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Medication against conflict☆

Andrea Berlanda [a], Matteo Cervellati [b,c], Elena Esposito [g], Dominic Rohner [d,e,c], Uwe Sunde [f,c,*]

[a] University of Padova, Italy
[b] University of Bologna, Italy
[c] CEPR, United Kingdom
[d] University of Lausanne, Switzerland
[e] E4S, Switzerland
[f] University Munich, Germany
[g] University of Torino, Collegio Carlo Alberto, Torino, Italy

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ABSTRACT

Adverse health conditions and social conflict constitute major impediments for developing countries. The potential for reducing social conflict by successful public health interventions is largely unknown. This paper closes this gap by evaluating the effect of a major health intervention—the successful expansion of antiretroviral therapy (ART) to combat the HIV/AIDS pandemic in Africa. Combining exogenous time variation in access to ART with cross-sectional variation in the scope for treatment for identification, we find that the ART expansion significantly reduced the number of violent events in African countries and sub-national regions. The effect pertains to social conflict, not civil war. The evidence also shows that the effect is related to health improvements, greater approval of government policy, and increased trust in political institutions. Results of a counterfactual simulation reveal that the ART expansion reduced the number of social conflict events by about 10%.

1. Introduction

Adverse health conditions and recurrent violence constitute major problems for developing countries. This is particularly the case in Africa, which is plagued by widespread social conflict, insecurity, and unrest. At the same time, Africa is particularly affected by the spread of communicable diseases. A growing body of empirical research has sought to shed light on the determinants of social conflict. This literature typically interprets adverse health conditions as a consequence of social conflict and instead focuses on population dynamics, weak institutions, ethnic tensions, natural resource competition, income and commodity price shocks, short-term weather driven shocks, and climate as the key drivers, as discussed in more detail below. However, the evidence from these studies often has no clear implications for policy, or policy implications that are difficult to implement.

Recent evidence indicates that causality might also go the other way, with health shocks leading to social conflict. If this were the case, it would raise the question whether public health interventions, which are often very successful in improving public health, might also have a mitigating effect on social conflict. Yet, surprisingly little is known about the consequences of major health interventions in this domain.

This paper closes this gap in the literature by investigating whether health interventions play a potentially relevant role in reducing social conflict. To address this question, we perform a first systematic empirical investigation of the effects of a large-scale health policy, the roll-out of combined antiretroviral therapy (ART) to combat HIV/AIDS, on violent events in Africa. We ask whether, by successfully combating the HIV/AIDS pandemic in Africa, the ART expansion also led to a reduction in social conflict, and, if so, through which channels.

The HIV/AIDS pandemic constitutes a major global public health challenge. Around 24 million people in Africa still live with HIV, with an annual death toll of half a million and a prevalence of a fourth of the population in some countries. Besides the serious health consequences, the HIV pandemic led to lower labor productivity, increased expenditures for medication and assistance, and increased poverty. Following

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* Corresponding author at: University Munich, Germany.
E-mail address: uwe.sunde@lmu.de (U. Sunde).

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the massive increase in HIV prevalence and in view of projections of global infections and mortality, scientists and international organizations raised serious concerns regarding the grim outlook for the socio-economic consequences of the pandemic. This included warnings of the risk of widespread anger, social unrest and violence in the face of inadequate health policies (Birmingham, 2000; Kumar, 2000; Fourie and Schönteich, 2001; Feldbaum et al., 2006; de Waal, 2010). International organizations emphasized repeatedly that the dissatisfaction with government policies and the associated erosion of trust in institutions potentially plays an important role for the failure of many countries in building peaceful and inclusive societies (see, e.g., OECD, 2017; United Nations, 2021). Soon after the turn of the millennium, a massive worldwide roll-out of ART for HIV-positive individuals followed as consequence of a substantial decline in the costs of drug production. This health intervention yielded substantial health improvements, reductions in mortality, and a recovery of labor productivity. To the extent that labor productivity and opportunity costs play important roles for explaining incentives to engage in protests, riots and other forms of social conflict, the success of such public health interventions like the ART roll-out may be expected to also reduce social conflict. Hence, besides restoring labor productivity and fostering individual medical and economic well-being, public health interventions might help restoring confidence and trust in institutions and the government and thereby have a pacifying effect. However, evidence for the hypothesis that major health interventions like the expansion of ART reduce conflict is still missing.

Our empirical analysis combines cross-sectional variation in the potential for ART treatment (based on HIV prevalence before the availability of ART) with time variation in the access to ART at the global level (based on the global variation in prices and production costs of ART drugs that was driving the dynamics of coverage with ART worldwide). The analysis is conducted at the level of countries and sub-national regions, applying a variety of estimation methods and robustness checks.

We provide evidence that the expansion of coverage with ART led to a significant reduction in the number of violent events in African countries and sub-national regions. This reduction pertains, in particular, to riots and demonstrations related to economic and human rights motives, but not to large scale armed conflict. A large set of potential confounds can be ruled out as driving the result. The effect works partly through a reduction in economic grievances, but we find evidence for an independent effect of health interventions that does not work through economic well-being *per se*. An analysis of potential channels reveals that the expansion of ART was associated with an increase in individual trust in institutions like the parliament and the local government, and with an increase in individual approval of government policies related to the management of HIV, of basic health provision, and economics in general, but not with policies related to education. Taken together, these findings imply that ill health may be a potent driver of social unrest and violence, and that besides improving health and economic conditions, public health interventions can also help curbing social conflict. The results of a counterfactual simulation analysis suggest that the expansion of ART lead to a sizable reduction of social conflict events, especially in countries with high HIV prevalence.

Our analysis contributes to the recent literature in several ways. Existing empirical studies on the root causes of social conflict have focused on purely economic motifs, using income and commodity price shocks (Dube and Vargas, 2013; Bazzi and Blattman, 2014; McGuirk and Burke, 2020; Berman et al., 2021), short-term weather driven shocks (Miguel et al., 2004; Dell et al., 2014; König et al., 2017; Harari and Ferrara, 2018), and climate (Theisen et al., 2013; Burke et al., 2015; Breckner and Sunde, 2019) to identify causal links. Related work has pointed at the role of weak institutions (Besley and Persson, 2011), ethnic tensions (Esteban et al., 2012), natural resource competition (Caselli et al., 2015; Berman et al., 2017; Rohner, 2018) and population (Acemoglu et al., 2020). A few recent studies have found evidence for weather-related health shocks as a previously largely overlooked cause of social conflict (Cervellati et al., 2017, 2022). Evidence for the impact of public health interventions, and an evaluation of whether and through which channels public health interventions affect social conflict, however, is largely missing. Our paper fills this gap.

While addressing the role of major health interventions is of foremost importance from a policy perspective, to our knowledge, there exists no systematic evaluation of the effects of major health interventions on social conflict. Our work thereby complements research on the effects of policy for social conflict, which has considered foreign aid (de Ree and Nillesen, 2009; Savun and Tirone, 2012; Nunn and Qian, 2014), cash transfers (Crost et al., 2014), infrastructure investments (Berman et al., 2011), reconciliation (Ciliers et al., 2016), and employment policies (Blattman and Annan, 2016; Fetzer, 2020), but which has neglected the role of health interventions. In fact, the results of the existing literature suggest that the effects of policy interventions to prevent or reduce social conflict are generally mixed, and policies that resulted in the disbursement of appropriable cash were generally much less successful than policies that led to a higher opportunity cost of fighting (see, e.g., Rohner and Thoenig, 2020, for a survey). This is exactly what health interventions accomplish, so our results contribute an important missing piece of evidence regarding the scope of policy interventions against conflict. Our findings also provide evidence that support arguments that health interventions help fostering trust in states and policies (see, e.g., Khemani, 2020).

On a more general level, the result that health interventions also help reducing social conflict implies that taking into account additional societal and economic benefits beyond individual health effects is key for appraising the impact of public health policy. The results therefore complement findings of economic effects of major health interventions such as the ART expansion in specific countries (see, e.g., Baranov et al., 2015; Baranov and Kohler, 2018). Our analysis also complements findings of a positive effect of the expansion of ART on economic growth (Tompsett, 2020) and of recent work that has documented a positive effect of the expansion of ART on consumption and used this to evaluate the relative importance of health improvements and economic growth for increasing welfare (Da Costa, 2023). Our findings thereby suggest the usefulness of a broad assessment of the overall socio-economic benefits of health policies.

From the perspective of political economy, the findings indicate that public health interventions are a key source of political legitimacy for institutions and incumbent governments. The critical role of trust in institutions for building peaceful and inclusive societies, and the role of satisfaction with government policies, has been emphasized repeatedly by international organizations (see, e.g., OECD, 2017; United Nations, 2021), but direct evidence for how specific policies, in particular health policies, contribute to strengthening trust in institutions is still scarce. In particular, our findings complement recent evidence on the role of economic hardship and public support for democracies as well as the rise of populism (e.g., Algan et al., 2017; Claassen, 2020). Evidence for public health interventions helping to restore trust in government contributes a new aspect to the literature on the role of state responses to epidemics (Cordell et al., 2023) and of state performance for political trust (see, e.g., Citrin and Stoker, 2018, for a survey). Our evidence is also consistent with recent findings for the role of life expectancy for democratic attitudes (Lechler and Sunde, 2019). In light of recent calls by international organizations for the need of fostering trust in institutions in order to maintain economic and political security (OECD, 2017; United Nations, 2021), our results are informative about policies that are effective in this dimension.

The remainder of the paper is organized as follows. Section 2 describes the data and the empirical methodology. Section 3 presents the empirical results, Section 4 shows evidence for the underlying mechanisms, Section 5 provides a discussion of the quantitative implications and policy implications, and Section 6 concludes.

