Journal of Development Economics 163 (2023) 103094

Contents lists available at ScienceDirect

Journal of Development Economics

journal homepage: www.elsevier.com/locate/devec

Regular article

Tradition and mortality: Evidence from twin infanticide in Africa ☆

James Fenske [a,*,1], Shizhuo Wang [b,1]

[a] University of Warwick, United Kingdom
[b] New York University, United States of America

ARTICLE INFO

JEL classification:
Z13
N37
J13
I15
O12

Keywords:
Non-persistence
Twins
Infanticide
Africa

ABSTRACT

Traditions can limit investment in early life health, even if they have been abandoned. We introduce data on historic twin infanticide and merge it with recent birth records from 23 African countries. We use the full sample and a border sample of adjacent societies with and without past twin infanticide. Both samples provide no evidence that past twin infanticide predicts greater differential twin mortality today. This null result is likely a consequence of suppression efforts by Africans, missionaries, and colonial governments. Where these channels were weak, we find evidence of greater twin mortality today.

1. Introduction

Traditions, including those that are no longer practiced, affect individuals' attitudes, beliefs, and behavior (Fernández, 2011; Nunn, 2012). Although health investments in early life can dramatically improve child survival and later-life outcomes (Almond and Mazumder, 2013; Almond et al., 2018), there is evidence of low demand for these investments in developing countries (Banerjee and Duflo, 2011; Dupas, 2011; Dupas and Miguel, 2017). Beliefs arising from past experiences, both recent and historical, can constrain demand for investments such as vaccines (Lowes and Montero, 2021; Martinez-Bravo and Stegmann, 2022). Similarly, beliefs and practices rooted in tradition also reduce early-life investments; descriptive evidence from Africa, for example, suggests that antenatal care can be delayed due to belief in traditional herbal treatments (Waiswa et al., 2008), that food taboos for pregnant women can lead to lower birth weight (Adejuyigbe et al., 2008), that breastfeeding may be delayed or not practiced exclusively due to religious reasons (Bee et al., 2018; Oche et al., 2011; Tawiah-Agyemang et al., 2008), that beliefs about witchcraft shape how the umbilical cord is treated (Mrisho et al., 2008), and that some children are perceived, following traditional notions, as "born to die" (Asakitikpi, 2008).

Infanticide is perhaps the most extreme form of failure to invest in early life health. This too is partly rooted in traditional beliefs such as son preference, and societies with traditions of sex-selective infanticide continue to have male-biased sex ratios in the present (Lee and Wang, 2001; Sudha and Rajan, 1999). In this paper, we focus on twin infanticide, a practice that was widely prevalent in the past in sub-Saharan Africa; roughly one quarter of all births in our data on 23 African countries come from ethnic groups that historically practiced the killing of twins. We show that twin mortality is no higher in the present among ethnic groups in sub-Saharan Africa that practiced twin infanticide in the past. We therefore provide an example of cultural change and rapid evolution of social norms through institutions and socialization (Bisin and Verdier, 2011; Giuliano and Nunn, 2021; Young, 2015). Our results, then, are an example in which the mechanisms that could give rise to historical persistence have been removed (Kelly, 2020; Voth, 2020).

We construct novel data on the former practice of twin infanticide among more than 270 ethnic groups in sub-Saharan Africa, at any point in their history. We code this using a wide set of ethnographic sources, covering more than 300 books and articles. We assemble data on more than 1 million children born in 23 African countries between 1958 and

☆ We are grateful to Cora Neumann for translation assistance, and to Belinda Archibong, Prashant Bharadwaj, Bishnupriya Gupta, Dozie Okoye, Roland Pongou, David Pratten, Claudia Rei, Andreas Stegmann and audiences at Economic Research Southern Africa, The Laboratory for the Economics of Africa's Past, Lund University, the North East Universities Development Consortium, the University of Duisburg–Essen, the University of Sheffield, the University of Warwick, and the University of Zurich for comments.

* Corresponding author.
E-mail addresses: J.Fenske@warwick.ac.uk (J. Fenske), shizhuo.wang@nyu.edu (S. Wang).

[1] Both authors contributed equally to this manuscript.

https://doi.org/10.1016/j.jdeveco.2023.103094
Received 12 December 2021; Received in revised form 13 March 2023; Accepted 18 March 2023
Available online 18 April 2023

2018, including more than 33,000 twins, from the Demographic and Health Surveys (DHS). Merging these sources, we test in two samples for a link between infant and child mortality of twins in the present and a past societal tradition of twin infanticide. First, in the *full sample*, we test for greater mortality of twins relative to non-twins among formerly twin-killing groups, conditioning on controls, including (in alternative specifications) country, sub-national region, and mother fixed effects. Second, in a *border sample*, we compare individuals living within 100 km of a border separating groups that previously practiced twin infanticide and those that did not. This follows work by Moscona et al. (2020) and Lowes (2020), and focuses comparisons on groups in close proximity with similar observable characteristics that differ in their historical treatment of twins. Across both specifications, we find no evidence of greater mortality among twins in the present among groups with a past tradition of twin infanticide. We also find no evidence of differential early-life investments in twins' health such as vaccination and the duration of breastfeeding among groups with a past tradition of twin infanticide. Twins' differential anthropometric health outcomes such as height for age similarly do not differ between these groups.

It is not that there is no impact of twin killing norms on twin mortality. When it was practiced, twin infanticide had a direct effect on twin mortality. Rather, that effect has waned over the past several decades. In order to understand the historical processes by which former traditions of twin infanticide have become quantitatively unimportant in the present, we begin by considering the possible mechanisms that could link them to present-day mortality. We divide these into direct and indirect channels. By "direct", we mean the possible continued practice of twin infanticide. While journalistic sources still mention isolated instances today, continued infanticide is unlikely to be common: it is illegal. We focus instead on "indirect" channels — possible negative attitudes towards twins that might lead to lower investments in twin health. These have been documented by anthropologists and journalists within living memory. Indeed, among births from the 1970s and earlier in older DHS surveys, we do find evidence of greater differential twin mortality among formerly twin-killing groups. This would be expected if, for example, suppression efforts initiated a gradual process of cultural change that transitioned over time to a new equilibrium (Bisin and Verdier, 2011), but that was not yet complete by the time of the earliest births in our sample.

Next, we turn to the historical record to understand how twin infanticide and negative attitudes towards twins were suppressed. This was a process that drew on the initiative of Africans, of missionaries, and of colonial governments. Together, their efforts took three of the key channels for historical persistence (multiple equilibria, culture, and domestic institutions Nunn, 2009) and either rendered them inoperative or transformed them into mechanisms of non-persistence. We use heterogeneity analyses to show that where these historical processes were weak or absent – far from Protestant missions, distant from colonial cities, in former French colonies (which were more extractive, provided less mass schooling, and received fewer Protestant missions), and among mobile, non-agricultural societies – we do still find evidence of a mortality penalty for twins relative to non-twins that is greater in formerly twin-killing societies.

Our null result in the full sample is robust to several alternative empirical approaches, including considering a sample of only twins, the inclusion of regression discontinuity polynomials in the border sample, recoding ethnic groups for which the evidence on twin infanticide is poor or contradictory, adding additional maternal, geographic, and ethnographic controls, restricting observations to the rural sample, and considering the possible misreporting of twin births. We find no evidence that the presence or absence of a differential mortality penalty for twins by past tradition varies across broad regions of Africa, by access to a health facility, by pre-colonial institutions, by ethnic diversity, by migration, by conflict exposure, or by sex composition of the twin pair. Nor does it emerge only in periods of adverse rainfall.

1.1. Contribution

We contribute primarily to three literatures in economics. The first considers historical persistence. Over the past two decades, several studies have shown how history matters for a wide set of outcomes in the present. These include conflict (Moscona et al., 2020), culture (Giuliano and Nunn, 2021; Michalopoulos, 2012), beliefs (Lowes et al., 2017; Nunn and Wantchekon, 2011), gender roles (Alesina et al., 2013; Ashraf et al., 2020), institutions (Giuliano and Nunn, 2013), economic development (Alesina et al., 2016; Alsan, 2015; Michalopoulos and Papaioannou, 2014; Nunn, 2008; Nunn and Puga, 2012), and individual well-being (Michalopoulos et al., 2019). Less is known about the effects of cultural norms on health outcomes, including mortality. We provide evidence of non-persistence of one particular historical tradition, and outline the processes by which it became inoperative over time.

The second literature to which we contribute examines child survival rates in low-income countries. Economic and political variables shape child survival (Baird et al., 2011; Dehejia and Lleras-Muney, 2004; Kudamatsu, 2012; Miller and Urdinola, 2010), including the survival of twins (Pongou, 2013; Pongou et al., 2017). We provide evidence on the impact (in this case its absence) of cultural norms, about which less is known (see Arthi and Fenske (2018) for an exception). The causes of twin mortality relative to that of singletons have also received less attention from economists, and we contribute to this literature by ruling out one possible explanation.

The third literature to which our work is related studies the allocation of scarce resources among children. There is evidence both of a trade-off between family size and child quality (Hanushek, 1992; Rosenzweig and Zhang, 2009; Rosenzweig and Wolpin, 1980), and that investments made by parents reinforce initial endowments (Almond et al., 2018; Almond and Mazumder, 2013), though the selective survival of twins to birth complicates inference in this literature (Bhalotra and Clarke, 2020). Several contributions have also examined the degree to which additional births affect outcomes of older siblings (Angrist et al., 2010; Black et al., 2005; Qian, 2009). We test for differential investment in twins, which would be consistent with the implications of the quality–quantity trade-off. We show no evidence that this differential varies by prior traditions of twin infanticide.

We also contribute more narrowly to the set of studies on twin infanticide itself, including Granzberg (1973), Lester (1986), and Ball and Hill (1996). This literature has generally considered pairwise correlations between the practice of twin infanticide and other cultural characteristics in samples coded using the Human Relations Area Files. We add to this literature by coding a larger sample of ethnic groups than any previous study of which we are aware, using multivariate statistical analyses, and considering possible consequences of twin infanticide.

The remainder of this paper proceeds as follows. In Section 2, we explain our empirical strategies. We outline our sources of data in Section 3. In Section 4, we present our results on mortality and child investments. In Section 5, we discuss "mechanisms". We consider the possible links between past tradition and contemporary mortality that have been shut down, outline the historical processes by which this occurred, and use heterogeneity analyses to show that, where these processes were weak, mortality remains high among twins relative to non-twins in formerly twin-killing societies. In Section 6, we discuss the robustness of both our main results and these heterogeneity analyses. We also rule out alternative explanations of our results and briefly discuss additional results that are contained in the appendix. Section 7 concludes.

2. Empirical strategies

Our data will consist of more than one million children born between 1958 and 2018 from 23 African countries and more than 700

ethnic groups. We will use two broad empirical strategies. The first will use the full sample of observations:

$$\begin{aligned} Mortality_{iemt} =& \alpha + \beta_1 Twin_{iemt} + \beta_2 TwinKilling_e \\ &+ \beta_3 Twin_{iemt} \times TwinKilling_e \\ &+ x'_{iemt}\gamma + \delta_x + \epsilon_{iemt} \end{aligned} \quad (1)$$

Here, $Mortality_{iemt}$ is an indicator for whether child i from ethnic group e born to mother m in year t died. We use infant mortality (death within the first 12 months of life) and child mortality (death within the first 60 months) as outcomes. $Twin_{iemt}$ is an indicator for whether the child is a twin.

$TwinKilling_e$ is an indicator for whether the child's ethnic group has a tradition of twin infanticide. We code this (alternatively) by self-reported ethnicity, or by location relative to the ethnicity polygons in the Murdock (1959) map of Africa. That is: in this alternative coding, we code $TwinKilling_e$ based on whether the ethnic territory in which an individual lives is that of a group that once practiced twin infanticide, regardless of her self-reported ethnicity. Coding tradition by self-reported ethnic group allows us to test for possible links between past tradition and contemporary mortality at the individual level, including for migrants who no longer live in their ethnic groups' core ancestral regions. Coding by location, by contrast, allows for the possibility that links between past tradition and contemporary mortality might operate within locations. This would permit migrants into a location with traditions differing from those of their own ethnic groups to be affected by the traditions in this new location.

β_3, the coefficient on the interaction of $Twin_{iemt} \times TwinKilling_e$, is the coefficient of interest. It assesses the degree to which twin mortality is differentially greater among ethnic groups that practiced twin infanticide in the past. x_{iemt} is a vector of controls. In the baseline, it includes female, birth order, and year of birth. In robustness checks, we add maternal, geographic, ethnographic, and other controls. δ_x is, in alternative specifications, fixed effects for country, region, or for mother. Regions are defined as in the survey data, and are generally second-level sub-national administrative units. In all three cases, because we use only one survey wave per country, these absorb survey year fixed effects. We cluster standard errors by ethnic group. Because there are two ways in which we code $TwinKilling_e$ – by self-reported ethnicity or location in Murdock (1959) – we will change the clustering variable across specifications to match the measure of ethnicity by which $TwinKilling_e$ is coded.

