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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 launched an anti-vaccine propaganda campaign 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 information discrediting vaccination campaigns can negatively affect trust in health services and demand for immunization.

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1 Introduction

Vaccines are responsible for some of the largest improvements in welfare in human history. A current example is the development of the Covid-19 vaccine, which is expected to be the key in ending one of the deadliest pandemics in recent history. Despite all the benefits that immunization can generate for society, some people remain skeptical and hesitate to get vaccinated or to administer vaccines to their children. This is the case even for well established vaccines, such as those for measles or polio, that have proven their safety and effectiveness for decades. Low levels of immunization coverage in certain groups of the population have led to numerous outbreaks of measles in the last decades.[1] Vaccine skepticism has oftentimes been fueled by groups ideologically opposed to vaccines, which have spread misinformation about 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.[2]

Despite the potential negative implications of generalized vaccine skepticism, we have a limited understanding of how the disclosure of information that discredits vaccines affects immunization rates and demand for formal medicine more generally. In this paper, we exploit a sequence of recent events in Pakistan that negatively 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.[3]

The disclosure of this information caused uproar in Pakistan. Leveraging on the new piece of information, the Pakistani Taliban launched an anti-vaccine propaganda campaign to discredit medical workers and to cast doubt on vaccines. They accused health workers of being CIA spy agents[4] and claimed that the polio vaccination campaigns were a conspiracy

[1] 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)

[2] See Kennedy (2016).

[3] 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).

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

to sterilize the Muslim population.[5]

In this paper, we evaluate how the disclosure of the vaccine ruse and the subsequent anti-vaccine propaganda campaign affected immunization rates and other forms of health seeking behavior. Our main results on vaccination rates take advantage of a rich household survey that contains detailed immunization records for a large sample of children, as well as precise information on their date of birth. We implement a *Difference-in-Differences* strategy across cohorts and districts. The cohort variation is indicative of the children's exposure to the new information. In particular, we distinguish between fully-exposed, non-exposed, and partially-exposed cohorts depending on the fraction of their early months in life that were spent 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 granted greater credibility to their anti-vaccine messages.[6]

Our estimates indicate that the disclosure of the vaccine ruse had substantial negative effects on vaccination rates: districts in the 90th percentile of the distribution of Islamist support experienced a decline in vaccination rates between 23% and 39% relative to districts in the 10th percentile of Islamist support. The results are highly statistically significant and robust to the inclusion of a host of controls, including district and monthly-cohort fixed effects. We provide several pieces of evidence that are consistent with the assumption of a lack of pre-existing trends.

We also present evidence of effects on disease prevalence. Exploiting variation at the district and year level, we find that a one standard deviation increase in support for Islamist groups is associated with an increase in 0.8 cases of polio per district, which is equivalent to duplicating the average number of cases per district.

These results are consistent with the hypothesis that the disclosure of the vaccine ruse damaged the reputation of vaccines and formal medicine. There is substantial anecdotal evidence supporting this interpretation. These accounts oftentimes describe the vaccine ruse as the triggering factor and the Taliban propaganda as fueling vaccine skepticism. We review this anecdotal evidence in the background section.

We provide a number of additional exercises to shed light on the mechanisms driving our results. First, we provide evidence that our estimates on vaccination rates are mainly

[5] Roul (2014).

[6] 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).

explained by changes in the demand for vaccines rather than changes in supply. Using detailed administrative data on the timing and scope of vaccination drives, we show that the intensity of vaccination activities did not systematically differ across districts with different levels of Islamist support after the disclosure of the vaccine ruse. We also show that our results on vaccination rates are robust to flexibly controlling for these detailed measures of vaccine supply. Furthermore, we provide evidence that households' health seeking behavior changed in a way that is consistent with a lower demand for formal medicine: households became less likely to consult formal doctors when their children got sick and were more likely to use informal doctors and traditional birth attendants.

Second, we provide a number of pieces of evidence that are consistent with the Taliban's propaganda playing an important role. We show that our effects are driven by districts where a large fraction of people do not trust or consume mainstream media. These people tend to rely more on religious leaders, or word of mouth to get information on events in Pakistan. While we do not have a precise measure of the extent to which parents were exposed to Taliban propaganda, we construct a proxy computing the fraction of the population that get their news mainly from religious leaders and also express support for the Taliban. Our estimates indicate that vaccination rates experienced larger declines in regions where this share of the population is larger. We also show that the negative effects on immunization rates are larger for girls than for boys. This result is consistent with some parents granting greater credibility to the rumor spread by the Taliban that the polio vaccine was intended to sterilize Muslim girls. Finally, 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.

This paper is related to the literature that has investigated the determinants of demand for health care in developing countries. See Banerjee and Duflo (2011) and Dupas and Miguel (2017) for literature reviews. This literature has found that individuals oftentimes exhibit low levels of demand for highly effective treatments. While the reasons are varied, misconceptions about the effectiveness of these treatments and skepticism regarding their benefits are common. Vaccines are a key product for which skepticism abounds. In such contexts, the level of trust in health workers and in medical treatments is oftentimes described as fundamental to achieve good public health outcomes.

Despite the seemingly wide consensus on the importance of trust for demand of health-care, there is limited empirical evidence documenting this relationship.[7] Only recently, two

[7]The medical literature has examined the correlates to vaccine hesitancy and has tested a number of interventions to reduce it. See Sadaf et al. (2013) for a literature review. 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

contemporaneous papers studied the consequences of medical malpractice on trust and demand for formal medicine. 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. The authors find that Black men living close to Tuskegee later developed lower levels of demand for formal medicine. Lowes and Montero (2020) study the long-run effects of the French colonial campaigns against the sleeping sickness in Central Africa. They exploit cross sectional variation in the location of the colonial campaigns and find negative long-run effects on health outcomes.[8]

We contribute to this literature by exploiting the disclosure of information that directly damaged the reputation of vaccines and examining 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 misinformation 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 cross-sectional factors.

The presence of an active political group trying to discredit the reputation of vaccines also connects this paper to the literature on persuasive communication. See DellaVigna and Gentzkow (2010) for a literature review. This literature has mainly focused on the effects 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.[9]

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

be explained by an increase in mistrust in the midwife's recommendation to vaccinate the children.

[8]See also Gonzalez-Torres and Esposito (2018). They show that the attempts to contain the Ebola epidemic generated civil conflict in the areas where mistrust in government was higher.

[9]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 et al. (2016, 2017), and Bursztyn et al. (2020).

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 partner 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. The objective was 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 hiding in the compound.[10]

To carry out the vaccine ruse, the CIA recruited a Pakistani doctor, Dr. Shakil Afridi. The doctor, in turn, hired low-ranked health workers, who were unaware of the espionage motives behind the vaccination campaign. Without knowledge or consent from the Pakistani health authorities, Dr. Afridi and his team 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 May 2011, U.S. special forces carried out an 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.[11] The article described the collaboration of Dr. Afridi with the CIA and the attempts of health workers to obtain DNA samples from children.[12]

The involvement of health personnel in the operations to capture Osama Bin Laden was intensely criticized, both in the US and in other countries.[13] In January 2013, the deans

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

[11] Ibid.

[12] In January 2012, the U.S. Defense Secretary confirmed that Dr. Afridi had collaborated with the CIA. The doctor was accused of conspiracy against the state and was sentenced to serve 33 years in jail.
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).