2. Data and empirical strategy

2.1. Background: HIV and ART coverage in Africa

The human immunodeficiency virus (HIV) impairs the function of white blood cells in the immune system (CD4 cells) and replicates itself inside these cells. As consequence, infected individuals experience a weakening of the immune system, making the body vulnerable to infections and some types of cancer. In advanced stages, the infection turns into the acquired immunodeficiency syndrome (AIDS), which ultimately leads to death. Recent evidence suggests that the most infective strain of HIV crossed from chimpanzees to humans probably before 1920 in Cameroon, while the beginning of the spread of HIV across Africa has been traced back to Kinshasa, located in today's Democratic Republic of Congo, around 1920 (Gao et al., 1999; Faria et al., 2014). From the late 1970s onwards, the spread of HIV turned into an epidemic that swept across Africa. By 1980, about half of human infections in the Democratic Republic of Congo were observed outside of Kinshasa. In Africa, the virus subsequently diffused out of the Democratic Republic of Congo, first towards the great lakes area and then along the East of Africa, eventually reaching the Mediterranean basin and South Africa as well as the North-West towards Nigeria during the 1990's (Kalipeni and Zulu, 2012). By 2000, an estimated 26 million adults and children lived with HIV/AIDS in Africa, constituting more than 70 percent of the global infections.[1]

During the early 1980s, the then still unknown disease rapidly spread across the world, leading to the first clinical and epidemiological observations of AIDS in 1981. The severity led to intense microbiological research. During the early 1980s, the retrovirus responsible for AIDS (the HIV-1 virus) was isolated successfully, and subsequent discoveries concerned the transmission and life cycle of HIV. The identification of the main receptors of the HIV led to the development of combination antiretroviral therapy (ART) in the late 1990s (see, e.g., Barré-Sinoussi et al., 2013, for a survey of the history of HIV research). Parallel to the scientific advances, campaigns to inhibit a further spread of HIV and the development and widespread distribution of drugs to treat HIV/AIDS also became important issues on the political agendas of national governments and international organizations. This led to mounting pressure by international non-government organizations (NGOs) on pharmaceutical companies to no longer prevent the distribution of generics, which culminated in the introduction of generic drugs for antiretroviral therapy in 2001. The subsequent expansion of the availability of ART drugs, which was heavily supported by the Global Fund and the WHO through its "3-by-5" initiative, led to a significant reduction in morbidity and mortality and a restoration of immunity in infected persons. Ultimately, the availability of ART transformed HIV infections from fatal to a manageable chronic disease with moderate implications for life expectancy if treated appropriately, and international organizations and NGOs continue to exert great effort on expanding coverage of ART, particularly in Africa.

2.2. Data

Our analysis is based on observational data at the country level for 50 African countries and at sub-national administrative level 1 for 170 regions in 18 African countries over the period 1990–2017.

We use geo-localized data for events of social conflict from multiple sources. The baseline analysis uses the Social Conflict Analysis Database (SCAD), which is a compilation of conflict events based on global press coverage. The SCAD data represents a complete and extensive measure of social conflict of different forms (protests, demonstrations, riots, strikes, and other forms of social disturbances) and comprises a classification of different event types, including organized events, spontaneous events, and events related to elections, economic grievances, or human rights. In addition, the data contain information on event sizes, in terms of casualties and participants. Based on the narratives contained in the data set, it is also possible to isolate different event types related to targets or actors involved in events (such as NGOs, health workers, or civil servants), which allows a detailed investigation of the mechanisms underlying outbreaks of social conflict. The main advantage of the SCAD data in comparison to other frequently used data sources is that it focuses on social conflict defined as social and political unrest, as opposed to large-scale organized armed conflicts. Moreover, the SCAD data are available for long time periods and exhibit high data quality.

In further analysis, we also use data on riots and protests from alternative sources such as the Armed Conflict Location and Event Data (ACLED), the Global Database of Events, Language, and Tone (GDELT), and data on organized violence involving the state collected by the Uppsala Conflict Data Program (UCDP) to gain a more complete picture. Detailed descriptions of the various data sources, the definitions of violent events, and the different aspects covered by the different data sets are contained in the Supplementary Appendix.

Data for HIV prevalence and coverage with ART at the country level are provided by UNAIDS for 50 African countries. HIV prevalence information is based on model estimates by UNAIDS, which collects all country estimates and reviews them in order to guarantee that estimates are comparable across regions and countries over time. Information on coverage of ART is based on national registers of antiretroviral therapy, and is compiled by UNAIDS. For the analysis, we construct a measure of ART coverage measured as the share of individuals receiving treatment over the total population. Regional HIV prevalence (at administrative level 1) is constructed by us using survey data from the Demographic and Health Survey Program (DHS), which represents a comprehensive source of sub-national information to map HIV prevalence. We assembled sub-national level measures of HIV prevalence for 170 regions over 18 African countries (see Figures 1 and A1 in the Supplementary Appendix).

The identification strategy makes use of data on the global price of the first line of combined ART treatment as well as of information about the costs of the active pharmaceutical ingredients used in the production of these treatment lines. The respective data have been collected by the WHO Global Price Reporting Mechanism and by the Global Fund Pooled Procurement Mechanism Reference Pricing and cover approximately 70-80 percent of the global transactions of the respective drugs.

Additional data on population and life expectancy at birth is provided by the UN Population Division and various Census reports. Information on GDP is from the World Bank. Information on trust in institutions is extracted from individual survey responses from the Afrobarometer.

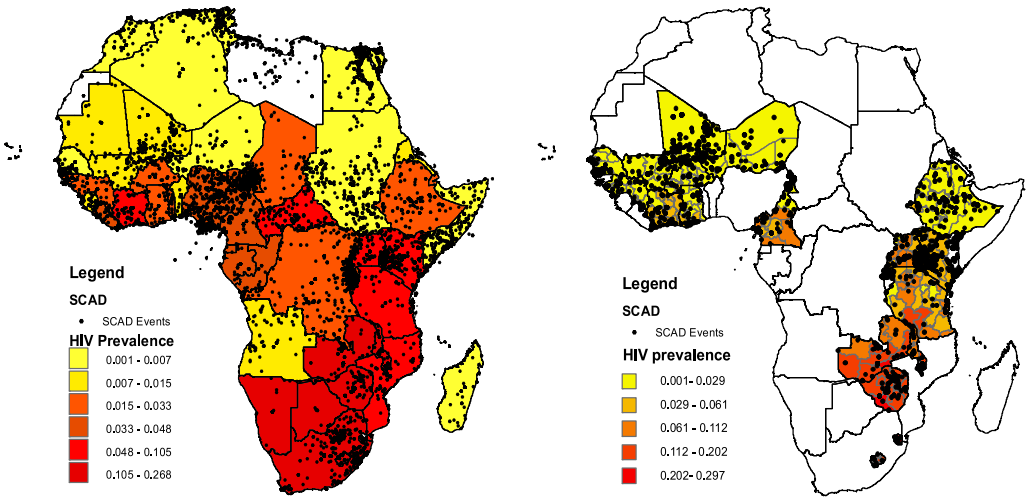
Detailed information about data sources, variable definitions and the construction of the variables used for estimation as well as of the construction of the samples at the country-level and at sub-national level is contained in the Supplementary Appendix (Section A1).

2.3. A graphical illustration of the conceptual approach

During the 1990s, HIV prevalence in Africa increased steadily to almost 5% of the African population. Starting with the expansion of ART during the early 2000s, which led to a coverage of around 50% of infected persons by the mid 2010s, HIV prevalence began to decline (see also Appendix Figure A2). This reversal prevented an estimated 9.5 million deaths and brought considerable economic benefits (Forsythe et al., 2019), mainly by contributing to a substantial reduction in mortality (Bor et al., 2013; Tompsett, 2020) and leading to a recovery of labor productivity (Habyarimana et al., 2010; Bor et al., 2012; Baranov et al., 2015).

Fig. 1 shows a map of HIV prevalence in 2001 and the distribution violent events (SCAD) aggregated over the entire observation period

[1] See, e.g., the December 2000 AIDS epidemic update by UNAIDS/WHO.



(a) Country Sample (b) Sub-National Regions Sample

Fig. 1. HIV Prevalence and Social Conflict in Africa: SCAD
Note: Panel (a): HIV prevalence in 2001 and location of violent events (SCAD) aggregated at the country level. Panel (b): HIV prevalence and location of violent events (SCAD) at the level of sub-national regions as contained in the sample. See Appendix A.3 for summary statistics.

for the country sample and for the sample of sub-national regions. The descriptive statistics indicate that countries with HIV prevalence above the median in Africa experienced substantially more events of social conflict prior to the expansion of ART (i.e., before 2001) than countries with low HIV prevalence. In contrast, in the period after 2001, the incidence of social conflict is about the same (see Appendix Table A2).[2]

We test the hypothesis that the expansion of ART was causally responsible for a relative decline in social conflict. To illustrate the logic of the identification strategy followed below and to obtain a first impression of the impact of the availability of ART on social conflict, Fig. 2 shows the results of applying a synthetic control approach. This approach constitutes a data driven procedure to compare countries with different intensity of the treatment in the context of the expansion of ART. This is done by comparing the social conflict outcomes of a country with relatively high treatment intensity to a weighted average of the outcomes of a group of comparison countries with low treatment intensity. The comparison group is constructed in a way to closely resemble the characteristics of the country with high treatment intensity prior to treatment (Abadie and Gardeazabal, 2003; Abadie et al., 2010, 2015; Abadie, 2021). In the figure, we consider the 10% of countries with the highest coverage of ART (relative to the population) after 2001 and contrast them with a time-varying counterfactual unit for each country which is constructed from the bottom 10% of countries with lowest coverage of ART after 2001 based on a list of covariates; alternatively, we compare the top 25% with the bottom 25%.[3] The graph illustrates that the synthetic control method delivers a counterfactual that closely mimics the treatment group during the period prior to the expansion of ART. After the onset, the group with more intense treatment experienced a more moderate development of social conflict than the synthetic control group. In the next section, we present our main empirical strategy to account for systematic variation of potentially confounding factors.

[2] A similar pattern is found at the level of sub-national regions, see Appendix Table A3.

[3] The counterfactual for each treated unit is constructed using a weighted combination of different control units based on covariates. The covariates are social conflict and population between 1995 and 2000, HIV prevalence among the population age 15–49 between 1995 and 2000, shares of land within 100 km of ice-free coast, of desert and of land in tropical climate, as well as latitude and longitude. Figure A5 in the Appendix shows the corresponding results for relating coverage of ART to HIV prevalence.