In our second empirical strategy, we restrict our sample to children within 100 km of a border in Murdock (1959) that separates a group with a tradition of twin infanticide from one without this tradition.[2] Our goal here is to limit the possibility of omitted variables bias by comparing members of ethnic groups in close proximity; because these groups will be similar in their observed characteristics, they are also more likely to be similar in their unobserved characteristics. Similar approaches have been used by Moscona et al. (2020), in assessing the impact of segmentary lineage organization on conflict in modern Africa, and by Lowes (2020) to evaluate the impact of matriliny on spousal cooperation.

We begin by estimating Eq. (1) in this border sample. Because our main result will be that β_3 is small and statistically insignificant, this baseline specification has only a parsimonious set of controls. We do, however, extend this specification to include regression discontinuity polynomials of the form $f(location_{iemt}, Twin_{iemt})$ for robustness. For example, we will be able to include distance from the boundary, its interaction with $Twin_{iemt}$, and its interaction with $Twin_{iemt} \times TwinKilling_e$.[3]

[2] The 100 km bandwidth follows Lowes (2020), though we will show robustness to alternative distance cutoffs.

[3] See Table A16 for estimates that include these polynomials.

The DHS data we will use are randomly displaced up to 5 km in rural areas and up to 2 km in urban areas. Displacement is done to ensure respondent anonymity, but may create measurement error in $TwinKilling_e$ when we code respondents by their location relative to polygons in Murdock (1959). However, since this will only occur in specifications where a household is assigned to the wrong side of a border that separates an ethnic group with a tradition of twin infanticide from a group without the same tradition, we expect this will only create attenuation bias for a small fraction of observations in the border subsample.

3. Data

3.1. Infant and child mortality

In sub-Saharan Africa, one in five twins die by the age of five (Monden and Smits, 2017). Twins are three times as likely to die as children as singletons, and twins are a rising share of child deaths in Africa (Christensen and Bjerregaard-Andersen, 2017). This mortality differential is concentrated in the first year of life, and in particular in the first month (Pongou et al., 2019). Among World Health Organization regions, Africa and South East Asia have the highest rates of neonatal mortality for twins (Bellizzi et al., 2018).

There is a substantial literature on the excess mortality of twins, which focuses on several reasons for the twin mortality penalty, including growth retardation and low birth weight (Pongou et al., 2019). Twins are more likely to be born early and to have birth defects, and their mothers are more likely to face complications such as anemia, hemorrhaging, and hypertension (Monden and Smits, 2017). The disadvantages faced by twins are worsened in Africa by lack of medical care and lack of awareness about the difficulties that correlate with twinning (Christensen and Bjerregaard-Andersen, 2017).

Our data on infant and child mortality are taken from the Demographic and Health Survey (DHS) datasets. These are nationally representative surveys of women aged 15–49, and have been conducted in more than 90 countries since 1984. We limit our sample to countries in sub-Saharan Africa for which there is information on both respondent locations (i.e. latitude and longitude) and ethnicity, since these variables will be essential for us to code the presence of a tradition of twin infanticide. In this sample of 23 countries, we use the most recent data set that was available when we began this project in 2019.

In particular, we use data from the Births Recode modules. These ask women about all births they have ever had, including the sex of the child, birth order, year of birth, whether the child was a twin, and, if the child has died, how long the child lived. Across surveys, these give us information on more than one million children born between 1958 and 2018. Of these, 7.5% died in the first 12 months of life, while 12.3% died in the first 60 months of life. We take these as indicators of infant and child mortality, respectively.

Our focus is not on infant and child mortality *per se*, but rather on the excess mortality of twins relative to non-twins. We show two maps of this excess mortality, in Figs. 1 and 2. The first map depicts survey clusters — units that roughly approximate villages. We compute, for every cluster, the child mortality rates of twins and of non-twins. We take the difference as a measure of excess child mortality. The second map performs the same exercise, but using the ethnic polygons in Murdock (1959). There is not a clear geographic pattern in either figure, though some regional pockets of high relative twin mortality stand out in the eastern Central African Republic, southern Chad, Niger, and non-highland Ethiopia. In particular, the lack of any clear geographical pattern in Fig. 1 is in stark contrast to the clustering of twin infanticide that we show below in Fig. 3, even though the two are drawn with the same color scheme.

While the Demographic and Health Surveys are a widely used and high-quality data source, misreporting is possible, and systematic misreporting could give rise to systematic biases. If formerly twin-killing

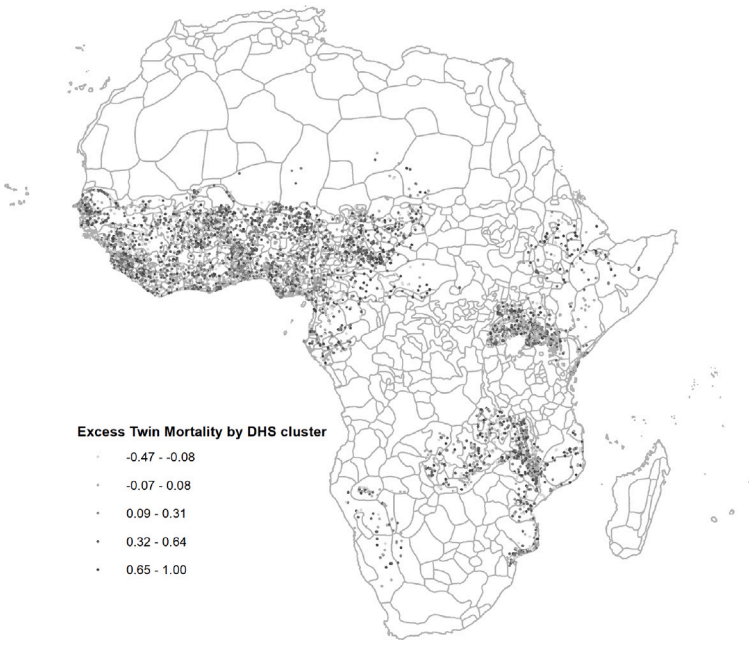

Fig. 1. Excess twin mortality by DHS cluster.

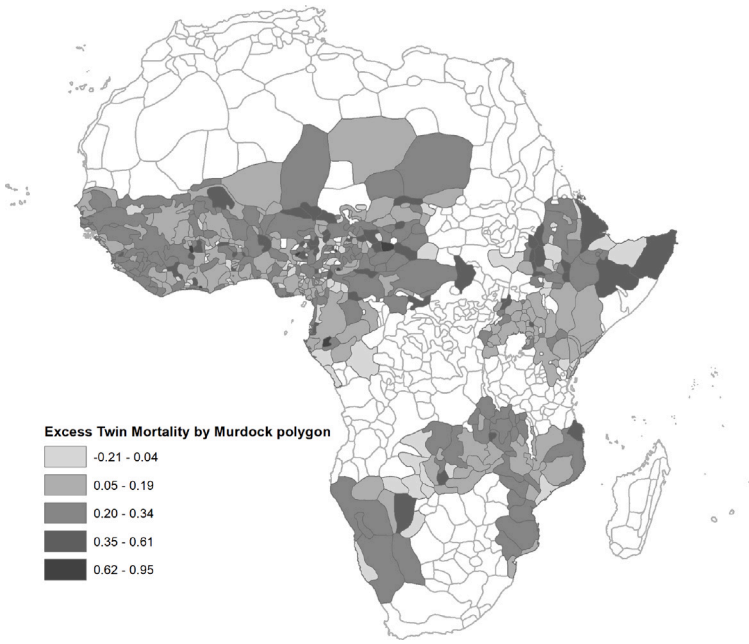

Fig. 2. Excess twin mortality by Murdock (1959) ethnicity. *Note*: Unshaded polygons are ethnic groups not in our sample.

societies were to dis-proportionately misreport twins as singletons, it would lead us to spuriously find "anti-persistence" – differentially low mortality among twins in former twin-killing societies. By contrast, if formerly twin-killing societies were to dis-proportionately misreport twins as surviving when in fact they did not, it would bias our estimates towards zero. We acknowledge this potential limitation, but show below that we find no difference in twinning rates between the two groups.

3.2. Twin infanticide

3.2.1. Twin infanticide: the ethnographic literature

Twin infanticide is the act of disposing of either one or both infants from a twin pair, and has been practiced in the past by several societies around the globe (Granzberg, 1973). Methods of infanticide differed across African societies, but included smothering, drowning, exposure, strangulation, and live burial (Scrimshaw, 1984). In some societies, only one twin was killed. The twin killed might be the weaker one, as among the Khoikhoi of South Africa (Lagercrantz, 1941, p. 169), or selected by gender, as among the Chaga of Tanzania (Carey, 1925, p. 22). In other cases, as with the Itsekiri of Nigeria (Granville and Roth, 1899, p. 106), both twins were killed. In some examples, such as the Efik of Nigeria, the mother would also be killed (Imbua, 2013, p. 142). Anthropologists have paid particular attention to twin infanticide in Africa, since its prevalence was made clear by the earliest ethnographic research on the continent (Ball and Hill, 1996). While twin infanticide is not unique to Africa (e.g. Sarkar (2012)), we focus on Africa because

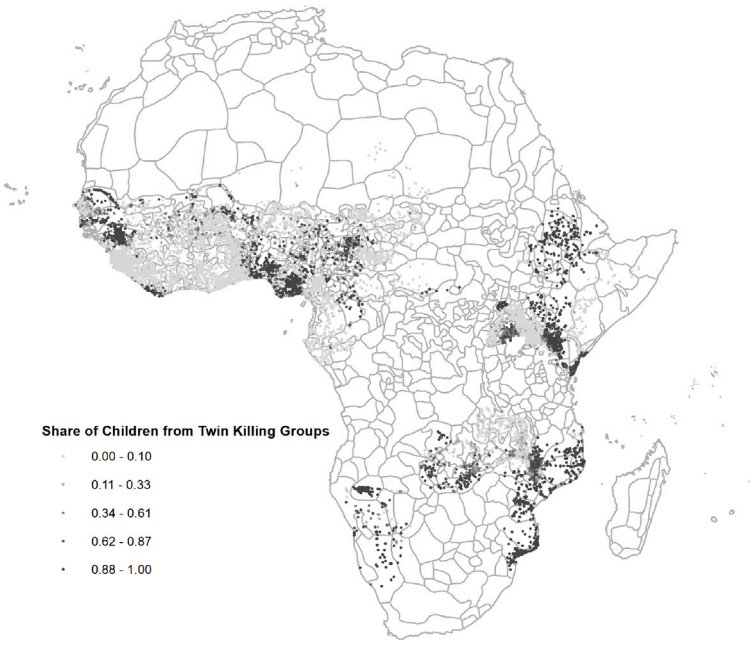

Fig. 3. Twin infanticide by DHS cluster.

of the availability of ethnographic literature that makes it feasible to code our key variables.

It is not the aim of this paper to explain the practice of twin infanticide. Rather, we use existing theories from the literature to identify potentially confounding variables that we include as controls. Accounts of twin infanticide are often divided into emic and etic explanations — those originating from within the society that practices it and those originating from the researcher. Emic explanations of twin infanticide differ considerably across African societies, and include fears that twins are abnormal, that they can kill the sick, that they arise from adultery, or that they are cursed or evil (Granzberg, 1973, p. 406). Emic explanations may, however, be constructed retrospectively; Leis (1965, p. 102) provides the example of an explanation adopted by Christian converts among Nigeria's Ijaw (that twin infanticide was established in response to a pair of twins who had become destructive, cruel giants) that was unknown by older members of the community.

Etic explanations are more likely to appeal to logic familiar to economists. Granzberg (1973) proposes a "materialistic" explanation, that twin infanticide exists where resources are not sufficient for a mother to raise two children at once while meeting other responsibilities, based on the help available to mothers and the degree to which mothers are free from work. Related explanations stress infanticide, including twin infanticide, as the result of a tradeoff between investments in the survival of different children (Hrdy, 1992) or as a means of reducing population stress on local resources (Milner, 2000).

Other etic perspectives complicate this materialist view. Lester (1986) notes that twin infanticide tends to coexist with male dominance in societies where women have a relatively inferior status. Ball and Hill (1996) show that, while twin infanticide tends to coexist with the killing of other low-viability infants, it does not tend to exist in the same societies that use infanticide as a form of population control or the killing of infants conceived under what a society deems inappropriate circumstances. Marroquín and Haight (2017) argue for an identity economics interpretation; twin infanticide was a costly practice that preserved inclusion in the community. To account for possible determinants of twin infanticide that may also influence the relative mortality of twins, we will show robustness to controlling for a broad set of geographic and ethnographic variables. We will show, however, that few of these correlate with twin infanticide.[4] Our data, then, do not clearly distinguish between these competing explanations.

