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Abstract

Using a generalized difference-in-differences approach, we find that children residing in high-conflict areas in Iraq are more likely to be vaccinated against tuberculosis and measles than children residing in low-conflict areas. We draw household data on vaccination from the Multiple Indicator Cluster Surveys and we identify high-conflict area-years using geolocational conflict data from the Iraq Body Count project. While previous literature generally finds that conflict harms public health, a potential explanation for our result is heavy presence of international aid organizations in conflict areas, a phenomenon which researchers have noted in other contexts.

Keywords: Iraq war, vaccinations, armed conflict, Middle East.
JEL Classifications: F51, I15, J13, N45.

1. Introduction

Average life expectancy increased by more than 30 years over the 20th century, and the US Centers for Disease control has consistently cited vaccination as the single most important public health achievement responsible for this increase (CDC 1999). Evidence appears conclusive that vaccination reduces child mortality (Peter 1992; Lehmann et al. 2005). The public sector and the private sector invest substantial sums in vaccine production and research, and the list of vaccine-preventable diseases continue to grow (Institute of Medicine 2003). According to 2020 report by the World Health Organization, while the majority of children receive recommended vaccines and these vaccines save at least 2 million lives every year, global vaccination coverage has remained flat in recent years (WHO 2020).

An unfortunate aspect of current societies known to have strong effects on public health is violent conflict. The number of violent conflicts has been on a decline since 1945 (Gates et al. 2016), but the world recently experienced a spike in violent conflicts, with the year 2014 alone registering 40 armed conflicts with a minimum of 25 casualties, the largest number since 1999 (Pettersson and Wallensteen 2015). Even though the number of related deaths has been declining, the latest, recent conflicts generated the largest number of conflict casualties since 1989. The deadliest conflicts have occurred in the Middle East, with Iraq and Syria accounting for more than 65% of conflict-related casualties in 2014 (Gates et al. 2016).

While the most visible effects of armed conflict are the destruction of life and property, there are other indirect effects that are less obvious, but that potentially have serious consequences for conflict-affected populations. Furthermore, many of these consequences persist in measurable ways over long-time spans (Kesternich et al. 2014). Recent work suggests that women and children bear the brunt of these costs, including health impacts (United Nations 2002; Diwakar et al 2019), access to nutrition (Alderman et al. 2006) and food insecurity (Brück et al, 2019a), sexual and domestic violence (Clark et al. 2010; Haj-Yahia and Clark 2013; Horn et al. 2014; Usta and Farver 2010; Vinck and Pham 2013; Malcolm et al. 2019), education as conflict lowers the probability of passing exams, reduces test scores, and the probability of being admitted to tertiary education institutions (Brück et al, 2019b), and child labor (Naufal et al. 2019).

One aspect of the relationship between violent conflict and child health that remains relatively unexplored is conflict's impact on vaccine coverage. Theoretically, the relationship is ambiguous. On one hand, violent conflict destroys and displaces local health resources and may reduce the ability of households to vaccinate their children. On the other hand, the international community's response can mitigate these effects, and conflict-affected areas are often a locus of support by international organizations. If this support increases access to vaccinations above what would have been the baseline in the absence of conflict, then it is possible that violent conflict indirectly leads to an increase in vaccination rates.

In this paper, we use household data from Iraq to study the association between conflict levels and child vaccination. Using several years of data and a generalized difference-in-differences approach, we find that children residing in high-conflict areas are *more* likely to receive vaccinations against tuberculosis and measles. Our result suggests that sustained investments by international organizations in conflict-affected areas have the potential to alter public health and – at least on some dimensions – to offset the damage that violent conflict imposes on civilian health.

2. Literature Review

2.1. Vaccination and Conflict

Empirical evidence on the effects of violent conflicts on households has been limited, although it has grown in recent years, owing in large part to better micro-level data from conflict-affected areas. In this section, we review the limited literature that exists on the relationship between conflict and immunization.

A study of 16 countries (Afghanistan, Chad, Central African Republic, Cote D'Ivoire, Democratic Republic of Congo, Ethiopia, Kenya, Myanmar, Nigeria, Pakistan, Somalia, the Sudan, South Sudan, Uganda, Ukraine and Yemen) by Grundy and Biggs (2018) found that this small set of countries was responsible for over two thirds (67%) of global polio cases and for 39% of global measles cases between 2010 and 2015, and that 14 of these countries had DTP3 vaccine (to prevent diphtheria, tetanus and pertussis) coverage below the global average of 85%. The authors note that the onset of conflict and "tense security conditions, along with damaged health infrastructure and depleted human resources have contributed to infrequent outreach services, and delays in new vaccine introductions and immunisation campaigns" at the national and subnational levels.