2.4. Estimation and identification

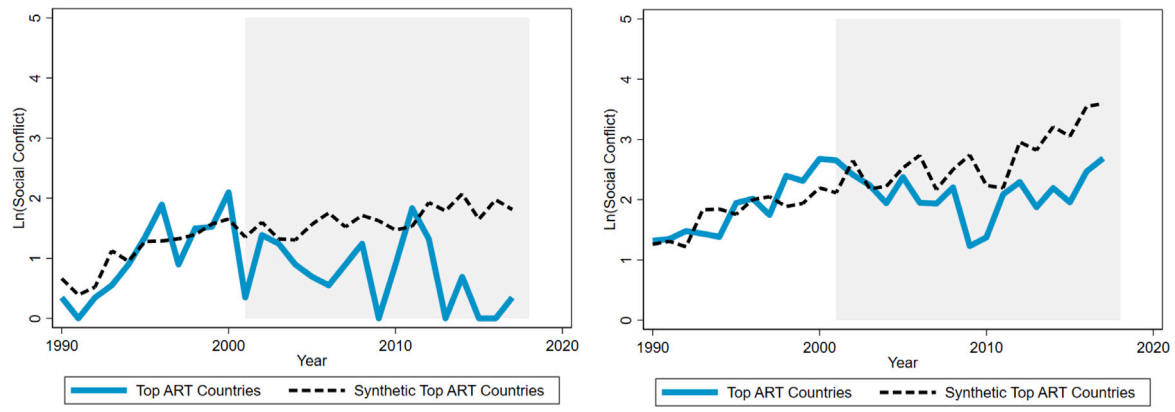
Estimation. The empirical analysis is conducted at the country level as well as on the level of sub-national regions as units of observations. The availability of data implies the necessity of employing slightly different empirical approaches for the analysis at the country level and at the level of sub-national regions. On the country level, the empirical analysis to identify the effect of interest is based on the model

$$Violence_{c,t} = \beta \cdot ART_{c,t} + \gamma X_{c,t} + \delta_c + \zeta_t + \rho_R \cdot t + \varepsilon_{c,t} \quad \text{(OLS/2SLS–Stage 2)}$$

which is a regression of social conflict in country c and year t on coverage of ART, control variables $X_{c,t}$, country fixed effects δ_c, year fixed effects ζ_t, African-subregion-specific linear time trends $\rho_R \cdot t$, and an error term ε. As an alternative to African-subregion-specific linear time trends, in extended specifications we include country-specific linear time trends.

The identification of the effect of coverage of ART (ART) on social conflict, β, relies on the assumption that coverage of ART is uncorrelated with unobserved or omitted confounding factors contained in the error term ε. Violation of this assumption leads to biased estimates and may materialize in a spurious effect. In particular, this would be the case if coverage of ART and the level of social conflict are both correlated with unobserved factors that create problems of omitted variables or reverse causality. Examples for omitted confounders include institutions: if countries with better institutions and public governance, or just a better economic performance, are more effective in providing health services and coverage of ART and, at the same time, more effective in reducing social tensions and violence, this would imply simultaneity bias. Examples for reverse causality include political pressure: if social conflict in terms of strikes and demonstrations in a country leads to an intensified effort to treat HIV by governments, international organizations or international aid donors, this would reflect reverse causality from violence to coverage of ART.

The inclusion of country fixed effects accounts for concerns related to systematic time-invariant confounders operating at the country level, such as average institutional quality, public governance, or variation in population size or population density. Likewise, the inclusion of time fixed effects accounts for factors that affect social conflict in a given year and that are common to all countries, which include the possible role of events that affect several countries at the same time and whose influence might vary over time (such as the Arab spring movements, or health initiatives by international donors or organizations).



(a) Top 10% vs. Bottom 10% (b) Top 25% vs. Bottom 25%

Fig. 2. ART Expansion and Social Conflict: Synthetic Control Approach
Note: Results based on the synthetic control method. For each treated unit, the incidence of social conflict is computed under the average treatment and for the synthetic counterfactual. The graph plots averages across all treated units. With the intervention period beginning in 2001, the synthetic control is computed for each treated unit by minimizing the mean squared prediction error (MSPE) relative to the treated units during the pre-intervention period 1990 to 2000. As predictor variables for the construction of the weighted counterfactual of each treated unit, the procedure uses the average log number of conflict events, population and HIV prevalence (all measured between 1990 to 2000), the fraction of the country area within 100 km from the coast, the fraction of desert and of tropical forest, latitude and longitude.

The inclusion of an extensive set of time-varying control variables accounts for a variety of potential confounds. Specifically, the empirical specification includes controls for (i) country-specific trends in HIV prevalence to account for country-specific initial conditions in terms of HIV prevalence at the onset of the ART expansion; (ii) time trends for macro-regions within Africa to account for time-varying effects related to variation or interventions in specific macro areas (e.g., the increase in Islamic militant violence in Northern Africa during the early 2000s); and (iii) country-specific time trends for countries to account for trend-varying confounders operating in different countries with similar level of HIV.

Identification strategy. To further address identification concerns related to time-varying unobserved factors or reverse causality, the analysis employs an identification strategy that is based on instrumental variables and 2SLS estimation. The instrument for coverage of ART combines cross-sectional variation in the local scope for the expansion of ART, $Z_{c,2001}$, and the global time-series variation in the access to ART, $ART_{IV,t}$. The resulting first stage regression model with instrument $Z_{c,2001} \cdot ART_{IV,t}$ is

$$\text{ART}_{c,t} = \alpha \cdot Z_{c,2001} \cdot ART_{IV,t} + \gamma X_{c,t} + \delta_c + \zeta_t + \rho_R \cdot t + u_{c,t}\,. \quad \text{(2SLS–Stage 1)}$$

We use different measures in both dimensions to construct the instrumental variable as discussed in detail below.

In the intention-to-treat (ITT, or reduced form) analysis, social conflict is regressed directly on the instrument. This analysis does not require a reliable geo-referenced and time-varying measure of coverage of ART as instrumented variable. This implies that, in addition to a country-level analysis, this analysis can also be conducted at the level of sub-national regions, where such data are unavailable. For comparability, we therefore conduct intention-to-treat estimations at the national and sub-national levels. The estimation framework is given by

$$Violence_{r,t} = \phi \cdot Z_{r,2001} \cdot ART_{IV,t} + \gamma X_{r,t} + \delta_r + \zeta_t + \rho_c \cdot t + \epsilon_{r,t}\,, \qquad \text{(ITT)}$$

for data at the level of countries or sub-national, administrative regions r; the specification includes country-specific linear time trends $\rho_c \cdot t$. Throughout, the main effect (linear term) of the cross-sectional term of scope for ART, $Z_{c,2001}$ or $Z_{r,2001}$, is absorbed by the (country or region) fixed effects, δ_r, and the time-varying instrument for coverage of ART, $ART_{IV,t}$, is absorbed by the year fixed effects ζ_t. Extended specifications also include country-year fixed effects, implying that the estimates are based on variation occurring within the same country during a given year.

Identification assumptions. The major concerns for identification are related to unobserved third factors that correlate with both social conflict and coverage of ART (e.g., quality of institutions and governance), or to reverse causality, with the incidence of events of social conflict influencing the access to ART in a given year and country or region (e.g., by political pressure on governments or international donors). The instrumentation addresses these concerns and allows identifying the effect of interest, β (or ϕ, respectively).

Technically, we construct the instrument using a measure for the cross-sectional differences in potential for ART $Z_{c,2001}$ – capturing *where* coverage of ART had a greater scope to increase upon availability. This is combined with a measure of the global expansion of ART treatment intensity $ART_{IV,t}$ – capturing *when* coverage of ART increased. The validity of the instrument requires relevance (i.e., the instrument should be a relevant predictor of coverage of ART) and the exclusion restriction: the instrument should affect social conflict only through its effect on coverage of ART. Concretely, this requires that the *interaction* between cross-sectional variation in potential for treatment in terms of HIV prevalence prior to the ART expansion (as of 2001), and global dynamics in the access to ART treatments, is exogenous to the incidence of social conflict in a given year in a country or region, and hence that $Z_{c,2001} \cdot ART_{IV,t}$ (or $Z_{r,2001} \cdot ART_{IV,t}$, respectively) is uncorrelated with ϵ.

The rationale for the instrumentation approach is based on a differences-in-differences logic. First, an increase in coverage of ART is expected to have had more pronounced effects in countries or regions that exhibited a higher level of HIV prevalence at the time when ART became widely available. In the baseline implementation of the instrumentation strategy, the scope for coverage of ART at the onset of the roll out in HIV treatment, $Z_{c,2001}$ is measured by the HIV prevalence in a country in 2001, i.e., prior to the world-wide expansion of ART, $HIV_{c,2001}$. Contrary to country-level data, HIV prevalence is not available for the same year (2001) in all regions; instead, HIV_r measures the HIV prevalence in the respective region in the year closest to 2001 for which data are available. The details of the variable construction can be found in the Supplementary Appendix (Appendix Section A.1.3). Before 2001, ART treatments were effectively not available in Africa, and hence the cross-country variation in potential for ART (HIV prevalence) is unrelated to potential confounds for the analysis that affect subsequent coverage of ART that are absorbed by the extensive set of control variables. Specifically, possible direct effects of local (country-specific or sub-national region-specific) variation in potential for ART expansion on violence are accounted for by (country or region) fixed

effects, and time-varying effects of HIV prevalence before 2001 on violence are accounted for by the inclusion of control variables and flexible specifications of country-specific trends related to HIV prevalence. In addition, differences in time invariant factors such as historical factors or institutions are accounted for by country or region fixed effects. Systematic differences in factors related to particular parts of Africa or country-specific factors, such geo-political pressures, country-specific health policies, or variation in economic development, are controlled by region-specific trends, country-specific trends in HIV prevalence, and country-specific trends, respectively. Variation in global factors that affect all countries are controlled by year fixed effects.

Second, the worldwide expansion of ART availability, captured by $ART_{IV,t}$, largely occurred for reasons unrelated to what happened within each African country (or sub-national region). In particular, the time variation in global ART treatment expansion is related to global factors like the decline in the price for medication and the resulting increase in availability of ART drugs that were the result of international political agreements and innovation in the pharmaceutical industry and that were unrelated to region-specific or country-specific time trends in HIV prevalence or social conflict. To implement a measure of global dynamics in ART availability and construct the instrument, we collected time series data of the prices for the most common first line of ART treatment regimens for adults and construct the instrument by interacting $Z_{c,2001}$ with the median world price of ART treatment regimens as measure for ART treatment intensity $ART_{IV,t}$ (ART Price). This measure has the advantage that the instrument does not respond, by construction, to the country-specific level of social conflict or any policy intervention that is specifically targeted to a given country in a given year. Moreover, conceptually, this measure is directly related to actual ART treatment in a country since the reduction in prices constitutes the ultimate driver of the increase in coverage of ART. The global dynamics were unrelated to the dynamics of social conflict in particular African countries or sub-national regions, and the direct effects of global dynamics in ART treatment availability are accounted for by time fixed effects and region-specific time trends.

In sum, the instrument combines these two dimensions, the potential for ART treatment, $Z_{c,2001}$, and global variation over time in the access to ART treatment responsible for the ART treatment expansion, $ART_{IV,t}$, to predict the country-specific expansion of ART coverage, and hence captures variation that is exogenous to the evolution of social conflict. Controlling for country/region fixed effects and time-varying covariates accounts for systematic variation that might violate the exclusion restriction for the measures of cross-sectional heterogeneity in scope for ART treatment. Moreover, the inclusion of year fixed effects, time-trends for African regions, or country-specific time trends accounts for trends in social conflict that might violate the exogeneity of the global dynamics in the ART treatment expansion. Below, we present additional results for alternative constructions of the instrument. While conceptually capturing the same underlying phenomenon, the interactions of different cross-sectional measures of potential for ART treatment with different measures of the global expansion of ART treatment intensity differ in terms of data quality and potential concerns regarding the validity of the identifying assumptions of the corresponding interaction term that is used as instrument.

