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The Legacy of Colonial Medicine in Central Africa†

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Between 1921 and 1956, French colonial governments organized medical campaigns to treat and prevent sleeping sickness. Villagers were forcibly examined and injected with medications with severe, sometimes fatal, side effects. We digitized 30 years of archival records to document the locations of campaign visits at a granular geographic level for five central African countries. We find that greater campaign exposure reduces vaccination rates and trust in medicine, as measured by willingness to consent to a blood test. We examine relevance for present-day health initiatives; World Bank projects in the health sector are less successful in areas with greater exposure. (*JEL* F54, I12, I15, I18, N37, N47, Z13)

Between the 1920s and 1950s, French colonial governments undertook extensive medical campaigns in sub-Saharan Africa aimed at managing tropical diseases. In Cameroon and former French Equatorial Africa (present-day Central African Republic, Chad, Republic of Congo, and Gabon, henceforth AEF; see Figure 1 for a map), the colonial governments organized campaigns against a variety of diseases, including sleeping sickness, leprosy, yaws, syphilis, and malaria.[1] The most extensive of these campaigns focused on sleeping sickness, a lethal disease spread by the tsetse fly. Over the course of several decades, millions of individuals were subjected to medical examinations and forced to receive injections of medications with dubious efficacy and with serious side effects, including blindness, gangrene, and death. The sleeping sickness campaigns constituted some of the largest colonial health investments, and for many, these campaigns were their first exposure to modern medicine (Headrick 1994, Lachenal 2014).

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[1] Yaws is a skin infection caused by a subspecies of the bacterium that causes venereal syphilis.

Figure 1. Map of Cameroon and Former French Equatorial Africa

There is a large body of anecdotal evidence from Africa of mistrust in medicine leading to under-utilization of health care.[2] Relatedly, research in developing countries has highlighted that even when there is access to high-quality preventative and therapeutic tools, demand remains puzzling low (Dupas 2011, Dupas and Miguel 2017, Banerjee et al. 2010). Motivated by work from anthropology and history which links colonial medical campaigns against sleeping sickness and mistrust in medicine (Feldman-Savelsberg, Ndonko, and Schmidt-Ehry 2000; Lachenal 2014), we hypothesize that the colonial medical campaigns may have had a series of unintended effects on both beliefs about modern medicine and the success of modern health interventions. The campaigns may have affected use of medicine because villagers were forced to receive injections, many of the medications had serious negative side effects, and the medications were ineffective. Additionally, the campaigns may have caused the spread of contagious diseases because of the reuse of

[2] For example, during the 2019 Ebola outbreak in eastern Congo and the 2014 outbreak in West Africa, distrust of medical workers was cited as a barrier to effective containment (Vinck et al. 2019; Blair, Morse, and Tsai 2017). In northern Nigeria, communities boycotted the polio vaccination leading to a large outbreak of a nearly eradicated disease (Jegede 2007).

unsanitary needles during the campaigns (Pépin 2011, Lachenal 2014). Thus, we examine the effects of historical colonial medical campaigns on present-day vaccination rates, trust in medicine, and the success of World Bank health projects.

To measure exposure to colonial medical campaigns, we construct a novel dataset from over 30 years of archival data from French military archives for five countries. We digitized hundreds of tables documenting the locations of sleeping sickness campaign visits at a granular geographic level, either the ethnicity-district or the subdistrict level, between 1921 and 1956. Our measure of exposure to the medical campaigns is the share of years that a location is visited during the years of the campaigns.

We focus on two key outcomes. First, we examine vaccination rates using data from the Demographic and Health Surveys (DHS) for our sample countries. Vaccinations are an important and effective tool for preventing many diseases. Despite this, an estimated 20 million children are at risk of vaccine-preventable diseases because they are not vaccinated (WHO 2019). In our area of interest, vaccination rates are low, often below herd immunity rates. We construct a vaccination index, which is the share of completed vaccines of nine possible vaccines for children under five.[3] We find that greater exposure to the campaigns is associated with lower vaccination rates for children. Being visited for 15 years, the average number of years an area is visited, is associated with a 5.8 percentage point decrease in the vaccination index relative to a mean of having completed about one-half of the nine vaccinations.

We then examine a potential proxy for trust in medicine. We measure trust in medicine by whether an individual consents to a free and noninvasive blood test for either anemia or HIV in the DHS. We consider consent to the blood tests to be a revealed preference measure of trust.[4] We find that increased exposure to colonial medical campaigns is correlated with lower levels of trust in medicine today. Approximately 4.8 percent of the sample refuse the blood tests. Being visited by the colonial medical campaigns for 15 years increases refusals by 5.4 percentage points. The strong correlation remains when we examine anemia blood test refusals or HIV blood test refusals separately. We also discuss alternative interpretations of the blood test refusal measure.

The results are robust to a variety of geographic, colonial, pre-colonial, and individual level controls. In our baseline set of covariates we include controls for geographic and historical characteristics, such as temperature, precipitation, land suitability, suitability for malaria, tsetse fly suitability, initial measures of sleeping sickness prevalence, exposure to the Atlantic slave trade, and exposure to missionaries. We also present results with contemporary controls, including educational attainment and wealth fixed effects.

After presenting the correlations between medical campaign exposure and vaccinations and blood test refusals, we address concerns of reverse causality and omitted variable bias using an instrumental variable strategy. The reverse causality concern is that the medical campaigns targeted places to visit based on their initial propensity to vaccinate or levels of trust in medicine (or trust more broadly, given that many of these places would have had little to no exposure to modern medicine prior

[3] The vaccines that the DHS reports on are: polio 0, bcg, dpt 1, polio 1, dpt 2, polio 2, dpt 3, polio 3, and measles.
[4] The DHS does not collect any survey measures of trust in medicine.

to these campaigns). For this to bias upward the magnitude of the observed effects, the medical campaigns would need to have targeted less trusting places. The second concern is omitted variable bias: that there is some other variable that is jointly determining the number of campaign visits and our outcomes of interest.

A natural instrument for medical campaign exposure might be the tsetse fly suitability index (TSI) developed by Alsan (2015), which predicts where the tsetse fly is able to live and therefore is correlated with the prevalence of animal and human sleeping sickness. However, as shown in online Appendix Figure B8(a), our areas of interest are all highly suitable for the tsetse fly, so the TSI does not strongly predict campaign exposure. Thus, we include it as a disease suitability control in our specifications.

We construct an instrument for exposure to the medical campaigns based on geographic features that increase human exposure to tsetse fly habitat, and thus may have led to greater perceived prevalence of sleeping sickness, despite equally suitable tsetse fly conditions. The instrument uses soil suitability for cassava, a new world crop, relative to millet, a traditional crop. The logic of the instrument is explained in greater detail in the text, but in short, sleeping sickness researchers and colonial administrators had noted a correlation between growing cassava and sleeping sickness. This is likely due to two features of growing cassava. First, the processing of cassava, which requires soaking the cassava in water, increases the risk of exposure to the tsetse fly.[5] In fact, cassava processing was identified as one of the key risk factors for acquiring sleeping sickness in early assessments of the disease (Martin-LeBoeuf-Roubaud 1909). Second, cassava produces more calories per acre than traditional crops, so that less land needs to be cleared to produce a fixed amount of calories; this leads to more tsetse fly-harboring "bush." Thus, the suitability for cassava relative to millet captures the perceived need for medical campaign visits because of the increased potential for human interaction with the tsetse fly habitat (Headrick 1994, Martin-LeBoeuf-Roubaud 1909). We use the soil suitability for cassava relative to millet, rather than just soil suitability for cassava, to avoid concerns that we are just capturing the effects of being overall more suitable for agriculture.

The IV estimates suggest that medical campaigns have a large and significant effect on the vaccination index and willingness to consent to a blood test. Being visited by the colonial medical campaigns 15 years decreases the vaccination index by 12.5 percentage points and increases refusals by 8.2 percentage points. In a robustness check, we find that the effect we estimate is specific to cassava relative to millet, rather than other crops relative to millet.

One potential concern with the instrument is that soil suitability for cassava relative to millet directly affects vaccination rates and blood test refusals. To test whether this is the case, we conduct a falsification exercise comparing former British Cameroon with former French Cameroon, which presently share common national institutions. British Cameroon was not exposed to medical campaigns, and therefore, the instrument should have no predictive value for vaccination rates or blood test refusals in former British Cameroon. To increase the comparability of the

[5] This processing is required because otherwise cassava contains cyanide.

regions, we focus on a 50 kilometer bandwidth around the border between former British and French Cameroon (as in Dupraz 2019). The results from the falsification test confirm that the instrument only has predictive power for vaccination rates and blood test refusals in former French Cameroon. This suggests that the instrument does not directly affect vaccination rates or trust in medicine.

We use complementary data from the Afrobarometer from Cameroon and Gabon, which has a series of questions on: interaction with the health sector, frequency of seeking medical treatment, and ease of access to health facilities. Consistent with the DHS results, we find that despite no reported differential access to a health clinic, individuals from areas more exposed to the campaigns are more likely to report no interaction with the health sector and a longer amount of time without seeking medical treatment.

We then turn to examining the relevance of historical medical campaigns for present-day health policy by examining how differential exposure to colonial medical campaigns affects success of present-day health interventions. We use data from AidData (2017) on the location of World Bank projects approved between 1995 and 2014 to examine how exposure to medical campaigns affects project success. The World Bank rates projects from "highly unsatisfactory" to "highly satisfactory." We compare the success of health projects and non-health projects by historical medical campaign intensity. We find that greater exposure to the campaigns is correlated with less successful health projects but does not negatively affect the success of projects in other domains. The effect size for health projects is equivalent to changing the rating from "moderately satisfactory" to "moderately unsatisfactory." These results highlight the importance of the colonial medical campaigns for understanding the efficacy of present-day health policies, and more broadly, how historical experiences can affect policy.