There are also studies that explore the relationship between conflict and vaccinations through the use of regression-based modelling. In the Middle East, Cetorelli (2015) uses data from Iraq to find that war-exposed children are about 22 percentage points less likely to receive neonatal polio immunization. Leone et al. (2018) investigate maternal and child health outcomes in the occupied Palestinian territories from 2000 to 2014, and they also find that intensity of conflict is negatively associated with vaccination, with boys more likely to be vaccinated than girls. In Afghanistan, Norris et al. (2016) examine the relationship between conflict and incidence of polio, and show a positive correlation between the presence of Improved Explosive Devices (IED) and polio incidence over 2004-2010. They attribute this relationship to reduced rates of polio vaccination due to violence, which they explain through vaccination campaign staff being targeted by armed groups, and a lack of public trust in government and international organizations that run vaccination campaigns.

Exploring the relationship between conflict and vaccinations in Africa, Agadjanian and Prata (2003) use one year of data from Angola to find significantly lower levels of immunization for children most affected by fighting, net of rural-urban differences that disadvantage children in remote rural areas. Sato (2019) uses data from the Demographic and Health Surveys program to explore the effect of the Boko haram insurgency on vaccination in north-eastern Nigeria. The author finds a large negative effect of conflict events on the likelihood of vaccination, with residence within 10 kilometers of a conflict occurrence reducing the odds of child vaccination by 47.2%. The author additionally finds that the magnitude of this decline is even larger where mothers are less educated, reducing the odds of any vaccination by 64.3%.

The studies above, and others, point to various pathways through which conflict affects vaccinations, such as through destruction of healthcare facilities and workers (Grundy and Biggs, 2018; Ngo et al., 2019), lack of public trust in vaccination campaigns (Norris et al., 2016), and displacement of families (Ngo et al., 2019). Silwal et al. (2006) uses the context of armed conflict in Nepal to descriptively categorize these difficulties in performing immunization services into service-provider and service-consumer based challenges. The former relates to difficulties in transportation of vaccines, personal safety, and restriction of movement. Service-consumer problems in turn focus on insecurity, irregular services, and the presence of service providers from areas outside of the locality which sometimes created fear and language barriers in effective communication. Finally, studies also point to differential effects, such as by rural-urban residence (Agadjanian and Prata, 2003), gender of the child (Leone et al., 2018), or by the education of the mother (Sato, 2019).

While the majority of this literature finds a negative association between conflict and child vaccination, it is important to note that the opposite result is theoretically plausible. In the context of other public health issues, researchers have found that interventions by aid organizations in conflict areas can be powerful enough to effect lasting changes in public health. For example, Zakanj et al. (2000) argue that distribution of infant formula by aid organizations in Croatia led to a decline in breastfeeding in conflict-affected areas there. Teshome and Takea (2017) find the same in Iraq and highlight extensive formula distribution there. While the consequences in that case were negative (higher rates of infant malnutrition), the key point is that international organizations invest heavily in some conflict-affected areas and, although there can be challenges with delivery of aid, these investments do have the potential to alter household behavior (European Commission 2020).

Our paper builds on the work of Cetorelli (2015), who also examined the impact of conflict on vaccination in Iraq and extends it in three important ways. First, while Cetorelli examines only the polio vaccine, we study other important vaccines as well. Second, Cetorelli's difference-in-differences approach is to use the relatively peaceful Kurdish areas as a control group. By contrast, we employ a generalized difference in differences approach together with conflict data by province to provide a more comprehensive measure of time-varying differences in conflict across Iraq's provinces. Third, we add the 2018 wave of the Multiple Indicator Cluster Surveys (MICS) dataset to our analysis, only recently available.

2.2. Iraq

With one of the most conflict-affected and youngest populations in the world, Iraq is a suitable setting to study the relationship between vaccination and conflict. The country has experienced several major wars in the last four decades starting with the Iran-Iraq war in the 1980s, followed by the Gulf War in 1991, the US invasion in 2003, the recent armed conflict with the ISIL, and lately violent protests due to deteriorating economic conditions. The series of armed conflicts killed and injured hundreds of thousands of Iraqis and destroyed much of the Iraqi economy and its infrastructure. The Iraq Body Count (IBC) project estimates the number of recorded civilian deaths from the start of the US invasion of Iraq in 2003 to 2020 to be at least 185,000 (IBC 2020). The Iraqi economy shrank in real terms five times between 2006 and 2018, recording negative growth in standard of living (World Bank 2020). Wars in Iraq have also greatly damaged its educational infrastructure, resulting in a decline in the youth literacy rate and the number of children enrolled in primary education (Diwakar 2015). The fact that the distribution of conflict in Iraq has also been highly uneven, both by location and across time, presents ample opportunities for research designs that explore the effect of war on households.