Our baseline instrumentation approach complements recent work by Acemoglu et al. (2020) that combines cross-sectional variation in mortality from several diseases prior to treatment and assumes that the respective mortality declined to zero in the context of the global epidemiological transition in order to investigate the effects of population dynamics on civil conflict (adapting a similar strategy from earlier work by Acemoglu and Johnson, 2007). In contrast, rather than using a proxy for the latent mortality decline based on the cross-sectional pre-treatment variation in mortality, our approach makes use of several alternative proxies for cross-sectional treatment scope in combination with several measures of time variation in treatment intensity that are based on global dynamics of the price or cost of treatment, or of the actual treatment intensity outside Africa. Our approach also complements related recent work on the economic effects of ART treatment expansion by Tompsett (2020) and Da Costa (2023) who made use of time variation in coverage of ART in low and middle income countries. In addition to our baseline instrumentation based on time variation in prices and cost of drugs, in the robustness checks below we also conduct the analysis using global variation in coverage of ART in low and middle income countries outside Africa. This accounts for potential concerns of endogeneity due to cross-country spill-overs across African countries as the result of external interventions in several African countries that might correlate with unobservable heterogeneity affecting both ART coverage and social conflicts.

The sub-national region analysis has the further advantage of allowing us to account for region fixed effects, country-specific time trends, and even country-specific year fixed effects. This specification thereby implicitly accounts for many of the confounds for identification at the country level that might vary over time. In particular, health policies are mostly under the control of national governments; international aid by donors and international organizations as well as regulations of patents, procurements of treatments and agreements with pharmaceutical companies are typically organized at the country level; strikes, demonstrations and protests exerting pressure on health provision are likely to trigger responses by national governments and donors only if they are sufficiently visible and important at country levels; social disruptions of lower scale should not be expected to have a major impact on national or international policies. The identification of the effect from variation within countries thus absorbs many of these potential confounds through country effects and trends, or, in extended specifications, country-year fixed effects. The disadvantage of this approach is that without reliable geo-referenced and time-varying data on ART coverage at the region level it is not possible to conduct an analysis based on a 2SLS approach as at the country level.

3. Empirical findings

3.1. Baseline results

Table 1 presents the baseline results. All coefficients reported in this and other tables represent standardized coefficients and correspond to the effect per standard deviation increase in the respective explanatory variable to ensure direct comparability. OLS regressions in Column (1) deliver a significantly negative association between coverage of ART and the incidence of social conflict at the country level. The 2SLS estimates in Column (2) reveal that the association remains significant and is quantitatively slightly larger. These results suggest an upward bias in the OLS estimates towards zero. This is consistent with possible problems of measurement error related to coverage of ART, problems of simultaneity due to omitted factors that correlate positively with social conflict and coverage of ART, or with reverse causality due to social conflict directly influencing HIV prevalence (McInnes, 2009; Iqbal et al., 2010). One example of a confound are more foreign military or humanitarian interventions in countries or regions with a high incidence of social conflict that are associated with better access to health provisions and, in particular, greater coverage of ART. In fact, the evidence is consistent with such a confound. In particular, the data show a positive correlation between foreign interventions (measured in terms of the cumulative annual Global Fund disbursement) and social conflict (events) of 0.23. At the same time, the correlation between foreign interventions and coverage of ART is 0.49. Hence, failing to account for such foreign interventions might induce an upward bias in the OLS estimates. The use of an instrument that combines cross-sectional variation in the potential for ART treatment determined *before* the availability of ART treatment, with time variation in the global expansion related to the decline in prices for ART treatment, provides exogenous variation that allows for a consistent estimation of the causal effect of ART treatment on social conflict. By exploiting the interaction

Table 1
Effect of ART expansion on social conflict.

	Social Conflict (log events) - SCAD Data			
	OLS	2SLS	ITT	
	(1)	(2)	(3)	(4)
ART	−0.1515***	−0.1757**		
	(0.054)	(0.066)		
$Z_{c,2001} \times ARTIV,t$			−0.1621***	−0.1671***
			(0.060)	(0.034)
Instrument				
$Z_{i,2001}$		$HIV_{c,2001}$	$HIV_{c,2001}$	$HIV_{r,2001}$
$ART_{IV,t}$		ART Price	ART Price	ART Price
Observations	1394	1394	1394	4760
Clusters	50	50	50	170
R2	0.27	0.27	0.27	0.13
Kleibergen-Paap		133.06		
Unit f.e.	Country	Country	Country	Region
Year f.e.	√	√	√	√
HIV Trend	√	√	√	√
Geo Time Trend	Macro-region	Macro-region	Macro-region	Country

Note: Dependent variable: natural logarithm of the number of social conflict events in a year (measured as ln(#events + 1)) at country level (Columns 1 to 3) and at sub-national level (administrative regions) (Column 4); data source: SCAD database. All coefficients refer to standardized explanatory variables. ART: coverage of ART relative to the population, based on data from UNAIDS; the measure is standardized. Column 1: OLS estimates. Column 2: 2SLS estimates of the effect on violent events of instrumented coverage of ART; results of first stage regressions are reported in Appendix Table A4. Columns 3–4: coefficients from intent-to-treat regressions of the effect of instrument for coverage of ART on violent events. Instruments are interactions between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ ($i = c$ at country level and $i = r$ at region level), and a time-varying measure of ART treatment expansion, $ART_{IV,t}$; the interaction term has been standardized; see text for details. Results for time period 1990–2017. All country-level specifications control for country effects, year effects, macro-region linear time trends, and linear time trend interacted with HIV prevalence in a country in 2001; sub-national region-level specification includes controls for region effects, year effects, country-specific linear time trends, and a linear time trend interacted with average region-level HIV prevalence. */**/*** indicate significance at 10%/5%/1%, respectively; standard errors in parentheses clustered at the country level (Columns 1-3) or sub-national region level (Column 4). Summary statistics are contained in Appendix A.3.

between country-specific potential for ART treatment and the global increase in treatment intensity as instrumental variable, the instrumental variables approach therefore accounts for these identification concerns. An intention-to-treat approach at the country level, as shown in Column (3), or at the sub-national level, as in Column (4), delivers similar results.

3.2. Alternative specifications and samples

In this subsection, we briefly describe the results of various checks of robustness of the baseline findings related to alternative specifications of the estimation framework, alternative scalings of ART treatment coverage, alternative data sources for the instrument construction, and different subsamples. The detailed results are contained in the Supplementary Appendix.

Alternative specifications. Table 2 presents the estimation results for alternative specifications of the controls for trends in social conflict. The country-level results are contained in Columns (1)–(3). Column (1) presents results for a parsimonious specification that includes country and year fixed effects as well as a country-specific trend in HIV infections. The specification in Column (2), which corresponds to the baseline specification of the analysis in Table 1, additionally includes a trend for a macro-region in Africa. Column (3) shows results for a specification that includes a country-specific time trend. The coefficients are almost identical across all three specifications. Columns (4)–(6) show the results for sub-national regions. Column (4) contains results for a two-way fixed effects specification, Column (5) shows results for a specification with country-specific time trends, and Column (6) for a specification with country-year fixed effects in addition to a sub-national region fixed effect. Again, the estimates are virtually identical across all specifications, which rules out that the results are driven by a variety of confounds that vary at the level of the respective controls.

Alternative scaling. Quantitatively larger coefficient estimates are obtained when estimating the model using raw (non-standardized) measures (Table A5). An inverse hyperbolic sine transform of the dependent variables delivers similar results as those obtained with the log transformation (Table A6). Moreover, quantitatively and qualitatively similar results were found when including a control for population (Table A7). Likewise, the finding that the expansion of ART coverage led to a reduction in social conflict consistently emerges when considering social conflict relative to the population as measured by the log events per population (Table A8).

Sub-samples. The results are not sensitive to the inclusion/exclusion of single countries (Figures A6 and A7) or years (Figure A8). Similar findings emerge when accounting for separate, non-linear time trends across African regions (Table A9). Separate estimates for different subsamples of countries suggest that the instruments are stronger for the sub-samples of sub-Sahara Africa, or the sample of countries with high HIV prevalence within Africa, but the overall results are similar to the baseline (Table A10).

3.3. Exogeneity and alternative instruments for $ART_{IV,t}$

Instrument exogeneity. Conceptually, the instrumentation approach combines cross-sectional variation in the scope for ART treatment expansion, $Z_{c,2001}$, with time variation in the dynamics of the expansion of ART treatment intensity $ART_{IV,t}$. Using the global decline in the price of the most important treatment regimens for $ART_{IV,t}$ provides plausibly exogenous variation from the perspective of single countries in Africa. One limitation for this instrument is that a reduction in the prices paid by a government might release budget resources that can be used for alternative policies and, accordingly, might lead to a reduction of social conflict. Moreover, to the extent that prices for ART treatments might be determined by monopolistic pricing of pharmaceutical multinational corporations, international organizations might exert an indirect effect through their influence on price negotiations. This would show up in terms of a decline in prices due to lower mark-ups over costs, raising concerns about simultaneity.

To investigate the sensitivity of the results with respect to violations of the exclusion restriction of strict exogeneity, we estimated extended specifications that relax the restriction that the direct effect of the instrument on the outcome is exactly equal to zero (Conley et al., 2012). These estimates reveal that, in order for the effect of interest to be not statistically different from zero, the direct effect, conditional on all controls, would have to be almost of the order of magnitude as the effect of interest, which we consider implausible (Figure A9).

Alternative instrument for $ART_{IV,t}$. To assess the robustness of our baseline findings, we construct an alternative measure for $ART_{IV,t}$ to address these concerns based on the evolution of the cost of the active pharmaceutical ingredients of the main first line ART treatments for adults (ART Cost). By capturing the dynamics of global production costs that led to the increase in worldwide production, this measure also maps into the reduction in prices, but the time variation of the two series differs because of variation in the markups charged by pharmaceutical companies, particularly due to increasing competition with the introduction of generics. The validity of the instrument based on ART Cost is based on similar arguments as that based on ART Price without relying on changes of markups of pharmaceutical companies, which might be influenced by political pressure or pressures by international organizations. On the other hand, this instrument is subject to more severe data limitations in terms of availability and coverage, which requires interpolation of data for years with missing information. As a

Table 2
Effect of ART expansion on social conflict: Alternative specifications.