Other discussions have aimed to understand infanticide, including twin infanticide, within the broader social and cultural context (Carolus and Ringen, 2018; Devlieger, 2013; Laughlin, 1994; Minturn and Stashak, 1982; Pector, 2002; Piontelli, 2008; Stewart, 2000). Our narrow focus on twin infanticide as opposed to all forms of infanticide is motivated, first, by the exceptionally high mortality of twins in Africa (Pongou, 2013; Pongou et al., 2017) and, second, by feasibility. While twins can be identified in standard datasets, other circumstances that have been taken as reasons for infanticide, such as breech birth or conception from adultery, are often difficult to measure. Further, many of the sources that make it possible to identify twin infanticide are reference works focused on twins, not on infanticide (Lagercrantz, 1941; Peek, 2011).

3.2.2. *Twin infanticide: Coding*

Although some past studies have made lists of ethnic groups that have practiced twin infanticide, we are not aware of any source with a sufficiently large sample for multivariate analyses, nor for implementation of our border sample design. Thus, we use ethnographic sources to code the presence or absence of twin infanticide for the ethnic groups in our data. We do this two ways — first, for ethnic groups recorded in the DHS data and, second, for the ethnic groups in the polygons of the Murdock (1959) map that intersect the countries in our data. We code these variables as 1 if the literature records that a group practiced twin infanticide at any point in its history.

Coding groups as 0 requires more care. We do not wish to assume that absence of evidence is evidence of absence. Yet, unless twin infanticide is of particular interest to an ethnographer, its absence is unlikely to be reported directly. So, we code twin infanticide as 0 for an ethnic group if any of the following conditions is met:

(1) The literature records that it did not practice twin killing.
(2) The literature records that it has a positive or neutral attitude to twins.

[4] See Table A7.

(3) The literature records that it has a negative attitude to twins but no direct evidence shows that it killed twins.
(4) There exists literature on the group's tradition of infanticide but twins are not mentioned as one of the situations.

We code a small number of groups as 0 for other reasons, for example if special names are given to twins and we have not identified any other discussion of the role of twins in that society.

We begin by using existing sources that have compiled information on the treatment of twins in multiple societies. The sources of this type from which we will be able to code twin infanticide for the largest number of ethnic groups are Hartland (1921), Carey (1925), Lagercrantz (1941), Granzberg (1973), Pison (1987), Ball and Hill (1996), and Peek (2011). However, many of the ethnic groups recorded in either the DHS data or in Murdock (1959) are not covered by these sources. As a result, we turn to more than 300 additional books and articles.

We now provide examples for each of the codings in our data. As a group coded 1, the Igbo of Nigeria are perhaps one of the most well-known cases of twin infanticide in Africa, in part due to descriptions in Achebe (1958):

> The children are thrust into an old waterpot without even a passing thought for the pain inflicted. Cocoanut fiber or leaves are thrown in to cover them, and the pot is then deposited in some lonely spot in the bush. The newly born infants receive no attention whatsoever. They are cast away at once, as unclean in the sight of gods and men. ... This method of dealing with twins is reckoned to be the only one open to the parents, as by acting thus they hope to avert further calamity. To permit the children to live would amount to a direct challenge to the malignant spirits, and the parents, and indeed the whole community, would be exposed to all manner of dangers (Basden, 1921, p. 57–58).

While the ethnographic literature does allow us to code the past presence of twin infanticide, the sources available do not generally contain enough detail to measure whether adherence to tradition was complete in any one society. For example, Schapera (1927), describing the !Kung of South Africa, states briefly that "when twins are born, which is very seldom, one child is buried alive by the midwife or mother immediately after the birth". Some discussions in the literature are even more terse. Granzberg (1973) records twin infanticide as "present" among the Amhara of Ethiopia and Kikuyu of Kenya, with no further information. For the Amhara, he cites the PhD thesis of Messing (1957), who notes briefly (p. 431) that "[v]ery likely, the weaker of twins is neglected, which greatly increases the natural mortality of twins". Granzberg (1973) provides no specific citation for the Kikuyu, and an alternative source, Dundas (1921), states only briefly (p. 234–5) that "in Kikuyu, both twins are left to die in the bush".

For an example of a group that is coded 0 because *the literature records that it did not practice twin killing*, consider the Masai of Kenya. Table 2 on p. 861 of Ball and Hill (1996) lists 38 ethnic groups from around the world and whether they practiced infanticide in the cases of twins, poor quality infants, too many infants, or inappropriate conception. The Masai are coded 0 for both twins and "too many" in this table, and 1 for poor quality and inappropriate conception.

For an example of a group that is coded 0 because *the literature records that it has a positive or neutral attitude to twins*, consider the Fon of Benin:

> The notion of twin beings ... expresses the equilibrium maintained between opposites, which is the very nature of the world. The ideal birth is a twin birth (Mercier (1963, p. 219), quoted in Peek (2011, p. 9)).[5]

For an example of a group that is coded 0 because *the literature records that it has a negative attitude to twins but no direct evidence shows that it killed twins*, consider the Dakarkari of Nigeria:

> Male twins are not wanted because it is said that, if they live, their father will die, and female twins are not wanted because they are thought to cause the death of their mother. Mixed (male and female) twins are regarded favorably, as it is thought that the male counterbalances the female, and vice versa.
>
> The killing of unwanted twins does not ever appear to have been the custom, but, to this day, a certain ceremony must be observed two years after the birth of male or female twins in order to avert calamity to the father or mother, as the case may be (Harris, 1938, p. 134).

For an example of a group that is coded 0 because *there exists literature on the group's tradition of infanticide but twins are not mentioned as one of the situations*, consider the Bariba of Nigeria:

> These signs are indicative of unusual features of either the infant or the birth process and include: (1) breech birth; (2) birth occurring at eight months; (3) babies who slide on their stomachs at birth; (4) babies born with teeth; and (5) babies whose teeth appear first in the upper gums. Babies displaying these signs either at birth or during teething were customarily killed or abandoned (Sargent, 1988, p. 80).

For an example of a group we have coded 0 for other reasons, consider the Teke–Mbede of Gabon. Green (2017, p. 244) reports the presence of rituals surrounding twin births without providing additional information: "Historically, when twins were born in Teke society a basket was placed next to their heads, in which visitors placed small gifts". This case shows attention to the role of twins among the Teke–Mbede but does not mention infanticide. That Knight (2003) and Dupré (1974) also discuss twins among the Teke–Mbede without mentioning infanticide reinforces our interpretation that, had infanticide been present, it would have appeared in the ethnographic literature.

There are a small number of cases in which conflicting information is available in the available record. The Senufo of the Ivory Coast are one such example. While Knops (1938, p. 484) reports that twins are a blessing,[6] a sentiment reiterated by Lagercrantz (1941, p. 22), Bah and Fanny (2018, p. 101) report the presence of twin infanticide among the Senufo.[7] We show robustness to recoding these groups. In addition, for robustness, we also present results in which we recode all groups for which we lack positive evidence of the presence of twin infanticide as 0.

We are able to code 288 groups, or 81.5% of the sample of births, by self-reported ethnic group and 272 groups, or 74.8% of the sample of births, by location relative to the Murdock (1959) map. This is comparable to similar exercises in the literature: Moscona et al. (2020), for example, code the presence of segmented lineages for 145 ethnic groups covering 38% of the population of sub-Saharan Africa. 28.4% of the sample of births comes from ethnic groups with a history of twin

[5] Although some of our sources do provide information on attitudes towards twins (e.g. map 7 in Lagercrantz (1941), which shows societies where twins are "welcome"), we do not attempt to code beliefs such as twin reverence. These would only be available for a subset of the societies in our data, qualitative features of this type would be difficult to compile consistently across sources, and the inherent subjectivity of these beliefs would lead to more measurement error than with the presence or absence of infanticide.

[6] "La naissance de jumeaux est considéreé comme une bénédiction, une récompense des fétiches et des esprits ancestraux".

[7] "D'abord, á la naissance, les matrones prennent acte de la situation et en informe le père. Une résolution discrète est prise pour sauver le père. Ainsi, tous les jumeaux, n'ont pas la chance de sortir vivant de l'accouchement. Cette opération est réservée aux matrones. L'ordre lui est donné par les proches d'agir. Ceci est un secret atteste une septuagénaire lors de notre enquête".

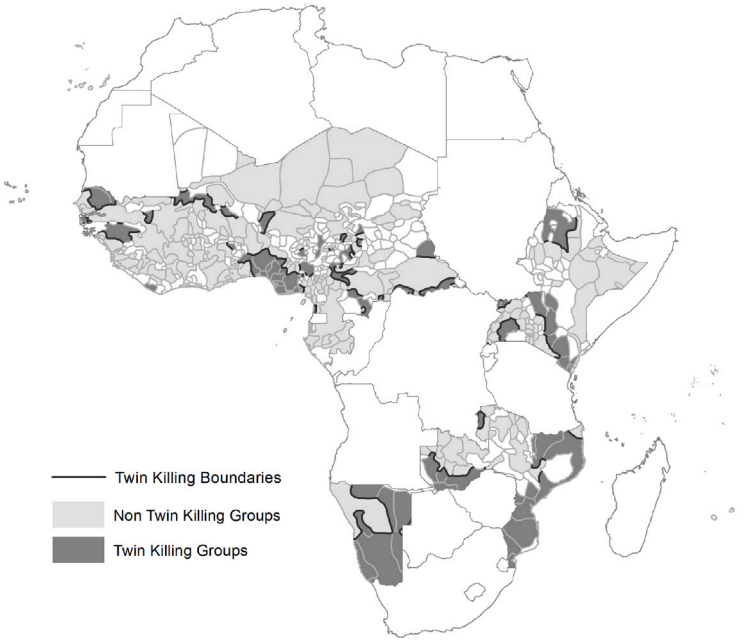

Fig. 4. Twin infanticide by Murdock (1959) ethnicity.

infanticide by self-reported ethnicity, and 24.8% by location relative to the Murdock (1959) map. While we cannot code all ethnic groups in the sample, we will show below that controlling for correlates of missing data or recoding all missing groups as zeros does little to our results.[8]

We provide maps of twin infanticide in Figs. 3 and 4. Fig. 3 plots the share of births in each DHS survey cluster that is from ethnic groups that practiced twin infanticide. Fig. 4 does the same for the Murdock (1959) map, and also shows the boundaries separating twin-killing from non-twin-killing groups, which we will use to define our boundary sample. There is clear geographic clustering in these maps. Twin infanticide is most prevalent in Southern Africa, including Namibia, southern Zambia, and Mozambique, in Western Kenya, and in Southern Nigeria.[9]

3.3. Other variables

We include a number of additional variables in our analyses. Because our main result will be a null, we will mostly include these in robustness exercises reported in the appendix, rather than in our baseline estimates. First, we take *maternal controls* from the DHS Births Recodes. We record rural/urban status, as well as mother's age, religion, wealth, and level of education. Wealth is an index included the DHS data and based on a principal components analysis of durable goods ownership.[10] We have harmonized the religions across the various DHS waves into the categories of Animist, Christian, Missing, Muslim, None, and Other.

Geographic controls included in the child-level regressions are taken from the DHS GIS file. We record latitude and longitude, precipitation, aridity, a vegetation index, and malaria incidence. We use the 2015 values of these variables for consistency across surveys. We also include an indicator for rural from the Births Recodes. In additional analyses, we will assess the degree to which the presence of twin infanticide correlates with the geographic characteristics of the ethnic polygons reported in Murdock (1959). These include area shares by major vegetation type from White (1983), explorer routes and colonial railroads from The Century Company (1897), caloric suitability from Galor and Özak (2016, 2015), altitude, pasture suitability, forest cover, precipitation, slope, temperature, and suitability for several crops from the Food and Agriculture Organization of the United Nations (FAO) Global Agro-Ecological Zones project, humidity from the Climatic Research Unit at the University of East Anglia, tsetse suitability from Alsan (2015), suitability for nomadic pastoralism from Beck and Sieber (2010), ruggedness from Nunn and Puga (2012), malaria suitability from Kiszewski et al. (2004), population density in various years from both the Gridded Population of the World and Klein Goldewijk et al. (2010), pre-colonial conflicts recorded in Brecke (1999), mines recorded in U.S. Geological Survey, missions recorded in Roome (1925), and ecological diversity from Fenske (2014).[11] We also compute distance from the coast, area, and absolute latitude ourselves.

