Historical malaria burden and present-day witchcraft beliefs

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Abstract

We study the relation between long-run disease burden and present-day witchcraft and evil eye beliefs in sub-Saharan Africa (SSA). Scholars have distinguished several psychological and economic arguments for why a heavy disease burden may promote witchcraft & evil eye beliefs, but there is limited empirical evidence for such a relation. We focus on malaria, which is one of the major diseases in historical and contemporary SSA, and for which we can rely on a measure of ethnicity-level historical malaria mortality. Relating this measure to contemporary witchcraft & evil eye beliefs across individuals and ethnic groups within 17 SSA countries, we find a statistically significant positive association that is robust to the addition of a large number of individual, ethnicity and regional-level control measures. This result, in combination with a substantial body of anthropological, psychological, economic, and evolutionary literature detailing underlying mechanisms, bolsters the idea that the disease environment played a role in explaining the emergence of witchcraft & evil eye beliefs in SSA.

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1. Introduction

Culturally embedded beliefs affect economic and institutional change and explain the persistence of different development paths (e.g. Alesina and Giuliano, 2015; Gorodnichenko and Roland, 2010; Mokyr, 2014). Gaining a proper understanding of how humans form their beliefs is therefore key to understanding economic development patterns and is "*fundamental to a new social science*" (North, 2008:1005).

Some belief systems have sparked extensive interest among economists, while others remain largely unexplored and poorly understood. For instance, a growing body of research has produced important insights into the economic origins and drivers of the world's dominant religions (e.g. Iannaccone, 1998; Michalopoulos et al., 2012). In contrast, economic literature on the roots and dynamics of other globally prevalent belief systems, such as ancestral worship or witchcraft, is still in its infancy (see for e.g. Gershman, 2022).

We contribute to this line of research by studying the long-run drivers of present-day witchcraft and evil eye beliefs in sub-Saharan Africa (SSA). 'Witchcraft & the evil eye' is used to denote a complex set of magical beliefs about the use of occult forces by humans[1] (Geschiere, 2011). These beliefs appear around the world, but remain especially powerful in SSA, where they are said to have a profound influence on economic life (e.g. D'Angelo, 2014; Leistner, 2014; Platteau, 2014). Although witchcraft & evil eye beliefs and practices take a variety of forms across cultural groups, and their specifics depend on local contexts, there are cross-cultural similarities within and beyond SSA (Koning, 2013; Leistner, 2014). These similarities are the key factor motivating our analysis, as they suggest the existence of cross-cultural drivers of witchcraft & evil eye beliefs.

The driver we focus on is historical disease burden. We investigate the hypothesis that the historical disease burden explains cross-cultural variation in the prevalence of witchcraft and evil eye beliefs. This hypothesis is informed by work in various disciplines that has associated cultural differences and evolution with the disease environment (e.g. Fincher et al., 2008; Inglehart, 2016; McNeill, 1976; Thornhill et al., 2009; Webb, 2006). In particular, a heavy infectious disease burden has been empirically associated with collectivistic or embedded cultures (Fincher et al., 2008; Thornhill et al., 2009). The fact that witchcraft & evil beliefs are associated with collectivistic cultures (Gersham 2022 & Platteau, 2014) already hints at a possible relation with the disease environment. Several strands of research substantiate this link by identifying specific psychological

[1] In this study witchcraft and evil eye denote beliefs which involve human agency causing misfortunate. Any reference to witchcraft should be viewed as synonymous with the belief in the evil eye, following Gersham (2016, 2022).

and economic mechanisms through which a heavy disease burden can promote witchcraft & evil eye beliefs (e.g. Keinan, 2002; Leistner, 2014; Miguel, 2005; Platteau, 2014).

However, to the best of our knowledge there is to date limited empirical evidence in support of such a relationship (see for example, Gersham 2022). The aim of this study is to contribute to filling this gap by quantitatively investigating the relation between long-run disease burden and contemporary witchcraft & evil eye beliefs across countries and ethnic groups in SSA. We focus on the long-run burden of malaria, which is one of the major diseases in historical and contemporary SSA.

To estimate the malaria-witchcraft/evil eye relation, we combine survey data on self-reported beliefs with ethnicity-level data on historical malaria mortality. The witchcraft and evil eye data are taken from a survey conducted by the PEW Research Forum in 2008-2009 and record beliefs for 20,592 respondents across 17 countries in SSA (Pew Research Centre, 2009). Overall, 54 % of respondents reports to believe in witchcraft or the evil eye, with important cross-ethnic and cross-country variation. The historical malaria mortality measure is taken from Depetris-Chauvin and Weil (2016) and relies on estimates of the frequency of the sickle cell gene in a population, which results from the selective pressures exerted by malaria. These genetic data are used to calculate the historical probability of dying from malaria before reproductive age for a particular ethnic group.

We find that a one standard deviation increase in historical malaria mortality is associated with an increase of individual level witchcraft & evil eye beliefs by about 3 to 8 percentage points. This result is robust to the use of various estimation strategies and to the inclusion of individual, regional and ethnicity-level control variables.

The control vectors serve to rule out alternative channels that may drive a positive relation between malaria burden and witchcraft & evil eye beliefs. For instance, malaria had important effects on historical African settlement patterns (e.g. Webb, 2006) and colonizer settlement (Flückiger and Ludwig, 2017), which could affect witchcraft beliefs today through their impact on economic development. Yet, we cannot fully exclude the possibility that the location of ethnic groups, and thus our measure of historical malaria mortality, is associated with unobserved group-level characteristics that also affect witchcraft beliefs. Our finding should therefore not be interpreted as causal evidence, but as a robust conditional correlation.

The positive disease-witchcraft/evil eye correlation is in any case consistent with direct psychological and economic mechanisms derived from different strands of literature. The psychological channels involve the idea that witchcraft & evil eye beliefs meet a psychological need to find explanations or scapegoats for misfortune in the form of disease. The economic channels

state that witchcraft beliefs strengthen resilience in the face of disease risk by instilling and enforcing strong norms of solidarity through social control and through simple mutual redistribution mechanisms via witchcraft accusations against well off members of society forcing them to share their surplus (Posner, 1980). Experimental evidence from Hadnes and Schumacher (2012) confirm this finding, however Le Rossignol et al. (2021) find the opposite effect, that those who hold strong traditional beliefs tend to receive less pro-social behavior from others even when they themselves hold traditional beliefs.

We attempt to distill some empirical insights into the relevance of these mechanisms by conducting a comparative analysis of other types of magical beliefs, such as angels and spirits, and beliefs related to protection against misfortune. Our findings indicate that the disease-belief relation only arises for beliefs that relate to misfortune caused by human agency, namely witchcraft and the evil eye. We conclude that what matters is not the need to merely explain misfortune, but rather the need to obtain visible control over the (perceived) causes of misfortune or the need to mitigate its economic impact.

The next section discusses witchcraft beliefs in SSA and how they may relate to the disease environment. Section 3 describes our key measures of witchcraft/ evil eye belief and historical malaria mortality. Section 4 presents the baseline estimation framework and results, and in Section 5 we address various alternative explanations for our baseline result and presents a number of robustness checks, and Section 6 concludes.

2. Background and hypotheses

2.1. Witchcraft & Evil Eye in SSA

Witchcraft is a notion riddled with definitional and conceptual controversy, as aptly described by Geschiere (2011: 233):

> *"'Witchcraft' (like 'sorcery,' 'magic,' sorcellerie, etc.) is a precarious translation – especially because of the pejorative implications of this Western notion – of African terms that often have much broader implications and might therefore be better translated by a more neutral term like 'occult force' or even 'special kind of energy.' However, these Western terms have been so generally appropriated by the African public that it has become impossible to ignore or even avoid them."*

Consequently, in this study we will use the terms 'witchcraft & the evil eye' as an abstraction to indicate a complex series of beliefs regarding the use of occult powers by humans (for doing good or doing harm) (Gersham 2016;Leistner, 2014; Thornton, 2003).

Anthropologists have a long tradition of studying witchcraft and the evil eye, observing its omnipresence and importance in African societies as an integral part of religious, political, economic, and community life (e.g. Comaroff and Comaroff, 1999; Evans-Pritchard, 1937; Mbiti, 1990). The past decades have seen a renewed interest in the study of witchcraft & the evil eye, with various scholars noting that witchcraft beliefs remain as powerful as ever in African societies and may even be growing in importance (Geschiere, 1997; Kohnert, 2007; Koning, 2013; Leistner, 2014; Platteau, 2014). Cross-country surveys corroborate this observation, finding that about 504% of the surveyed population across various countries in SSA reports to believe in witchcraft or the evil eye (Gallup World Poll, 2009; Pew Research Centre, 2009). Beleif in witchcraft and the evil eye is not limited to SSA, a new global dataset created by Gersham (2022) finds for 95 countries, 40% of individual self report beleif in withcraft and the evil eye which corresponds to close to billion followers globally.

Witchcraft is widely argued to have a profound influence on economic life in SSA through its effect on public and private decision-making (e.g. Comaroff and Comaroff, 1999; D'Angelo, 2014; Kohnert, 1996; Leistner, 2014; Platteau, 2014). Recent studies by Gersham (2023, 2020 and 2016) find that witchcraft and evil eye beleifs effect trust and subjective well being negatively and are more prevalanet in ethnic groups which had a high degree of exposure to the slave trade. LeMay-Boucher et al. (2013) show that households in Cotonou, Benin, spend a significant income share on protection against occult forces. Gershman (2022) argues for evil eye beliefs as a culturally evolved mechanism for reducing conspicuous consumption and status signaling under conditions that incentivize destructive competition.

Given the continued vitality of witchcraft & evil eye beliefs and their proposed effects on (economic) life, it becomes important to understand why these beliefs exist and persist. A small but growing body of work on witchcraft has aimed to shed light on this question by studying its historical and contemporary drivers (e.g. Comaroff and Comaroff, 1999; Geschiere, 1997; 2011; Koning, 2013; Nunn and Sanchez de la Sierra, 2017; Oster, 2004; Shaw, 1997; Thornton, 2003; van de Grijspaarde et al., 2013).[2]

In this study we focus on the historical side, hypothesizing that groups exposed to a higher disease burden in the long run are more likely to hold witchcraft & evil eye beliefs today. Our

[2] There is an important distinction between witchcraft beliefs and witch trials or killings. The latter have been studied by economists in various works, and can be seen as (extreme) outcomes of witch beliefs following particular shocks, such as extreme rainfall (Miguel, 2005; Oster, 2004). Hence, we expect their dynamics to be different: a rise in witch killings must not necessarily imply an increase or strengthening of witch beliefs, and the absence of witch trials or killings should not be interpreted as the absence or weakness of witch beliefs. As we are interested in long-run dynamics, it is more appropriate to study the underlying beliefs rather than shock-driven outcomes such as witch killings. In addition, even actual accusations of witchcraft generally do not produce such extreme outcomes as witch killings. Studying the latter would thus entail an inevitably narrow perspective on a much broader phenomenon.

hypothesis is rooted in the general observation that various psychosocial behaviors among human populations are evolved mechanisms to protect against disease (Chiao and Blizinsky, 2010; Fincher et al., 2008; McNeill, 1976; Thornhill et al., 2009). For the specific case of witchcraft and evil eye beliefs, several psychological and economic mechanisms can explain why they may have emerged and persisted in response to a heavy disease burden.

2.2. Psychological mechanisms

Anthropologists have long argued that witchcraft & evil eye beliefs provide a framework for explaining misfortune – especially death and disease (Foster, 1976; Green, 1999; Liddell et al., 2005; Maslove et al., 2009).[3] Foster (1976: 775) for instance categorizes most medical systems in SSA as mainly 'personalistic', where disease is explained as "*due to the active, purposeful intervention of an agent, who may be human (a witch or sorcerer), nonhuman (a ghost, an ancestor, an evil spirit), or supernatural (a deity or other very powerful being).*"

Psychological and evolutionary research has identified a cognitive underpinning for this anthropological observation. Humans have a strong psychological motivation to understand, predict, and control their environments, evidenced by the fact that undermining perceived control can have important negative effects on psychological and physical well-being (Case et al., 2004; Keinan, 2002). Evolved psychological predispositions of the human brain, such as the search for intentionality and human attributes, as well as easy recall of supernatural concepts, have resulted in a strong tendency to rely on supernatural human-like entities for explaining salient misfortune such as disease (Beck and Forstmeier, 2007; Boyer, 2003). 'Witches', as human agents that possess supernatural powers, are especially compatible with these psychological predispositions.[4]

A closely related argument stems from scapegoat theory and posits that individuals and groups have a psychological tendency to assign unmerited blame for misfortune to others, either in a process of displaced anger and frustration or as a way of diverting attention from the true underlying cause of misfortune (Jensen, 2007). Studies of witch hunts in Europe often mention scapegoating as one of the explanations, and Oster (2004) relies on the scapegoat argument to

[3] Witchcraft tends to explain not the biological side of disease contraction ('how did I become ill?), but the ultimate reason for the occurrence or persistence of illness ('why did I become ill/do I remain ill?) (Liddell et al., 2005; O'Neill et al., 2015). In a Tanzanian case study, Muela et al. (1998) for instance describe how the community explains malaria infections by mosquito-transmitted parasites, but also believes that witches are able to make parasites invisible in the blood, so that the disease is not detected in a hospital, or to provoke the same symptoms as malaria during an attack to camouflage it and thereby gain more time to harm the victim.

[4] Leistner (2014:55-57) for instance writes: "*In its broadest sense, witchcraft is an attempt to make sense of, and deal with, the afflictions of a world dominated by unpredictable occult forces, and to secure an agreeable personal and social life. …People naturally want to understand the reasons for the hardships and disasters they have to suffer. ... where common-sense explanations fail, invisible forces are seen to be at work.*"

explain a positive empirical relation between food shortages and the upsurge of witch trials in Medieval Europe. Leeson and Russ (2017) in contrast find that competition for religious market share in confessionally contested areas performs considerably better in predicting European witch hunts than temperature-induced food shortages.

2.3. Economic mechanisms

Next to meeting psychological needs, witchcraft beliefs may contribute to the survival of a community by strengthening the group's ability to deal with the negative economic effects of disease.

