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Armed conflict and maternal mortality: A micro-level analysis of sub-Saharan Africa, 1989–2013

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There is existing country-level evidence that countries with more severe armed conflict tend to have higher Maternal Mortality Rates (MMR). However, during armed conflict, the actual fighting is usually confined to a limited area within a country, affecting a subset of the population. Hence, studying the link between country-level armed conflict and MMR may involve ecological fallacies. We provide a more direct, nuanced test of whether local exposure to armed conflict impacts maternal mortality, building on the so-called "sisterhood method". We combine geo-coded data on different types of violent events from the Uppsala Conflict Data Program with geo-referenced survey data from the Demographic and Health Surveys (DHS) on respondents' reports on sisters dying during pregnancy, childbirth, or the puerperium. Our sample covers 1,335,161 adult sisters aged 12–45 by 539,764 female respondents in 30 countries in sub-Saharan Africa. Rather than aggregating the deaths of sisters to generate a maternal mortality ratio, we analyze the sisters' deaths at the individual level. We use a sister fixed-effects analysis to estimate the impact of recent organized violence events within a radius of 50 km of the home of each respondent on the likelihood that her sister dies during pregnancy, childbirth, or the puerperium. Our results show that local exposure to armed conflict events indeed increases the risk of maternal deaths. Exploring potential moderators, we find larger differences in rural areas but also in richer and more educated areas.

1. Introduction

Maternal health and mortality are vital concerns to the sustainable development agenda. Every year about 210 million women become pregnant worldwide and give birth to some 140 million newborn babies (McDougall et al., 2016). In 2015, the estimated number of maternal deaths globally amounted to 303,000, which implies a Maternal Mortality Rate (MMR) of 216 per 100,000 live births (WHO, UNICEF, UNFPA, World Bank and UNPD, 2015). Developing regions accounted for approximately 99% (302,000) of the total global maternal deaths in 2015, with sub-Saharan Africa alone accounting for roughly 66% (201,000) (ibid.).

Pregnancy-related deaths include all deaths during pregnancy, childbirth, and the postpartum period, irrespective of cause. Broadly speaking, maternal mortality includes two categories of related deaths: direct obstetric causes (such as haemorrhage and eclampsia) and indirect causes (such as malaria, HIV, and anaemia, that might be aggravated in pregnancy) (Hanson et al., 2015). Whereas the most recent years have seen some improvements in maternal health, progress has been slow in sub-Saharan Africa (SSA). A recent review puts the odds that a woman in SSA will die from complications related to pregnancy and childbirth at one in 20 compared to one in 6250 in the developed world (UN, 2012).

In SSA, where most countries have experienced armed conflict since the end of the Cold War (Allansson et al., 2017), the poor performance may – at least in part – be due to detrimental effects of armed conflicts on maternal health (Østby et al., 2018). Armed conflict and post-conflict situations are widely held to hinder the progress of maternal mortality reduction, in particular through the breakdown of health systems, which can cause a dramatic rise in deaths due to complications that would be easily treatable under stable conditions (WHO, UNICEF, UNFPA, World Bank and UNPD, 2015).

However, we also know that maternal mortality tends to be high in more peaceful poor countries as well. Hence, the main aim of this paper is to try to isolate the effect of armed conflict on maternal deaths as far as possible. More specifically, we ask: *To what extent does armed conflict affect the risk of maternal deaths at the local level in sub-Saharan Africa?*

In a commentary piece in *the Lancet*, Nordenstedt and Rosling

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(2016) criticized the United Nations Population Fund (UNFPA)'s (2015) statement that "60% of maternal deaths happen in humanitarian situations like refugee camps". According to Nordenstedt and Rosling, this is an oversimplified and exaggerated estimate – mainly due to the fact that the figure is simply based on the total population of the 50 worst performing countries according to a global fragility ranking. Indeed, it is rarely the case that an armed conflict - or another type of emergency for that sake – engulfs the entire territory of a country. Furthermore, like armed conflict and natural disasters, various development- and health indicators tend to vary sharply within countries. For example, in Nigeria, the maternal mortality rate is significantly higher in the poorer northern regions than in the southern part of the country. Nordenstedt and Rosling (2016) provide a more sober estimate of the magnitude of maternal mortality in emergency settings and they estimate that the yearly number of maternal deaths in humanitarian settings accounts for approximately 17% of the yearly maternal deaths in the world (ibid.).

However, although Nordenstedt and Rosling's 17%-estimate seems far more candid than the UNFPAs' 60%-estimate, they do admit that their estimate is indeed quite crude. For example, one might ask what constitutes a humanitarian emergency and what is the basis behind the estimate of the 130 million people in need of humanitarian assistance. Moreover, what do we know about the population composition and the fertility rate in crisis settings? Also, humanitarian emergencies can be very different in nature and magnitude and the duration of the exposure, ranging from around 14,000 killed in the war between IS and the Government of Iraq in 2017 to some 25 people killed during intergroup conflict between the Toubou and the Zaghawa in Chad the same year (Petterson and Eck, 2018). Given this broad variety, we argue that one should focus on the *local* effects of armed conflict exposure on maternal deaths.

In theory, conflict is likely to have a negative impact on maternal deaths, for example through undermining economies both locally and nationally; and by destroying infrastructure including health centers, hospitals, and roads. Previous research has indeed shown that geographical and temporal proximity to organized violence significantly reduces the likelihood of giving birth at a health facility (Østby et al., 2018). However, the correlation between institutional birth and maternal mortality is far from perfect, and armed conflict may impact the likelihood that a mother survives beyond her access to skilled birth assistance.