We also include a number of *ethnographic controls* – other characteristics of the ethnic groups in our data recorded in the Murdock (1967) *Ethnographic Atlas*. We focus on five variables that have featured in other empirical work on path dependence in Africa: Jurisdictional Hierarchy, Patrilineal, Polygynous, Importance of Agriculture, and Female Participation in Agriculture. The Ethnographic Atlas reports information on 1265 ethnic groups from around the world, 486 from sub-Saharan Africa excluding Madagascar. We merge these to our data based on the name of the ethnicity in the DHS when we code twin infanticide based on self-reported ethnicity, and by the name of the ethnicity in Murdock (1959) when we code it based on location.

Jurisdictional Hierarchy, used previously by both Gennaioli and Rainer (2007) and Michalopoulos and Papaioannou (2013), is based on Variable 33 in the Atlas. It measures state centralization, and records the number of jurisdictional levels above the local community, ranging from none to four. We construct an indicator for whether a society has more than one level of hierarchy above the local. Patrilineal, based on Variable 43 in the Atlas, captures whether descent is through the male line. Matriliny, an alternative to patriliny, is the main focus of Lowes (2020). Polygyny, previously used by Fenske (2015), is based

[8] See Tables A6 and A17, respectively.

[9] While we cannot include Botswana, Zimbabwe, South Africa, and Tanzania due to lack of suitable ethnicity or geographic data in the DHS, substantial geographic clusters of twin infanticide also exist in these countries.

[10] While this is in the Births Recodes in most cases, for some rounds we merge this variable in from other sections of the survey.

[11] Explorer routes, colonial railroads, and missions were digitized first by Nunn (2014).

Table 1
Summary statistics.

	(1) Mean	(2) s.d.	(3) Min	(4) Max	(5) N
Infant mortality	0.075	0.26	0	1	1 015 316
Child mortality	0.12	0.33	0	1	1 015 316
Twin killing (DHS)	0.28	0.45	0	1	827 525
Twin killing (Murdock)	0.25	0.43	0	1	759 610
Twin	0.033	0.18	0	1	1 014 753
Female	0.49	0.50	0	1	1 015 316
Birth order	3.30	2.23	1	18	1 015 316
Year of birth	2002	8.77	1958	2018	1 015 316
Border sample	0.40	0.49	0	1	1 003 106

on Variable 8 in the Atlas. This measure codes the mode of domestic organization categorically, and we create a dummy equal to 1 if a society is recorded either as "polygynous: unusual co-wives" or "polygynous: usual co-wives". The Importance of Agriculture, previously used by Michalopoulos et al. (2019), codes the dependence of a society on agriculture for subsistence into ten categorical levels, from 0%–5% dependence to 86%–100% dependence. We will use a dummy variable equal to 1 if the importance of agriculture is greater than 55%. Female participation in agriculture, previously used by Alesina et al. (2013), is based on Variable 54 in the Atlas. We create an indicator equal to 1 if female participation is equal to that of men or greater.

As additional outcomes, we measure *investments in child health*. We take these from the DHS Children's Recode (KR), which asks only about children born within five years of the survey date, and so gives us a smaller sample than in our baseline analysis of mortality. Mothers are asked a series of questions about vaccinations, duration of breastfeeding, the conditions under which children were born, and their current health outcomes.

We report summary statistics in Table 1. For the more than one million children in the sample, we have been able to code the past presence of twin infanticide for more than 825,000 based on DHS ethnicity and more than 750,000 based on location relative to the Murdock (1959) map. A bit more than 3% of births in our sample are twins, consistent with the high twinning rates found in sub-Saharan Africa (Smits and Monden, 2011). While the earliest births in the sample are in the late 1950s, the mean year of birth is 2002. Approximately 7.5% of births in the sample are children who died in the first year of life, and roughly 12% died in the first five years. Approximately 40% of the sample is within 100 km of a border separating an ethnic group that once practiced twin infanticide from one that did not.

4. Results

In this section, we present our estimates of Eq. (1) in the full and border samples, and of (2) in the sample of twins. If twins face an additional mortality penalty among former twin-killing groups relative to the twin mortality penalty among other groups, it is both quantitatively small and statistically insignificant. We also present our estimates taking investment in child health as outcomes. We find no evidence that twins receive fewer health investments among former twin-killing groups, nor that their health is differentially worse among these groups.

4.1. Baseline mortality results

In Table 2, we present our estimates of Eq. (1) in the full sample. In the first three columns, we use infant morality as an outcome. In the next three columns, child mortality is the dependent variable. For each outcome, we report results including country fixed effects, region fixed effects, and mother fixed effects. The last of these are collinear with the variable $TwinKilling$. The number of observations falls in this specification because some women in the sample have only had one birth.

In Panel A, twin infanticide is coded by self-reported ethnicity in the DHS data. Across columns, the coefficient on $Twin \times TwinKilling$ is insignificant. It is also small (0.003–0.009) when compared with mean mortality (0.07–0.12) or the coefficient on $Twin$ (0.17–0.18). In Panel B of Table 2, we code twin infanticide based on the Murdock (1959) map. Across columns, the coefficient on $Twin \times TwinKilling$ is again small and insignificant. It is also negative in several columns. In the full sample, then, we find no evidence of greater twin mortality among former twin-killing groups.

Because it is possible that groups with a former tradition of twin infanticide differ along unobserved dimensions from those without this tradition in ways that could contribute directly to the twin mortality penalty, we present our estimates of Eq. (1) in our border sample in Table 3. Groups in close proximity to each other should be more similar in their observed and unobserved characteristics. Here too, we find no evidence of a differential mortality penalty for twins in former twin-killing societies. As in Table 2, we show results for both infant and child mortality, coding twin infanticide by both self-reported and Murdock (1959) ethnicity. We include, alternatively, country, region, and mother fixed effects. Again, across columns and panels, the coefficient on $Twin \times TwinKilling$ is insignificant and quantitatively small when contrasted with the size of the twin mortality penalty, which ranges from 16.3 to 19.6 percentage points across specifications.

4.2. Investments in children

Using the DHS Children's Recode, we are able to examine a large number of investments made for children born within the five years preceding the survey. These include vaccination, duration of breastfeeding, and health outcomes. In Table 4, we present estimates of (1) with these taken as outcome variables. We find no evidence of differential investment in twins relative to non-twins in societies with a past history of twin infanticide. Most coefficient estimates are small and insignificant relative to the means of the dependent variables. In many cases they are positive, suggesting that, if anything, health investments twins receive relative to non-twins are greater in former twin-killing societies. For space, we only report results coding respondents by self-reported (DHS) ethnicity. Anthropometric measures of health – weight for height, weight for age, height for age, birth weight, and subjectively reported size at birth – tell a similar story. The gap in health outcomes between twins and non-twins is no worse in former twin-killing societies. We show below that results using ethnicity based on the Murdock (1959) map are similar.[12]

5. Mechanisms

So far, we have shown that there is no differential mortality penalty in the present for twins among ethnic groups with a former history of twin infanticide. This means that both direct and indirect channels connecting this past tradition to present outcomes have been reduced to quantitative unimportance. In this section, we discuss the likely mechanisms linking past infanticide to present mortality that might have been deactivated in the sample. We then outline the historical processes identified in the literature that led to the end of twin infanticide in Africa. We then show that, where these processes are weak – distant from Protestant missions, from colonial cities, in non-agricultural societies, and in formerly French Africa – the data continue to suggest a continued differential mortality penalty for twins in formerly twin killing societies compared to others. Finally, we show a number of empirical results suggesting that alternative mechanisms are likely to have been unimportant in the suppression of the direct and indirect legacies of twin infanticide.

[12] See table A20.

Table 2
Full sample results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality			Child mortality		
Panel A. Twin killing coded by DHS ethnicity						
Twin × TwinKilling	0.003	0.003	0.003	0.007	0.009	0.007
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.011)
Twin	0.171***	0.173***	0.184***	0.180***	0.183***	0.198***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)
TwinKilling	−0.004	0.000		−0.014	−0.004	
	(0.004)	(0.002)		(0.010)	(0.002)	
Observations	827,065	827,065	788,399	827,065	827,065	788,399
Clusters	288	288	288	288	288	288
Outcome mean	0.0740	0.0738	0.0754	0.123	0.123	0.126
Panel B. Twin killing coded by murdock ethnicity						
Twin × TwinKilling	−0.003	−0.003	−0.001	−0.003	−0.002	0.002
	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)
Twin	0.176***	0.177***	0.188***	0.186***	0.188***	0.202***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
TwinKilling	−0.007**	−0.001		−0.019**	−0.002	
	(0.004)	(0.002)		(0.009)	(0.003)	
Observations	759,183	759,183	722,651	759,183	759,183	722,651
Clusters	272	272	272	272	272	272
Outcome mean	0.0737	0.0737	0.0751	0.121	0.121	0.124
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes	No	Yes	Yes
Mother fixed effects	No	No	Yes	No	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by the DHS ethnicity in Panel A, and Murdock Ethnicity in Panel B. Controls are female, birth order, and year of birth.

Table 3
Border sample results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality			Child mortality		
Panel A. Twin killing coded by DHS ethnicity						
Twin × TwinKilling	−0.000	−0.000	0.002	0.010	0.010	0.012
	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)
Twin	0.163***	0.164***	0.174***	0.174***	0.177***	0.186***
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
TwinKilling	−0.000	0.000		−0.006	−0.002	
	(0.004)	(0.002)		(0.008)	(0.003)	
Observations	337,534	337,534	321,641	337,534	337,534	321,641
Clusters	240	240	237	240	240	237
Outcome mean	0.0686	0.0686	0.0698	0.114	0.114	0.117
Panel B. Twin killing coded by murdock ethnicity						
Twin × TwinKilling	0.001	0.001	0.003	0.001	0.001	0.004
	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.013)
Twin	0.167***	0.168***	0.180***	0.182***	0.184***	0.196***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
TwinKilling	−0.001	−0.002		−0.005	−0.002	
	(0.003)	(0.002)		(0.006)	(0.003)	
Observations	331,891	331,891	315,989	331,891	331,891	315,989
Clusters	175	175	175	175	175	175
Outcome mean	0.0677	0.0677	0.0688	0.111	0.111	0.114
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes	No	Yes	Yes
Mother fixed effects	No	No	Yes	No	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by the DHS ethnicity in Panel A, and Murdock Ethnicity in Panel B. Controls are female, birth order, and year of birth.

Table 4
Investments in children.

	(1) Received bcg	(2) Received polio 0	(3) Received measles	(4) Number of polio 1 to 3 vaccines received	(5) Number of DPT 1 to 3 vaccines received
Twin × TwinKilling (DHS)	0.006	0.024	−0.015	0.004	0.033
	(0.014)	(0.000)	(0.016)	(0.043)	(0.047)
Twin	0.044***	0.054***	0.039***	0.058**	0.095***
	(0.009)	(0.011)	(0.010)	(0.023)	(0.029)
TwinKilling(DHS)	0.046	0.009	0.025	−0.043	0.107
	(0.055)	(0.050)	(0.035)	(0.048)	(0.154)
Controls + Country FE	Yes	Yes	Yes	Yes	Yes
Observations	179,521	179,651	178,713	178,576	178,663
Clusters	285	285	285	285	285
Mean of dependent variable	0.815	0.657	0.602	2.179	2.090
	(6) Number of vaccines received	(7) Months of breastfeeding	(8) Below Median months of Breastfeeding	(9) Place of delivery: home	(10) Assistance: doctor
Twin × TwinKilling (DHS)	0.031	−0.182	0.003	−0.007	0.025*
	(0.092)	(0.504)	(0.027)	(0.000)	(0.015)
Twin	0.193***	−2.964***	0.140***	−0.114	0.076***
	(0.050)	(0.295)	(0.015)	(0.000)	(0.008)
TwinKilling(DHS)	0.082	0.334	0.002	−0.004	0.031*
	(0.221)	(0.239)	(0.012)	(0.000)	(0.017)
Controls + Country FE	Yes	Yes	Yes	Yes	Yes
Observations	176,756	103,535	103,535	215,086	216,456
Clusters	285	283	283	285	285
Mean of dependent variable	4.881	11.63	0.503	0.403	0.0823
	(11) Weight/Height percentile	(12) Weight/Age percentile	(13) Height/Age percentile	(14) Birth weight in grams	(15) Size of child at birth
Twin × TwinKilling (DHS)	190.082	117.134	102.793	8.549	−0.035
	(119.106)	(120.502)	(134.059)	(47.955)	(0.045)
Twin	−459.939***	−842.032***	−844.510***	−643.980***	0.517***
	(73.081)	(64.609)	(81.045)	(20.110)	(0.020)
TwinKilling(DHS)	−154.907	66.340	173.904	−20.148	0.031
	(112.910)	(181.285)	(206.051)	(15.210)	(0.026)
Controls + Country FE	Yes	Yes	Yes	Yes	Yes
Observations	129,721	128,590	128,590	103,497	203,552
Clusters	285	285	285	272	285
Mean of dependent variable	3775	2397	2479	3199	2.738

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by the DHS ethnicity. Controls are female, birth order, and year of birth.