Further, Iraq is home to one of the youngest populations in the world. Children aged 0-14 years constitute 42% of its population (averaged 1995-2019), and its average population growth for the same period is 2.8%, which is even higher than that of sub-Saharan African countries. The median age of the population in 2019 was 21.2 years, which places Iraq as the 41st youngest country in the world, and the third youngest in the Middle East and North Africa region after Palestine and Yemen (Central Intelligence Agency Factbook 2020). Finally, Iraq also has excellent micro-level quantitative data on issues related to young children, described in the next section.

3. Data and Methods

3.1. Data

Household data are from the Multiple Indicator Cluster Survey (MICS), a joint project of UNICEF, local, and national governments that aims to collect data on women and children in the developing world. The characteristics of the sample are pegged to census data to ensure adequate regional and demographic coverage, but otherwise households are randomly selected. For the present study, we use the 2006, 2011 and 2018 MICS surveys. The sample sizes are 17,873 households, 36,592 households and 20,318 households in 2006, 2011 and 2018, respectively, with response rates of 98.6%, 99.6% and 99.5%.

For sampled households, data on immunization were collected on children aged up to 36 months. Our final sample consists of approximately 13,000 such children in 2006, 29,000 children in 2011 and 2500 children in 2018. The sample sizes vary slightly by vaccine type owing to missing data issues. For each child in the sample, we construct the following five indicators, which constitute the dependent variables for our paper.

1. Has the child ever received any vaccinations?
2. Has the child ever been given a BCG vaccination?
3. Has the child ever been given a Hepatitis B, DPT or Pentavalent vaccination?
4. Has the child ever been given a measles or MMR vaccination?
5. Has the child ever been given a polio vaccination?

The BCG vaccine prevents tuberculosis. The Pentavalent vaccine offers protection against diphtheria, pertussis, tetanus, hepatitis B and Hib, while the DPT vaccine covers only the first three. Children who do not receive the Pentavalent vaccine are typically administered DPT and hepatitis B immunizations simultaneously. As such, we have combined them for our analysis. Similarly, the MMR vaccine offers protection against measles, mumps and rubella, so we have combined this vaccination with stand-alone measles immunization. The survey instrument requests that the survey administrator check parent-provided responses against the child's official immunization card.

Iraq's National Immunization Schedule recommends administration of BCG, hepatitis B and polio vaccinations at birth, with administration of a measles vaccine at 9 months of age (Iraqi Ministry of Health 2014). These are consistent with current WHO guidelines (World Health Organization 2019A). Table 1 gives immunization statistics among the children in our sample. In 2006 and 2011, polio vaccination coverage is 99%, and coverage for vaccinations against other diseases is over 90%, with the exception of measles vaccination, presumably because this is not recommended for the children in our sample aged younger than 9 months. 2018 vaccination coverage appears to be somewhat lower, owing to a slightly different sample construction in MICS.

Our primary explanatory variable is the number of conflict-related casualties per 1000 population in the governorate in which the family resides. These data are collected from the Iraq Body Count project, which records timestamped death records of conflict-related casualties in Iraq, identified at the level of the governorate. The project relies primarily on media sources, but also collects data from government records and from non-governmental organizations. While the database is likely to undercount the true level of casualties, it nevertheless remains a definitive source on conflict in Iraq (Carpenter et al. 2013).

To check the robustness of our results, we use three different proxies for our measure of household conflict exposure – Conflict-related casualty rate in the household's governorate one year prior to survey administration, two years prior to survey administration and contemporaneous to survey administration. We use these three variables to construct a treatment group with high conflict exposure and a control group with low conflict exposure, as described in section 3.2. Note from the summary statistics provided in Table 1 that there is a great deal of variation in these casualty rates across regions and over time. This variation proves to be useful for estimation purposes.

In addition to conflict exposure, we employ a variety of child and household controls that are common in the literature on development and health. Child controls include the child's age, gender, weight for age percentile, height for age percentile and whether the child is the son or daughter of the head of household. Household controls include the age and gender of the head of household, educational attainment of the child's mother, the child's father, and the head of household, the total number of household members, the total number of household members less than 17 years old, the number of bedrooms in the home and an indicator for whether the home is in an urban area. Number of bedrooms is the closest proxy for household wealth in our sample. While the 2011 and 2018 surveys contain a wealth indicator (by quintile), the 2006 survey contains no direct information on household income or wealth. Summary statistics for all these variables are given in Table 1. We have separated the statistics by the samples we will use for our analysis of each vaccine. As mentioned earlier, this is due to slightly different samples for each vaccine, owing to missing data issues for some records.

