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Abstract

Using pairing of household level and armed conflict data with a generalized difference-in-differences approach, we find that households located in conflict affected areas are more likely to have access to drinking water through direct access to the dwelling or through bottled water than through public access and mobile trucks.

JEL Classification: F51, I15, J13, N45
Keywords: Iraq war, infrastructure, armed conflict, Middle East

Introduction and Motivation

This paper examines the relationship between armed conflict and basic household infrastructure. We look at the impact of armed conflict on one basic household need: type of drinking water source. Drinking water is ideally provided to households through a pipe that gives access to clean drinkable water to household members directly in their own dwelling. Other sources include wells, rainwater collection, tanker-truck, bottled water, and surface water (pond, lake, etc.). Access to drinking water and waste disposal, have well documented effects on health (Bisung and Elliott, 2017; Ntouda et al 2013; Yongsi, 2010) and hence better understanding the impact of armed conflict on these needs is critical. While one would expect armed conflict to greatly affect government services (including water provision and waste removal), its effects on households are not clear. The overlook in the literature is mainly due to lack of opportunities to study the association. While the world has experienced a recent increase in armed conflicts, the overall number of conflicts has been declining since 1945 (Gates et al, 2016). The recent spike is mainly located in the Middle East region with turbulent times in Libya, Iraq, Syria, Yemen, and more recently Lebanon. Another hurdle to study the effects of armed conflict on households residing in affected regions, is the lack of microlevel data on armed conflict. In this paper, we circumvent this by joining household level data from Iraq and armed conflict data from the Iraq Body Count (IBC) project to link the effects of armed conflict on households residing in areas affected by conflict. Specifically, we focus on an essential household services: drinking water source. Besides adding to the conflict literature, this paper also sheds light on a critical concern in a region that is known as the "most water-scarce region" in the world (Food and Agriculture Organization of the United Nations, 2018) with "17 countries below the water poverty line" (Scott, 2019).

To examine this question, we use micro level data from the Iraq Multiple Indicator Cluster Survey (MICS). MICS-Iraq is a nationally representative data set of Iraqi households that was collected by a joint effort between the Iraqi government and the United Nations International Children's Emergency Fund (UNICEF). We use three waves of data that are publicly available from 2006, 2011, and the recently added 2018 wave. Iraq offers a unique opportunity to study this question given its history of armed conflict and turbulent periods causing significant damage to its infrastructure, the struggles of successive Iraqi government in managing its water resources (Human Rights Watch, 2019), and the availability of conflict data through the IBC project which complements the MICS data. The IBC project has recorded civilian causalities since 2003 and contains verified records of deaths that are substantiated by various sources (media reports, hospital, morgue, NGO, and other official records). This data allows us to construct a measure of conflict intensity represented by the number of civilian deaths. The next section summarizes the small literature on armed conflict and infrastructure (mainly water access). The following section presents the data and methodology followed by the results and conclusion.

Literature Review

The obvious consequence of armed conflicts, beside deaths, is destruction of physical infrastructure, which is most evident through damage to roads, buildings, structure (such bridges, airports, ports, etc.). Less clear impacts include effects on services across the affected areas such as water, electricity, waste management, etc. At the household level, drinking water access/source is essential to the daily routine of the household members. Theoretically, at the macro level, a two-way relationship is recognized between armed conflict and water, where increasing water scarcity at the national and subnational level can increase the prevalence of water-related conflict, while conflict in turn can negatively affect the presence of water infrastructure. On the latter pathway, the literature recognizes the negative effects of armed conflict to span the destruction of infrastructure and services, including water supplies and wastewater systems. In this process, access to potable water and sanitation is also affected (Kadir et al., 2018; UNEP, 2009; Ghobarah et al., 2003).

While the conceptual links are evident, the empirical literature on the effect of conflict on household access to water and sanitation "is at best scarce" (Gates et al., 2012). One study of 146 countries finds that an increase in conflict fatalities is associated with a statistically significant decrease in access to potable water (Gates et al., 2012). A conflict with around 2500 battle deaths is estimated to deprive 1.8% of the population from access to potable water. Though a negative relationship is also observed with regards to conflict deaths and access to sanitation, the results lack statistical significance at conventional levels (Gates et al., 2012).