5.1. Past mechanisms that have ceased in importance

One possible mechanism that would have led to a persistent mortality penalty among twins would be a direct one: continued twin infanticide. Both international and African news sources do report that the practice continues in certain villages, for example among the Bassa Komo in Nigeria,[13] or among the Bakusu in Kenya.[14] However, given the legal status of infanticide, we would not expect this direct channel to be of quantitative importance in the present.

Rather, a more plausible channel that would explain a persistent mortality penalty would be the survival of negative attitudes towards twins — attitudes that would shape, even subconsciously, how twins are treated and the investments made in them. This mechanism would be analogous to the role of religious rituals, notions of female safety and purity, and gender norms in explaining differential health investments in children by gender (Bharadwaj and Lakdawala, 2013; Jayachandran, 2015). Bastian (2001, p. 24), for example, recounts views she encountered during her Nigerian fieldwork during the 1980s:

> From this we may gather that multiple births are still considered something of an embarrassment. ... One set of twins who were spoken of with some frequency had spent most of their lives in the United Kingdom, supposedly because they were also albinos. ... It was claimed that if they were to come home to live in Onitsha, the twins would surely die from the heat.

She also encountered, in 1987, a recent mother of twins in a hospital in Enugu (Nigeria) that was being displayed as a curiosity to more well-off visitors (p.24). In 1991, 9% of Efik, Ibibio, and Annang women in Nigeria believed twins had inhuman origins, 2.3% stated they would reject them, and 2.6% stated they would have them killed (Asindi et al., 1993). Some Haya in Tanzania believe today that twins can inflict vitiligo on those who upset them (Lutatinisibwa, 2017).

Other recent anthropological work has identified the recent existence of beliefs that twins are unusual and potentially dangerous. Diduk (2001, p. 33) reports a woman from a wealthy family in Cameroon who, in 1990, reported that she was not told her sister had died while studying medicine in Germany until the sister was buried in Cameroon. She had not been told in order to prevent the living twin from being drawn back to the "die world". In 1998, the cost of rituals for twins in Kedjom society (Cameroon) was more than 1000 USD (ibid., p. 39). In Niger, Masquelier (2001, p. 47,51) reported that twins were still associated with witches and spirits and believed to possess exceptional powers. During the 1990s, adherents to the recently formed Izala faction of Islam were spreading the view that twins were due to maternal adultery (ibid., p. 56). Renne (2001, p. 67) reports the testimony of

[13] https://www.reuters.com/article/us-nigeria-infanticide-twins-idUSKBN1H419S and https://www.theguardian.com/working-in-development/2018/jan/19/twin-baby-dies-secret-killings-nigeria-remote-communities.

[14] https://www.bbc.co.uk/news/world-africa-12280109 and https://www.standardmedia.co.ke/entertainment/crazy-monday/2001252098/blessing-or-curse-communities-that-celebrate-or-kill-twins.

Table 5
Results for births before 1980.

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality			Child mortality		
Twin × TwinKilling (DHS)	0.062**	0.061**	0.060**	0.059**	0.058**	0.054**
	(0.030)	(0.030)	(0.030)	(0.025)	(0.025)	(0.024)
Twin	0.274***	0.273***	0.277***	0.273***	0.272***	0.277***
	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)	(0.014)
TwinKilling (DHS)	0.007	0.006	0.001	−0.011	−0.011	−0.013**
	(0.007)	(0.007)	(0.004)	(0.009)	(0.009)	(0.005)
Observations	94,032	94,030	94,017	94,032	94,030	94,017
Clusters	290	289	283	290	289	283
Mean of dependent variable	0.141	0.141	0.141	0.261	0.261	0.261
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Dataset fixed effects	No	Yes	Yes	No	Yes	Yes
Dataset × Region fixed effects	No	No	Yes	No	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by DHS ethnicity. Controls are female, birth order, and year of birth.

one older Yoruba woman in Nigeria that parents were reluctant to take twins to Western hospitals, preferring shrines instead. Similar evidence of present-day attitudes comes from journalistic sources, such as in the Ivory Coast.[15]

Since the existence of these types of attitudes has been attested to by anthropologists and journalists within living memory, we use Table 5 to assess whether there is any evidence of a differential twin mortality penalty among former twin-killing groups in the earliest births in our data — those from 1980 and earlier. Ideally, we would test for this differential in data from the colonial period. Unfortunately, given the nearly complete absence of data in the DHS on births prior to independence, we are instead only able to test for this differential in later years. While it is possible that the efforts of Africans, of missionaries, and of colonial administrators that we detail below might have eliminated the differential by 1980, the attitudes reported by anthropologists and journalists make it plausible that a twin mortality penalty could still persist after independence. This could be the case if attitudes towards twins were transmitted vertically and horizontally, despite state and missionary efforts against overt practices. These efforts may have initiated cultural transition dynamics that had not yet reached a new equilibrium (Bisin and Verdier, 2011).

We select 1980 as a cutoff date defining these early births because it predates the ethnographic evidence we describe but preserves sample size, given the scarcity of data from earlier birth years. In order to increase the number of births in the data from these years, we add all earlier DHS waves that contain ethnicity data, bringing the total number of datasets used in Table 5 to 49. Even in this larger sample, only 1153 births and 38 twins are born in 1960 and earlier, while 17,937 births, including 494 twins, are born in 1970 and earlier. This is less than 1% of the sample. We do not add any new countries to these data, and so our results in Table 5 are not driven by changes in sample composition. No more than six countries are surveyed in any one year, and so we cannot restrict the sample to countries surveyed in the same year. Because these earlier waves lack latitude and longitude coordinates, we are only able to re-estimate Eq. (1) in the full sample, with $TwinKilling$ coded by self-reported ethnicity.

The positive and significant coefficient on $Twin{\times}TwinKilling$ in this sample is evidence of differential mortality of twins among former twin-killing groups for births dating from before 1980. In the full sample, the additional mortality penalty for twins is close to 6 percentage points, roughly 20% of the typical twin mortality penalty given by the coefficient on the indicator for twin. The coefficient on $Twin \times TwinKilling$ is not only significantly different from zero, it is significantly different from the coefficient estimated in the baseline sample. We show this in Table A1, in the appendix. There, we pool our baseline sample and the births before 1980 together. We add $Before1980{\times}Twin{\times}TwinKilling$, $Before1980 \times Twin$, $Before1980 \times TwinKilling$, and $Before1980$ as additional controls. The coefficient on $Before1980{\times}Twin{\times}TwinKilling$ is significant at the 10% level.

Because the choice of 1980 is, ultimately, arbitrary, we show in Fig. 5 that we find similar coefficient estimates using other cutoff years. We begin with 1975, before which less than 3% of our extended sample of children from 49 datasets had been born. Using dates from 1975 to the mid-1980s to define the sample split, the coefficient estimates are positive and similar to those we estimate when splitting the sample at 1980, though they are only significant at the 5% level in the early 1980s. By the early 1990s, the twin mortality gap between formerly twin-killing societies others and is not only statistically insignificant, it is also small in magnitude. In Figure A1, in the appendix, we show that this trend is visible in the raw data on twin mortality. Death rates are higher for twins in former twin-killing societies in the late 1970s and early 1980s, before they converge across groups.

5.2. How twin infanticide was suppressed

How, then, were both twin infanticide and negative attitudes towards twins suppressed in Africa? Our reading of the secondary historical literature is that this was due to the initiative of Africans, of missionaries, and of colonial administrators. Nunn (2009) has identified multiple equilibria, culture, and domestic institutions as three of the principal mechanisms that lead to historical persistence. Together, actions of Africans, missionaries, and administrators acted on these three channels, preventing them from leading to persistence.

First, it was the actions of Africans that led to the end of twin infanticide. By 1900, the Zulu had largely adopted colonial and Christian notions towards child killing (Badassy, 2011, p. 21). Similarly, many of the Yoruba-speaking peoples of Nigeria had reversed the tradition of twin infanticide prior to colonial rule (Renne, 2001, p. 64). One tradition holds that this was due to a decision of Ajaka, the Alafin of Oyo (ibid.). An alternative version stresses cultural diffusion, after a Yoruba woman gave birth in Isokun (Benin), where twin infanticide was not practiced (Chappel, 1974, p. 252). In Calabar (Nigeria), African rulers such as King Eyo Honesty II began to offer refuge to twins and their mothers during the 1850s (Imbua, 2013). African mothers in Zimbabwe actively resisted pressure from others in their communities, even before colonial rule, and sought help from missionaries in protecting their children (Zimudzi, 2004, p. 514, 516). Bastian (2001, p. 18) gives similar examples from Onitsha (Nigera). In Okitipupa (Nigeria), the reforming chief Nigwo of Igbotako confronted the Ijamo Society of chiefs on several occasions to oppose twin infanticide until the British

[15] https://www.arabnews.com/node/1402781/offbeat and https://www.npr.org/sections/goatsandsoda/2017/11/25/563341944/photos-people-think-the-twins-of-abidjan-can-make-a-wish-come-true?t=1597086104888.

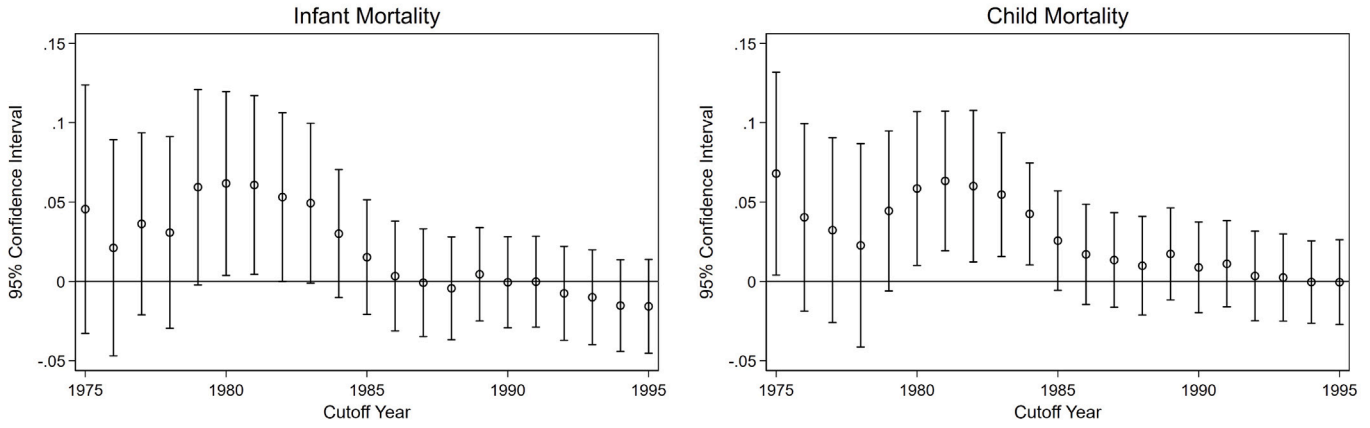

Fig. 5. Results using other cutoff dates. These figures present estimates and 95% confidence intervals for the coefficient on $Twin \times TwinKilling$ corresponding to columns (1) and (4) of Table 5 with alternative cutoff dates.

banned the society for its continued support of the practice (Richards, 1983, p. 11).

African Christians were particularly important in changing norms around twins. Pratten (2007, p. 67) gives the example of a woman within the small Christian community at Ibeno (Nigeria) who had been banished from her town for giving birth to twins and later enslaved before marrying a local chief. When he 'put away' eleven of his wives on converting to Christianity, she married one of the preachers at the Qua Iboe Mission, evidencing her integration into this new community. In Natal (South Africa), Christian converts had rejected infanticide before the twentieth century (Badassy, 2011, p. 21). Among the Annang (Nigeria), mothers of twins were among the outcast groups, also including slaves and strangers, that were disproportionately represented among converts (Pratten, 2007, p. 67). When twin infanticide was prohibited in the Annang region in 1899, it was a Christian convert, Etia, who nursed twins until they would be accepted by their mothers (Pratten, 2007, p. 68).

Other African attitudes towards twins have also changed due to African initiative. Among the Kedjom of Cameroon, the practice of giving a twin child to the chief began to be replaced in the 1940s by gifts of money as the cash economy and practice of wage labor both spread (Diduk, 1993). Christian belief and western education have, similarly, undermined twin rituals in Yoruba regions of Nigeria (Renne, 2001, p. 72).