So, what is the direct, local relationship between armed conflict and the risk of dying during pregnancy or childbirth? In order to answer this question, we need to know in greater detail both where and when armed conflict events happen as well as where and when women die during pregnancy, childbirth, or the puerperium. However, even with detailed, local data on armed conflict dynamics and mortality figures, it is still difficult to assess magnitudes such as the percentage of the maternal deaths that happen in conflict settings. In particular, this depends on how one defines conflict and what constitutes a conflict setting. Also, it is a question of how immediate- and long-lasting the effects from conflict are expected to be.

In this article we provide a more detailed and direct test of whether local exposure to armed conflict impacts maternal mortality, building on the so-called "sisterhood method". We combine geo-coded data on different types of violent events from the Uppsala Conflict Data Program with geo-referenced survey data from the Demographic and Health Surveys (DHS) on respondents' reports on sisters dying during pregnancy, childbirth, or the puerperium. Our sample covers 1,335,161 adult sisters aged 12–45 by 539,764 female respondents in 30 countries in sub-Saharan Africa.

However, rather than aggregating the deaths of sisters to generate a maternal mortality ratio, we analyze the sisters' deaths at the individual level. We use a sister fixed-effects analysis to estimate the impact of recent organized violence events within a radius of 50 km of the home of each respondent on the likelihood that her sister dies during pregnancy, childbirth, or the puerperium. That is, we compare each sister to herself before and after a conflict in the area. Exploring heterogeneous effects (moderators), we also account for rural-urban differences, economic welfare measures, and local education levels.

We find that local exposure to armed conflict events significantly increases the risk of maternal deaths. For each additional logged conflict event, the risk that a woman dies in relation to pregnancy increases by approximately 10%. The effect is particularly strong for women aged 20–35, where we find that each additional logged conflict event increases the risk of maternal deaths by 14%. Exploring heterogeneous effects, we find - as expected – that the reinforcing effect of conflict on maternal deaths is stronger in rural than in urban areas. However, although maternal deaths are more frequent overall in poorer and less educated areas, we find that the effect of conflict in increasing the risk of maternal deaths is stronger in relatively richer and more educated areas.

The rest of the article is organized as follows: In Section 2 we briefly review previous literature on armed conflict and maternal deaths and theorize how local armed conflict exposure might impact the risk of dying during pregnancy, childbirth or in the postpartum, deriving a set of testable hypotheses. Section 3 describes our research design, including a discussion of the so-called sisterhood method and our application of it at the individual level, Section 4 provides our empirical results and Section 5 concludes.

2. The impact of armed conflict on maternal mortality

While males are more likely to be killed in direct conflict events (Urdal and Chi, 2013), several global conflict studies have suggested that in some conflict contexts excess mortality, i.e. indirect deaths due to conflict, may be greater for women (Plümper and Neumayer, 2006; Ghobarah et al., 2003), a situation that continues post-conflict (Li and Wen, 2005). This implies that women are more vulnerable to indirect health consequences of conflict, and poor maternal health is likely to be a key contributor (Ghobarah et al., 2003). Petchesky (2008) highlights the need to address the gender dimensions in conflict, particularly those related to sexual and reproductive health. A growing body of research suggests that there are significant challenges to improve maternal health post-conflict (see e.g. Urdal and Chi, 2013). In a study of 42 African countries, O'Hare and Southall (2007) found that Maternal Mortality Ratios (MMRs) were 45% higher in post-conflict countries than in non-conflict countries. However, they did not control for other factors. Non-conflict countries typically also score better on education levels and other factors that reduce MMR.

Several case studies have been carried out to evaluate how reproductive health care is affected by conflict. Kottegoda et al. (2008) reported higher levels of poverty, early marriage, and higher maternal mortality among conflict-affected women in Sri Lanka. High maternal mortality ratios were also reported in parts of Burma where the military junta had attempted to cut off all resources, and alternative ways of delivering health care had to be sought (Mullany et al., 2008). Chandrasekhar et al. (2011) showed how the conflict in Rwanda led to a decrease in the number of births given in a health facility. Some populations affected by conflict may on the other hand experience an improvement in health. For example, refugees and IDPs living in camps that receive the attention of international or local health providers have been found to be as well or even better off than both people in their home communities and non-camp neighboring populations (Howard et al., 2008).

In contrast to the above case studies there is a lack of large-N studies that specifically investigate the effects of conflict on aspects of maternal health. Furthermore, while research on causes and consequences of civil war has increased dramatically over the past decades, there has generally been little integration over disciplinary divides. One notable exception is a study by Urdal and Chi (2013). They argue that only maternal mortality can be a sufficiently important cause of death