	Social Conflict (log events) - SCAD Data					
	Country Analysis			Regional Analysis		
	(1)	(2)	(3)	(4)	(5)	(6)
ART	−0.1760***	−0.1757**	−0.1744**			
	(0.066)	(0.066)	(0.067)			
$Z_{c,2001} \times ART\,IV,t$				−0.1671***	−0.1671***	−0.1656**
				(0.034)	(0.034)	(0.079)
Instrument						
$Z_{i,2001}$	$HIV_{c,2001}$	$HIV_{c,2001}$	$HIV_{c,2001}$	$HIV_{r,2001}$	$HIV_{r,2001}$	$HIV_{r,2001}$
$ART_{IV,t}$	ART Price	ART Price	ART Price	ART Price	ART Price	ART Price
Observations	1394	1394	1394	4760	4760	4760
Clusters	50	50	50	170	170	170
R2	0.25	0.27	0.13	0.08	0.13	0.00
Kleibergen-Paap	133.67	133.06	128.83			
Unit f.e.	Country	Country	Country	Region	Region	Region
Year f.e.	√	√	√	√	√	Country-Year
HIV Trend	√	√	×	√	√	√
Geo Time Trend	×	Macro-region	Country	×	Country	×

Note: Dependent variable: natural logarithm of the number of social conflict events in a year (measured as ln(#events + 1)) at country level (Columns 1 to 3) and at sub-national level (administrative regions) (Columns 4 to 6); data source: SCAD database. All coefficients refer to standardized explanatory variables. ART: coverage of ART relative to the population, based on data from UNAIDS; the measure is standardized. Columns 1–3: 2SLS estimates of the effect on violent events of instrumented coverage of ART ; results of first stage regressions are reported in Appendix Table A4. Columns 4–6: coefficients from intent-to-treat regressions of the effect of instrument for coverage of ART on violent events. Instruments are interactions between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ ($i = c$ at country level and $i = r$ at region level), and a time-varying measure of ART expansion, $ART_{IV,t}$; the interaction term has been standardized; see text for details. Results for time period 1990–2017. All country-level specifications control for country effects, year effects, a linear time trend interacted with HIV prevalence in a country in 2001; in addition, the specification in Column (2) includes linear time trends for macro-regions in Africa, the specification in Column (3) includes country-specific linear time trends. The sub-national region-level specifications include controls for region effects, year effects, and a linear time trend interacted with average region-level HIV prevalence; in addition, the specification in Column (5) includes country-specific linear time trends, the specification in Column (6) includes country-year fixed effects. */**/*** indicate significance at 10%/5%/1%, respectively; standard errors in parentheses clustered at the country level (Columns 1-3) or sub-national region level (Columns 4-6). Summary statistics are contained in Appendix A.3.

second alternative measure for $ART_{IV,t}$, we constructed the evolution of a synthetic price index of the main first line ART treatments for adults (ART Synth. Price). This measure is exclusively based on information about the initial price of first line treatment regimens of the first line of ART treatment in 2001, prior to the expansion of ART demand (and thus prior to potential influence of donors on the price development), and on price data after the major expansion (2015–2017). For the intermediate time period, the price index is constructed based on the assumption of a constant proportional decline of the price-over-cost mark-up (of 20%) each year. By construction, this index is therefore unrelated to political interventions and to any other sort of demand-driven price decline while resembling the typical evolution of drug prices after the end of patent exclusivity, and after the introduction of generic drugs. As a third alternative measure for $ART_{IV,t}$, we make use of data on expansion of ART coverage in low and middle income countries outside Africa (ART Cov).[4] Conceptually, this is closest to the variation captured by the instrumented variable (coverage of ART in African countries), while offering high data quality and longer and more coherent time coverage compared to the data on the dynamics of prices and costs of treatment regimens. A similar identification strategy has previously been applied successfully at the country level to explore the economic effects of ART expansion (Tompsett, 2020), who made use of time variation in coverage of ART in low and middle income countries. Differently from this application, the approach applied here combines cross-sectional heterogeneity in disease (HIV) prevalence prior to the treatment expansion in combination with time variation in coverage of ART in low and middle income countries *outside* Africa, which is conceptually not affected by the level of coverage of ART in a specific country and the inclusion of year fixed effects accounts for global shocks. This avoids potential endogeneity through cross-country spill-overs across the African continent and ensures that the interaction is exogenous to social conflict at the country-year level, conditional on the control variables.

Alternative instrument for $Z_{i,2001}$. To address potential concerns about the exogeneity of the cross-sectional variation in the scope for ART expansion, $Z_{c,2001}$, we conduct extensive robustness checks, including tests of parallel trends, placebos, different base years, or additional controls and interaction terms as reported below. The most salient concern about the use of cross-sectional variation in HIV prevalence in 2001 is a potential correlation with institutions and other factors that would otherwise question the exclusion restrictions. The extensive specifications with country fixed effects and additional controls, and recent findings that interaction terms with one potentially endogenous factor require weaker identification assumptions than standard exclusion restrictions (Bun and Harrison, 2019), alleviate this concern. We constructed an alternative proxy measure of the country-specific scope of ART treatment that exclusively relies on geography, HIV_{geo}. Concretely, we compute the geography-related exposure to HIV as the effective distance from Kinshasa, using exclusively information about first nature geographic characteristics and a minimum criterion for population, based on the fast-marching method (Sethian, 1996, 1999). The resulting proxy variable therefore reflects the effective distance to the origin of the HIV epidemic that measures the potential exposure to HIV in Africa during the late 20th century.[5] By construction, this measure is not related to institutional, cultural or political features that could have affected the evolution of the HIV epidemic in a country prior to 2003 and that might challenge the exclusion restrictions.

[4] Details of the construction of each of these variables can be found in the Supplementary Appendix (Sections A.1.5, A.1.6, and A.2). Despite the different construction, the instruments are highly correlated, with pairwise correlations of around 0.98.

[5] The details of the variable construction can be found in the Supplementary Appendix (Appendix Section A.1.4).

Table 3
ART expansion and social conflict – alternative instrumentation.

	Social Conflict (log events) - SCAD Data							
	Country Analysis				Regional Analysis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ART	−0.1757**	−0.1729**	−0.1764***	−0.1693**				
	(0.066)	(0.065)	(0.064)	(0.065)				
$Z_{c,2001} \times ARTIV,t$					−0.1671***	−0.1583***	−0.2172***	−0.1799***
					(0.034)	(0.032)	(0.046)	(0.037)
Instrument								
$Z_{i,2001}$	$HIV_{c,2001}$	$HIV_{c,2001}$	$HIV_{c,2001}$	$HIV_{c,2001}$	$HIV_{r,2001}$	$HIV_{r,2001}$	$HIV_{r,2001}$	$HIV_{r,2001}$
$ART_{IV,t}$	ART Price	ART Cost	ART Cov	ART Synth. Price	ART Price	ART Cost	ART Cov	ART Synth. Price
Observations	1394	1394	1394	1394	4760	4760	4760	4760
Clusters	50	50	50	50	170	170	170	170
R2	0.27	0.27	0.27	0.27	0.13	0.13	0.13	0.13
Kleibergen-Paap	133.06	125.94	111.49	132.64				
Unit f.e.	Country	Country	Country	Country	Region	Region	Region	Region
Year f.e.	√	√	√	√	√	√	√	√
HIV Trend	√	√	√	√	√	√	√	√
Geo Time Trend	Macro-region	Macro-region	Macro-region	Macro-region	Country	Country	Country	Country

Note: Dependent variable: natural logarithm of the number of social conflict events in a year (measured as ln(#events + 1)) at country level; data source: SCAD database. All coefficients refer to standardized explanatory variables. ART: coverage of ART based on data from UNAIDS, measure standardized. 2SLS estimates of the effect on violent events of instrumented coverage of ART ; results of first stage regressions are reported in Appendix Table A4. Instruments are interactions between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ ($i = c$ at country level and $i = r$ at region level), and a time-varying measure of ART treatment expansion, $ART_{IV,t}$; the interaction term has been standardized; see text for details. Results for time period 1990–2017. All country-level specifications control for country effects, year effects, macro-region linear time trends, and a linear time trend interacted with HIV prevalence in a country in 2001 and linear time trends for macro-regions in Africa. The sub-national region-level specifications include controls for region effects, year effects, a linear time trend interacted with average region-level HIV prevalence, and country-specific linear time trends. */**/*** indicate significance at 10%/5%/1%, respectively; standard errors in parentheses clustered at the country level. Summary statistics are contained in Appendix A.3.

Results for alternative instruments. Table 3 presents results of 2SLS regressions with instruments constructed from different measures of in comparison to the results for the baseline measures that are presented in Column (1). The remaining columns show results for different measures of the variation in the access to ART $ART_{IV,t}$ to construct the instrument $Z_{i,2001} \times ART_{IV,t}$. The first stage results indicate that all instruments are relevant. Although conceptually capturing the same variation, the alternative instrument constructs differ in terms of data quality and potential concerns regarding the validity of the identifying assumptions, and thus provide useful alternatives to assess the sensitivity of the baseline instrumentation. The comparison of second stage estimates from the different specifications of the instrumental variable suggest that the results are not sensitive to the different instrument constructions, supporting the validity of the main findings to potential confounds. The results of statistical tests regarding instrument selection reveal that the joint validity of all instruments is never rejected while none of the instruments is redundant in the sense that asymptotic efficiency of the estimation is improved by each instrument. Since the instruments are highly correlated, the null of orthogonality is rejected for each combination of instruments, suggesting the use of a single instrument at a time, rather than a combination of instruments. More details on identification are contained in the Appendix Section A.2. Additional analyses confirm the robustness of the results also for an alternative measure of the local scope for the expansion of ART based on latent geographic exposure to HIV, $HIV_{geo,16K}$, interacted with the time varying measure of global access to ART (Table A.11).[6]

Price/cost data for alternative treatment regimens. The results are not sensitive to the use of price and cost information for a specific first line treatment regimen. In particular, the results are similar when using the price for an alternative, first line regimen (Appendix Table A12). This suggests that the findings are not driven by the specific ART treatment used to construct the instruments. A similar comment applies when alternative time-varying measures of ART treatment expansion are combined with the alternative measures of cross-country variation in the scope for expansion (Appendix Table A13).

