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Examining the effect of nearby armed conflict on access to maternal and child health services in Burkina Faso's primary healthcare facilities

Felix Amberg ,[1] Karl Blanchet ,[2] Neha S Singh ,[3] Valéry Ridde ,[4,5] Emmanuel Bonnet ,[5] Pierre Yaméogo ,[6] Ali Sie ,[7] Mariam Seynou ,[7] Julia Lohmann ,[1,8] Manuela De Allegri [1]

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For numbered affiliations see end of article.

Correspondence to
Felix Amberg;
feamberg@gmail.com

ABSTRACT

Background Armed conflict is increasing in sub-Saharan Africa, impacting access to vital health services. However, scant evidence exists on the effects of the recently escalated conflict in Burkina Faso, a country severely affected by rising violence.

Methods We conducted a longitudinal study, aligning conflict event data from the Uppsala Conflict Data Program with Burkina Faso's Health Management Information System data spanning from 2013 to 2021. Applying negative binomial regression models with health facility fixed effects, we assessed the impact of nearby armed conflict events (within 25 km of primary healthcare centres) on access to six essential maternal and child health services. We investigated effect heterogeneity by varying conflict intensity and duration, and facility characteristics.

Results Any nearby armed conflict significantly reduced the incidence of all examined health services, except for non-significant caesarean section declines. Specifically, antenatal care 4 visits decreased by 3.9%, facility-based deliveries by 7.2%, caesarean sections by 9.4%, postnatal care 1 visits by 4.3% and outpatient care visits for children under 5 and aged 5–14 by 7.2% and 12.0%, respectively. High-intensity conflict events significantly amplified the negative effects across all health services. We observed less pronounced effects on children under 5 compared with those aged 5–14 not encompassed by existing fee removal policies. Prolonged conflicts did not adversely affect outpatient care visits for children. Rural facilities bore a more pronounced effect than urban facilities.

Conclusions Our findings show a significant disruption of health services due to contemporaneous conflict in Burkina Faso. However, child curative care services seem to exhibit a stabilisation trend in prolonged conflicts, and the mitigating effects of existing fee removal policies were evident. This underscores the need for nuanced policy interventions that consider varying conflict intensities, service types and financing schemes and highlights the importance of detailed, fine-scale analyses during conflict scenarios.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ In 2016, terrorist attacks bore immediate impacts on the organisation of care in the capital Ouagadougou with mobilisation of personnel and communication between centres exhibiting effectiveness but challenges with co-ordination and resource allocation.

⇒ Terrorist attacks reduced the utilisation of maternal healthcare services at the commune level between 2016 and 2018, including antenatal care visits, facility deliveries and caesarean sections.

⇒ Available evidence is affected by at least one of the following spatial and methodological limitations: (1) Only examines the early stages of the conflict between 2016 and 2018; (2) Only focuses on the capital Ouagadougou or used a rather imprecise approach in which commune aggregates were used and (3) Only examines maternal health services.

BACKGROUND

Over half of the world's women and children reside in countries that are currently facing armed conflicts.[1] In these politically unstable and insecure environments, women's and children's health is under significant threat due to ongoing insecurity, forced displacement, infrastructure destruction and economic disruptions.[2] Sub-Saharan Africa (SSA) is particularly affected by this issue, experiencing armed conflicts more frequently than other regions worldwide. Since 1980, almost 70% of SSA countries have been involved in armed conflicts.[3] One region within SSA that has been particularly affected by conflict is the Sahel, particularly Nigeria, Mali, Sudan, Niger, Chad, and most recently, Burkina Faso. In 2022, three of the eight high-intensity conflicts classified by the Peace Research Institute Oslo were located in the Sahel, with Niger, Mali and Burkina Faso recording substantial increases in conflict-related deaths

WHAT THIS STUDY ADDS

⇒ Our analysis also includes child health services, the intention being that of examining access to health services during conflict more comprehensively.

⇒ Our analysis covers a more extensive period, thereby also considering the escalation of the conflict between 2019 and 2021, and does not only focus on attacks by jihadist groups, but purposely includes all armed conflict events.

⇒ Using geographical coordinates enables us to define 25 km conflict bands around health facilities and run more solid regressions including health facility fixed effects as well as time-varying health-facility level controls, thereby considering local dynamics and accounting for, instead of overlooking, differences between facilities.

⇒ Access to health services in Burkina Faso's primary healthcare facilities is profoundly affected by nearby conflict, but services of a different nature are affected differently, depending on the intensity and duration of the conflict, facility type and location as well as on whether the services are covered by pre-existing user fee removal policies.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our analysis shows both the need to study access to health services during conflict at the finest possible scales as well as across different services (eg, maternal and child health services; covered or not covered by user fee removal policies).

⇒ Strategies to ensure continuous access to care should be varied across the spectrum of services and financing schemes, meeting health needs of different population groups.

⇒ Supportive spatial analyses and qualitative analyses are needed to understand local dynamics and contextual factors, as well as to differentiate the extent to which disruptions are due to demand or supply factors.

⇒ Policy-makers in Burkina Faso are called to design novel strategies and improve existing ones aimed at maintaining the functionality of the health system, to the extent possible, even in this situation of high insecurity.

compared with previous years.[4] Despite this recent vulnerability to conflict, the region receives very little attention in the literature. In this paper, we explicitly focus on Burkina Faso, so far understudied in relation to conflict and health.

The context in Burkina Faso is unique in that, up until the escalation of conflict in 2019, despite looming insecurity and first evidence of its detrimental effect on access to health services,[5] the country was on a good path to universal health coverage in regional comparison, although at still low levels in absolute terms.[6] Health service coverage increased until 2019 and was at 43 out of 100 according to the 2019 universal service coverage index.[7] Mali, Niger and Chad achieved less significant improvements and were at 42, 37 and 28, respectively.[7] Similar differences across countries were observed in relation to maternal and child health (MCH) service coverage. In Burkina Faso, MCH services have been a particular focus, with notable progress in antenatal care (ANC), facility-based deliveries and caesarean sections. As of 2019, before the escalation of conflict, 79% of pregnant women attended at least ANC4 visits,[8] and 66% of births occurred in health facilities, surpassing figures from Mali (50%), Niger (40%) and Chad (23%).[9] Caesarean section rates stood at 3.7%, while postnatal care (PNC) coverage was 70% within 2 days of birth.[8] Outpatient care visits for children under 5 were robust, with 3.6 visits per child per year, significantly higher than in neighbouring countries.[8] These figures are remarkable, especially given that the country has a low gross domestic product (GDP) per capita and relatively low spending on health. Health spending remained relatively consistent at around US$37.7 per capita per year from 2015 to 2019,[10] with the government contributing approximately 43% of the total health expenditures during this period.[11] One reason for the progress until 2019 is the government's implementation of several health financing reforms to gradually improve financial protection[12] and improve coverage and health inequalities.[13 14] For example, in 2016, Burkina Faso was one of the first countries in SSA to abolish healthcare user fees for children under 5 years of age and for pregnant and lactating women.[12]

Recent literature, however, suggests that the improvements in health service coverage are fragile and are likely to disappear rapidly if either a new barrier is introduced[15] or existing lingering barriers such as distance to health facilities, informal costs and low quality of care are reinforced.[16–19] One emerging challenge that has decisively undermined the government's longstanding efforts to improve health service coverage is the rising level of insecurity. An Islamist insurgency by jihadist groups is challenging the Burkinabè state and igniting underlying ethnic and social tensions. The ongoing situation, coupled with counterinsurgency efforts by the Burkinabè military, is generating a feeling of permanent insecurity and is increasing the risks for women and children needing and trying to seek care, as well as for the local health workers trying to provide it in some locations. As a result, both the population's ability to access healthcare and the capacity of local health systems to deliver it have been severely constrained.[20 21]

Only two analyses were carried out on the links between conflict and level of access to healthcare in Burkina Faso, but this evidence is limited to the early stage of the conflict between 2016 and 2018, which was mainly characterised by one-sided violence in the form of attacks by non-state armed groups, or more specifically, jihadist groups. First, a qualitative analysis by Ridde *et al* suggests that these attacks had immediate impacts on the organisation of care in Burkina Faso's capital Ouagadougou in 2016.[22] Second, Druetz *et al* examined an insecurity barrier to maternal healthcare access in Burkina Faso using multiple (pooled) interrupted time-series analyses that leverage time-series data on the utilisation of healthcare services.[5] Their analysis documents the presence of an insecurity barrier to maternal care access between 2016 and 2018, but this evidence is generated using an approach in which commune aggregates of health service counts and conflict deaths are used instead of using a precise geospatial approach that matches facilities to

nearby conflict events. A few studies conducted in other Sahelian countries affected by conflict exist, but their analyses provide only limited insight into the matter.[23–25] Notably, none of the studies used longitudinal evaluation methods to assess the immediate effects of conflict events. Instead, they relied on data from cross-sectional surveys that lacked specific time frames for such events, leading to potential historical bias in interpretation due to time gaps and a limited number of time points.[26]

Our study examines the impact of nearby armed conflict on access to essential MCH services in Burkina Faso's primary healthcare centres and district hospitals. Our aim is to examine how disruptions caused by nearby conflict ultimately affect access to health services, thereby contributing to the debate on strengthening access to healthcare in Burkina Faso during and following periods of conflict.