Finally, we examine plausible mechanisms. We first explore whether the observed mistrust is specific to trust in medicine or more generalizable to trust in other people or institutions. We use Afrobarometer data from Cameroon and Gabon on trust in a variety of other people and institutions—e.g., neighbors, people you know, local government, police, traditional leaders—to test whether exposure to medical campaigns affects other forms of trust. Both the average effect size (AES) coefficients and the coefficients on individual survey questions suggest that there is no effect of exposure to the medical campaigns on trust in these nonmedical individuals and institutions.[6] These results suggest the mistrust is specific to the medical domain.

We also test for evidence of vertical and horizontal transmission of trust. We test whether the exposure to the medical campaigns of an individual's own ethnic group or the exposure to the medical campaigns of the ethnic groups of those located in an individual's DHS cluster predict blood test refusal. One can think of this as a test of the relative importance of vertical transmission of cultural values, i.e., from parent to child, and of horizontal transmission of cultural values (Bisin, Topa, and Verdier 2004; Tabellini 2008). Using detailed ethnicity maps from historical UN reports and the 2004 DHS for Cameroon, we construct a measure of (i) the average exposure

[6] These are the only countries in our sample for which Afrobarometer data are available. We make use of all available survey rounds for these countries and all available questions related to trust. There are no survey questions on trust in medicine.

of the other ethnic groups located in the DHS cluster, excluding the exposure of the individual's ethnic group, and (ii) a measure of the individual's own ethnic group's exposure, and examine their importance in predicting blood test refusals. We find that an individual's ethnic group's exposure to the historical medical campaigns has a large, positive, and significant effect on blood test refusals. However, the coefficient on the exposure of individuals from other ethnic groups in an individual's present location is also positive and sizable. These results suggest that vertical transmission of trust in medicine may be an important mechanism, but does not rule out a role for horizontal transmission as well.

The paper speaks to several diverse literatures. First, we contribute to the broader literature on how historical events are important for understanding Africa's comparative development (Nunn 2009). In particular, many papers have focused on exploring the long-term impacts of pre-colonial institutions and colonial policies in Africa on modern development outcomes (Gennaioli and Rainer 2007; Nunn 2008; Michalopoulos and Papaioannou 2013, 2014, 2016). Other work has examined the role of geography, such as Alsan (2015) who examines the effect of tsetse fly suitability and sleeping sickness in animals on long-run development. Huillery (2009) examines the effects of colonial investments in education in former French West Africa, and Cagé and Rueda (2020) document a correlation between exposure to Christian missionaries and HIV prevalence. Anderson (2018) presents evidence that colonial legal origins affect HIV prevalence and the infection rates of women relative to men in sub-Saharan Africa. We build on this work in three ways. We compile a novel historical dataset on colonial medical activity that has yet to be studied. Second, we test how colonial health investments affect present-day vaccination rates and blood test refusals in a setting where, at least anecdotally, trust in medicine is low. Finally, we test if historical exposure to colonial medical campaigns can partially explain the success of present-day health projects in the region.[7]

We speak to the large body of evidence from randomized controlled trials trying to understand barriers to use of health services, such as liquidity constraints, present bias, and psychological costs of accessing healthcare (see Dupas and Miguel 2017 for a review). Sub-Saharan Africa has a disproportionate percentage of the global disease burden. The region accounts for 90 percent of all malaria deaths, 70 percent of people living with HIV, and has some of the highest under-five mortality rates in the world (WHO 2017a, b; UNAIDS 2014). Given the extent of the disease burden, under-utilization of health care is puzzling. We present evidence that mistrust generated by historical experiences with medicine may be another important demand constraint and that this mistrust is linked to worse health outcomes.

Our work is also related to a literature on the unintended consequences of aid interventions, such as Nunn and Qian (2014); Dube and Naidu (2015); and Crost, Felter, and Johnstown (2014), papers which examine the effects of US food aid, US military aid, and World Bank aid respectively on conflict in various settings. We build

[7] The paper is also related to the literature on the economic impacts of historical health interventions (e.g., Acemoglu and Johnson 2007). For Africa in particular, Osafo-Kwaako (2012) finds that a WHO campaign to eliminate yaws in the late 1950s in Ghana had large effects on educational attainment, and Kazianga, Masters, and MacMillan (2014) find that the elimination of river blindness in Burkina Faso led to greater population growth. We provide the first quantitative evidence of the effects of the extensive efforts to treat and prevent sleeping sickness during the colonial era.

on this work by providing detailed empirical evidence on how even well-intentioned colonial policies can have long-lasting negative effects on health.

Finally, our project is also related to a broader literature on the historical origins of trust. Trust has been shown to matter for economic development in a variety of settings (Nunn and Wantchekon 2011, Algan and Cahuc 2010). There is a growing interest in the relationship between trust and health. For example, Alsan and Wanamaker (2018) find that the revelation of the Tuskegee experiment negatively affects black men's trust in medicine and their health. In a subsequent paper, Alsan, Garrick, and Graziani (2019) find that black men are more likely to get a flu vaccine and take blood tests when randomly paired with a black doctor rather than a white doctor. Martinez-Bravo and Stegmann (2017) find decreased vaccination rates in Pakistan in the wake of the search for Osama bin Laden. We contribute to this literature on trust in several ways. First, we demonstrate that historical negative experiences with the health sector can affect the health-seeking behavior of subsequent generations. Second, we then demonstrate the relevance for health policy by examining the success of World Bank projects across our sample. Finally, the campaigns were not an isolated incident; we examine a "treatment" that was relevant across many sub-Saharan African countries and which resulted in millions of individuals being forcibly treated for sleeping sickness.

The paper is structured as follows. Section I provides background on the colonial medical campaigns. Section II describes the archival and modern data used in the empirical analysis. Section III presents the OLS and IV results on the association between the medical campaigns and vaccination rates and blood test refusals. Section IV examines the implications for World Bank project success. Section V further examines mechanisms, and Section VI concludes.

I. Colonial Medical Campaigns

French, British, and Belgian colonial governments implemented a wide variety of medical campaigns beginning in the early twentieth century.[8] The introduction of these efforts coincided with greater European penetration into rural areas and to large outbreaks of human African trypanosomiasis, also known as sleeping sickness. The largest and most pervasive medical campaigns organized by the French focused on the treatment and prevention of sleeping sickness. However, the campaigns also targeted other diseases including yaws, malaria, leprosy, and yellow fever (Headrick 1994, 2014; Pépin 2011).

Sleeping sickness is a lethal parasitic disease transmitted by the bite of a tsetse fly, which is only present in Africa. There are two stages of the disease. An individual in the first stage of the disease experiences joint pain, headaches, and fever. The disease can cause drowsiness and swelling in the lymph nodes. In the second stage, the disease infects the nervous system, and the individual experiences extreme lethargy and eventually dies. There are two types of human sleeping sickness. The more acute and rapid acting form of the disease, *Trypanosoma brucei rhodesiense*, is

[8] For an overview of the approaches used by various colonizing countries, see Headrick (2014). In short, while the French focused on treating the individual, the British focused on controlling the disease environment. The Belgians largely modeled their health initiatives after the French.

found in Eastern and Southern Africa. However, most sleeping sickness cases in humans are from the chronic form of the disease, *Trypanosoma brucei gambiense*, which is found in Western and Central Africa. There is also a form of sleeping sickness that affects domesticated animals, *Trypanosoma brucei brucei*, which is known as *nagana*. The sleeping sickness epidemics motivated a large European response during the colonial era. This was partially due to humanitarian concerns but also due to concerns about labor supply, particularly in the sparsely populated equatorial zone. Scientific and nationalistic motivations were also important, as the colonial governments competed over developing advances in tropical medicine (Headrick 1994, 2014).

In French colonies, the military organized and implemented campaigns through a system of mobile medical teams that focused exclusively on sleeping sickness. In Cameroon, the mobile medical teams were first organized in 1921. AEF organized mobile teams, called the *Service de la prophylaxie de la trypanosomiase* (Trypanosomiasis prophylaxis service), beginning in 1927. The mobile teams generally consisted of one French military doctor, several African nurses, two white corporals, several African soldiers, and a large number of porters to carry equipment. The teams faced the challenging task of visiting rural villages at a time of minimal road infrastructure. During a medical team's visit to a village, villagers were forced, often at gunpoint, to undergo a physical examination. The examinations included neck palpitations to check for swelling of the lymph nodes, blood tests to check for trypanosomes in the blood, and spinal taps. If an individual was believed to have sleeping sickness, an effort was made to determine whether the patient was in the first or second stage of the disease. However, this diagnosis process was often imperfect (Headrick 1994, 2014).

The campaigns initially focused exclusively on the treatment of sleeping sickness. One of the earliest forms of treatment for sleeping sickness was the drug *atoxyl*, an arsenic-based drug. While the name atoxyl literally means nontoxic, the drug had a chemotherapeutic index close to one. This means that the dose of treatment required to rid the body of the trypanosomes was almost equal to the dose that would be lethal to the patient. Additionally, the drug caused partial or total blindness in up to 20 percent of patients (Headrick 2014). The drug was administered to patients regardless of whether they were known to have sleeping sickness. While the drug was effective in treating the disease during the first stage, it could actually increase speed of death in the second stage. However, accurate staging of the disease was difficult, particularly in the field. The coverage of the campaigns was impressive. For example, in Cameroon in 1928, the mobile medical teams examined 663,971 people, of whom 17 percent were identified as having sleeping sickness (Le Gouvernement Français 1929).

Despite the negative side effects of atoxyl, the French continued to use the drug well into the 1930s, while in non-French colonies it had stopped being used a decade earlier (Headrick 1994). There were several key factors driving the use of atoxyl. First, atoxyl was very cheap relative to any alternatives, almost seven times cheaper than the next cheapest drug. Second, it was relatively easy to use. This was a particularly important consideration given that the mobile teams worked in difficult environments and that local nurses were often administering the shots. For example, tryparsamide, a less toxic alternative to atoxyl, could cause immediate skin reactions in patients, leading to abscessing at the injection site if the needle and skin were not perfectly clean. Finally, atoxyl was relatively, though not completely, stable in tropical environments. As described by Headrick (1994, p. 330): "Atoxyl's grip remained because its price and convenience were unbeatable. The health service tolerated accidents and blindness because they did not usually appear at the moment of injection, unlike an abscess from a faulty tryparsamide shot." More broadly, the campaigns themselves were less concerned with the health of individual patients, than with the broader public health effects of the campaigns. The doctors in charge of the campaigns were willing to tolerate the negative effects on individual patients if it meant that other individuals were then less likely to get sleeping sickness.