[13] 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."*

of twelve leading public health schools sent an open letter to President Obama protesting against the use of vaccination programs in espionage activities.[14] 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.

2.2 Political Context in Pakistan

Pakistan is a parliamentary democracy which had held regular election since the end of the Musharraf regime in 2008. Between 2008 and 2018, two main political forces have been alternating in power: the Pakistan Peoples Party (PPP)—a center-left political party—and the Pakistan Muslim League (PML-N)—a right-wing nationalistic party. A number of smaller political parties also participate in elections. Between 2002 and 2008, the main six Islamist parties contested elections forming the *Muttahida Majlis-e-Amal* (MMA) coalition. These parties strongly emphasize Islamist moral and principles in every day life.

Several authors have documented the close political, financial, and ideological connections 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).

MMA obtained 11% and 3% of votes in the 2002 and 2008 general elections, respectively. Figure 1 shows the geographical distribution of support for MMA in the 2008 election across districts. While the average vote share was low, there was wide variation. In some districts MMA's vote shares was above 20%. Importantly, MMA did not manage to control any of the local executive governments after the 2008 election.

2.3 The Pakistani Taliban's Anti-Vaccine Propaganda

Islamist groups in Pakistan have repeatedly tried to discredit formal medicine and vaccines. By discrediting services provided by the state, the Taliban can increase the reliance of the

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).

[14]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).

population on non-state actors (Acemoglu et al. 2020). Taliban leaders spread their messages through Friday prayers in radicalized mosques, radicalized newspapers, and illegal radio shows.[15] 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 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.]"[16] The concern that vaccines are a conspiracy to sterilize Muslim children, girls in particular, has been recurrent.[17]

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.[18] For instance, in an article published in *The Guardian* the following was argued:

> *"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."*[19]

While the vaccine ruse only provided seeming confirmation for some of the rumors—those 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 vaccine ruse by intensifying their propaganda campaign against vaccines. They leveraged on their new credibility and issued a number of religious edicts (*fatwas*), directly linking vaccination campaigns to espionage activities by the CIA.

> *"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.""*[20]

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

[16] 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).

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

[18] 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).

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

[20] Roul (2014), page 18.

The Taliban have also exerted violence against vaccination workers. Seventy health workers had been killed during a campaign of violence that started in July 2012.[21] Taliban leaders also boycotted immunization campaigns by banning immunization drives. These boycotts and many of the attacks took place in the FATA region, which is not included in our study sample.[22] Furthermore, our main analysis focuses on children born between January 2010 and July 2012, hence, before the violence campaign against vaccination workers started. Nevertheless, we discuss the intimidation of health workers as an alternative channel for our effects on vaccination rates later in the paper.[23]

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 on the grounds of religious concerns.[24]

2.4 Propaganda and Vaccine Skepticism

There is substantial anecdotal evidence that the messages spread by the Taliban fueled vaccine skepticism among parents. For instance, an article under the title "We Believed Our Cleric" narrates the story of a father that did not vaccinate his son in 2012 and who later became paralyzed from poliomyelitis.[25]

> *"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.*

[21]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).

[22]See section 3 for further details on our study sample.

[23]In April 2013, the Pakistani Taliban pledged not to interfere with the polio vaccination drives as long as the drives were not used for espionage purposes and the vaccine was manufactured in accordance with Islamic laws. However, the conflict between the Taliban, the Pakistani government, and the US has continued to affect the immunization campaigns, predominantly in the FATA region (Roul, 2014; Ahmad et al. 2015).

[24]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).

[25]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).

(...) 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.' "[26]

Some of these anecdotal accounts describe skepticism against the vaccine—such as questioning whether vaccines are safe or in accordance with Islam. However, others reported sources of skepticism related to health workers—such as arguing that they may be spies. It is likely that both sources of skepticism were present and reinforced one another.[27]

2.5 Immunization in Pakistan

Children in Pakistan typically receive three main vaccines at a young age through routine immunization activities: the vaccine against poliomyelitis (or polio vaccine), the DPT (vaccine against diphtheria, pertussis, and tetanus) vaccine; and the 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.

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.[28]

However, the main way in which Pakistani children are immunized are through vaccination drives. There are national as well as subnational immunization days during which vaccinators (typically lady health workers joined by other volunteers) provide vaccines at households' doorstep. These activities are organized by the Expanded Program on Immunization of Pakistan (EPI, henceforth) which is financed by the federal government of Pakistan. 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.[29]

[26] Ibid.

[27] One may have expected the vaccine ruse to only affect distrust against health workers. After all, the vaccines distributed during the ruse were, to the best of our knowledge, safe. However, once there are seeds of distrust on medical practitioners, naturally parents would also question the adequacy of the product that practitioners recommend. Hence, it is difficult, both conceptually and empirically, to disentangle between distrust on health personnel and on vaccines.

[28] 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.

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

There are additional polio-vaccination campaigns that 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. All the vaccines provided during immunization drives or at public health facilities are free of charge.

3 Data

Our main data source is the Pakistan Social and Living Standards Measurement (PSLM), a household survey provided by Pakistan's Bureau of Statistics. This survey contains 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. Children are geo-coded at the district level. We focus on children living in the 115 districts that belong to the four provinces of Pakistan—Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh— and the capital city of Islamabad, which contain 97% of the population.[30]

Our baseline sample records the vaccination status of 18,795 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.[31] 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

[30]Note that the data is not available for the Federally Administered Tribal Areas (FATA) or the semi-autonomous territories of Gilgit-Baltistan and Azad Kashmir. These areas regularly experienced conflict during this time and the Pakistani government did not have full control of their territory. North and South Waziristan are not included in our sample since they were part of the FATA region during our study period.

[31]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)).

zero otherwise.[32,33]

As a measure of support for Islamist groups, we collected electoral data from the 2008 legislative elections, which were the closest in time that preceded the disclosure of the vaccine ruse. The data provide vote shares at the electoral constituency level, which are smaller than districts. We aggregate the results at the district level in order to merge the electoral data with our household survey data.[34] Our main measure of support for Islamist groups is the vote share of the Islamist coalition MMA. 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.[35] 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.

See Appendix Table 2 for descriptive statistics and Appendix Table 3 for a tabulation of the cohorts included in our baseline sample. 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 2 of the Online Appendix.

4 Empirical Strategy

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 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.[36]

[32]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. We believe that 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. Furthermore, note that the share of parents that are in possession of the vaccination card does not change after the disclosure of the vaccine ruse. See section 6 for further discussion.

[33]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.

[34]In particular, for each district and party, we compute the weighted average vote share across all constituencies within a district. We use constituency population as weights. We obtain these data from the Electoral Commission of Pakistan.

[35]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.

[36]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.

Next, we discuss how cohort of birth determines the exposure to the shock. We begin by documenting when children typically receive the different vaccines. Figure 2 presents age profiles of the immunization rate for each vaccine in the pre-treatment period.[37] These figures show the percentage of children that had taken the first dose of each vaccine by their month of age at the time of interview. The first panel of Figure 2 presents the age profile of the polio vaccine. While the polio vaccine is supposed to be administered at birth, the age profile indicates that most children receive their first dose during the first three months of life. During this period, parents are likely to experience opportunities to vaccinate their children (e.g. during vaccination drives), and a fraction of them agree to vaccinate their children. The age profile also reveals that the probability of having received a vaccine reaches a plateau after the third month. This suggests that parents are likely to have decided whether or not to vaccinate their child after the kid's third month of life: additional time does not seem to further increase the probability of vaccination.