Witchcraft & Evil eye beliefs can serve as a way to instill and enforce strong in-group solidarity. Although stringent solidarity norms can be economically costly by limiting growth and dynamic efficiency, under conditions of high risk and income uncertainty they can promote the static efficiency and resilience of a community (Gorodnichenko and Roland, 2010; Platteau, 2014). Thus, in areas with high disease risk, more powerful witchcraft & evil eye beliefs could have made communities better equipped to survive by boosting in-group solidarity. In his work on pre-industrial societies in West-Africa, Vansina, (2012: 318) aptly describes this mechanism:

> *"the ultimate effect of this set of [witchcraft] beliefs was to provide the very foundation of their celebrated solidarity within kingroups and/or local community groups, without which the existence of such groups could not have been sustained for very long. Indeed, both the fear of being accused and the need to stick together to guard against the attacks of witches created this solidarity and kept it alive. Consequently, belief in witchcraft actually undergirded the social basis of kinship and community."*

This aspect of witchcraft beliefs is still relevant today. In particular, community members who violate sharing norms, thereby threatening the network of solidarity relations, face the risk of being accused of witchcraft (Geschiere, 1997; Platteau, 2014). The far-reaching strategies undertaken by those who want to escape solidarity obligations – wealth concealment at significant cost, religious conversion, or even migration (Platteau, 2014) – is testimony to the strength of solidarity norms and the fear of being accused of witchcraft. Platteau (2014) thus identifies witchcraft as an external enforcement strategy that complements the ever-imperfect internalization of solidarity norms and the associated values.

Yet, witchcraft beliefs may also contribute to the internalization process itself. Historians and anthropologists often emphasize the nature of witchcraft beliefs as an ethical discourse, where witches are associated with selfishness, greed, and individualism – as opposed to solidarity, other-

regarding values, and collectivism (e.g. Geschiere, 1997; Leistner, 2014; Shaw, 1997; Thornton, 2003; Vansina, 2012).[5] Indeed, a salient element of present-day witchcraft beliefs across cultures is the idea that witches use their occult powers to accumulate private wealth, and that they can only garner sufficient power by taking the life force of others through human sacrifice (Geschiere, 2013; Leistner, 2014; Stoop and Verpoorten, mimeo).

Empirical research offers indirect supportive evidence for this economic mechanism, finding that areas with a heavy infectious disease burden are more likely to be inhabited by collectivistic cultures (Fincher et al., 2008; Thornhill et al., 2009, Gresham 2021). One of the main explanations for this finding is that human evolution positively selected for strong in-group solidarity (or 'parochial altruism') in high disease environments, because it allows communities to better manage the negative effects of morbidity and mortality (Fincher et al., 2008; Henrich, 2004; Hruschka and Henrich, 2013). The widely replicated anthropological observation that witchcraft accusations are generally targeted to members of one's intimate circle, such as neighbors and kin (e.g. Geschiere, 2013), fits well with a key role of in-group solidarity.

3. Data sources and description

3.1. Witchcraft/Evil eye beliefs

We take our main data on witchcraft beliefs from surveys conducted by the PEW Research Forum between December 2008 and April 2009 among 25,091 respondents across 19 countries in SSA (Pew Research Centre, 2009). The surveys interviewed between 1,000 to 1,500 persons per country in nationwide samples and collected individual-level information on a wide range of cultural and religious beliefs and practices. Beliefs were recorded as *yes* or *no* answers to the question '*Which, if any, of the following do you believe in?*' followed by various categories such as *witchcraft*, *the evil eye, evil spirits, heaven*, *hell*, and *angels*.

Witchcraft and the evil eye are similar beliefs in the sense that they both involve a human causing harm through occult forces. As such, one could argue that the evil eye belief is also compatible with the psychological and economic mechanisms outlined in the previous section. In the PEW survey, the question in relation to the evil eye asks whether a respondent believes in the

[5] Thornton (2003:282) offers the following telling example: *"Merchants of any race or nationality were especially vulnerable to the charge of being witches because the necessarily individualistic behavior of merchants in the face of a folk ethic of sharing and community service could easily be seen as greed, the root of witchcraft."* Another illustrative element of witchcraft discourse is the fact that witchcraft represents not simply a danger to individuals, but a fundamental threat to the survival of the community (Leistner, 2014).

"evil eye," or that "certain people can cast curses or spells that cause bad things to happen to someone." Classified in this way makes the evil eye belief virtually in-distinguishable for the belief in witchcraft. Following the convention by Gersham (2017) we merge these questions to give a joint measure of belief in witchcraft and the evil eye.

Figures 1 & 3 shows the share of respondents reporting to believe in witchcraft and the evil eye for each country in the PEW survey. There is considerable variation across countries, from a low of 31 % in Ethiopia to a high of 96 % in Tanzania. Overall, 54 % of our sample reports to believe in witchcraft & the evil eye.

Table 1 compares selected socio-economic characteristics for individuals who report to believe in witchcraft or the evil eye and those who report not to. Believers in witchcraft or the evil eye are statistically significantly older, less educated, worse off economically and more likely to be Christian or ethnoreligionist (following an ancestral, tribal, animistic, or other traditional African religion) than Muslim.[6]

Using self-reported data raises the issue that people may not be willing to openly profess their belief in witchcraft & the evil eye, which could result in underestimations of true beliefs. Although the number of people refusing to answer is low for most countries (2%) (Table A.2 in Appendix A), respondents may give false negative answers for various reasons (e.g. Leistner, 2014). By analyzing beliefs within countries only, we account for sources of measurement error that operate at the country level, such as colonial history and anti-witchcraft policies. This leaves us with sources of measurement error operating across ethnic groups within countries, such as the social acceptability of talking openly about witchcraft. To the extent that cross-ethnic measurement error is determined by (pre)colonial European influence, patterns of economic development, the embeddedness in traditional culture, the presence of conflict, the legacy of slavery or the influence of Islam and Christianity, our individual, regional and ethnicity-level control vectors should account for it. As for issues of different translations of witchcraft across ethnic groups, an average 60 % of interviews per sample country were conducted in the same language, and 45 % of interviews were conducted in European languages, whose translations for witchcraft have been widely adopted by the African public (Geschiere, 2011).

[6] Among ethnoreligionists, 84 % reports to believe in witchcraft & the evil eye, but this group makes up only 1.6 % of the sample (compared to an estimated 9 % of the population according to the World Religion Database (2015)). As the PEW survey targeted Christians and Muslims, ethnoreligionists are presumably underrepresented.

3.2. Long-run disease burden

As the proposed links between disease burden and witchcraft beliefs run through morbidity and mortality effects, our empirical exercise would ideally rely on a measure of disease-related long-run morbidity and mortality. Since such a comprehensive measure does not exist, we rely on a measure developed by Depetris-Chauvin and Weil (2016) that provides the closest approximation available: historical malaria mortality.

This measure infers the historical mortality burden of malaria from data on the prevalence of the sickle cell gene, which is the most important and widespread genetic polymorphism that protects against malaria infections in SSA (Carter and Mendis, 2002).[7] The long-run selective pressures of malaria are therefore reflected in the prevalence of the sickle cell gene in a population.

To construct their measure, Depetris-Chauvin and Weil (2016) rely on a geo-database of sickle cell gene frequencies from Piel et al. (2010). These frequencies are calculated from blood sample surveys of populations that are representative of the indigenous population in a particular location. Combining the sickle cell gene data with a genetic transmission model, the authors derive the historical malaria mortality rate for over 800 ethnic groups across Africa. The resulting measure is interpreted as the estimated proportion of individuals that would have died of malaria (through malaria itself or sickle cell disease) before reproductive age, conditional on not dying of something else. This proportion is on average 6 % for ethnic homelands in SSA, but shows high cross-ethnic variation from a low of 0 % to a high of 15 %.

Historical malaria mortality is a better approximation of the long-run malaria burden than contemporary malaria morbidity and mortality for several reasons. Most importantly, the contemporary malaria burden is strongly determined by recent socio-economic development (Asenso-Okyere et al., 2011; Gething et al., 2010; McCann, 2011) and may be influenced by changing climatic conditions since the mid-20th century (Alsan, 2015; Béguin et al., 2011). Such recent changes do not affect the historical malaria mortality measure.[8]

[7] Receiving this gene from both parents causes sickle cell disease, which results in premature death in the absence of modern medical care. Receiving the gene from just one parent instead confers a significant level of protection against malaria (see Depetris-Chauvin and Weil (2016) for an extensive discussion). Although malaria mortality rates among adults are lowered through such protective genetic polymorphisms, as well as acquired functional immunity, morbidity and mortality can still have significant psychological and economic consequences. Mortality rates among young children and pregnant women are high; most adults experience some morbidity shocks with possibly severe complications; malaria infection increases vulnerability to a host of other diseases and health problems; and severe infections can leave survivors with permanent cognitive or physical disabilities (Carter and Mendis, 2002; Snow and Omumbo, 2006). These morbidity and mortality effects create several types of economic costs, including opportunity costs of lost labor and the costs of anticipatory coping strategies such as adjusted agricultural practices (Asenso-Okyere et al., 2011; Chima et al., 2003).

[8] An alternative dataset offers indices of historical pathogen prevalence for several infectious diseases (Murray and Schaller, 2010), but these data are so far only available at the national level or at the level of pre-industrial societies in

A disadvantage of the historical measure is that it may suffer from larger measurement error. Although Piel et al. (2010: 5) only consider indigenous populations, which they define as populations for which "*no information was available from the author to suspect that the population did not evolve locally in relation to the historical prevalence of malaria*", it is possible that the location of indigenous populations in the sickle cell gene database does not match their historical location. However, such measurement error should mainly attenuate our results, and cause bias only if migration patterns are systematically related to witchcraft beliefs. We cannot fully exclude this possibility, but have not found any indications in witchcraft literature that this is the case.

3.3. Historical malaria mortality and witchcraft/evil eye beliefs

The historical malaria mortality measure is calculated at the level of ethnic groups as defined in Murdock's Tribal Map of Africa (Murdock, 1959), and thus proxies malaria mortality in precolonial times within the area defined as the historical ethnic homeland. We match the individual information from the PEW data to ethnicity-level malaria mortality by matching the PEW respondent's self-reported ethnicity to the ethnic groups identified by (Murdock, 1959). The matching was based on ethnicity matches identified in previous empirical studies (Deconinck and Verpoorten, 2013; Gershman, 2016; Nunn and Wantchekon, 2011), and on ethnographic and linguistic sources (Olson, 1996; Simons and Fennig, 2016; Wimmer et al., 2009).

Since information on ethnicity is missing for Rwanda and South Africa in the original PEW data, these two countries are excluded from the analysis. Another 1,881 individual observations for other countries are excluded because of missing information on ethnicity. The final sample counts 20,592 observations for 334 distinct Murdock groups across 17 countries (cf. Appendix C for details).

This sample is then combined with the malaria mortality measure, with other datasets containing ethnicity-level characteristics, and with geographical and climatic measures calculated in geo-processing software. Due to the limited availability of historical ethnographic data, the baseline regression sample includes 19,115 individual observations for 314 Murdock ethnic groups. Although coverage for certain ethnic groups is limited, this regression sample represents a significant part of the population across 17 countries in SSA.

Figure 2 presents historical malaria mortality across 334 ethnic homelands alongside the share of present-day witchcraft believers in each ethnic group. Both measures vary considerably across ethnic groups, and the spatial patterns suggest a correspondence between areas with high

the Standard Cross-Cultural Sample. Combining these data with the PEW dataset would result in a sample of 17 to 28 units of observation – too few for a rigorous econometric analysis.

malaria mortality and areas with a high prevalence of witchcraft beliefs. Figure 3 shows the share of present-day evil eye believers in each ethnic group

This pattern is confirmed in Figure 4, which presents the correlation between historical malaria mortality and the prevalence of witchcraft and evil eye beliefs across ethnic groups, for the raw data (0.37) and conditional on country dummies (0.22). The correlation is positive in both cases, but is substantially smaller once we partial out the influence of country-level variables.

4. Estimation framework and baseline results

We estimate the relation between historical malaria mortality and present-day witchcraft and evil eye beliefs at the level of the individual. The advantage of the individual-level analysis is that we can increase the precision of our estimates by controlling for a host of individual-level factors affecting witchcraft beliefs. In the robustness section to capture group effects, we change the unit of analysis to ethnic groups across countries because we are estimating a long-run relation that has likely evolved within cultural groups. Ethnic groups in SSA tend to be better approximations of cultural groups than political units and go further back in time. The reason for only presenting the ethnic-country analysis in the robustness section is that the number of ethnic groups in our baseline regression sample is relatively small, and the number of individual observations available to calculate the share of witchcraft believers in an ethnic group can be small. Nevertheless, we show that our findings are highly similar when we use the ethnic group as the unit of analysis.

4.1. Estimating equations

To assess the effect of historical malaria mortality on the individual probability of believing in witchcraft, we estimate the following equation:

$$W_{ierc} = \beta M_{ec} + B' X_{iec} + \Theta' C_{ec} + \partial' D_{rc} + \varphi_c + \varepsilon_{iec} \quad (1)$$

where the subscript *i* refers to the individual, *e* refers to the ethnic group, and *c* refers to the country. The dependent variable *W* is a dummy variable taking value 1 if the respondent reports to believe in witchcraft or the evil eye, and 0 otherwise. The regressor of interest *M* is the standardized historical malaria mortality measure. The vectors *X*, *C* and *D* are sets of individual-level, ethnicity- and regional level control variables (in which continuous variables are standardized).[9] φ refers to country dummies and ε is the heteroskedastic error term.

[9] See Appendix B for a detailed description of all variables used in the analysis and their data sources.

To estimate the relation between historical malaria mortality and ethnicity-level prevalence of witchcraft & evil eye beliefs, we estimate the following specification:

$$W_{ec} = \delta M_{ec} + \Phi' C_{ec} + \varphi_c + \epsilon_{ec} \quad (2)$$

where the dependent variable *W* gives the share of respondents reporting to believe in witchcraft or the evil eye for ethnic group *e* in country *c*. The rest of the equation is analogous to equation (1), with the exception that the vector of individual-level controls is excluded.

In our main analysis we rely on OLS to estimate equation (1), treating equation (1) with its binary dependent variable as a linear probability model. In the robustness section we show that our findings for equation (1) are robust to the use of a nonlinear logit model and estimating equation (2) with sample restrictions.