In the Middle East, too, there remains a dearth of empirical literature linking armed conflict to water and sanitation. One study in southern Syria found that between 2016 and 2017, piped water as the main water source for households declined from 22.0% to 15.3% over the survey rounds. To access water from predominantly private trucking networks as a result, households would spend on average a fifth of their income on water (Sikder et al, 2018). Beyond quantitative analysis, another study drawing on a type of meta-analysis of unpublished literature on Basra (Iraq), which explored the impact of armed conflict on drinking water service from 1978-2013, observes a step-wise decline in service quality of water, which authors attribute to a lack of water treatment chemicals, spare parts, and a brain drain of water service staff (Zeitoun et al., 2017). Also, in Iraq, Dowdeswell and Hania (2014) acknowledge the limited access to potable drinking water and adequate sewage systems that many communities in Iraq face because of the war, where public water sources are often contaminated.

In turn, the effects of inadequate water, sanitation, and hygiene facilities in conflict-affected contexts are also expounded in the literature. One study finds that in 16 conflict-affected countries including Iraq, almost three times more children under the age of 15 die from inadequate water, sanitation, and hygiene (WASH) facilities than from violence that is directly linked to conflict (UNICEF, 2019). These countries typically have underdeveloped WASH systems, that are further destroyed during persistent conflict. In this context, understanding the relationship between armed conflict on WASH has important implications for long-term development outcomes.

Data and Methodology

The paper uses micro level data from the MICS which is a is a nationally representative data set of Iraqi households collected by a joint effort between the Iraqi government and the United Nations

International Children's Emergency Fund (UNICEF). We use the three waves of data that are publicly available from 2006, 2011, and the recently added 2018 wave to. Households are randomly selected to be presentative of the 18 governorates which make up Iraq with a response rate to the survey is that at least 98% (for the 2006 wave) and 99% for the other two years. Our unit of observation is the household which includes 17,739 households in 2006, 35,663 in 2011, and 20,206 in 2018 for a total of 73,608 households. As the MICS survey have evolved over the years, the survey team has targeted different sample sizes across the three waves. Our main variable of interest comes from the response to the following question: "What is the main source of drinking water used by members of your household?" The survey offers options for the participant (mainly the head of the household) to select. These options include piped water (piped into dwelling, to yard, to neighbor, etc.), well (whether protected or not), spring, rainwater, tanker-truck, and packaged water. For simplicity and taking advantage of similarities, we group these into four main categories:

1. Piped water which includes piped into dwelling, piped to yard or plot, or piped to neighbor
2. Public water which includes dug wells (protected, unprotected), public tap, spring, rainwater, surface water (river, dam, lake, etc.)
3. Tank on truck/cart water which includes tanker truck, and cart with tank
4. Bottled water which includes packaged water, bottled water, and any desalinized/sterilized water.

Each of the above category represents different dynamics in terms of the source of drinking water. Piped water reflects the safest and most convenient option as it does not require leaving the household (in some instance household members will need to go to the neighbor or a nearby plot) to acquire drinking water, although it does not necessarily means it provides the best quality of water. Public water source requires household members to travel to locations of water that are most likely crowded areas. Tankers carrying water would come to your household and pump water to water tanks. Bottled water would either be purchased or delivered to the dwelling offering conflicting scenarios in terms of whether household members would have to acquire these in person (going to the store). On one hand, one would expect higher conflict intensity would hinder traveling and lower the likelihood of public, tank on truck, and bottled water (under the assumption that its being purchased) while increase the piped water access. On the other hand, damaged infrastructure due to war could also imply less access to piped water access directly into the dwelling.

Our question is therefore an empirical one and reflects household behavior towards acquiring access to drinking water. Our main variable of interest is the intensity of armed conflict which we measure with the number of conflict-related civilian casualties per 1,000 population in the governorate in which the household located. The source of the data is the IBC which remains the most complete source on conflict data in Iraq (Carpenter et al, 2013). We use three different measures of conflict intensity for robustness checks: conflict-related casualty rate in the household's governorate one year prior to survey administration, two years prior to survey administration and contemporaneous to the survey administration year. We use each of these measures to construct a treatment variable that is one if a governorate was experiencing high conflict during that time and zero if the governorate experiences low conflict intensity. Following Diwakar et al (2019), Malcolm et al (2019), and Naufal et al (2019) we define high conflict as the 75th percentile of civilian casualty rates following the distribution of casualties across all governorates for that specific year. So, the treatment variable is one if the number of civilian casualties per 1,000 is higher than the 75th percentile of all governorates for that year. Table 1 presents the summary statistics of households by both treatment and control groups, and year of the survey. Household characteristics such as age, gender, education, size, number of members, and location (urban/rural) are to a certain extent uniform across treatment and control groups and even across the three data waves (even though there is a considerable difference in number of years between the three surveys).