3.2. Statistical Methods

Simple regression of conflict levels on vaccine indicators is likely to suffer from serious omitted variables bias. There are a multitude of unobserved factors that affect household decisions related to child health (e.g. cultural factors) that presumably vary by region and that could be correlated with conflict levels. In other words, families who live in high-conflict areas might be different from families in low-conflict areas even in the absence of conflict. Differences-in-differences estimation was designed to deal with this problem when the researcher has access to quasi-experimental data. The basic idea is to identify a treatment group that is exposed to some event and a control group that is not exposed and to collect pre- and post-event data from both groups. If there is a statistically significant difference in the change in the response variable across the treatment and control groups, then this provides evidence of a treatment effect. For example, if vaccine coverage increased by a larger amount in areas exposed to a public awareness campaign than in similar areas not exposed to a campaign, this would provide evidence for the efficacy of the campaign. The advantage is that one is not drawing inferences by direct comparison of the treatment and control groups, but rather by contrasting changes over time *within* the treatment and control groups.

A standard difference-in-differences setup has a treatment group, a control group, and two time periods. Cetorelli (2015) adopted this approach in her analysis of polio vaccination rates in Iraq. Generalized difference-in-differences is an extension that admits more than two periods, and allows groups to switch between treatment and control states – so that a particular group need not be a treatment group or a control group across the entire study. This approach is especially useful in our context since the high-conflict areas in Iraq have changed over time. For example, the northern parts of Iraq that are dominated by the Kurds were relatively unscathed following the 2003 Iraq war, but were badly impacted by violence surrounding ISIL after 2014.

For generalized difference-in-differences, the model is as follows (Hansen 2020).

$$Y_{i,t} = \beta_0 + \beta_1 T_{i,t} + \beta_2 C_{i,t} + \alpha_i + \delta_t + \varepsilon_{i,t}$$

Here, $Y_{i,t}$ is the outcome for entity i in period t. $T_{i,t}$ is the treatment status of entity i in period t. Importantly, this treatment status is allowed to vary within groups (regions in our case). A particular region might be part of the high-conflict treated group in one period, but a part of the low-conflict control group in another. $C_{i,t}$ is a vector of control variables. α_i is a set of region dummies and δ_t is a set of period dummies. These are just the general versions of the treatment and post-year indicators in the simple difference-in-differences setup. Assuming that the model is properly specified β_1 is the effect of treatment on the outcome variable.

In our case, the outcome variables are indicator variables, so we adopt the conventional approach of nesting a difference-in-differences setup within a probit model. That is, the equation we are estimating is as follows:

$$\Pr\left(Y_{i,t} = 1\right) = \Phi\left(\hat{\beta}_0 + \hat{\beta}_1 T_{i,t} + \hat{\beta}_2 Child_{i,t} + \hat{\beta}_3 HH_{i,t} + \alpha_i + \delta_t\right)$$

$Y_{i,t}$ is the vaccination outcome and $T_{i,t}$ is treatment status, equal to 1 for households residing in high-conflict areas and equal to 0 for households residing in low-conflict areas. For this study, we define high conflict as a governorate-year with casualty rates above the 75th percentile in casualties across the panel. In our main analysis, we use casualty rates lagged by one year prior to the survey administration. As discussed in 3.1, we also perform robustness checks by lagging casualty rates two years prior to the survey administration and by using contemporaneous casualty rates to identify treatment and control governorate-years. $Child_{i,t}$ is a vector of child controls and $HH_{i,t}$ is a vector of household controls. One disadvantage of nonlinear panel models is that there is no way to construct a consistent estimator of the marginal effect of T on Y (Greene 2010). That is, although the sign of $\hat{\beta}_1$ indicates the *direction* of the marginal effect and we can use standard tests to determine its statistical significance (i.e. whether it is significantly different from zero), such models offer no reliable way to estimate the magnitude of the effect.

4. Results

Table 2 gives our main results. Residing in a high-conflict area is associated with an increase in the probability that a child has been vaccinated at all, an increase in the probability that a child is vaccinated against tuberculosis (the BCG vaccination) and an increase in the probability that a child is vaccinated against measles. There is no significant association between high conflict and the probability of vaccination against hepatitis B or polio.

As discussed in 3.1, we checked the robustness of these results by constructing our treatment group slightly differently. While our main results lag casualties by one year to identify high-conflict governorate years, the results in Table 3 use contemporaneous casualty rate and then the casualty rate lagged by two years to identify the treatment group – again using the 75th percentile of casualty rates over the panel as the cutoff. The regressions in Table 3 use all the same controls as in our main results, but we show only the coefficient on the high conflict treatment dummy. Again, residing in a high-conflict area is associated with an increase in the probability that a child has been vaccinated at all and an increase in the probability that a child is vaccinated against tuberculosis, although the latter result is only marginally significant when the treatment group is identified using casualty rates lagged two years prior to the survey. Residing in a high-conflict area is associated with an increase in the probability of vaccination against hepatitis B when we use contemporaneous conflict to identify the treatment group. Note that there is no significant association between conflict and the administration of the polio vaccine in any of our specifications. One potential explanation for this result is that polio vaccination is so universal among Iraqi children – coverage of 99% in both the treatment groups and the control groups in 2006 and 2011 – that there is not much variation to exploit in estimating the impact of conflict. This is in contrast to the other vaccines, with lower coverage rates in our sample.

