330)	
2010 × Islamist Support		-0.032
		(0.340)
2011 × Islamist Support		1.004*
		(0.519)
2014 × Islamist Support		0.626*
		(0.372)
	456	456
Observations	0.475	0.478

Notes: Robust standard errors in parentheses. The unit of observation is the district-year. There are 114 districts in the sample. We obtained data on the cases of poliomyelitis for the years 2009, 2010, 2011, and 2014. The variable post takes value 1 for the years 2011 and 2014. Most of the cases of poliomyelitis detected in 2011 correspond to the end of the year. See Center for Disease Control and Prevention, Weekly, Vol. 62 No.17, May 2013. https://www.cdc.gov/mmwr/pdf/wk/mm6217.pdf Figure in page 337. (Last accessed on July 5th, 2019)

Appendix Table 10. Effects on Health Seeking Behavior (DHS Survey)

	Dependent Variables:		
	Dummy for Illness in Last 2 Weeks	Dummy for Consulted Anyone	Dummy for Consulted Formal Medical Sector
	(1)	(2)	(3)
	Panel A. Children Illness: Diarrhea		
Mean Dep. Var.	*0.318*	*0.744*	*0.671*
Post July 2011 × Islamist Support	-0.018	-0.110***	-0.060**
	(0.019)	(0.026)	(0.027)
Observations	6,234	1,975	1,976
R-squared	0.078	0.167	0.169
	Panel B. Children Illness: Cough		
Mean Dep. Var.	*0.352*	*0.803*	*0.816*
Post July 2011 × Islamist Support	-0.029	-0.021	0.019
	(0.030)	(0.024)	(0.023)
Observations	6,230	2,183	1,956
R-squared	0.089	0.083	0.146
	Panel C.Any Children Illness		
Mean Dep. Var.	*0.520*	*0.938*	*0.900*
Post July 2011 × Islamist Support	-0.032	-0.048***	-0.026
	(0.026)	(0.016)	(0.022)
Observations	6,227	2,746	2,607
R-squared	0.109	0.107	0.103

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, the formal sector is defined as seeking medical treatment or treatment in public facilities.

Appendix Table 11. Effects on Trust Measures (Displaying Estimates of All Interaction Terms)

	Dependent variables. Trust in:									
	Civil Service	Police	The Courts	Parliament	Political Parties	Army	Central Government	Provincial Government	Local Government	z-score
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean Dep. Var.	*0.46*	*0.53*	*0.49*	*0.47*	*0.58*	*0.50*	*0.53*	*0.50*	*0.58*	*0.00*
	Panel A. Effects on Trust									
Post	0.139***	0.449***	0.114***	0.152***	0.498***	-0.441***	0.065**	-0.048*	0.063**	0.223***
	(0.026)	(0.023)	(0.026)	(0.026)	(0.023)	(0.023)	(0.026)	(0.027)	(0.026)	(0.032)
Post x (Isl Support > Average)	-0.076**	-0.135***	-0.063	-0.094**	-0.190***	0.144***	-0.052	0.012	0.089**	-0.081*
	(0.039)	(0.036)	(0.039)	(0.039)	(0.036)	(0.035)	(0.039)	(0.039)	(0.039)	(0.049)
Observations	3,252	3,252	3,252	3,252	3,252	3,252	3,252	3,252	3,252	3,252
R-squared	0.054	0.208	0.029	0.054	0.215	0.204	0.050	0.041	0.055	0.069
	Panel B. Effects on Trust by Ownership of TV									
Post	0.039	0.439***	0.073*	0.088**	0.434***	-0.498***	0.005	-0.142***	0.003	0.100**
	(0.038)	(0.032)	(0.039)	(0.038)	(0.035)	(0.030)	(0.038)	(0.038)	(0.037)	(0.046)
No TV	-0.146***	-0.004	-0.03	-0.095**	-0.102***	-0.084**	-0.085**	-0.130***	-0.104**	-0.174***
	(0.042)	(0.035)	(0.043)	(0.042)	(0.039)	(0.033)	(0.042)	(0.042)	(0.042)	(0.052)
Post x No TV	0.189***	0.066	0.226***	0.111	0.084	0.110*	0.154**	0.237***	0.033	0.270***
	(0.067)	(0.060)	(0.065)	(0.068)	(0.061)	(0.061)	(0.067)	(0.069)	(0.067)	(0.079)
Post x (Isl Support > Average)	0.04	-0.100**	-0.031	-0.03	-0.099**	0.158***	0.003	0.107**	0.153***	0.045
	(0.050)	(0.045)	(0.051)	(0.050)	(0.047)	(0.042)	(0.050)	(0.050)	(0.050)	(0.063)
Post x (Isl Support > Average) x No TV	-0.271	-0.218	-0.120	-0.154	-0.305	0.109	-0.236	-0.268	-0.084	-0.345
	(0.108)	(0.098)	(0.103)	(0.106)	(0.096)	(0.096)	(0.105)	(0.107)	(0.103)	(0.136)
Observations	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212
R-squared	0.054	0.209	0.034	0.056	0.222	0.215	0.052	0.045	0.058	0.071