The above categories which describe drinking water access represent our dependent variables of interest. We propose a generalized difference-in-differences approach to account for more than two time periods and allow governorates to switch between treatment and control groups over time. A generalized difference-in-differences is an extension to the baseline difference-in-differences allowing us the ability to better take advantage of the nature of the Iraqi conflict context. Iraq's armed conflict has changed dramatically from the first data wave (2006) to the most recent one (2018). In 2006, Iraqis were experiencing conflict related to the US 2003 invasion and toppling of the Saddam regime while in 2018 they were facing the aftermath of the fall of the Islamic State of Iraq and the Levant (ISIL). Our generalized difference-in-differences model below expands existing work on armed conflict in Iraq (Cetorelli, 2015; Malcolm et al, 2019; Diwakar et al 2019; and Naufal et al, 2019) and is based on Hansen (2020):

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

Here, $Y_{i,t}$ is the outcome (type of water access) for governorate i in period t. $T_{i,t}$ is the treatment status of governorate i in period t. Importantly, this treatment status can vary within groups (regions in our case). A governorate might be part of the high-conflict treated group in one period, but a part of the low-conflict control group in another. $HH_{i,t}$ is a vector of household level 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 as in the simple difference-in-differences setup. Assuming that the model is properly specified β_1 is the effect of treatment on the type of water access variable.

Given the nature of the outcome variable (type of drinking water access), we estimate a probit generalized difference-in-differences model as described below:

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

Where $Y_{i,t}$ is the drinking water access as the outcome dependent variable and $T_{i,t}$ is treatment status as described above. One disadvantage of nonlinear panel models is the difficulty in identifying a consistent estimator of the marginal effect of T on the outcome of interest Y (Greene, 2010). That is, such models do not allow a reliable way to estimate the magnitude of the treatment effect but just the direction and statistical significance.

Results

Table 2 presents the main results with the treatment variable is based on the governorate's total of civilian casualties per 1,000 population being above the 75th percentile of the number of casualties per 1,000 population lagged one year across all governorates for each year. Our unit of observation is the household and hence Table 2 suggests that being in a high conflict area is associated with a higher probability of piped drinking water and bottled water, and a lower probability of public and tank on truck water. The findings suggest that households in areas with higher conflict are more likely to find ways to get drinking water as close to their dwelling as possible (through pipping) and are less likely to travel to get access to water (public and tank on truck) most likely due to the more dangerous and volatile situation when conflict is intense. There is also a positive association between armed conflict and bottled drinking water highlighting the importance of quality of drinking water (we are implicitly assuming here that bottled water assures the highest quality of drinking water).

While the results in Table 2 represent our main specification, and as mentioned above, we also present robustness checks measures of conflict intensity through two measures: contemporaneous and lagged two years (Table 3). The regressions in Table 3 use all the same controls as in the main results in Table 2, but for simplicity we show only the coefficient on the high conflict treatment dummy. The results here are not as homogenous with Table 3 except for piped water access coefficient that is still positive and significant. The lagged two years measure shows consistent measures for three out of the four regressions except for the bottled water. Table 3 results perhaps shed light on interesting temporal dynamics in terms of household behavior adjustments to armed conflict. Households in high intensity conflict areas may respond initially with a short-term solution to water access but eventually adjust this to long term solutions as more information and opportunities become available.

Given that the estimated model is a Probit, we report marginal effects at the mean in the Appendix A. This allows us to better understand the magnitude effect of armed conflict. If we use the main specification estimates, each 1-unit increase in the casualty rate is associated with an increase in prevalence of piped water by slightly above 2% and an increase in the use of bottled water by almost 5%. The same change is associated with a reduction in access to public water, tank on truck/cart, and travel to water source by 0.8%, 1.2%, and 0.7% respectively. The most substantial impact is the increase in the reliance on bottled water.

As for other household controls, education of the head of the household is positively related to piped access and bottled water, and negatively related to public and water tankers. As expected, households in urban areas are also more likely to have piped water access and bottled waters and less of the other two methods. The same finding is also present for the age of the head of the household. Relative to female headed households, male headed households are less likely to have access to piped drinking water and more likely to access public drinking water. Note that most Iraqi households are headed by male (about 90%). The size of the dwelling in terms of number of bedrooms and number of members of households offer interesting opposite findings. The more number of rooms, the more likely the household has access to piped drinking water and less public water (with no statistical significance for the remaining other methods) while the larger the household in terms of number of members the less access to piped and bottled water and more access to public and water tankers. The last result is consistent with the urban/rural finding.