As for the other control variables, older children are more likely to be vaccinated, as are boys, although the latter result is only marginally significant. Older parents are more likely to vaccinate, although again this is only marginally significant. The strongest predictors of vaccination are parental education levels. Both primary and secondary school completion, for both mothers and fathers, are positively associated with the probability of child vaccination, across all types of vaccines. Further, all of these coefficients are significant at the 1% level. Relatedly, households that reside in urban areas are more likely to vaccinate. This result is also significant at the 1% level and applies to all vaccinations studied. Children who live in wealthier households (proxied by the number of bedrooms in the home) and in households with a smaller total number of children are also more likely to be vaccinated, although these associations are weaker.

5. Conclusion

The literature on the effects of violent conflict for household behavior is small, but growing, and researchers are developing an increasing awareness of the long-term effects of conflict on civilian populations. Children surely form an important piece of this analysis. A host of influential work by Heckman and others has shown the importance of a child’s formative years on a whole range of lifetime outcomes, and health is a key part of this landscape (Heckman 2012; Campbell et al. 2014). Note that many of these outcomes have public consequences, not just private costs for affected children, and Heckman (2012) argues that they are large enough to show up in macroeconomic statistics for decades. If conflict has an effect on child health, then the implication is that understanding these effects is an important part of assessing the cost of conflict to civilian populations, and should also inform allocation of resources aimed at mitigating the harm done to people who live in conflict areas. There is an urgent need, specifically, for more research on the Middle East, which is conflict-prone and has a young population.

Vaccination is important for child health, and it is among the most cost-effective ways to reduce mortality and morbidity. The list of vaccine-preventable conditions continues to grow, and we have made major strides in expanding vaccine coverage over recent decades. Most previous research has found a negative association between conflict and vaccination. However, using a large micro-level dataset and new statistical techniques, we find the opposite for the case of Iraq. Children living high conflict area-years are *more* likely to have access to vaccination generally, and specifically are more likely to be vaccinated against tuberculosis and measles than their counterparts who are not exposed to high conflict.

In our view, the most likely explanation of this result is a heavy presence of international aid organizations in conflict-affected areas; administration of vaccines is a key objective of international health organizations. Prior researchers have observed in other contexts that these organizations can exert enough influence to effect measurable changes in public health, and indeed the WHO funds an active vaccination campaign in Iraq (World Health Organization 2019B). Such effects could reflect supply side in rapid intervention, distribution chain, but also a demand side reflected in locals trusting such efforts. While we would certainly not suggest that increasing conflict is a recipe for directing more attention to child health, our results do at least give us some evidence that conflict-related relief efforts can yield good outcomes for civilians who have access to them. The main policy implication of this work is that efforts by the international community to promote vaccination in conflict areas appear to be effective, and ideally these successes can inform vaccination campaigns even in non-conflict areas. These efforts not only reduce mortality and morbidity, but they lead to considerable long-term economic benefits, and developing a reliable infrastructure around immunization enables faster and more effective response to new epidemics that arise.

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Table 1. Summary Statistics

Any Vaccine

		Control			Treatment		
		2006	2011	2018	2006	2011	2018
Child	Received any vaccine	0.94	0.95	0.81	0.92	0.94	0.82
	Child age	1.45	1.48	1.14	1.47	1.48	1.18
	Child gender	0.51	0.51	0.50	0.51	0.51	0.49
	Weight for age percentile	39.97	38.72	41.18	45.39	40.89	42.24
	Height for age percentile	31.61	36.46	40.16	33.87	29.05	40.29
	Son/daughter to head of household	0.77	0.70	0.62	0.71	0.69	0.59
Household	Head of household age	40.95	41.84	44.45	43.12	42.60	44.69
	Head of household gender	0.95	0.95	0.94	0.91	0.95	0.92
	Head of household primary education	0.35	0.38	0.36	0.28	0.37	0.37
	Head of household secondary education	0.44	0.39	0.40	0.53	0.42	0.46
	Father primary education	0.36	0.41	0.38	0.30	0.41	0.39
	Father secondary education	0.50	0.45	0.47	0.62	0.47	0.49
	Mother primary education	0.48	0.49	0.39	0.49	0.56	0.54
	Mother secondary education	0.29	0.26	0.32	0.37	0.22	0.28
	Number of household members	7.84	8.45	8.91	7.77	8.80	8.63
	Number of household members under 17	4.37	4.53	4.71	4.08	4.78	4.45
	Number of bedrooms	2.11	2.34	2.76	2.36	2.45	2.66
	Urban	0.61	0.55	0.54	0.64	0.50	0.64
Casualties	Current year	0.29	0.08	0.08	1.85	0.29	1.48
per 1000	Lagged one year	0.16	0.06	0.09	1.10	0.28	1.27
population	Lagged two years	0.18	0.07	0.10	0.86	0.35	1.08
	Mean lagged two years	0.17	0.07	0.10	0.98	0.31	1.18
	Accumulated lagged two years	0.34	0.14	0.19	1.96	0.62	2.35
	Sample size	10330	23661	1850	3026	5824	626