Second, missionaries were important agents of cultural change. Individual missionaries such as Mary Elms, Hope Waddell and Mary Slessor campaigned against the practice (Proctor, 2000). In southeastern Nigeria, twin infanticide was one of the main causes taken up by missions, and the practice had largely ended by the 1930s (Bastian, 2001, p. 13). In Onitsha (Nigeria), European and African missionaries of all denominations worked against the practice. (ibid., p. 14). The Catholic Holy Ghost Fathers built a Christian village that would accept twins (p. 18), while the Church Missionary Society established a twin house that local elders agreed to help fund (p. 19). Renne (2001, p. 65–66) gives a similar timing of events in the areas of Yorubaland (Nigeria) outside Oyo control; north of Kabba, twin infanticide continued into the 1920s, while in Okitipupa Division African Christians accused the local Native Authorities of continuing to support the practice in the 1940s. At Egbe (Nigeria), the Christian mission took on unwanted babies, including twins (ibid.).

Wangila (2007, p. 111) names the spread of Christianity as one reason for the abandonment of twin killing in Kenya. The Girls' Institute operated by the Qua Iboe Mission in Nigeria became a refuge for mothers of twins (Pratten, 2007, p. 162). In Southern Rhodesia (Zimbabwe), James Hay Upcher would visit kraals in which twins had been born and warned parents that they could be prosecuted if twins were harmed (Zimudzi, 2004, p. 514). The missionary impact on African attitudes towards twins was broader than condemnation of infanticide. In northern Cameroon, Catholic and Swiss Presbyterian churches preached against rituals related to twins (Diduk, 1993).

Third, colonial administrators took actions that helped bring about the end of twin infanticide and changed attitudes. Clauses against twin infanticide were included in treaties between the British and local Nigerian rulers as early as the 1850s (Pratten, 2007, p. 74). As with other forms of infanticide, colonial courts treated twin infanticide as homicide (Devlieger, 2013). It was prosecuted by colonial governments, and the leniency they showed fell over time (Badassy, 2011; Harris, 1922). In Southern Rhodesia (Zimbabwe), offenders were sentenced to death but then shown mercy and not executed (Zimudzi, 2004, p. 512). Pratten (2007, p. 159) gives similar examples from Nigeria. In 1909 in Oron, provisions were made under the Births and Deaths Ordinance that parents of twins were required to register them and present them at court every three months. The Ikot Obong Court took action in 1907 against husbands who deserted their wives for giving birth to twins, and many women were then accepted back into their families. Some officials were even more proactive; the Native Commissioner of Matobo District (Zimbabwe) kept a register of all twins born (Zimudzi, 2004, p. 514).

Those involved knew that they were changing an equilibrium from which deviation could be difficult for any individual African, even if they did not use the language of economics. The 1907 report on Nigeria's Ikot Ekpene district, after stating that the Minor Court had taken action against husbands of twin-bearing women who had abandoned them, noted:

> In many cases the owners of these women, before the Court took action, had been willing to receive them back but were not prepared to stand the taunts and jibes of their neighbors for so doing. The Native Court having taken the initiative removed all scruples in this respect and the women were taken back.[16]

Missionary efforts were sometimes supported by specific administrators, such as John Beecroft and Claude MacDonald in the case of Mary Slessor in Nigeria (Imbua, 2013). The line between missionary and colonial official could be a blurry one; Slessor was made a vice-consul with authority to preside over a local court (Proctor, 2000). When chiefs at Etinan (Nigeria) asked the Irish missionary Samuel Bill not to interfere with twin infanticide, he replied that he would appeal to the British Consul for assistance, with force if needed, were he to

[16] National Archives of Nigeria, Enugu, Cal. Prof. 14/4/119.

Table 6
Results for subsamples distant from missions.

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality			Child mortality		
Panel A: Above-median distance from mission						
Twin × TwinKilling (DHS)	0.030**	0.029**	0.025	0.041***	0.041***	0.032**
	(0.014)	(0.014)	(0.017)	(0.014)	(0.014)	(0.015)
Twin	0.183***	0.183***	0.195***	0.192***	0.193***	0.210***
	(0.009)	(0.009)	(0.011)	(0.009)	(0.009)	(0.009)
TwinKilling(DHS)	0.002	0.000		−0.002	−0.005	
	(0.004)	(0.003)		(0.007)	(0.004)	
Observations	389,856	389,856	374,630	389,856	389,856	374,630
Clusters	241	241	240	241	241	240
Mean of dependent variable	0.0835	0.0835	0.0847	0.144	0.144	0.147
Panel B: Above-median distance from protestant mission						
Twin × TwinKilling (DHS)	0.032**	0.032**	0.028*	0.042***	0.042***	0.033**
	(0.014)	(0.014)	(0.016)	(0.014)	(0.013)	(0.015)
Twin	0.182***	0.182***	0.196***	0.191***	0.192***	0.211***
	(0.009)	(0.009)	(0.011)	(0.009)	(0.009)	(0.010)
TwinKilling(DHS)	0.001	−0.001		−0.002	−0.007*	
	(0.004)	(0.003)		(0.007)	(0.004)	
Observations	390,547	390,547	375,191	390,547	390,547	375,191
Clusters	234	234	231	234	234	231
Mean of dependent variable	0.0829	0.0829	0.0841	0.143	0.143	0.146
Panel C: Protestant mission >25 km						
Twin × TwinKilling (DHS)	0.019	0.020*	0.014	0.023*	0.025**	0.016
	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	(0.013)
Twin	0.173***	0.174***	0.187***	0.183***	0.186***	0.203***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)
TwinKilling(DHS)	−0.001	0.001		−0.009	−0.002	
	(0.004)	(0.002)		(0.008)	(0.002)	
Observations	614,161	614,161	588,691	614,161	614,161	588,691
Clusters	281	281	281	281	281	281
Mean of dependent variable	0.0783	0.0783	0.0795	0.132	0.132	0.135
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes	No	Yes	Yes
Mother fixed effects	No	No	Yes	No	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by DHS ethnicity. Controls are female, birth order, and year of birth.

hear about such practices (Pratten, 2007, p. 73). The role of colonial intervention should not, however, be overstated; Leys (1959), for example, mocked the "fatuous ineptitude" of a newspaper in Southern Rhodesia (Zimbabwe) that noted how "natives" had gone from killing twins to being proud of them under white "partnership".

5.3. Heterogeneity

We now show a number of heterogeneity analyses, demonstrating how estimates of Eq. (1) differ across sub-samples of the data. Across these, a pattern emerges: where the mechanisms by which twin infanticide and negative attitudes towards twins were suppressed have been weaker historically, we do find some evidence of the continued existence of a mortality penalty for twins that is greater among previously twin-killing societies relative to others. We focus specifically on two channels that we can measure well — exposure to missionaries and exposure to colonial government.

5.3.1. Missionaries

Splitting the sample by proximity to missions, there is suggestive evidence of greater differential mortality of twins among groups with a former tradition of twin infanticide that are distant from Protestant missions. In particular, in Table 6, we cut the sample by whether a DHS cluster is above or below the median distance to a colonial mission reported in Roome (1925). While this is by no means a complete map of missions in Africa, it captures some of the oldest and most durable missions on the continent and has been used by at least 30 studies of missions (Jedwab et al., 2018). Panel A shows that child mortality is 3 or 4 percentage points greater for twins from formerly twin-killing groups in locations distant from colonial missions. In Panel B, this differential is driven entirely by Protestant missions. Using instead the preferred distance cutoff from Nunn (2014), 25 km, there is evidence of a greater mortality penalty distant from Protestant missions, though it is only statistically significant in some specifications. We do not report results where we instead cut the sample by distance from Catholic missions; there is no evidence of a mortality penalty in either the above-median or below-median sub-sample based on distance from a Catholic mission. This suggests that Catholic missions were quantitatively irrelevant to the abandonment of twin infanticide.

Why Protestants? The literature has documented a wide-ranging impact of missions on outcomes such as education (Okoye and Pongou, 2014; Wantchekon et al., 2015), gender roles (Nunn, 2014), newspaper readership (Cagé and Rueda, 2016), and democracy (Woodberry, 2012). Our results complement this literature. The Catholic-Protestant distinction has several likely sources. Protestant missionaries were more numerous per capita in sub-Saharan Africa (Gallego and Woodberry, 2010). In British colonies, where indirect rule kept traditional authorities in power, missions brought new beliefs, norms, and alternatives to village life that reduced cooperation with these authorities (Okoye, 2021). Conversionary Protestants were particularly active in promoting religious freedom, mass education, printing and the spread of newspapers, civil society, colonial reforms, and legal codes that protected Africans (Woodberry, 2012). Protestant missions also placed greater weight on the education of women (Nunn, 2014). Together, these suggest distance from a Protestant mission will be more salient than distance from a Catholic mission.

In Table A2 in the appendix, we show that these differences are statistically significant. For each moderator variable, i.e. for each measure of mission proximity, we add $Moderator \times Twin \times TwinKilling$,

Table 7
Results for subsamples distant from cities in 1960.

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality			Child mortality		
Panel A: Above-median distance from city						
Twin × TwinKilling (DHS)	0.024**	0.024**	0.023*	0.027**	0.028**	0.019
	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)
Twin	0.171***	0.171***	0.184***	0.182***	0.183***	0.202***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)
TwinKilling(DHS)	−0.001	0.001		−0.005	−0.001	
	(0.003)	(0.002)		(0.005)	(0.003)	
Observations	390,922	390,922	374,006	390,922	390,922	374,006
Clusters	248	248	246	248	248	246
Mean of dependent variable	0.0733	0.0733	0.0744	0.120	0.120	0.122
Panel B: Below-median distance from city						
Twin × TwinKilling (DHS)	−0.013	−0.013	−0.013	−0.007	−0.005	−0.002
	(0.013)	(0.013)	(0.015)	(0.013)	(0.014)	(0.015)
Twin	0.171***	0.173***	0.183***	0.177***	0.182***	0.192***
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.011)
TwinKilling(DHS)	−0.008	−0.001		−0.027*	−0.005	
	(0.006)	(0.002)		(0.015)	(0.003)	
Observations	425,102	425,101	403,755	425,102	425,101	403,755
Clusters	272	272	271	272	272	271
Mean of dependent variable	0.0747	0.0747	0.0764	0.126	0.126	0.129
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes	No	Yes	Yes
Mother fixed effects	No	No	Yes	No	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by DHS ethnicity. Controls are female, birth order, and year of birth.

$Moderator \times Twin$, $Moderator \times TwinKilling$, and $Moderator$ as additional controls. In any specification in which the coefficient on the mission proximity measure in Table 6 is significant at the 10% level, the coefficient on the triple interaction $Moderator \times Twin \times TwinKilling$ is significant at the 10% level in Table A2. These differences are not explained solely by the effects of missions on religion and education; in Table A3, we show that the results are largely unchanged when controlling for mother's religion and level of education.

5.3.2. Colonial government

In Table 7, we similarly show that the differential mortality of twins is greater among former twin-killing groups in areas distant from colonial cities. In particular, we use data on cities and their locations from Africapolis.[17] Taking cities that existed in 1960 as an approximation of cities present in the late colonial period, we show that the interaction of $Twin \times TwinKilling$ is positive and significant in areas more than median distance from a city in these data. The magnitude of this differential, roughly 2.5 percentage points, is greater than 10% of the usual twin mortality penalty.[18] It was from cities such as these that the colonial state projected its authority, and even in the present day the state is often weak distant from major cities (Bubb, 2013; Michalopoulos and Papaioannou, 2014). In Zimbabwe, those convicted of killing twins could not use ignorance of the law as a defence, but remoteness from European centers was considered a mitigating factor and offenders were punished more severely if they had killed twins near European centers (Zimudzi, 2004, p. 513).

Splitting the sample by colonizer, there is suggestive evidence of greater differential mortality of twins among groups with a former tradition of twin infanticide in former French colonies. We present these results in Table 8, breaking the sample into British colonies, French colonies, and all others — Ethiopia, Liberia, Mozambique, and Namibia. There is some evidence that relative child mortality, though not relative infant mortality, remains higher among twins from formerly twin-killing groups in former French colonies.[19]

French colonization differed from British colonization in many ways that would have weakened the forces working to eliminate twin infanticide and its associated beliefs: it provided less mass education (Asiwaju, 1976; Cogneau and Moradi, 2014; Dupraz, 2019), created less state capacity (Cogneau et al., 2021), extracted more (Huillery, 2014), and relied more heavily on forced labor (Van Waijenburg, 2018). Protestant missions were particularly concentrated in British colonies, where they faced fewer restrictions on their operation (Gallego and Woodberry, 2010).

6. Robustness

In this section, we briefly outline robustness checks and additional results that we present in the appendix. We demonstrate the robustness

[17] https://www.africapolis.org/home.