Conclusion

The literature on the impact of armed conflict on households residing in affected areas is small (even though slowly growing). There is however a strong interest in these effects because they go beyond the direct obvious effects (deaths and destruction) and often have long terms consequences on the local population. Among these effects, household access to clean drinking water must be at the center stage. The public health literature on the relationship between water access and psychological and physical health of the population is clear. Populations without stable access to drinking water experience strong psychological effects and often are more prone to diseases. There are already concerns about disparities in access to drinking water, so any notable relationship between armed conflict and water would only exacerbate these inequalities.

Using geographical pairing of households and armed conflict data, and a generalize difference-in-differences approach, we examine the relationships between conflict intensity and access to drinking water. Data from Iraq show that conflict is positively associated with piped water, bottled water, and negatively associated with public and water mobile tanks. These findings are not entirely surprising as they reflect household behavior and adjustments to armed conflict. Households seem to avoid traveling to crowded areas (public water access), and mobile water trucks are not able to deliver water to households located in less safe areas. With the same motivation, households are working towards getting access to drinking water to their own dwelling (or a nearby location, whether a neighbor or a yard/plot). This last finding does not really suggest that piped drinking water is safe nor but rather accessible. Hence, we also see a positive association with bottled water and armed conflict. In terms of policy dimension to the findings, one needs to further examine the potential tradeoff between water access and quality of water. How do Iraqi households perceive the quality of water by type of access? What can the local government with international organization do to improve the quality of water and the perception among households?

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Table 1: Main Water Source

		Control			Treatment		
		2006	2011	2018	2006	2011	2018
Household demographics	Head of household age	45.40	45.19	46.97	46.47	45.59	47.81
	Head of household gender	0.90	0.91	0.91	0.88	0.92	0.90
	Head of household primary education	0.31	0.34	0.33	0.27	0.33	0.32
	Head of household secondary+ education	0.43	0.40	0.50	0.53	0.47	0.55
	Number of bedrooms	2.04	2.13	2.45	2.25	2.22	2.40
	Number of members in household	6.50	6.61	6.54	6.46	6.99	6.36
	Urban	0.67	0.61	0.69	0.73	0.54	0.67
Main water source	Piped	0.75	0.58	0.42	0.89	0.64	0.82
	Public	0.12	0.10	0.09	0.04	0.11	0.04
	Tank on truck/cart	0.05	0.04	0.21	0.04	0.16	0.02
	Bottled water	0.01	0.10	0.27	0.01	0.08	0.12
Casualties per 1,000 population	Current year	0.44	0.08	0.11	1.79	0.30	1.36
	Lagged 1 year	0.21	0.06	0.11	1.19	0.29	1.19
	Lagged 2 years	0.19	0.07	0.12	0.99	0.35	1.03
	Mean lagged 2 years	0.20	0.07	0.11	1.09	0.32	1.11
	Accumulated lagged 2 years	0.40	0.13	0.23	2.18	0.64	2.21
	Sample size	14,278	29,271	15,892	3,461	6,392	4,314

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population lagged one year across all governorates by year.

Table 2: Determinants of Water Source - Generalized Difference-in-Differences Estimates

VARIABLES	(1) Piped	(2) Public	(3) Tank on truck/cart	(4) Bottled water
High conflict	0.091***	-0.064**	-0.095**	0.314***
	(0.029)	(0.029)	(0.039)	(0.079)
Head of household age	0.004***	-0.004***	-0.007***	0.003***
	(0.000)	(0.001)	(0.001)	(0.001)
Head of household gender	-0.097***	0.131***	0.027	0.022
	(0.020)	(0.028)	(0.028)	(0.028)
Head of household primary education	0.178***	-0.165***	-0.245***	0.093***
	(0.017)	(0.021)	(0.022)	(0.023)
Head of household secondary+ education	0.287***	-0.300***	-0.456***	0.222***
	(0.017)	(0.021)	(0.022)	(0.023)
Number of bedrooms	0.012**	-0.048***	-0.011	-0.005
	(0.005)	(0.012)	(0.008)	(0.005)
Number of members in household	-0.010***	0.021***	0.019***	-0.018***
	(0.002)	(0.003)	(0.003)	(0.003)
Urban	0.816***	-1.111***	-0.511***	0.085***
	(0.012)	(0.016)	(0.015)	(0.016)
Constant	1.577***	-1.137***	-2.390***	-3.558***
	(0.049)	(0.062)	(0.107)	(0.069)
Governorate FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	73,608	73,608	73,608	73,608

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population lagged one year across all governorates by year. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Robustness Checks - Alternative Measures of Conflict

VARIABLES	(1) Piped	(2) Public	(3) Tank on truck/cart	(4) Bottled water
Current Year	0.059**	0.072**	0.286***	-0.210***
	(0.026)	(0.028)	(0.031)	(0.062)
Lagged 2 Years	0.260***	-0.102***	-0.120***	-0.118**
	(0.025)	(0.027)	(0.035)	(0.054)
Governorate FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	73,608	73,608	73,608	73,608

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population for the current year across all governorates by year. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Each coefficient is from a regression with control variables from the main specification regression.