By including country dummies in the estimating equations, we only exploit within-country variation in witchcraft beliefs and historical malaria mortality. This approach allows us to account for a variety of potentially important country-level drivers of witchcraft beliefs today, such as state-sponsored religion, national policies regarding witchcraft (e.g. anti-witchcraft laws), public health policies and investments, country-level economic development and inequality, and conflict history (e.g. Geschiere, 1997; Leistner, 2014). However, it also requires us to treat individuals of the same ethnic group but living in different countries as different units of observation. We argue that this approach in any case is conceptually more appropriate, as it accounts for the possibility that ethnic groups divided by national borders experienced a different history of (de)colonization, nation-state building, and national policies, and are therefore no longer culturally homogenous today.

Now that national-level confounders are accounted for, we need to address within-country factors that may interfere with our hypothesized relation. To this end, we include a number of plausibly exogenous individual-level, ethnicity-and regional level control variables in our baseline specifications.

The basic individual-level controls consist of age and gender. It is commonly assumed that younger generations are less likely to hold magical beliefs such as witchcraft, as these are eroded by ongoing processes of socio-economic modernization. As for gender, anthropological and ethnographic literature suggests that witchcraft beliefs can have particular gender dimensions (e.g. Ciekawy, 1999). The extended individual controls included are the level of education of the individual, type of residence (urban/rural), self-reported measures of economic situation, ethnic conflict, religion, crime and technical literacy[10]

[10] The full list of variables and their creation is described in the supplementary appendix.

The list of ethnicity-level controls is more extensive. As economic development is associated with witchcraft & evil eye beliefs and disease burden, we need to separate the effect of economic development patterns from the effect of historical malaria mortality. Since individual or ethnicity-level income may be endogenous to witchcraft & evil eye beliefs, we control for deep correlates of long-run economic development: absolute latitude, suitability of land for agriculture, area, mean altitude, access to a river, distance from the coast, and distance from the nearest lake (Alsan, 2015; Gershman, 2016). The presence of water bodies and mean altitude also serve as proxies for accessibility or connectivity of the area, which is related to within-country differences in the impact of national institutions and policies (cf. Michalopoulos and Papaioannou, 2014).[11]

A number of anthropological studies have argued that the slave trade in SSA played an important role in shaping witchcraft beliefs and conversely, that witchcraft played an important part in the slave trade – for instance as a justification for selling slaves (e.g. Shaw, 1997; Thornton, 2003).[12] We capture exogenous variation in slave trade intensity through distance to the coast, which Nunn and Wantchekon (2011) show to be a good predictor of slave exports and also directly controlling for the intensity of slave trade.

Witchcraft is related to religion in several ways. For instance, religion can be seen as protective against witchcraft, and Catholic churches often take vocal stances against the existence of witchcraft (Geschiere, 2013; Kohnert, 1996; Leeson and Russ, 2017; Leistner, 2014). As individual religious affiliation is most likely endogenous to witchcraft beliefs, we include measures of the historical influence of the two dominant religions in SSA: Christianity and Islam. For Christianity, this measure is the historical presence of Christian missions in the ethnic homeland (Nunn, 2010; Nunn and Wantchekon, 2011). The number of missions may be associated with the local malaria burden, although a priori the direction of the effect is unclear: a high malaria burden could both increase (e.g. higher need for missionary health care) or decrease (e.g. obstacle to settlement) the presence of missions. For Islam, we rely on the finding of Michalopoulos et al. (2012) that inequality in land endowments, measured by variability in land suitability for agriculture, was a major driver of the spread of early Islam. Variability in land suitability for agriculture has also been identified as a deep driver of ethnolinguistic diversity (Michalopoulos, 2012). Since

[11] Michalopoulos and Papaioannou (2014) find specifically that the impact of national institutions decreases with distance to capital cities. As the PEW data do not include GPS coordinates or administrative units below regions, we cannot exploit variation in distance to the capital directly.

[12] The link between malaria mortality and slave trade is less clear. There may have been less demand for slaves from areas with a high infectious disease burden, but the data indicate that slave trade intensity is positively correlated with disease burden. If areas with a high malaria mortality were less economically or politically developed, one would also expect less slave trade (Nunn, 2008). A further possible link could stem from the positive correlation between disease burden and geographic factors that facilitated the slave trade, such as closeness of water bodies.

historical malaria mortality has been linked to the diversity and strength of ethnic identities (Chiovelli et al., 2015), variability in land suitability also serves to absorb any impact of ethnolinguistic diversity.

Finally, climate is an important determinant of the malaria burden and may affect witchcraft beliefs indirectly through economic development or directly as another source of misfortune (e.g. in the form of extreme rainfall). Broad climate zones are captured by absolute latitude, which is already included. We control for recent climatic conditions through the mean and standard deviation of annual rainfall and temperature during the growing season for the period 1957-2002 (Guariso and Rogall, 2016). Historical climate is proxied by mean daily humidity and temperature in 1871 (Alsan, 2015). To control for another important source of misfortune that may be correlated with the malaria burden, we include a measure developed by Alsan (2015) that captures climatic suitability for the Tse Tse fly, which is the disease vector for trypanosomiasis.[13]

The inclusion of regional level controls is to account for confounding variables which were not accounted for in the individual or ethnicity level controls. Nunn and Puga (2012) have shown that land ruggedness is correlated with African development and slave trade. To account for regional differences in land ruggedness which may have impacted historical malaria mortality, we include mean land ruggedness as a control. We have controlled for the economic situation of an individual on the basis of self-reported economic shortages or their experience of shortages of money, these might be overreported in the survey. Therefore, we include nighttime lights per capita at the regional level as a proxy for economic development. Disease burden strengthened kinship in small groups but perhaps may have led to a weaker connection with other members of society (to reduce the risk of catching communicable diseases), to control for this we include a measure of ethnolinguistic polarization labelled the ethnolinguistic index which was created by Gersham (2016) and finally we include a measure of conflict (which is different from the self-reported perceived causes of conflict) at the regional level since conflict has been associated with witchcraft (Nunn and Sanchez de la Sierra, 2017; Wlodarczyk, 2009), and may be associated with the frequency of disease epidemics.

[13] Aside from malaria, the second infectious disease presumed to have affected political, economic, and cultural development in SSA in major ways is trypanosomiasis (Akyeampong, 2006; Webb, 2006). We do not consider the long-run burden of trypanosomiasis in this study for two reasons. First, we do not have a comparable measure of long-run mortality related to trypanosomiasis. Second, an analysis of the trypanosomiasis burden would be complicated by its important effects on several precolonial political and economic characteristics (Alsan, 2015), which interacted in dynamic ways with witchcraft beliefs (Koning, 2013). Depetris-Chauvin and Weil (2016) in contrast find that historical malaria mortality is only strongly correlated with population density in precolonial SSA (Depetris-Chauvin and Weil, 2016).

4.2. Calculating standard errors

Error terms will likely be correlated between individuals of the same ethnic group because of a common cultural heritage. However, Murdock ethnic groups are not necessarily culturally independent units; many groups are likely to be culturally related because they share a common ancestry or history. Such cultural relatedness is more likely for ethnic groups that are genealogically related or geographically close. Alsan (2015) addresses this by allowing error terms to be correlated within cultural provinces, which are larger groupings devised by Murdock that should be culturally independent from each other. Hence, we allow for standard errors to be clustered at the level of these cultural provinces.

Once all baseline control variables are included, our regression sample counts 37 cultural provinces with unbalanced cluster sizes. Since this data structure increases the risk of incorrect statistical inference (inflated p-values) for cluster-robust standard errors, we check whether our results hold when cluster-robust standard errors are calculated using pair-wise bootstrapping with asymptotic refinement.[14] [15]

4.3. Baseline results

Table 2 presents estimation results for equation (1). In columns (1) - (6) we include a progressively richer set of control variables. The final column (7) shows results when bootstrapped cluster-robust standard errors are used. In all columns, historical malaria mortality is positively and statistically significantly correlated with the individual probability of believing in witchcraft or the evil eye. All else equal, a one standard deviation increase in historical malaria mortality is associated with an approximately 4 percentage point higher probability of believing in witchcraft on average. This estimate corresponds to an increase of 8 % of the sample average or a 0.08 standard deviation increase. Historical malaria mortality explains 15% of the variation in present day witchcraft & evil eye belief at the individual level.

[14] We rely on the program clustse which bootstraps the pivotal t-statistic by sampling observations (independent and dependent variables together) with replacement by cluster groups, and uses the distribution of the t-statistic over the bootstrap samples for statistical inference. The program code was developed by Andrew Menger in 2015 and provided by the Boston College Department of Economics in its series Statistical Software Components with number S457989. As this program does not provide estimates of standard errors, all tables only show significance values for the coefficient estimates when bootstrapped cluster-robust standard errors are used. The R-squared is not reported for these estimates as post-estimation procedures cannot be run on this model.

[15] We also conducted two-way clustering for the full individual specification at the province-regional and province-ethnicity level using the command by Cameron et al (2011) [psacalc] and find our results are robust to this type of clustering. The results are not shown but are available upon request.

5. Alternative explanations

A number of alternative explanations for the positive malaria-witchcraft relation remain. We account for them by enriching our specification with a large number of (potentially endogenous) additional variables that are organized into contemporary individual factors, precolonial ethnicity-level characteristics, measures of European settlement and influence and regional characteristics. We then discuss to what extent our finding can be explained by reverse causality.

5.1. Contemporary individual characteristics

5.1.1. Control variables

Classic modernization theory assumes that processes of modernization such as income growth, urbanization, the spread of education, and technological advancement erode religion, superstition, and magical beliefs (e.g. Iannaccone, 1998). If this is true for SSA, the positive malaria-witchcraft relation could arise when areas with a high malaria burden were the last to 'modernize', e.g. because these areas attracted less foreign investments (Sachs and Malaney, 2002).

To capture the possible influence of education and urbanization, we include dummies for secondary education, tertiary education, urban residence, and semi-urban residence. As the PEW data do not include measures of income that are comparable across countries, we proxy income with a dummy variable indicating self-reported money shortages in the past year and a categorical variable indicating whether the respondent rates his economic situation as (somewhat or very) bad (plus its squared term). Technology use is captured by dummies indicating use of the internet, email, or a pc, which may also partly capture income.

If classic modernization theory is incorrect, it is still possible that areas with a higher malaria burden were the places where traditional African culture and worldviews persisted for a longer time, for instance because Europeans were less likely to settle there. To address this possibility, we include an index for personal engagement in practices that are associated with traditional life and culture, and a dummy for reliance on a traditional healer in case of illness.

We further control directly for the influence of religion by including two dummies for Christian religion and ethnoreligion and an index of religiosity.[16] We also include a Herfindahl index for Christian denominations (at the regional level) to account for the possibility that different

[16] We obtain similar results when we include a more refined measure of religious affiliation that distinguishes between different branches of Christianity (Protestantism, Anglicanism, African independent churches, and the Ethiopian Orthodox Church; results not reported, but available on request).

denominations compete for religious market share by offering protection against witchcraft (Leeson and Russ, 2017).

Conflict has been associated with witchcraft (Nunn and Sanchez de la Sierra, 2017; Wlodarczyk, 2009), and may be associated with the frequency of disease epidemics. We therefore control for perceived severity of crime, religious conflict, and ethnic conflict.

Finally, van de Grijspaarde et al. (2013) find that in eastern Sierra Leone witchcraft manifestations are higher in communities that experience the competing pull of traditional and market-based institutions and norms. Potential non-linear effects of this sort may already be captured by semi-urban residence and by the quadratic function of personal economic situation. We further include a dummy variable indicating whether the respondent believes that Western popular culture has hurt morality in the country, which may capture a perceived conflict between different cultures or value systems.

5.1.2. Results

Table 3 presents OLS estimation results for the extended individual-level specification. Columns (1)-(6) report estimation results when we include a progressively richer set of additional controls. The coefficient estimate for historical malaria mortality remains statistically significant at the 10 % level in all columns.

Table 3 also shows estimation results for the control variables, as these offer some noteworthy insights into the contemporary correlates of witchcraft beliefs. We highlight the main findings.

Most results for measures of modernization are inconsistent with the standard predictions of modernization theory, and support anthropological observations on the 'modernity' of witchcraft (Geschiere, 1997). In particular, age and education do not matter once we control for embeddedness in traditional culture and religiosity, and urban residents are more likely to hold witchcraft beliefs – suggesting that these beliefs are not a relic of rural village life.

As for income, money shortages and assessing one's personal economic situation as bad is insignificantly correlated with witchcraft & evil eye beliefs.

Finally, the results point to an important role of traditional culture and religion in witchcraft beliefs (i.e: the positive and statistically significant correlation between traditional practices and the use of a traditional healer and belief in witchcraft/the evil eye), and give some support to the hypothesis that perceived tension between different value systems matters.

5.2. Precolonial characteristics of the ethnic group

5.2.1. Control variables

Historical malaria mortality could have been affected by two important group-level adaptive strategies: (semi-)nomadic settlement patterns that allowed groups to avoid high transmission periods through seasonal migration, and low population densities that limited the risk of contagion and spread of a disease. In addition, societies with more complex institutions or centralized power may have been better able to control infectious diseases (e.g. through faster quarantine or evacuation in case of epidemics). As these three features of group organization and settlement could also be related to witchcraft & evil eye beliefs and their evolution (Geschiere, 1997; Koning, 2013), they may interfere with our hypothesized relation.

To address this issue, we extend the list of controls in equation (1) to the complexity of precolonial settlement patterns (Murdock 1967), precolonial institutional centralization (Murdock 1967), and two alternative estimates for precolonial population density: colonial population density (Murdock 1967) and the presence of cities with over 20,000 inhabitants in 1800 (Chandler, 1987). Precolonial centralization of institutions also allows us to better control for within-country variation in contemporary economic development (Michalopoulos and Papaioannou, 2013) and (post-)colonial governance quality (Gennaioli and Rainer, 2005; 2007).

Finally, witchcraft and evil eye beliefs have been linked to wealth inequality and social stratification, which are historically associated with pastoralism and agriculture (Gershman, 2015; Koning, 2013). As the historical malaria burden is also related to agricultural development (Carter and Mendis, 2002), we include a dummy for strong dependence of precolonial production on agriculture or husbandry.