Notes: Robust standard errors in parentheses. The unit of observation is the individual. The dependent variables are indicators for whether the respondent reported trusting "a great deal" or "quite a lot" the different organizations. In Panel A, the regressor of interest is the interaction of an indicator for the 2013 wave of the SouthAsia Barometer and an indicator for provinces with support for MMA above the average (i.e., Khyber Pakhtunkhwa, Balochistan, Sindh). All regressions include as controls: province fixed effects, wave fixed effects, age, gender, years of schooling, and type of locality indicators. In Panel B also include interactions for the 2013 wave and province fixed effects with an indicator for TV ownership. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 12. Effects on Supply of Health Services

	Dependent Variable:			
	Time travel to Health Clinic	Time travel to Basic Health Unit	Indicator: Any Immunzation Activity	Number of Targeted Children Per Capita
	(1)	(2)	(3)	(4)
Mean Dep. Var.	*1.509*	*1.566*	*0.601*	*0.136*
Post × Islamist Support	-0.047	0.073	-0.010	-0.004
	(0.055)	(0.083)	(0.014)	(0.006)
Observations	16,618	16,611	8,208	8,136
R-squared	0.396	0.432	0.578	0.535
Number of Clusters	109	109	114	113

Notes: Standard errors clustered at the district-level in parentheses in columns. The unit of observation is the child-level in Columns 1 and 2. In Columns 3 and 4, the unit of observation is the district-month level. In Columns 1 and 2, the sample consists of children born between January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude children that were partially treated. See the notes of Table 1 for details on the excluded cohorts. In Columns 3 and 4, the sample consists of all districts, observed at monthly frequency for the time period 2008 to 2013. All regressions include district and monthly time of interview fixed effects. *** p<0.01, ** p<0.05, *p<0.1.

Appendix Table 13. Disentangling Demand Channels: Changes in Beliefs or Intimidation by the Taliban

	Dependent Variables: First Dose of			
	Polio	DPT	Measles	All Vaccines
	(1)	(2)	(3)	(4)
Mean Dep. Var.	*0.423*	*0.456*	*0.232*	*0.207*
	Panel A. Taliban Conflict Events in 2010			
Post × Islamist Support	-0.054***	-0.048***	-0.050***	-0.055***
	(0.020)	(0.018)	(0.017)	(0.016)
Post × Conflict Measure	-0.014	-0.018*	-0.009	-0.006
	(0.009)	(0.010)	(0.008)	(0.008)
Observations	16,624	16,624	12,459	12,459
R-squared	0.262	0.241	0.252	0.259
Number of Clusters	108	108	108	108
	Panel B. Taliban Conflict Events 2010 - 2013			
Post × Islamist Support	-0.053**	-0.047**	-0.052***	-0.058***
	(0.020)	(0.019)	(0.017)	(0.016)
Post × Conflict Measure	-0.015	-0.019	-0.004	-0.001
	(0.010)	(0.012)	(0.008)	(0.007)
Observations	16,624	16,624	12,459	12,459
R-squared	0.262	0.241	0.252	0.258
Number of Clusters	108	108	108	108

Notes: Standard errors clustered at the district-level in parentheses. The sample consists of children born between January 2010 and July 2012 that are less than 24 months of age at the time of interview. We exclude partially treated children. See the notes of Table 1 for details on the excluded cohorts. In Panel A, the measure of conflict is the number of conflict events within a given district in the year 2010 for which one of the actors involved was identified as the Pakistani Taliban. In Panel B, the measure of conflict is the total number of conflict events within a given district in the time period 2010-2013 for which one of the actors involved was identified as the Pakistani Taliban. All regressions include district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions. The dependent variables take value 1 if the first dose of each vaccine was received, 0 otherwise. The outcome for all vaccines combines all of these requirements. *** p<0.01, ** p<0.05, *p<0.1.