Appendix A - Marginal Effects

Marginal Effects: Treatment High Conflict Previous Year				
	Average Marginal Effects			
	(1)	(2)	(3)	(4)
	Piped	Public	Tank on Truck/Cart	Bottled
High conflict	0.023***	-0.008**	-0.012**	0.047***
	(0.007)	(0.004)	(0.005)	(0.013)
Head of household age	0.001***	-0.000***	-0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Head of household gender	-0.025***	0.017***	0.003	0.003
	(0.005)	(0.003)	(0.003)	(0.004)
Head of household primary education	0.045***	-0.022***	-0.030***	0.013***
	(0.004)	(0.003)	(0.003)	(0.003)
Head of household secondary+ education	0.074***	-0.039***	-0.056***	0.031***
	(0.004)	(0.003)	(0.003)	(0.003)
Number of bedrooms	0.003**	-0.006***	-0.001	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)
Number of members in household	-0.003***	0.003***	0.002***	-0.003***
	(0.001)	(0.000)	(0.000)	(0.000)
Urban	0.226***	-0.168***	-0.068***	0.012***
	(0.003)	(0.003)	(0.002)	(0.002)
Observations	73,608	73,608	73,608	73,608
Governorate FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population lagged one year across all governorates by year. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Marginal Effects: Alternative Measures of Conflict

	Average Marginal Effects			
	(1)	(2)	(3)	(4)
	Piped	Public	Tank on Truck/Cart	Bottled
Current Year	0.015**	0.010**	0.038***	-0.028***
	(0.007)	(0.004)	(0.005)	(0.008)
Lagged 2 Years	0.066***	-0.013***	-0.015***	-0.016**
	(0.006)	(0.003)	(0.004)	(0.007)
Observations	73,608	73,608	73,608	73,608
Governorate FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population for the current year across all governorates by year. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Each marginal effect is from a regression with control variables from the main specification regression.

Appendix B - Linear Regression

Linear Regression: Treatment High Conflict Previous Year				
	(1)	(2)	(3)	(4)
	Piped	Public	Tank on Truck/Cart	Bottled
High conflict	0.014***	-0.007*	-0.006	-0.031***
	(0.005)	(0.004)	(0.004)	(0.003)
Head of household age	0.001***	-0.000***	-0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Head of household gender	-0.027***	0.020***	0.004	0.003
	(0.005)	(0.004)	(0.004)	(0.004)
Head of household primary education	0.045***	-0.026***	-0.036***	0.008***
	(0.004)	(0.003)	(0.003)	(0.003)
Head of household secondary+ education	0.076***	-0.042***	-0.062***	0.022***
	(0.004)	(0.003)	(0.003)	(0.003)
Number of bedrooms	0.003**	-0.004***	-0.002	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Number of members in household	-0.003***	0.002***	0.003***	-0.002***
	(0.001)	(0.000)	(0.000)	(0.000)
Urban	0.229***	-0.171***	-0.060***	0.004*
	(0.003)	(0.003)	(0.002)	(0.002)
Constant	0.896***	0.187***	0.065***	-0.105***
	(0.010)	(0.007)	(0.006)	(0.007)
Observations	73,608	73,608	73,608	73,608
R-squared	0.351	0.132	0.130	0.186
Governorate FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population lagged one year across all governorates by year. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Linear Regression - Alternative Measures of Conflict

VARIABLES	(1) Piped	(2) Public	(3) Tank on truck/cart	(4) Bottled water
Current Year	0.026***	0.009***	0.033***	-0.064***
	(0.005)	(0.003)	(0.003)	(0.003)
Lagged 2 Years	0.066***	-0.011***	-0.009***	-0.075***
	(0.005)	(0.004)	(0.003)	(0.003)
Governorate FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	73,608	73,608	73,608	73,608

Notes: High conflict is one if number of casualties due to armed conflict per 1,000 population is above the 75th percentile of the number of casualties per 1,000 population for the current year across all governorates by year. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Each coefficient is from a regression with control variables from the main specification regression.