METHODS

Setting

Security context in Burkina Faso

Burkina Faso is a landlocked low-income country with a population of approximately 21 million people[27] and surrounded by Mali, Niger, Benin, Togo, Ghana and Côte d'Ivoire. With more than 40% of its population living on less than 420 CFA francs (CFAF) (<US$1) per day and being ranked 184 out of 191 countries on the 2021/2022 Human Development Index,[28 29] it is one of the poorest countries in the world. Despite this widespread poverty, Burkina Faso was long seen as a beacon of stability in the crises-affected region and was characterised by peaceful coexistence of various ethnic groups as well as a steady progress towards democratisation. In 2015, the country even took a step towards democracy by holding its first free election after the Comparoé presidency. However, since 2016, instead of cementing its progress, Burkina Faso has been plunged into the same dynamic seen in neighbouring Sahel countries, with jihadist groups challenging the state, and with that igniting underlying ethnic and social tensions, causing mobilisation along ethnic lines. The jihadist militant groups Islamic State – Sahel Province (ISSP), prior to 2022 known as Islamic State in the Greater Sahara (ISGS), and Jama'at Nusrat al-Islam wal Muslimeen (JNIM), formed by the merger of Ansar Dine, al-Mourabitoun and the Saharan branch of al-Qaeda in the Islamic Maghreb in 2017 and Ansaroul Islam in 2018, have been responsible for numerous attacks on civilians, security forces and infrastructure in the northern regions, with violence later spreading to the eastern parts of the country.[30] This complex and evolving situation has escalated dramatically since 2018/2019 (figure 1A). From 2019 onwards, the very high levels of violence and insecurity – caused by a mixture of radical Islamic terrorism, counterinsurgency operations and retaliatory actions by the Burkinabè military, banditry, and inter-community conflicts – have also gained an increasingly clear-cut ethnic dimension. Jihadist groups, often perceived as representing the Fulani ethnic group, triggered retaliatory attacks against Fulani civilians. In turn, jihadist groups initially targeted Mossi communities, who were viewed as supporters of the Koglweogo, a local self-defense militia that gained prominence amid the conflict. After 2020, jihadists expanded their targets to include anyone considered hostile to their cause, particularly individuals associated with the Volunteers for the Defence of the Homeland (VDPs), a civilian auxiliary force supporting the military. These dynamics, combined with unpredictable waves of civil unrest and ongoing political instability with several attempted and actual coups resulted in a humanitarian catastrophe, with widespread displacement, food insecurity and human rights abuses. The Burkinabè government has been trying to combat the jihadist groups, but the situation has remained volatile and complex. In 2021, the country recorded the second highest number of terror-related conflict deaths worldwide[31] and, in 2022 alone, the country experienced two coups d'état, which further limited the government's ability to fight the jihadist groups.[32]

Health system of Burkina Faso

Burkina Faso's health system is primarily public, with a district-based structure where staff, drugs and infrastructure are centrally managed. An essential health package, which includes Maternal, Newborn and Child Health (MNCH) services, is provided at the primary care level and is free of charge at the point of service, a policy facilitated by Gratuité, a user fee exemption initiative.[6 12] This package also ensures that patients are referred to higher levels of care in cases of complications. Key indicators from 2019 (before the main escalation of conflict) highlight the effectiveness of the system up to this point: maternal mortality decreased to 283 per 100 000 live births,[33] while under-5 mortality stood at 87 per 1000 live births.[34] Utilisation rates of key MNCH services were high, with ANC coverage for at least four visits reaching 72%, and skilled birth attendance at 96%.[35] Despite these efforts, the system faced significant challenges, including geographical barriers and supply chain disruptions in remote areas, as well as high staff turnover driven by inadequate remuneration and difficult working conditions.

Data and data sources

Our work relied on two main secondary data sources: Burkina Faso's national Health Management Information System (HMIS) and the Uppsala Conflict Data Program Georeferenced Events Dataset (UCDP GED). Additional data sources are listed in table 1.

HMIS data consist of monthly facility-specific service counts across all facilities in all 70 health districts in the country[36] and have shown to be of sufficient quality to enable meaningful and reliable analyses.[37–40] Since we aimed to quantify both short-term and long-term effects of conflict, we leveraged monthly HMIS data for the period 2013–2021, which constitutes a reliable time series of a maximum of 108 months of observation per facility. In our analysis, all public facilities at the primary care