Given this age profile, we are going to consider the first three months of life of children as the critical window when parents typically decide whether to administer the polio vaccine to their child. The greater the fraction of this period that takes place *after* the disclosure of the vaccine ruse, the greater the predicted exposure to the information shock. Hence, children born after July 2011 are considered *fully exposed*: their entire childhood takes place after the information had been disclosed. Children born in the three months before July 2011 are considered *partially exposed*: only a fraction of the three-month critical window takes place under the new information scenario. Children born before the critical window are considered *non exposed*: the parents of these children are likely to already have taken the decision of whether to administer the polio vaccine or not by the time the information is disclosed.[38]

The age profile for DPT—presented in the second panel of Figure 2—is very similar to the one for the polio vaccine. Hence, we rely on the same definitions of cohort exposure as for polio. The age profile for the measles vaccine—third panel of Figure 2—shows that the probability of receiving the first dose rapidly increases after the 9th month—which is the official age of vaccination—and reaches a plateau after the first year of life. Hence, when considering the measles vaccine, we will consider children born in the year prior to July 2011 as partially exposed and children born prior to July 2010 as non-exposed.[39]

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

[38] Note that the *non-exposed* cohorts are not a pure control group since parents parents can always decide to vaccinate their children at later ages. However, the fact that the vaccination age profiles reach a plateau is suggestive of parents not being eager to vaccinate their children after a certain point, which is likely to remain the case after the disclosure of the vaccine ruse. Hence, these cohorts provide a good approximation to a control group.

[39] Note that the age profiles are produced using pre-treatment survey waves. Hence, our classification of

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. 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 vaccines, and decided not to vaccinate their children.[40]

Regression Framework

While the previous results are a transparent way of illustrating the main source of variation, they do not control for differences across districts or cohorts. Next, we present our more rigorous econometric specifications.

First, we implement a *Difference-in-Differences* (DID, henceforth) strategy were we compare vaccination rates between fully-exposed and non-exposed cohorts. Note that, to provide a stark comparison, we exclude partially exposed cohorts from the sample. We estimate

$$Y_{ikaj} = \beta Post_k I_j + \gamma_k + \gamma_j + \gamma_a + \delta c_i + \epsilon_{ikaj} \tag{1}$$

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. $Post_k$ takes value 1 for cohorts fully exposed to the disclosure of the vaccine ruse—that is, children born after July 2011—, and takes value 0 for non-exposed cohorts. I_j is the district-specific measure of treatment intensity,

cohorts by exposure to the shock is done only on the basis on when did children receive their doses prior to the treatment. Also note that the age profiles report the prevalence of vaccinations for children of different ages at the time of interview, hence belonging to different cohorts. That is the reason why for a few instances the vaccination rates of older children seem lower than their one-month-younger counterparts.

[40]The reason why the decline in vaccination rates is highest for older children is because they are born at a time closer to the disclosure event—July 2011. As we show later in the paper, the effects are the largest for these cohorts.

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). Standard errors are clustered at the district level.[41]

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. The inclusion of these rich controls strengthens our confidence that the remaining variation captured by our interaction term $Post_k I_j$ captures the effects of exposure to the information scenario post-disclosure of the vaccine ruse. The main identifying assumption 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.

For some of our outcomes of interest, we will exploit time instead of cohort variation. For instance, we will examine effects on cases of polio at the district and month level. In those cases we estimate the following related specification:

$$Y_{tj} = \beta Post\_July\_2011_t I_j + \gamma_t + \gamma_j + \epsilon_{tj} \tag{2}$$

where Y_{tj} is the outcome of interest of district j, observed at time t; $Post\_July\_2011_t$ for periods after July 2011; I_j is electoral support for Islamist parties in standard deviations; γ_t are time fixed effects; γ_j are district fixed effects.

Second, we estimate a more flexible DID model that allows for the estimation of cohort-specific treatment effects.

$$Y_{ikaj} = \sum_k \beta_k D_k I_j + \gamma_k + \gamma_j + \gamma_a + \delta c_i + \epsilon_{ikaj} \tag{3}$$

where D_k is a dummy indicating whether the child belongs to month-year cohort k. The other variables are the same as those defined in equation (1). The coefficients $\hat{\beta}_k$ capture the cohort-specific treatment effects. Since these are allowed to fully vary, we incorporate partially treated cohorts in this analysis and empirically study the magnitude of their effects. The omitted category corresponds to the last cohort of the non-exposed cohorts (i.e., February

[41] A few districts have experienced divisions during our study period. We cluster the standard errors at the level of the 110 districts in existence in 2008.

2011 for polio and DPT and June 2010 for measles).

The pattern of $\hat{\beta}_k$ offers a first check on the validity of the identification assumption. In the absence of pre-existing trends in vaccination rates that correlate with Islamist support, we expect to find no effects for non-exposed cohorts, i.e., $\hat{\beta}_k \approx 0$. For fully-exposed cohorts, we expect $\hat{\beta}_k < 0$, as exposure to the news of the vaccine ruse and the Taliban propaganda would make some parents reluctant to vaccinate their children. For partially treated cohorts we also expect negative effects, as part of their early months in life take place under the new information scenario.

5 Results

Effects on Immunization Rates

Table 1 presents the main DID estimates that result from estimating equation (1). Panel A presents the $\hat{\beta}$ coefficients 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 in vaccinations rates of 5.8 percentage points for the polio vaccine and of 5.4 for the DPT, and measles vaccines. These declines are large in magnitude. They represent 12% to 20% declines in vaccination rates over the corresponding sample means. Column 4 shows that exposed cohorts are 5.7 percentage points less likely to have received the first dose of the three vaccines. This effect represents a 23% decline over the sample mean.

Panel B of Table 1 presents the effects 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. Since the number of observations is smaller—as there are more partially treated cohorts—, in the remainder of the paper we focus on first doses. Further results on full immunization can be found in the Online Appendix.

Overall, the estimated effects are highly statistically significant and large in magnitude. They are consistent with the hypothesis that the disclosure of the vaccine ruse and subsequent propaganda had severe negative consequences for immunization rates. Note that, the declines in effective protection against these diseases are likely to be even larger since these estimates do not take into account the externalities generated by individual decisions to refuse vaccination.

Next, we provide estimates of the flexible DID specification described in equation (3). Figure 4 plots the $\hat{\beta}_k$ coefficients, which capture the cohort-specific treatment effects. The shaded horizontal lines capture the predicted pattern of coefficients. Consistent with what we expected, the estimates for non-exposed cohorts fluctuate around 0 and do not follow any specific trend. This finding constitutes a first validity check supporting 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. Given the limited number of partially exposed cohorts for the polio and DPT vaccine, it is demanding to see a clean monotonic pattern. For the measles vaccines, for which we have a larger set of partially exposed cohorts, we observe a more clear downward trend in the treatment effects of partially exposed cohorts. This is consistent with stronger negative effects for the partially exposed cohorts that are exposed to the new information for a longer period of time during the first months of life.[42,43]

Overall, the pattern of cohort-specific treatment effects is broadly 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 7 we provide further supporting evidence for this channel.