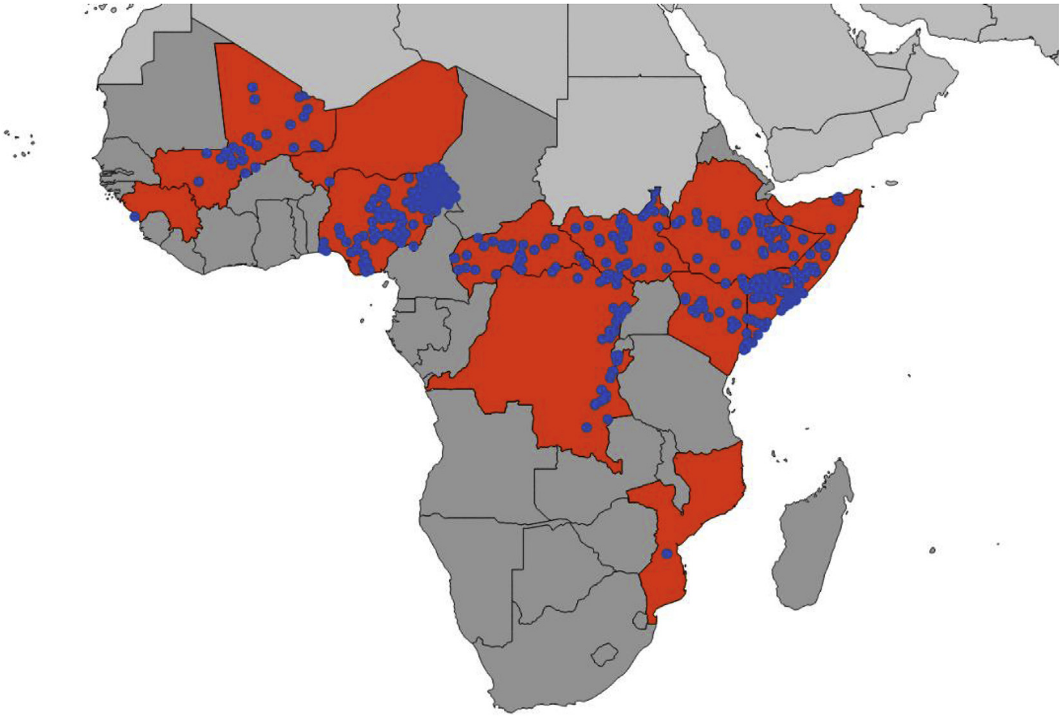

Fig. 1. Areas affected by conflict in 2015 (50 km buffer zones) in sub-Saharan Africa.

disproportionally affecting women that it may account for any large-scale female excess mortality during and after war. In a cross-sectional study of developing countries, they found that a conflict of 2500 battle-related deaths is associated with 10% increase in the national maternal mortality rate.

A key weakness of such cross-national comparisons, however, is that armed conflicts rarely affect entire countries equally, but are typically confined to limited geographical areas (Buhaug and Rød, 2006). This is effectively illustrated by the map in Fig. 1. The map highlights in red color the countries in sub-Saharan Africa that experienced at least one conflict event in 2015. The blue areas on the other hand represent all the actual conflict events and 50 km buffer zones around each. In fact, the blue conflict areas (where the fighting was actually going on) only occupied 18% of the territory of the conflict countries.

Moreover, as shown by Østby et al. (2018) institutional child delivery tends to be highly uneven within countries (see also Countdown Group 2008), and we hence also have good reason to believe that maternal mortality is also likely to vary widely within countries. There is the risk that studies of country-level maternal death aggregates may lead to an ecological fallacy by incorrectly deducing inferences from these aggregate studies about individual maternal deaths during conflict. Hence, geographically disaggregated studies and micro-level evidence are crucial, as we know that both conflict patterns and access to services vary significantly within countries. In addition, both regional and especially country level mortality and conflicts are correlated with a myriad of factors that are difficult to control for without an explicit design to do so.

One such contribution is a study by Østby et al. (2018), whom conduct an individual-level analysis of mothers in 31 African countries and the likelihood that their children are born in a health facility, as a function of recent, local (sub-national) exposure to armed conflict. They found that geographical and temporal proximity to organized violence significantly reduces the likelihood of giving birth at a health facility.

Although it seems obvious that access to birth facilities and professional care during childbirth should reduce maternal mortality, the evidence from observational studies is difficult to interpret as women with complications are more likely to access skilled care. Hence, any association may be biased in places where the share of institutional delivery is low. Moreover, the correlation between institutional birth and maternal mortality is far from perfect, and organized violence may impact the likelihood that a mother survives in many other ways beyond her access to birth assistance. In the current paper we offer a more direct test of whether local exposure to armed conflict impacts maternal mortality, building on the so-called "sisterhood method", that is elaborated below. To our knowledge, the current study is the first to disaggregate patterns of organized violence and maternal mortality across several countries.

2.1. Hypotheses

As indicated above, armed conflict may influence maternal mortality in various ways: through a deterioration of the health care system, through higher rates of abortion and pregnancy terminations, through shortage of skilled health professionals, and through greater risks of contracting infections combined with higher levels of malnutrition during pregnancies and after child birth (Gizelis and Cao, 2016). Add to this the financial hardships and poor access to food in displaced populations further increase the risk of malnutrition and infections (Plümper and Neumayer, 2006; Urdal and Chi, 2013). All these factors can exacerbate the risk of maternal deaths in conflict settings. Based on this, we derive the first broad, general hypothesis:

H1. The more exposed a mother is to armed conflict in her home area, the higher is the likelihood that she will suffer from maternal death.

Even in areas with a considerable conflict level, various socio-economic factors may determine the resilience of women with respect to surviving pregnancy and childbirth (McGinn, 2000). We expect that these factors affect communities' and individuals' capacity to adapt to increasingly complex social, political and economic environments. For example, socio-economic factors like rural/urban residence, wealth and education have been found to greatly affect the use of maternal health care services across very different contexts. First, we expect that urban women will be less affected by armed conflict than rural women since the supply of health care in urban areas generally is much higher than in rural areas, which implies that urban women should more easily be able to shift from one supplier to another if armed conflict in the case of service disruption. Women in rural areas, who typically have to rely on one or few suppliers, are likely more vulnerable to armed conflict. In order to assess whether urbanity conditions the relationship between armed conflict and maternal deaths we propose the following hypotheses:

H2. The reinforcing effect of armed conflict on the risk of maternal death is stronger in rural than in urban areas.

Another well-established finding is that wealthier women generally receive better care (Fapohunda and Orobaton, 2014; Pathak et al., 2010) and nutrition. We expect that women from wealthier families, who are able to purchase access to private health care, will be less vulnerable to service disruption due to armed conflict:

H3. The reinforcing effect of armed conflict on the risk of maternal death is stronger in poorer areas.

Finally, educated mothers tend to have healthier families overall. Furthermore, there is some existing evidence that educated mothers are more likely than uneducated mothers to receive antenatal care from a medically trained person, or to get professional delivery care (Bell et al., 2003; Fapohunda and Orobaton, 2014; Pathak et al., 2010). We expect that this will in turn also reduce the risk of maternal deaths:

H4. The reinforcing effect of armed conflict on the risk of maternal death is stronger in areas where women have less education.