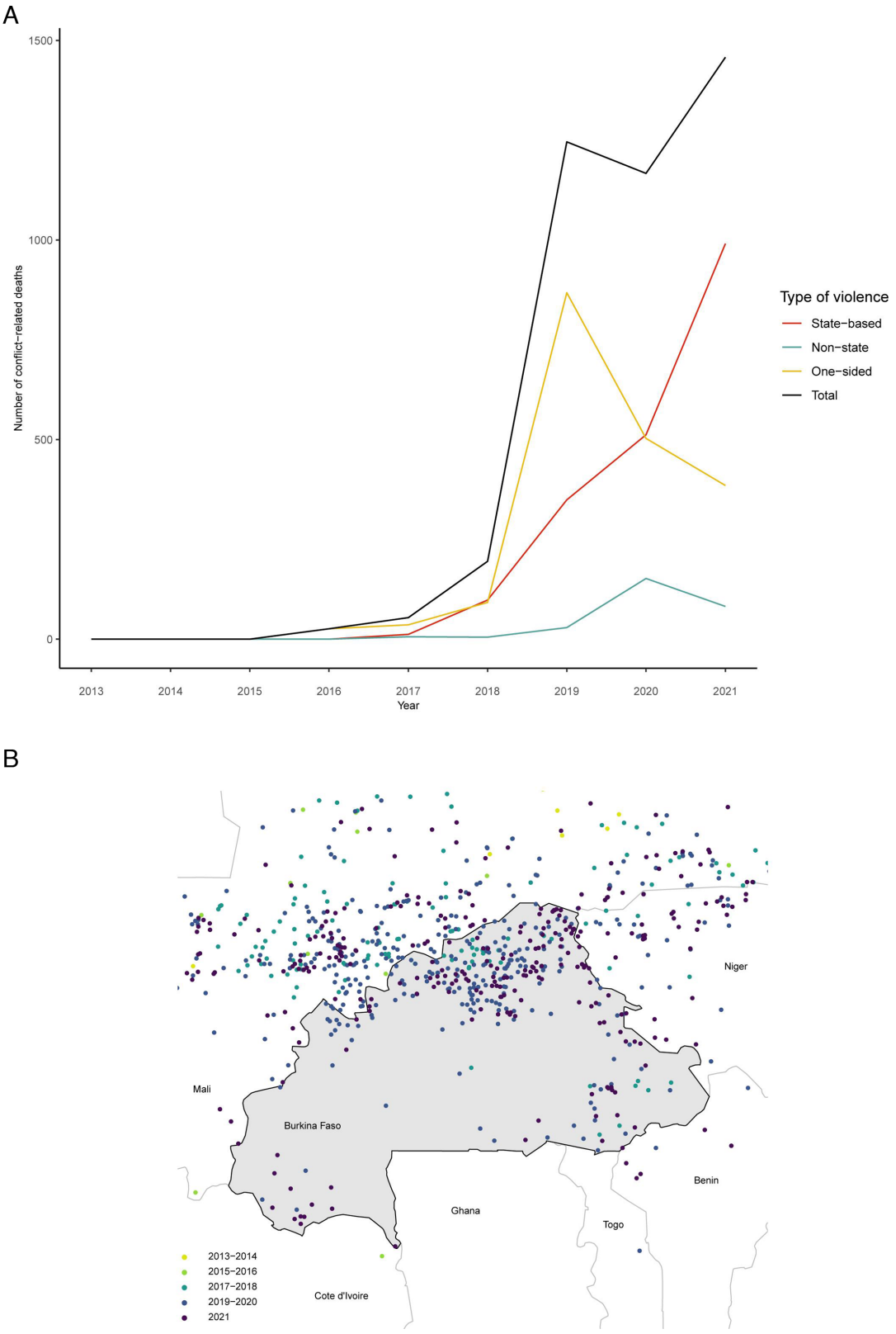

Figure 1 (A) Conflict-related deaths by type of violence over time, 2013–2021. The figure on the top shows the UCDP conflict-related deaths over time from 2013 to 2021, total and by type of violence. In our analysis, we used conflict events of any type of violence – State-based: The use of armed force between two parties, of which at least one is the government of a state; Non-state: The use of armed force between two organised armed groups, neither of which is the government of a state; One-sided: The use of armed force by the government of a state or by a formally organised group against civilians. (B) Distribution of armed conflicts in Burkina Faso and neighbouring countries, 2013–2021. The map on the bottom shows the UCDP conflict location data in Burkina Faso and neighbouring countries, with changing location over time from 2013 to 2021. The study country Burkina Faso is shown in grey with thick borders. UCDP, Uppsala Conflict Data Program.

Table 1 Variables, measurements and data source

Variables	Measurement	Data source
Outcomes		
Maternal health		
(A) Number of pregnant women having four ANC visits*	Monthly service counts	HMIS
(B) Number of facility-based deliveries of any kind (uncomplicated deliveries, complicated deliveries, caesarean sections)	Monthly service counts	HMIS
(C) Number of deliveries by caesarean section	Monthly service counts	HMIS
(D) Number of women having one PNC visits 6–8 weeks after birth	Monthly service counts	HMIS
Child health		
(E) Number of curative care visits (children under 5 years)	Monthly service counts	HMIS
(F) Number of curative care visits (children aged 5–14 years)	Monthly service counts	HMIS
Exposure variables		
Binary conflict exposure		
Armed conflict event resulting in direct conflict-related deaths within 25 km of the health facility in the month of health service access	0=No,	UCDP GED
	1=Yes	
Categorical conflict exposure		
Conflict intensity		
Below or above median number of conflict deaths (for all conflicts in our dataset) within 25 km of the health facility in the month of health service access	0=No conflict,	UCDP GED
	1=Below median,	
	2=Above median	
Quartile of the number of conflict deaths (for all conflicts in our dataset) within 25 km of the health facility in the month of health service access	0=No conflict,	UCDP GED
	1=1–2 deaths,	
	2=3–4 deaths,	
	3=5–14 deaths,	
	4≥14 deaths	
Conflict duration		
Consecutive months of deadly conflict within 25 km of the health facility leading up to the month of health service access	0=No conflict,	UCDP GED
	1=In current month only,	
	2=2 consecutive months,	
	3=3 consecutive months,	
	4=4 consecutive months,	
	5=5+ consecutive months	
Covariates		
Facility-level time-varying controls		
Average temperature in the month of health service access	°C 2 m above surface in closest grid centroid to health facility	ERA5-Land gridded dataset, 0.1°×0.1° resolution
Average rainfall in the month of health service access	Depth in metres the water would have if it were spread evenly over the closest grid box to the health facility	ERA5-Land gridded dataset, 0.1°×0.1° resolution
Average night-time luminosity in the month of health service access	Average intensity value (0–63) in a 10×10 km square centred around health facility	VIIRS (Visible Infrared Imaging Radiometer Suite)

*We used ANC4, instead of the updated WHO recommendation of ANC8 because Burkina Faso has not yet fully adopted it and only ANC4 data are available in the HMIS.
ANC4, four antenatal care; HMIS, Health Management Information System; PNC, postnatal care; UCDP GED, Uppsala Conflict Data Program Georeferenced Events Dataset.

level were considered, that is, primary healthcare centres (CSPSs=Centres de santé et de promotion sociale) and district referral hospitals (CMs=Centres médicaux, CMAs=Centres médicaux avec antenne chirurgicale). We geocoded the health facilities using geographical coordinates available in the Health Resources Availability Mapping System (HeRAMS) dataset as well as the national topographic database (Base Nationale de Données Topographiques). We corrected all facilities for outliers in their monthly service counts. We detected outliers using a rolling modified z-score within each facility (considering previous and coming 24 months in each iteration) and considered a rolling modified z-score of greater than 15 as an outlier. Outliers were then corrected by a rolling median within each facility (considering previous and coming 12 months in each iteration). Furthermore, we imputed internal missing counts (ie, missing values between the first and last non-missing) for facilities with a maximum number of consecutive missing counts less than or equal to 10 and at least 10 non-missing values over the study period. Addressing missing values was important for the study since Burkina Faso also experienced a health sector crisis in 2019, with refusal to provide statistical reports from April to November. Imputation was done using local polynomial regression within each facility. Consistent with the existing literature on handling missing data,[41–45] we trust that this approach yielded results with reduced bias compared with analysing incomplete data.

The UCDP GED provides detailed information about the time, location, type and intensity of conflict-related events from 1946 until today (exact location available from 1 January 1989 to today).[46–48] A conflict event in the UCDP GED is defined as 'an incident where armed force was used by an organised actor against another organised actor or against civilians, at a specific location and a specific date'.[48] The UCDP identifies, categorises and localises conflict events from news sources, non-governmental organisation (NGO) reports, case studies, truth commission reports, historical archives and other sources of information.[49] To define exposure to conflict, we preselected all conflict events in the UCDP dataset that occurred in Burkina Faso and its neighbouring countries from 2013 to 2021 (figure 1B). During this time, the UCDP GED recorded 673 conflict events in Burkina Faso with 4146 conflict-related deaths (excluding neighbouring countries). The geographical coordinates in all datasets allowed us to match each health facility in HMIS to all relevant UCDP conflict events (meaning within 25 km, including events in neighbouring countries for facilities located at the borders).

Variables and measurement

Outcome variables were selected to reflect the most important services along the continuum of MCH care,[50] but also considering feasibility concerns, that is, services that had a comparably low number of missing observations throughout the study period and that are routinely reported by primary healthcare facilities. Table 1 provides a description of all outcomes, exposure variables and covariates.

Statistical analysis

Our study is a fine-scaled, precise spatiotemporal and longitudinal study that used multiple (pooled) interrupted time series analyses to isolate the contemporary and longitudinal effect of nearby conflict events on facility-level provision counts. Even though the outcomes consisted of count variables, negative binomial regression was chosen over Poisson regression due to the presence of overdispersion.