Heterogenous Effects by Gender

Next, we examine whether our baseline results are heterogenous as a function of the child's gender. Our prior is that the decline in vaccination rates should be larger for girls than for boys, since a number of rumors spread by Islamist groups claimed that vaccines

[42]Note that the March 2011 coefficient in the polio and DPT figures is larger in magnitude than expected. As a result, we do not observe a clear declining pattern in the coefficients for partially exposed cohorts. This is likely due to idiosyncratic factors in the estimation of this specific coefficient. Appendix Figure 4—which includes 90% confidence intervals—indicates that this estimate has the largest standard errors. Moreover, the expectation to document exclusively monotonic patterns is likely very demanding given that only a few cohorts are predicted to be partially exposed in the case of the polio and DPT vaccine. In the case of immunization outcomes for which we have a larger number of partially exposed cohorts, we do observe a clearer monotonically decreasing pattern of estimated treatment effects. See for instance the results for the measles vaccine in Figure 4 or the results for full immunization in Appendix Figure 6. Finally note that in the presence of measurement error in the date of birth, our predicted window of partially exposed cohorts would naturally expand.

[43]In order to examine the medium-run effects, in Appendix Figure 10 we extend our analysis to a larger set of fully-exposed cohorts. The results indicate that, while cohorts born around the time of the disclosure 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. See section 8 for further discussion.

were a conspiracy to sterilize Muslim children, girls in particular. We further discuss this result in our mechanism section 7.

We empirically investigate this hypothesis by adding a triple interaction *Post*×*Islamist_support*×*female* where *female* is an indicator for whether the child is female. The results presented in Table 2 indicate that the decline in immunization was indeed larger for girls. The triple interaction 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 *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.

Effects on Number of Polio Cases

Next, we examine whether the drop in vaccination rates was accompanied by an actual increase in disease prevalence. We focus on the number of cases of poliomyelitis at the district and year level for years 2009, 2010, 2011, and 2014. Unfortunately, we were unable to find comparable data for other diseases.[44]

We implement the *Difference-in-Differences* strategy across years and districts described by equation (2). In particular, our dependent variable corresponds to the number of cases of polio in each district and year and our main regressor is the interaction between the vote share of Islamist parties and an indicator for years 2011 and 2014.[45]

Column 1 of Table 3 indicates that a one standard deviation increase in support for Islamist parties is associated with an increase in the number of cases of polio of about 0.83, which represents a 93% increase over the sample mean. In column 2, we decompose the effects by year and we show that the positive effects are driven by years 2011 and 2014. The fact that the coefficient on 2010 is small and insignificant supports the parallel-trends assumption.

In the next columns, we present an additional exercise to assess how the magnitude of the increase in the disease relates to the drop in vaccination rates. First, we compute the the district-level polio vaccination rate for children younger than 2 years of age before and after July 2011. In column 3 we show the result of regressing the number of polio cases

[44]We obtained data on the number of cases of polio through the Expanded Program of Immunization. The data available for the other diseases was of insufficient quality to grant a meaningful regression analysis. See section 2 of the Online Appendix for details.

[45]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. 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).

on the polio vaccination rate, and controlling for year and district fixed effects. While the point estimate is negative, it is small and insignificant. However, the coefficient is likely to be upward biased, as there may be greater efforts to vaccinate children in areas were the disease is more prevalent. In column 4, we present the result of an instrumental variable strategy where we instrument the vaccination rate with the interaction *Post_July_2011* × *IslSup*. This exercise is valid under the assumption that, conditional on district and year fixed effects, the aforementioned interaction only affects the number of cases of poliomyelitis through its effects on the vaccination rate. The resulting estimate is negative, significant, and large in magnitude. The estimate suggests that a one percentage point increase in the share of children that have received the polio vaccine decreases the number of cases by almost half a case.[46]

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 spread. While observed poliomyelitis cases are relatively infrequent during this period, the magnitude of the increase in polio cases suggest that the decline in immunization rates may have had serious health and welfare consequences for a highly vulnerable population.[47]

6 Robustness Checks

In this section, we present the main robustness checks. Additional tests and analysis can be found in section 3 of the Online Appendix.

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.

The evidence presented in Figure 4 is supportive of this assumption. The estimates for the 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 addition to this, 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

[46]Column 5 shows the first stage of the instrumental variable strategy, which is strong according to conventional levels.

[47]Note that, on average, only 1 out of 200 children infected with the polio virus shows visible symptoms. Accordingly, even a single case of the disease indicates that the virus can be widely spread in a community.

from the vaccine ruse are more noisily estimated, they fluctuate around zero and do not follow any systematic pattern.

In Table 4, we assess the robustness of our results to flexibly control for a number of factors that could generate differential trends across districts. Column 2 incorporates as controls the average value of the dependent variable for non-exposed cohorts, interacted with yearly-cohort fixed effects. Column 3 controls for the share of mothers with low access to health services and column 4 controls for the share of mothers with no formal education, both variables interacted with cohort fixed effects. In column 5, we incorporate controls for local economic conditions. Using data from satellite images we compute the level of luminosity for each district and year. We incorporate the resulting variable as a control for the year and district of birth of each child in our sample. In columns 6 and 7, we explore whether incidence of conflict affects our results.[48] In column 6, we control for the number of conflict events that occurred in a child's district of residence during her first year of life. In column 7, we construct a measure of pre-treatment conflict and interact it with yearly-cohort fixed effects. All results are highly robust to the inclusion of these controls, which suggests that it is unlikely that our results are driven by omitted variable bias.

In section 3 of the Online Appendix, we present a number of additional tests. For instance, we show that our estimates are unlikely to be affected by selective migration. We also present a number of tests on the quality of our measurement of the vaccination status. In particular, we mitigate the concern that under-reporting of vaccination outcomes is affecting our results by showing that there is no increase in the share of parents who claim not to have vaccinated their children. Furthermore, we show that there are no differences across districts in the effect of the vaccine ruse on the propensity to hold a vaccination card.

7 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. Note that in section 1 of the Online Appendix we present a model of Bayesian updating that formalizes the mechanism that, we argue, is behind our results.

[48] We construct different measures of conflict (contain battles, violence by non-state actors, and violence against civilians) using the Armed Conflict Location & Event Data Project (ACLED). Our results are robust to using measures of conflict that involve the Taliban as an actor.

7.1 Are Effects Driven by Demand for or Supply of Vaccines?

In this subsection we discuss a number of analyses that suggest that the decline in vaccination rates is associated with changes in the demand for vaccines, i.e., by parents reducing their levels of vaccine acceptance. While we cannot completely rule out that supply factors played some role, the evidence does not support the hypothesis that these factors are the driving force behind our results.

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. Next, we assess the effects on different measures of health seeking behavior. We estimate equation (2) where we substitute the cohort with the time dimension. While we lose our rich and detailed cohort variation, we believe the evidence is still indicative of changes in parental responses after the disclosure of the vaccine ruse.[49]

First, we examine the effects on the type of medicine that parents consulted when their children felt sick. In column 1 of Table 5, we first examine the effects on incidence of sickness: the dependent variable is an indicator for whether the child was sick in the two weeks prior to the survey. 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 medical assistance that parents sought. In columns 2 and 3, we restrict the sample to children that reported being sick in the last two weeks. Since this is a selected sample, we estimate a Heckman 2-stage selection model. Column 2 shows that parents in areas with high support for Islamist groups were 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 access non-formal medicine, such as spiritualists, homeopaths, chemists, or other. In column 4 we examine another measure of access to informal medicine. The dependent variable is an indicator for whether the family was assisted by a traditional birth attendant in the birth of their youngest child.[50] The results indicate that a one standard deviation increase in support for Islamist groups is associated with a 3.8 percentage point increase in the probability of being assisted in labor by a traditional birth attendant. This represents a 11% over the

[49] We control for quarter-year of interview fixed effects, district fixed effects and individual-level controls (dummy for rural region and monthly age of child). We focus on the same sample of children included in our immunization results but retaining in the sample partially treated kids in a cohort sense. The results are similar if we drop children partially treated in a cohort-sense.