5.2.2. Results

Table 4 present OLS estimation results for equation (1). In columns (2)-(4) we show that our result is robust to the gradual inclusion of the precolonial control variables discussed above. The positive coefficient estimate for historical malaria mortality remains statistically significant at the 5 % level.

5.3. European settlement and influence

5.3.1. Control variables

Disease burden affects not only the indigenous population, but also (and often more so) immigrant populations. As such, a heavy historical malaria burden could have discouraged European settlement during the colonial era. European settlement patterns in turn are found to predict contemporary patterns of urbanization and economic development within countries (Flückiger

and Ludwig, 2017; Jedwab et al., 2017). Hence, it is possible that areas with a heavier historical malaria burden have less witchcraft & evil eye beliefs today because they continue to be less urbanized and economically developed. These regional effects may not be fully captured by the controls outlined above. Alternatively, a higher presence of European settlers, who brought with them different cultural beliefs, values, and norms, in low malaria areas could have initiated processes of cultural change (Nunn, 2012) that eroded witchcraft beliefs in those areas.

To check whether our finding is driven by these alternative channels, we need to control for within-country variation in European settlement patterns.[17]

Given that regional centers established by Europeans often persisted into urban centers today (Flückiger and Ludwig, 2017; Jedwab et al., 2017), the already included measures of colonial population density and the presence of a city in 1800 should capture part of the effect of spatial patterns in European settlement.

In addition, Jedwab et al. (2017) show that in Kenya the location of colonial railways importantly determined the location of European settlers, Asian traders, and main cities at independence. In a similar vein, Nunn and Wantchekon (2011) measure exposure to European influence in the colonial era across SSA by the pass-through of colonial railways and European explorer routes in the ethnic homeland. We add both measures as additional controls to our regression specification.

5.3.2. Results

Column (5) in Table 4 presents OLS estimates when we add the railway and explorer route variables to the list of precolonial controls. Since these measures are unavailable for several countries in our dataset, we lose about a third of the regression sample shown in Table 2, but can still rely on over 7,000 individual observations. Our positive coefficient estimate for historical malaria mortality remains statistically significant at the 5% level.

5.4. Slave trade and Trust

5.4.1. Control variables

The slave trade has been shown to effect economic development in SSA which could have effected settlement patterns and thus belief in witchcraft and the evil eye (see for example Nunn 2017), therefore we control for slave trade using a measure of slave exports developed by (Nunn, 2007).

[17] Acemoglu et al. (2002) rely on historical settler mortality data to proxy for European settlement patterns, but others have argued that settler mortality is a poor predictor of European settlement patterns within Africa (Albouy, 2012; Olsson, 2004). In any case, these data are only available at the country level.

Gersham (2017) has shown that witchcraft and evil eye beliefs negatively affect trust which has been shown to effect economic development, hence we include measures of general trust and trust in people of different religions.

5.4.2. Results

Columns (6) and (7) show the inclusion of these controls. The effect of malaria burden on present day witchcraft and evil eye belief remains statistically significant at the 5% level.

5.5. Ruggedness, Night lights, Ethnolinguistic fractionalization and Conflict

5.5.1. Control variables

The inclusion of regional level controls is to account for confounding variables which were not accounted for in the individual or ethnicity level controls. Nunn and Puga (2012) have shown that land ruggedness is correlated with African development and slave trade. To account for regional differences in land ruggedness which may have impacted historical malaria mortality, we include land ruggedness. We have controlled for the economic situation of an individual on the basis of self-reported economic shortages or their experience of shortages of money, these might be misreported in the survey. Therefore, we include nighttime lights per capita at the regional level as a proxy for economic development. Disease burden strengthened kinship in small groups but perhaps may have led to a weaker connection with other members of society (to reduce the risk of catching communicable diseases), to control for this we include a measure of ethnolinguistic polarization labelled the ethnolinguistic index which was created by Gersham (2016) and finally we include a measure of conflict (which is different from the self-reported perceived causes of conflict) at the regional level since conflict has been associated with witchcraft (Nunn and Sanchez de la Sierra, 2017; Wlodarczyk, 2009), and thus may be associated with the frequency of disease epidemics.

5.5.2. Results

Table 5 (column 7), Table 6 (column 6) and Table 7 (column 8) show the inclusion of these regional level variables. In each model, the inclusion of these controls does not reduce the statistical significance of historical malaria burden on belief which remains statistically significant at the 10% level.

5.6. Reverse causality

Qualitative and quantitative work has argued that magical beliefs can negatively affect preventive and treatment behavior (Briones Alonso, 2015; Stoop et al., 2017). For instance, patients may not seek biomedical treatment because they see it as unable to deal with illness caused by occult forces. The question then arises whether historically the strength of witchcraft beliefs could have affected malaria mortality.[18] We argue that this scenario is unlikely. Highly effective prevention strategies such as insecticides and bed nets were unavailable in precolonial SSA, and treatment methods sufficiently effective so as to change selective pressures were presumably not available either.[19]

A more indirect channel of reverse causality would entail historical witchcraft beliefs affecting exposure to malaria by influencing settlement location.[20] As we cannot fully exclude this possibility, we emphasize that our finding remains correlational.[21]

5.7. Robustness checks

We check the robustness of our main finding to a number of alternative estimation strategies.

Since the dependent variable in equation (1) is a binary variable, we verify whether our results hold under a logit model. Table 8 presents estimated marginal effects for various specifications of equation (1), and confirms the main results obtained using OLS estimation.

[18] Historical malaria mortality is also correlated with contemporary disease burden (Depetris-Chauvin and Weil, 2016), which raises the question whether historical malaria mortality might capture a positive effect of strong witchcraft beliefs on contemporary malaria burden. Our results do not change when we control for contemporary intensity of malaria transmission (Kiszewski et al., 2004) (results not reported, but available on request).

[19] The biomedical sciences did not uncover the cause and transmission of malaria until the 19th century. This in itself does not imply the absence of knowledge on malaria prevention and treatment among precolonial societies in SSA, as many human populations independently developed biomedically consistent knowledge of and treatment for infectious diseases (Briones Alonso, 2015). However, we have found no research suggesting the existence of effective prevention or treatment (rather than symptom alleviation) for malaria, or accurate knowledge on its transmission mechanism, among precolonial societies in SSA. In addition, any such treatment or prevention method would need a high degree of effectiveness to significantly change selective pressures at the population level.

[20] An important determinant of settlement location is success in inter-group conflict. Yet, if conflict explains settlement location, we should find a negative malaria-witchcraft relation. Nunn and Sanchez de la Sierra (2017) argue that witchcraft beliefs help communities in DR Congo to win violent conflict today. In historical terms, a growing body of evolutionary literature argues that in-group solidarity or parochial altruism, which is said to be promoted by witchcraft beliefs, evolved among humans precisely because it increased the odds of surviving inter-group conflict (Bowles, 2009). Hence, one would expect stronger witchcraft beliefs to be associated with success in conflict and thus with settlement on desirable land with a lower disease burden (conditional on agricultural suitability).

[21] Following Depetris-Chauvin and Weil (2016), we attempted to instrument historical malaria burden with a temperature-dependent index reflecting the climatic suitability of an area to the malaria vector and parasite. This instrument, however, does not fully solve the issue at hand, as unobserved characteristics of human populations (such as historical witchcraft beliefs or military success) can determine where populations ultimately settle, and thus the suitability of their homeland to malaria. We present these results in Table 13.

To verify whether the observed positive correlation is particular to Witchcraft & Evil eye beliefs, we explore the relation between historical malaria mortality and other magical beliefs. If our hypothesis is correct, we should find a statistically insignificant relationship between historical malaria mortality and other magical beliefs which do not involve belief in human agency and adverse events.

Table 9 presents OLS estimation results for equation (1), the PEW survey documents four other beliefs associated with traditional African worldviews: belief in evil spirits, and the belief that you can protect yourself from 'bad things happening' through sacrifices to spirits or ancestors, through certain spiritual people, or through juju, shrines, or other sacred objects. Another set of magical beliefs documented in the PEW survey are more strongly associated with Islam or Christianity: belief in heaven, hell, angels, and miracles. If the relation between witchcraft/evil eye and historical malaria mortality is explained solely by the fact that it allows one to explain and protect against misfortune, we might expect a similar positive relation between historical malaria mortality and these other magical beliefs. The absence of such a relation would be consistent with the argument that there is something particular about witchcraft & evil eye beliefs that explains a positive relation with historical malaria mortality.

None of the individual beliefs or belief indices are statistically significantly related to historical malaria mortality at the individual level except traditional beliefs that is statistically significant at the 10 % level (this includes: witchcraft, the evil eye, evil spirits, protection from sacrifices to ancestors, protection from certain spiritual people, protection from sacred objects).

These findings give us two important pieces of information that may shed light on the underlying mechanisms, even though they do not allow us to unequivocally exclude one or the other. First, the fact that we find no relation whatsoever with beliefs related to protection against harm suggest that any psychological mechanism centers around the clear identification of the cause of misfortune, rather than a general need to feel protected against misfortune. Second, the two beliefs that show the strongest relation with disease burden, witchcraft and the evil eye, have in common that they involve a human agent of misfortune. As non-human agents such as evil spirits are often invoked to explain disease as well (e.g. Foster, 1976; Liddell et al., 2005) these results suggest that the underlying mechanism involves something more than a mere identification of the cause of misfortune, and that human agency plays a key role in it.

We see two possible reasons for the importance of human agency. First, the identification of a human cause of misfortune may facilitate scapegoating or give a greater sense of control over misfortune, by allowing a clear removal of the threat (a human can be visibly removed from the community). Second, spirits do not take active part in the social (kinship) relations and concurrent

sharing norms of the living members of a community. In other words, one cannot enforce material solidarity from non-human agents..

Yet, in theory these mechanisms are compatible with other types of beliefs, including belief in non-human supernatural entities. For instance, it is possible to have spiritual leaders consult the ancestors as to which person has angered them and brought disease upon the community, or to enforce solidarity norms by instilling fear of punishment by the gods if the norms are violated. Why would witchcraft and the evil eye in particular have emerged and persisted ?

The answer may lie in the decentralized nature of these beliefs. In principle, anyone can accuse another of witchcraft (or the evil eye); the process does not require higher-level institutions or persons of authority, even though spiritual or political leaders may be involved to arbitrate and resolve accusations. This decentralized, community-driven characteristic could have generated two important types of advantages. The first is lower transaction costs and informational advantages, for instance in identifying breaches of solidarity norms within kinship networks. The second is greater flexibility and adaptability. Systems embedded in higher-level institutions or particular power structures may be more rigid and less capable of surviving major societal transformations, such as the erosion of traditional power structures by colonial governments[22]. Recent anthropological work has indeed emphasized the dynamic nature of witchcraft and its ability to adapt to new political and economic environments (Comaroff and Comaroff, 1999; D'Angelo, 2014; Geschiere, 1997; 1998). These two types of advantages may explain why witchcraft and the evil eye outcompeted alternative systems and retained so much of its power until today.

We also present the results of equation (2) in Table 10 as a further robustness check by collapsing individual level observations at the ethnicity-country level and restricting the results to ethnicities which have at least 10 observations across countries. The sample size is restricted to permit comparison across different specifications and reassuringly our main estimates hold and remain statistically significant at the 5% level.

Finally, for equation (1) we check whether our main finding is driven by any particular country. We re-estimate the richest specifications (i.e. including all individual, regional and ethnicity-level control variables) for an adjusted sample that excludes one country, and repeat this exercise for all countries.

Figure 5 presents the coefficient estimates and confidence intervals for historical malaria mortality. The estimates generally remain within the same range, and the confidence intervals are

[22] This flexibility of witchcraft beliefs is well illustrated by the fact that it can be seen as a desirable quality of leaders, enabling them to protect the community against attacks, or as a dangerous power that corrupts leaders into greed and selfishness. As such, witchcraft can serve both to support existing power structures, or to justify community-driven uprisings against and removal of unwanted leaders (Thornton, 2003).

above zero in all cases which suggests that the results are not driven by the inclusion of certain countries.

5.8. Additional Analysis

5.8.1. Heterogeneity by pre-colonial group characteristics

So far, we have investigated in detail the effect of a historical disease burden and its effect on belief in witchcraft & the evil eye today across various ethnic groups distributed across various countries in SSA. In order to distil our analysis further, we now investigate the heterogeneity in witchcraft belief across different ethnic groups in SSA. For that purpose we use the information provided in the Murdock Atlas on various characteristics of ethnic groups such as the level of Jurisdictional hierarchy in the ethnic group, the settlement pattern of the ethnic group, the reliance of the ethnic group on hunting, fishing, animal husbandry and agriculture. We focus on these characteristics based on our reading of the anthropological literature on the evolution and development of witchcraft beliefs in pre-colonial SSA (Mesaki, 1995: Swantz, 1990; Latham, 1972: Nadel, 1935). In our regression specification in equation (1), we include an interaction term which captures the effect of historical malaria burden on witchcraft & evil eye belief through the identification of a particular characteristic of the ethnic group in question. In what follows we discuss the results we find. In the ethnographic atlas, Murdock defines the historical reliance of an ethnic group on hunting which varies between (0-5%) to (35-45%). We compare ethnic groups which have a higher than median reliance (15-45%) on hunting as having a high reliance on hunting vs those groups that do not (0-5%). In Table 11, we present the results for the individual specification which includes the exhaustive list of controls. We do not find statistically significant results for individuals that belonged to an ethnic group with a high reliance on hunting vs those that did not in terms of their present day belief in witchcraft.