Subsequent medications for sleeping sickness, such as Lomidine (also known as Pentamidine in the United States), were less toxic, but often had serious side effects. Lomidine was believed to work as a prophylactic, which means it was supposed to prevent individuals from getting sleeping sickness, rather than treating those who already had sleeping sickness. During the campaigns, all individuals in a village were required to receive Lomidine injections. The Lomidine injection needed to be administered every six months in order for it to effectively prevent sleeping sickness in an individual. Even though Lomidine was believed to prevent the spread of sleeping sickness, it was also associated with significant side effects. The injections themselves were painful and caused dizziness and low blood pressure. Entire villages were required to rest under the supervision of the medical team after receiving the injections. Lomidine injections were also associated with several serious accidents, including the development of gangrene at the injection site and death. In fact, Lomidine was considered too dangerous for use on Europeans. Ultimately, Lomidine was shown to be ineffective at prevention, but for a short term would reduce the number of trypanosomes circulating in the blood (Lachenal 2017, p. 174). In fact, in 1974, a French doctor involved with the colonial medical campaigns declared that the Lomidine injections were "pointless, dangerous, and therefore pointlessly dangerous" (Lachenal 2017, p. 182).[9]

Historians and anthropologists have linked the sleeping sickness campaigns to mistrust in modern medicine, as individuals were often forced to participate in the campaigns and the treatments had severe negative side effects. Furthermore, the efficacy of the drugs used in the campaigns was dubious. Anecdotally, the experience of these campaigns has affected present-day views of medicine. Feldman-Savelsberg, Ndonko, and Schmidt-Ehry (2000, p. 162) explain resistance to a tetanus campaign in Cameroon in 1990 by noting that "[the modern medical campaigns] … awakened negative collective memories of French colonial efforts to wipe out sleeping sickness." Similarly, Giles-Vernick (2002, p. 106) reports on rumors and memories that were still circulating in the late 1980s in the Nola region of Central African Republic (CAR) that the injections for sleeping sickness brought death. In fact, the Eton ethnic group from Central Cameroon has a song about the sleeping sickness campaigns

[9] In 2018, results were released from a medical trial that suggest that a new orally administered drug, fexinidazole, can effectively treat late stage sleeping sickness, a breakthrough relative to the present first line treatment therapy of oral nifurtimox and intravenous eflornithine that must be administered in a hospital setting (Mesu et al. 2018, Maxmen 2017).

and the negative side effects of the sleeping sickness injections. Part of the song lyrics are as follows (see Lachenal 2014):

> *The injection against sleeping sickness was too painful*
> *The injection against sleeping sickness was too painful*
> *They gave me an injection in the head*
> *They gave me an injection in the neck*
> *They gave me an injection in the back*
> …
> *They ask me to go draw water from the well*
> *If I drag my feet*
> *The policemen hit me on the head*
> *The injection against sleeping sickness was too painful*

The song highlights that the memory of the sleeping sickness campaigns remain, how memories of the campaigns may be transmitted across generations, and that the campaigns were characterized as painful by the participants.

Additionally, epidemiologists have examined the effects of the unsanitary practices used during the campaigns on the spread of contagious disease. While the campaigns followed standard contemporaneous medical procedures, they may have contributed to the proliferation of certain blood-born diseases from the reuse of unsanitary needles (Pépin 2011). For example, campaigns against schistosomiasis in Egypt have been associated with the *iatrogenic* spread (illness related to medical practice or treatment) of Hepatitis C (Frank et al. 2000). Medical researchers have documented a link between exposure to colonial medical campaigns and Hepatitis C virus (HCV) infection rates in Cameroon, which today has one of the highest Hepatitis C infection rates in the world (Nerrienet et al. 2005).[10] Pépin and Labbé (2008) and Pépin et al. (2010) link HCV and Human T-Cell Lymphotropic Virus (a retrovirus that causes adult T-cell leukemia) rates in former AEF countries and Cameroon to colonial medical campaign exposure. Additionally, Pépin (2011) hypothesizes that in AEF, the medical campaigns may have contributed to the initial spread of HIV prior to its initial identification, as it gave the virus access to large swaths of population to which it would not have otherwise had access.[11]

II. Description of Data

A. *Historical Data*

The historical data for this paper come primarily from the *Service Historique de la Defense*, military archives in France. The colonial governments of Cameroon, Central African Republic, Chad, Gabon, and the Republic of Congo submitted annual reports to France on the health activities undertaken that year within the colony with a primary focus on the sleeping sickness campaigns. An aggregated

[10] Epidemiologists often use HCV to examine iatrogenic transmissions of diseases because HCV is generally nonlethal and difficult to spread through sex.

[11] In related work, Pépin (2012) provides evidence that treatment of sex workers in Léopoldville (present-day Kinshasa) for STDs may have also contributed to the spread of HIV.

report for the whole of AEF was also produced on an annual basis.[12] These records include administrative, medical, demographic, geographic, and climate data for each colony. Importantly, the reports include the places visited by the sleeping sickness medical teams and the types of treatments administered at a granular geographic level.

In January 2014, we collected these records from the military archive to construct a panel dataset for Cameroon and former AEF countries. For the AEF countries we digitize data for 1927 to 1956. These data are at a subdistrict level. For Cameroon, the data are at an ethnicity-district level for the years 1921 to 1950. See online Appendix Figure B1(a) for an example of the archival data from Gabon and Figure B1(b) for an example of the archival data for Cameroon. The tables on the sleeping sickness campaigns include detailed information on estimated number of people in an area, the number of people visited, the number of newly sick individuals, number of previously sick individuals, the number of lumbar punctures administered, and the number of previously sick individuals who had recovered. Often, the number of injections of various types of drugs was reported. The reports also included narrative descriptions of the activities undertaken by the health teams. Many of the reports include maps of where the teams visited and the geographic distribution of the prevalence of various diseases. Online Appendix Figure B2(a) is an example of a map documenting areas visited in 1941 in Cameroon, and online Appendix Figure B2(b) is an example of a map of AEF countries documenting prevalence of sleeping sickness in 1944.

We are able to construct detailed measures of when and where the campaigns went and what they did during various visits. Our measure of exposure to the colonial medical campaigns is the share of years visited of the 30 potential years. Figure 2 shows the variation in number of visits to ethnicity-districts for Cameroon and subdistricts for former AEF countries between 1921 and 1956. The number of visits varies between 0 and over 20. Northern Chad was not visited by the mobile teams, likely because it is not suitable for the tsetse fly (see online Appendix Figure 8(a)) and therefore did not have sleeping sickness.[13]

In online Appendix Table B10 we present the correlates of the medical campaign visits. The most important predictors of the campaign visits are the disease suitability measures. Consistent with the difficulty in reaching remote areas, rural areas are less likely to be visited. Areas with more exposure to missions are also less likely to have been visited. We control for these various factors in our main specifications.

[12] Similarly, the countries that comprised French West Africa (Mauritania, Senegal, Mali, French Guinea, Ivory Coast, Burkina Faso, Benin, and Niger) submitted annual reports on their health activities. We focus on AEF and Cameroon because the historical literature on medical campaigns has focused on these areas and the extensive amount of work required to digitize the historical records. Cameroon had a special status because it was a German colony, but after World War I the country was divided between the French and the British. While Cameroon was not officially part of AEF, it was administered similarly.

[13] See online Appendix Figures B3 to B6 for the estimated distribution of sleeping sickness when first measured, the average sleeping sickness prevalence across the first three years of visits, the year in which sleeping sickness prevalence is first estimated, and the highest rates of sleeping sickness ever reported for an area.