[50] For this specification we exploit cohort-district. See the table notes for details. Note that there are no effects on the number of births in health facilities.

sample mean.

The decline in household contact with formal medicine and the increased reliance on informal medicine is consistent with a decline in the level of confidence in formal medicine after the disclosure of the vaccine ruse. Note that while these measures are typically initiated by parents—hence, demand driven—we cannot completely rule out that the availability of these services played some role. Next, we empirically examine whether changes in the supply of health services could have influenced our results.

Controlling for Supply of Vaccines with Administrative Data

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.[51] Second, the region that suffered the most intense violence —i.e., the FATA region—is not part of our estimating sample.

In order to assess the relevance of a supply mechanism, we collected administrative data on immunization drives, which are the main venue through which children are immunized. We obtained the data from the Expanded Program on Immunization. They contain the number of polio vaccination drives that took place in Pakistan in each month and district between 2008 and 2013. First, we verify that the number and scope of vaccination drives did not change differentially across districts after the disclosure of the vaccine ruse. The results are presented in Appendix Table 11.

Next, we verify that our main estimates are robust to controlling for measures of supply of vaccines. The results are presented in Table 6. Column 1 presents the baseline results for comparison. In columns 2 to 5 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 her district of residence. 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

[51] 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 Appendix Figure 10 and section 3 of the Online Appendix for details.

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.

7.2 Unbundling Demand

In our main analysis we use the vote share to Islamist parties as a main measure of support for the Taliban, which may also proxy for exposure and persuasion effects of anti-vaccine propaganda. This measure has the advantage of being standard in the way it is measured and being available for all districts. However, it may bundle different district and household characteristics. This makes it difficult to assess the channel behind our results. To *"unbundle"* the different channels, we leverage data collected for a research project by Fair et al. (2015), which was graciously shared by the authors. These data consist of a large household survey conducted with 7,648 individuals in 79 districts in the year 2013. The survey contained a number of detailed questions on media consumption, support for different political groups, and knowledge of different events. Using these data, we provide several pieces of suggestive evidence that are consistent with the relevance of the anti-vaccine Taliban propaganda. One caveat of this analysis is that the survey on media consumption and attitudes was collected *after* the disclosure of the vaccine ruse. Hence, these measures may be endogenous to the shock. While we believe that our analysis mainly relies on cross-sectional variation that may not change much over time, the results should be considered as providing suggestive evidence.

Media Consumption and Exposure to Radicalized Information Sources

One important question for our analysis is whether the effects are driven by the disclosure of the vaccine ruse or by the subsequent anti-vaccine propaganda. Since mainstream media had a good coverage of the vaccine ruse, if this information was the main driver of our effects, we would expect greater effects in regions where people consume and trust more mainstream media. In contrast, if exposure to Taliban propaganda was the main driver, we expect to find the opposite.

Using the Fair et al. (2015) data, we compute the fraction of respondents that get their news from informal sources, such as religious leaders, traditional gatherings, or family members. In particular, we focus on the share of respondents that explicitly say that they do not get their news from mainstream media sources such as, Pakistani public or private television channels or Pakistani English or Urdu newspapers.[52] We also compute an alternative measure with the fraction of people whose most trusted source of news is an informal source.

[52]See section 2 in the Online Appendix for precise variable definitions.

Then, we re-estimate our main regression, replacing our measure of support for Islamist groups with either measure of media consumption.

Table 7 shows the results. We find that lack of exposure or lack or trust on mainstream media are predictive of larger declines in immunization rates. These results suggest that access to mainstream information on the vaccine ruse or other events is unlikely to explain our effects.[53] The effects are consistent with access to "alternative", more informal sources of information leading to declines in trust in vaccinations. While we should interpret these results with caution—they may not capture causal effects of information exposure—, the results are broadly consistent with our proposed mechanism.

Support for the Taliban and Exposure to Anti-Vaccine Propaganda

Next, we examine whether individuals with greater exposure to Taliban propaganda exhibit larger declines in vaccination rates. First, using the Fair et al. (2015) data, we compute the share of people for whom religious leaders are their main source for information *and* who express support for the Pakistani Taliban.[54] Column 4 of Table 7 indicates that the larger the fraction of respondents in this category, the larger the declines in vaccination rates. This is consistent with exposure to Taliban propaganda being a relevant driver of our results.

Our second proxy of exposure to Taliban propaganda consists on being aware of US-led drone attacks against Taliban militants in the FATA region. Condemnation of these attacks was a recurrent topic in the Taliban propaganda. In column 4 of Table 7, we find that the decline in vaccination rates was greater in districts where more people have heard about drone attacks on the FATA region. The results are similar when we use the share of people that oppose those attacks.

Finally, note that the larger negative effect on vaccination rates for girls—described in section 5—is consistent with parents granting credibility to the rumor that vaccines were a conspiracy to sterilize Muslim children, girls in particular.

Overall, while none of these measures represents an ideal proxy for exposure to Taliban propaganda, the pattern of effects is consistent with exposure to the Taliban messages being a likely driver of the effects presented in this paper. See section 3 in the Online Appendix for further results and discussion.

[53] Please note that mainstream media was generally supportive of vaccines and dispelled conspiracy theories against vaccines. This is consistent with the empirical results presented in this section.

[54] Note that conditioning on support for the Taliban is important because many religious leaders are not sympathetic to the tenets of the Taliban.

Changes in Beliefs or Intimidation

There are different reasons why the demand for 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. 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.

In order to assess the relevance of this alternative channel, we use measures of conflict involving the Taliban 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 Pakistani security forces and the Taliban.

In Appendix Table 12 we implement 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.[55] 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 changes in attitudes and beliefs are a more likely explanation for the decline in vaccination rates than the threat of violence or reprisals from the Taliban.

8 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 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.

[55] 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.

Our estimates are large in magnitude: a one standard deviation increase in support for Islamist parties is associated with 12 to 20% declines in vaccination rates.

We provide additional empirical evidence that suggests that these effects are likely to be driven by a reduction in the demand for vaccines. We show that other forms of health seeking behavior were also negatively affected. Furthermore, our results are robust to controlling for the intensity of vaccination campaigns measured through detailed administrative data. We also provide a number of additional pieces of information that support the hypothesis that the effects are driven by greater exposure to the Taliban propaganda. Regions where a larger fraction of the population get their news from religious leaders and support the Taliban experience larger declines in vaccination rates.

Our findings highlight the importance of safeguarding trust in health systems, particularly in contexts with some underlying level of skepticism in formal medicine. Events that cast doubt on the integrity of health workers or vaccines can have severe consequences for the acceptance of health products such as vaccines, that are characterized by having large positive externalities. This lesson seems particularly relevant at a time when public acceptance of the new vaccines against Covid-19 is deemed a crucial element in the fight against the virus. This paper also suggests that events that cast doubts against vaccines can be magnified in the presence of motivated groups with the objective of seeding mistrust.