We modelled the relationship between armed conflict and access to health services by using the following negative binomial regression models estimated via unconditional maximum-likelihood:

$$y_{it} = \beta_1 D_{it} + \beta_2 X_{it} + \alpha_i + \epsilon_{it} \quad (1)$$

$$y_{it} = \sum_{r=1}^{2} \beta_r D_{it}^r + \beta_3 X_{it} + \alpha_i + \epsilon_{it} \quad (2)$$

$$y_{it} = \sum_{q=1}^{4} \beta_q D_{it}^q + \beta_5 X_{it} + \alpha_i + \epsilon_{it} \quad (3)$$

$$y_{it} = \sum_{p=1}^{5} \beta_p D_{it}^p + \beta_6 X_{it} + \alpha_i + \epsilon_{it} \quad (4)$$

where y_{it} where is the monthly facility-specific service count of a given health service, indexed for health facility i and time t. The main predictor in equation 1, D_{it}, is a binary indicator, indexed to health facility i and time t, representing whether an armed conflict event resulting in direct conflict-related deaths occurred within 25 km of the health facility in the month of health service access (see table 1). 25 km as a radius represents a distance that a person can walk in 1 day and hence is a reasonable proxy for conflict exposure.[51] The parameter of interest, β_1, was expressed as an incidence rate ratio (IRR). In equations 2, 3 and 4, the main predictors are vectors of indicators ($D_{it}^r, D_{it}^q, D_{it}^p$), representing conflict exposure of intensity r and q, as well as duration p. The intensity index r in equation 2 indicates below or above median number of conflict deaths for all conflicts in our dataset. The intensity index q in equation 3 represents the quartile of the number of conflict deaths for all conflicts in our dataset. The duration index p in equation 4 denotes the consecutive years of deadly conflict within 25 km of the health facility leading up to the month of health service access. We estimated the β_r, β_q, and β_p terms, which represent the effects of conflict exposure of intensity r and q as well as of duration p on access to healthcare, again expressed as an IRR. We used the framework by Levesque *et al* in which access to healthcare is defined both in supply and demand terms.[52]

All the equations also include health facility fixed effects α_i to avoid cross-sectional comparisons. The

health facility fixed effects allowed us to identify the main effects within each health facility. Therefore, the IRR allows us to compare the incident rate of the examined health services within health facilities during months of conflict as compared with months without conflict. If the IRR is less than 1, the incident rate is lower during conflict compared with non-conflict. By including health facility fixed effects, we used only within-health-facility variation in conflict and access to healthcare over time, which controlled for all time-invariant cross-sectional differences between health facilities, whether observed or not (eg, that bigger and more urban facilities feature less pronounced conflict than smaller more rural facilities with lower access to healthcare).[53 54] The implicit assumption is that there are no residual confounders that change within the health facility over time. The standard errors (SEs) were clustered at the health facility level, the primary sampling unit.[55]

The X_{it} in equations 1–4 represents a vector of time-varying facility-level controls (not considered by Druetz *et al* due to less precise commune-level analysis).[5] The vector comprises several variables that, at a local level, could plausibly affect both the risk of conflict and access to healthcare, including monthly-varying average temperature and rainfall (which have been shown to influence conflict incidence) in the closest grid centroid of the health facility as well as a yearly-varying nightlight luminosity value within a 10 km by 10 km square centred on the health facility (a correlate of poverty, population size and population density).[56–58] In the online supplemental appendix, we provide more information on the construction of these time-varying cluster-level controls (p 14). In addition, two other time-varying variables were entered in the models: the monthly variation (calendar month) and a baseline trend (time units since January 2013). Furthermore, the linearity of the relationship between the outcome and continuous covariate was assessed by adding a quadratic term of the baseline trend. ε_{it} represents residual errors.

In addition, we examined effect heterogeneity by testing equations 1–3 for different facility characteristics. We investigated effect heterogeneity by location (urban or rural), facility type (CSPS, CM or CMA) and preconflict service volume (high or low), with the preconflict period spanning the years 2013–2015 (see also figure 1A). Effect heterogeneity was examined for all services except for caesarean sections which are only performed in 46 urban CMAs.

Beyond the effect of conflict intensity and duration, as well as effect heterogeneity, we additionally conducted a supplementary analysis in which we ran our analysis at the health district level. At this level, we were able to translate the monthly service counts into indicators that capture access to health services by constructing outcome variables that account for the underlying target population living in a health district. The health district population estimates are obtained from the annual HMIS statistics. Even if this supplementary analysis is only possible at the health district, it allowed us to test whether our findings are robust to including population data.

Finally, we ran multiple robustness checks regarding equations 1–3. First, we tested the sensitivity of our estimates to the precision of the conflict event location in the UCDP GED by excluding and down-weighting imprecise events. Second, we examined our primary models using the Armed Conflict Location and Event Data (ACLED) data, an alternative source of conflict data.[3] Third, we focused on a potential bias from missing data. HMIS data are subject to non-random missingness since facilities located in areas with higher insecurity could be more prone to cease data entry in record books or transmission of information to the Ministry of Health (MoH). Therefore, in our main analysis, we ran our regression with an imputed dataset. In a robustness check, we checked whether our estimates are less pronounced when using the non-imputed dataset. Next, we checked the robustness of our results to using year-month fixed effects instead of a baseline time trend. Our final robustness check examined the validity of the conflict exposure definition by testing whether the effects are stronger for facilities that, in the HeRAMS survey in April 2022, explicitly stated no external support, inaccessibility and non-functionality.

All analyses were performed with R software using the function feglm from the package fixest, which provides a family of functions to perform estimations with multiple fixed effects.

RESULTS

We found that nearby conflict events significantly diminished access to health services in Burkina Faso's primary healthcare facilities. When exposure is either defined by any nearby armed conflict, more than median exposure or quintile increases (figure 2, table 2), we identified two different gradients. First, for the maternal health services (figure 2A–D), the effects' magnitude of armed conflict events (per health facility per month) was more severe for caesarean sections than for facility-based deliveries and PNC1 visits, which in turn was more important than for ANC4 visits, regardless of the intensity. For example, the incidence of ANC4 visits following any conflict-related death was immediately reduced by 3.9% (IRR 0.961, 95% CI 0.932 to 0.991). For facility-based deliveries and caesarean sections, the percentage reduction was –7.2% (IRR 0.928, 95% CI 0.905 to 0.952) and –9.4% (IRR 0.906, 95% CI 0.760 to 1.079), respectively, while it was –4.3% (IRR 0.957, 95% CI 0.917 to 0.999) for PNC1 visits. For the child health services (figure 2E,F), the negative effects were larger for outpatient consultations of children aged 5–14 compared with children below 5. For instance, the incidence of outpatient consultations of children aged 5–14 was significantly reduced by 12.0% (IRR 0.880, 95% CI 0.856 to 0.904), while the incidence for children below 5 decreased by 7.2% (IRR 0.928, 95% CI 0.906 to 0.951). Second, negative effects increased with