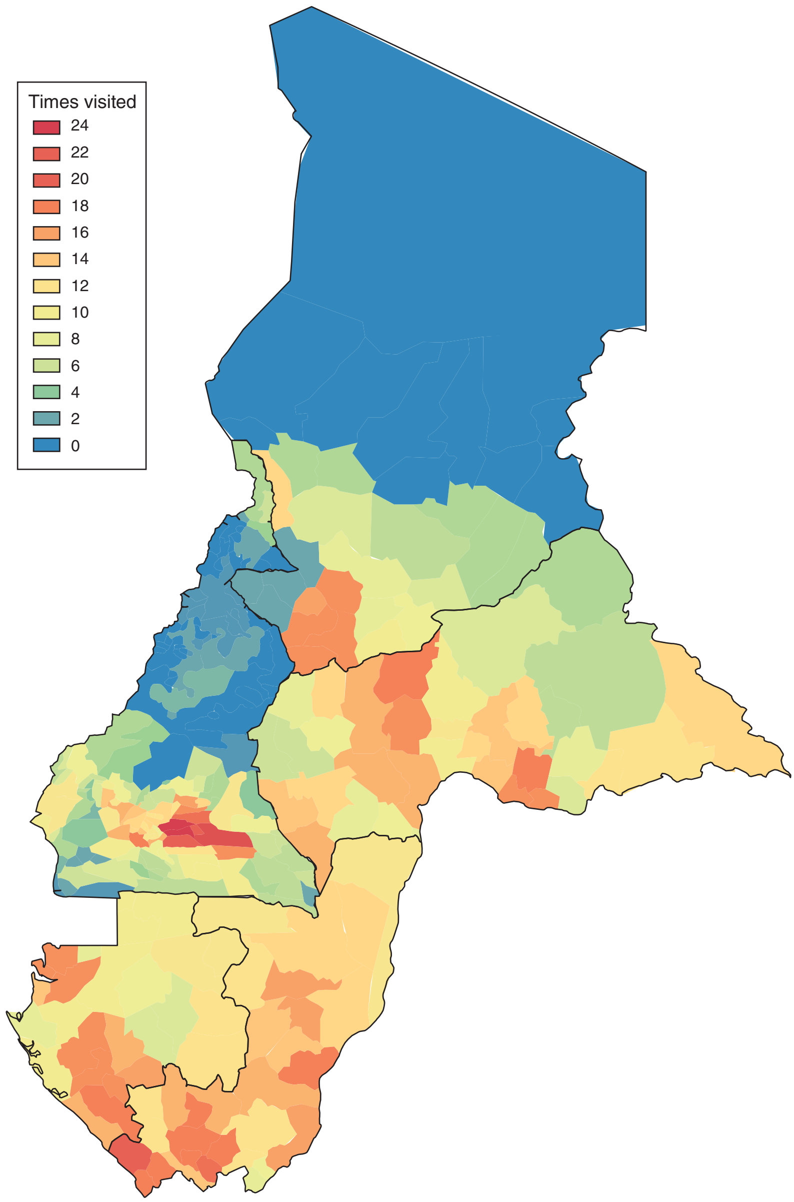

FIGURE 2. SLEEPING SICKNESS VISITS BETWEEN 1921–1956

B. *Modern Data*

We combine the historical data on colonial medical campaign visits with DHS data for our countries of interest. The datasets in our analysis include DHS data for men, women, and children for Cameroon for 2004 and 2011, Gabon for 2012, Congo for 2011, Chad for 1996, 2004, and 2014, and Central African Republic for 1994 (ICF 1991–2014). The distribution of DHS clusters for the countries that report geo-located cluster information is shown in online Appendix Figure B7. For the Republic of Congo and for two waves of data for Chad, the DHS does not report geolocated cluster information and only reports the district of a cluster.

We also combine GIS data on climate (Hijmans et al. 2005), geography (Ramankutty et al. 2002; Fischer et al. 2000; Lehner, Verdin, and Jarvis 2008; GADM 2015a, b), and disease suitability (Kiszewski et al. 2004, Alsan 2015) with colonial data (Roome 1924, Nunn 2010) and pre-colonial data (Nunn and Wantchekon 2011, Murdock 1967, Alsan 2015) to control for potential covariates that could affect both exposure to campaigns and vaccinations and trust in medicine today. Extensions of our main analysis use several other data sources. We use geolocated Round 5 and Round 6 data from the Afrobarometer for Cameroon and Gabon, the only countries in our sample for which Afrobarometer data are available (Afrobarometer 2013, 2015; BenYishay et al. 2017). We also use geolocated data on World Bank development projects from AidData. See online Appendix Section A for detailed information on these datasets.

We have two key outcome variables. The first outcome variable is a vaccination index. To construct the vaccination index, we combine information on vaccination completion for all of the vaccinations that are reported in the DHS. Vaccination data are only collected for children under five. The data report whether a child has completed 9 different vaccinations against: polio; tuberculous; diphtheria, tetanus, and pertussis (DPT); and measles. The vaccination index thus represents the share of completed vaccines of the nine possible vaccines for children under five. The benefit of the vaccination index measure is that vaccination completion is an important health indicator because vaccinations are an effective tool for preventing certain illnesses. Additionally, there are also herd immunity benefits to many vaccines, making high vaccination rates within a population important. A shortcoming of the vaccination measure is that we are unable to account for differences in access to vaccinations.

The second key outcome variable is a potential proxy for trust in medicine. The DHS does not include survey questions on trust in medicine. However, randomly selected survey participants are asked whether they are willing to take a blood test for anemia or HIV. We use refusal to consent to a blood test as a proxy for mistrust in medicine. This has the benefit of being a revealed preference measure of trust, rather than a self-reported measure.

Importantly, these blood tests are noninvasive and include relevant and actionable information. For the anemia tests, they simply involve a finger prick, and results are delivered within minutes. If an individual is identified as anemic, they are told by the survey enumerator that they are anemic and given information on how to get treatment.[14] For the HIV test, blood spots are collected on filter paper from a finger prick. These filter papers are taken to a laboratory for testing. Because the HIV tests are anonymous, individuals are not provided with their results.[15] However, a voluntary

[14] See the Measure DHS website, https://dhsprogram.com/Topics/Anemia.cfm for additional details on the anemia blood test.

[15] See the Measure DHS website, https://dhsprogram.com/topics/HIV-Corner/HIV-Prevalence-and-HIV-Testing.cfm for additional details on the HIV testing.

counseling and testing team follows up with individuals who consent to the blood test to offer them an additional HIV test for which they receive the results.[16]

While we consider the blood test refusal to be a proxy for trust in medicine, it is important to highlight alternative interpretations. An important feature of the blood test is that it is financially costless. Thus, in the absence of mistrust, full take-up might be expected. However, there may be non-financial costs outside of mistrust that affect willingness to consent to the blood test. For example, respondents may refuse the blood test because of the medical risk associated with the finger prick or because the test itself is unpleasant. However, the medical risk of a finger prick should not differ across regions, nor should the physical discomfort from the test, and therefore this should not explain the blood test refusal patterns we observe. An additional potential cost is the fear of knowing the test outcome. For this reason, we present both HIV and anemia results, because the psychological cost of knowing anemia results is presumably much lower than HIV. Thus, while our preferred interpretation of the blood test refusal is that it proxies for mistrust in medicine, we acknowledge that there are alternative interpretations.

III. Analysis

We examine the correlation between exposure to colonial medical campaigns and our outcomes of interest by estimating the following equation:

$$y_{irct} = \gamma_1 ColonialMedicine_r + \mathbf{X}'_{irct}\mathbf{B} + \mathbf{X}'_r\mathbf{\Gamma} + \delta_{ct} + \varepsilon_{irct}, \tag{1}$$

where y_{irct} is the outcome of interest for individual i residing in colonial medical report region r for DHS country c from data collected in year t. For Cameroon r is an ethnicity-district, for Gabon and CAR r is a subdistrict, and for Chad and Congo r is at the district level, due to the aggregation in the DHS reporting of data.[17] We include $\mathbf{X}'_{irct}$, a vector of individual-level covariates and $\mathbf{X}'_r$, a vector of region-level covariates. The individual and region controls are described in detail below. The standard errors are clustered at the region level r. All regressions include survey-year fixed effects, δ_{ct}.

We measure $ColonialMedicine_r$ as the share of years a region r was visited between 1921 and 1956. Specifically, we define $ShareofYearsVisited_r = \sum_{y=1921}^{1956} Visited_{y,r} \times (1/30)$, where $Visited_{y,r}$ is an indicator variable equal to 1 if region r was visited by the campaigns in year y. We normalized the measure by 30 years in the construction as this represents the total number of years of data we have for Cameroon (spanning 1921–1950) and AEF (spanning 1927–1956).

[16] Note, the CAR has not collected biomarker data, and therefore, we do not have any data on blood test refusals for CAR. For Cameroon, there are some ethnic group-districts for which there is no DHS cluster visited.

[17] Northern Chad is a desert area that did not have any colonial medicine visits nor is it suitable for the tsetse fly. Northern Chad is excluded from the main analysis, but the results are not changed with its inclusion. We present all of the results including Northern Chad in online Appendix Tables B7 and B12.

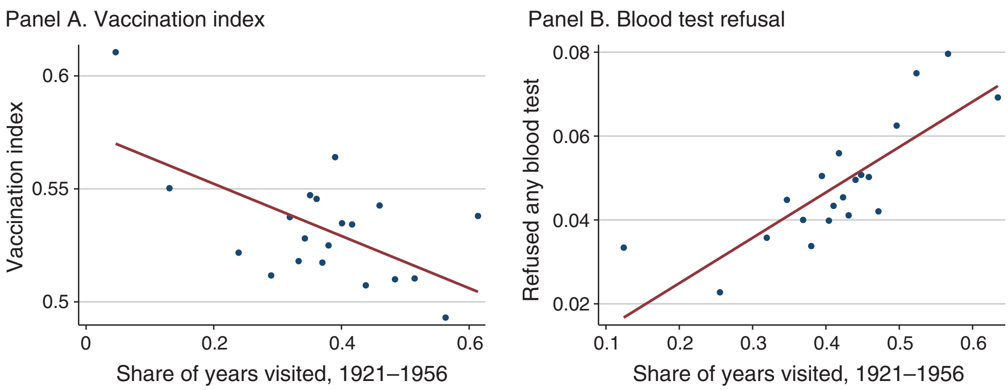

Figure 3. Binscatter: Share of Years Visited

Notes: Data are from the DHS for Cameroon (2004 and 2011), Gabon (2012), Congo (2011), CAR (1994), and Chad (1996, 2004, 2014). *Vaccination index* is the share of vaccines completed out of nine possible vaccines for children in the DHS. *Blood test refused* is an indicator variable for refusing to consent to a blood test (for either HIV or anemia) in the DHS data. *Share of years visited* measures the share of years the mobile medical teams visited a region for sleeping sickness treatment between 1921 and 1956. Regressions control for age, age squared, gender, urban-rural status, and include survey-year fixed effects, geography and climate controls, disease suitability controls, colonial controls, and contemporary controls (see Table 1).

A. *OLS Estimates*

We first examine the correlation between medical campaign visits and vaccinations and blood test refusals. Figure 3 is a binscatter of the share of years visited and (panel A) the vaccination index and (panel B) refusal to consent to a blood test.[18] The simple binscatter suggests a strong negative relationship between exposure to the medical campaigns and the vaccination index and a positive relationship between exposure to the medical campaigns and refusal to consent to the blood test.

We present the OLS estimates for the effect of $\textit{Share of Years Visited}_r$ on the vaccination index and blood test refusals in Table 1. The coefficient in column 1 suggests being visited 15 years reduces the vaccination index by 4.64 percentage points. This is relative to a baseline completion of 53.2 percent for the sample as a whole. Column 1 includes survey-year fixed effects and basic demographic controls (age, age squared, gender, and urban-rural status). It also includes controls for geography and climate, disease suitability, and colonial presence. Geography and climate controls include temperature, precipitation, land suitability and elevation. Disease suitability controls include mean malaria ecology index, tsetse fly suitability index, and estimated sleeping sickness prevalence at first visit by the colonial medical teams. Colonial controls include total number of slaves taken from each ethnic group during the Atlantic slave trade and the number of mission stations in each ethnic group. Column 2 adds contemporary controls: educational attainment fixed effects and wealth index fixed effects. Including the contemporary controls increases the coefficient slightly, so that being visited 15 years decreases the vaccination index by 5.8 percentage points. This suggests a large and significant correlation between

[18] A binscatter is a nonparametric way of visualizing the relationship between two variables by plotting the average y-value for each x-value bin.