3. Research design

In this section we describe our data sources and empirical strategy, as well as the main findings from our analyses. First, however, we introduce the sisterhood method, and show how we approach the measurement of maternal mortality at the individual level.

3.1. The sisterhood method

Measuring maternal mortality is associated with significant challenges. Even after three decades of measurement innovation and data collection, maternal mortality estimates are widely found to be of poor quality, or, as put by one measurement expert, 'guilty until proven innocent' (Storeng and Béhague, 2017). As maternal mortality is a relatively rare event - even in the poorer and unstable countries - one of the greatest challenges to measuring maternal mortality is the need for very large sample sizes.

One way to overcome the problem of large sample sizes and thus reduce costs, has been the so-called 'sisterhood method'. Its first trial was in 1987 in The Gambia (Graham et al., 1989) and it has later been applied in many settings. It is an indirect measurement technique of the kind frequently used to measure a variety of demographic parameters (such as child or adult mortality), which has been adapted for the measurement of maternal mortality.

Four simple questions are asked of all adults interviewed during a census or survey:

1) How many sisters (born to the same mother) have you ever had who were ever-married (including those who are now dead)?
2) How many of these ever-married sisters are alive now?
3) How many of these ever-married sisters are dead?
4) How many of these dead sisters died while they were pregnant, or during childbirth, or during the six weeks after the end of pregnancy?

Aggregate data are then used to calculate the proportion of sisters dying during pregnancy, childbirth, or up to 6 weeks after the end of pregnancy (puerperium), and standard adjustment.

Another variant of this approach - the *direct* sisterhood method - is used in Demographic and Health Surveys. This method asks respondents to provide more detailed information about each of their sisters, including those who have reached adulthood and those who have died, the age at death of each sister, whether the death was maternal, and the year in which the death occurred. With such nuanced data we can exploit the information on maternal mortality at the level of each individual sister. In particular, we get individual level longitudinal data for a large sample which enables us to assess if the risk of dying from maternal related causes is higher immediately after as compared to immediately before conflicts.

3.2. Data and empirical strategy

Benefiting from a large amount of geo-referenced Demographic and Health Surveys conducted at various points in time in sub-Saharan Africa, our main sample consists of all reported sisters to the respondents, aged between 12 and 45 who are still alive. In total we have an unbalanced sample of around 1,335,161 individuals for a maximum of 25 years (1989–2013), which amounts to 17,749,269 observations. That is, we have longitudinal data at the sister level where we know if each sister is alive at any given point in time and how many die in a given year and place.

Fig. 2 shows all the survey clusters in the 30 countries where the respondents were interviewed. The DHS coordinates are randomly displaced by up to 5 km to ensure respondent confidentiality, so they are not precise at very local level.

3.3. Black dots represent DHS cluster locations

In addition to the spatio-temporal variation there is variation across individuals in dates of conception. The strongest test of the relationship between conflict and maternal mortality is to have individual sister fixed effects and compare each sister with herself before and after conflict. Such an estimation will purge away all factors that are stable over time at the individual level such as latent health, cognitive ability, education, ethnicity etc.

We can also analyze the data at other levels of analysis. As almost all women have children and they give birth at different points in time, we can simply compare women close to a recent conflict to women that are not close to a recent conflict in order to get valid estimates. Such an analysis would not consider the fact that it is not random where and when conflict occurs. We can of course add fixed effects at the country-, cluster-, or family level to narrow down on the comparison. Everything at the cluster level and below will essentially only exploit the variation induced by the conflict timing as all clusters experience the same conflict. As selection into conflict is hardly driven by the individual woman, cluster fixed effects are likely to purge away much of the selection bias. Nonetheless, there may be compositional issues that are correlated with factors such as poverty or institutional factors which in turn may be correlated with conflict. That is, some people may be more likely to die for other reasons or move from an area if it becomes poorer and this may induce conflict as well as change our sample. Such compositional considerations are controlled for by having individual fixed effects. On the other hand, the more narrowly we focus the comparison, the more noise it will be in the data that may bias the result towards zero. Hence, it will be interesting to see how the effects vary at different levels of analysis.

In order to assess whether and how armed conflict intensity impacts maternal deaths, we link the survey data from Demographic Health Surveys (DHS) with conflict data from the Uppsala Conflict Data Program's (UCDP) Georeferenced Event Dataset (GED) (Sundberg and Melander, 2013). The UCDP-GED includes information on the location of conflict events, as well as the number of deaths caused by each event. Events are included for all conflicts for dyads and actors that have crossed the 25 deaths threshold in any year of the UCDP annual data.