BCG Vaccine

		Control			Treatment		
		2006	2011	2018	2006	2011	2018
Child	Received BCG vaccine	0.96	0.96	0.89	0.97	0.93	0.89
	Child age	1.49	1.51	1.24	1.52	1.51	1.25
	Child gender	0.51	0.51	0.50	0.51	0.51	0.50
	Weight for age percentile	39.63	38.53	41.02	45.49	40.54	41.42
	Height for age percentile	31.48	36.36	40.45	33.64	28.90	39.56
	Son/daughter to head of household	0.77	0.70	0.63	0.72	0.69	0.56
Household	Head of household age	40.86	41.87	44.18	43.13	42.67	45.26
	Head of household gender	0.95	0.95	0.94	0.91	0.95	0.91
	Head of household primary education	0.35	0.38	0.37	0.28	0.37	0.38
	Head of household secondary education	0.44	0.40	0.42	0.54	0.43	0.46
	Father primary education	0.36	0.41	0.37	0.30	0.41	0.39
	Father secondary education	0.50	0.46	0.49	0.63	0.47	0.49
	Mother primary education	0.47	0.48	0.40	0.49	0.56	0.54
	Mother secondary education	0.30	0.26	0.32	0.38	0.23	0.29
	Number of household members	7.79	8.43	8.71	7.72	8.73	8.73
	Number of household members under 17	4.34	4.51	4.60	4.04	4.72	4.42
	Number of bedrooms	2.10	2.35	2.72	2.36	2.45	2.73
	Urban	0.62	0.56	0.56	0.64	0.50	0.65
Casualties	Current year	0.29	0.08	0.08	1.87	0.29	1.51
per 1000	Lagged one year	0.16	0.06	0.09	1.11	0.28	1.30
population	Lagged two years	0.18	0.07	0.10	0.87	0.35	1.11
	Mean lagged two years	0.17	0.07	0.10	0.99	0.31	1.20
	Accumulated lagged two years	0.34	0.13	0.19	1.97	0.63	2.40
	Sample size	9647	22531	1495	2793	5465	511

Hep B, DPT or Pentavalent Vaccine							
		Control			Treatment		
		2006	2011	2018	2006	2011	2018
Child	Received Hep B, DPT or Pentavalent vaccine	0.94	0.96	0.74	0.94	0.95	0.73
	Child age	1.48	1.51	1.23	1.52	1.51	1.26
	Child gender	0.51	0.51	0.50	0.51	0.51	0.50
	Weight for age percentile	39.71	38.53	41.06	45.57	40.58	41.22
	Height for age percentile	31.49	36.34	40.34	33.61	28.99	39.20
	Son/daughter to head of household	0.77	0.70	0.63	0.72	0.69	0.56
Household	Head of household age	40.87	41.87	44.16	43.11	42.69	45.30
	Head of household gender	0.95	0.95	0.95	0.91	0.95	0.91
	Head of household primary education	0.35	0.38	0.37	0.28	0.37	0.38
	Head of household secondary education	0.44	0.40	0.43	0.54	0.43	0.46
	Father primary education	0.36	0.41	0.38	0.29	0.41	0.40
	Father secondary education	0.51	0.46	0.49	0.63	0.47	0.49
	Mother primary education	0.47	0.48	0.40	0.49	0.56	0.54
	Mother secondary education	0.30	0.26	0.33	0.38	0.23	0.29
	Number of household members	7.79	8.44	8.74	7.72	8.73	8.76
	Number of household members under 17	4.34	4.51	4.62	4.04	4.72	4.46
	Number of bedrooms	2.11	2.35	2.73	2.36	2.45	2.73
	Urban	0.62	0.56	0.56	0.64	0.50	0.65
Casualties per 1000 population	Current year	0.29	0.08	0.08	1.88	0.29	1.51
	Lagged one year	0.16	0.06	0.09	1.11	0.28	1.29
	Lagged two years	0.18	0.07	0.11	0.87	0.35	1.10
	Mean lagged two years	0.17	0.07	0.10	0.99	0.31	1.19
	Accumulated lagged two years	0.34	0.13	0.20	1.97	0.63	2.38
	Sample size	9578	22433	1376	2777	5432	461