In the ethnographic atlas, Murdock defines the historical reliance of an ethnic group on fishing which varies between (0-5%) to (55-65%). We define ethnic groups which have a higher than median reliance (25-100%) on fishing as having a high reliance on fishing and compare it to those groups that do not (0-25%). In Table 10, Column 2 we present the results including all the controls. We do not find evidence of Malinowski's theory (1948) which argued that open sea/ocean fishing leads to superstitious behavior and magical thinking[23]. We do not find statistically significant results for individuals that belonged to an ethnic group with a high reliance on fishing vs those that did

[23] We also tried an alternative method to investigate this theory by defining a dummy variable for coastal regions and then include the interaction term of the coastal dummy and a fishing dummy (from 1-4) but found the results were still insignificant.

not in terms of their present day belief in witchcraft & the evil eye. The only significant effect we find is for individuals that belonged to an ethnic group with a higher than median reliance on animal husbandry were 3.4% less likely to believe in witchcraft compared to those individuals which had a lower than median reliance on animal husbandry the result being statistically significant at the 15% level. For ethnic groups that had a high reliance of agriculture, we do not find statistically significant results for individuals and ethnic groups that were historically exposed to malaria. For ethnic groups that were nomadic in nature, we do not find statistically significant results for individuals and ethnic groups that were historically exposed to malaria. Finally, for ethnic groups that had some degree of jurisdictional hierarchy, we do not find statistically significant results for individuals that were historically exposed to malaria.

In summary, we find the strongest effect of ethnic group characteristics on belief in witchcraft & the evil eye for ethnic groups that relied on animal husbandry. Research in malaria endemic areas in the Indian subcontinent and Asia show a high propensity for malaria carrying mosquitos to feed on livestock, a process which is defined as zoo prophylaxis or the use of wild or domestic animals which are not the reservoir host of a disease to divert the blood seeking malaria vector away from human hosts (Asale et al, 2017, Waite et al, 2017 and Muller et al, 2018). It is possible that ethnic groups historically which used animals were using zoo prophylaxis to reduce the spread of malaria therefore reducing the need to develop a belief system to explain the prevalence of the disease thus explaining the results we find of a reduction in witchcraft/evil eye belief for ethic groups that were more reliant on animals.

5.8.2. General trust

We have argued that the effect of a heavy disease burden is to promote a society which is inward looking to combat the adverse effects of a heavy disease burden. Work by Gersham (2016) has demonstrated that belief in witchcraft reduces societal trust in SSA. In the individual specifications we controlled for trust, however in Table 12, we investigate if a heavy disease burden leads to a reducing in general trust (in other people). We find that a one s.d increase in malaria burden leads to a reduction in trust in other people by 5.4%[24]

5.8.3. Instrumental variables

In the preceding analysis we have attempted to account for co-founding factors by including a wide range of controls at various levels of aggregation however there exists the threat of reverse causality and bias in our point estimates, therefore we exploit variation in a temperature dependent

[24] We also investigated if a heavy malaria burden led a reduction in trust of individuals which belong to other religions but found no statistically significant effects here (the results are not shown but available upon request)

index developed by Gething et al (2011) to instrument for the historical malaria mortality measure we deploy as our indicator of historical disease burden following the example of Chauvin & Weil (2016). Temperature affects the life cycle of the mosquito vector and plasmodium parasites therefore it directly affects the landscape of Malaria and we stipulate it should satisfy the independence assumption as the temperature dependent index should only effect belief in witchcraft through its effect on the Malaria parasite. The instrument is developed using a dynamic biological model which incorporates how temperature effects malaria transmission (it takes into account the changing of temperature over time on the vector of parasite populations), therefore it is potentially a better instrument than the one developed by Kisezewski et al (2004) because it does not depend on the actual distribution of the malaria mosquito vector therefore avoiding a potential endogeneity problem. In Table 13 Panel A, we look at the ability of Plasmodium suitability (Gething et al, 2011) and Malaria Ecology (Kisezewski et al, 2004) to predict historical malaria burden. We find Plasmodium suitability is a stronger predictor of Historical malaria burden compared to Malaria Ecology[25]. This is an important check as Plasmodium suitability is constructed from temperature data and can indirectly effect development through agricultural productivity or disease.

The statistically significant point estimate in column 1 and 3 suggests that one standard deviation increase in Plasmodium suitability predicts almost a fourth of a standard deviation increase in historical malaria burden. We next run the same exercise for Malaria Ecology and do not find a statistically significant standardized beta coefficient for predicting historical malaria mortality. Finally, we run horse races between our proposed instrument and malaria ecology and find that regardless of the addition of all controls the plasmodium suitability index outperforms malaria ecology as a predictor for malaria burden. Table 13, Panel B presents the point estimates of the reduced form on belief in witchcraft & the evil eye at the individual level. While we still find a positive association between plasmodium suitability & malaria ecology on belief in witchcraft & the evil eye, the estimates are not statistically significant. Therefore, after instrumenting for historical malaria mortality with plausible exogenous variation we do not find the same significant results for belief in witchcraft and the evil eye.

6.0 Conclusion

We set out to study the link between long-run disease burden and witchcraft/evil eye beliefs in SSA. Based on various psychological and economic mechanisms proposed in different strands of

[25] The 1st stage is run on a collapsed dataset at the ethnicity-country level following the example of Chauvin & Weil (2016)

literature, we hypothesize that long-run exposure to a heavy disease burden promoted witchcraft & evil eye beliefs. These underlying mechanisms, if accurate, could still be actively stimulating witchcraft & evil eye beliefs in contemporary African societies, but not necessarily. It is possible that witchcraft & evil eye beliefs and practices find their origins in these mechanisms, but became institutionalized into a self-sustaining and self-perpetuating belief system.

Our empirical findings are consistent with our hypothesis: historical malaria mortality is significantly and positively associated with contemporary witchcraft beliefs. This result applies to a sample of at least 7,000 individuals belonging to more than 200 ethnic groups for 17 countries in SSA. Although coverage is limited for some ethnic groups and regions in the sample countries, the dataset nevertheless spans a significant geographic area and share of the population in SSA.

We rule out a number of alternative explanations for our finding by including a battery of relevant individual, regional and ethnicity-level controls. Yet, as we cannot fully exclude the possibility that historical witchcraft & evil eye beliefs affect settlement location, or that both witchcraft & evil eye beliefs and malaria burden are determined by unobserved group characteristics, we emphasize that our finding should be interpreted as correlational rather than causal evidence.

In line with anthropological literature on 'the modernity of witchcraft', we further find that contemporary individual and national characteristics perform better in explaining present-day witchcraft beliefs than historical factors, including the malaria burden. Nevertheless, the fact that witchcraft & evil eye beliefs today are robustly and significantly associated with the historical disease environment resonates well with recent evolutionary literature on the persistent role of the disease environment in shaping human cultures and in directing the path-dependency of cultural change (e.g. Inglehart, 2016).

Our study also captures just one aspect (mortality) of one infectious disease (malaria). As SSA suffers from the highest infectious disease burden of all continents, both historically and today, our empirical finding may underestimate the true witchcraft-disease relation. If comparable measures of the historical burden of other diseases become available, a broader replication exercise of our analysis would be useful.

Since we are not able to identify any particular mechanism(s) as the main driver of our finding, further research in this area is also needed. Survey data on collectivistic and individualistic values and behaviors, in particular in-group solidarity or parochial values, and psychological characteristics related to perceived control and scapegoating could be useful for identifying the underlying mechanisms.

Gaining a better understanding of how beliefs are formed and how they change is, as noted by North (2008: 1005), "*fundamental to a new social science*". Given the omnipresence and profound influence of witchcraft and the evil eye in present-day SSA, a deeper understanding of its origins and evolution could shed light on contemporary issues and dynamics. The witchcraft-disease relation in particular can provide historical context for recent upsurges of superstitious belief discourse following the AIDS and Ebola epidemics (BBC, 2014; IFRC, 2014; Kalichman and Simbayi, 2004; Thomas, 2007).

A proper understanding of major culture traits can also improve policy effectiveness. Some examples of possible benefits are greater cultural compatibility or a better assessment of the broader impact and implications of policies. Studying contemporary dynamics alongside historical, long-run processes may thus prove to be a fruitful research agenda for understanding how and why witchcraft & evil eye beliefs affect African societies today.

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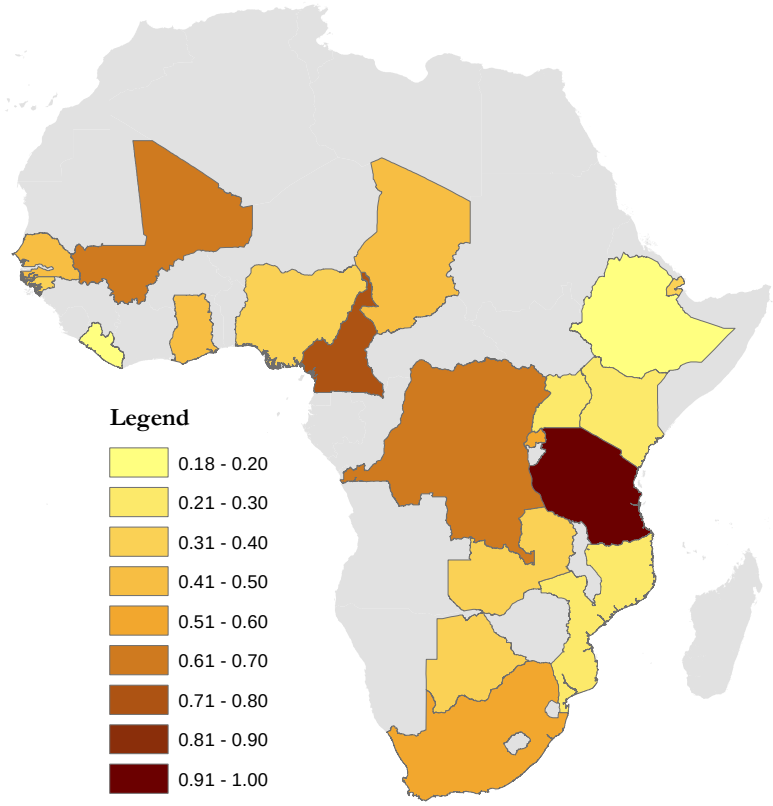
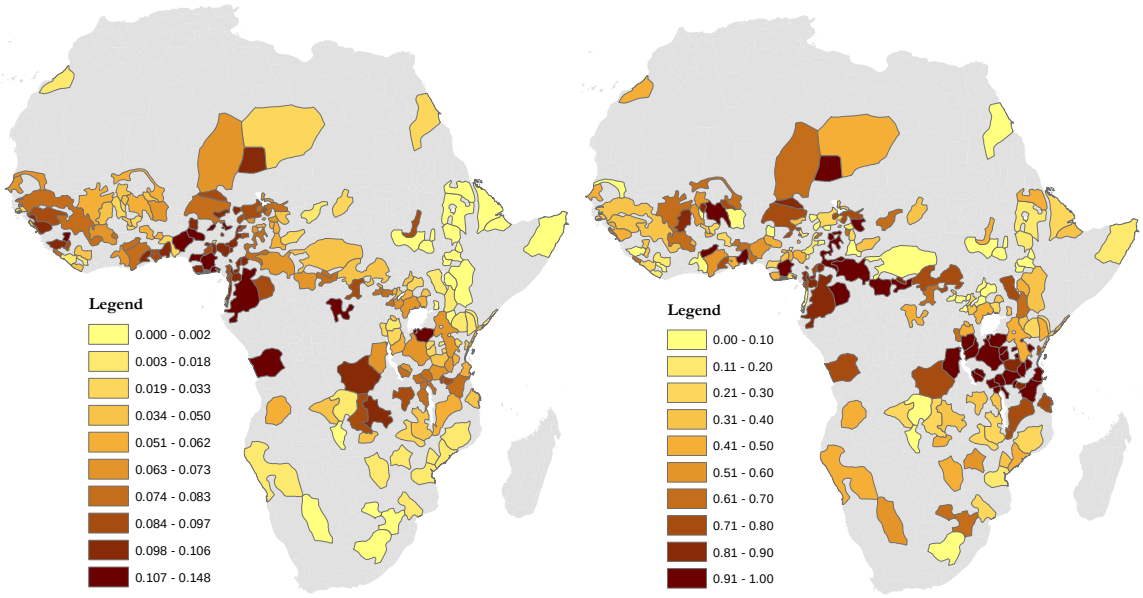
Figures

Figure 1: Share of respondents reporting to believe in witchcraft across surveyed countries.



Note: This figure shows all countries included in the original PEW survey.

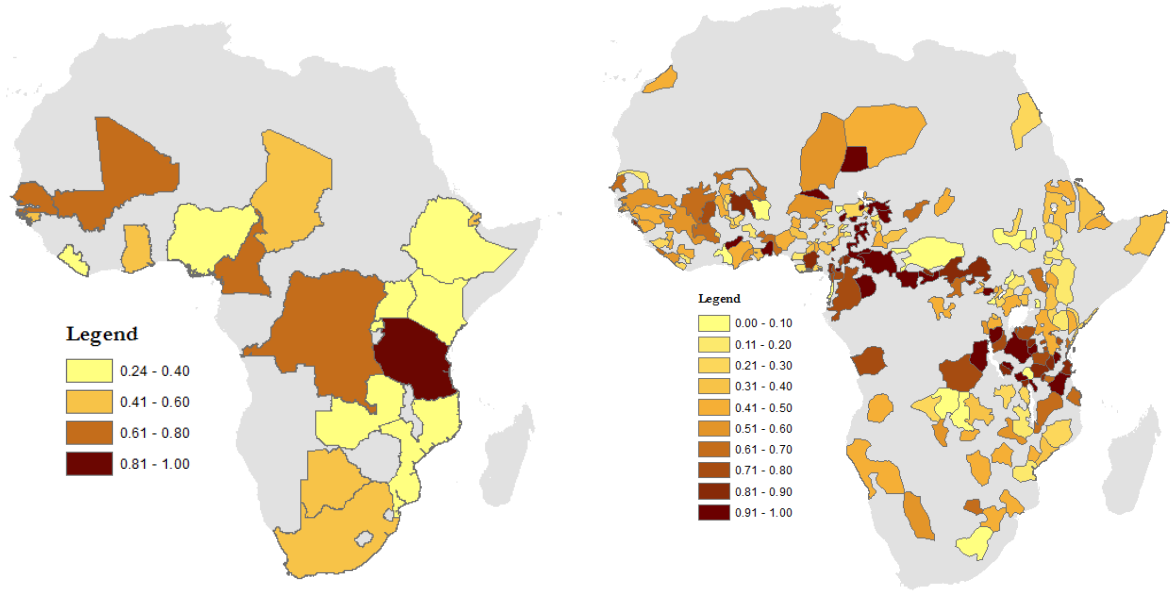
Figure 2: Historical malaria mortality and witchcraft beliefs across ethnic groups.