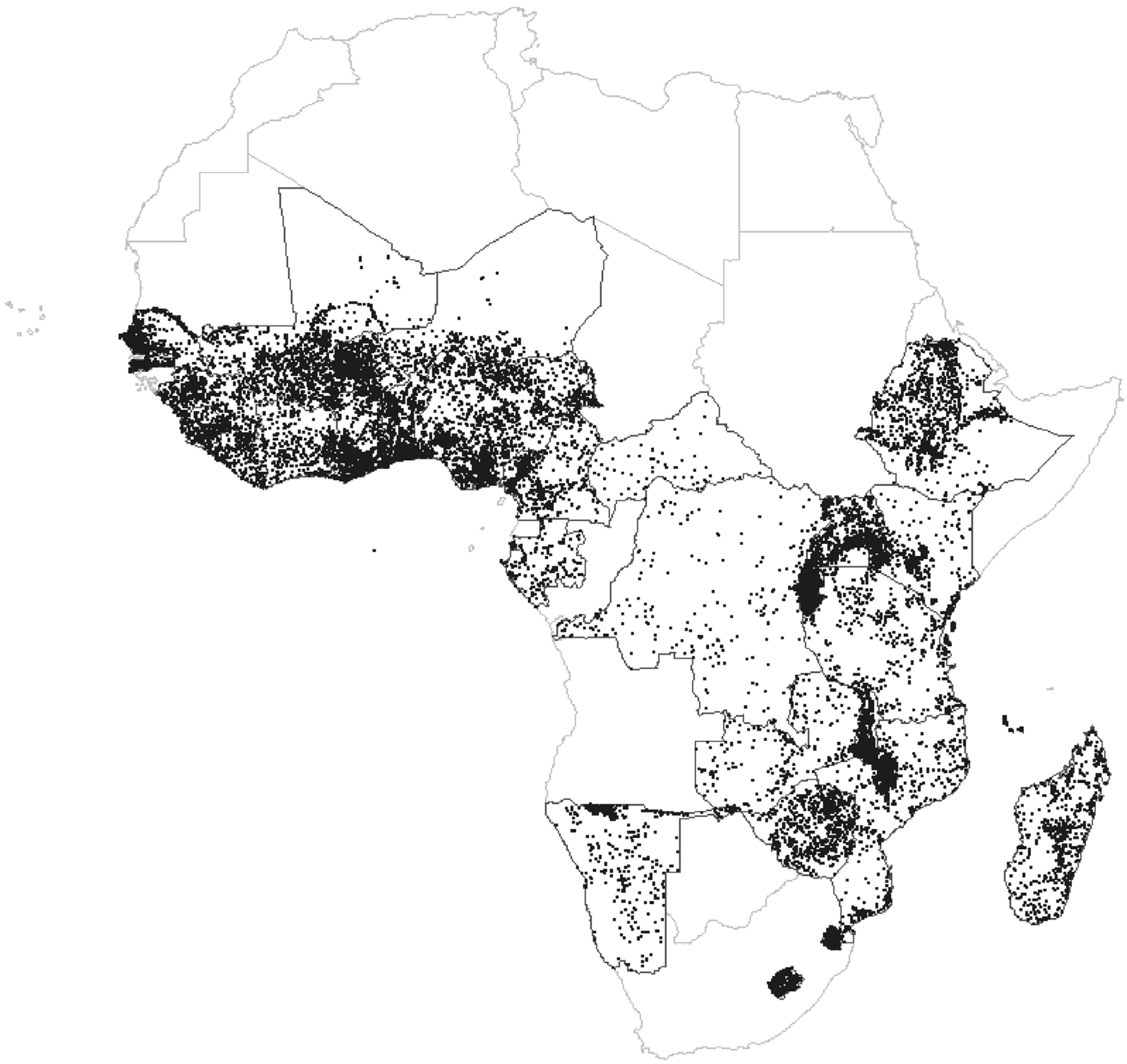

Fig. 2. Location of DHS survey sites in Sub-Saharan Africa, 1989–2014.

Hence, the UCDP GED defines an event as 'An incidence where armed force was by an organized actor against another organized actor, or against civilians, resulting in at least 1 direct death at a specific location and a specific date' (Croicu and Sundberg, 2016). Point coordinates represent each event, where the location has been retrieved using news reports and georeferenced using global gazetteers. Fig. 3 maps all conflict events in the UCDP-GED data for years 1989–2014 for the countries included in the following analysis. We employ counts of both conflict events and battle deaths in our analysis.

In order to link the survey data with the conflict data, we create buffer zones around each DHS survey point and count the number of conflict events and/or deaths within each buffer for a given year. The choice of size of the buffer zones is somewhat arbitrary. On the one hand we want areas to be reasonably close to conflicts. However, on the other hand, too small areas introduce larger noise as the sample sizes are smaller and since there is random displacement of the DHS data. We hence follow previous literature in the choice of main buffer zones and the most common choice is to use a 50 km buffer (Isaksson and Kotsadam, 2018a; 2018b; Kotsadam et al., 2018; Knutsen et al., 2017; Østby et al., 2018). With such large buffers, the random displacement of the DHS clusters is inconsequential. We also show results where we use 25 km buffer zones.

4. Results

For each year we measure if there is conflict nearby and we measure "conflict" and "nearby" in several different ways. Starting with the individual level fixed effects and the most common measure of conflict exposure in recent research, the log of the number of conflict events within 50 km from the survey cluster last year (e.g. Østby et al., 2018), we see that conflict has an effect on maternal mortality in Table 1. We have rescaled the maternal mortality variable to be deaths per 100,000 living women and we find that increasing the conflict by 1 logged event in the 50 km vicinity causes 8.5 additional women per 100,000 to die in relation to pregnancy.

In column 2 we also include a lagged variable for conflict and in column 3 we include both a lag and a lead. We see that the contemporaneous effect dominates as the lagged variable is smaller and not statistically significant. That is, there does not seem to be a strong persistence in the effects beyond a year after the conflict. In column 3 we see that the lead coefficient is negative which implies, that the maternal mortality is lower in areas before conflict happens. In column 4 we show the effect of one extra conflict event. Column 5 shows the effect of 1000 extra battle deaths and column 6 takes the log of the battle deaths. Also, for these estimations we see a clear effect of conflict. Finally, column 7 shows the effect of having at least one conflict event nearby. As such, it is a kind of average total measure of the effects of