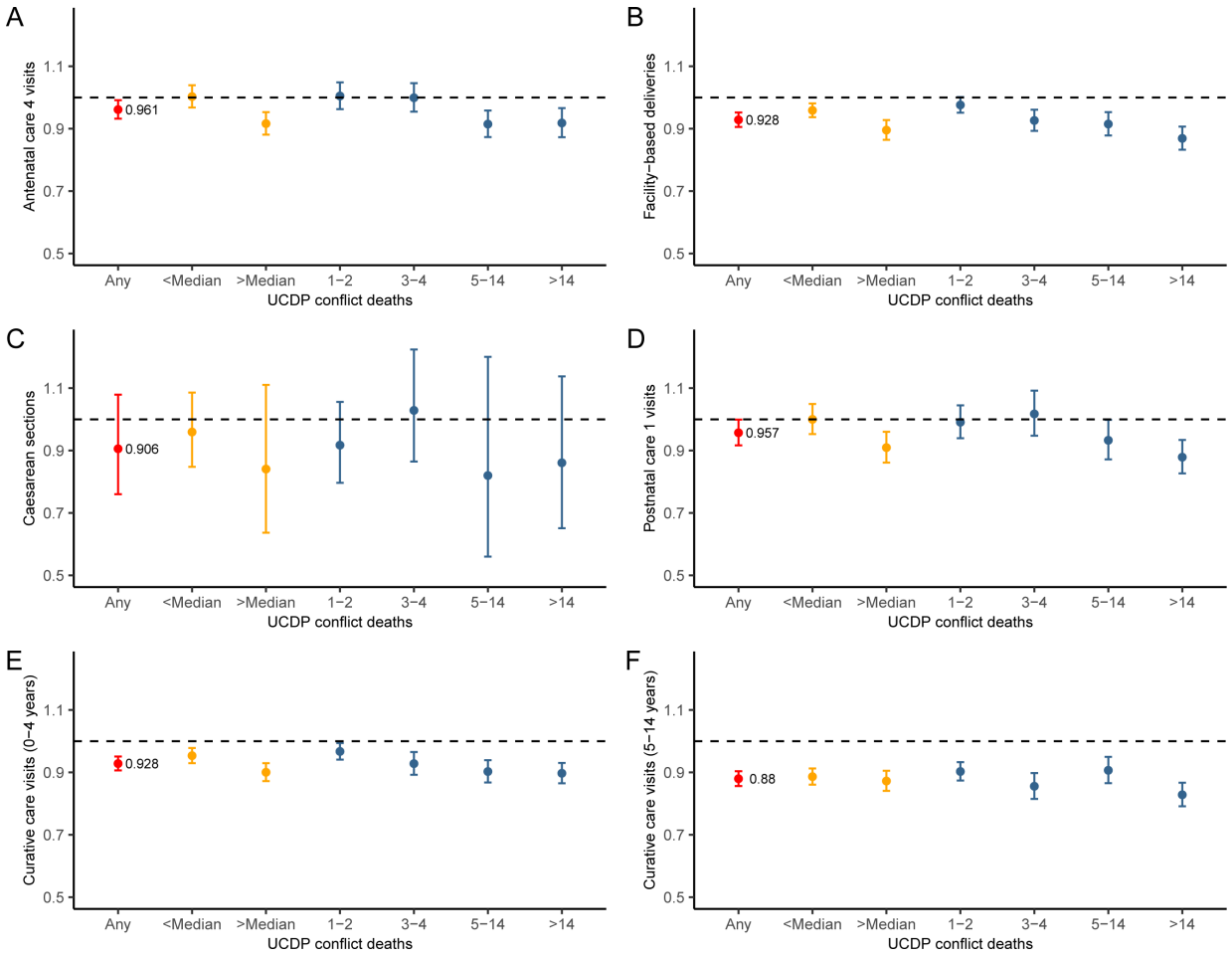

Figure 2 Effect of nearby armed conflict on access to health services in Burkina Faso's primary health care facilities. This figure shows the effect of any conflict within 25 km of the health facility (red bar) and conflicts of increasing intensity [orange bars represent below- and above-median intensity (>4 deaths), blue bars depict the quartiles of the number of conflict deaths] in the month of health service access. The y axis indicates the incidence rate ratio (IRR) also reported in the main text. Error bars represent 95% CIs, corresponding to p<0.05 in table 2. UCDP, Uppsala Conflict Data Program; CIs, confidence intervals.

exposure to high-intensity conflicts, both for more than median exposure and for quintile increases, regardless of the outcome (figure 2, table 2). Given the relatively smaller number of CMAs performing caesarean sections (n=46) compared with the larger number of primary healthcare centres not performing them (208 CMs and 2184 CSPSs), it is understandable that the t-tests yielded significant results only for the latter group, despite the effects being more pronounced in the former.

When examining conflict duration (figure 3, table 2), we found that the negative effect of conflict increased with the number of consecutive months of conflict for all maternal health services (figure 3A–D). For these indicators, the percentage reduction in the incidence following conflicts lasting at least 5 consecutive months was 6 (for ANC4 visits) to 18 (for PNC1 visits) times as large as the percentage reduction in the incidence following short conflicts (<1 month). The child health services (figure 3E,F) show a different pattern in that the negative effect was larger for conflicts lasting 2, 3 or 4 months compared with conflicts lasting less than 1 month, but either less pronounced or not significantly different from zero for prolonged conflicts (≥5 months).

Our analysis of effect heterogeneity (figure 4) suggests that location is an important determinant for access to healthcare. Rural facilities exhibited a stronger negative effect than urban facilities throughout the examined services. With regard to facility type, CSPSs were more affected by conflict than CMs, and the negative effects were larger for facilities with high preconflict volume compared with low preconflict volume facilities.

In the online supplemental appendix, we present the results of the supplementary analysis. When running the analysis with monthly coverage rates instead of solely service counts at the health district level, we found very similar results (p 4–5).

In the online supplemental appendix, we also present the results of multiple robustness tests (p 6–12). First, our primary estimates were not considerably sensitive to the precision level of the conflict codes. Both robustness checks, excluding and down-weighting imprecise events, yielded very similar estimates. Second, the results were

Table 2 Effect of conflict intensity and duration

	ANC4 visits		Facility-based deliveries		Caesarean sections		PNC1 visits		Curative care visits (0–4 years)		Curative care visits (5–14 years)	
Equation 1												
Any death	0.961**	(0.932–0.991)	0.928***	(0.905–0.952)	0.906	(0.760–1.079)	0.957**	(0.917–0.999)	0.928***	(0.906–0.951)	0.880***	(0.856–0.904)
Equation 2												
Below median	1.003	(0.968–1.039)	0.959***	(0.937–0.981)	0.959	(0.848–1.086)	1.000	(0.953–1.049)	0.954***	(0.930–0.978)	0.886***	(0.861–0.913)
Above median	0.916***	(0.881–0.953)	0.895***	(0.864–0.928)	0.841	(0.637–1.110)	0.909***	(0.861–0.960)	0.900***	(0.872–0.929)	0.872***	(0.841–0.905)
Equation 3												
1–2 deaths	1.005	(0.963–1.049)	0.976*	(0.951–1.001)	0.917	(0.797–1.056)	0.991	(0.939–1.045)	0.967**	(0.941–0.994)	0.903***	(0.874–0.933)
3–4 deaths	0.999	(0.955–1.046)	0.926***	(0.893–0.961)	1.029	(0.865–1.224)	1.017	(0.948–1.092)	0.928***	(0.892–0.965)	0.855***	(0.815–0.898)
5–14 deaths	0.915***	(0.873–0.958)	0.915***	(0.878–0.953)	0.820	(0.560–1.200)	0.933**	(0.872–0.999)	0.903***	(0.868–0.939)	0.907***	(0.866–0.950)
14+ deaths	0.918***	(0.873–0.966)	0.869***	(0.833–0.907)	0.861	(0.651–1.138)	0.879***	(0.827–0.934)	0.897***	(0.865–0.930)	0.828***	(0.791–0.867)
Equation 4												
Month 1 only	0.972**	(0.948–0.995)	0.951***	(0.933–0.969)	0.951	(0.823–1.098)	0.978	(0.942–1.016)	0.941***	(0.921–0.961)	0.895***	(0.873–0.917)
2 consecutive months	0.963	(0.887–1.045)	0.869***	(0.825–0.914)	0.734**	(0.572–0.941)	0.900**	(0.822–0.986)	0.895***	(0.851–0.941)	0.836***	(0.787–0.888)
3 consecutive months	0.893*	(0.791–1.008)	0.842***	(0.764–0.927)	0.647***	(0.587–0.713)	0.841***	(0.739–0.957)	0.821***	(0.761–0.887)	0.799***	(0.725–0.881)
4 consecutive months	0.768*	(0.578–1.021)	0.726***	(0.600–0.879)			0.902	(0.660–1.233)	0.807***	(0.706–0.923)	0.738***	(0.610–0.893)
5+ consecutive months	0.645*	(0.393–1.058)	0.689**	(0.486–0.976)			0.583***	(0.421–0.808)	0.961	(0.669–1.381)	0.773*	(0.578–1.036)
Observations	208 074		208 685		4556		186 863		215 499		215 328	

Data are IRRs (95% CI) or n. All specifications include time-varying health facility level controls, health facility fixed effects, calendar months as well as a baseline trend and a quadratic term of the baseline trend. Conflict is represented as a binary exposure (equation 1) and is broken down into categorical indicators representing conflict intensity (equations 2 and 3), and conflict duration (equation 4). The estimates under equations 1–3 (figure 2) represent the IRR within health facilities during months of conflict (within 25 km of the health facility) as compared with months without conflict. If the IRR is less than 1, the incident rate is lower during conflict compared with non-conflict. The remaining estimates under equation 4 (figure 3) represent the IRR within health facilities during conflict (within 25 km of the health facility) lasting 1 month only or for consecutive months leading up to the month of health service access as compared with month without conflict. Standard errors (SEs) are clustered at the health facility level.
*p<0.1; **p<0.05; ***p<0.01.
ANC, antenatal care; IRR, incidence rate ratio; PNC, postnatal care.