(a) Historical malaria mortality (b) Witchcraft beliefs

Notes: The categories for historical malaria mortality correspond to 10 quantiles (rounded up to three decimals). Ethnicity-level witchcraft beliefs are measured as the share of respondents of that ethnicity reporting to believe in witchcraft.

Figure 3: Share of respondents reporting to believe in the evil eye across surveyed countries (a) and ethnic groups (b).

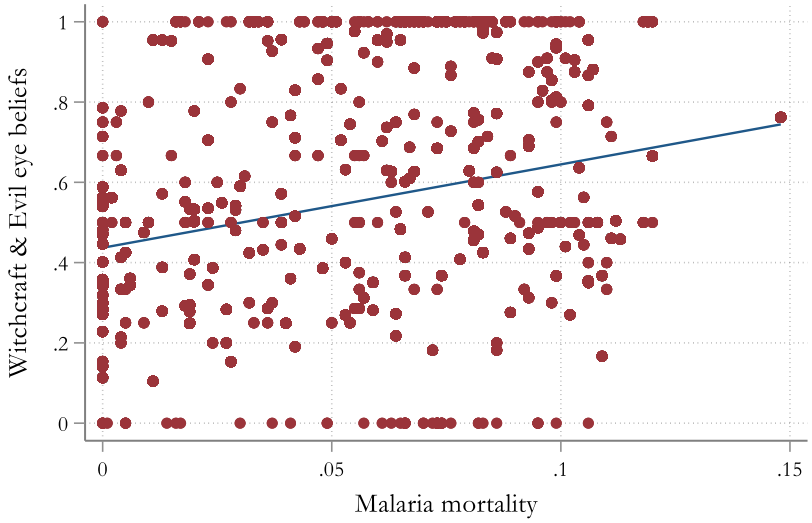


(a) (b)

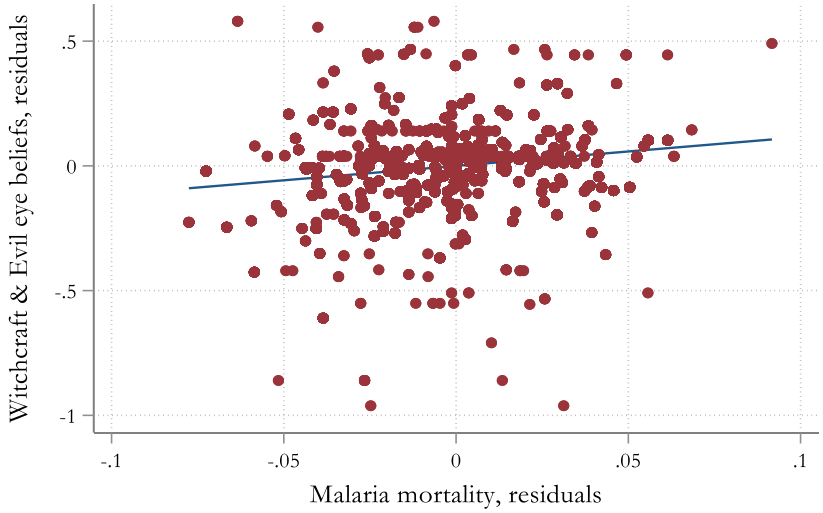
Note: Panel (a) shows all countries included in the original PEW survey.

Figure 4: Correlation between historical malaria mortality and witchcraft & evil eye beliefs across ethnic groups.

(a) Raw data

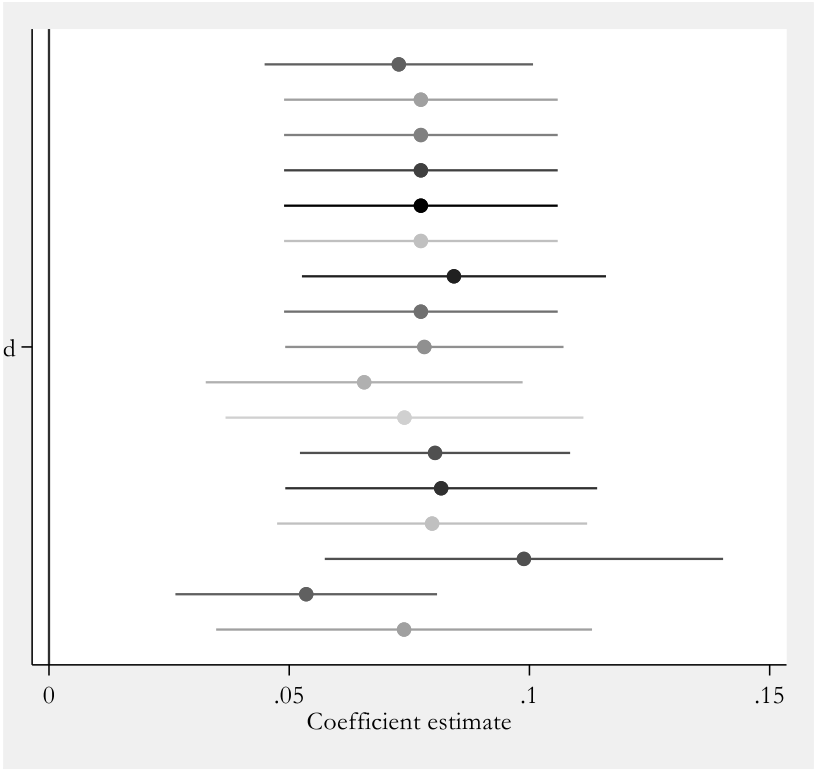


(b) Conditional on country fixed effects



Notes: Panel (a) shows the raw data. To ease visual interpretation, data points show the averages for historical malaria mortality and witchcraft & evil eye beliefs within equal-sized groups of observations (bins) based on the malaria mortality value. In Panel (b), the vertical and horizontal axes show residuals from regressions of historical malaria mortality and individual-level witchcraft & evil eye beliefs on country dummies. The lines show fitted values for a linear regression of individual-level witchcraft & evil eye beliefs on historical malaria mortality.

Figure 5: Estimated relation between historical malaria mortality and witchcraft/evil eye beliefs, for adjusted samples excluding one country at a time from individual level regressions.



Equation (1)

Notes: The dots indicate the magnitude of the coefficient estimate and the horizontal lines represent the corresponding 95 % confidence interval for each of the 17 adjusted samples

Tables

Table 1: Descriptive statistics for selected individual characteristics in full sample, by self-reported belief in witchcraft & evil eye

Variable	Belief in witchcraft & evil eye		Difference	Full sample	N
	Yes	No			
Basic Individual Controls:					
Age	34.40	32.50	1.6***	33.40	20022
Female	0.53	0.53	0.01	0.54	20150
Extended Individual Controls:					
Rural residence	0.61	0.60	0.01	0.61	20150
Completed primary education or less	0.43	0.33	0.10***	0.39	19787
Completed secondary education (or part)	0.38	0.44	0.06***	0.41	19787
Post-secondary education	0.17	0.22	0.04***	0.19	19787
Christian religion	0.57	0.61	0.04***	0.59	20054
Muslim religion	0.37	0.37	0.01	0.37	20054
Traditional religion	0.03	0.02	0.03***	0.02	20054
Self-reported economic situation somewhat or very bad	0.43	0.50	0.06***	0.47	19990
Self-reported money shortages in past year	0.65	0.69	0.04***	0.67	19990
Economic development controls					
Absolute Latitude	9.18	9.66	-	9.40	20150
Mean Land Suitability	4.10	4.20	-	4.15	20096
Area of Ethnic Homeland on Murdock Map	57732	57807	-	57766	20150
Mean Altitude	0.37	0.40	-	0.39	20037
Access to River	0.71	0.72	-	0.72	20037
Distance from Murdock homeland to nearest point on the coast	477929	473206	-	475760	20150
Distance from Murdock homeland to nearest water body	137711	139710	-	138629	20150
Religion controls					
Christian Missions per 1000 Sq km in Murdock homeland	0.01	0.01	-	0.01	20150
Climate controls					
Mean Annual Precipitation on ethnic homeland	7.48	6.40	-	7.14	20150
Mean annual temperature on ethnic homeland	4.62	4.33	-	4.48	20150
Mean SD of Annual Precipitation	0.03	0.03	-	0.03	20150
Mean SD of Annual temperature	0.05	0.06	-	0.06	20150
Mean SD in suitability of Agriculture for Murdock homeland	1.51	1.51	-	1.51	19951
Mean Daily Humidity	57.45	57.40	-	57.40	20037
Mean Daily Temperature	24.65	24.43	-	24.55	20037
Humidity*Temperature	1392	1381	-	1387	20037
TseTse suitability index	0.09	-0.03	-	0.04	20037
Precolonial settlement					

Settlement patterns of ethnicity from EA	5.70	5.40	-	5.60	19085
Precolonial centralization					
Political centralization of ethnicity from EA	0.59	0.57	-	0.58	18401
Population density					
Log of population density of ethnic homeland	2.30	2.43	-	2.35	16329
City in 1800	0.14	0.13	-	0.13	20033
Agro-pastoralism					
High dependence on Agriculture or Pastoralism	0.38	0.38	-	0.38	20037
European settlement controls					
Historic contact with European explorer	0.56	0.52	-	0.54	12739
Historic integration into Colonial Railway network	0.36	0..39	-	0.37	12739
Slave trade					
Slave exports from ethnic homeland	0.48	0.41	-	0.45	20001
Trust					
Self reported measure of trust in other people	0.58	0.71	-	0.64	19682
Self reported measure of trust in people from other religion	0.52	0.52	-	0.52	19002
Regional Controls					
Mean ruggedness	0.58	0.68	-	0.63	20150
Mean lights per capita	0.001	0.001	-	0.001	20150
Total ACLED events	1.23	1.83	-	1.51	20150
Ethnolinguistic Fractionalization Index	0.59	0.54	-	0.57	20150

Notes: The first two columns show the average for age and shares for dummy variables for each group. The third column shows the difference between the first two columns along with significance values for tests of differences in proportions or differences in means (for age). The fourth column shows the means and shares for the full sample *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 2: OLS estimates for relation between malaria and individual belief - baseline specification

Dependent variable	Individual probability of believing in witchcraft or the evil eye						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.082***	0.044***	0.045***	0.041***	0.042***	0.036***	0.036***
	(0.022)	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	No	No	Yes	Yes	Yes	Yes	Yes
Economic development controls	No	No	No	Yes	Yes	Yes	Yes
Religion controls	No	No	No	No	Yes	Yes	Yes
Climate controls	No	No	No	No	No	Yes	Yes
Observations	19,717	19,717	19,717	19,717	19,717	19,717	19,717
R-squared	0.026	0.144	0.146	0.149	0.151	0.153	
Number of clusters	38	38	38	38	38	38	37

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). Column (7) shows significance levels for cluster-robust standard errors calculated using pairs-bootstrapping with asymptotic refinement (standard errors are not reported by the command, the p-value>t is 0.05). Section 4 & 5 provides details on control variables. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 3: OLS estimates for relation between malaria and individual beliefs - additional individual controls

Dependent variable	Individual probability of believing in witchcraft or the evil eye					
	(1)	(2)	(3)	(4)	(5)	(6)
Historical malaria mortality	0.030**	0.028**	0.027**	0.028**	0.029**	0.029**
	(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	
Secondary education		-0.033**	-0.022*	-0.015	-0.015	-0.015
		(0.014)	(0.013)	(0.013)	(0.013)	
Tertiary education		-0.050**	-0.032	-0.023	-0.025	-0.025
		(0.021)	(0.019)	(0.019)	(0.019)	
Urban residence		0.021	0.037**	0.041**	0.041**	0.041**
		(0.016)	(0.016)	(0.018)	(0.017)	
Semi-urban residence		-0.018	-0.008	-0.006	-0.007	-0.007
		(0.051)	(0.051)	(0.053)	(0.054)	
Bad economic situation		0.010	0.029	0.023	0.021	0.021
		(0.027)	(0.025)	(0.026)	(0.026)	
(square) Bad economic situation		0.001	-0.002	-0.002	-0.002	-0.002
		(0.006)	(0.005)	(0.005)	(0.005)	
Shortage of money in past year		0.019	0.007	0.009	0.006	0.006
		(0.015)	(0.015)	(0.015)	(0.015)	

Use of internet		0.023	-0.001	-0.006	-0.009	-0.009
		(0.027)	(0.023)	(0.024)	(0.025)	
Use of a pc		-0.043**	-0.029	-0.027	-0.027	-0.027
		(0.018)	(0.019)	(0.018)	(0.018)	
Use of email		-0.010	0.002	0.008	0.010	0.010
		(0.027)	(0.025)	(0.027)	(0.028)	
Western popular culture hurts morality		0.034***	0.033***	0.038***	0.039***	0.039***
		(0.011)	(0.010)	(0.010)	(0.010)	
Traditional practices			0.079***	0.074***	0.074***	0.074***
			(0.008)	(0.007)	(0.007)	
Reliance on traditional healer			0.101***	0.099***	0.100***	0.100***
			(0.012)	(0.012)	(0.012)	
Christian religion				0.017	0.019	0.019
				(0.016)	(0.016)	
Ethnoreligion				0.147***	0.149***	0.149***
				(0.048)	(0.053)	
Religiosity				-0.049***	-0.048***	-0.048***
				(0.007)	(0.008)	
Competition among Christian denominations				-0.005	-0.003	-0.003
				(0.016)	(0.015)	
Perceived crime					-0.009	-0.009
					(0.009)	
Perceived religious conflict					-0.005	-0.005
					(0.008)	
Perceived ethnic conflict					0.008	0.008
					(0.007)	
All Table 2 Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,000	16,000	16,000	16,000	16,000	16,000
R-squared	0.163	0.171	0.213	0.220	0.221	
Number of clusters	38	38	38	38	38	38

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). Column (7) shows significance levels for cluster-robust standard errors calculated using pairs-bootstrapping with asymptotic refinement (standard errors are not reported by the command, the p-value>t is 0.02). Section 4 & 5 provides details on control variables. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 4: OLS estimates for relation between malaria and individual witchcraft belief - Extended precolonial controls