Measles or MMR Vaccine							
		Control			Treatment		
		2006	2011	2018	2006	2011	2018
Child	Received measles or MMR vaccine	0.86	0.90	0.57	0.86	0.90	0.59
	Child age	1.48	1.50	1.23	1.51	1.51	1.26
	Child gender	0.51	0.51	0.50	0.51	0.51	0.50
	Weight for age percentile	39.82	38.59	41.02	45.59	40.65	41.28
	Height for age percentile	31.51	36.41	40.67	33.65	28.97	39.54
	Son/daughter to head of household	0.77	0.70	0.63	0.72	0.69	0.56
Household	Head of household age	40.89	41.89	44.23	43.13	42.68	45.13
	Head of household gender	0.95	0.95	0.94	0.91	0.95	0.91
	Head of household primary education	0.35	0.38	0.36	0.28	0.36	0.38
	Head of household secondary education	0.44	0.40	0.43	0.54	0.44	0.46
	Father primary education	0.36	0.41	0.37	0.29	0.41	0.40
	Father secondary education	0.51	0.46	0.49	0.63	0.48	0.49
	Mother primary education	0.47	0.48	0.40	0.49	0.56	0.54
	Mother secondary education	0.30	0.27	0.33	0.38	0.23	0.30
	Number of household members	7.79	8.43	8.67	7.72	8.72	8.78
	Number of household members under 17	4.34	4.50	4.56	4.03	4.71	4.45
	Number of bedrooms	2.11	2.35	2.72	2.36	2.44	2.75
	Urban	0.62	0.56	0.56	0.64	0.51	0.65
Casualties per 1000 population	Current year	0.29	0.08	0.08	1.88	0.29	1.53
	Lagged one year	0.16	0.06	0.09	1.11	0.28	1.31
	Lagged two years	0.18	0.07	0.10	0.86	0.35	1.11
	Mean lagged two years	0.17	0.07	0.10	0.99	0.31	1.21
	Accumulated lagged two years	0.34	0.13	0.19	1.97	0.63	2.42
	Sample size	9359	22335	1416	2727	5397	480

Polio Vaccine								
		Control			**Treatment**		
		2006	**2011**	**2018**	**2006**	**2011**	**2018**
Child	Received polio vaccine	0.99	0.99	0.94	0.99	0.99	0.97
	Child age	1.49	1.51	1.24	1.52	1.52	1.25
	Child gender	0.51	0.51	0.50	0.51	0.51	0.50
	Weight for age percentile	39.63	38.52	40.85	45.50	40.57	41.26
	Height for age percentile	31.47	36.36	40.35	33.61	28.91	39.35
	Son/daughter to head of household	0.77	0.70	0.63	0.72	0.69	0.56
Household	Head of household age	40.84	41.88	44.23	43.15	42.66	45.18
	Head of household gender	0.95	0.95	0.94	0.91	0.95	0.91
	Head of household primary education	0.35	0.38	0.36	0.28	0.37	0.38
	Head of household secondary education	0.44	0.40	0.42	0.54	0.43	0.46
	Father primary education	0.36	0.41	0.37	0.30	0.41	0.39
	Father secondary education	0.50	0.46	0.49	0.63	0.47	0.49
	Mother primary education	0.47	0.48	0.40	0.49	0.56	0.54
	Mother secondary education	0.30	0.26	0.32	0.38	0.23	0.29
	Number of household members	7.79	8.44	8.72	7.72	8.72	8.69
	Number of household members under 17	4.34	4.51	4.60	4.04	4.72	4.40
	Number of bedrooms	2.10	2.35	2.72	2.36	2.45	2.72
	Urban	0.62	0.56	0.56	0.64	0.50	0.65
Casualties per 1000 population	Current year	0.29	0.08	0.08	1.87	0.29	1.52
	Lagged one year	0.16	0.06	0.09	1.10	0.28	1.30
	Lagged two years	0.18	0.07	0.10	0.87	0.35	1.11
	Mean lagged two years	0.17	0.07	0.10	0.99	0.31	1.20
	Accumulated lagged two years	0.34	0.13	0.20	1.97	0.63	2.41
	Sample size	9650	22541	1496	2792	5482	512

Notes: Treatment group is children residing in households in governorates where number of casualties due to armed conflict per 1000 population is above the 75th percentile of the number of casualties per 1000 population lagged one year across all governorates by year. Child gender and head of household gender is 1 for male. Son/daughter to head of household is 1 if the child is the son or daughter of the head of the household. Primary education is 1 if the individual completed primary school, but not secondary school. Secondary education is 1 if the individual completed secondary school or higher. Urban is equal to 1 if the household resides in an urban area.