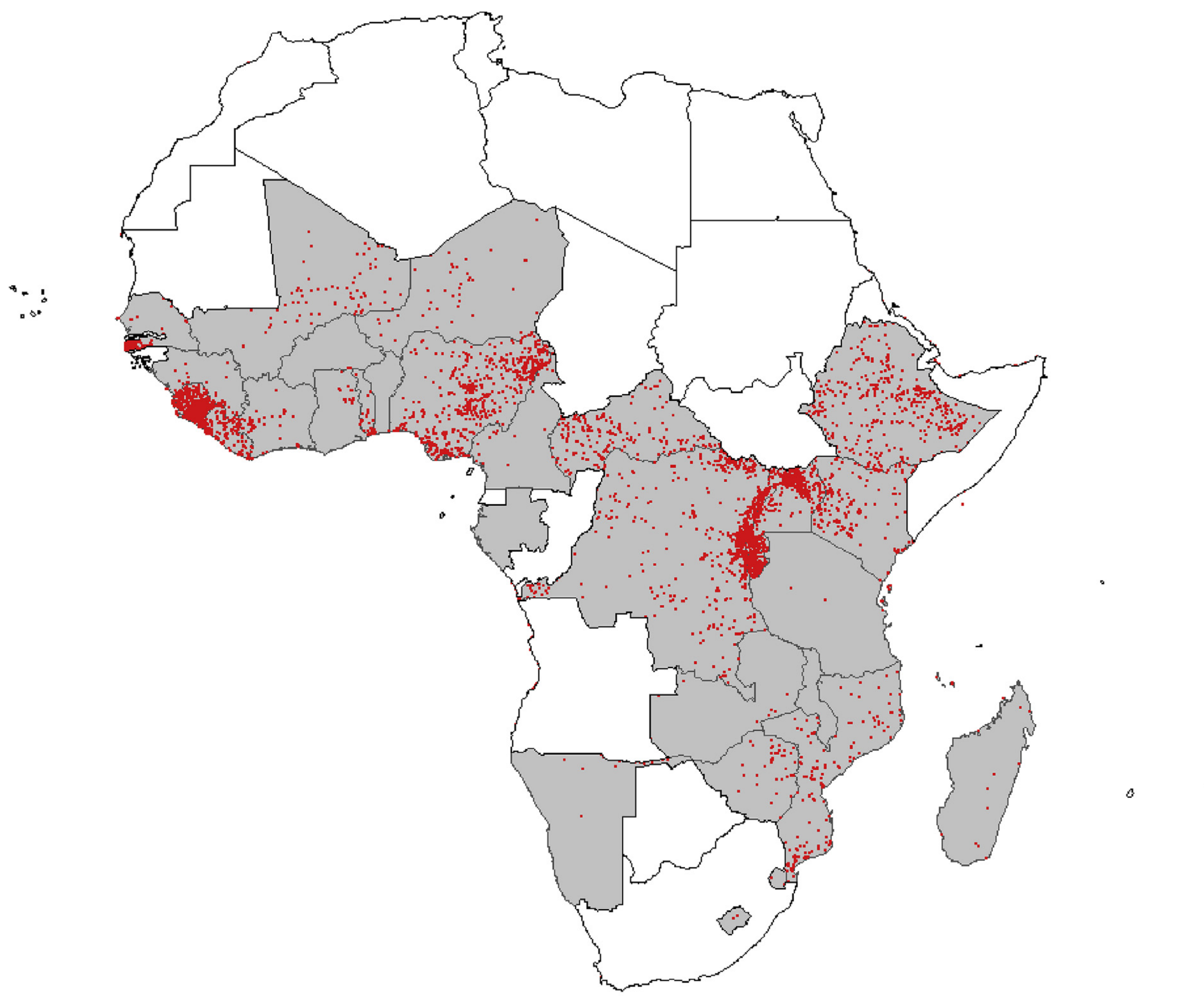

Fig. 3. Conflict events in sample countries, 1989–2014.

conflicts of any magnitude. We see that living in a conflict area causes 2.8 more women out of 100.000 to die in relation to pregnancy, but this effect is not statistically significant. In Appendix Table A1 we show that the results are robust to clustering the standard errors at the cluster level, that is taking into account that the sisters are nested in clusters and that conflict variable only varies at the DHS cluster level. In Appendix Table A2 we present results for a smaller area (25 km radius of conflict exposure) and we see that the results are very similar, albeit larger. The average total effect of any conflict is highly statistically significant at this level of analysis. Hence, if anything our use of 50 km buffer zones is likely to lead to conservative estimates.

4.1. Moderators

We also analyze the heterogeneity of the results by conducting a set of sample splits. That is, we split the samples based on the levels of potential moderators in order to investigate if the effects are different for different samples. In Table 2, columns 1 and 2 we split the sample into areas where the average level of female education is high or low depending on whether the level is above the median level. We see larger effects in areas with more educated women. As the average number of maternal deaths is much higher in the low educated areas, however, the difference in effects is even larger in percentage terms. When we compare the percentage effects in communities with high and low wealth, again split by the median level in the sample, we see that the effect is larger in richer areas. Both these results go against our initial hypotheses. The effect is, however, larger in both absolute and in percentage terms in rural than in urban areas.

So far, we have taken the whole sample of sisters but it is also not obvious what age cutoff we should use. In the baseline regressions we include women as young as 12 and as old as 45. By focusing on such a wide age group, we are likely to underestimate the effects for the population most at risk. We therefore also present results in Table 3 where we control for age dummies and test different restrictions on the sample. The effects of conflict are largest in the sample of women aged between 20 and 35 years old (SeeTable A3 and A4).