3.4. Effect dynamics

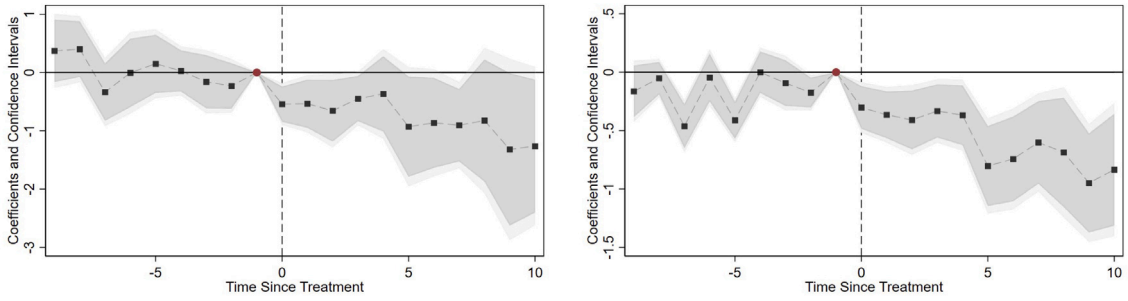
Parallel trends assumption and alternative base years. Additional analysis suggests that the parallel trends assumption that underlies the empirical identification is plausible (i.e., that the dynamic evolution of social conflict across countries was similar prior to the availability of ART). In fact, neither the raw data nor group-year averages reveal any evidence for systematic trend differences in social conflict across countries with different HIV prevalence in 2001 (Appendix Figures A10 and A11). To test the sensitivity of the results with respect to the choice of 2001 as base year for HIV prevalence to measure the scope of ART treatment expansion, the estimation was repeated with alternative base years with similar results (Tables A14 and A15, Figure A12).

Event study. To assess the robustness of our results with respect to pre-trends and dynamic treatment effects, we conducted an event-study analysis based on estimators that are robust to heterogeneous treatment effects, across units or over time. In particular, our setting corresponds to the definition of a continuous treatment that is not staggered but monotonically increasing over time for all treatment units, which is a special case of a continuous and staggered treatment design (see, e.g., Athey and Imbens, 2022; de Chaisemartin and D'Haultfoeuille, 2023). To allow for dynamic effects, we rely on units whose treatment does not change up to a particular point in the observation window and that can be used as valid controls (see Section 4.3 of de Chaisemartin et al., 2022; de Chaisemartin and D'Haultfoeuille, 2023, for a detailed discussion).

Fig. 3 displays the reduced form effect of the instrumental variable on social conflict when allowing for a dynamic treatment effects through the inclusion of lags and leads.[7] In terms of controls, each

[6] Specifically, the construction of the alternative measure $HIV_{geo,16K}$ is based on the distance from the origin of the spread of the virus in Kinshasa and exclusively uses information on first nature geography. The first stage relevance of this measure is somewhat weaker but still exhibits an acceptable performance.

[7] The estimation is performed with the `did_multiplegt` routine devised by de Chaisemartin and D'Haultfoeuille (2020) and using for each pair of consecutive time periods countries with a change in HIV prevalence below 0.015 as control (threshold for stable treatment). We report robustness on the choice of this threshold in the Appendix Figure A13.



(a) Country-Level (b) Region-Level

Fig. 3. Reduced Form Estimates – Event Study Plots
Note: The figure plots event study graphs for the coefficient of interest from the ITT model. The empirical specification is as in Table 2, Columns (2) and (5) of the paper, using $HIV_{c,2001}$×ART Price as instrument. The estimation is conducted using the routine devised by Chaisemartin and Haultfoeuille (2020). Dark shades show the corresponding 90% confidence interval, light shades the corresponding 95% confidence interval.

estimation replicates an analogous specification as in the baseline in Table 1 Column (3). In addition to the instantaneous effect, each estimation is performed including 8 placebo effects to assess the effect dynamics and the plausibility of parallel trends assumption. The specification also allows for 10 dynamic effects to explore the evolution of the effect over time. The omitted coefficient (for the year prior to the expansion of ART in 2002) is reported as zero, and the time axis has been normalized by 0 as the first year of the expansion of ART. The results show consistently insignificant effects of the pre-trends: Countries that experience a more pronounced increase in coverage of ART, as proxied by the instrument, are not experiencing any significantly different decrease or increase in social conflict in the years preceding the increase in coverage of ART. In terms of timing of the effect, the graph indicates that the effect materializes right on impact and then increases monotonically over time in terms of magnitude. Similar patterns emerge for alternative instrument constructions.[8]

4. Mechanisms

In this section, we present additional results that can help shedding light on the potential mechanisms behind the finding that the ART expansion led to a reduction in social conflict documented in the previous section.

4.1. Other diseases and third factors

Falsification: Malaria prevalence and malaria treatment. To further investigate the validity of the instrument and the exclusion restriction, we conducted a falsification exercise by exploiting information about the prevalence of malaria and about the time evolution of prices for anti-malaria treatment. Malaria is a disease of major importance in Africa that has been subject to extensive health campaigns promoted by governments and international organizations. Moreover, weather-driven malaria shocks have been documented to lead to outbreaks of social conflict (Cervellati et al., 2022). Similar to HIV treatment, the treatment of malaria has attracted funds from international organizations and global efforts have led to substantial reductions in prices for treatments. The validity of the identification strategy implies that alternative instruments that combine scope for HIV treatment with the price of malaria treatment, or variation in global access to ART treatment with scope for malaria treatment should not predict coverage of ART. The results of the corresponding falsification tests show that a combination of information about malaria prevalence with time variation in the expansion of ART coverage, or of pre-expansion HIV prevalence with variation in world prices of anti-malaria treatments, do not predict coverage of ART (Appendix Table A16). This supports the hypothesis that the results are driven by HIV and not by malaria.

Placebo and overidentification: Heterogeneity in institutional quality. As alternative test of the validity of the instrument and the exclusion restriction, we replicated the estimation while using various measures of institutional quality as cross-sectional component of the instrumentation stage and replacing the scope for treatment, $Z_{c,2001}$, in the instrument $Z_{c,2001} \cdot ART_{IV,t}$ on the first stage of the 2SLS framework (2SLS–Stage 1) by the institutional placebo $X_{c,2001}$, and estimating the model with instrument $X_{c,2001} \cdot ART_{IV,t}$ (Tables A17 and A18). Alternatively, we estimated an extended version of model (2SLS–Stage 1) using $X_{c,2001} \cdot ART_{IV,t}$ as additional control (A19 and A20). Both sets of robustness checks provide no indication of a violation of the identification assumptions and confirm the main results. The only other variable for which an effect materializes is when measuring the local scope for the expansion of ART using aid disbursed by the Global Fund. This is to be expected as it reflects the fact that a substantial share of Global Fund spending was on the provision of ART drugs.

Confounds related to international aid, institutions, and economic development. The potential role of particular time-varying country-specific characteristics that could drive both health policies and social conflict has been discussed in the context of the differences between OLS and 2SLS results. We explored this aspect in various dimensions. Results from extended specifications with controls for the level of health aid (measured by the extent of Global Fund donations received by a country in a given year), for the level of development (in terms of GDP per capita), or for the quality of public governance (in terms of democracy), confirm the baseline results (Table A21) and indicates that the main results are not affected by controlling for these factors. The stability of the coefficient estimates across the different specifications also suggests that these potentially endogenous variables do not affect the estimates of interest. Moreover, instrument performance is not affected by including these controls, which provides support for the notion that the identifying variation contained in the instruments is exogenous and not driven by these time-varying country-specific features.

Another potential confound is related to the multifaceted efforts to combat the HIV pandemic and to achieve the millennium development goals, which placed substantial emphasis on increasing access to schooling. As consequence, many governments in Africa lowered the cost of schooling around the time of the expansion of ART coverage. The identification strategy accounts for these confounds. In particular, in the sub-national analysis, the inclusion of country-specific linear time trends and linear time trends interacted with average region-level HIV prevalence accounts for the associated variation.

[8] We use a simplified version of our instrument, namely the interaction between HIV prevalence in 2001 and a dummy variable taking value of 1 after 2001; this corresponds to a continuous and staggered version of our baseline event study. See Appendix Figure A13.

Improvements in health and income. We also investigated whether the negative effect of improved public health on social conflict and unrest might reflect general improvements in living conditions that have been documented in the context of the ART treatment expansion (see, e.g., Tompsett, 2020; Da Costa, 2023). Additional analysis confirms earlier findings that the expansion of ART coverage in the context of the HIV/AIDS epidemic in Africa did lead to an overall improvement in aggregate economic prosperity as measured by income per capita growth.[9] We also find a significant increase in life expectancy as result of the expansion of ART. When investigating whether the effect of the expansion of ART coverage affected social conflict through improvements in life expectancy, we find strong and statistically highly significant effects on life expectancy in the first stage. In the second stage, the results show a significant reduction in social conflict in response to the increase in life expectancy predicted by the ART treatment expansion, but this effect only materializes for social conflict as measured in the SCAD data, not for major armed conflicts as measured in the UCDP data (see Appendix Tables A23 and A24). Taken together, this evidence sheds new light on earlier findings for adverse effects of health improvements on income and conflict (Acemoglu and Johnson, 2007; Acemoglu et al., 2020) and suggests that health interventions might play an important independent role for reducing social conflict. These findings support the view that health interventions exhibit an additional "dividend" by reducing social conflict that goes beyond the effects on health and economic well-being that have been documented previously.[10] Additional analysis reveals no evidence for education enrollment as a potential confound or channel for the main results. For the baseline specification, there is no indication that the ART treatment expansion is related to higher primary or secondary school enrollment, while the results are robust to controlling for school enrollment (Tables A25 and A26).

Confounds related to international organizations or interest groups. The discussion of the identification assumptions suggests a potential violation of the exclusion restriction as the result of interventions at the international level that led to changes in coverage of ART or prices. To explore this possibility, text analysis was applied to the narratives of SCAD events to assess whether the results are driven by specific event types or events involving particular groups of participants, such as events involving NGOs or health workers, public employees or strikes. The analysis reveals no evidence in this direction (Tables A27 and A28). This suggests that the main findings are not driven by events that could be connected to political pressure on governments or international organizations or, for instance, the use of budget resources freed by the reduction in prices under the pressure of specific categories of actors or events.

4.2. Different events of social conflict

Additional analysis explores the validity of the results for different types of violent events by investigating whether the effect emerges for low-intensity social conflict or large-scale conflicts. To do so, we replicate the analysis for conflict data from various different sources.