[18] As with our results on proximity to missions, we use a fully interacted specification to show in Table A2 in the appendix that these sub-sample results are statistically different from results obtained using the full sample. For any result that is significant at the 10% level in Table 7, the corresponding triple interaction in Table A2 is also significant at the 10% level. Similarly, we show in Table A3 that the results are nearly identical when controlling for mother's religion and level of education. In Table A4, in the appendix, we provide supporting evidence from the importance of agriculture in precolonial society as measured in the Murdock (1967) *Ethnographic Atlas*. Dividing the sample into those above and below 55% dependence on agriculture, we find greater differential twin mortality among formerly twin-killing societies in the less agricultural sub-sample. As with peoples far from colonial cities, non-agricultural peoples also remained distant from colonial authority due to their exceptional mobility, often resisting taxation and incorporation into the cash economy (Gardner, 2012). This is analogous to parts of the Southeast Asian Massif where several peoples have used swidden agriculture and picking as strategies to evade incorporation into lowland rice producing states (Scott, 2009).

[19] In Table A2 in the appendix, we use a fully-interacted specification to test if this result for French colonies differs statistically from that in the full sample. While the triple interaction is significant at the 10% level with country and with region fixed effects, it is not significant at conventional levels with mother fixed effects.

Table 8
Results by colonizer.

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality			Child mortality		
British Africa						
Twin × TwinKilling(DHS)	−0.014	−0.014	−0.015	−0.013	−0.011	−0.012
	(0.013)	(0.013)	(0.015)	(0.014)	(0.014)	(0.015)
Twin	0.170***	0.171***	0.182***	0.177***	0.180***	0.193***
	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)	(0.011)
TwinKilling(DHS)	−0.012**	−0.003		−0.032**	−0.007**	
	(0.005)	(0.002)		(0.013)	(0.004)	
Observations	386,408	386,408	368,152	386,408	386,408	368,152
Clusters	162	162	162	162	162	162
Outcome mean	0.0708	0.0708	0.0722	0.115	0.115	0.118
French Africa						
Twin × TwinKilling(DHS)	0.021	0.023	0.016	0.036**	0.039***	0.027*
	(0.017)	(0.017)	(0.019)	(0.015)	(0.015)	(0.016)
Twin	0.170***	0.171***	0.181***	0.180***	0.182***	0.197***
	(0.010)	(0.010)	(0.011)	(0.009)	(0.009)	(0.010)
TwinKilling(DHS)	0.010**	0.002		0.013*	−0.002	
	(0.004)	(0.003)		(0.008)	(0.003)	
Observations	365,274	365,274	349,125	365,274	365,274	349,125
Clusters	94	94	94	94	94	94
Outcome mean	0.0757	0.0757	0.0769	0.131	0.131	0.134
Other (Ethiopia, Liberia, Mozambique and Namibia) Africa						
Twin × TwinKilling(DHS)	−0.002	−0.002	0.012	−0.006	−0.006	0.015
	(0.029)	(0.029)	(0.031)	(0.026)	(0.025)	(0.028)
Twin	0.205***	0.209***	0.220***	0.222***	0.226***	0.234***
	(0.025)	(0.025)	(0.026)	(0.021)	(0.021)	(0.024)
TwinKilling(DHS)	0.000	0.015***		−0.007	0.012**	
	(0.007)	(0.003)		(0.011)	(0.006)	
Observations	75,383	75,383	71,122	75,383	75,383	71,122
Clusters	33	33	33	33	33	33
Outcome mean	0.0825	0.0825	0.0843	0.121	0.121	0.124
Fixed effects	Country	Region	Mother	Country	Country	Country
Controls	Yes	Yes	Yes	Yes	Yes	Yes

*** Significant at 1%. ** Significant at 5%. * Significant at 10%. Ordinary least squares estimates. Standard errors in parentheses clustered by ethnicity. Controls are female, birth order, and year of birth.

of the main, null, result. We then show the robustness of the heterogeneity results relating to missions, distance from colonial cities, and colonizers. We then outline a number of additional results that help exclude alternative explanations of the lack of a present-day differential mortality penalty for twins in former twin-killing groups. We then present additional results, showing that we find no differences in our main result by the gender of the twin pair, or in times of adverse rainfall shocks.

6.1. Robustness of the main result

6.1.1. Twins sample

In our baseline estimation, we focus on the relative mortality of twins and singletons. As an alternative, we focus solely on the sample of more than 33,000 twins. In this case, we estimate:

$$Mortality_{iemt} = \alpha + \beta TwinKilling_e + x'_{iemt}\gamma + \delta_x + \epsilon_{iemt} \quad (2)$$

All variables in Eq. (2) are defined as in Eq. (1). However, now our focus has changed. The parameter of interest is now β – the absolute, rather than relative, mortality of twins in ethnic groups with a tradition of twin infanticide. We estimate Eq. (2) in both the full and border samples, with and without fixed effects (δ_x) for country and region. We cannot include mother fixed effects in this specification because they would be collinear with $TwinKilling_e$.

In Table A5, we focus instead on the absolute mortality of twins and present estimates of Eq. (2). We show results for both infant (columns 1 and 2) and child (columns 3 and 4) mortality. Similarly, we code twin infanticide by DHS ethnicity (panels A and C) and location in the Murdock (1959) map (panels B and D) in the full (panels A and B) and border (panels C and D) samples. We show results with country and region fixed effects, but not mother fixed effects, since these are collinear with $TwinKilling$. Across specifications, we find little evidence of greater twin mortality in former twin-killing groups. The lone positive and significant coefficient of 0.019 – in column (4) of Panel A – is significant at the 10% level and is, in magnitude, less than 10% of the average child mortality rate among twins, which is 0.299. Other coefficients in the table are insignificant, sometimes negative, and small relative to the means of the outcome variables.

6.1.2. Balance and additional controls

We begin in Table A6 by reporting the correlates of whether we have been able to code the presence or absence of twin infanticide in an ethnic group. Our sample here is the 543 groups in the Murdock (1959) map that intersect the countries in our data. We report the coefficient and standard error from several simple regressions. In each, the dependent variable is whether the twin infanticide variable is missing and the independent variable is a single geographic or ethnographic characteristic of the ethnic group. For ease of interpretation, any variable that is not a percentage (e.g. share or percentage woodland) or a dummy (e.g. river) has been normalized to have mean 0 and standard deviation 1.

There are several variables that predict whether a group is missing from the data. Generally, these tell a consistent story: groups in more difficult environments (woodland, forest, greater temperature, presence of malaria), in areas that were harder to access (further from coast, absence of a river), those with less contact with Europeans (fewer slave exports, lack of a colonial railroad, lack of the presence of explorers, fewer missions), and those that are smaller (sparser population, smaller area, smaller total population) are less likely to appear in the data. To bound the possible bias due to the fact that groups are not missing at

random from the data, we report robustness to recoding all missing groups as 0.[20]

In Table A7, we report balance tests. That is, we assess whether the presence of twin infanticide correlates with observable characteristics of the ethnic groups in our sample. Mirroring A6, our sample is the 304 groups in the Murdock (1959) map that we have successfully coded.[21] We again report the coefficient and standard error from several simple regressions. Only a handful of variables correlate significantly with twin infanticide. Notably, other important ethnicity-level variables that have appeared in the economics literature – the importance of agriculture, polygyny, the presence of states, patriliny, and female participation in agriculture – do not correlate with twin infanticide.

Among the significant correlations, the presence of a colonial railroad, proximity to the coast, the presence of missions (in particular Protestant missions), and greater total population all predict the presence of twin infanticide. We interpret these as showing a similar pattern: greater contact with European observers increased the probability that twin infanticide was detected while it either continued to exist or had still existed recently enough to be uncovered in oral testimony. We address the relationship between missions and twin infanticide in Section 5.3. For additional robustness, we will include these significant correlates of twin infanticide as controls below.

We also use this table to show results of the same exercise performed on the subsample along a border separating groups that once practiced twin infanticide and those that did not. Results are similar, though two geographic variables (semi-desert vegetation and woodland) become significant correlates of twin infanticide, while a handful of others cease to become significant correlates.

In Table A8, we show that the DHS wealth index and maternal years of schooling do not correlate strongly with a tradition of twin infanticide. We regress these variables on our two measures of $TwinKilling$ and fixed effects, either for country or region. The sole specification in which these correlate with $TwinKilling$ – when we code respondents by their location relative to polygons in Murdock (1959) and include country fixed effects – suggests they correlate *positively* with a past tradition of twin infanticide.

In our baseline regressions, we have only included a sparse set of controls. Because our main result is a null effect, we wish to avoid biasing our results towards zero due to a too demanding specification or towards insignificance by including a set of controls collinear with twin infanticide. It is, however, possible that omitted variables that predict twin infanticide correlate negatively with twin mortality, biasing our baseline estimates.

To alleviate this concern, in Table A9, we show the results of adding several additional controls to our baseline specification. In successive columns, we show results controlling for variables from the *Ethnographic Atlas* (importance of agriculture, polygamy, jurisdictional hierarchy, patrilineal, role of women in agriculture), characteristics of mothers (age, age squared, education, rural, religion) and geography (precipitation, aridity, surface temperature, vegetation index, malaria prevalence). These controls do little to change the results.

In Table A10, we control for an alternative set of additional controls — the DHS wealth index, maternal education in years, and mean infant mortality at the ethnicity level. These too have little impact on the results. In Table A11, we control for birth spacing as the number of months since the previous birth. For first births, we code this as zero and control for a dummy for first born. Results change little. In Table A12, we perform a similar exercise. We control for all variables from Table A7 that were significantly different between twin-killing and non twin-killing groups.

[20] See Table A17.

[21] This number is greater than the 272 groups we have coded by location relative to the Murdock (1959) map since not every polygon in Murdock (1959) contains a survey cluster in the DHS data.

6.1.3. Additional robustness

In our baseline estimation, we compare groups with a tradition of twin infanticide to all other ethnic groups in our data. We take three alternative approaches to limiting the comparison group to ethnicities that are likely to be more similar to former twin-killing groups. First, in Table A13, we limit the comparison group to ethnic groups that are recorded as having negative attitudes towards twins, but did not practice twin infanticide. Second, in Table A14, we alternatively control for positive attitudes towards twins and their interaction with whether the child is a twin. Third, in Table A15, we limit the sample to societies that once practiced twin infanticide and those that Ball and Hill (1996) record as having practiced any other type of infanticide. In all three tables we find no evidence of a greater mortality penalty for twins in former twin-killing societies. A positive attitude towards twins, by contrast, positively predicts the survival of all children.

Our baseline border sample estimations did not include regression discontinuity polynomials, as we did not wish to bias them towards zero with a too demanding specification. In Table A16 we add these polynomials. First, column (1) controls for a linear polynomial in distance to the border. We allow the slope to change at the border. Second, column (2) implements a procedure similar to that in Dell (2010) by controlling for latitude and longitude. Neither of these have a notable effect on our coefficient estimates. In columns (3) and (4) we report that our results are largely unchanged if we either double or halve the bandwidth used to define our border sample. In column (5), we show results are similarly unchanged if we control for border segment (i.e. ethnicity pair) fixed effects.

There are some groups in the data for which the evidence in the literature is contradictory or of poor quality. In Table A17 in the appendix, we show that this does not drive our results. In particular, for 26 ethnic groups, we show the result of either recoding the group to the opposite coding of $TwinKilling$, or recoding it as missing.

Because the durability of tradition may be stronger in rural societies, and because we measure ethnicity with more error in urban contexts – particularly when using location in the Murdock (1959) map – we show in Table A18 that our results remain similar when estimated on the rural sub-sample of the data.

Finally, because it is possible that we may fail to find a continued mortality penalty among formerly twin-killing groups because they conceal twin births, we show in Table A19 that twinning rates reported in the DHS data are no lower in these societies. In particular, we make whether the birth is a twin a dependent variable. The coefficient on $TwinKilling$ is small in both the full and border samples.[22] This is also evidence against a more general link between the prevalence of twin births and the former practice of twin infanticide.

In Table A20 we show that the results presented in Table 4 are similar if we code twin killing by location in the (Murdock, 1959) map, rather than DHS ethnicity.

6.2. Robustness of the heterogeneity results

While it is not the case that colonial missions are as good as randomly placed – Jedwab et al. (2018) show that several geographic variables predict their presence – we can show that the presence of Protestant missions does not correlate with other ethnographic features of the societies in our data. In Table A21, we regress each of the ethnographic controls we consider (jurisdictional hierarchy, patrilineal,

[22] Because many DHS surveys do not count all pregnancies and ask only about whether the respondent has ever had a terminated pregnancy and not whether it was spontaneous or induced (Sánchez-Páez and Ortega, 2019), we are unable to directly examine abortion. While abortion is more common in sub-Saharan Africa than in Europe or North America, it remains widely unsafe and illegal, and is less common than in Asia and North Africa (Bearak et al., 2020; Lauro, 2011).

polygynous, importance of agriculture, and female participation in agriculture) on the density of Protestant missions. As in Table A7, our sample is groups in the Murdock (1959) map, and mission density is normalized to be $N(0,1)$. The correlations between missions and these other characteristics of ethnic groups are small and statistically insignificant.