We can also do analyses with different types of fixed effects. In column 1 of Table 4 we first show an analysis with country fixed effects instead of sister fixed effects. This analysis then compares sisters within the same country before and after conflict. In column 2 we instead include cluster level fixed effects (so that we compare women within the same cluster before and after conflict) and in column 3 we include

Table 1
Baseline results at the sister level: Maternal mortality per 100,000 living women. 50 km, buffer zones.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	8.489***	4.701***	7.384***				
	(1.582)	(1.731)	(1.994)				
Logged conflict events one year before		1.646	2.195				
		(1.583)	(1.691)				
Logged conflict events one year after			−8.056***				
			(1.964)				
Conflict events				1.626***			
				(0.182)			
Battle deaths in 1000s					1.436***		
					(0.175)		
Logged Battle deaths						65.515***	
						(6.527)	
At least one conflict							2.845
							(2.558)
Observations	17,749,269	16,414,108	15,145,899	17,749,269	17,749,269	17,749,269	17,749,269
R-squared	0.163	0.180	0.183	0.163	0.163	0.163	0.163
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	87.193	89.985	83.299	83.299	83.299	83.299

Robust standard errors clustered at the sister level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

family fixed effects so that sisters within a family are compared to each other. Interestingly, we see that both the coefficient estimates as well as the R-squared increase as we narrow down the comparison from country to cluster. But then coefficients decrease somewhat when going to the family fixed effects results. They are still larger here than in the individual fixed effects regressions. This may indicate less measurement error in the analyses at the cluster level. Table A5, A6 and A7 in the Appendix show the results of these regressions for all conflict variables.

5. Discussion and conclusion

Maternal mortality is still very high in many parts of the world and sub-Saharan Africa is the region lagging the most behind in this respect. Most countries in sub-Saharan Africa have suffered from armed conflict over the last decades, and this is one of the assumed causes of the high maternal mortality that is reported in many of these countries. There is an emerging literature addressing the health and demographic consequences of violent conflict that inform humanitarian policies. Data collection efforts have established global war-related mortality using a variety of approaches and sources (e.g. Lacina and Gleditsch, 2005). During conflicts, the most obvious victims are the direct casualties. However, major losses of life and negative health effects also stem from indirect consequences of armed conflict. Conflicts weaken societies' capacity to handle morbidity and mortality (Foege, 2000), and have detrimental health effects through hampering food production and displacing populations (Bundervoet et al., 2009). There is an ongoing debate within the research community concerning the relationship between armed conflict and such indirect health effects, that are often referred to as 'excess mortality'. The latter are negative health effects that do not include those directly killed in battle but refer to poor health stemming from the overall deterioration of the social, economic and political fabric, health effects that would not have happened had it not been for the war. Researching the overall health effects in conflict areas is fraught with controversy and methodological challenges and measuring broader health impacts by collecting population survey data is typically not a priority during the chaos of a conflict (Murray et al., 2002).

Up until this point systematic analyses that allow for drawing causal inferences on the armed conflict–maternal mortality nexus have been lacking. Combining fine-grained data from the UCDP-GED database (Melander et al., 2016) with individual-level data on sisters' maternal deaths from the Demographic and Health Surveys, we provide the first detailed and direct test of whether local exposure to armed conflict impacts maternal mortality.

A challenge with our approach is of course that we cannot be sure where the sisters of the respondents in the DHS surveys actually live.

Table 2
Heterogeneity results at the sister level: Maternal mortality per 100,000 living women.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	High edu	Low edu	High wealth	Low wealth	Urban	Rural
Logged conflict events	9.828***	4.376	8.212***	8.004***	3.594	8.204***
	(2.568)	(3.123)	(2.650)	(2.775)	(2.613)	(2.855)
Observations	7,283,030	6,844,968	7,252,357	6,863,226	5,064,111	9,064,813
R-squared	0.144	0.184	0.153	0.175	0.162	0.168
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	72.470	96.114	66.213	102.517	66.665	93.560

Robust standard errors clustered at the sister level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table 3
Baseline results at the sister level. Effects for different age groups. 50 km buffer zones.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	control age	> 15	16–44	16–34	16–29	20–35	20–40
Logged conflict events	8.450***	11.134***	10.979***	12.644***	10.558***	15.230***	13.924***
	(1.582)	(1.896)	(1.908)	(2.121)	(2.263)	(2.632)	(2.393)
Observations	17,749,269	14,737,182	14,607,084	12,111,019	9,819,849	9,371,280	10,794,541
R-squared	0.163	0.204	0.204	0.225	0.256	0.282	0.259
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	97.610	97.692	93.518	84.441	106.805	109.138

Robust standard errors clustered at the sister level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table 4
Fixed effects at different levels. 50 km buffer zones.

Variables	(1)	(2)	(3)
	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	4.869***	11.634***	9.394***
	(1.278)	(1.554)	(1.562)
Observations	17,749,269	17,749,269	17,749,269
R-squared	0.000	0.002	0.047
Country FE	Yes	No	No
Cluster FE	No	Yes	No
Family FE	No	No	Yes
Year FE	Yes	Yes	Yes
Mean in sample	83.299	83.299	83.299

We make the heroic assumption that they live within the same survey cluster (e.g. 50 km buffer) as their sister. However, we do have a fair reason to expect that family members tend to live not too far apart. Also, we would expect that the fact that some sisters live far away should, if anything, deflate our results. In any case, our sample, consisting of as many as 1,335,161 adult women, proved sufficiently large to detect a localized strong and statistically significant positive effect of exposure to organized violence on maternal deaths. For each additional logged conflict event, the risk that a woman dies in relation to pregnancy increases by approximately 10%. The effect is particularly strong for women aged 20–35, where we find that each additional logged conflict event increases the risk of maternal deaths by 14%. Our findings are robust to various robustness checks. Exploring heterogeneous effects, we find - as expected – that the reinforcing effect of conflict on maternal deaths is stronger in rural than in urban areas. However, although maternal deaths are more frequent overall in poorer and less educated areas, we find that the effect of conflict in increasing the risk of maternal deaths is stronger in relatively richer and more educated areas. One potential explanation could be that people in poorer areas have developed better coping mechanisms to deal with pregnancy and child birth during poverty and crises. However this is only speculation and cannot be tested with the data at hand. Future research should try to unpack and explain this finding.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2019.112526.