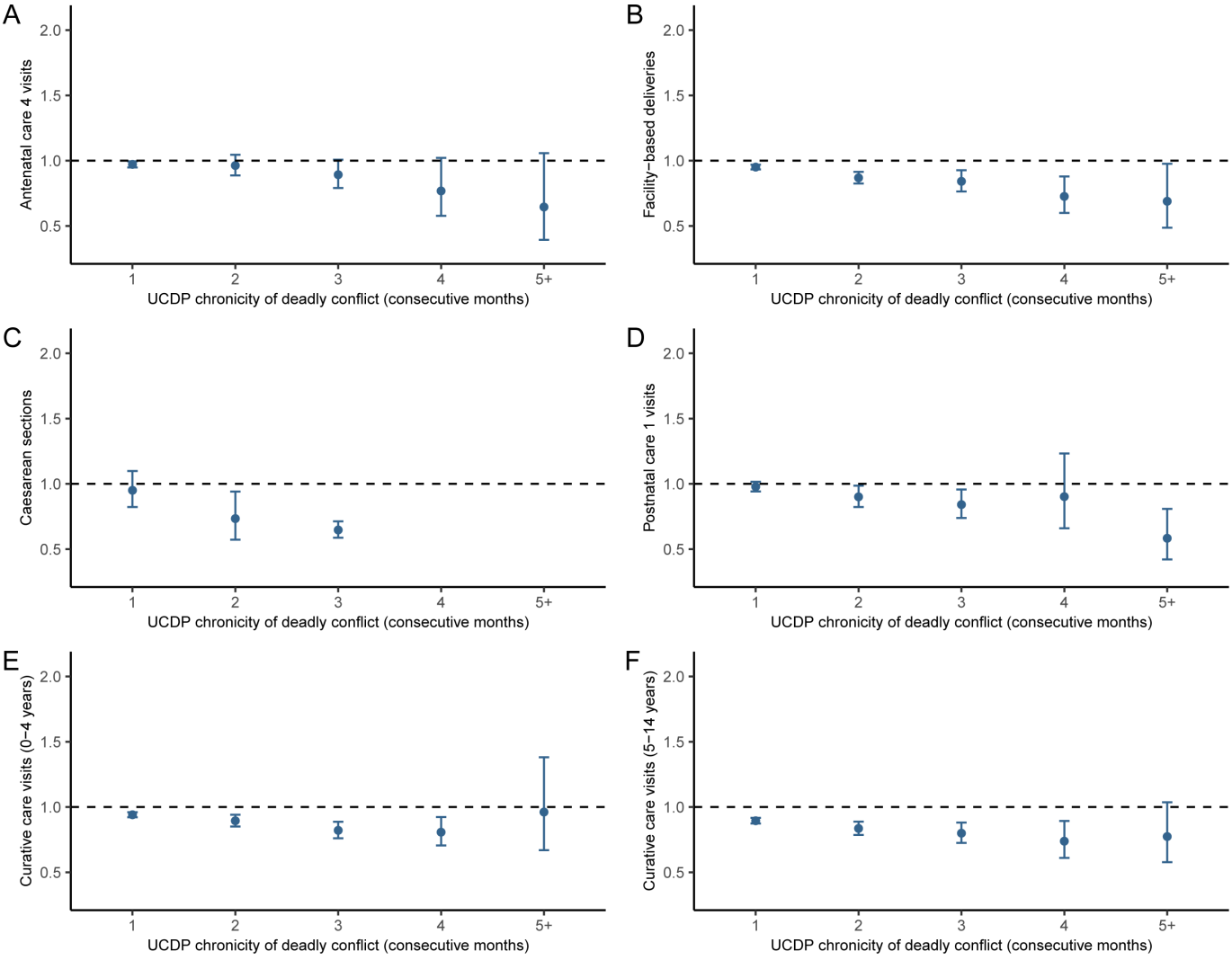

Figure 3 Effect of long-lasting nearby armed conflict on access to health services in Burkina Faso's primary healthcare facilities. This figure shows the effect of conflicts of increasing duration. Exposure is estimated based on the number of consecutive months of conflict within 25 km of the survey cluster leading up to the month of health service access. In panel D, we do not show the point estimate for 4 and 5+ consecutive months of conflict because caesarean sections are only performed in the 46 CMAs and only a few of them were exposed to 4 or 5+ consecutive months of conflict, therefore yielding very large CIs. The y axis indicates the incidence rate ratio (IRR) also reported in the main text. Error bars represent 95% CIs, corresponding to p<0.05 in table 2. UCDP, Uppsala Conflict Data Program; CIs, confidence intervals.

robust to using the ACLED data, an alternative conflict data source that can be leveraged to geolocate conflict events.[3] Third, when using the non-imputed instead of the imputed dataset, we obtained very similar estimates. Next, we showed that the main results were very similar when using year-month fixed effects instead of a baseline time trend. Finally, we found that the effects were stronger for facilities that, in the HeRAMS survey in April 2022, explicitly stated no external support, inaccessibility and non-functionality, further supporting that our conflict definition is valid. In the online supplemental appendix, we also present the geographical distribution of the different health facilities used in the analysis, separated by type (p 13).

DISCUSSION

Since 2015, Burkina Faso has experienced a dramatic insecurity crisis that has worsened year by year. This is the first geospatial study that investigated how access to MCH care services in Burkina Faso's primary healthcare centres and district hospitals changed in response to nearby armed conflict events. Our findings clearly highlight that contemporaneous nearby conflict events drastically reduced access to health services, with more pronounced negative effects being observed for high-intensity conflict events across all MCH services. We also found that the effect on curative care visits was more pronounced for children aged 5–14 years compared with children below 5. Conflict duration appears to affect all health services,