Table 1—OLS Estimates: Colonial Medical Campaign Visits, Vaccinations, and Blood Test Refusals

	Vaccination index			Blood test refused		
	(1)	(2)	(3)	(4)	(5)	(6)
Share of years visited, 1921–1956	−0.0928	−0.116	−0.116	0.128	0.108	0.115
	(0.0473)	(0.0442)	(0.0435)	(0.0351)	(0.0284)	(0.0293)
Geography and climate controls	Yes	Yes	Yes	Yes	Yes	Yes
Disease suitability controls	Yes	Yes	Yes	Yes	Yes	Yes
Colonial controls	Yes	Yes	Yes	Yes	Yes	Yes
Contemporary controls	No	Yes	Yes	No	Yes	Yes
Lasso-selected controls	No	No	Yes	No	No	Yes
Observations	50,773	50,668	50,668	71,052	71,001	71,001
Clusters	207	207	207	160	160	160
Mean dependent variable	0.532	0.532	0.532	0.048	0.048	0.048

Notes: Data are from the DHS for Cameroon (2004 and 2011), Gabon (2012), Congo (2011), CAR (1994), and Chad (1996, 2004, 2014). Standard errors are clustered at the ethnic group-district level for Cameroon, at the colonial subdistrict level for Gabon, CAR, and Chad (2014), and at the district level for Congo and Chad (1996, 2004). *Vaccination index* is the share of vaccines completed out of nine possible vaccines for children in the DHS. *Blood test refused* is an indicator variable for refusing to consent to a blood test (for either HIV or anemia) in the DHS data. *Share of years visited* measures the share of years that the mobile medical teams visited a region for sleeping sickness treatment between 1921 and 1956. Regressions control for age, age squared, gender, urban-rural status, and include survey-year fixed effects; however, estimates with *Lasso-selected controls* use lasso methods from Belloni, Chernozhukov, and Hansen (2014a) to select controls from the full set of controls. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, centroid latitude, centroid longitude, and mean altitude. *Disease suitability controls* include mean malaria ecology index, tsetse fly suitability, and initial sleeping sickness prevalence. *Colonial controls* include total number of slaves taken from each main ethnic group in a region during the Atlantic slave trade and number of missions in each main ethnic group in a region. *Contemporary controls* include educational attainment fixed effects and wealth index fixed effects.

historical exposure to medical campaigns and vaccinations today. Finally, column 3 presents the results using lasso methods from Belloni, Chernozhukov, and Hansen (2014a) (see also Belloni, Chernozhukov, and Hansen 2014b) to select controls from the full set of controls.

Columns 4 to 6 present the equivalent specifications for blood test refusal. Mean refusal rates are 4.8 percent. Column 5 suggests that being visited 15 years increases blood test refusals by 5.4 percentage points. The results are robust to examining the refusal of the anemia test only or the HIV test only (see online Appendix Section B.8), suggesting that the results are not driven by an aversion to taking an HIV test nor by the slightly more invasive nature of the HIV test relative to the anemia test.

Online Appendix Section B.8 presents a series of robustness tests. We present the results: adding each set of controls sequentially; for the anemia test only and the HIV test only; including pre-colonial ethnicity level controls (i.e., political centralization, use of plow, indigenous slavery, and practice of agriculture); including controls for sleeping sickness prevalence at various points in time; with Northern Chad included; and using WHO data for the vaccination measure. The findings are robust to these alternative specifications, controls, and data sources.

B. *Instrumental Variable Estimates*

The results presented in Table 1 suggest that there is a negative correlation between exposure to medical campaigns and vaccinations and a positive correlation between medical campaigns and blood test refusals today. However, this does not identify the causal effect of medical campaign exposure on vaccinations or blood test refusals. It is possible that there is an omitted variable that both determines exposure to campaigns and our outcomes of interest. To address this concern, we present results using an instrumental variable approach. An appropriate instrument will predict exposure to colonial medical campaigns but will not affect vaccinations or blood test refusals through any other channel than through the campaigns.

An instrument we considered is the TSI created by Alsan (2015), which predicts the extent to which the environment is hospitable to the tsetse fly. However, in the areas of interest, there is not much variation in tsetse fly suitability. In fact, most places are extremely suitable for the tsetse fly (see online Appendix Figure B8(a) for the spatial variation in tsetse fly suitability in the region). Therefore, we include the TSI as a control variable in our specifications to account for the disease environment.[19]

Our proposed instrument is the difference in the log soil suitability for cassava, a new world crop, relative to log suitability for millet, a traditional crop. First, we will explain the logic behind the instrument. We will then discuss potential concerns with the instrument. The choice of instrument is motivated by historical accounts of what factors people thought determined sleeping sickness. Prior to the identification of the vector in 1903, scientists hypothesized that sleeping sickness was actually caused by the consumption of cassava (Ziemann 1902, Trouillet 1908).[20] Even once the tsetse fly was identified as the vector, it had been noted that there was a positive correlation between growing cassava and sleeping sickness. This correlation was likely due to two features of cassava. First, much of cassava processing is done near water. Thus, the processing of cassava itself increases risk of exposure to the tsetse fly habitat. A 1909 report on the state of sleeping sickness in Congo identified cassava holes, locations along river banks where women left their cassava to soak, as one of the key locations in which individuals were likely to be exposed to the tsetse fly (Martin-LeBoeuf-Roubaud 1909).[21] Second, cassava yields four times the number of calories per acre and 13 times the weight per acre as millet. Thus, to obtain a fixed number of calories, farmers need to clear less land. However, clearing less land means that there is more tsetse fly harboring bush and therefore potentially more exposure to the tsetse fly (Headrick 1994). For these two reasons, the instrument captures the extent to which an individual is likely to interact with the tsetse fly habitat. We use the measure of soil suitability for cassava relative to millet, rather than simply suitability for cassava, to address concerns that we are just identifying places that are overall more suitable for agriculture.[22]

[19] In fact, the TSI is a strong predictor of the initial historical prevalence of sleeping sickness as estimated by the medical campaigns. Additionally, the TSI likely serves better as a control variable because in Alsan (2015) it is used to predict animal sleeping sickness and its effects on pre-colonial centralization.

[20] Scientists thought that sleeping sickness was caused "by chronic intoxication with a toxic material ingested with the food," and the key staple in the region with sleeping sickness epidemics was cassava (Ziemann 1902, p. 313). Sleeping sickness was likened to pellagra, which was a disease believed to be caused by a toxin in corn (but which is actually caused by a niacin deficiency, which can occur if corn is not prepared properly).

[21] Martin-LeBoeuf-Roubaud (1909 p. 392) writes, "we observed the location of the *palpalis*, in the neighborhood of men, with the greatest sharpness. At the crossing of the fords, at the campsites of the caravans that are always near the water, the "manioc holes" where the indigenous women immerse the roots of the plant… at all of these water points where villagers frequent every day, one can meet the tsetse fly."

[22] We take the log of the suitability measure to reduce the influence of outliers. The log of the suitability measures is the transformation suggested by box cox tests in order to have a distribution that is closer to a

Table 2—"Zero-th" Stage IV Estimates–Relationship between Instrument and Initial Sleeping Sickness Prevalence

	Initial sleeping sickness prevalence				
	(1)	(2)	(3)	(4)	(5)
Relative suitability: cassava versus millet	0.0232	0.0272	0.0303	0.0306	0.0308
	(0.0083)	(0.0079)	(0.0090)	(0.0089)	(0.0094)
Geography and climate controls	No	Yes	Yes	Yes	Yes
Disease suitability controls	No	No	Yes	Yes	Yes
Colonial controls	No	No	No	Yes	Yes
Lasso-selected controls	No	No	No	No	Yes
Observations	347	347	347	347	347
Mean dependent variable	0.044	0.044	0.044	0.044	0.044

Notes: Data are from the French Colonial Medical Reports. Robust standard errors are in parentheses. *Initial sleeping sickness prevalence* is the first reported sleeping sickness rate for a colonial medicine region. *Relative suitability: cassava versus millet* is the differences in log suitabilities for cassava and millet. All regressions include survey-year fixed effects; estimates with *Lasso-selected controls* use lasso methods from Belloni, Chernozhukov, and Hansen (2014a) to select controls from the full set of controls. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, centroid latitude, centroid longitude, and mean altitude. *Disease suitability controls* include mean malaria ecology index and tsetse fly suitability. *Colonial controls* include total number of slaves taken from each main ethnic group in a region during the Atlantic slave trade and number of missions in each main ethnic group in a region.

To demonstrate that the suitability for cassava relative to millet is a reasonable instrument, we first conduct a "zero-th" stage analysis. Specifically, we test whether the instrument predicts the initial sleeping sickness prevalence as estimated by colonial officials during the campaigns. We present the estimates in Table 2. Greater relative suitability for cassava does indeed predict the estimated prevalence of sleeping sickness as we would expect if it increases exposure to tsetse habitat. Additionally, we conduct a similar exercise using data from Ford and Katondo (1977), who estimate the share of each ethnic group for sub-Saharan Africa that has sleeping sickness based on tsetse distribution. For this broader sample, the instrument also predicts presence of sleeping sickness (see online Appendix Table B11). While it is reassuring that the instrument does indeed predict sleeping sickness prevalence, it may be the case that sleeping sickness prevalence itself directly affects our outcomes of interest (or indirectly through an effect on health outcomes). For this reason, we control for the initial estimated sleeping sickness prevalence in our disease suitability controls in addition to the TSI and the malaria ecology index.[23]

Panel A of Table 3 presents the first stage estimates for the instrument. The instrument predicts visits by colonial medical teams, with an F-statistic close to or over 10.0 in all specifications. Panel B of Table 3 presents the second-stage estimates for the vaccination index and blood test refusal. In column 2, an increase in the years visited from 0 to 15, the mean number of years visited, decreases the share of completed vaccinations by 12.6 percentage points. Similarly, in column 5, being

normal distribution. Online Appendix Figure B9 plots the distribution of the relative suitability measure and the relative log suitability measure.