Appendix

Table A1
Baseline results at the sister level. 50 km buffer zones.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	8.489***	4.701**	7.384***				
	(1.804)	(1.916)	(2.168)				
Logged conflict events one year before		1.646	2.195				
		(1.724)	(1.825)				
Logged conflict events one year after			−8.056***				
			(2.145)				
Conflict events				1.626***			
				(0.203)			
Battle deaths in 1000s					1.436***		
					(0.186)		
Logged Battle deaths						65.515***	

(*continued on next page*)

Table A1 (*continued*)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
						(6.900)	
At least one conflict							2.845
							(2.901)
Observations	17,749,269	16,414,108	15,145,899	17,749,269	17,749,269	17,749,269	17,749,269
R-squared	0.163	0.180	0.183	0.163	0.163	0.163	0.163
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	87.193	89.985	83.299	83.299	83.299	83.299

Robust standard errors clustered at the DHS cluster level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A2
Baseline results at the sister level, 25 km radius conflict exposure. 25 km buffer zones.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	14.665***	12.149***	15.095***				
	(2.162)	(2.359)	(2.655)				
Logged conflict events one year before		−0.257	0.059				
		(2.063)	(2.216)				
Logged conflict events one year after			−8.751***				
			(2.534)				
Conflict events				2.246***			
				(0.310)			
Battle deaths in 1000s					1.810***		
					(0.299)		
Logged Battle deaths						91.751***	
						(10.056)	
At least one conflict							9.471***
							(3.029)
Observations	17,749,269	16,414,108	15,145,899	17,749,269	17,749,269	17,749,269	17,749,269
R-squared	0.163	0.180	0.183	0.163	0.163	0.163	0.163
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	87.193	89.985	83.299	83.299	83.299	83.299

Robust standard errors clustered at the sister level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A3
Baseline results at the sister level. Sample of women aged 20–35.50 km buffer zones.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	15.230***	11.787***	13.877***				
	(2.632)	(2.712)	(3.090)				
Logged conflict events one year before		−0.352	−0.184				
		(2.392)	(2.548)				
Logged conflict events one year after			−5.652*				
			(3.075)				
Conflict events				2.584***			
				(0.324)			
Battle deaths in 1000s					2.023***		
					(0.314)		
Logged Battle deaths						94.163***	
						(11.790)	
At least one conflict							6.555*
							(3.958)
Observations	9,371,280	9,059,138	8,384,092	9,371,280	9,371,280	9,371,280	9,371,280

(*continued on next page*)

Table A3 (*continued*)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
R-squared	0.282	0.288	0.291	0.282	0.282	0.282	0.282
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	106.805	107.118	111.258	106.805	106.805	106.805	106.805

Robust standard errors clustered at the DHS cluster level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A4
Heterogeneity results at the sister level. Sample of women aged 20–35.50 km buffer zones.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	High edu	Low edu	High wealth	Low wealth	Urban	Rural
Logged conflict events	18.861***	8.494*	13.796***	15.280***	9.499**	15.981***
	(4.028)	(4.865)	(3.816)	(4.490)	(3.885)	(4.530)
Observations	3,844,531	3,618,427	3,825,189	3,630,673	2,675,932	4,787,503
R-squared	0.252	0.311	0.269	0.293	0.272	0.288
Sister FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	96.501	119.831	84.702	132.014	87.259	119.290

Robust standard errors clustered at the DHS cluster level in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A5
Baseline results at the sister level: Country FE

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	4.869***	8.205***	8.769***				
	(1.278)	(1.643)	(2.028)				
Logged conflict events one year before		−5.868***	−5.946***				
		(1.501)	(1.602)				
Logged conflict events one year after			−2.142				
			(1.850)				
Conflict events				1.360***			
				(0.160)			
Battle deaths in 1000s					1.620***		
					(0.186)		
Logged Battle deaths						74.210***	
						(6.695)	
At least one conflict							−3.540*
							(2.096)
Observations	17,749,269	16,414,108	15,145,899	17,749,269	17,749,269	17,749,269	17,749,269
R-squared	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	87.193	89.985	83.299	83.299	83.299	83.299

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A6
Baseline results at the sister level: Cluster FE

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	11.634***	12.384***	11.028***				

(*continued on next page*)

Table A6 (*continued*)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
	(1.554)	(1.806)	(2.108)				
Logged conflict events one year before		−1.915	−2.667				
		(1.557)	(1.660)				
Logged conflict events one year after			1.226				
			(1.908)				
Conflict events				1.779***			
				(0.186)			
Battle deaths in 1000s					1.646***		
					(0.186)		
Logged Battle deaths						78.842***	
						(6.897)	
At least one conflict							7.941***
							(2.466)
Observations	17,749,269	16,414,108	15,145,899	17,749,269	17,749,269	17,749,269	17,749,269
R-squared	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cluster FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	87.193	89.985	83.299	83.299	83.299	83.299

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A7
Baseline results at the sister level: Family FE

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality	Maternal mortality
Logged conflict events	9.394***	8.902***	9.073***				
	(1.562)	(1.770)	(2.057)				
Logged conflict events one year before		−1.808	−1.976				
		(1.579)	(1.681)				
Logged conflict events one year after			−2.504				
			(1.942)				
Conflict events				1.648***			
				(0.183)			
Battle deaths in 1000s					1.566***		
					(0.182)		
Logged Battle deaths						73.627***	
						(6.735)	
At least one conflict							4.532*
							(2.507)
Observations	17,749,269	16,414,108	15,145,899	17,749,269	17,749,269	17,749,269	17,749,269
R-squared	0.047	0.051	0.054	0.047	0.047	0.047	0.047
Family FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in sample	83.299	87.193	89.985	83.299	83.299	83.299	83.299

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

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