In Table A22, we report alternative versions of our subsample analysis by distance from a colonial mission. In columns (1) through (3), we report results in the border sample. The greater relative mortality rate of twins relative to non-twins among formerly twin-killing societies distant from missions remains. This gap continues to be driven by distance from Protestant missions, though the differential is no longer significant with mother fixed effects. In columns (4) through (6) we code twin-killing by location in the Murdock (1959) map, rather than DHS ethnicity. Here, the results are qualitatively similar to those in Table 6, though they are not always statistically significant.

In Tables A23 and A24, we consider heterogeneity by colonizer in alternative samples or with alternative codings. In Table A23, we show results in the border sample. Here, the interaction of $Twin \times TwinKilling$ remains positive and significant in the French sub-sample with child mortality as an outcome in specifications without mother fixed effects.

6.3. Alternative mechanisms

In Table A25, we find no evidence that the results differ by United Nations region — West Africa, Central Africa, East Africa, or South Africa. It would be possible that excess mortality would continue to be high among twins from former twin-killing groups if health facilities were unavailable, making investments in their health particularly costly. We show in Table A26, however, that this is not the case. We measure the availability of a health facility for each DHS cluster by the share of respondents who claim that one is available. Splitting the sample by the median availability of health facilities shows no significant interaction on $Twin \times TwinKilling$ in either sub-sample.

In Table A27, we consider the possibility that pre-colonial institutions may have inhibited the disappearance of twin infanticide and associated negative attitudes towards twins. We consider four institutional and cultural characteristics of societies that have featured prominently in recent work in economics: polygyny, jurisdictional hierarchy, patriliny, and female participation in agriculture. Across samples, we find little evidence of a differential twin mortality penalty among formerly twin-killing groups. The exception is one specification in the non-polygynous sample. Since this represents less than 2% of the sample and varies by which fixed effects are included, we do not take this as evidence of meaningful heterogeneity.

In Tables A28, A29, and A30, we consider three measures of factors that might have recently disrupted existing social norms — ethnic diversity, migration, and conflict. We begin by computing an ethnic diversity measure for each cluster in the DHS data by computing a Herfindahl index based on the shares of the sample coming from each ethnic group in the survey. Despite substantial intra-group heterogeneity, ethnic identity is a predictor of norms, values and preferences (Desmet et al., 2017). Splitting the sample by clusters above and below the median according to this fractionalization measure, the coefficient on $Twin \times TwinKilling$ is insignificant in both sub-samples. We measure migration by counting the fraction of respondents in the DHS data who claim that they were born somewhere other than the cluster in which they are currently living. Dividing the sample by the median rate of migration, we show in Table A29 that the coefficient on $Twin \times TwinKilling$ is again insignificant in both samples.

We consider a related exercise in Table A31, in which we assess the possible importance of twin infanticide among other ethnic groups in the same region. We compute a new variable, $Others\ TwinKilling$, that measures the prevalence of twin infanticide among other ethnic groups in the same region. For each birth in the data, we compute the share of births to ethnic groups other than the respondent's that come from groups with a tradition of twin infanticide. We include this variable and its interaction with $Twin$ as additional controls in our principal specification. Neither variable is predictive of infant or child mortality.

To measure conflict, we consider battle deaths in the Uppsala Conflict Data Program's Georeferenced Event Dataset Global version 20.1 (Pettersson and Öberg, 2020; Sundberg and Melander, 2013). This source reports the number of battle deaths in more than 200,000 conflict events since 1989. For each survey cluster, we count the number of battle deaths occurring within 50 km, and divide the sample into clusters that have experienced above-median and below-median conflict intensity. Table A30 shows that the coefficient on $Twin \times TwinKilling$ is insignificant in both sub-samples. Alternative distance cutoffs such as 25 km and 100 km give similar results, but are omitted for space.

6.4. Additional results

For some cases in our data it is mentioned in the ethnographic record that twin infanticide would be selective by gender. In Table A32, we show that we find no significant differences by the gender of the twin pair. To do this, we estimate:

$$\begin{aligned} Mortality_{iemt} =& \alpha + \beta_1 Twin_{iemt} + \beta_2 TwinKilling_e \\ &+ \beta_3 Twin_{iemt} \times TwinKilling_e \\ &+ \beta_4 TwinKilling_e \times BothFemale_{iemt} \\ &+ \beta_5 TwinKilling_e \times Mixed_{iemt} \\ &+ \beta_6 BothFemale_{iemt} + \beta_7 Mixed_{iemt} \\ &+ x'_{iemt}\gamma + \delta_x + \epsilon_{iemt} \end{aligned} \tag{3}$$

All but two new variables are defined as in Eq. (1). The two new terms are $BothFemale_{iemt}$ and $Mixed_{iemt}$. We code $BothFemale_{iemt}$ equal to 1 for twin pairs that are both female, and 0 for both singletons and other twin pairs. We code $Mixed_{iemt}$ equal to 1 for twin pairs that have a boy and a girl, and 0 for both singletons and other twin pairs. Because these two variables are 0 for non-twins, the triple interaction terms $Twin_{iemt} \times TwinKilling_e \times BothFemale_{iemt}$ and $Twin_{iemt} \times TwinKilling_e \times Mixed_{iemt}$ do not appear in the regression.

This means that β_1 captures the differential mortality of all-male twin pairs relative to non-twins. β_6 measures whether this is greater if both children are female. β_7 measures whether this is greater if the pair is mixed. β_3 captures whether the mortality of twins relative to non-twins is greater in formerly twin-killing societies. β_4 captures if this additional penalty is any greater for all-girl pairs than for all-boy pairs. β_5 does the same for mixed pairs, relative to all-boy pairs. Across specifications, Table A32 shows no differential mortality penalty for twins in formerly twin-killing societies, nor any significant deviations of the penalties for all-female and mixed pairs from that for all-boy pairs.

It is possible that, while twin infanticide and lingering negative attitudes towards twins no longer matter on average, in periods of distress these could shape investments made in child health and the selective survival of twins relative to non-twins. Similar patterns have been found for gender-biased survival rates in countries with son preference; in India, for example, favorable rainfall has a greater impact on the survival of girls than of boys (Rose, 1999; Jayachandran, 2015).

We test for this in Table A33. We use geocoded data on gridded rainfall between 1900 and 2017 from version 5.01 of Willmott and Matsuura (2001). For births that are no later than 2017 and for which the survey cluster has valid coordinates, we record annual rainfall in the first year of life at the grid point nearest to the survey cluster. We use these data to estimate:

$$\begin{aligned} Mortality_{iemt} =& \alpha + \beta_1 Rain_{iemt} \times Twin_{iemt} \times TwinKilling_e \\ &+ \beta_2 Rain_{iemt} \times TwinKilling_e + \beta_3 Rain_{iemt} \times Twin_{iemt} \end{aligned}$$

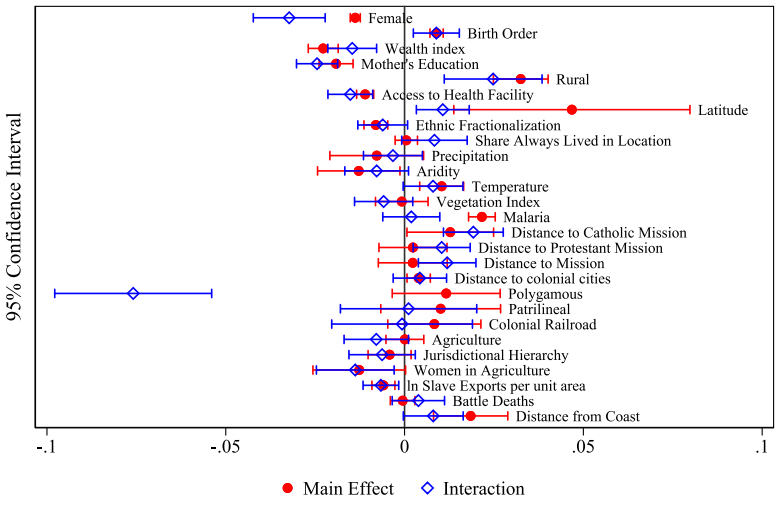

Fig. 6. Moderators of the twin penalty.

$$+ \beta_4 Twin_{iemt} \times TwinKilling_e + \beta_5 Rain_{iemt} + \beta_6 Twin_{iemt} + \beta_7 TwinKilling_e + x'_{iemt}\gamma + \delta_c + \eta_t + \epsilon_{iemt} \quad (4)$$

While many variables are defined as in Eq. (1), there are new terms. $Rain_{iemt}$ is annual rainfall in the survey cluster in the child's year of birth. Controls x_{iemt} are now restricted to a female dummy and birth order. Our fixed effects δ_c and η_t are now for survey cluster and year of birth. This specification, then, exploits the panel-like variation in the data, so that $Rain_{iemt}$ can be interpreted as the impact of an exogenous rainfall shock, since identification is now based of deviations from cluster and year means. The coefficient of interest is β_1, which captures the degree to which any mortality penalty for twins relative to non-twins that is greater in formerly twin-killing societies becomes greater or smaller if rainfall is more or less abundant. If droughts were to activate dormant attitudes that lessen twin survival, we would expect β_1 to be negative. Table A33 shows that this is not the case; while greater rainfall reduces child mortality, this is not different across twins and non-twins, and it does not differ by past tradition or its interaction with twin.

If not tradition, what explains twin mortality in Africa? The large and positive coefficient on "Twin" that is visible in many of our tables shows very little sensitivity to the inclusion of fixed effects — for countries, for sub-national regions, for survey clusters, or for mothers. Nor is the twin penalty sensitive to controlling for additional observable features of the child, mother, community, or ethnic group. There are, however, many observable variables that moderate the Twin coefficient. We re-estimate (1) replacing the "Twin Killing" dummy with several alternative moderators that we take from our list of controls. We use the specification with child mortality as an outcome and control for country fixed effects.

In Fig. 6, we report the coefficients on the moderator itself as "Main Effect", and the interaction with "Twin" as "Interaction". While this analysis is suggestive, a general pattern emerges. Characteristics such as maternal education and greater wealth that predict greater child survival also predict a smaller mortality penalty for twins. By contrast, characteristics such as rural and birth order that predict greater child mortality also predict a greater mortality penalty for twins.

7. Conclusion

We have taken two approaches to assessing whether mortality of twins is higher in the present, relative to that of non-twins, among African societies that previously practiced twin infanticide. Our results suggest no effect of a former tradition of twin infanticide on twin mortality in Africa in the present. Twin infanticide and its indirect legacies have been suppressed through a mix of African and external forces, including cultural diffusion and missionary enterprise. We show that, where these channels of suppression are weak – distant from colonial missions and authority, and in former French colonies – there is evidence that twin mortality remains elevated among formerly twin-killing groups.

These results contrast, then, with many other results in the literature that show considerable persistence in culture, including among migrant populations. These include past histories of selective infanticide that continue to influence sex ratios in East and South Asia (Lee and Wang, 2001; Sudha and Rajan, 1999). Other notable examples of historical persistence in culture include gender norms, trust, and individualism (Becker, 2019; Bazzi et al., 2020; Alesina et al., 2013; Xue, 2018). And yet the literature has noted cases in which culture has changed rapidly. Fernández (2011), for example, cites attitudes in the United States towards women working outside the home and towards premarital sex, explaining these changes using the presence of multiple equilibria and endogenous learning. Voigtländer and Voth (2012), similarly, note that the transmission of anti-Semitism across generations in Germany was attenuated by trade and mobility. Our results are relevant, then, to other traditions with adverse health impacts such as female genital mutilation, which persist in some regions and have been abandoned in others (Johansen et al., 2013).

The suppression of twin infanticide and its indirect legacies by African and external forces has several common features with these cases of change, and differences with cases of persistence. The reverence for twins in some societies and abhorrence of twins in others provides more variation in attitudes than does the existence or absence of a preference for sons. The prevalence of adjacent ethnic groups with very different attitudes towards twins facilitated the transmission of *culture*. Missions that fought twin infanticide induced permanent cultural change; Christianity is now the most common religion in sub-Saharan Africa, and this has led to lasting changes in other areas, including health and sexual behavior (Cagé and Rueda, 2020). Efforts of *institutions* such as colonial courts against infanticide did not involve the same trauma as other colonial interventions such as medical campaigns and natural resource extraction that have left legacies of distrust (Lowes and Montero, 2020, 2021). The status of twins is not as central as the status of women is to other equilibria involving marriage, inheritance, and the division of labor, and so changing the status of twins does not necessarily entail wide-ranging changes in other domains. Once twin infanticide had been suppressed, the existence of *multiple equilibria* inhibited its return, as individuals adhered to new social norms (Marroquín and Haight, 2017).

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jdeveco.2023.103094.

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