Dependent variable	Individual probability of believing in witchcraft or the evil eye							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Historical malaria mortality	0.075***	0.071***	0.077***	0.077***	0.073***	0.080***	0.077***	0.077***
	(0.018)	(0.016)	(0.012)	(0.012)	(0.012)	(0.014)	(0.014)	
All Table 2 and Table 3 Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial Settlement & Centralization	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population density & City in 1800	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Agro-pastoralism	No	No	No	Yes	Yes	Yes	Yes	Yes
European settlement controls	No	No	No	No	Yes	Yes	Yes	Yes
Slave trade	No	No	No	No	No	Yes	Yes	Yes
Trust	No	No	No	No	No	No	Yes	Yes
Observations	7,421	7,421	7,421	7,421	7,421	7,421	7,421	7,421
R-squared	0.234	0.234	0.234	0.237	0.237	0.238	0.238	
Number of clusters	23	23	23	23	23	23	23	23

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (7). Column (8) shows significance levels for cluster-robust standard errors calculated using pairs-bootstrapping with asymptotic refinement (standard errors are not reported by the command, the p-value>t is 0.00). Section 4 & 5 provide details on control variables. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 5: OLS estimates for relation between malaria and individual belief - Regional controls

Dependent variable	Individual probability of believing in witchcraft or the evil eye						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.082***	0.044***	0.045***	0.041***	0.042***	0.036***	0.036***
	(0.022)	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	No	No	Yes	Yes	Yes	Yes	Yes
Economic development controls	No	No	No	Yes	Yes	Yes	Yes
Religion controls	No	No	No	No	Yes	Yes	Yes
Climate controls	No	No	No	No	No	Yes	Yes
Regional Controls	No	No	No	No	No	No	Yes
Observations	19,717	19,717	19,717	19,717	19,717	19,717	19,717
R-squared	0.027	0.147	0.148	0.151	0.151	0.153	0.154
Number of clusters	38	38	38	38	38	38	38

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). Column (7) shows significance levels for cluster-robust standard errors calculated using pairs-bootstrapping with asymptotic refinement (standard errors are not reported but the p-value>t is 0.00). *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 6: OLS estimates for relation between malaria and individual witchcraft beliefs - additional individual controls

Dependent variable	Individual probability of believing in witchcraft or the evil eye						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.030**	0.028**	0.027**	0.028**	0.029**	0.028**	0.028**
	(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.012)	
All Table 2 Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extended Individual Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Traditional life	No	No	Yes	Yes	Yes	Yes	Yes
Religion	No	No	No	Yes	Yes	Yes	Yes
Conflict	No	No	No	No	Yes	Yes	Yes
Regional Controls	No	No	No	No	No	Yes	Yes
Observations	16,000	16,000	16,000	16,000	16,000	16,000	16,000
R-squared	0.030	0.163	0.171	0.213	0.220	0.221	
Number of clusters	38	38	38	38	38	38	38

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). Column (7) shows significance levels for cluster-robust standard errors calculated using pairs-bootstrapping with asymptotic refinement (standard errors are not reported but the p-value>t is 0.00).. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 7: OLS estimates for relation between malaria and individual witchcraft belief - Extended precolonial controls

Dependent variable	Individual probability of believing in witchcraft or the evil eye								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Historical malaria mortality	0.046***	0.042***	0.077***	0.046***	0.044***	0.041***	0.037***	0.035***	0.035***
	(0.011)	(0.011)	(0.012)	(0.011)	(0.009)	(0.010)	(0.010)	(0.010)	
All Table 2 and Table 3 Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial Settlement & Centralization	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population density & City in 1800	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agro-pastoralism	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
European settlement controls	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Regional Controls	No	No	No	No	No	Yes	Yes	Yes	Yes
Slave trade	No	No	No	No	No	No	Yes	Yes	Yes
Trust	No	No	No	No	No	No	No	Yes	Yes
Observations	8,839	8,839	7,421	8,839	8,839	8,839	8,839	8,839	8,839
R-squared	0.229	0.230	0.237	0.231	0.231	0.234	0.234	0.236	
Number of clusters	26	26	26	26	26	26	26	26	26

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (8). Column (9) shows significance levels for cluster-robust standard errors calculated using pairs-bootstrapping with asymptotic refinement (standard errors are not reported but the p-value>t is 0.00). *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 8: Logit estimates of marginal effects for relation between malaria and individual belief

Dependent variable	Individual probability of believing in witchcraft or the evil eye						
	(1)	(2)	(3)	(4)	(5)	(6)	(6)
Historical malaria mortality	0.03***	0.05***	0.08***	0.06***	0.07***	0.06***	0.06***
	(0.022)	(0.016)	(0.020)	(0.020)	(0.013)	(0.013)	(0.013)
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	No	Yes	Yes	Yes	Yes	Yes
Extended individual controls	No	No	No	Yes	Yes	Yes	Yes
Precolonial controls	No	No	No	No	Yes	Yes	Yes
European settlement controls	No	No	No	No	No	Yes	Yes
Population Density	No	No	No	No	No	No	Yes
Observations	7,961	7,961	7,961	7,961	7,961	7,961	7,961
Number of clusters	38	38	38	38	36	26	23

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Standardized continuous regressors. Marginal effects reported at means. Cluster-robust standard errors at the level of cultural provinces in parentheses. Sections 4 and 5 provide details on control variables. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 9: OLS estimates for the relation between malaria and other magical beliefs, at the individual level

Dependent variable	All 'traditional' beliefs	Protection against misfortune	Evil spirits	Abrahamic beliefs
	(1)	(2)	(3)	(4)
Historical malaria mortality	0.128**	0.041	0.019	-0.010
	(0.052)	(0.028)	(0.017)	(0.030)
All controls in Tables 2, 3 & 4	Yes	Yes	Yes	Yes
Observations	8,650	8,970	9,234	9,101
R-squared	0.414	0.405	0.226	0.118
Number of clusters	26	26	26	26

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses. The first column shows result for an index that captures all surveyed beliefs associated with a traditional African worldview (witchcraft, the evil eye, evil spirits, protection from sacrifices to ancestors, protection from certain spiritual people, protection from sacred objects). Column (2) shows results for an index that only captures beliefs related to protection against misfortune. Column (3) show results for belief in evil spirits and Column (4) for Abrahamic beliefs using an index of beliefs typically related to Christianity and Islam (heaven, hell, angels, and miracles). *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 10: OLS estimates for relation between malaria and ethnicity-country level belief

Dependent variable	Share of individuals believing in witchcraft or the evil eye				
	(1)	(2)	(3)	(4)	(5)
Historical malaria mortality	0.064**	0.068**	0.085**	0.090**	0.082**
	(0.028)	(0.026)	(0.036)	(0.035)	(0.039)
All Table 2 and Table 3 Controls	Yes	Yes	Yes	Yes	Yes
Precolonial Settlement & Centralization	No	Yes	Yes	Yes	Yes
Population density & City in 1800	No	No	Yes	Yes	Yes
Agro-pastoralism	No	No	No	Yes	Yes
European settlement controls	No	No	No	No	Yes
Observations	99	99	99	99	99
R-squared	0.852	0.852	0.867	0.873	0.886
Number of clusters	19	19	19	19	19

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Share of individuals believing in witchcraft or the evil eye is the share of individuals which belong to an ethnicity and reside in a certain country. Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (5). Section 4 & 5 provides details on control variables. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 11: OLS estimates for relation between malaria and individual belief - Heterogeneity

Dependent variable	Individual probability of believing in witchcraft or the evil eye					
	(1)	(2)	(3)	(4)	(5)	(6)
Hunting*Malaria Burden	0.035					
	(0.027)					
Hunting reliance	0.033					
	(0.023)					
Fishing*Malaria Burden		-0.007				
		(0.015)				
Fishing reliance		-0.050				
		(0.034)				
Pastoralism*Malaria Burden			0.010			
			(0.029)			
Agropastoralism			-0.034*			
			(0.020)			
Agriculture*Malaria Burden				0.017		
				(0.021)		
Agriculture reliance				0.005		
				(0.023)		
Nomadic*Malaria Burden					0.047	
					(0.284)	
Nomadic Settlement					0.043	
					(0.282)	
Hierarchy*Malaria Burden						0.027
						(0.023)
Hierarchy (some)						-0.014
						(0.017)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,839	8,839	8,839	8,839	8,831	8,838
R-squared	0.242	0.242	0.242	0.242	0.242	0.242
Number of clusters	26	26	26	26	26	26

Notes: Standardized continuous regressors. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 12: OLS estimates for relation between malaria and individual trust

Dependent variable	Trust in other people								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Historical malaria mortality	0.005	-0.048***	-0.050***	-0.057***	-0.055***	-0.055***	-0.055***	-0.052***	-0.054***
	(0.014)	(0.011)	(0.012)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extended individual controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial settlement	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial centralization	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Population density	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Agro-pastoralism	No	No	No	No	No	Yes	Yes	Yes	Yes
European settlement controls	No	No	No	No	No	No	Yes	Yes	Yes
Regional Controls	No	No	No	No	No	No	No	Yes	Yes
Slave trade	No	No	No	No	No	No	No	No	Yes
Observations	8,617	8,617	8,617	8,617	8,617	8,617	8,617	8,617	8,617
R-squared	0.000	0.047	0.048	0.049	0.049	0.049	0.049	0.055	0.055
Number of clusters	26	26	26	26	26	26	26	26	26

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Trust in other people is a binary variable which is 1 if an individual reports that "generally people can be trusted". Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (9). *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level

Table 13: IV estimates

Dependent variable	Historical malaria burden at ethnicity country level		
	Panel A		
	(1)	(2)	(3)
Plasmodium Suitability	0.230**		0.250***
	(0.085)		(0.080)
Malaria Ecology			
		-0.075	-0.132
		(0.117)	(0.103)
All Controls	Yes	Yes	Yes
Observations	165	162	162
R-squared	0.783	0.774	0.786
Number of clusters	26	26	26
Dependent variable	Individual probability of believing in witchcraft or the evil eye		
	Panel B		
	(1)	(2)	(3)
Plasmodium Suitability	0.001		-0.005
	(0.018)		(0.023)
Malaria Ecology		0.024	0.026
		(0.023)	(0.027)
All Controls	Y	Y	Y
Observations	9,379	9,266	9,266
R-squared	0.229	0.231	0.231
Number of clusters	26	26	26

Notes: Historical malaria mortality is the historical probability of dying from malaria before reproductive age for a particular ethnic group, this is standardized. Individual belief is a binary variable which is 1 if an individual reports belief in witchcraft or the evil eye. Panel A is at ethnicity country level shown in equation 2 and Panel B is at the individual level shown in equation 1. Standardized continuous regressors. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Supplementary Appendix

Historical malaria burden and present-day witchcraft beliefs

Appendix A. Additional tables

Table A.1 gives summary statistics for the full list of individual controls used in the empirical analysis, for the full sample.

Table A.2 shows the distribution of answers given to the survey question about belief in witchcraft & the evil eye across countries.

Table A.3 presents the distribution of individual observations across countries for the original PEW dataset and our baseline regression sample, as well as the number of Murdock ethnic groups per country in the baseline regression sample.

Table A.1: Summary statistics for individual characteristics in the full sample

Variable	Mean/Share	St. dev.	N
Belief in witchcraft	0.44	0.50	19,540
Belief in witchcraft or the evil eye	0.54	0.50	20,150
Age	33.44	12.88	20,463
Male	0.54	0.50	20,592
Rural residence	0.60	0.49	20,592
Completed primary education or less	0.39	0.49	20,186
Completed secondary education (or part)	0.41	0.49	20,186
Post-secondary education	0.20	0.40	20,186
Reports own economic situation as bad	0.47	0.50	20,415
Reports money shortages in past year	0.68	0.47	20,238
Use of internet (at least occasionally)	0.20	0.40	20,341
Use of computer (at least occasionally)	0.22	0.41	20,334
Use of e-mail (at least occasionally)	0.19	0.40	20,310
Reports crime as big problem	0.89	0.32	20,452
Reports religious conflict as big problem	0.57	0.50	20,168
Reports ethnic conflict as big problem	0.59	0.49	20,160
Thinks Western culture is hurting morality	0.73	0.45	19,441
Christian religion	0.59	0.49	20,490
Ethnoreligion	0.02	0.13	20,490
Index value for traditional practices (0 to 3)	0.70	1.00	19,703
Uses traditional religious healer when sick	0.43	0.50	19,678
Index value of religiosity (7 (lowest) to 1 (highest))	2.05	0.85	20,573
Belief in evil eye	0.45	0.50	19,544
Belief in evil spirits	0.49	0.50	19,616
Belief in protective power of sacrifices to ancestors	0.32	0.47	19,566
Belief in protective power of sacred objects	0.29	0.45	19,304
Belief in protective power of spiritual people	0.41	0.49	19,582
Belief in heaven	0.95	0.22	20,114
Belief in hell	0.84	0.36	19,966
Belief in angels	0.82	0.39	19,719
Belief in miracles	0.76	0.43	19,697

Notes: The first column shows the mean for continuous and index variables, and shows the share of observations for which the variable takes value 1 for dummy variables.

Table A.2: Responses to the survey question regarding witchcraft & evil eye beliefs, by country

Country	Yes (%)	No (%)	Don't know (%)	Refused (%)	N
Botswana	47	49	3.5	0.2	980
Cameroon	86	14	0.07	0.0	1,410
Chad	56	44	0.8	0.0	1,181
DR Congo	69	26	4.5	0.8	806
Djibouti	43	49	7	1.2	1,339
Ethiopia	31	68	0.7	0.0	1,465
Ghana	54	44	2.1	0.0	1,490
Guinea-Bissau	50	44	5.7	0.2	893
Kenya	35	64	0.5	0.0	1,481
Liberia	35	64	0.61	0.0	1,486
Mali	27	67	5.5	0.2	937
Mozambique	43	56	0.6	0.0	1,136
Nigeria	44	55	0.8	0.0	1,493
Senegal	63	31	5.4	0.0	990
Tanzania	96	4	0.3	0.0	1,482
Uganda	41	58	0.8	0.1	1,040
Zambia	42	58	0.4	0.1	983
Total	53	45	2.0	0.2	20,592

Notes: Data are shown for the full sample.

Table A.3: Distribution of individual observations and Murdock ethnic groups across countries in the original PEW dataset and the baseline regression sample.