A number of related and important questions remain open and deserve further research. Notably, one key 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.[56] 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. 2020).[57] 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. However, further research is needed to shed light on the question of whether and how trust can be regained.

[56] Alsan and Wanamaker 2017, Lowes and Montero, 2020.
[57] See also Andrabi and Das (2017).

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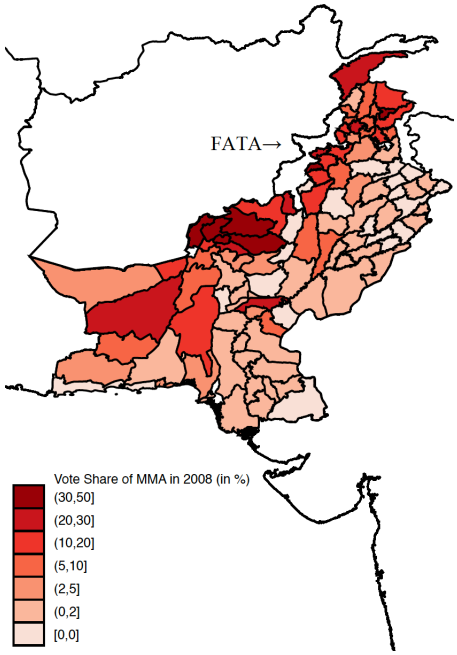
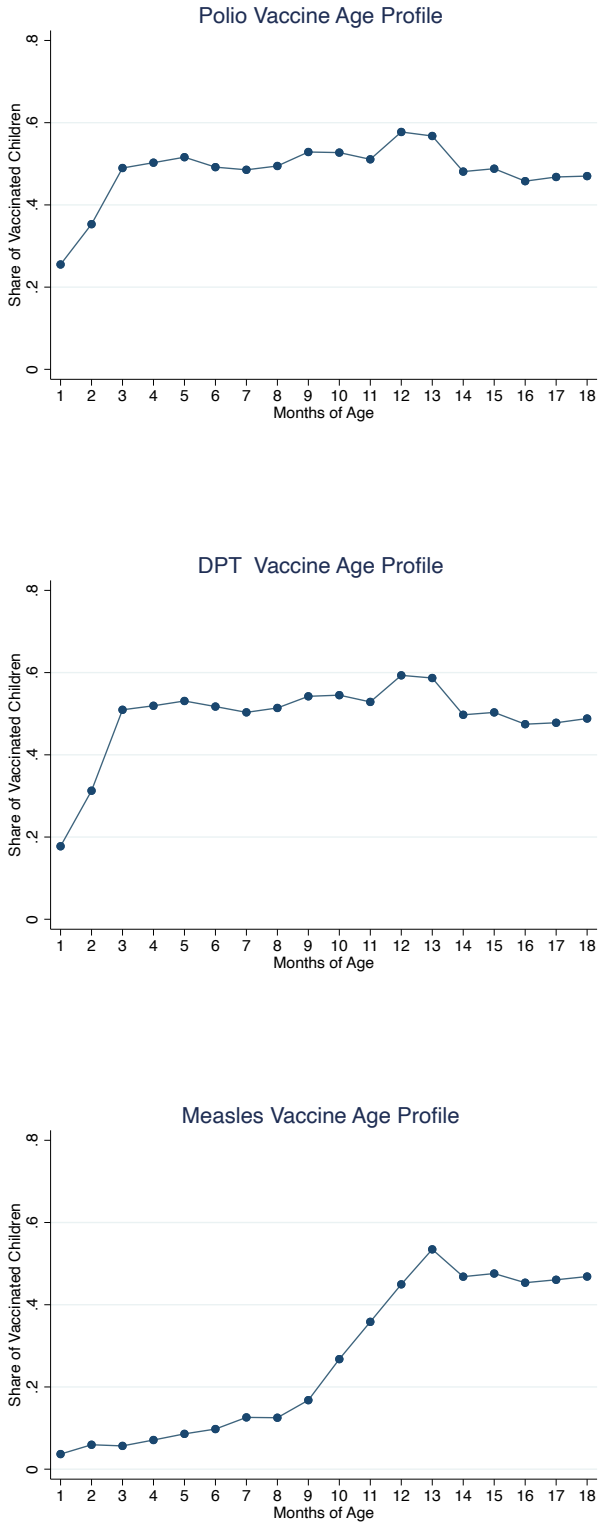
Figure 1: Distribution of Electoral Support for MMA



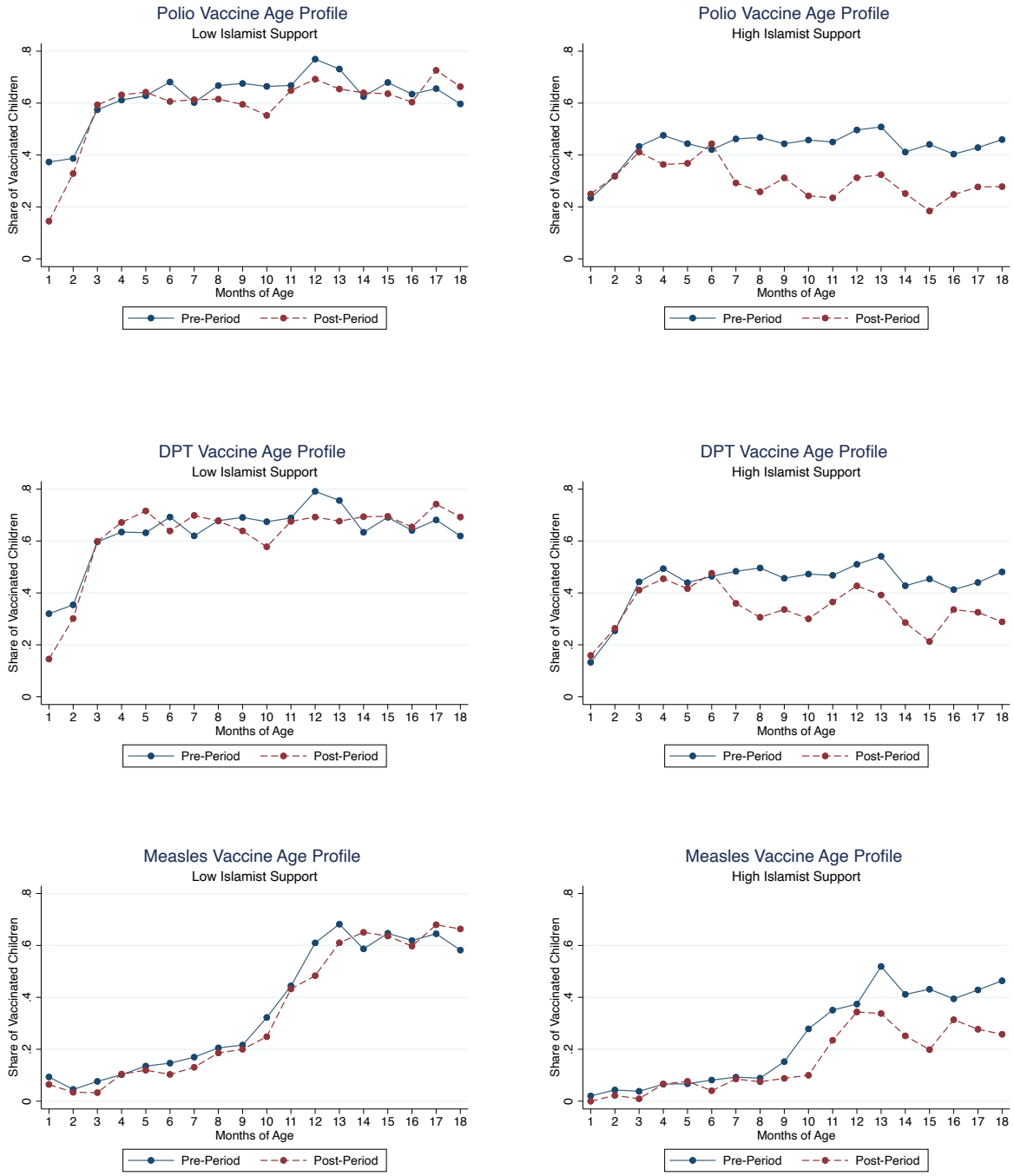
Notes: Map of Pakistan showing the geographic distribution of district-level vote shares for MMA in the 2008 legislative election.