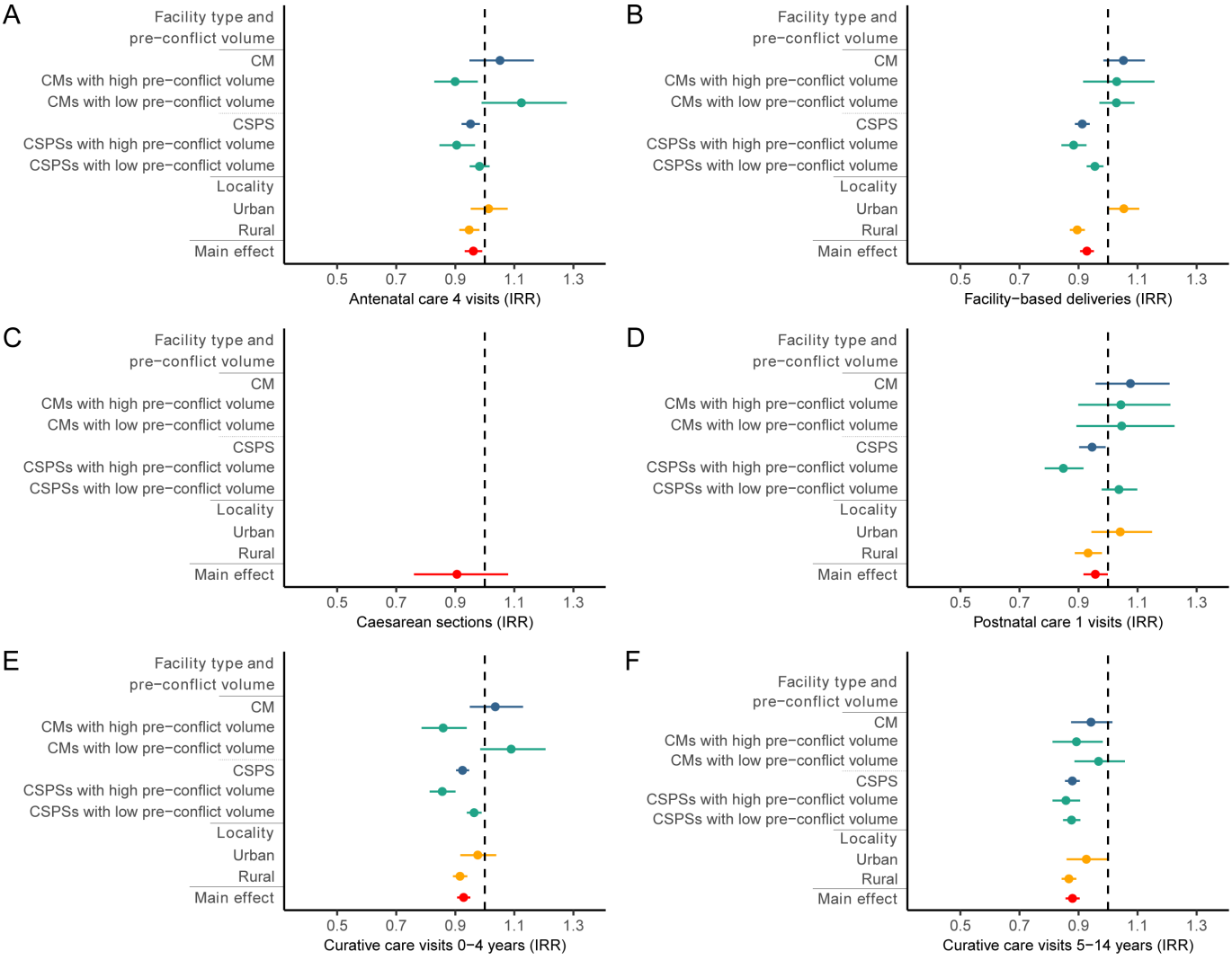

Figure 4 Heterogeneity in the binary effect of nearby armed conflict on access to health services in Burkina Faso's primary healthcare facilities. This figure shows heterogeneity in the binary effect of nearby armed conflict on access to health services in Burkina Faso's primary healthcare facilities (red bars in figure 2) by location (rural or urban), facility type (CSPS or CM), and pre-conflict service volume (high or low). Effect heterogeneity was examined for all services except for caesarean sections which are only performed in 46 urban CMAs. Due to this low overall number of CMAs (n=46), we also did not look at CMAs compared with CMs and CSPSs. Error bars indicate 95% CIs. CSPSs, Centres de santé et de promotion sociale; CMs, Centres médicaux; CMAs, Centres médicaux avec antenne chirurgicale; IRR, incidence rate ratio. CIs, confidence intervals.

except for outpatient care visits for children below 5 and aged 5–14 in prolonged conflicts. Finally, we observed that rural healthcare facilities were more affected than urban healthcare facilities.

Our findings from Burkina Faso confirmed that conflict in all of its shapes and manifestations bears a high toll on health services for women and children in Africa.[2] Moreover, our main results resonate both with previous other case studies that examined health services during conflict in countries other than Burkina Faso as reviewed by Singh *et al*[59] and with existing evidence from Burkina Faso by Druetz *et al*.[5] The latter examined three maternal health services at the commune level and found the same two gradients, that is, the effect size was higher for caesarean sections than for facility-based deliveries than for ANC visits, and increased with exposure to high-intensity conflicts. However, our estimates are higher in magnitude (caesarean sections: 0.906 vs 0.947; facility-based deliveries: 0.928 vs 0.962; ANC: 0.961 vs 0.998), suggesting that their less precise commune-level analysis either underestimated the effect of conflict on access to maternal healthcare or the higher effect magnitude is due to the more conflict-intense years added to our analysis (2019–2021). In case of the latter, we can state that the ongoing escalation of the conflict in Burkina Faso has exacerbated an existing access barrier to MCH services, which had already been observed and documented for certain services during the initial years of the conflict.[5] Regarding the interpretation of the first gradient, we agree with Druetz *et al*.[5] The decrease in healthcare services was moderate for ANC4 visits, possibly because these visits occurred during daytime and could be easily rescheduled or delegated to outreach in the community. However, the reduction was more substantial for facility-based

deliveries and caesarean sections. This finding is very concerning because these services are pivotal in reducing maternal and neonatal mortality.[60] The stronger effect on these two proximal indicators of maternal health could be partly attributed to the fact that deliveries and obstetric emergencies can occur at night when the psychosis of insecurity is at its peak.[61] As a result, women may opt to deliver in their villages, particularly if the nearest primary care facility no longer operates at night. An additional demand-side explanation, complementing the one offered by Druetz *et al*,[5] is that, compared with the other services, ANC is the easiest for which to redirect demand to another, non-conflict-affected facility if one facility is inaccessible. Furthermore, delivery care is more resource-intensive than ANC and relies more heavily on complex infrastructures, medical supply chains, and the availability of professional medical personnel. Therefore, supply-side factors, such as disruptions in the healthcare system caused by nearby conflict events, like lack of fuel and electricity, material shortages, staff absences, and lack of medical transportation to district hospitals, may also explain our findings. Insecurity and direct attacks on health facilities prompted healthcare staff to leave affected areas or to limit their activities, leading to an increasing number of non-functioning health facilities in the country.[20 21 62] Moreover, in areas under attack, armed groups often withdraw ambulances, which prevents the evacuation of women needing caesarean sections.[63] In addition, ANC is also the easiest service to provide as an outreach service if the facility is inaccessible, but some health workers are still able to travel.

Our results on child healthcare services showed that the effects were more pronounced for children aged 5–14 years compared with children under the age of 5. In 2016, with the Gratuité policy, Burkina Faso was one of the first countries in SSA that abolished healthcare user fees completely for children under 5 years of age and for pregnant and lactating women.[6 12] The stronger effects for children aged 5–14 years can be explained by the fact that this age group is not covered by the Gratuité policy and other user fee exemption policies. Conflict can decrease the demand for health services, particularly those involving costly user fees, due to a negative income effect.[51] Due to conflict and displacement, many people in Burkina Faso have also lost their homes, livelihoods and main income sources including harvests and livestock.[20 21] However, Burkina Faso's health financing policies have a protective effect on access to healthcare. For example, Offosse *et al* demonstrate that, even in conflict-affected areas, the Gratuité policy significantly influenced the continuation of health service utilisation. They make a strong case in favour of maintaining funding for the user fee exemption policy to safeguard against potential reversals in progress, particularly if the conflict shows no signs of abating.[64] Moreover, the Gratuité policy allows parents to be more proactive about seeking care for their children below 5 than for children aged 4–15. In a qualitative study involving various stakeholders of the Gratuité policy, health professionals reported that they have witnessed a trend of parents presenting their children under the age of 5 at health facilities earlier since the implementation of the policy.[65] In light of these positive outcomes, we strongly recommend sustaining the policy despite challenges during periods of instability and advocate for its extension to include older age groups. Beyond the Gratuité policy, curative care visits for children under 5 might also be seen as more important than for more resilient older children between the age of 5 and 14. Hence, parents might take greater risks to travel to a facility. On the supply side, under resource constraints, healthcare providers often prioritise children under 5 over older children because they are generally considered more vulnerable.

Our findings from the duration analysis suggest that the adverse impact of conflict on access to maternal health services tends to worsen with the duration of the conflict, but not for children's outpatient care services in prolonged conflicts. The identified effects are in line with Amberg *et al*,[66] who found the same pattern when examining health service coverage during conflict throughout SSA. The pattern has normally been explained as follows. While health systems, with or without support from humanitarian agencies, may manage to mitigate the disruption caused by conflict to reinstate relatively simple services such as routine outpatient care for children, they might face challenges providing more resource-intensive services such as deliveries. These services rely heavily on complex infrastructures, medical supply chains and the availability of professional medical personnel. Initial evidence supporting this generic explanation comes from the work of Gaffey *et al* who emphasise the feasibility of delivering curative child health services in conflict settings with varying intensity and in a cost-effective manner through integrated community case management and mobile programmes.[67] However, our results from Burkina Faso show that ANC and PNC, also less technically complicated services, are less affected by nearby conflict than outpatient consultations. If the supply side explanation described above were also true for Burkina Faso, we would expect similar effect magnitudes, which is not the case. Therefore, in Burkina Faso specifically, we think that the demand side offers additional explanations. We hypothesise that our findings also result from a disruption to the continuum of care in maternity services. Outside of conflict situations, it is well established that if women do not go for ANC, they are less likely to go for facility-based childbirth and PNC.[68] Being affected by conflict early in the maternity continuum of care may compound this effect.[69] We would not expect such a compounding effect for acute childhood conditions, which are independent of each other. As care for acute conditions is necessary, however, it is reasonable to assume that service provision and utilisation somehow stabilises as conflict becomes chronic.