[23] We view present-day sleeping sickness cases as less of a potential issue, with fewer than several thousand cases reported annually for all of sub-Saharan Africa since 2009. The vast majority of cases are in DRC, which is outside of our sample (Franco et al. 2020).

Table 3—IV Estimates: Colonial Medical Campaign Visits, Vaccinations, and Blood Test Refusals

	Share of years visited					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. First-stage estimates						
Relative suitability: cassava versus millet	0.0611	0.0600	0.0383	0.0853	0.0835	0.0472
	(0.0182)	(0.0178)	(0.0158)	(0.0196)	(0.0189)	(0.0165)
Geography and climate controls	Yes	Yes	Yes	Yes	Yes	Yes
Disease suitability controls	Yes	Yes	Yes	Yes	Yes	Yes
Colonial controls	Yes	Yes	Yes	Yes	Yes	Yes
Contemporary controls	No	Yes	Yes	No	Yes	Yes
Lasso-selected controls	No	No	Yes	No	No	Yes
Observations	50,773	50,668	50,668	71,052	71,001	71,001
Clusters	207	207	207	160	160	160
Mean dependent variable	0.372	0.372	0.372	0.416	0.416	0.416
F-statistic of excluded instrument	11.26	11.38	—	18.89	19.45	—

	Vaccination index			Blood test refused		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B. Second-stage 2SLS estimates						
Share of years visited, 1921–1956	−0.0820	−0.251	−0.297	0.201	0.164	0.271
	(0.149)	(0.148)	(0.167)	(0.068)	(0.059)	(0.064)
Geography and climate controls	Yes	Yes	Yes	Yes	Yes	Yes
Disease suitability controls	Yes	Yes	Yes	Yes	Yes	Yes
Colonial controls	Yes	Yes	Yes	Yes	Yes	Yes
Contemporary controls	No	Yes	Yes	No	Yes	Yes
Lasso-selected controls	No	No	Yes	No	No	Yes
Observations	50,773	50,668	50,668	71,052	71,001	71,001
Clusters	207	207	207	160	160	160
Mean dependent variable	0.532	0.532	0.532	0.048	0.048	0.048

Notes: Data are from the DHS for Cameroon (2004 and 2011), Gabon (2012), Congo (2011), CAR (1994), and Chad (1996, 2004, 2014). Standard errors are clustered at the ethnic group-district level for Cameroon, at the colonial subdistrict level for Gabon, CAR, and Chad (2014), and at the district level for Congo and Chad (1996, 2004). *Vaccination index* is the share of vaccines completed out of nine possible vaccines for children in the DHS. *Blood test refused* is an indicator variable for refusing to consent to a blood test (for either HIV or anemia) in the DHS data. *Share of years visited* measures the share of years the mobile medical teams visited a region for sleeping sickness treatment between 1921 and 1956. *Relative suitability: cassava versus millet* is the difference in log suitabilities for cassava and millet. Regressions control for age, age squared, gender, urban-rural status, and include survey-year fixed effects; however, estimates with *Lasso-selected controls* use lasso methods from Belloni, Chernozhukov, and Hansen (2014a) to select controls from the full set of controls. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, centroid latitude, centroid longitude, and mean altitude. *Disease suitability controls* include mean malaria ecology index, tsetse fly suitability, and initial sleeping sickness prevalence. *Colonial controls* include total number of slaves taken from each main ethnic group in a region during the Atlantic slave trade and number of missions in each main ethnic group in a region. *Contemporary controls* include educational attainment fixed effects and wealth index fixed effects.

visited the mean number of years increases blood test refusals by 8.2 percentage points. The corresponding OLS estimates are smaller in magnitude. This suggests that the OLS results are biased downward. This downward bias in the OLS results is consistent with the colonial campaigns avoiding visiting areas that were initially less trusting of the campaigns or more resistant to the campaigns. Online Appendix Section B.9 presents robustness to the inclusion of pre-colonial controls, the inclusion of Northern Chad, and controlling for additional measures of sleeping sickness prevalence over time.

C. *Falsification Exercise*

One concern with the results from Section IIIB is that the proposed instrumental variable does not satisfy the exclusion restriction. Namely, the concern is that soil suitability for cassava relative to millet might affect vaccinations or blood test refusals through channels other than exposure to the colonial medical campaigns. Given potential concerns about the violation of the exclusion restriction, we use the unique history of Cameroon to provide evidence that the instrument does not directly affect our outcomes of interest.

In 1884 Cameroon became a German colony. In World War I (WWI) the British invaded Cameroon from Nigeria, and the German forces in Cameroon surrendered in 1916. Cameroon was subsequently divided between France and Britain after WWI under a 1919 League of Nations mandate. Figure 4 shows the present-day boundaries of Cameroon, with the division between the former British area and French area. The British kept a strip of Cameroon bordering Nigeria and generally practiced "indirect rule" within their portion of Cameroon. The rule of British Cameroon has been characterized as "one of benign neglect" (Johnson 1970, Chiabi 1989). Unlike the French, the British did not pursue medical campaigns within their portion of Cameroon.[24] Shortly after French Cameroon gained independence from France in 1960, the southern part of British Cameroon voted in a 1961 referendum to join Cameroon. The northern strip of former British Cameroon (not depicted in Figure 4) voted to join Nigeria. Thus, present-day Cameroon has areas that were historically exposed to the campaigns (former French Cameroon) and areas that did not have equivalent campaigns (former British Cameroon).

This history provides a falsification test for the instrument. The instrument should only predict vaccinations and blood test refusals in those areas that also were exposed to medical campaigns. Thus, the instrumental variable should have no predictive power for our outcomes in former British Cameroon. We can test this by estimating the reduced form effect of the instrument on the vaccination index and blood test refusals for former British and French Cameroon. We restrict to 50 kms around the British and French Cameroon border to increase the comparability of the regions. In online Appendix Section B.10, we present results with alternative bandwidths around the boundary (75 kms and 100 kms). In online Appendix Figure B11, we also show that other important factors, such as ownership of various assets and school enrollment, are not predicted by differences in the instrument at the boundary.

Table 4 presents the reduced form results. For British Cameroon, there is no relationship between the instrument and the vaccination index or refusing the blood test. The coefficients are close to zero and not significant. This suggests that suitability for cassava relative to millet does not predict the vaccination index nor blood test refusals in places that did not have the colonial medical campaigns. However, for French Cameroon, there is a negative and significant relationship between the instrument and the vaccination index and a positive and significant relationship between the instrument and blood test refusals. We can reject that the coefficients across British and French Cameroon are the same. Thus, this falsification test suggests that

[24] In East Africa the British medical campaigns generally focused on managing the disease environment, e.g., spraying for mosquitoes or cutting down tsetse fly harboring bush (Headrick 2014).

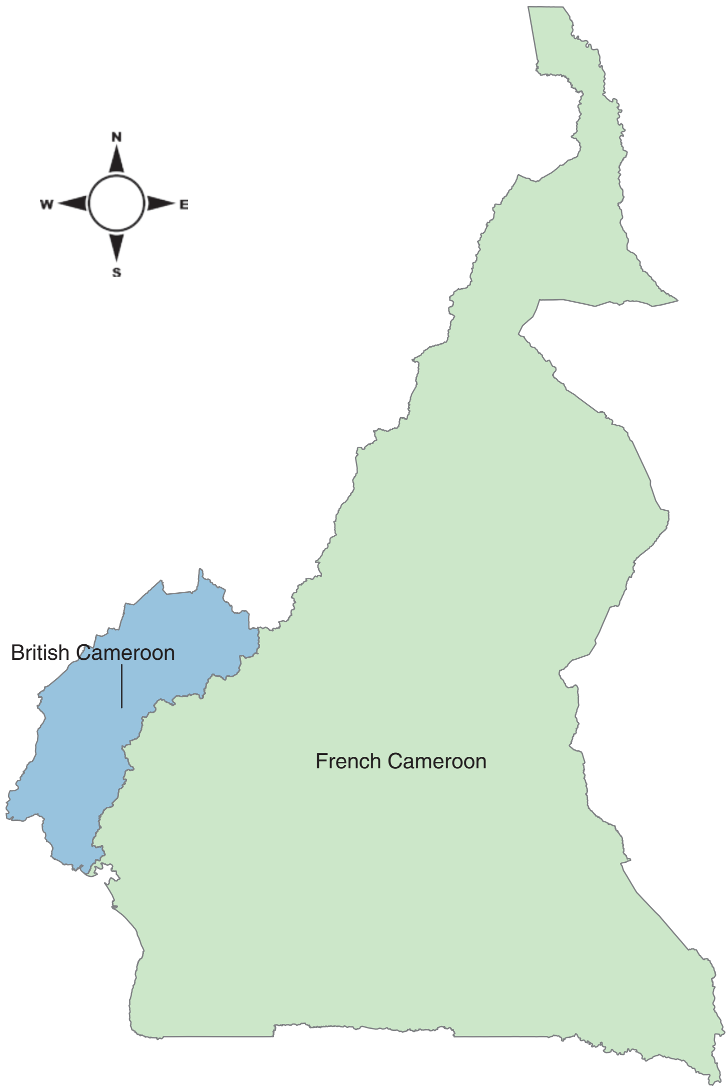

Figure 4. Former French Cameroon and British Cameroon

the instrument does not directly affect vaccinations or blood test refusals, our proxy for trust in medicine.

As an additional falsification exercise, we examine whether the suitability for cassava relative to millet predicts our outcomes of interest in a broader sample of British and Portuguese colonies relative to the AEF countries and Cameroon. We focus on British and Portuguese colonies as the counterfactual group because the British and Portuguese did not pursue equivalent campaigns.