Country	PEW dataset		Regression sample		Share of PEW observations in regression sample	Murdock ethnic groups (regression sample)
	Obs.	%	Obs.	%	%	Number
Botswana	1,002	4.0	817	4.5	82	21
Cameroon	1,503	6.0	1,395	6.8	93	55
Chad	1,503	6.0	1,040	4.5	69	17
DR Congo	1,519	6.1	722	2.9	48	16
Djibouti	1,500	6.0	1,081	5.9	72	2
Ethiopia	1,500	6.0	1,441	7.9	96	13
Ghana	1,500	6.0	1,429	7.8	95	25
Guinea Bissau	1,000	4.0	767	4.2	77	12
Kenya	1,500	6.0	1,433	7.7	96	25
Liberia	1,500	6.0	1,403	7.7	94	20
Mali	1,000	4.0	820	4.5	82	17
Mozambique	1,500	6.0	1,080	4.9	72	15
Nigeria	1,516	6.0	1,429	7.8	94	32
Rwanda	1,000	4.0	NA	NA	NA	NA
Senegal	1,000	4.0	880	4.8	97	17
South Africa	1,504	6.0	NA	NA	NA	NA
Tanzania	1,504	6.0	1,386	7.5	92	65
Uganda	1,040	4.1	1,022	5.6	98	16
Zambia	1,000	4.0	970	5.3	97	27
Total	25,091		19,115			

Notes: The first four columns show the number of individual observations per country and their share in the total dataset, for the original PEW dataset and for our baseline regression sample. The third column shows the share of individual observations from the original PEW dataset that was retained in our baseline regression sample. The final column shows the number of Murdock ethnic groups per country in our baseline regression sample after we have matched the individual PEW observations to ethnic groups identified by Murdock (1967).

Appendix B. Data sources and description

B.1. PEW survey data

Raw data and documentation for the PEW survey "Tolerance and Tension: Islam and Christianity in Sub-Saharan Africa" are available at http://www.pewforum.org/datasets.

Individual belief in witchcraft & Evil eye. Dummy variable equal to 1 if the respondent reports to believe in witchcraft or evil eye, and 0 otherwise.

Ethnicity-level prevalence of witchcraft beliefs. Proportion of people from Murdock group y in country x reporting to believe in witchcraft. Calculated based on matching of self-reported ethnicity in the PEW data to ethnic groups devised by (Murdock, 1967).

Age. Self-reported age.

Female. Dummy variable equal to 1 if the respondent is female, and 0 otherwise.

Secondary education. Dummy variable equal to 1 if the respondent reports to have attained some secondary education or completed secondary education, and 0 otherwise.

Tertiary education. Dummy variable equal to 1 if the respondent reports to have attained postsecondary education or higher, and 0 otherwise.

Urban residence. Dummy variable equal to 1 if respondent lives in an urban area, and 0 otherwise.

Semi-urban residence. Dummy variable equal to 1 if respondent lives in a semi-urban area, and 0 otherwise.

Personal economic situation. Categorical variable indicating how the respondent assesses his personal economic situation. On the ordinal scale: very good, somewhat good, somewhat bad, very bad.

Shortage of money in past year. Dummy variable equal to 1 if respondent reports that there have been times during the last year when he/she did not have enough money to buy food that the family needed, to pay for medical and health care that the family needed, or to buy clothing that the family needed. Equals zero when the respondent answers 'no' to all three questions.

Use of internet. Dummy variable equal to 1 if the respondent reports to "use the internet, at least occasionally", and 0 otherwise.

Use of a pc. Dummy variable equal to 1 if the respondent reports to use a computer at the workplace, at school, at home, or anywhere else on at least an occasional basis, and 0 otherwise.
Use of email. Dummy variable equal to 1 if the respondent reports to send or receive e-mail, at least occasionally, and 0 otherwise.

Perception of crime as a problem. Categorical variable indicating to what extent the respondent

thinks that crime is a problem in the country. On the ordinal scale: not a problem at all, small problem, moderately big problem, very big problem.
Perception of religious conflict as a problem. Categorical variable indicating to what extent the respondent thinks that conflict between religious groups is a problem in the country. On the ordinal scale: not a problem at all, small problem, moderately big problem, very big problem.

Perception of ethnic conflict as a problem. Categorical variable indicating to what extent the respondent thinks that conflict between ethnic groups is a problem in the country. On the ordinal scale: not a problem at all, small problem, moderately big problem, very big problem.

View on Western popular culture. Dummy variable equal to 1 if the respondent thinks that Western music, movies and television have hurt morality in the country.

Christian religion. Dummy variable equal to 1 if the respondent reports to be a Christian, and 0 otherwise.

Ethnoreligion. Dummy variable equal to 1 if the respondent reports to have an ancestral, tribal, animist, or other traditional religion, and 0 otherwise.

Traditional practices. Index variable capturing the respondent's engagement in practices associated with traditional religion or culture. Equals the number of questions to which the respondent answers yes, for the following questions: (i) do you have traditional African sacred objects in your home, such as shrines to ancestors, feathers, skins, skulls, skeletons, powder, carved figures or branches, spears, cutlasses or animal horns? (ii) do you ever participate in traditional African ceremonies or perform special acts to honor or celebrate your ancestors? And (iii) do you ever participate in traditional African puberty rituals or manhood/womanhood initiation rituals for friends, relatives or neighbors in your area, such as endurance or challenge tests, or initiation to a traditional dance?

Use of traditional healer. Dummy variable equal to 1 if the respondent says that he/she or their family ever use traditional religious healers when someone is sick, and 0 otherwise.

Religiosity. Index variable indicating the frequency with which the respondent engages in religious activities and the importance of religion in his/her life. The index is based on the following categorical variables with ordinal scales: Frequency of attending religious services (never, seldom, a few times a year, once or twice a month, once a week, more than once a week); frequency of praying (never, seldom, a few times a month, once a week, a few times a week, once a day, several times a day); frequency of reading religious scripture (never, seldom, several times a year, once or twice a month, at least once a week); frequency of sharing religious views (never, seldom, several times a year, once or twice a month, at least once a week); importance of religion in one's life (not at all important, not too important, somewhat important, very important).

B.2. Regional controls

Competition among Christian denominations. Herfindahl index capturing the religious market share of the different Christian denominations in a region. Religious market share is calculated as the share of Christian respondents in a region reporting to follow denomination *d*.

Nighttime lights per capita. Data on luminosity come from the Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) that reports stable images of Earth at night captured between 20:00 and 21:30. The measure ranges from 0 to 63 and is available for cells at 30 arc-second resolution, see Henderson et al. (2012) for technical details. We aggregate luminosity data for 2008 and 2009 at the regional level and then take their average. The latter is then divided by the region's population size (see below) to obtain the final measure of lights per capita. Source: http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html.

ACLED events. Geographical coordinates for all fighting events during 1997–2009 are taken from the Armed Conflict Location and Event Database (ACLED, version 3). We calculate the total number of events for each region. Source: http://www.acleddata.com/data/.

Ethnolinguistic fractionalization. Standard ELF index based on regionally representative household surveys (DHS and MICS), and the original Pew Forum survey. Details available upon request.

Ruggedness index. Index of terrain ruggedness as constructed by Nunn and Puga (2012) for cells at 30 arc-second resolution. The variable used in the analysis is the average value of the index across cells in each region. Source: http://diegopuga.org/data/ rugged/#grid.

B.3. Ethnicity-level controls

For all own calculations, the geo-processing software ArcMap 10.4 was used to spatially match geographical information to ethnic homelands on the Murdock (1959a) Tribal Map of Africa and to perform the necessary analyses.

Geographic controls

Historical malaria mortality. Estimated proportion of children in the Murdock ethnic group that would have died of malaria (through malaria itself or sickle cell disease) before reproductive age, conditional on not dying of something else. Source: (Depetris-Chauvin and Weil, 2016).

Absolute latitude. Absolute latitude of the centroid of the Murdock ethnic homeland. Source: (Alsan, 2015), (Depetris-Chauvin and Weil, 2016), and Murdock (1959a).

Mean land suitability. Based on the index of suitability of land for rain-fed agriculture (maximizing technology mix) provided by the FAO GAEZ dataset (plate 46). Coded on a scale from 1 (very high suitability) to 8 (not suitable) for cells at 5 arc-minute resolution. The variable used in the analysis is the average value of the suitability index across cells in each Murdock ethnic homeland. Source: FAO GAEZ dataset (plate 46) downloaded at http://webarchive.iiasa.ac.at/Research/LUC/GAEZ/index.htm, and own calculations.

Variation in land suitability. Based on the same data as mean land suitability. Calculated as the standard deviation of index values across cells in each Murdock ethnic homeland.

Area. Area of the Murdock ethnic homeland measured in 1000 sq. km. Source: own calculations based on the sinusoidal projection for Africa and Murdock (1959a).

Mean altitude. Average elevation in km. Source: (Alsan, 2015).

Access to river. Dummy variable taking value 1 if the historical ethnic homeland has access to a river, and 0 otherwise. Source: (Alsan, 2015).

Distance to coast. Geodesic distance from the centroid of the Murdock ethnic homeland to the nearest point on the coast in meters. Source: own calculations using the coastline shapefile downloaded at http://www.naturalearthdata.com.

Distance to lake. Geodesic distance from the centroid of the Murdock ethnic homeland to the nearest water body in meters. Source: own calculations using the shapefile for water bodies in Africa downloaded at http://geoportal.rcmrd.org.

Slave exports. Natural logarithm of one plus the number of exported slaves of a given ethnicity normalized by the area of land historically inhabited by the respective ethnic group. Source: Nunn and Wantchekon (2011), dataset available at http://scholar.harvard. edu/nunn/pages/data-0.

Climate data

Mean annual rainfall (1957-2002). Weighted average of mean annual rainfall (m) during the growing season for the period 1957-2002 across cells for the Murdock ethnic homeland. Weights based on relative area of the cell compared to total area of the Murdock ethnic homeland. Source: own calculations based on data obtained from (Guariso and Rogall, 2016). See Guariso and Rogall (2016) for more information on the underlying data (ERA-40).

Mean annual temperature (1957-2002). Weighted average of mean annual temperature (C°) during the growing season for the period 1957-2002 across cells for the Murdock ethnic homeland. Weights based on relative area of the cell compared to total area of the Murdock ethnic homeland. Based on the same data as mean annual rainfall for this period.

Mean daily humidity (1871). Relative humidity (%) in the earliest year of available data (20th Century Reanalysis version 2.0). Source: (Alsan, 2015).

Mean daily temperature (1871). Temperature (C°) in the earliest year of available data (20th Century Reanalysis version 2.0). Source: (Alsan, 2015).

Tse Tse Suitability. Tse Tse suitability index capturing the normalized steady state population of the Tse Tse fly for the Murdock ethnic homeland depending on historical temperature and humidity. Source: (Alsan, 2015).

Precolonial political and economic outcomes

Complexity of settlement pattern. A measure of the complexity of the precolonial settlement pattern of the ethnic group constructed by (Murdock, 1967), on the ordinal scale: nomadic or fully migratory; semi-nomadic; semi-sedentary; compact but impermanent settlements; neighborhoods of dispersed family homesteads; separated hamlets, forming a single community; compact and relatively permanent settlements; complex settlements. Source: (Nunn and Wantchekon, 2011) and (Gershman, 2016).

Centralization of institutions. Dummy variable equal to 1 if the precolonial jurisdictional hierarchy (constructed by (Murdock, 1967)) is at least 2 levels above the local authority, and 0 otherwise. Source: (Alsan, 2015).

Historical population density. Proxied by population data estimated by (Murdock, 1959b) for African ethnic groups for approximately the 20th century. Population density is defined as the logarithm of inhabitants per square kilometer. Source: (Nunn and Wantchekon, 2011) and (Alsan, 2015).

Presence of city in 1800. Dummy variable equal to 1 if a city with over 20,000 inhabitants was located on the Murdock ethnic homeland in 1800, and 0 otherwise. Source: (Alsan, 2015), based on (Chandler, 1987).

High dependence on agro-pastoralism. A dummy variable equal to 1 if the ethnic group depended on agriculture or husbandry for at least 66 % of subsistence production, and 0 otherwise. Source: (Alsan, 2015) and (Gershman, 2016).

Other ethnicity-level controls

Christian missions by area. Number of Christian mission stations on the Murdock ethnic homeland per 1000 sq. km. Source: own calculations using data from (Nunn, 2010), provided in shapefile available at https://scholar.harvard.edu/nunn/pages/data-0.

Connection to railway network. Dummy variable equal to 1 if any part of the railway network was built on land historically inhabited by the ethnic group. Source: (Nunn and Wantchekon, 2011).

European explorer route. Dummy variable equal to 1 if a European explorer traveled through land historically occupied by the ethnic group. Source: (Nunn and Wantchekon, 2011).

Appendix C. Additional details on data construction.

In the original PEW dataset, ethnicities are not recorded for Rwanda and South Africa. Hence, these two countries were dropped. The resulting sample included 17 countries, 22,587 individuals, and 697 self-reported ethnicity categories – of which a large number are synonyms, languages, or particular clans within an ethnic group.

For 370 individual observations (or 13 self-reported ethnicities) matching was not possible because the PEW ethnicity is reported as nationality or religion. The large majority of these cases (345) is due to respondents from Mozambique describing their ethnicity as Portuguese, which does not figure in the Murdock list of ethnic groups. An additional 268 respondents refused to answer or said not to know. For 1,243 individual observations, corresponding to 91 self-reported ethnicity categories, we could not find any information that allowed a match with a Murdock group. The 593 remaining self-reported ethnicities were then matched to 334 Murdock groups, resulting in a sample of 20,592 observations.

For 10 countries this final sample includes over 90 % of the observations from the original PEW dataset, and for 6 others we keep (roughly) between 70 % and 90 %. For the Democratic Republic of the Congo, the self-reported PEW ethnicity Bantu/other could not be matched to any Murdock group, resulting in the loss of 52 % of the original observations. Table A.3 in Appendix A shows the correspondence between the original PEW dataset and our baseline regression sample in terms of individual observations, and lists the number of Murdock ethnic groups for each country in the baseline regression sample. The same Murdock group may appear in several countries due to overlaps with national borders