We observed that the adverse effects of armed conflict on access to healthcare at primary healthcare facilities

are more pronounced in rural compared with urban settings and CSPSs compared with CMs. These findings can be explained by the fact that insecurity in Burkina Faso tends to be higher in proximity to rural facilities as opposed to urban facilities because conflict events are more pronounced in remote and isolated villages than in medium-sized towns or large cities.[63] When exposed to nearby conflict events, rural facilities are more likely to be forced to significantly reduce service volume. Ouedraogo *et al* showed that, with the closure and minimal functioning of certain health facilities in security-challenged areas, the healthcare workforce is concentrated in the urban areas of regional and district capitals, to the detriment of rural areas.[70] Moreover, rural populations are more likely to be faced with limited physical access compared with their urban counterparts. In urban settings, unless the facility has been directly hit, service provision often continues. Since CMs are usually in (semi)urban areas, whereas CSPSs are mostly located in rural areas, the same explanation applies to the identified difference between these facility types. Furthermore, except for the fact that high preconflict volume facilities are more affected in our study, the finding is aligned with existing evidence from neighbouring Mali. Bonnet *et al* revealed an important territorial heterogeneity of assisted deliveries in two conflict-affected districts in Mali.[62] To access maternal care, populations moved to less exposed areas and more efficient facilities, which are usually located in urban areas. The health facilities experiencing reduced rates of assisted deliveries were characterised by the reluctance of qualified health workers to practice, limited financial resources among the populations they served, and a tendency among the population to restrict travel in order to minimise exposure to insecurity. Our heterogeneity results suggest that a similar population movement and care-seeking behaviour (from more exposed rural to less exposed urban areas, and CSPSs to CMs) is happening in Burkina Faso, but supportive spatial analyses as well as qualitative data are needed to confirm this. The additional spatial studies should map the areas where there has been a sharp increase or decrease in access to healthcare and examine how these spatial shifts and their evolution over time relate to nearby conflict dynamics, health facility characteristics and geo-spatial determinants.

Our study's findings on the impact of armed conflict on health services in Burkina Faso align with patterns observed in other regions. In Mali, there is evidence that conflict has significantly disrupted MCH services, emphasising the need for adaptable funding and management mechanisms.[71] South Sudan displays a comparable situation, where conflict severely restricts access to healthcare services, exacerbated by barriers such as lack of security, transport and supplies.[72 73] Northern Uganda and Burundi also report declines in maternal healthcare utilisation due to conflict, highlighting ongoing challenges in service accessibility.[74–76] The Boko Haram insurgency in Nigeria mirrors these disruptions, reducing ANC and facility-based deliveries.[25] In northeastern Nigeria, humanitarian aid has somewhat mitigated the negative impacts of conflict on health services.[77] Afghanistan and Pakistan experience additional complications such as weak health systems and poor coordination, which further impair service delivery during conflict.[78 79] These comparisons underscore the widespread and diverse effects of conflict on health services, underscoring the need for targeted, context-specific interventions.

Limitations

Despite the strengths highlighted in the preceding paragraphs, the study has some limitations. First, due to the nature of the data used in our study, it was impossible to differentiate the extent to which disruptions in access to healthcare were caused by demand or supply factors. Second, there is a possibility of selection bias due to missing data, particularly in conflict-affected areas where data reporting is challenging and not prioritised.[80] Facilities situated in more insecure areas may be more likely to experience issues like ceased data entry in record books or interruptions in transmitting information to the health district. Consequently, this could lead to a downward bias in our estimates, which would tend to be even more negative if data availability and quality were comparable to peaceful times. Third, disruptions caused by COVID-19 were not factored into the models. However, the COVID-19 pandemic was perceived as merely one among several crises and did not significantly influence the broader context. In the case of Burkina Faso, there was the lockdown period with significant disruptions,[81] but conditions returned to normal relatively quickly.[82] Fourth, the routine HMIS data used in this study lack information about activities by humanitarian NGOs, which cover needs of the population in some conflict-affected areas. Fifth, our estimation relied on location estimates from the UCDP GED, which could introduce measurement error in conflict exposure due to spatial imprecision in location estimates of the UCDP conflict events. However, we addressed this concern by either excluding conflict events lacking precision or weighting observations based on their level of precision, resulting in largely unchanged results. Additionally, we guarded against this measurement error by using the UCDP GED, which adopts a more rigorous definition of armed conflicts compared with the ACLED dataset.[83] Moreover, the use of a 25 km conflict radius in measuring conflict exposure served to safeguard against measurement errors and ensured that we did not employ a conflict band that was too large, thereby maintaining the plausibility of the conflict effects. Finally, it was not possible to adjust the estimates for variations in populations at the health facility level. Reliable data on target populations was only available at the health district level. When we ran our analysis at the health district level, at which we were able to translate the monthly service counts into indicators that account for the underlying target population living in a health district, we found very similar effects.

CONCLUSIONS

Our study highlights the importance of investigating access to health services at the most detailed levels, considering and not overlooking local dynamics. Additionally, there is a need to explore accessibility to healthcare during conflict across various health services and financing schemes. Through our comprehensive and fine-scaled analysis of how the conflict crisis in Burkina Faso impacts access to maternal and child healthcare, we were able to examine why certain services are more affected by conflict than others. Nevertheless, grasping these effects becomes complex. Future research should conduct supportive spatial analyses and gather qualitative data to differentiate the extent to which disruptions in access to healthcare were caused by demand or supply factors and to gain a more comprehensive understanding of the local dynamics and contextual factors behind the effects identified in this study.

Our findings can also assist in prioritising MCH interventions in Burkina Faso's conflict crisis by offering valuable insights into which MCH services are most impacted by armed conflict. This information can guide the implementation of interventions during conflict, addressing the questions of what, where and how to approach these crucial interventions effectively. We trust our analysis to motivate the efforts of Burkina Faso's MoH to design innovative strategies or improve already implemented ones aimed at keeping the health system operational.

Author affiliations
[1]Heidelberg Institute of Global Health, Heidelberg University Hospital and Medical Faculty, Heidelberg University, Heidelberg, Germany
[2]Geneva Centre of Humanitarian Studies, University of Geneva Faculty of Medicine, Geneva, Switzerland
[3]Department of Global Health and Development, Faculty of Public Health and Policy + Health in Humanitarian Crises Centre, London School of Hygiene & Tropical Medicine, London, UK
[4]Centre Population et Développement, Paris, France
[5]Institut de Recherche pour le Développement, Paris, France
[6]Ministère de la Santé et de l'Hygiène Publique, Ouagadougou, Burkina Faso
[7]Centre de Recherche en Sante de Nouna, Nouna, Burkina Faso
[8]London School of Hygiene & Tropical Medicine, London, UK

X Karl Blanchet @BlanchetKarl, Neha S Singh @neha_s_singh and Valéry Ridde @ValeryRidde

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Contributors FA and MDA conceptualised and designed the study. FA extracted, cleaned, merged and analysed the data. FA wrote the first draft of the manuscript, which was critically revised by all authors. MDA accessed and verified the data and the analysis. FA, KB, NSS, VR, EB, SPY, AS, MS, JL and MDA had full access to all the data in the study, helped to interpret the results and took the final responsibility for the decision to submit for publication. FA, KB, NSS, VR, EB, SPY, AS, MS, JL and MDA are responsible for the overall content (as guarantor).

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ORCID iDs
Felix Amberg http://orcid.org/0000-0003-4066-9254
Karl Blanchet http://orcid.org/0000-0003-0498-8020
Neha S Singh http://orcid.org/0000-0003-0057-121X
Valéry Ridde http://orcid.org/0000-0001-9299-8266
Emmanuel Bonnet http://orcid.org/0000-0001-6735-5330
Pierre Yaméogo http://orcid.org/0000-0001-7019-171X
Ali Sie http://orcid.org/0000-0002-3959-2520
Mariam Seynou http://orcid.org/0000-0002-2847-0923
Julia Lohmann http://orcid.org/0000-0003-4136-9296
Manuela De Allegri http://orcid.org/0000-0002-8677-1337

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