Fig. 4 plots the standardized IV estimates of the coefficient of interest for the baseline specification as in Table 2 Column (2). The significantly negative effect of the ART treatment expansion emerges for the data on social conflict from the Social Conflict Analysis Database (SCAD) as well as for data from the Armed Conflict Location and Event Data (ACLED) or data from the Global Database of Events, Language, and Tone (GDELT). Similar to SCAD, both alternative data sources contain information about frequent and recurrent events of social conflict, in terms of protests and riots, and deliver comparable estimates (see also for detailed results with alternative instrumentation strategies for ACLED data base, Tables A29 and A30; and for GDELT data, Table A31). In contrast, we find no significant effect of ART treatment expansion on civil conflict, as measured by the Uppsala Conflict Data Program (UCDP), consistent with the conjecture that health interventions mainly affect social conflict rather than civil wars (Table A32). Additional results for different subsets of conflicts without casualties versus with casualties, or for different numbers of participants, confirm this view (see Table A33). To rule out the possibility that social conflict and coverage of ART could be related to ongoing major civil conflicts, we also estimated an extended specification with social conflict based on the SCAD data as dependent variable, while including ongoing major armed conflicts (based on the UCDP data) as additional control. The results are basically unaffected, again highlighting that health interventions mainly affect social conflict (Table A34).

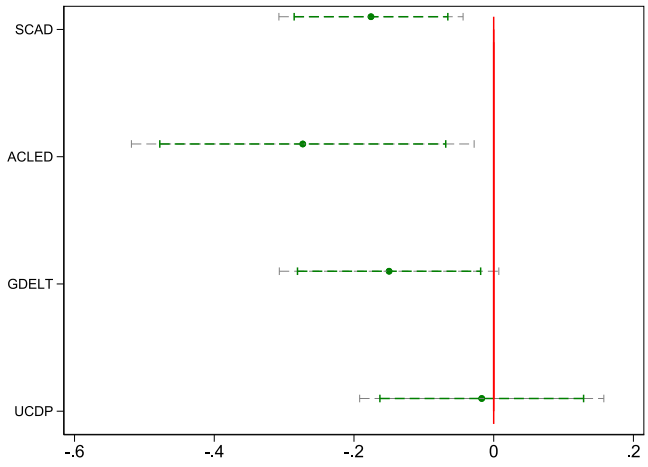


Fig. 4. Mechanisms: Different Intensities of Social Conflict
Note: 2SLS estimates of β at the country level (see Section 2.4). The dependent variable is log events of social conflict from the different data sets (SCAD, ACLED, GDELT, UCDP, see text for details). Instrument: interaction between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ (measured by HIV prevalence at country level, 2001), and a time-varying measure of ART treatment expansion, $ART_{IV,t}$ (measured by the global variation in the median world price of ART treatment regimens, ART Price); the interaction term has been standardized. Coefficients are based on the same specification as in Table 1 Column (2). Whiskers indicate 90% and 95% confidence intervals, respectively.

4.3. Motifs of social conflict

To investigate the underlying mechanisms in more detail, we replicate the estimation at the sub-national level using events of different types and with different underlying motifs, based on categories provided by the SCAD database, as dependent variable. Violent events are classified based on information about types of events (all, spontaneous, organized) or motifs (events related to elections, economic factors, human rights) in the SCAD data set. Intention-to-treat regressions are based on the (log) number of events in a particular category as outcome variable (see Appendix Sections A.1.1 and A.5.3.1 for details).

Fig. 5 reports the respective intention-to-treat estimates of the coefficient of interest at the sub-national region level for the baseline specification. The results document that the reduction in violent events is particularly pronounced for organized events of social conflict. This is consistent with fewer demonstrations, strikes, or other forms of social discontent as result of better provision with ART treatment. In contrast, no significant effect is found for spontaneous outbreaks of social conflict. In terms of motives behind social conflict, we find that better treatment coverage reduces social conflict related to economic factors

[9] While the precision of the estimates varies across different specifications and data sets, they confirm earlier findings of positive economic effects in the literature, see Appendix Figures A15 and A16.

[10] We do not find strong evidence for a similar mediation working through improvements in GDP per capita.

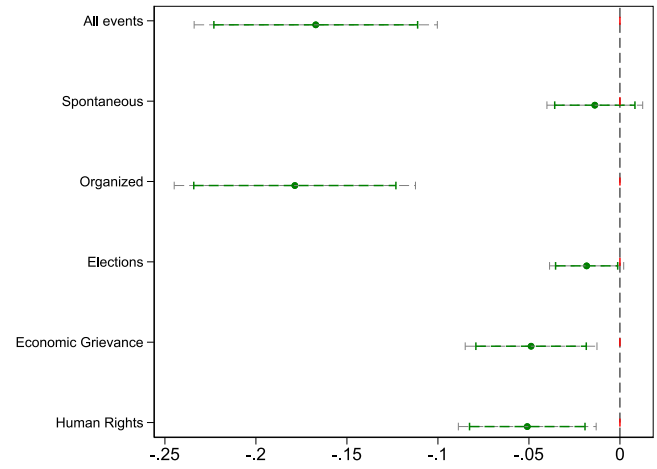


Fig. 5. Mechanisms: Motifs for Social Conflict
Note: Intention-to-treat estimates of ϕ at the regional level (see Section 2.4). The dependent variable is log events of social conflict, classified by motives; classification of social violent events is based on the codification in the SCAD database. Instrument: interaction between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ (measured by HIV prevalence at region level, 2001), and a time-varying measure of ART treatment expansion, $ART_{IV,t}$ (measured by the global variation in the median world price of ART treatment regimens, ART Price); the interaction term has been standardized. Coefficients are based on the same specification as in Table 1 Column (2). Summary statistics about the incidence of different social conflict categories are contained in Table A3. Whiskers indicate 90% and 95% confidence intervals, respectively.

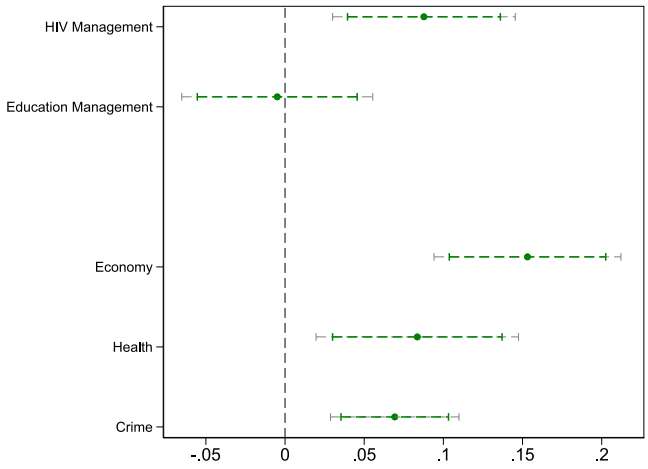


Fig. 6. Mechanisms: Approval of Government Policy
Note: Intention-to-treat estimates of ϕ at the regional level (see Section 2.4). Dependent variables: survey responses to responses to questions about how well the current government handles various policy issues (HIV/AIDS, basic health provision, the economy, and crime). Data are from Afrobarometer. Instrument: interaction between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ (measured by HIV prevalence at region level, 2001), and a time-varying measure of ART treatment expansion, $ART_{IV,t}$ (measured by the global variation in the median world price of ART treatment regimens, ART Price); the interaction term has been standardized. Coefficients are based on the same specifications as in Table 1 Column (2). Corresponding estimates at sub-national region level are reported in Table A36. Whiskers indicate 90% and 95% confidence intervals, respectively.

and human rights, but we find no significant reduction in violence associated with political or electoral reasons (see also Appendix Table A35).

The fact that the results generalize to different coding of violent events is interesting as it provides an indication that the results are not limited to a particular type of social conflict. At the same time, the results again indicate that health interventions mainly reduce social conflict events, which might reflect a reduction in discontent with the government or the (health-related) living conditions, but not major armed conflict or civil wars. This is also consistent with the findings of the analysis of potential confounds related to international interventions or interest groups, which revealed that the effects mainly emerge for social conflict that does not involve organized actors like strikes, NGOs, or public health workers or civil servants (Tables A27 and A28). Moreover, the consistency of the results is reassuring regarding the validity of the instruments as the exclusion restrictions are conceptually different as discussed above.

4.4. Individual approval of government policy

The results shown so far point towards health interventions leading to a reduction in social conflict. One possibility is that successful interventions change attitudes towards, and perceptions of, government and state actors. We therefore investigate whether a greater approval of governmental policies qualifies as a potential mechanism behind the reduction in social conflict. With the successful expansion of ART treatment leading to improved health and, indirectly, alleviating concerns about overall economic and political living conditions, this might have led to a decline in, e.g., organized social unrest like protests and riots. To investigate the empirical validity of this conjecture, we conducted additional analysis based on survey data from the Afrobarometer. In particular, we consider responses to questions that relate to the individual approval of policy, as dependent variables. Survey questions about individual approval of government policies range from individual assessments of how well the government handles HIV/AIDS, to provision with basic health, management of the economy, or combatting crime (see Appendix Section A.1.7.2 and A.5.4 for details).

Fig. 6 displays the intention-to-treat estimates of the coefficient of interest corresponding to the survey responses to the subjective approval of government policies in various dimensions. A higher coverage of ART is associated with a significantly higher approval rate of the government's management of HIV, whereas the approval of the government's management of education is unaffected by the ART treatment expansion. Hence, the decline in violence is associated with a more positive assessment of the government's actions in the dimension of dealing with HIV. This also has implications for a greater approval of government policies in the domain of basic health provision, the economic domain, and, to a lesser extent, with a reduction of crime (see also Appendix Table A36).

4.5. Individual trust in institutions

Finally, better perception of government policies dealing with HIV might also contribute to a greater trust of individuals in institutions and policy makers. To shed light on greater trust in institutions as part of the potential underlying channel of transmission we conducted additional analysis based on survey responses to questions that relate to trust in various dimensions as dependent variables. Again, survey questions are from the Afrobarometer and refer to trust in specific institutions (the parliament, the local government, the police, see Appendix Sections A.1.7.2 and A.5.4 for details).