Table 2. Determinants of Vaccination – Generalized Difference-In-Differences Estimates

	Any Vaccine	BCG	Hep B / DPT / Pentavalent	Measles / MMR	Polio
High conflict	0.178***	0.123**	-0.018	0.090**	-0.112
	(0.047)	(0.055)	(0.052)	(0.041)	(0.099)
Child age	0.260***	0.061***	-0.039***	0.164***	0.105***
	(0.011)	(0.011)	(0.010)	(0.008)	(0.020)
Child gender	0.035*	-0.011	0.007	0.006	-0.028
	(0.020)	(0.023)	(0.022)	(0.017)	(0.039)
Weight for age percentile	-0.001***	0.000	-0.001*	-0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Height for age percentile	-0.000	-0.001	0.001	-0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Son/daughter to head of household	0.035	-0.007	-0.076	-0.030	0.118
	(0.045)	(0.050)	(0.047)	(0.037)	(0.077)
Head of household age	0.002	0.001	0.002	0.002*	0.003
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Head of household gender	-0.043	-0.010	-0.119*	-0.056	-0.048
	(0.053)	(0.065)	(0.067)	(0.049)	(0.106)
Head of household primary education	0.098**	0.017	0.046	0.043	-0.007
	(0.043)	(0.051)	(0.049)	(0.039)	(0.082)
Head of household secondary education	0.109**	0.006	0.087	0.058	0.040
	(0.048)	(0.058)	(0.054)	(0.042)	(0.100)
Father primary education	0.145***	0.191***	0.174***	0.115***	0.277***
	(0.044)	(0.051)	(0.049)	(0.039)	(0.080)
Father secondary education	0.192***	0.359***	0.287***	0.230***	0.356***
	(0.048)	(0.055)	(0.053)	(0.042)	(0.094)
Mother primary education	0.177***	0.203***	0.261***	0.186***	0.136**
	(0.029)	(0.033)	(0.031)	(0.025)	(0.057)
Mother secondary education	0.321***	0.385***	0.496***	0.346***	0.206***
	(0.037)	(0.046)	(0.043)	(0.031)	(0.075)
Number of household members	0.005	0.000	0.005	0.017**	0.018
	(0.008)	(0.012)	(0.010)	(0.007)	(0.015)
Number of household members under 17	-0.049***	-0.024*	-0.041***	-0.057***	-0.023
	(0.010)	(0.014)	(0.012)	(0.009)	(0.019)
Number of bedrooms	0.051***	0.040*	0.019	0.019	-0.025
	(0.015)	(0.022)	(0.018)	(0.013)	(0.021)
Urban	0.079***	0.211***	0.195***	0.211***	0.178***
	(0.079)	(0.029)	(0.027)	(0.021)	(0.046)
Constant	1.431***	1.858***	1.809***	1.117***	2.002***
	(0.116)	(0.145)	(0.133)	(0.097)	(0.216)
Governorate FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	45,317	42,442	42,057	41,714	42,473

Notes: Probit regression used throughout. Treatment group is children residing in households in governorates where number of casualties due to armed conflict per 1000 population is above the 75th percentile of the number of casualties per 1000 population lagged one year across all governorates by year. Child gender and head of household gender is 1 for male. Son/daughter to head of household is 1 if the child is the son or daughter of the head of the household. Primary education is 1 if the individual completed primary school, but not secondary school. Secondary education is 1 if the individual completed secondary school or higher. Urban is equal to 1 if the household resides in an urban area. Robust standard errors in parentheses. *** indicates significance at 1%, ** at 5% and * at 10%.

Table 3. Robustness Checks – Alternative Measures of Conflict

Contemporaneous conflict

	Any Vaccine	BCG	Hep B / DPT / Pentavalent	Measles / MMR	Polio
High conflict	0.369*** (0.074)	0.430*** (0.096)	0.172*** (0.076)	0.087 (0.058)	0.030 (0.144)
Governorate FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	45,317	42,442	42,057	41,714	42,473

Conflict lagged two years

	Any Vaccine	BCG	Hep B / DPT / Pentavalent	Measles / MMR	Polio
High conflict	0.102*** (0.040)	0.079* (0.048)	-0.056 (0.046)	0.068 (0.035)	-0.114 (0.087)
Governorate FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	45,317	42,442	42,057	41,714	42,473

Notes: Regressions identical to those in Table 2 except as to the definition of the treatment group. Here, the treatment group consists of children residing in households in governorates where number of casualties due to armed conflict per 1000 population is above the 75^{th} percentile of the number of casualties per 1000 population in the current year, and casualties per 1000 population lagged two years, respectively. All regressions employ the same controls as the main regressions in Table 2. Robust standard errors in parentheses. *** indicates significance at 1%, ** at 5% and * at 10%.