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



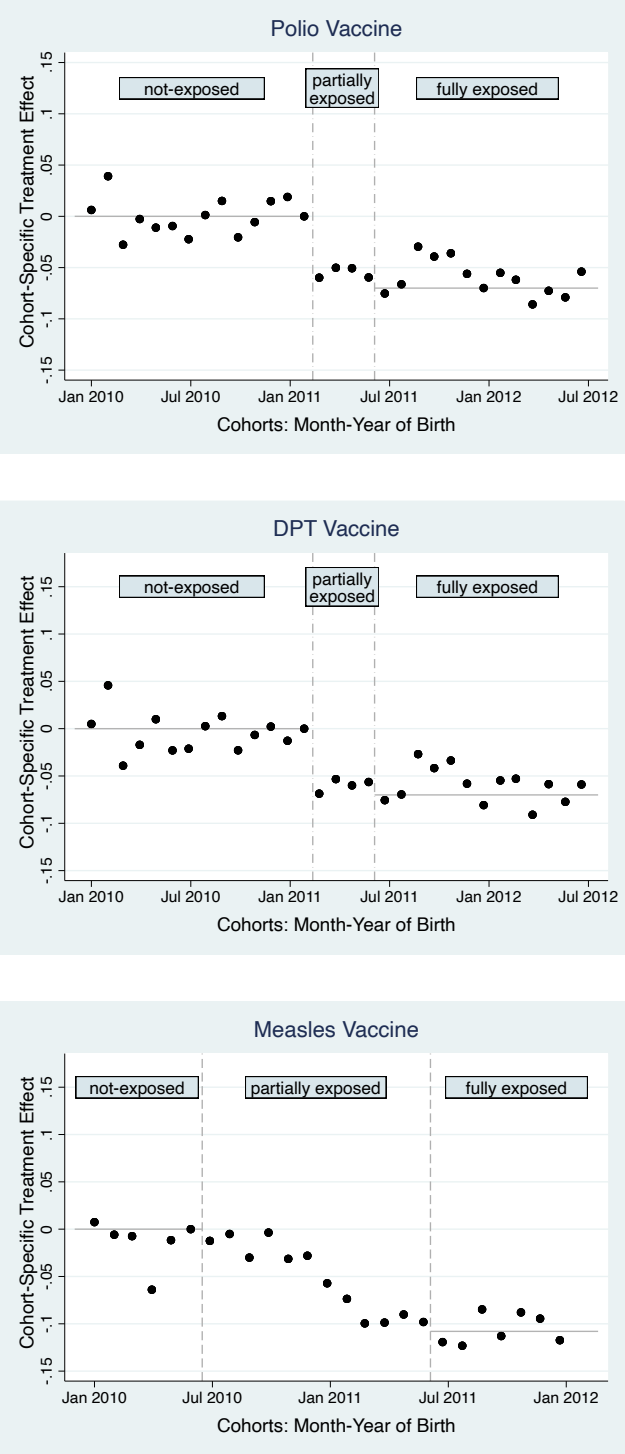
Notes: These figures show the fraction of children that received the first dose of each vaccine by their age at the time of interview. Only the pre-treatment waves of the survey (2008/9 and 2010/11) are used.

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.

9 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*	*0.278*	*0.249*
Post × Islamist Support	-0.058***	-0.054***	-0.054***	-0.057***
	(0.020)	(0.018)	(0.016)	(0.016)
Observations	16,788	16,788	12,577	12,577
R-squared	0.260	0.240	0.252	0.258
Number of Clusters	110	110	110	110
	Panel B. All Doses of Each Vaccine			
Mean Dep. Var.	*0.381*	*0.418*	*0.278*	*0.263*
Post × Islamist Support	-0.062***	-0.058***	-0.054***	-0.049***
	(0.019)	(0.018)	(0.016)	(0.015)
Observations	11,294	11,294	12,577	11,294
R-squared	0.275	0.245	0.252	0.271
Number of Clusters	110	110	110	110

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: 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: 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*	*0.278*	*0.249*
Mean Dep. Var. for Males	*0.426*	*0.459*	*0.283*	*0.256*
Mean Dep. Var. for Females	*0.414*	*0.447*	*0.273*	*0.243*
Post × Islamist Support	-0.045**	-0.039**	-0.042**	-0.044***
	(0.020)	(0.018)	(0.017)	(0.016)
Post × Islamist Support x Female	-0.028**	-0.031**	-0.024	-0.029
	(0.013)	(0.016)	(0.018)	(0.018)
Observations	16,788	16,788	12,577	12,577
R-squared	0.260	0.240	0.253	0.258
Number of Clusters	110	110	110	110
	Panel B. All Doses of Each Vaccine			
Mean Dep. Var.	*0.381*	*0.418*	*0.278*	*0.263*
Mean Dep. Var. for Males	*0.388*	*0.424*	*0.283*	*0.268*
Mean Dep. Var. for Females	*0.373*	*0.412*	*0.273*	*0.257*
Post × Islamist Support	-0.036*	-0.036*	-0.042**	-0.036**
	(0.019)	(0.020)	(0.017)	(0.016)
Post × Islamist Support x Female	-0.056**	-0.048*	-0.024	-0.029
	(0.023)	(0.026)	(0.018)	(0.019)
Observations	11,294	11,294	12,577	11,294
R-squared	0.276	0.246	0.253	0.272
Number of Clusters	110	110	110	110

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 3: Effects on the Number of Polio Cases

	Dependent Variables:				
	Number of Polio Cases				Share with First Dose of Polio Vaccine
	Reduced Form		OLS	2SLS	First Stage
	(1)	(2)	(3)	(4)	(5)
Mean Dep. Var.	*0.886*	*0.886*	*0.886*	*0.886*	*33.05*
Post July 2011 × Islamist Support	0.828**				-1.755***
	(0.329)				(0.605)
2010 × Islamist Support		-0.031			
		(0.339)			
2011 × Islamist Support		1.001*			
		(0.517)			
2014 × Islamist Support		0.624*			
		(0.370)			
Vaccination Rate			-0.017	-0.472**	
			(0.011)	(0.231)	
Kleibergen-Paap F-Statistic					8.41
Observations	458	458	458	458	458