Online Appendix Table B17 presents the results from this broader falsification exercise for both outcomes. The coefficient for non-French colonies is effectively zero, is 8 to 10 times smaller than for the AEF countries, and we can reject that the coefficient is the same as the AEF. We interpret the results from this broader falsification exercise as consistent with the British Cameroon relative to French

TABLE 4—FALSIFICATION TEST: FORMER BRITISH AND FORMER FRENCH CAMEROON

	Instrument falsification test: Suitability for cassava relative to millet							
	DHS vaccination index				Blood test refused			
	Former British Cameroon		Former French Cameroon		Former British Cameroon		Former French Cameroon	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Relative suitability: cassava versus millet	0.0044	0.0045	−0.0104	−0.0111	−0.0016	−0.0018	0.0062	0.0067
	(0.0046)	(0.0045)	(0.0053)	(0.0047)	(0.0033)	(0.0032)	(0.0031)	(0.0031)
Geography and climate controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Disease suitability controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Colonial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contemporary controls	No	Yes	No	Yes	No	Yes	No	Yes
p-value: Former British versus French coefficients	—	—	0.035	0.017	—	—	0.083	0.057
Bandwidth	50 km	50 km	50 km	50 km	50 km	50 km	50 km	50 km
Observations	2,019	2,019	3,605	3,605	4,867	4,867	7,891	7,891
Clusters	141	141	241	241	141	141	241	241
Mean dependent variable	0.774	0.774	0.743	0.743	0.028	0.028	0.062	0.062

Notes: Data are from the DHS for Cameroon (2004 and 2011). Standard errors are clustered at the DHS cluster level. *Vaccination index* is the share of vaccines completed out of nine possible vaccines for children in the DHS. *Blood test refused* is an indicator variable for refusing to consent to a blood test (for either HIV or anemia) in the DHS data. *Relative suitability: cassava versus millet* is the difference in log suitabilities for cassava and millet at the DHS cluster. Bandwidth reports the distance used from the former British and French Cameroon border to restrict the sample. All regressions control for age, age squared, gender, urban-rural status, and include survey-year fixed effects. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, centroid latitude, centroid longitude, and mean altitude. *Disease suitability controls* include mean malaria ecology index and tsetse fly suitability. *Colonial controls* include total number of slaves taken from each main ethnic group in a region during the Atlantic slave trade and distance to the nearest mission. *Contemporary controls* include educational attainment fixed effects and wealth index fixed effects.

Cameroon results: namely, that the instrument does not directly affect vaccinations or blood test refusals in places that did not have colonial medical campaigns.

D. *Afrobarometer and Accessing Healthcare*

The Afrobarometer for Cameroon and Gabon also asks several questions about health care utilization and ease of access. First, the survey records whether there is a health center located in the respondent's enumeration area. It asks in the past year whether the respondent has had contact with a public clinic or hospital. Conditional on having had contact, it asks how difficult it was to access the health center. The survey also asks how often the respondent or anyone in the respondent's family has gone without medicine or treatment. We examine how exposure to colonial medical campaigns affects these outcomes. The OLS coefficients are plotted in Figure 5.[25]

[25] See online Appendix Table B19 for the results in table format.

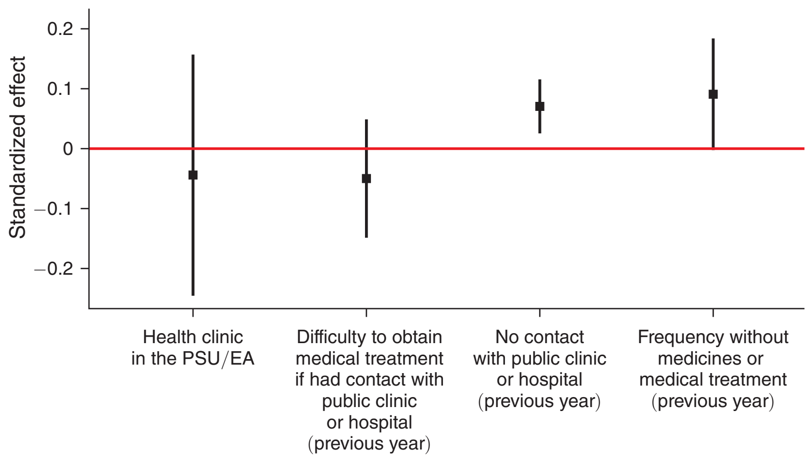

Figure 5. OLS Estimates: Access to Health Center and Interactions with Health System

Notes: Data are from the Afrobarometer for Cameroon (Round 5 and Round 6) and Gabon (Round 6). See online Appendix Table B19 for more information on variable definitions and for the results in table format.

Importantly, we find that there is no difference in likelihood of having a health center in the enumeration area, nor, conditional upon trying to access medical care, is there any difference in difficulty of obtaining medical care. However, individuals in places that were more exposed to the campaigns are more likely to have had no contact with the health system in the past year and are more likely to have gone without treatment in the past year. These results are consistent with the vaccination and blood test refusal results, as they suggest that, despite similar ability to access health care, individuals are less likely to seek out medical treatment the greater the historical exposure to the medical campaigns.

IV. Success of World Bank Projects

To understand the relevance of historical campaigns for present-day health policy, we examine the implications for the success of health initiatives more broadly using geolocated data on World Bank projects for our sample countries. This data, made available by AidData (2017), includes information on the location and sectors of World Bank funded projects between 1995 and 2014. A subset of these projects are given an outcome rating based on "the extent to which the operation's major relevant objectives were achieved, or are expected to be achieved, efficiently" on a six-point scale ranging from highly unsatisfactory to highly satisfactory. We limit the sample to those projects that are given a rating. Projects are classified by the World Bank as belonging to up to five sectors, such as: health, central government administration, general public administration, other social services, railways, and roads and highways. We define a project as being in the health sector if one of its five sector categories corresponds to health.[26]

[26] Note that none of the projects in CAR received a rating, which is why there are no projects in CAR in our sample.

We use this data to test whether areas that were more exposed to the medical campaigns have less successful health projects, measured by the outcome rating assigned by the World Bank. Formally, we estimate the following OLS specification for health and non-health projects:

$$(2) \quad y_{prc} = \gamma HealthProject_{prc} \times ShareofYearsVisited_r + \chi ShareofYearsVisited_r + \mathbf{X}_r'\mathbf{\Gamma} + \mathbf{X}_{pc}'\mathbf{B} + \delta_c + \alpha_c \times HealthProject_{prc} + \varepsilon_{prc},$$

where y_{prc} is the outcome of interest, the World Bank outcome rating, for a project p occurring in colonial medical report region r for country c. The variable $HealthProject_{prc}$ is an indicator equal to 1 if project p is a health project. We include $\mathbf{X}_r'$, a vector of region-level covariates, $\mathbf{X}_{pc}'$, a vector of project-level covariates, δ_c, country fixed effects, and $\alpha_c \times HealthProject_{prc}$, country-by-health-project fixed effects. The region and project controls are described in the notes of each table and figure. Standard errors are clustered at the colonial medical report region level r as in specification (1).

One limitation of our analysis is that it does not address the selection of the type of projects pursued in particular locations. Thus, we can only examine the effects on health projects, or projects more generally, conditional on a project being present. However, in online Appendix Table B18 we test whether colonial medical campaigns predict: whether a location receives a project in any sector, whether a location receives a project in the health sector, and whether a project receives a rating. We do not find any significant relationship between colonial medical campaigns and receiving any World Bank project, receiving a project in the health sector, nor on the probability of a project receiving a rating. The estimated coefficient is effectively 0 for all specifications and outcomes. This helps assuage concerns about selection, i.e., that projects are allocated, selected, or rated based on historical colonial medicine campaigns.

We present the results of a pooled regression of the project outcome on the share of years visited during the colonial medical campaigns in Table 5. On average, World Bank projects receive a rating between moderately unsatisfactory and moderately satisfactory. For health projects, we find a sizable and negative effect of share of years visited on the rating received. The estimated effect on the outcome rating for a World Bank health project occurring in an area with the average number of colonial medicine campaign visits is equivalent to moving projects from being rated moderately satisfactory to moderately unsatisfactory. Additionally, in online Appendix Section B.12, we present binscatters of the relationship between colonial campaign visits and World Bank ratings for health and non-health project separately, as well as coefficient plots by sector. This analysis provides evidence that the historical medical campaigns not only matter for individual health choices, but more broadly for the success of health initiatives.

V. Mechanisms

Thus far we have found significant and sizable effects of medical campaigns on vaccinations and blood test refusals. We have documented that the campaigns are

Table 5—OLS Estimates: Share of Years Visited and World Bank Project Rating

	World Bank project rating Pooled regression with all projects				
	(1)	(2)	(3)	(4)	(5)
Health project × share of years visited, 1921–1956	−2.090	−2.103	−2.098	−2.100	−1.979
	(0.662)	(0.666)	(0.670)	(0.668)	(0.640)
Geography and climate controls	Yes	Yes	Yes	Yes	Yes
Disease suitability controls	No	Yes	Yes	Yes	Yes
Colonial controls	No	No	Yes	Yes	Yes
Contemporary controls	No	No	No	Yes	Yes
Lasso-selected controls	No	No	No	No	Yes
Observations	215	215	215	215	215
Clusters	72	72	72	72	72
Mean dependent variable	3.66	3.66	3.66	3.66	3.66

Notes: Data are from AidData for World Bank aid projects. Standard errors are clustered at the ethnic group-district level for Cameroon, at the colonial subdistrict level for Gabon, Congo, and Chad. *World Bank project rating* is a variable ranging from 1 to 5, where 1 = a project was rated as highly unsatisfactory, 2 = unsatisfactory, 3 = moderately unsatisfactory, 4 = moderately satisfactory, and 5 = satisfactory. *Share of years visited* measures the share of years the mobile medical teams visited a region for sleeping sickness treatment between 1921 and 1956. *Health project* is an indicator variable equal to 1 if the project was labeled a "health" sector project by the World Bank in the sector designations for a project. All regressions control for country fixed effects and country by health project fixed effects; estimates with *Lasso-selected controls* use lasso methods from Belloni, Chernozhukov, and Hansen (2014a) to select controls from the full set of controls. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, latitude, longitude, and mean altitude of each cluster. *Disease suitability controls* include mean malaria ecology index, tsetse fly suitability and initial sleeping sickness prevalence. *Colonial controls* include total number of slaves taken from each main ethnic group in a region during the Atlantic slave trade and distance to the nearest mission for each main ethnic group in a region. *Contemporary controls* include the total funds committed for each project.

also associated with less successful World Bank health projects. These results are consistent with medical campaigns undermining trust in medicine, and thus reducing vaccination rates and the success of health projects. We explore several additional mechanisms. First, we examine whether the campaigns affect other forms of trust. Second, we examine how these beliefs are transmitted.