Fig. 7 displays the intention-to-treat estimates of the coefficient of interest corresponding to the survey responses about trust in institutions. The findings reveal that the ART treatment expansion, as proxied by the instrument for a greater coverage of ART at the sub-national level, is associated with greater trust in the national parliament as well as in the local government. In contrast, no significant effect is found for trust in institutions that are related to implementing law and order (represented by the police), rather than policy making in relation to HIV. This suggests that health interventions do not increase the trust in institutions in general, but trust in specific institutions and actors that

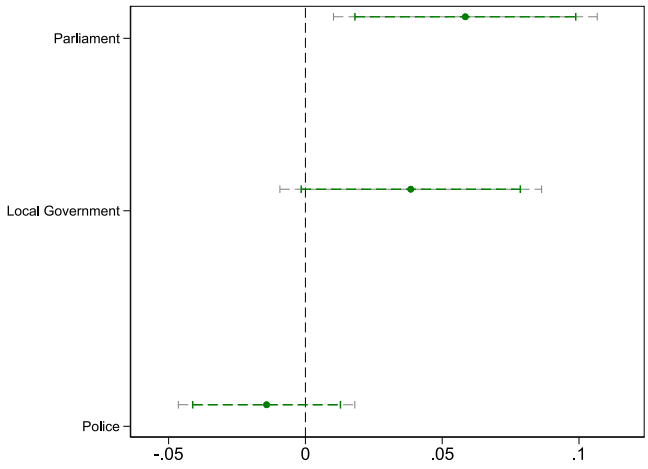


Fig. 7. Mechanisms: Trust in Institutions
Note: Intention-to-treat estimates of ϕ at the regional level (see Section 2.4). Dependent variables: survey responses to responses to questions about trust in institutions (parliament, local government, police). Data are from Afrobarometer. Instrument: interaction between cross-sectional variation in the potential for ART treatment, $Z_{i,2001}$ (measured by HIV prevalence at region level, 2001), and a time-varying measure of ART treatment expansion, $ART_{IV,t}$ (measured by the global variation in the median world price of ART treatment regimens, ART Price); the interaction term has been standardized. Coefficients are based on the same specifications as in Table 1 Column (2). Corresponding estimates at sub-national region level are reported in Table A37. Whiskers indicate 90% and 95% confidence intervals, respectively.

individual respondents associate with the successful implementation of these interventions (see also Appendix Table A37).[11]

5. Quantification and policy implications

Our results so far document that the expansion of ART coverage in the context of the HIV/AIDS epidemic in Africa led to a significant reduction in social conflict. These findings extend earlier evidence regarding the consequences of the ART treatment expansion for increased life expectancy, incomes, and quality of life in various dimensions. From a policy perspective, however, the findings suggest another channel through which health interventions have the potential to break the vicious cycle of poor living conditions, short-sighted behavior, and lack of development: health interventions can also play an important role in reducing social tensions and unrest. Considering the impact of health policies over a relatively short time horizon in which population responses can be expected to be limited, we find that public health improvements lead to a significant decline in social conflict, but have no effect on large-scale civil conflicts. Quantitatively, the 2SLS results of Table 1 suggest that an increase in coverage of ART by one standard deviation implies a reduction in events of social conflict of about 18% of a standard deviation (or, equivalently, a 10% increase in coverage reduces conflicts by about 10% of the unconditional mean). However, as the potential for treatment depends on variation in HIV prevalence, this interpretation of an average effect of coverage of ART is not straightforward.

To provide an illustration of the quantitative relevance of the results, we therefore conducted a simulation exercise that contrasts, for each country, the average number of violent events that are predicted by the model estimates with the counterfactual number of violent events that are predicted by the model estimates if each country had not seen any expansion in ART coverage. Specifically, we use our baseline estimates to predict social conflict for each country and year in the sample. We then replicate this prediction while switching off the ART expansion. This counterfactual prediction corresponds to the counterfactual number of social conflict events that would be predicted in the absence of the ART expansion. Based on these two predictions, we compute the percentage of predicted conflict events that were prevented as a result of the expansion of coverage with ART.[12]

Fig. 8 illustrates the corresponding numbers for all countries in our sample. For illustration, we order countries by the scope for expansion as proxied by the HIV prevalence in the population in 2001, as indicated by the long (blue) bars in the positive domain. The short (green) bars in the positive domain depict the corresponding average ART coverage relative to the population in these countries over the observation period. The bars in the negative domain (orange) depict the corresponding counterfactual predicted reduction in social conflict that the country has experienced due to the expansion in ART coverage relative to the predicted social conflict in the absence of the ART expansion. The results indicate that, on average over the observation period and all countries, social conflict events were reduced by almost 10% due to the health intervention of ART. The numbers are higher for countries with higher HIV prevalence in 2001. Importantly, the effect is significant even in countries with comparably low levels HIV prevalence. When interpreting the results one has to keep in mind, however, that the instrumental variables estimates only capture the average effect of the expansion of ART, and not the effect of exceptional implementation relative to comparable countries. For such an analysis, one would have to allow for effect heterogeneity and make assumptions about relevant comparison groups. We leave this aspect to future research interested in the cases of particular countries.

6. Concluding remarks

In this paper, we documented new evidence for the impact of HIV treatment on social conflict in Africa. The identification strategy exploits the reduction in global prices of antiretroviral drugs in interaction with heterogeneity in the scope for the adoption of ART. The empirical results indicate that effective disease treatment, here in the context of HIV, alleviates a root cause of hardship and goes along with a decline in social conflict. The results consistently emerge both at the level of countries and the level of sub-national regions and for alternative specifications and samples. The findings are confirmed in extensive robustness checks, including the use of alternative instrumentation strategies and empirical methodologies that allow studying effect dynamics. In light of this evidence it appears unlikely that the results are driven by other specific policies, such as education policies, although accompanying measures and policies might have contributed in selective cases.

When investigating the underlying mechanism, we accounted for confounders such as institutional quality, aid, or activities of international organizations, and confirm that the effects are confined to HIV-related health interventions and work through improvements in general living conditions, particularly in health. The effect pertains to social conflict rather than large scale armed struggles. In terms of motifs, we find evidence for a reduction in economic grievances and protests for human rights. Using individual data to evaluate the impact on personal attitudes, we document that the pacifying effect of health interventions is associated with a greater approval of governmental policies, consistent with conceptual considerations. The effect on policy approval is confined to interventions that improve general health and economic conditions and does not pertain to other policies such as education. Consistently, HIV-related health interventions also lead

[11] Unreported estimates for trust in other institutions, like the president, the ruling party, or the electoral commission reveal similarly insignificant findings.

[12] The estimates are based on coverage of ART relative to the population, as in Table 1. Qualitatively similar, but quantitatively larger effects are found when using coverage of ART relative to the population infected with HIV. Details are available upon request.

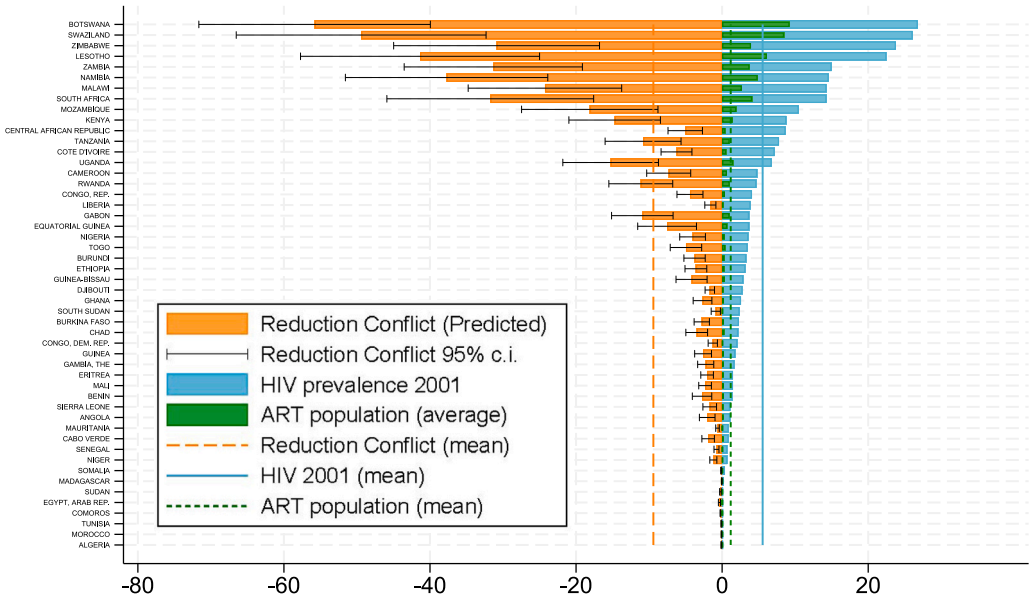


Fig. 8. Quantification: Counterfactual Reduction in Conflict Events Due to ART
Note: Counterfactual % reduction in violent events between 2000 and 2017 based on a prediction of a country-specific coverage of ART relative to a prediction of conflict for a country-specific coverage of ART set to zero. Predictions are based on the same specification as baseline model estimates (Table 1(2)), changes relative to observed values. Countries are sorted according to observed HIV prevalence in 2001. Vertical lines indicate the average predicted reduction in violent events due to the ART expansion (orange, dashed), average ART coverage 2000–2017 (black, dotted), and average HIV prevalence in 2001 (blue, solid). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

to higher trust in institutions, but only for actors that are seen as responsible for the successful implementation of these interventions.

The findings call for sustained efforts to fight HIV and other infectious diseases by showing that the predicted benefits go beyond improvements in health and economic conditions. This is corroborated by a counterfactual analysis that suggests that health policies led to a sizable reduction in conflict events in countries with high (HIV) prevalence. Evidence that the expansion of ART reduced social conflict through greater government approval corroborates the view that health interventions can foster trust in states and policies and contributes a new perspective on the mixed evidence for the role of policy interventions to curb conflict.

Taken together, the results suggest that by improving individual health, promoting labor productivity, and attenuating social tensions, health interventions have the potential to generate a “triple dividend". In light of these findings, further research extending beyond ART treatment is warranted to explore the external validity of the effects of public health interventions on social conflict documented here. Another promising direction for future research is to further explore the role of health policies for building trust in institutions.

CRediT authorship contribution statement

Andrea Berlanda: Formal analysis, Conceptualization, Data curation, Methodology, Software, Visualization. **Matteo Cervellati:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Elena Esposito:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – review & editing. **Dominic Rohner:** Writing – review & editing, Methodology, Conceptualization, Funding acquisition, Investigation. **Uwe Sunde:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data and code for replication are available for download; see Supplementary Data.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jdeveco.2024.103306.

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Andrea Berlanda [a], Matteo Cervellati [b,c], Elena Esposito [g], Dominic Rohner [d,e,c], Uwe Sunde [f,c,*]

[a] University of Padova, Italy
[b] University of Bologna, Italy
[c] CEPR, United Kingdom
[d] University of Lausanne, Switzerland
[e] E4S, Switzerland
[f] University Munich, Germany
[g] University of Torino, Collegio Carlo Alberto, Torino, Italy

The authors would like to correct the affiliations of Elena Esposito:
University of Torino (ESOMAS Department), Italy.
Collegio Carlo Alberto, Torino, Italy.
CEPR, United Kingdom.
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* Corresponding author. University Munich, Germany.
E-mail address: uwe.sunde@lmu.de (U. Sunde).

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