Notes: Robust standard errors in parentheses. The unit of observation is the district-year. There are 115 districts in the sample. All regressions include district and year fixed effects. 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 thereafter. The share of children with the first dose of the polio vaccine is calculated as the district-level average share of children who obtained the first dose of the polio vaccine. In particular, district observations in 2009 and 2010 are assigned the average share of children who had obtained the first dose of the polio vaccine and were born prior to the disclosure of the vaccine ruse. District observations in 2011 and 2014 are assigned the average share of children who had obtained the first dose of the polio vaccine and were born after the disclosure of the vaccine ruse. 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)

Table 4: Main Robustness Checks

	Baseline	Mean of Dep Var Pre-Treatment x Cohort FE	Initial Health x Cohort FE	Initial Education x Cohort FE	Nightlights at Birth	Conflict Events in the First Year of Life	Conflict Events in 2010 x Cohort FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel A. First Dose of Polio Vaccine						
Post × Islamist Support	-0.058***	-0.059***	-0.053***	-0.044**	-0.053***	-0.058***	-0.058***
	(0.020)	(0.020)	(0.019)	(0.020)	(0.019)	(0.020)	(0.019)
Observations	16,788	16,788	16,788	16,788	16,788	16,758	16,758
R-squared	0.260	0.260	0.263	0.261	0.261	0.260	0.260
	Panel B. First Dose of DPT Vaccine						
Post × Islamist Support	-0.054***	-0.056***	-0.055***	-0.055***	-0.053***	-0.054***	-0.054***
	(0.018)	(0.019)	(0.016)	(0.019)	(0.018)	(0.017)	(0.017)
Observations	16,788	16,788	16,788	16,788	16,788	16,758	16,758
R-squared	0.240	0.240	0.243	0.240	0.240	0.240	0.241
	Panel C. First Dose of Measles Vaccine						
Post × Islamist Support	-0.054***	-0.052***	-0.046***	-0.049***	-0.047***	-0.054***	-0.053***
	(0.016)	(0.016)	(0.015)	(0.017)	(0.015)	(0.016)	(0.016)
Observations	12,577	12,439	12,577	12,577	12,577	12,557	12,557
R-squared	0.252	0.253	0.256	0.254	0.254	0.252	0.253
	Panel D. All Vaccines						
Post × Islamist Support	-0.057***	-0.055***	-0.046***	-0.040**	-0.047***	-0.057***	-0.057***
	(0.016)	(0.016)	(0.016)	(0.017)	(0.014)	(0.016)	(0.016)
Observations	12,577	12,439	12,577	12,577	12,577	12,557	12,557
R-squared	0.258	0.260	0.262	0.262	0.263	0.258	0.258

Notes: Standard errors clustered at the district-level in parentheses. There are 110 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 as controls the mean of the dependent variable for the non-exposed cohorts interacted with yearly cohort fixed effects. Column 3 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 4 adds controls for share of mothers that had no formal education in 2008/9 interacted with yearly cohort fixed effects. Column 5 adds as control a district-level measure of nightlight luminosity in the year in which the child was born. Column 6 adds as a time-varying control the number of conflict events in the first year of life (excluding protests and riots). Column 7 adds controls for the number of conflict events in 2010 interacted with yearly cohort fixed effects.

Table 5: Effects on Health Seeking Behavior

	Dependent Variables:			
		Heckman Selection Model		
	Dummy for Illness in Last 2 Weeks	Dummy for Consulted Anyone	Dummy for Consulted Formal Medical Sector	Labor Assisted by Traditional Birth Attendant
	(1)	(2)	(3)	(4)
Mean Dep. Var.	*0.190*	*0.980*	*0.923*	*0.330*
Post July 2011 × Islamist Support	0.025*	-0.023*	-0.060**	
	(0.013)	(0.013)	(0.027)	
		[0.010]	[0.019]	
Inverse Mills Ratio		-0.052	-0.109**	
		(0.032)	(0.042)	
		[0.026]	[0.035]	
Post × Islamist Support				0.038***
				(0.013)
Observations	18,795	3,568	3,568	18,366
R-squared	0.064	0.077	0.152	0.138
Number of Clusters	110	109	109	110

Notes: Standard errors clustered at the district-level in parentheses. Standard errors derived from a bootstrap procedure with 1,000 bootstrap replications in square brackets. The unit of observation is the child level. In Column 4, the sample is restricted to only the youngest child born to a mother in the sample. All regressions in Columns 1 to 3 include district fixed effects, quarter of interview fixed effects, monthly age fixed effects, and a dummy for rural regions. The regression in Column 4 includes district, monthly cohort, monthly age, and calendar month of interview fixed effects and a dummy for rural regions. While Columns 1 to 3 rely on variation in the interview timing, Column 4 exploits variation in the cohort dimension. The selection equation includes as an excluded instrument a proxy for the disease environment: the share of children that are sick in the same quarter and district (excluding a child's own illness status). The formal medical sector corresponds to hospital, basic health units and lady health workers.

Table 6: Robustness to Controlling for Supply of Health Services

	Baseline	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)
	Panel A. 1st Dose of Polio Vaccine				
Post × Islamist Support	-0.058***	-0.060***	-0.060***	-0.060***	-0.062***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Observations	16,788	16,654	16,654	16,612	16,612
R-squared	0.260	0.262	0.263	0.261	0.261
Number of Clusters	110	109	109	109	109
	Panel B. 1st Dose of DPT Vaccine				
Post × Islamist Support	-0.054***	-0.056***	-0.056***	-0.056***	-0.059***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Observations	16,788	16,654	16,654	16,612	16,612
R-squared	0.240	0.241	0.242	0.240	0.240
Number of Clusters	110	109	109	109	109
	Panel C. 1st Dose of Measles Vaccine				
Post × Islamist Support	-0.054***	-0.054***	-0.055***	-0.054***	-0.058***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.017)
Observations	12,577	12,479	12,479	12,437	12,437
R-squared	0.252	0.253	0.253	0.252	0.252
Number of Clusters	110	109	109	109	109
	Panel D. Full Immunization				
Post × Islamist Support	-0.057***	-0.057***	-0.058***	-0.058***	-0.062***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.017)
Observations	12,577	12,479	12,479	12,437	12,437
R-squared	0.258	0.259	0.260	0.258	0.259
Number of Clusters	110	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 and 3 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 4 and 5 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.

Table 7: Evidence on Media Consumption & Support for the Taliban

	Dependent Variable: 1st Dose of Polio Vaccine				
	(1)	(2)	(3)	(4)	(5)
Post × Islamist Support	-0.069**				
	(0.027)				
Post × Not Using Mainstream Media		-0.080***			
		(0.027)			
Post × Not Trusing Mainstream Media			-0.064***		
			(0.023)		
Post × Support Pak Taliban & Trust Religious Leaders				-0.054**	
				(0.022)	
Post × Know of Drone Strikes					-0.062***
					(0.017)
Observations	13,823	13,823	13,823	13,823	13,823
R-squared	0.257	0.258	0.258	0.256	0.259
Correlation coefficient of key regressor and Islamist Support	1.00	0.53	0.47	0.48	0.25
Number of Clusters	80	80	80	80	80

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 table 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 variable takes value 1 if the first dose of polio vaccine was received, 0 otherwise. The alternative measures used in the interaction with the post dummy are calculated using survey data collected by Fair, Kalthenthaler and Miller (2015). Please refer to the Data Appendix for a full citation of the data source and a more detailed variable description for these variables.