A. *Other Trust Outcomes*

To understand if the observed effects on trust are specific to medicine or are more generalizable to other institutions and people, we use geolocated data for Cameroon and Gabon from the Afrobarometer.[27] In Round 5, the Afrobarometer asks how much the respondent trusts: neighbors, parents, people they know, and most people. In Round 6, the trust questions are more focused on institutions; for example, it asks about parliament, local government, the ruling party, and traditional leaders, among others. These data allow us to examine whether the observed effect of exposure to the medical campaigns on trust in medicine extends to other people and institutions.

Table 6 presents the AES coefficients across the various trust questions. Across both rounds of the Afrobarometer, the coefficient on share of years visited is

[27] The Afrobarometer only provides names of villages, rather than their coordinates. The corresponding geolocations of villages were provided by AidData.org (BenYishay et al. 2017).

Table 6—OLS Estimates: Other Trust Outcomes

	Trust questions–AES coefficients			
	Round 5		Round 6	
	(1)	(2)	(3)	(4)
Share of years visited, 1921–1956	−0.0101	−0.0063	0.0029	0.0029
	(0.0094)	(0.0094)	(0.0058)	(0.0058)
Geography and climate controls	Yes	Yes	Yes	Yes
Disease suitability controls	Yes	Yes	Yes	Yes
Colonial controls	Yes	Yes	Yes	Yes
Contemporary controls	No	Yes	No	Yes
Observations	762	762	1,782	1,782
Clusters	38	38	64	64

Notes: Data are from the Afrobarometer for Cameroon (Round 5 and Round 6) and Gabon (Round 6). Standard errors are clustered at the ethnic group level for Cameroon and at the colonial subdistrict level for Gabon. *Trust questions* for *Round 5* are "How much do you trust each of the following?": (1) neighbors, (2) parents, (3) people you know, and (4) most people. *Trust Questions* for *Round 6* are "How much do you trust each of the following?": (1) president, (2) parliament, (3) electoral commission, (4) tax department, (5) local government, (6) ruling party, (7) opposition party, (8) police, (9) army, (10) courts, (11) traditional leaders, and (12) religious leaders. All trust questions range from 0–3 (0 = Not at all, 1 = Just a little, 2 = Somewhat, 3 = A lot) except for "Do you trust most people?" which ranges from 0–1 (0 = Do not trust most people, 1 = Trust most people). *Share of years visited* measures the share of years the mobile medical teams visited a region for sleeping sickness treatment between 1921 and 1956. All regressions control for age, age squared gender, urban-rural status, and include survey round fixed effects. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, centroid latitude, and centroid longitude of each cluster. *Disease suitability controls* include mean malaria ecology index, tsetse fly suitability, and initial sleeping sickness prevalence. *Colonial controls* include total number of slaves taken from each main ethnic group in a region during the Atlantic slave trade and number of missions in each main ethnic group in a region. *Contemporary controls* include educational attainment fixed effects.

negligible and insignificant. This suggests that there is no effect of the colonial medical campaigns on trust in the other individuals or institutions. Online Appendix Figures B13 and B14 plot the coefficients for each question alongside the estimated AES coefficient. Again, the results suggest that exposure to historical medical campaigns is uncorrelated with other measures of trust.

B. *Horizontal and Vertical Transmission*

Mistrust in medicine may be vertically transmitted (i.e., from parent to child), it may be a product of horizontal transmission (i.e., from an individual's peers), or both. One strategy to examine these two potential channels is to examine to what extent (i) an individual's ethnic group's exposure and (ii) the average exposure of the other ethnic groups present in the DHS cluster predict likelihood of refusing a blood test.

We undertake this exercise in Table 7 for Cameroon because the historical data for Cameroon was reported at the ethnic group level and the 2004 DHS for Cameroon reports an individual's ethnicity.[28] Column 1 presents the results of an individual's

[28] This exercise is similar to the one performed in Nunn and Wantchekon (2011). However, in that paper, the authors construct their measure of other ethnic group's exposure using the exposure of the ethnic group who

Table 7—OLS Estimates: Ethnic Group versus Location Based Measure of Exposure to Colonial Medical Campaigns

	Blood test refused				
	(1)	(2)	(3)	(4)	(5)
Ethnicity-based measure of share of years visited, 1921–1956	0.0879	0.0864	0.0908	0.0740	0.0960
	(0.0354)	(0.0366)	(0.0365)	(0.0321)	(0.0346)
	[0.130]	[0.156]	[0.146]	[0.116]	[0.094]
Average share of years visited, 1921–1956 among other ethnicities in same location	—	0.0295	0.0473	0.0326	0.0638
		(0.0399)	(0.0434)	(0.0413)	(0.0342)
		[0.406]	[0.240]	[0.374]	[0.072]
Geography and climate controls	Yes	Yes	Yes	Yes	Yes
Disease suitability controls	No	No	Yes	Yes	Yes
Colonial controls	No	No	No	Yes	Yes
Contemporary controls	No	No	No	Yes	Yes
Lasso-selected controls	No	No	No	No	Yes
Observations	8,239	7,189	7,189	7,189	7,189
Clusters	25	25	25	25	25
Mean dependent variable	0.113	0.119	0.119	0.119	0.119

Notes: Data are from the 2004 Cameroon DHS surveys. Standard errors are clustered at the DHS ethnic group level. All regressions control for age, age squared, gender, urban-rural status, and include survey-year fixed effects; however, estimates with *Lasso-selected controls* use lasso methods from Belloni et al. (2014a) to select controls from the full set of controls. p-values obtained using the wild bootstrap procedure with 1,000 draws are presented in brackets. *Blood test refused* is an indicator variable for refusing to consent to a blood test (for either HIV or anemia) in the DHS data. *Ethnicity-based measure of share of years visited* measures the share of years the mobile medical teams visited an individual's reported DHS ethnic group for sleeping sickness treatment between 1921 and 1956. *Average share of years visited among other ethnicities in same location* measures the share of years the mobile medical teams visited other individuals' reported DHS ethnic groups within an individual's DHS cluster for sleeping sickness treatment between 1921 and 1956, excluding an individual's own reported DHS ethnic group. *Geography and climate controls* include mean temperature, mean precipitation, mean land suitability, the mean surface area, centroid latitude, centroid longitude, and mean altitude of each ethnic group. *Disease suitability controls* include mean malaria ecology index, tsetse fly suitability, and initial sleeping sickness prevalence. *Colonial controls* include total number of slaves taken from each ethnic group during the Atlantic slave trade and number of missions in each ethnic group. *Contemporary controls* include educational attainment fixed effects and wealth index fixed effects.

own ethnicity's exposure to the medical campaigns on blood test refusals. An individual's ethnic group's exposure to the campaigns leads to an 8.79 percentage point increase in refusals. In columns 2–5 we add a measure of the average exposure of the ethnic groups of others in the same DHS cluster and various controls.[29] While this measure of others' exposure is positive, the results provide suggestive evidence that the effect of exposure to colonial medical campaigns is driven by the exposure of an individual's own ethnic group. Note that we cannot reject that the coefficients are statistically different. However, comparing the point estimates suggests that the effect of exposure to colonial medical campaigns is twice as large for an

traditionally lives in a location, rather than the average of the individuals actually observed in the cluster. While the results are qualitatively similar with the former measure, we use the latter measure as current residents are more likely to influence individuals' behavior today.

[29] The 2004 Cameroon DHS contains 25 ethnicities in our regions of interest. Thus, we report wild-bootstrapped p-values in the square brackets in the table.

individual's own ethnic group compared to others' exposure. This is consistent with the importance of vertical transmission, but does not rule out a role for horizontal transmission.

VI. Conclusion

We examine the effects of medical campaigns conducted by the French military in Cameroon and former AEF countries between the 1920s and 1950s. These campaigns were intended to control the growing epidemic of sleeping sickness. The mobile medical units forced villagers to receive treatment and prophylaxis for sleeping sickness. Over the course of several decades, millions of individuals were exposed to the campaigns. The medications for sleeping sickness had significant negative side effects including blindness, gangrene, and death.

To examine the effects of the colonial medical campaigns, we collected and digitized annual data from archival sources. We construct a dataset of exposure to the medical campaigns at a granular geographic level for 30 years for 5 central African countries. This dataset itself is important for understanding the medical and public health history of several sub-Saharan African countries.

We use an instrumental variables strategy to examine how historical exposure to the medical campaigns affects vaccinations for children and willingness to consent to a free and noninvasive blood test, our revealed preference measure of trust in medicine. We find that greater exposure to the campaigns decreases completed vaccinations for children and increases blood test refusals. These results are large in magnitude, significant, and robust to variety of controls.

We examine the implications of historical exposure to medical campaigns for present-day health policy. We find that health interventions are less successful in areas with greater exposure to the campaigns. World Bank projects in the health sector receive lower ratings in areas with greater exposure to the campaigns. However, this is not the case for non-health-related projects, suggesting this negative effect is specific to the health sector.

The results provide strong evidence that the colonial medical campaigns have had negative consequences for vaccinations and consent to a blood test, our proxy for trust in medicine. This has important implications for the health of individuals and for understanding their response to health policies in these countries. These results highlight the significant cost of the legacy of medical campaigns and that building demand for health services may require rebuilding trust in medicine. Finally, the results suggest the importance of understanding historical events for designing development interventions.

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